Yongxiang Lu *Editor*

A History of Chinese Science and Technology

Volume 2

上海交通大學出版社
SHANGHAI JIAO TONG UNIVERSITY PRESS

Springer

A History of Chinese Science and Technology

Yongxiang Lu
Editor

A History of Chinese Science and Technology

Volume 2

上海交通大學出版社
SHANGHAI JIAO TONG UNIVERSITY PRESS

Springer

Editor
Yongxiang Lu
Chinese Academy of Sciences
Beijing
China

Translated by Chuijun Qian, Hui He
Proofread by Weige Li, Dianhua Zhao

ISBN 978-3-662-44165-7 ISBN 978-3-662-44166-4 (eBook)
DOI 10.1007/978-3-662-44166-4

Jointly published with Shanghai Jiao Tong University Press
ISBN: 978-7-313-11708-3 Shanghai Jiao Tong University Press

Library of Congress Control Number: 2014947137

Springer Heidelberg New York Dordrecht London

© Shanghai Jiao Tong University Press, Shanghai and Springer-Verlag Berlin Heidelberg 2015
This work is subject to copyright. All rights are reserved by the Publishers, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publishers' locations, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publishers can accept any legal responsibility for any errors or omissions that may be made. The publishers make no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

It has been in my mind for many years that the rich Chinese culture and civilisation should be communicated more extensively to the world. The ancient Chinese civilisation—one of the world's earliest civilisations flourished in the fertile basin of the Yellow River and the Yangtze River valleys in the Neolithic era. As a significant part of the Chinese civilisation, Chinese science and technology with a rich history plays a vital role in the development of Chinese social culture as well as the world's science, technology, culture and civilisation. This English version of *A History of Chinese Science and Technology* will be informative knowledge to help us further understand the evolution of Chinese science and technology over the past few centuries.

With the rise of China, she has become more important to the region and the world's economic and social development. China's stability and continuous evolution is fundamental to the attainment of global peace, and advancement and the progress of mankind. By comprehending the history of Chinese science and technology, we will be enlightened on how the Chinese society has evolved, how the advent of Chinese culture and civilisation has developed over the past few millenniums and shaped the Chinese society with its unique culture today. These books—*A History of Chinese Science and Technology*—which contain copious information on wisdom in many aspects, personify the spirit of the unparalleled achievements of ancient China. They encompass a variety of subjects which include astronomy, mathematics, physics, agriculture, biology, medicine, four great inventions, and ceramic, textile, construction, mining, mechanical, water, transportation and military technologies.

The latest science and technology inventions, developments and innovations did not occur by chance and did not surface at one time. As the great scientist Sir Isaac Newton said: "If I have seen further, it is by standing on the shoulder of giants", all modern technologies and scientific discoveries were built on past achievements. I truly appreciate the evolution of science and technology cited in the books. A good example is the evolution of the navigation technology applied on board ships. As one of the four great inventions in the ancient China, the compass served as a historically significant navigation tool in the maritime and

shipping industry, which aided Zheng He and many seamen to travel across oceans to reach to their destinations. When I first started sailing in the 1950s, navigation in the open sea was conducted with laborious calculations based on the Sextant measurement of the altitudes of planets and stars, and the accuracy of the ship's position such as latitude, longitude, was measured in miles. Then the SatNav, a satellite navigating system, was invented, but soon, it was replaced by the superior Global Positioning System Navigation system in which accuracy is measured in metres. The newly developed technology has tremendously revolutionised position fixing at sea, resulting in convenient, effortless and seamless navigation, which reduces manning required on ships—a device that has become indispensible to mariners today. Throughout the books, we can understand why these inventions and developments are relevant to us and how they have transformed our lives and our work. Being deeply involved in the maritime industry for more than six decades, I realise that it is beneficial to stay abreast on trends and techniques and examine the evolving work-style and lifestyle preferences.

At present, many Chinese adopt the western culture and their advanced management methods, but as a Chinese, we should be aware of our history and culture, and understand our roots. With the world's focus shifting from the West to the East, it is imperative for us to learn more about Asia, including the Chinese culture. I believe these books can serve as a meaningful gift to the Chinese who are born, raised or educated overseas so that they can understand the profound contributions of Chinese science and technology to the world and promote them.

I cannot close this foreword without expressing my sincere appreciation to those who were instrumental in the planning, designing, writing, compiling and production of these books. Special thanks to the chief editor Prof. Yongxiang Lu, former President and member of Chinese Academy of Sciences (CAS); Dr. Baichun Zhang, Director of Institute for the History of Natural Sciences (IHNS) and Prof. Yuqun Liao, former Director of IHNS, for their immense efforts in producing the English version of these books so that they are accessible to everyone. I would also like to thank Shanghai Jiao Tong University Press for publishing these books. I am very happy to see this set of books being published successfully, and I am very honoured to be given the opportunity to play my part in promoting Chinese science and technology around the world.

Tan Sri Frank Tsao

曹文錦

Prelude

The grand mansion of modern science is constantly changing the course of civilization and the daily life of human beings, and influencing the mind of the human race with its infinite charisma. However, the emergence, development, and historical effects of science and technology remain the least understood part of the entire human civilization over a very long period of time. Since the mid-twentieth century, when the history of science became a relatively independent discipline, experts and scholars from the two fields of science and technology, and humanities gradually begin to cast their look on this emerging discipline that has been playing an important role in the process of human progress since ancient times and that is still exercising profound influence on contemporary society. Its profound significance is dual renaissance, just as George Sarton, the noted historian of science remarked in generalizing the outlines of the so-called new humanism: for humanity scholars, it is the revival of science; for scientists, it is the revival of humanities.

The Chinese Academy of Sciences established "The Research Committee for the History of Natural Sciences in China" back in 1954 and the "Research Office for the History of Natural Sciences in China" early in 1957, which gradually developed into an independent institute. Despite the fact that its scale is not large, the Institute for the History of Natural Sciences (IHNS) is characteristic and important too. This is because I have always upheld the view that science is the inexhaustible river for mankind to perceive the world, while technology is the indefatigable creation of sustainment and development modes for mankind. Investigation in the history of science is essentially study of the history created by the human race. It enables us to carry forward the cause pioneered by our predecessors and forge ahead into the future. And therefore, it is of important value and significance. In 2008, the IHNS undertook and completed the task of delivering lectures on the history of ancient Chinese science and technology for leading comrades. The series of lectures, including 44 individual lectures, began vertically with *Ancient Chinese Science and Technology in the Process of Human Civilizations* and horizontally with *Overview of Ancient Chinese Science and Technology*, and carried out deep discussion into "Several Issues in the History of

Science and the Needham Puzzle," interspersed with the knowledge systems of Astronomy, Arithmetic, Agriculture and Medicine, "The Four Great Inventions," as well as various technological areas closely related to clothing, food, shelter and transportation. For lecturers, IHNS enlisted the service of senior experts of lasting prestige from within and without the institute, as well as middle-aged scientific mainstays currently active in academic research. After the process of trial lecture, discussion, revision, etc., each lecture satisfied the requirements of rich in content, appropriate in exposition and argumentation, and reflective of the latest research level, and was therefore positively accepted and acclaimed by the leading comrades. After those lectures, the above mentioned experts and scholars meticulously collated their lecture notes and compiled them into a book, so that people from all walks of life may be able to share the academic findings.

China boasts a long history of civilization and eye-catching achievements in ancient science and technology, in which the author has harbored a keen interest. Learning them not only enriches cultural literacy but also has the significance of enabling learning from history. Review from the historical perspective of the regularity and evolutional trend of science and technology, evolution in scientific and technological systems of different countries and the underlying causes, evolution of IPR system and situation of scientific and technological development in later-developing countries, means for nurturing scientific and technological competence of different countries, national objectives and scientific and technological planning and programs, the historical path for the creation and development of the National Innovation System, historical development of important contemporary cutting-edge disciplines, etc. Review will reveal the developmental regularity and trends on the basis of tracing the evolution path, and provide referential analyses for choosing the direction and path for the development of science and technology in China, and for the reform of the scientific and technological system. In addition, although there is already no geographic difference in the modern science and technology rising in the West, the interactions remain between science and technology and social, political, cultural, religious, etc. factors. Therefore, comparative research from the international perspective of development, dissemination and schools of science and technology is also one of the purports for learning and investigating the history of science. In addition, we should also be attentive to the fact that the development of modern science and technology is not only changing the material world, but also profoundly changing the spiritual world of the human race. Therefore, it is also of great significance to find a solution to the contradiction between fast-developing economy and relatively lagging cultural construction, promote the scientific culture development in China, carry forward the scientific spirit, advocate scientific methods, and accelerate the construction of innovative culture. In recent years, IHNS research staff has spearheaded interdisciplinary research in the cultural connotations of science and technology, the social environment of scientific activities, and the compatibility between scientific culture and humanistic culture. This would be beneficial for the process of pursuing independent scientific innovation and achieving coordinated and common development of

science, technology, society, and culture. Firstly, the development of science and technology will drive socio-economic and cultural development; second, economic and cultural environments will boost and ensure the development of scientific and technological innovation, and to realize mutual promotion, beneficial cycle, sustainable development, construction of an innovation system, and a harmonious society.

Last, the author wishes to extend his heartfelt thanks to Shanghai Jiao Tong University Press, which is dedicated to the cause of scientific history and cultural construction, for its investment of manpower and financial resources to make possible publication of this book with beautiful design and exquisite binding, and pictures complementing essays.

Yongxiang Lu

Contents

Medicine 1
Yuqun Liao
1 Lecture 1 Overview of Traditional Chinese Medicine 1
2 Lecture 2 TCM Classics and Celebrated Masters 57
3 Lecture 3 Sino-Overseas Exchanges of Medicine 96
References 157

The Four Great Inventions 161
Jialu Fan, Qi Han, Zhaochun Wang and Nianzu Dai
1 Lecture 1 Invention, Development, and Influences of Papermaking Technology 161
2 Lecture 2 Printing 194
3 Lecture 3 The Invention of Gunpowder and Its Influence on the World 239
4 Lecture 4 The South-Pointing Needle and Compass 270

Ceramics Technology 301
Wenjie Li
1 Preface 301
2 Lecture 1 History of Pottery-Making Technologies in Ancient China 302
3 Lecture 2 History of Porcelain-Making Technology in Ancient China 354
4 Conclusion 376
References 377

Weaving Technology 379
Feng Zhao
1 Lecture 1 Overview of Weaving Technology in China 379
2 Lecture 2 Looms and Fabric Varieties 404
3 Lecture 3 The Silk Road and Textile Culture
Exchange Between East and West 459
References 493

About Tan Sri Frank Tsao

Tan Sri Frank Tsao Founder and Senior Chairman of the IMC Group, is a much respected and acclaimed veteran in the shipping industry.

Born in Shanghai in 1925 and a graduate of St John's University, Tan Sri Frank Tsao founded the International Maritime Carriers Ltd (IMC) in Hong Kong in 1966. Under his leadership, IMC has established a strong foothold and developed a good brand name for its strengths in the international shipping and logistic arena. Besides shipping, he also diversified into other businesses that serve the basic human needs such as cement, textiles, vegetable oils, palm oil crushing mills and plantations, pharmaceuticals, and real estate developments in different parts of the world. With these as the foundation, IMC has developed into a diversified group with interests in the strategic business areas of industries (maritime and industrial solutions), lifestyle/real estate (Octave), investments, learning, and wellness (East West Group) with staff strength of over 8,000 employees in 13 countries working towards fulfilling its mission "to serve human well-being and create wealth at the same time".

Throughout his long and illustrious career, Mr Tsao has played a pivotal role in shaping the growth of the maritime industry and promoting maritime education and research in Asia. In Malaysia, he partnered the Malaysian Government in 1968 to help establish its first national shipping line—the Malaysian International Shipping Corporation Bhd and draft the first maritime law in Malaysia. In 1973, His Majesty, the Yang di-Pertuan Agong (the Bahasa Malaysia term for "King") of Malaysia conferred upon Mr Tsao the title of "Tan Sri" in recognition of his great contributions to the country.

In Singapore, Tan Sri Tsao provided valuable feedback to the Maritime and Port Authority of Singapore (MPA) on the conceptualisation of Singapore's Approved International Shipping Enterprise Scheme, which has successfully attracted over 100 international shipping groups since 1991. He was also instrumental in the

setting up of the permanent secretariat of the Asian Shipowners' Forum (ASF) in Singapore in 2007. He drove the establishment of the NUS Centre for Maritime Studies at the National University of Singapore, and oversees the Centre's advancement through serving as its Chairman since its inception in 2005. In 2008, Tan Sri Frank Tsao was conferred the Singapore's Honorary Citizen Award by the Singapore Government for his outstanding contributions to the country's growth and development.

In China, Tan Sri Frank Tsao supports the advancement of maritime education and training through scholarships and bursaries in many universities including Dalian Maritime University, Dalian University of Technology, Hong Kong Polytechnic University, Qingdao Ocean Shipping Mariner's College, Shanghai Jiaotong University, Shanghai Maritime University, Shanghai Tongji University, Tsinghua University and Zhejiang International Maritime College. He also provides the financial resources for the academics and the maritime community and has sponsored the set-up of the IMC-Frank Tsao Maritime Library and Research & Development Centre in the Hong Kong Polytechnic University.

Currently, Tan Sri Frank Tsao is the Chairman of Suntec Investment Pte Ltd, Vice Chairman of the Singapore-Zhejiang Economic and Trade Council (SZETC) and Member of Hong Kong Maritime Industry Council. Previous positions that he held include Chairman of Suntec Singapore International Convention and Exhibition Centre 1995–2009), Chairman of Hong Kong Shipowners Association (2003–2005), advisor to the Economic Development Board (EDB) (1991–1993). In addition, Tan Sri Tsao and his family have also set up the non-profit Tsao Foundation devoted to promoting successful ageing.

For his efforts, Tan Sri Tsao has earned numerous accolades, including: Lifetime Achievement Award from Seatrade Asia in 2008; Silver Bauhinia Star from the Hong Kong SAR Government and Honorary Citizen from the Dalian Government in 2006 apart from being the first Asian recipient of the CMA Commodore Award from the Connecticut Maritime Association of the US in 2002 and the Personality of the Year by Lloyd's List Maritime Asia in 1999.

The publication of this series of books has received support from Tan Sri Frank Tsao and IMC Group.

Abstract

Consisting of three volumes, i.e., Volume 1, Volume 2, and Volume 3, this series are the result of collation and consolidation of lecture notes by the Institute for the History of Natural Sciences (IHNS) on the history of ancient natural science for leading comrades. The series of lectures, including 44 individual lectures, began vertically with *Ancient Chinese Science and Technology in the Process of Human Civilizations* and horizontally with *Overview of Ancient Chinese Science and Technology*, and carried out deep discussion into "Several Issues in the History of Science and the Needham Puzzle," interspersed with the knowledge systems of Astronomy, Arithmetic, Agriculture, and Medicine, "The Four Great Inventions," as well as various technological areas closely related to clothing, food, shelter, and transportation. Mostly delivered by well-known experts of various expertise from IHNS, Chinese Academy of Science, the 44 lectures also involve noted scholars of relevant fields from other units.

The series are rich in content, systematic, and comprehensive, with objective argumentation, and extensive citation, and appropriate for people from all walks of life, especially teachers and students of history of science, philosophy of science, and other relevant disciplines.

Medicine

Yuqun Liao

1 Lecture 1 Overview of Traditional Chinese Medicine

In ancient Chinese civilization, astronomy, arithmetic, agriculture, and medicine are the four disciplines with earlier development and rich content. Although some may hold the view that it is inappropriate to call them "sciences," it is universally acknowledged that the "four disciplines" are irrefutably knowledge and skills with complete systems and the features of traditional Chinese culture. Among the four, medicine is the only traditional knowledge and skill system yet to be replaced by modern Western science and the only one still playing an important role in people's lives. However, traditional medicine was founded in an era without modern scientific knowledge. How can it survive in the situation when modern medical care can basically satisfy the demands (for healthcare and medical services), without being completely replaced? Is traditional Chinese medicine a science, or accumulated experience? Are there still possibilities and room for it to develop on its own track? Or is it doomed to be substituted by modern medicine? Those are topics that people care and talk about most.

1.1 Acknowledging Traditional Chinese Medicine

Among the Chinese, probably few have never seen a doctor of traditional Chinese medicine or taken traditional Chinese medicine in their life experience. In any case, even those physically strong and without much relation to "medicine" would know the existence of traditional Chinese medicine. Therefore, they may have little firsthand experience or needs, but they may persuade their relatives with health problems to try traditional Chinese medicine. Even if those who have accepted

Y. Liao (✉)
Chinese Academy of Science, Beijing, People's Republic of China

© Shanghai Jiao Tong University Press,
Shanghai and Springer-Verlag Berlin Heidelberg 2015

Y. Lu (ed.), *A History of Chinese Science and Technology*,
DOI 10.1007/978-3-662-44166-4_1

modern education in science since childhood, and followed a lifelong career in modern science (in medicine), even if they may have held the view that traditional Chinese medicine is unscientific and drossy, they will have to lower their head and seek the service of traditional Chinese medicine, when they are succumbed to diseases beyond the cure of modern medicine (Fig. 1).

Should those common trifles of daily life be seen as strange? However, watch the TV series *A Native of Beijing in New York* depicting the life of Chinese overseas and the subsequent movie *Skin Scraping*, and maybe we will not take everything in our lives for granted. Ah Chun, the heroine of *A Native of Beijing in New York*, gets sued in a court of law by her ex-husband, a foreigner, for letting an herbal doctor treat their son's arthropathy. *Skin Scraping* has a similar scenario—the subcutaneous bleeding resultant from skin-scraping therapy is taken as a criminal evidence of father abusing the son, leading to his loss of custody of his biological son.

In an era when modern medicine is sufficient to meet the social demands, why would the Chinese see herbal doctors, take traditional Chinese medicine, or advise others to try herbal treatment? Why would they find the foreigners ridiculous while watching the above video programs? All because they "acknowledge traditional Chinese medicine"—acknowledging that it is a science of medicine, or at least that it can cure patients. In no way should we belittle the value of such acknowledgment. Just imagine: Will it be possible for traditional medicine to survive in the present-day society when science has reached such prosperity as to dominate the sphere of knowledge, and even the thinking mode and value of the masses, if there is no such acknowledgement? When science has become strong enough to be synonymous with correctness, when modern science has become the only content of education for each and every one of us and beneficial to all aspects of our lives including clothing, food, shelter, and transportation to such an degree that deep down, we somehow begin to hold science in a worship and confidence like we do with religions. It is a thought-provoking issue for the Chinese to acknowledge traditional Chinese medicine as a science, even though it is so different from the scientific modern Western medicine.

Fig. 1 A Native of Beijing in New York and Skin Scraping

Which factors determine the acknowledgment of traditional Chinese medicine? A most common explanation would be that China has a vast territory and too large a population, and modern Western medicine has proven incapable of meeting the healthcare needs in the vast rural areas and underdeveloped regions for a long period of time after its introduction to China. Therefore, traditional Chinese medicine is required as a complementation. In addition, people find traditional stuff easier to accept while advanced science repugnant, under domination of a backward and conservative mentality. In one word, traditional Chinese medicine owes its survival to backwardness. However, neither of the two theories can hold water in reality. First, the circumstance of a penicillin or streptomycin shot beyond the wealth of an entire family is long gone. Moreover, economically, the prices of traditional Chinese medicines are not necessarily cheaper than Western medicines. Therefore, it just would not do trying to find the reason for the continued existence of traditional Chinese medicine from the perspective of economics (Fig. 2).

What is more worthy of notice is the fact that although modern medical care can meet the demands of citizens in medium-sized and large cities, people still have needs for traditional medicine. More often than not, when the convenient modern medicine cannot relieve the vexations of illnesses, they would go out of their way at all costs to look for herbal doctors famed as "Hua Tuo, the great doctor reborn." On the contrary, patients living in the rural areas and remote regions would often brave long journeys by boat or cars to go to the county seat, the provincial city, or even the capital to seek the most advanced cure at any cost. From those facts, we can see that there is no mentality of propinquity to tradition and

Fig. 2 A hairdresser doing massage

rejection of science. In short, the foundation sustaining the existence of traditional Chinese medicine is obviously not backwardness, and the fact will certainly be more conspicuous in the future. In modern society, Western medicine is better able to meet the basic needs for health care, while traditional Chinese medicine is better applicable to the objective situations of increased demand for health care as modern diseases and geriatric diseases troubling "urban aristocrats" are on the rise and their symptoms are becoming more complex. The more developed the economy, the more the need for various medical services. The more advanced the diagnostic instruments, the more the problems beyond the cure of modern medicine. The more advanced the physical, chemical, and surgical means are able to change the natural conditions of the human body, the more complex the diseases caused by medicine itself (iatrogenic disease). Medicine rehabilitating the natural status and functions of the human body is given a larger platform. Actually, this is the very reason for traditional Chinese medicine to survive in the modern society. Correspondingly, the death of a traditional knowledge system has its reason—none other than the one that the superiority of an emerging knowledge system reaches such extent as to replace the old system. Therefore, anyone daring to advocate inheritance or revival of the traditional Chinese astronomical or mathematic system would be seemed as guilty of extreme nationalism—because those old knowledge systems have basically lost the reason to go on living.

Whether a theory, technique, or thing will be acknowledged in a society is simply completely dependent on pragmatism. Therefore, the fundamental reason for acknowledgment of traditional Chinese medicine lies in the fact that it can treat diseases. In an era when the masses take scientific knowledge as "common sense" and have no recognition of the thinking mode of traditional philosophy which is closely related to traditional medicine, the only unique cultural gene hiding in the minds of the Chinese is none other than the opportunities for the Chinese to experience and witness the miracles of traditional medicine—if there is such a gene left.

1.2 Medicine Is Intention

Clear professional division occurred very early, and craftsmen had their own specialized techniques and knowledge, but knowledge related to "mankind" is an exception. Under the instruction of the analogical thought "make judgments from circumstances of the self and phenomena of other things without the self," the ancient sages believed that the heaven and the earth were a Tai Ji and so were the human body and that the structure and motional regularities of the heaven–earth macro-cosmos and the human body micro-cosmos were mutually confirmative and communicative. Although politically failing to win an orthodox position, the Taoist concept of "let nature take its course" has had profound impact on the masses. It also takes the law of nature as its theoretical basis analogizing the natural rules of germination, development, and death of things in the world. The basic

rules of "health preservation in different seasons" in *The Yellow Emperor's Classic of Internal Medicine*, i.e., sprouting in spring, flourishing in summer, astringing in autumn, and storing in winter, are a typical example of Taoist influence on medicine, as well as a path to understand how the traditional Chinese medicine has constructed its theory of health preservation.

Use of analog can be found in the construction of basic theories and the establishment of practical therapies, whether you leaf through the multitude monographs on traditional Chinese medicine of previous generations, or take a certain classic for careful investigation. In other word, if you do not understand analog, there is no way for you to read or understand traditional Chinese medicine. For example, in theory, *The Yellow Emperor's Classic of Internal Medicine* has the theory of visceral manifestations "heart holds the office of monarch, spleen the storage, liver the general, and gallbladder the justice" in echo of the officially promulgated theory of visceral functions. The prescription theory of different drugs acts as the monarch, minister, assistant, and guide, respectively. The channel system is compared to rivers of different sizes, in order to describe the differences in the amount of Qi and blood. *The Classic on Medical Problems* pushed the comparison of rivers further on the basis of inheriting previous knowledge and put forward the view that since there were lakes capable of adjust water volume in nature, there should be a similar mechanism for adjusting the flow of Qi and blood within the human body, thus establishing the theory of "Eight Extraordinary Channels," which helped to contain the overflow of Qi and blood. In pathology, it is assumed that the reason for pathogenic Qi to enter the human body is none other than that a certain room has formed within. So long as the unnecessary room is filled, the unwanted pathogenic Qi will be expelled. This gives rise to the theory "When there is sufficient healthy Qi inside, the pathogenic Qi has no way to invade the health body" and the "reinforcing method" for healthy Qi and "reduction method" for pathogenic Qi. Or malaise of the body is compared to silt-up water course leading to disastrous flooding in nature. Therefore, the therapeutic theory and method of depression-relieving, digestion promoting and purgation, etc., came into being. In drugs, sandal wood is too heavy to float in water and is therefore used for inducing downward movement of Qi and blood. The saying "the ascending effect common to all the flowers" means that flowers grown on the top of plants will naturally have the effect of inducing upward motion of Qi and blood. Actually, illustration of the reasons for concrete problems would often boil down to a simple principle—analogical thought (Fig. 3).

Ancient physicians used "medicine is intention" to generalized the extensive application of analogical thought—the mysteriousness of medical theory, the flexibility of curing method, and the savvy of the physicians can all be embodied by the word "intention." In other words, the romantic charm of traditional Chinese medicine is contained in its intrinsic flavor of "you can feel it but cannot describe it in words." The great modern scholar Liang Qichao once remarked "All branches of academia in China are invested with an understandable yet indescribable mysteriousness, and this is a considerable barrier to knowledge enrichment." The example used to augment his theory is medicine. Admittedly, traditional Chinese

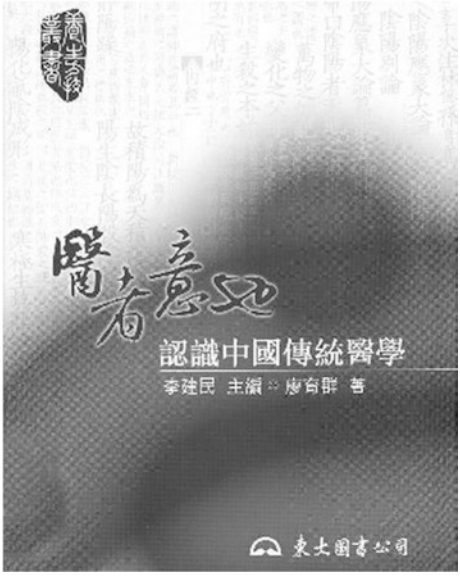


Fig. 3 *Medicine Is Intention* is published by East University Book Company of Taiwan in 2003. The book offers interpretation from the angle of "intention" for many issues of the theoretical system of traditional Chinese medicine. However, it was awarded Masterpiece Prize of the second-session Wu Ta-you Prize for Works of Science Popularization, despite the fact that it was an academic monograph. Therefore, it is not impossible to offer a clear account of traditional medicine and make the account appreciable by both the highbrow and lowbrow. On the contrary, if "traditional Chinese medicine believes so and so" becomes a pet phrase, then the knowledge system of traditional Chinese medicine will be constantly marginalized

medicine boasts stronger characteristics of traditional Chinese culture than any other precision science (such as astronomy and arithmetic) or practical skills. In other words, only traditional Chinese medicine can reflect the so-called understandable yet indescribable flavor of traditional Chinese culture. As of today, when people evaluate or study traditional scientific culture from different perspectives, on the one hand, they would discover with surprise that traditional Chinese medicine is the only one to boast inexhaustible vital force in an era when modern Western technology has become prosperous and popular around the world; meanwhile, the views and standards of modern Western technology are used to review, weigh, assess, demand, and reform this robust traditional science. Against this context, the charm of traditional Chinese medicine as represented by "medicine is intention"—a fundamental property completely incompatible with modern science and constituting a major barrier to knowledge enrichment—would be subject to more animadvert.

Philosophically, analogical thought is often described as an inductive theory of "heaven and human." It is universally acknowledged in the academic circle that "this is one of the basic principles in the thinking method of the Chinese.

Especially, induction between heaven and human constitutes an important component of their frame of thinking." This is seen in typical records in ancient literatures. For example, it is said in *Lv's Spring and Autumn Annals-Initial Survey* of the Qin and Han Dynasties "mutual attraction of the same kind, integration if Qi accords and resonance of same sounds" (mutual attraction between things of the same kind; integration is possible if things have the same Qi, resonance will occur when sounds are of the same nature.). Summing up the "induction" phenomena of his predecessors, Zan Ning of the Northern Song Dynasty (AD 919–1001) wrote *Wulei Xianggan Zhi* (*Notes of Induction between Different Things*), in which 77 kinds of "induction between things" were exemplified, starting with magnets pulling needles and ambers picking up weed seeds. Then, the books went on to record 448 special cases of induction divided into 12 categories, i.e., the human body, clothing, food, utensil, drug, diseases, stationery, fruit, vegetable, flowers and bamboo, poultry and fish, and the miscellaneous, reaching an insurmountable peak in enumerating phenomena. In the eyes of rationalists, those phenomena were metamorphosed into the basic principle "there is only induction and response in the world." Therefore, it is important to learn the important role played by analogical thinking while acknowledging the fact that traditional medicine contains a lot of experience and knowledge.

Induction is double-faceted, in that it may lead to magic, as well as science. For instance, the idea that harelips are the result of "pregnant women running into hares and eating hares" is obviously a magic taboo based on similarity law or law of contact. Ancient antenatal training is in fact founded on the same thinking, although it is believed to contain much scientific content. Li Shizhen is a "famous scientist of ancient times" with world renown and widespread popularity. However, in his *Compendium of Materia Medica*, "drug usage" obviously not rising from practice can also be found. For instance, ramrod was used for dystocia (for its triggering function to stimulate delivery); comb could be used to cure "breast milk obstruction" (combs can smooth). The former is certainly of no help. While the latter may not transfer its smoothing function to the breasts, "combing the area surrounding the breasts over one hundred times" has the same effect as massage (physical therapy). Such examples are inexhaustible. There are two points worthy of notice. The first is that assumptions on remedies and drug functions originating from analog have been constantly verified in practice, i.e., through the trial and error process. Therefore, only those effective survived, while the false ones were eliminated. Whether absurd and unfounded or effective, those techniques have the same principle in invention. The second is that analog as a simple, primitive, and fundamental thinking mode is not only extensively used in the early stages of human civilization. To some extent, the development of medicine in different ages is the result of expanded usage of this thinking mode. It is after the introduction of modern science to China, and positivism replaced analog to become the basic thinking mode of the people that the knowledge system of traditional medicine became obtuse and strange to ordinary people (Fig. 4).

Fig. 4 "Girl with smallpox" and "vaccination tool"—China started artificial vaccination in the Ming Dynasty to prevent smallpox and was thus heralded as "the pioneer of immunology." The reason for vaccination to be invented in an era without knowledge of immunology is none other than the thinking mode of "similar Qi seeking for and inducing each other," that is, the belief that smallpox was caused by fetal toxicity and if the toxicity was extracted, smallpox would be avoidable. In 1805 when cowpox method was introduced to China, the first book illustrating this method was entitled *The Overview on Vaccination*, betraying the same thought

1.3 Establishment and Vicissitudes of Traditions

Although over quite a long period of time, the vast land of China was basically in an isolated and conceited environment—it can even be said that the brilliant Chinese civilization is only possible in such a geographical surrounding—influences from alien cultures were never interrupted. However, in the late Ming Dynasty and early Qing Dynasty, the nature and influences of foreign cultures were essentially different. Before that time, there were foreign cultures introduced to China together with medicines from countries and regions in Western and Central-Southern Asia, such as India and Arab, Buddhism, Islam, and commercial trade. However, they generally did not cause vehement conflict. Instead, most of them were integrated and absorbed, for instance, absorption of foreign knowledge on drugs, surgical removal of cataract, and the theory of smallpox resulting from fetal toxicity. Even in 1805, when cowpox vaccination was introduced to China, physicians just believed that cows were tamest in nature; therefore, cowpox vaccination would naturally be safer than smallpox vaccination. Later, when the completely heterogeneous modern Western medicine founded on anatomy and positivism got incessantly introduced to China, Chinese physicians still upheld the views of "communication between Chinese and Western medicines" and "Western

medicine originating from Chinese medicine" in their argument that the two are essentially the same, with minor differences, especially differences in expression. Only when appeals rose demanding the government to follow the practice of Japan after the Meiji Restoration and completely repeal traditional Chinese medicine, did traditional Chinese medicine realize that Western medicine had become a flood and ferocious beast, and an archenemy, threatening its very existence. With the passage of time, it has become unnecessary for us to lavish our words on how traditional physicians with loft ideals struggled with all their strength to avoid the replacement of traditional medicine by its Western counterpart, while studying traditional Chinese medicine as a knowledge system. Instead, our emphasis should be placed on the changes to the knowledge system of traditional Chinese medicine under the influence of a heterogeneous medicine and the pressure of survival.

Firstly, without the introduction of Western medicine, there would be no need for the expression "Chinese medicine." If the medical system of modern west did not hold the dominating position, there would be no need for the expression "traditional medicine." Over the long course of the ancient society, medicine is medicine, and there is no differentiation between Chinese and Western medicines, or between orthodox and traditional medicines. Only when there is another medical system for comparison will people start thinking about the difference between this and their medical knowledge system. Only when survival is at stake will they consider arguing for it—illustrating its advantages and values for existence—and learn the advantages of its counterpart as much as possible so as to improve itself. Actually, one only needs to read carefully the periodicals and monographs since the period of Republic of China to discover how practitioners of traditional Chinese medicine had been imitating Western medicine to construct the complete system of traditional Chinese medicine, from theory to etiology, pathology, therapeutics, and materia medica. It can be seen that traditional Chinese medicine is unconsciously learning the logicality of Western medicine and learning ways as a doctor for looking on problems and logical arrangement thinking through imitation of compilation style (Fig. 5).

Secondly, the introduction of Western medicine made it possible for all doctors of traditional Chinese medicine to acquire unknowingly lots of basic knowledge of life science. Since the compilation of *The Yellow Emperor's Classic of Internal Medicine*, it had become common knowledge that a person would die if he did not eat and that the energy for life activities came from food; apex beat touchable by putting a hand to the chest was "the major channel of the stomach" which is in fact heartbeat, and urine was believed to be penetrating through the small intestine to the bladder; thus, "the bladder has an outlet but no inlet." Traditional knowledge like those has been imperceptibly replaced by the horse sense of modern life science.

Likewise, only after the introduction of Western medicine could traditional Chinese medicine realize that its theory on channels had nothing to do with blood vessels, thus prompting it to think what on earth is channel and what is viscera, and establishing its theoretical framework of channel theory and visceral phenomena theory, to differentiate itself from modern medicine. Thirdly, introduction

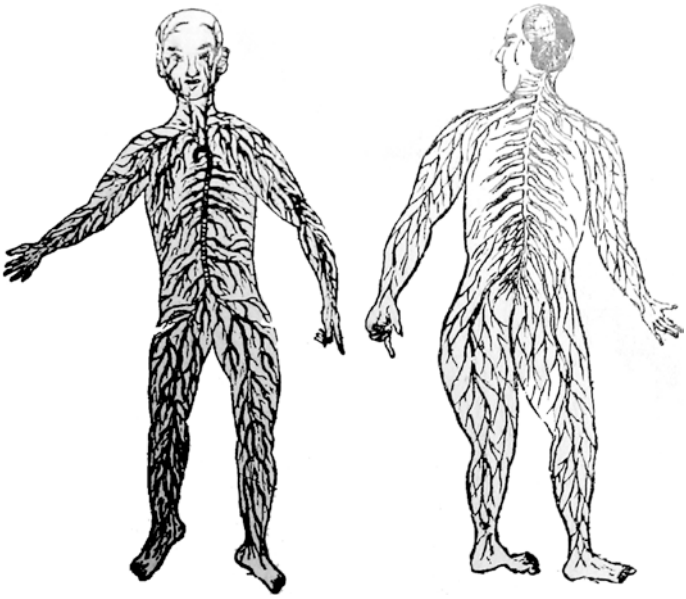


Fig. 5 "Qi Veins and pulse channel of the brain" in *The Essence of Medical Classic*, by Tang Zonghai the pioneer who mastered Chinese and Western medicines. It is the knowledge of the nervous system and the pulse system that has prompted traditional Chinese medicine to think and investigate: what is channel?

of Western medicine did pose certain pressures on traditional Chinese medicine. To safeguard its survival and seek to strengthen its contending abilities through development, traditional Chinese medicine started setting up schools, dedicating resources to talent cultivation, initiating various periodicals and academic organizations for academic research, translating Kampo monographs from Japan and developing Chinese medicines, posing an unprecedented industrious attitude to self-improvement. All those can be described as changes made possible after the introduction of Western medicine.

Seen historically, introduction of any alien culture would often add new content to the original culture, enriching it, and even sublimating it. Modern Western science is also a culture. It would not devastate traditional Chinese medicine, but bring new opportunities and support for its development. A continuation of this special historical period, the publication of the neo-type textbook on traditional Chinese medicine, commissioned by the Ministry of Health in 1958, compiled by Nanjing Higher Institute of Traditional Chinese Medicine and other schools can be deemed as an epoch-marking event. From then on, the course of Overview of Traditional Chinese Medicine becomes available, so does the concept and category of "basic theories of traditional Chinese medicine." The compilation of neo-type textbooks is construction of tradition, rather than a systematic collation—selecting critical content from the repository of various theories to act as the fundamental

system of traditional medicine. Although the currently prevailing textbooks have undergone repeated revisions, their basic framework and content have not been changed much (Fig. 6).

In the newly constructed "tradition," the channel theory no long contains "[those] visible on the body surface are main collaterals and [those] hidden deep within the body are channels," "green collaterals are cold syndrome and red heat syndrome" and other contents that are easily confused with the channel system of the human body and that are included in *The Yellow Emperor's Classic of Internal Medicine*. The "five zang organ" and "six fu organ" are defined as "physiological units," respectively—different from the organs of anatomy, and the official posts of the imperial government as in the preceding literature. Acupuncture is no longer a general term for external treatment such as cutting open carbuncles and pricking purulence. Instead, it is defined as a therapy of "adjusting the circulation of Qi and blood, and the function of the viscera through physical stimulation." In addition, the book sums up the basic characteristics of traditional Chinese medicine therapeutics and points out that its biggest difference from Western medicine lies in "implementing treatment on the basis of syndrome differentiation"—that is, treatment is decided according to the syndromes (such as deficiency, excess, cold, and heat) abstracted from comprehensive demonstration of the disease and the health fitness and the family conditions of the patient, instead of treating in isolation the part being troubled by ailments. Although Chinese physicians mostly take this as the treatment principles established by Zhang Zhongjing, the famous physician of the Han Dynasty, in fact without introduction of Western medicine, there would be no "connotative implementation treatment on the basis of syndrome differentiation." In Chinese, "证" (differentiation) and "症" (syndrome) are mutually replaceable. In the thought of physicians, the two are not consciously differentiated—whether it be deficiency, excess, cold, and heat syndromes, or stomachache

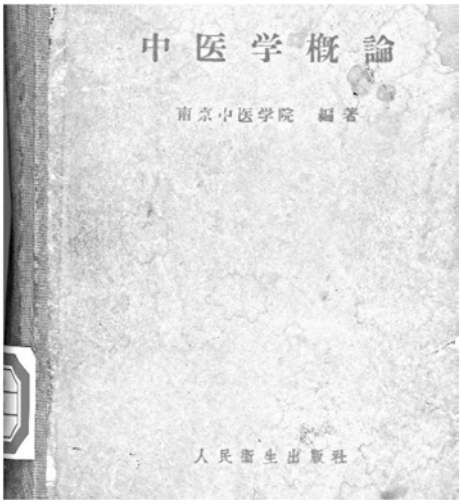


Fig. 6 *Overview of Traditional Chinese Medicine* published in 1958

and dizziness, they are diseases recorded in medical books. Any knowledge system or skill worthy of the title of cultural heritage is in no way unchangeable.

Instead, it is constantly changing in accordance with historical evolution. The present-day traditional Chinese medicine is by no means the traditional Chinese medicine of the era of *The Yellow Emperor's Classic of Internal Medicine* and vastly different from that of the Ming and Qing Dynasties, as well as that of the period of Republic of China. In one word, traditional Chinese medicine has already been modernized. It can even be said without exaggeration that the difference between ancient and modern forms of traditional Chinese medicine has far exceeded that between traditional Chinese medicine and Western medicine.

1.4 Understanding Traditional Chinese Medicine

Generally speaking, understanding traditional Chinese medicine has three levels. The first is the understanding of its way of thinking and knowledge of the attributes. The ancients used the simile "scholars study medicine, the way people grab a chicken in the cage" to describe how easy it was for scholars to study medicine, precisely because the knowledge attributes and basic way of thinking are communicated. Thus, contemporary people with profound cultural enrichment will not find it difficult to understand traditional Chinese medicine. Or, in order to understand traditional Chinese medicine, one must have rich knowledge in history and culture, especially the history of ideas and philosophy. In addition, there is a shortcut to the understanding of Chinese medicine—by learning the knowledge of cultural anthropology. This is particularly important for the contemporary scholars whose knowledge is mainly comprised of natural science. The reason is that anthropology takes the fundamental ways of thinking in various cultural systems as an important aspect of its research and outlines some of their basic characteristics and common properties. Therefore, it is necessary to obtain this knowledge. The reason that it is called the shortcut is the knowledge of anthropology can help lead us directly to the nature of the problem—interpretation by deduction of the specific materials needing to be addressed without having to begin with spending a lot of time in memorizing historical facts and background materials, before moving on to the understanding of their nature and common properties using the inductive method. For example, both the Chinese medicine insiders and the general public are undoubtedly familiar with the theory of Wu Wei (the five tastes) (i.e., spicy, sweet, sour, bitter, and salty). However, few knows that *The Rites of Zhou* mentioned Liu Wei (six tastes), with the addition of Hua (smooth) a taste believed to boast the function of orifice nourishment (dredging the orifices). People who do not know this cannot understand why "*The Yellow Emperor's Classic of Internal Medicine*" would boil husked sorghum porridge with water running from thousands of miles away to treat insomnia, a disease caused by the disordered yin and yang and obstructed channels. Nor can they understand why the bamboo and silk medical books unearthed in Mawangdui would use with rice

soup for the treatment of difficulty in urination. Admittedly, those therapies based on the "analog" thinking are unlikely to be effective. Later, rice soup is replaced with talcum powder, which increases the osmotic pressure and inhibits the reabsorption function of renal glomerulus, and the therapy becomes strongly diuretic. However, its theoretical foundation is still based on the "smooth" properties (Fig. 7).

Fig. 7 *The history of medicine in China* by Chen Bangxian, initially published in the period of the Republic of China, is a relatively earlier monograph systematically introducing the situations of generations of traditional Chinese medicine and the history of diseases. The figure shows a recent reprint. Since then, various monographs on medical history came in multitude, with attention gradually paid to the history of medical development, as well as its relation to culture and social background

In contemporary China, traditional Chinese medicine is undoubtedly the branch of natural sciences with the widest application of ancient knowledge and thus often the most ridiculed in the realm. However, to really understand traditional Chinese medicine, knowledge about ancient culture and history can never be too much. In the meantime, profound understanding of its fundamental philosophy should also be achieved.

As previously mentioned, "dialectical treatment," a most distinct feature of traditional Chinese medicine is a typical example. Due to complexities of the human body and diseases, there exist certain contradictions between modern medicine and "science." Claude Bernard stressed in *Study of Experimental Medicine* that, although doctors often told him that there were too many particularities in medicine, he still held the view that, now that it was science, no particularity should be allowed. This common sense and norm of sciences put the live soul of traditional Chinese medicine—the principle of dialectical treatment—at a very awkward condition.

Traditional Chinese medicine holds the view that no individual is completely the same as the other, nor will the diseases he is susceptible to. Therefore, there was no cut and dried or repeatable treatment. While the fact may not be so severe—practitioners of traditional Chinese medicine have been using some invariable prescriptions, theoretically the observation is true. Clinically, there are possibilities for the necessity to change a prescription in accordance with the concrete circumstances of a certain patient. There rises the fundamental contradiction between real-life situations and "repeatability" as stressed by science. Actually, it is not difficult to clarify the issue.

Firstly, one of the reasons for traditional Chinese medicine to disavow repeatability is that the objected being treated is "people," instead of carriers of "diseases." As people differ, treatment certainly cannot be repeated. Conceptually, traditional Chinese medicine holds advantages over Western medicine.

Secondly, seen from another angle, although prescriptions are not identical, the variance is only quantitative. This made it possible for traditional Chinese medicine to conclude some basic treatment principles and forever-working prescriptions. Thus, continued production of prepared traditional Chinese medicine becomes possible. Therefore, treatments by traditional Chinese medicine are not completely unrepeatable.

Lastly, the issue of repeatability is irrelevant controversy rising from different criterion of "difference" and "sameness" against the background of different "common senses." Sameness in traditional Chinese medicine does not necessarily mean identical symptoms, while difference in traditional Chinese medicine may be diagnosed as the same disease by modern medical science. So when clinical symptoms or modern medicine is taken as the standard of "difference" or "sameness," the "unrepeatable" issue of traditional Chinese medicine—that is, different treatment for the same disease or the same treatment for different diseases—becomes weird. The image of legendary doctor Hua Tuo was depicted with examples in those two perspectives in the History of the Three Kingdoms. However, traditional Chinese medicine is nothing but "same treatment for the same disease" and

"different treatments for different diseases" if the knowledge of pathology and pathogeny of traditional Chinese medicine is applied as the standards for "sameness" and "difference."

In this respect, an example cited most by the traditional Chinese medicine circle is the encephalitis epidemic in the middle of the twentieth century, when the prescriptions proven effective by Western doctors in the previous epidemic failed, and alternative prescription suggested by traditional Chinese medicine saved the day. The reason is that the two epidemics are the same in the eyes of Western doctors—both of them were encephalitis caused by pathogenic microbes. On the contrary, Chinese physicians believed that the causes of the disease were different in proportions of "humidity" and "heat," due to difference in time and geographic location. Another example is the Bolus (Bu Zhong Yi Qi Pill) for Reinforcing Middle Energizer and Replenishing Qi, a medicine available in the market. Originally, it was used by Li Donghuan, honored as member of "the Four Famous Doctors in Jin and Yuan Dynasties," in treatment of gastrosia. However, present-day physicians repeatedly claimed that it can be used to treat anemia, neurasthenia, rectocele, and other ailments. This is because in the eyes of Chinese physicians, while those ailments are different in symptoms, they are the same in pathogeny and nature. Similar incidents are happening to the patients and in the hospitals and thus are more than ordinary. Regrettably, our Western physicians are lucky enough to live in the oriental culture surroundings which Western doctors have no opportunity to access, but they turned a blind eye to them. Instead, they are always hoping to find an effective cure to a certain disease in the "treasure of traditional Chinese medicine" and grab it over for use without change.

Only on this basis can the second level be reached, i.e., specific understanding of the "Xue" and "Shu" of traditional medicine be possible. "Xue" means theory, while "Shu" refers to therapeutic techniques. This actually involves specific know-how inside the discipline. Just like non-professionals do not understand how antibiotics eliminate germs and the difference between antibiotics and sulfa drugs in combating inflammation, people not specialized in traditional Chinese medicine do not have to master the specific knowledge. However, it is interesting that, just because the lack of participation by natural science all along in its development, as long as you are literate, the specific knowledge of traditional Chinese medicine can be readily understood and even mastered without much difficulty—far easier than modern medical knowledge. It is more interesting that actually, traditional Chinese medicine does not know the objective basis of its knowledge system. As far as the two aspects constituting the theory and therapy of traditional Chinese medicine—acupuncture and drugs—are concerned, so far the objective mechanism of acupuncture remains unclear and the material entity of "channel" which is closely related to this remedy also remains fuzzy. In drug remedies, although research of "effective ingredients" has been going on for decades, there is still a long way to go before the mechanism of traditional Chinese medicines, especially "prescriptions" consisting of various drugs, can be interpreted.

The basic reason for traditional Chinese medicine to flexibly and effectively use acupuncture or drugs to realize its objectives of treatment without knowing

"the why" is that a complete system consisting of mutually linked concepts is used from [investigation of] pathogeny, pathology to [choice of] treatment method and drugs. Simply put, it is the correspondence between the property of diseases and the potency of the medicines. Take the depression-relieving Xiaoyao Pill (Carefree Pill) for example. The drug is used to treat "headache" resultant from Qi stagnation due to liver depression. Here, "liver" and "Qi" are physiological concepts; "depression" and "stagnation" are pathological concepts; depression-relieving is a therapeutic and pharmacological term. If detailed investigation was to be launched why Xiaoyao Pill (Carefree Pill), which composed of several drugs, can have the depression-relieving function, a series of theories and concepts will be involved. One more example is liver and spleen belong in nature to wood and earth, respectively. Wood counteracts and debilitates earth, and reinforcing earth (the spleen) helps inhibiting wood (the liver). Therefore, Tuckahoe should be used in the prescription, because it will not affect the "liver" but invigorate the spleen. If further questions on how Tuckahoe invigorates the spleen were asked, we will be back to the basic analogical thought—Tuckahoe is grown under centuries-old pines and cypresses, and are awarded with the essence of "earth." Therefore, it can invigorate "earth" (the spleen).

These are certainly not "science," but only by understanding these can we "understand" how traditional Chinese physicians are able to prescribe medication without referring to direct or indirect experience, when they are faced with new diseases. The reason is that Chinese medicine is not a purely empirical medicine, but a knowledge system capable of using its theory with drugs to deal with the problems in accordance with the manifestations (symptoms) of the disease. As for why so unscientifically constructed knowledge can be used to treat real diseases, that is another problem. Deciphering the underlying truth of those miraculous phenomena is the task of scientific research, as well as the highest level of understanding. It is only through modern scientific research can we know why. For example, talcum powder as mentioned above can increase the osmotic pressure, can inhibit re-absorption function of renal glomerulus, and therefore boasts strong diuretic competence.

Problem is still not over at this point. Using the yin and yang theory as the basic thinking tools to look at health issues and diseases, and administer medical practices, traditional Chinese medicine does have the characteristic of generally seizing the cause and effect without paying attention to the internal mechanism or evolving process. That is why it is also known as "philosophy of medicine." However, if we admit that human understanding can never exhaust all the links constituting the "causal chain," i.e., when a "black box" is open, you can see countless "black boxes," then the solution of seizing the cause and effect at the two ends of the problem will never be outdated. This, instead of the advantage over specific details, is the fundamental value of traditional Chinese medicine.

Actually, it is not that traditional Chinese medicine does not want to clarify its process in order to defend and prove its own "scientificalness," as this demand is particularly necessary in today's society. But why cannot it? It is precisely because the older generation of Chinese medicine practitioners does not understand

modern life sciences, including medicine. The newer generation learned some, but has not been able to really understand deep down the respective characteristics of two medical knowledge systems, or combine them and digest them. Objectively, the modern life science has not yet reached the level of furnishing explanations to all the complex phenomena of life. Subjectively, those within the circle are still learning and using the ancient knowledge system and are creating an impression of "being outdated" on the one hand and are undergoing the accusations of "going against the orthodox" at varying degrees for acceptance of modern medical education on the other hand. However, the reality is that their understanding of any kind of knowledge is insufficient, and therefore, it is naturally impossible for them to consciously use the modern scientific knowledge to explain "the whys" of Chinese medicine proven "true" by practice, or historically illustrate the "why false." From the above analysis, it is not difficult to see how necessary and important ancient history, Chinese medicine, and modern life sciences are to the real understanding of traditional Chinese medicine. Some knowledge of personal accomplishment may be dispensable for a clinician, but for those really hoping to understand the Chinese medicine, it is not the case.

1.5 Basic Theories

Represented by "*Science Technology and Society in Seventeenth Century England*" (in 1938) of Robert K. Merton, the science of sociology witnessed a major change after the 1970s. That is, with the rise of constructivism in Western Europe, the focus of sociology of science was shifted—it was no longer centered around the "science," but directed at the "scientific knowledge" itself. It was believed that scientific knowledge was constructed by the people in a social process, in which nature did not play any role. Constructivist point of view on sociology of science is undoubtedly tarnished by tendencies of the extreme, but it can be used for observation and analysis of traditional medicine. The ancient "scientific knowledge" undoubtedly lacks the "positivist" color of modern scientific and has stronger characteristics of "construction." But it also must be noted that traditional Chinese medicine is engaged medical activities under the guidance of this "constructivist" theories, and thus, it will not be easy to assess the value of these theories (Figs. 8 and 9).

1.5.1 The Theory of Yin and Yang, and Five Elements

The topic of "yin and yang, and the five elements" will not sound strange to the Chinese people. However, few people really understand the emergence and development history of such a theory closely related to all aspects of the traditional Chinese culture or relation between it and traditional Chinese medicine. First, from the perspective of the origins, the "yin and yang" and "five elements" are

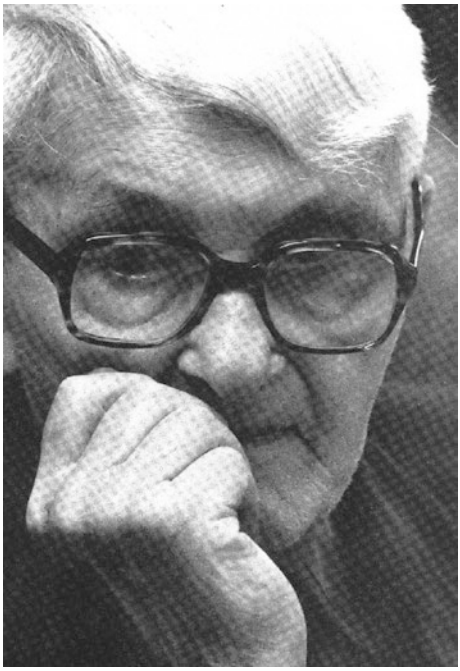


Fig. 8 Joseph Needham, the late historian of science

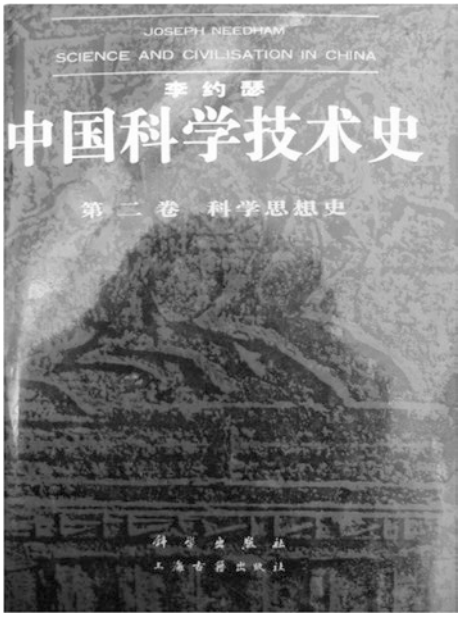


Fig. 9 Translated version of Volume 1, science and civilization in China by Joseph Needham

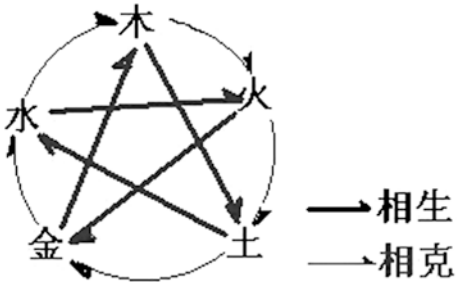


Fig. 10 Schematic diagram of complementation and cancellation among the five elements

originally two independent theories. From the perspective of academic values, the yin–yang theory is the most philosophical theoretical conception of the ancient Chinese sages. Joseph Needham called it "the ultimate principle for the Chinese to construct" in his *Science and Civilisation in China* (Fig. 10).

Regarding the impact to the development of medicine, the yin–yang theory preceded the theory of the five elements. In the pre-Qin remnant of medical historical data, there is virtually no profound impact of the theory of five elements, while the yin and yang theory has already witnessed some degree of application in interpretation of causes of disease, human physiology, and other aspects. It can even be said that, on the theoretical level, it is just under the guidance of the yin–yang theory that the traditional Chinese medicine has become the only ancient science to stay alive today, instead of being fully replaced by modern Western medicine. To facilitate understanding, we assume the number "0" on an axis stands for health status, while the infinite numbers on the two sides represent various diseases or symptom. Pick the number at random, for example, "5", to stand for the common cold. Then, the biggest difference between Chinese and Western medicine lies in that traditional Chinese medicine adds a positive or negative attributes for each disease (for example, *cold-induced febrile diseases* remarked that excess manifestation often occur in yang brightness syndrome, while deficiency in greater yin; yang brightness syndrome occurring in strong person, while greater yin syndrome in weak person, while differentiating properties of diseases in accordance with the theory of three yin and three yang); so the same disease naturally has two different treatments—yet the aim is unified., i.e., readjusting the imbalance between the balance of yin and yang to the midpoint." Another example is the treatment of insomnia by traditional Chinese medicine. Two different treatments are often used: heat purging for insomnia caused by "excess" (Biao), and replenishment of Qi and blood for that caused by "deficiency" (snail). However, in Western medicine, there is only one drug, i.e., sleeping pills, dedicated to insomnia. For insomnia induced by over excitement, sleeping pills can be a rational choice in that they help remedy the balance by making the "0" to move toward the middle. However, for insomnia caused by neurasthenia, the irrationality of continuing to make it leftward is self-evident (Figs. 11 and 12).

However, the speculative nature of this philosophy of the yin–yang theory is not innate. At the beginning of its birth, the theory was only used for the representation of the natural variability of four seasons and alternation between summer

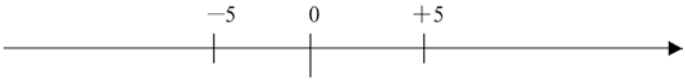


Fig. 11 Schematic diagram of yin and yang theory and the property of diseases

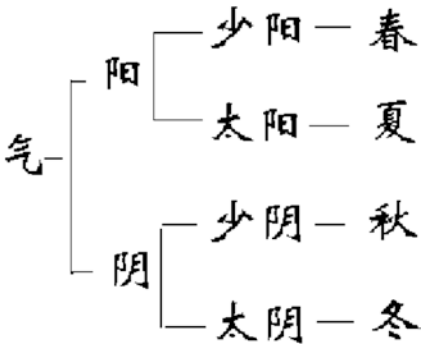


Fig. 12 Schematic diagram of yin and yang ranges

and winter, i.e., in the so-called the order of the four seasons. As the origin of all things in the universe, Qi is divided into yin and yang (cold and heat), while yin and yang are further divided into Shaoyang and Taiyang and Shaoyin and Taiying, respectively. Seemingly, the result of "philosophical dichotomy," the further division, is in fact nothing but the properties of the seasons. Studying "the order of seasons" and persuading rulers into abiding by nature's law in implementation of policies are the scholarship and survival of pre-Qin masters of yin–yang theory. Physicians accepted this theory, and as a result, there was the health-preserving theory of "Major Discussion on Regulation of Spirit According to the Changes of the Four Seasons" in *The Yellow Emperor's Classic of Internal Medicine*, i.e., sprouting in spring, flourishing in summer, astringing in autumn, and storing in winter.

In the course of the long historical period, yin–yang theory and the theory of five elements witnessed an interesting change: As the use of the infinitely divisible opposing properties of yin and yang became wider, enthusiasm in the "loop" property of yin and yang starting from scratch after a complete cycle gradually faded. However, the theory of five elements, originally used for differentiation of "categories" and determining "natures," prevailed because of the mutual complementation and cancellation theory to become the typical representative of the cycle concept. In *The Yellow Emperor's Classic of Internal Medicine*, the yin–yang theory was used more for describing the abstract concept of opposition and balance between yin and yang. Such a doctrine is in fact essentially different from that of the above-mentioned traditional yin–yang theory. The concept of yin and yang includes a facet of the integration of yin and yang constituting the ontology of the universe on the one hand, and a facet of emphasis on the different "phenomena" resulting from difference between yin and yang in property on the other

hand. In medical theory, the former becomes interpretations for the formation of life, degree of endowment, and emotions and physical characteristics, while the latter finds its use in specific instructions on diagnosis and treatment—identification of yin and yang lies at the core of "administering treatment dialectically." A supreme generalization would be (Fig. 13).

The yin and yang are the way of the heaven and earth, the skeletons of all things, the parents of all changes, the beginning of life and death, and the house of the gods. Diseases must be treated from the source. (*The Yellow Emperor's Classic of Internal Medicine—Plain Questions—Yin and Yang Reflected by Various Natural and Life Phenomena*.)

On the relationship between medical and yin–yang theory, there is another point worth noting: Zhang Jingyue, the Ming Dynasty physician said "Without knowledge about the Book of Changes it is impossible to understand medicine," adding that this was the exhortation of Sun Simiao, the famous doctor of the Tang Dynasty. So later advocates of "homology between medicine and the Book of Change 'and' medicine originating from the Book of Change" would cite this as the "supreme instruction." However, in the early medical writings, there is not even the slightest traces on the Book of Change in the original words of the Sun Simiao, who aimed at nothing but advising physicians to read books of all thoughts, including the Book of Changes. Never did Sun speak of the Book of Changes and medical writings or medical theories in the same breath. Likewise, in the books of Zhang Jingyue, the most famous researcher of the relationship between "medicine" and "the Book of Change" and ardent advocate of medicine originating from the Book of Changes, the substantive conclusion in the

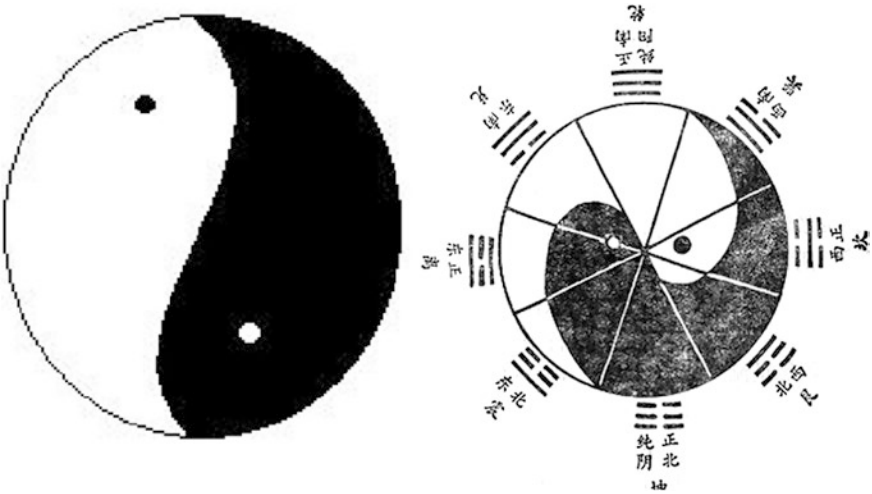


Fig. 13 From the "Taiji Liang Yi" to "three yin's and three yang's," the former shows that yin and yang each occupies a half and are intertwined; the latter shows that the proportions of yin and yang in each area are different

final analysis proceeded as "the relationship between medicine and the Book of Changes is only describable with yin and yang," i.e., to summarize the relationship between medicine and the Book of Changes, the theory of "yin and yang" is the only approach. The importance of the five elements theory is far below that of the yin and yang theory. The essence of the theory of five elements and its role in medicine is first a classifying and determining tool—all things can be included into the five attributes represented by "wood, fire, earth, metal, and water," such as the five directions of east, west, south, north, and the center, the five flavors of sweet, sour, bitter, pungent, and salty, the five colors of blue, yellow, red, white, and black, the five internal organs of heart, liver, spleen, lungs, and kidneys, and the five emotions of worry, anxiety, sadness, fear, and panic. And under the guidance of analogical thinking, certain links are established between things of the same category: The liver belongs to wood and is thus green in color and sour in flavor. So patients with a blue visage are afflicted with disease in the liver, and medicines with a sour taste should be administered for treatment. Based on the same analogical thinking, mutually complementary and cancelling relations are established among the five categories, like wood reinforces fire and inhibits earth, and fire reinforces earth and inhibits metal. Those relationships are instrumental for physicians to establish the links between the organs and indirect treatment methods (such as "replenishing water to inhibit fire"), but are not absolutely applicable in all cases. Regarding the author of The Classic on Medical Problems and his likes, their efforts to build the alternative relationship among the "five acupuncture points" are purely "forced" (farfetched) in the words of Sima Qian, the great historian.

The two theories of yin and yang and the five elements are often combined in the Eastern Han Dynasty. "The Movement and Qi theory" is a typical example. The "movement" refers to the "five kinds of motion" in the universe, i.e., the repetitious motion of wood, fire, earth, metal, and water. Through setting "excess" and "insufficiency" for each of them, the theory of five elements is combined with that of yin and yang. In the same way, "Qi" refers to the "six Qi's"—three ying Qi's and three yang-Qi's—operating in a repetitious cycle between heaven and earth. However, the five elements consist of two yang (wood and fire) and three ying (earth, metal, and water) elements. To make them correspond to the six Qi's, fire is fashioned into monarch fire and ministerial fire (Fig. 14).

This not only solved the issue of "inequality between yin and yang elements in number" discussed in 72AD when the emperor and the group of Confucian scholars gathered together in "Baihu Temple," but also made it possible for the five elements to match the six Qi's perfectly. Predicting the property of the diseases of each year according to the annual "movement" and "Qi" constitutes the "Theory of Movement and Qi." Unfortunately, contemporary enthusiastic advocates of traditional Chinese medicine as a science made a far-fetched interpretation in describing this purely fictional theory as a meteorological medicine. In short, the traditional Chinese medicine is related to yin and yang theory and the five elements theory in the form of "borrowing" relationship, giving full display to the latter two in medicine. Just as mentioned in *Overview of Traditional Chinese*

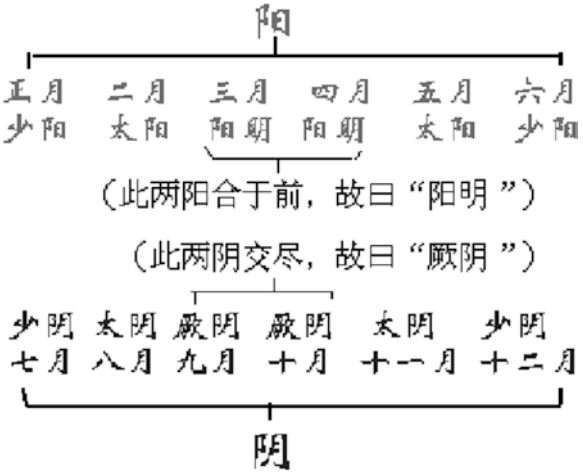


Fig. 14 Three yin and three yang are proportionally different in spatial concept, while boasting the meaning of “time segmentation” in temporal concept

Medicine, The traditional Chinese medicine view of nature and understanding of human physiology and pathology, as well as its understanding of diagnosis, treatment, drugs, etc., can all be described and interpreted using the yin and yang theory and the five elements theory.

1.5.2 Internal Organs and Visceral Phenomena

From the *Overview of Traditional Chinese Medicine* to *The Yellow Emperor's Classic of Internal Medicine,* “internal organs” remain an important component of the theoretical system and the constituents of “internal organs” have not been changed much.

1. Five internal organs: heart, liver, spleen, lung, and kidney;
2. Six internal organs: stomach, large intestine, small intestine, bladder, gallbladder, and triple energizer;
3. Extraordinary fu viscera: brain, marrow, bone, channel, gall, and uterus (womb).

Except for the “Sanjiao” Fu, the names of other organs are still in use, referring exactly to the same entities as modern anatomy. The only difference lies in the understanding of their functions—the ancient and modern understandings are different, so are Chinese and Western understandings. This is because the ancient names of organs originally came from actual observation. However, without the modern physiological and biochemical knowledge, it is impossible to establish a correct understanding of their functions. For instance, without knowledge of lung microstructure and air exchange, one cannot possibly correctly understand the true role played by the lungs during respiration; without chemical and biological knowledge that protein digestion and absorption is impossible without activated

trypsin, one can never know the function of the gallbladder and bile. In the years when people have no idea of the formation mechanism of urine, physicians from China and abroad would naturally be prone to think that urine is the water "permeating into" the bladder from the stomach and the intestine. That is what prompted the ancient Chinese medicine to "construct" a Sanjiao Fu, within the peritoneal organs yet beyond the internal organs, especially for the purpose of water metabolism. For this reason, modern Chinese medicine borrows the expression "visceral phenomena" from the title of "six chapters of visceral phenomena" in *The Yellow Emperor's Classic of Internal Medicine* to describe the internal organs in Chinese medicine as "the theory of visceral phenomena." In addition, it explains that the word "藏," also written as "脏," is a general term for the various internal organs of the body, while phenomena refer to various external demonstrations. Therefore, it can be simply said that "藏象" refers to the external phenomena displayed by all of the internal organs. Although in some cases, it does mean internal organs in the modern sense of the word, the term "internal organs" as mentioned in traditional Chinese medicine books primarily does not mean the organs themselves, but to the various phenomena demonstrated by them. In other words, the physiological and pathological phenomena observed on the surface of human body can be generalized and included in the sphere of influence of different internal organs. Knowing that the names of internal organs commonly used in traditional Chinese medicine are not necessarily referring to the various organs, but their phenomena instead, we cannot measure them with the concept of internal organs we are currently using (Table 1).

This is one of the specific demonstrations of the modernization of traditional Chinese medicine. Despite its inaccuracy, the ancient understanding of internal organs has become an inseparable part of the basic theoretic system of traditional Chinese medicine. Therefore, it is necessary to redefine the internal organs as used in traditional Chinese medicine. In the following section, we will use the existence of "gall" both in the "six internal organs" and "the extraordinary fu viscera" as

Table 1 The Yellow Emperor's Classic of Internal Medicine

Visceral	Capacity	Function
Heart	Office of monarch	Consciousness
Spleen	?	?
Lungs	Office of assistant	Management and regulation
Kidney	Office of strengthening	Procreation
Abdomen	Office of ambassador	Emotions of happiness
Stomach	Office of storage	Five flavors
Large intestine	Office of transformation	Change
Small intestine	Office of acceptance	Digestion
Bladder	Office of irrigation	Storage of urine
Gall	Office of justice	Decision-making
Three energizers	Office of sluices	Water outlet

the entry point of the analysis to further explore the "constructive" process of the visceral theory:

In *Plain Questions—Separate Treatise on Five Zang Viscera*, the Yellow Emperor put forward a question like this "some of the physicians told me that the brain and marrow are Zang viscera, while others said that the intestine and stomach are Zang viscera, and still others said that the intestine and stomach are be fu viscera. Their theories are mutually contradictory, and each claimed itself to be correct. I just do not get it. Could you elaborate the issue to me in detail?"

Qibo, the medical teacher of the Yellow Emperor, answered, "Brain, marrow, bone, channel, gall, uterus are six organ generated by earth Qi and thus boast the same trait of embracing everything like earth. Therefore, they store essence and Qi, instead of effusing them. They are called the extraordinary Fu. In contrast, stomach, large intestine, small intestine, three energizers, and bladder are five organs generated by heavenly Qi and thus are awarded the same qualities as heaven. Therefore, they cannot keep what you eat for long; instead, they discharge it. They are called the transformative Fu."

Qibo went on to say that "The five Zang viscera stores essence and vital force, and are thus full of essence and Qi but unable to be filled with foodstuff. On the other hand, the six Fu viscera transforms foodstuff instead of storing them, and are thus able to be filled foodstuff but not essence or Qi."

To facilitate understanding, the author straightened out Qibo's words into two tables, i.e., Tables 2 and 3. It can be seen from the two tables that in Qibo's answer, both systems include two types of viscera, one yin and the other yang, despite the difference in names—in one system, the names are "extraordinary fu" and "transformative fu," in the other, the names are "five zang viscera" and "six fu

Table 2 Comparison between "Extraordinary Fu Viscera" and "Transformative Fu Viscera"

Type	Number	Organs	Analogy	Function
Extraordinary Fu viscera	6	Brain, marrow, bone, channel, gall, uterus	Modeling earth	Storing without effusing
Transformative Fu viscera	5	Stomach, large intestine, small intestine, three energizers	Modeling heaven	Effusing without storing

Table 3 Comparison between five Zang viscera and six Fu viscera

Type	Number	Organs	Analogy	Function
Five Zang viscera	5	Heart, liver, spleen, lung, kidney	Modeling earth	Storing without effusing
Six Fu viscera	6	Stomach, large intestine, small intestine, bladder, gall	Modeling heaven	Effusing without storing

viscera." The two types of viscera are comprised of the odd number 5 representing yin and the even number 6 representing yang. With one type "modeling heaven" and the "modeling earth," the two types play their respective roles of "storing without effusing" and "effusing without storing." So in fact, the two are different types of viscera theories.

However, when later generations of physicians summed up the two theories into one system, the so-called Zangfu Theory of Traditional Chinese Medicine emerged with repeated appearance of "gall" and overlapping functions, as seen in *the Overview of Traditional Chinese Medicine* (see Table 4).

Therefore, to really understand traditional Chinese medicine, one has to have a historical view and to be good at using logical analysis. Only in this way can him clearly see the nature of construction and understand the process of "unifying different theories" by the ancients and that of "modern reconstruction" by the contemporaries (Figs. 15 and 16).

1.5.3 The Channel Theory

The system of channel theory in traditional Chinese medicine mainly includes the following components. Imagine the natural rivers, lakes, and creeks, and you will find it is not difficult to understand (Fig. 17).

1. Meridians: according to the channel theory, vertical trunk-like passages of blood and Qi are "meridians," and the "twelve meridians" closely linked to the viscera are the primary channels. Connected end to end, those channels form a loop-like cycle without terminals. The name of each meridian consists of three parts, i.e., the name of the viscus, "hand or foot," property of being one of the three yin's or three yang's, for instance, Lung Meridian of Hand Taiyin and Bladder Meridian of Foot-Taiyang.
2. Branches of meridians: major ramifications of meridians, playing the role of strengthening the connection between the meridians, as well as that between meridians and the corresponding viscera.
3. Collaterals: sub-branches of meridians forming horizontal links between meridians and are therefore called "collaterals." There are 15 major collaterals and countless fine collaterals called superficial collaterals or tertiary collaterals.

Table 4 Contemporary standard visceral theory

Type	Organs	Function
Five Zang viscera	Heart, liver, spleen, lung, kidney	Storing without effusing
Six Fu viscera	Stomach, large intestine, small intestine, three energizers ,bladder, gall	Effusing without storing
Extraordinary Fu viscera	Brain, marrow, bone, channel, gall, uterus	Storing without effusing

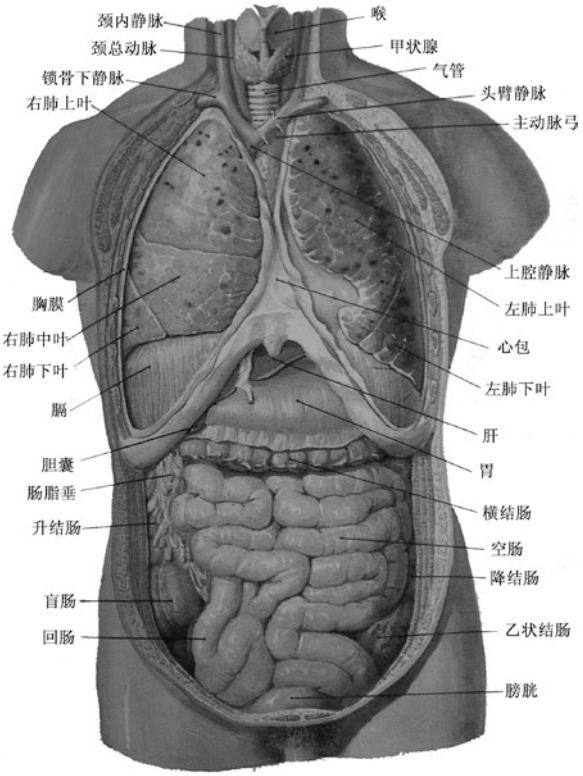


Fig. 15 The visceral diagram of modern medicine

4. Eight extraordinary channels: on the basis of the twelve meridians compared to rivers in *The Yellow Emperor's Classic of Internal Medicine, The Classic on Medical Problems* again compared other "vessels" mentioned in previous literatures to natural lakes storing the water from rivers, giving them the general name of "eight extraordinary channels." However, description of their properties by later generations has witnessed fundamental revision. Both physicians and qigong and martial arts practitioners have set greater store by the interpretation of conception and conception channel and governor channel in the central lines of the human body over the twelve meridians (Fig. 18).
5. Aponeurotic system and dermal parts: In The Yellow Emperor's Classic of Internal Medicine, the tendons, flesh, joints, and other tissues are subordinated to the twelve meridians, calling them "the twelve aponeurotic systems," and the surface of the human body is divided into "twelve dermal parts" in accordance with the circulation regions of the twelve meridians. Although they are not meridians or collaterals, they are the points of junction, gathering, dispersion, and connection for the Qi and blood of the twelve meridians.
6. Acupoints: the points for the entry and exit of Qi and blood, as well as intersection between the meridians and collaterals. However, there are "extraordinary

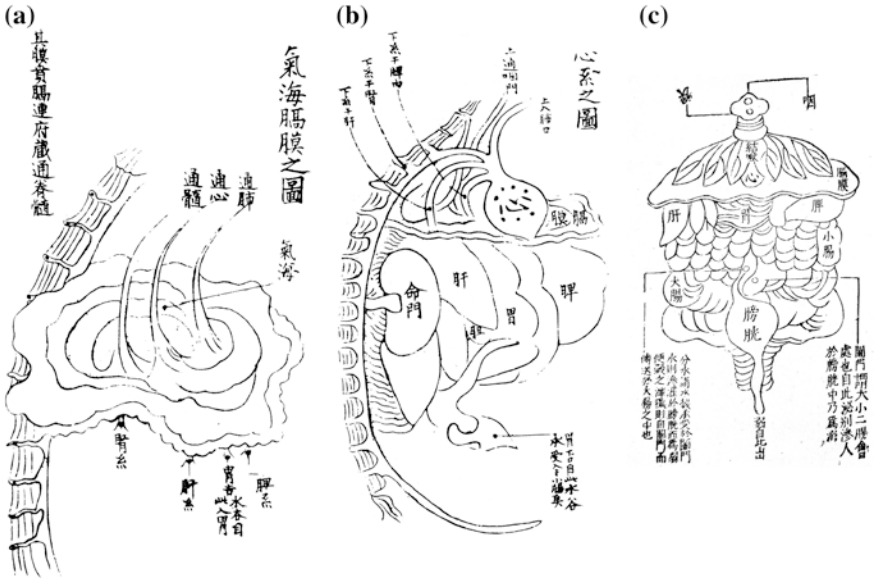


Fig. 16 Bronze figure denoting the acupoints handed down from the family of Ling. **a** Figure of qihai diaphragm. **b** Figure of the heart system. **c** Figure of viscera

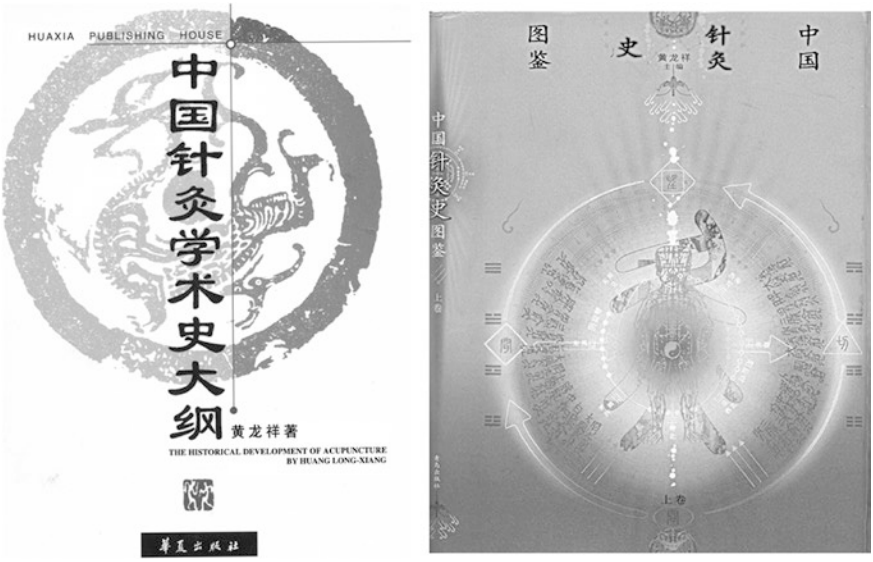


Fig. 17 Two monographs written by Huang Longxiang can be used as reference for deepening the understanding of the channel theory and acupuncture therapy

Fig. 18 The governor vessel, one of the eight extraordinary vessels, is located in the central line on the back of the human body

acupoints" irrelevant to meridians or collaterals, or ashi acupoints denoted by the feeling of pains (that is, the places where pain is felt are acupoints). This theory is obviously derived from the integration of acupuncture therapy and channel theory. "腧" is also synonymously written as "俞" and "输."

The channel theory is undoubtedly the most mysterious and most characteristic feature of traditional Chinese medicine, as well as the ancient knowledge of medicine attracting the widest attention from contemporary scientists. Although currently, there is no way to learn the nature of channel phenomena, it is not completely impossible to gain a deeper understanding of them.

Firstly, it should be pointed out that the systematization of the channel theory took a certain process. In the medical books unearthed in Mawangdui, there are only 11 channels, and the circulation lines were short. The meridians are not connected end to end to form circular loops or linked to the viscera. In addition, there is no clear record of acupoints. However, in the wooden human model unearthed in Mianyang, Sichuan Province, the marks of channels are completely different from the records in the medical books unearthed in Mawangdui. The channel theory used after the Han Dynasty is mainly summarized from the record of circulating path, mutual connection, and visceral attachment in *Lingshu-Meridians*, as well as the treatises on aponeurotic system and dermal parts in *The Yellow Emperor's Classic of Internal Medicine*. In the Song Dynasty, Wang Weiyi became famous for his bronze acupuncture figure marked with acupoints. Thus, the passage of Qi and blood, which were originally hiding within the human body, became clear superficial acupoint lines (Fig. 19).

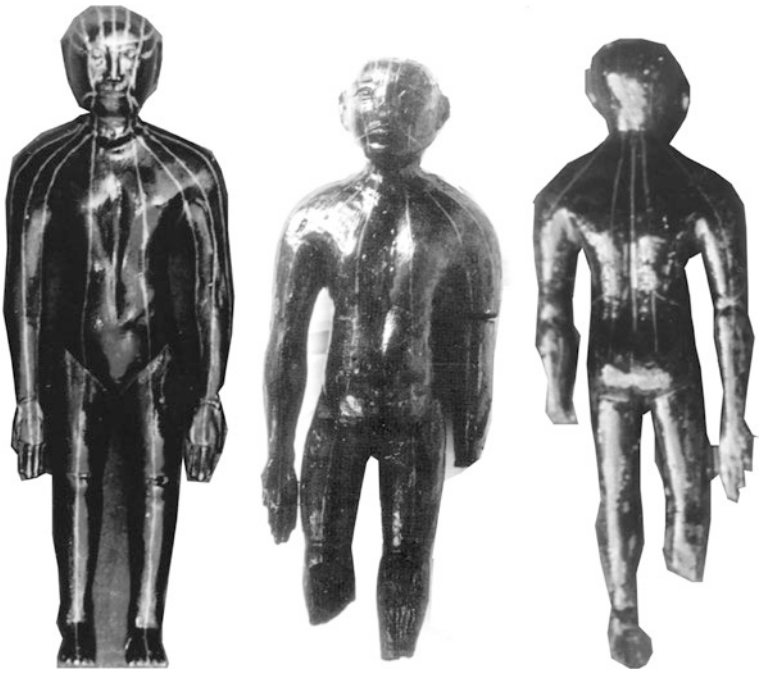


Fig. 19 Han Dynasty wooden figure unearthed in Mianyang, Sichuan Province

This wooden figure was believed to be representing the collaterals of the human body because of the various lines carved on it. Regrettably, there were no words of annotation. Therefore, deep research is scarce (the left is a restored model.)

Secondly, although it is generally believed that the theory of meridians is unique to traditional Chinese medicine, the fact is that there are descriptions to varying extents of "passages" for the circulation of blood and Qi in the human body. For example, in the Indian Medicine, the heart is described as a large radish, connected to 10 vessels; besides, there are another 24 vessels originated from the umbilicus. According to Tibetan medicine, there are two vessels within the human body, one black and the other white. Zhuang traditional medicine claims that the key to treatment is to dredge the "Dragon Path" and "Fire Path." The generality is that as ancient theories of the human body, they not only include knowledge resultant from actual observations, but also inevitably boast constructive content of analogy and imagination.

Thirdly, before the introduction of Western medicine, people had no idea that the channel and vessel system (including arteries, channels, and lymph vessels) and the nervous system are essentially different. Therefore, in "The Yellow Emperor's Classic of Internal Medicine," small blood vessels visible on the surface of the body are called minute collaterals; larger meridians are invisible for no other reason than the fact that they are "running deep within the body"; in events

of meridian-pricking for bloodletting, dark red means cold (small veins are punctured), crimson means hot (when capillaries or small arteries are punctured), and ulceration resultant from lymphatic tuberculosis is called "meridian leakage." Without clarifying this point, we cannot understand why the descriptions of the meridian system in traditional Chinese medicine classics, obviously refer to the blood vessels, yet fail to fully accord with blood vessels.

Fourthly, we must know the meridian theory is a complex. Therefore, even if one day modern science succeeds in ascertaining the essence of the phenomena of the meridian, it could never fully explain the entire system. For example, the physicians from the era of "The Yellow Emperor's Classic of Internal Medicine" were aware that there was a particular connection between the tender points on the two sides of the spine and the ailments of horizontally positioned organs. They determined the "back acupoints," which includes the lung acupoints, heart acupoints, liver acupoints, gallbladder acupoints, and kidney acupoints all the way down the spine, for the diagnosis and treatment of disorders in those organs. But in the system of meridian theory, these specific acupoints all belong to urinary bladder channel of foot-taiyang coursing upward along both sides of the spine. Without this knowledge, one cannot explain why the bladder meridian is associated with all the internal organs. Another example is the traditional Chinese medicine insisted that the ear is an inverted human microcosm. This interpretation is purely far-fetched. The reason is that the "ear meridian" and the resulting "ear acupuncture therapy" are not discovery or invention of the ancient Chinese medicine, but a phenomenon of life discovered by foreign doctors in the mid-twentieth century. In addition, this phenomenon of "part as the microcosm of the whole" is not merely seen in the ear. Therefore, when experience generates new knowledge, there must be a new theory to explain it. A third example is the starting point of "circulation loop of blood and Qi" consisting of the twelve regular meridians is not the heart, but the stomach instead. This is because back then the level of physiologic study can only infer that the power source for the circulation of blood and Qi lies in the digestion of the diet and absorption of the nutritious elements (Fig. 20).

The back acupoints of all viscera are mostly on the two sides of the spine, in the spinal nerve root horizontal to the position of the organ. Thus, the connection between pains in the location and the viscera are similar to nervous reflex pains in modern medicine.

Fifthly, there is a noteworthy and conspicuous difference between the meridian theory and the pharmaceutical knowledge systems: In the development history of the pharmaceutical system, we can see continued accumulation and update of knowledge—the variety of medicines is increasing; the recognition of the functions for each drug is being enriched; in addition, there is the process of gradually developing what are useful or healthy and discarding what are not in all respects. However, the meridian theory becomes stabilized when it has formed its stereotypes after a relatively short period of development—in the last 1,000 years, there are quite a few master physicians in each generation; however, they basically use or confirm this knowledge. Perhaps 1 day modern science can prove that aside from nerves and body fluids, there exists "a way of information conduction" in the human

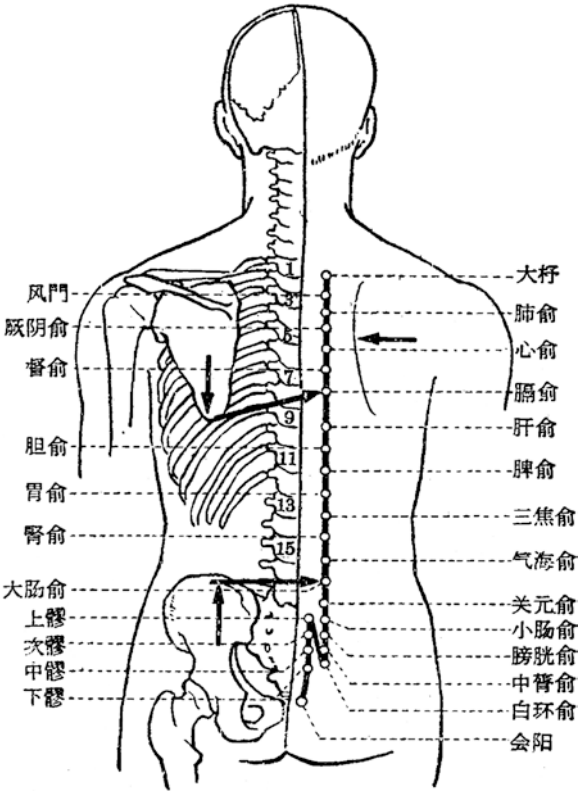


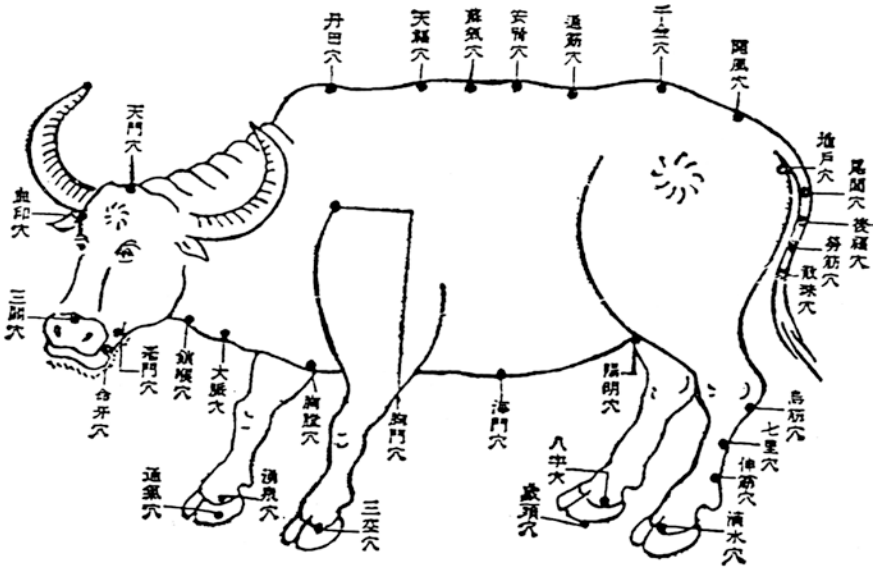
Fig. 20 Acupoints in the back

body according with the meridian theory. In that case, the source of knowledge for this system will become more difficult to understand, because neither the physician's "subjective feeling" nor the patient's "object representations" explain how the knowledge of the meridians and acupoints on animals is acquired (Figs. 21 and 22).

1.5.4 Pathogenic Theory

The theory on causes of disease in traditional Chinese medicine is very simple—generally speaking, there are three types of pathogenies: internal causes, external causes, and non-endo-non-exogenous causes. The so-called external factors believes that there are six Qi's between heaven and earth, namely wind, cold, heat, wet, dryness, and fire, and when one of them becomes too strong or appears where it is not supposed to, "excess" (evil) will occur. These evil Qi will invade the human body, causing "exogenous" diseases. If the weather is hot, but cold, chills, or other symptoms, which typically rise in winter due to exposure to "pathogenic cold," occurs; or if it is winter, but high fever resultant from "pathogenic heat" occurs, the causes are labeled "hidden pathogens"—pathogenies from exposure to cold in winter and heat in summer stays latent and bursts out in another season.

Fig. 21 The figure of "twelve meridians" in horses in the ancient writings of veterinarians. If the discovery of "Meridian Phenomenon" is related to perception, then what about animals?



针牛穴法名图（引自《元亨疗马集》）

Fig. 22 "Acupoint Figure of a Buffalo" in the ancient writings of veterinarians

Another example is beriberi. According to the laws of nature, the humid Qi rises from underground. Therefore, "Jiaoqi" (beriberi) (deficiency of vitamin B1, with weak feet as the main symptom) is due to invasion of the foot (jiao) by wet Qi, hence the name "Jiaoqi." Likewise, myocarditis caused by deficiency in vitamin B1 is called "disease of weak foot affecting heart." Since the cause is invasion of underground moist Qi in the body, patients should choose wheat, which is grown on dry land, over rice, which is grown in water. This accidentally "coincides" with the knowledge of modern natural science that refined white rice lacks vitamin B1, while pasta is rich in this ingredient. However, in ancient times, people could not distinguish which kind of ailments causing weak legs and action disorders are due to deficiency in vitamin B1, so diseases in the joints, poliomyelitis, etc., are often diagnosed as the same. The reason is that outwardly the ancient names of diseases indicate "pathogenic diagnosis," while denoting "symptom diagnosis" in fact—that is, the reasons are deduced and the name determined according to the symptoms of the disease. Partly because of the difference in the understanding of causes of diseases between the ancient and modern times, it is very difficult, or rather, simply impossible to define the modern counterpart of a certain ailment of the ancient times.

It is precisely because the etiological division of internal and external causes and the large amount of erroneous judgment of pathogenies just like "Jiaoqi" (beriberi) mentioned above, "exogenous" disorders naturally cover a wide range. This is the reason for "typhoid fever" to be frequently used as an independent division in the medical classification of different generations and to top in many large-scale comprehensive medical works as a general term of exogenous diseases.

The late Ming Dynasty and early Qing Dynasty witnessed a breakthrough in the understanding of the exogenous diseases. Wu Youxing, the physician who grew up on the shores of Taihu Lake, conscientiously observed the expansion of plagues and summed up a law: Exogenous diseases are not necessary due to violations of the human body by "six evils." Instead, there is a separate "疠气" "pestilential Qi" between the heaven and earth which enters the human body through the nose and mouth. The pestilential Qi must have different qualities, so that animals were not sick when chicken fell sick, and chickens were not sick when people fell ill. If we can figure out the nature of the "pestilential Qi," we will certainly have a material to curb it, without having to tailor the herbal prescriptions of monarch, minister, assistant, and guide drugs or administering dialectical treatments according to different syndromes. If Wu Youxing were to live up to modern times, gain some understanding of the pathogenic microorganisms, and learn to use antibiotics and other medicines for targeted therapies, he would say that "there is no essential difference between the Western and Chinese medicines." However, the question does not lie in the difference between the name of "pestilential Qi" or that of "pathogenic microorganism." The key issue is that Wu's understanding derives from logic speculation based on the investigation in the style of studying the world to exhaust the principle of things, rather than empirical science. Subsequently, along with the inevitable natural tendency of increased infectious diseases due to increasing population density in regions to the south of the Changjiang River, a

batch of successful physicians, known for their skillful treatment of "febrile diseases" and represented by Ye Tianshi, rose to the occasion in Jiangsu. Replacing "Six Confucian Classics Dialectical" with "Wei, Qi, Ying, and Xue" and "the upper, middle, and lower Jiao's," they used mulberry leaves, chrysanthemum, silver flower, forsythia, and other drugs which are pungent in flavor and cool in property to take the place of ephedra, cassia twig, and other drugs which are pungent in flavor and hot in property. However, although it broke the constraints of the "*Treatise on Febrile Diseases"* both in theory and in treatment, the School of Febrile Diseases essentially followed the same strain, instead of deviating from Wu Youxing the pioneer in treating febrile diseases. This is the power of "the tradition."

The internal causes include the various emotions and desires (seven emotions: happiness, anger, sadness, fear, love, hate, and desire; six desires: desire of life, death, ears, eyes, mouth, and nose), improper diet and exhaustion, and uninhibited sexual intercourse. In this regard, there are two points worth noting: First, under the control of the five elements theory, the traditional Chinese medicine believes that the human spirit and emotion are closely attached to the five internal organs. Under the concept of mental and physical unification, mental illnesses were considered as part of the somatic disorders, or rather, as certain symptoms of somatic disorders—for example, excessive heart Qi causes unstoppable laughter, while insufficient heart Qi would prompt crying. Naturally, the treatment would include acupuncture and drugs, and even psychotherapy. In the West, before the heroic act of "liberating the mentally ill sufferer" at the end of the eighteenth century, people with mentally illnesses were treated as criminals or "emissary dominated by the devil." They were locked up in cages and always brought to public display. Treatment is whipping for exorcism plus three hundred cold water baths every day. The second is the healthy standard of living guided by the golden mean and the concept of yin and yang balance. The traditional Chinese medicine emphasizes that exercises and temperance are beneficial to health and longevity, but by no means advocates asceticism and mortification. Being unmarried, widowed, and lonely is considered to be an important reason for causing some physical and mental disorders.

It is Li Dongyuan, one of the four eminent physicians in Jin and Yuan period, who heightened improper diet and exhaustion to the theoretical level and set great store by it. Li once wrote a book *Clarification of Perplexities about Internal and External Damage*, dedicated to discussion of ailments disguised as exogenous disorders, which were internal injuries in fact and which should be treated via recuperating the spleen and stomach. In addition, he also wrote *Treatise on the Spleen and Stomach*, pointing out that the stomach Qi was the "primordial Qi," and creating a series of famous prescriptions such as Decoction for Activating stomach and Lifting Yang, Decoction for Reinforcing Middle-jiao, and Replenishing Qi, which are still widely used as of today.

Non-endo-non-exogenous causes are not a major subject of theoretic study. They often refer to diseases resultant from injuries, animals and worms, intoxication, heredity, and other factors.

1.5.5 Diagnostic Theory

The diagnostic methods of traditional Chinese medicine are called "four diagnoses," namely watch, hear, ask, and touch. The four methods are used to gather information of diseases and make judgments regarding their properties and locations. In "The Yellow Emperor's Classic of Internal Medicine" and other classics, watch and touch receive the most attention, due to the fact that they are high in technical content and closely related to the theory of traditional Chinese medicine.

Watch refers to observing mainly the patient's physical form and complexion. However, regarding the theory of observing the exterior to learn the interior, the observation of complexion boasts much greater clinical significance than that of physical form and weight and athletic status. The science of observing complexion as a whole cannot be separated from the theory of five elements' attachment. For instance, the element of "fire" is attached to red and "metal" to white. Therefore, red color indicates heat, while white mostly denotes cold. Specifically, yellow is related to spleen and black to kidney. When orientations are involved, the center belongs to earth, the left or the east to liver and wood, and the right or the west to lung and metal. Therefore, "rosacea" indicates spleen dampness and stomach heat. The change of color in the left zygomatic indicates changed liver conditions and that in the right zygomatic indicates changed lung conditions. In addition, there is an important principle in observing complexions, that is, "luster" is more important than the "color"—luster is enough, regardless of the color, and lack of luster mostly denotes diseases. The tongue observation has gradually developed into a relatively independent and specialized method for Chinese medicine practitioners. Generally speaking, the main purpose for observation of the tongue body is to learning the circulating conditions of blood and Qi in the body. For example, pale denotes blood deficiency, and fat means Qi deficiency. Observation of the tongue coating is mainly aimed at understanding the property of the pathogenic Qi. For instance, white coating indicates wet and yellow coating indicates heat. The thicker the coating is, the stronger the pathogenic Qi; the closer the coating to the root, the deeper the part affected by the pathogenic Qi.

The use of diagnosis by watching is related to the meridian theory. For example, the conception vessel in the central line in the front of the body passes the philtrum (the vertical groove in the upper lip). So a beardless or flat philtrum indicates deficiency of channel Qi in the conception vessel, and people with such a philtrum are often susceptible to problems in reproductive function. Another example concerns eyebrows and ears. It is shown in life experience that people with longer eyebrows and bigger ears are more likely to have a longer life span. Therefore, expressions like "eyebrow longevity" and "longevity eyebrows" and complimentary remarks like "with ear lobes long enough to touch one's shoulders" are invented. In the system of medical knowledge, "eyebrows are flowers of the marrow" and "ears are the aperture for kidneys." Therefore, eyebrows and ears are observed to determine whether the bone marrow is full and natural endowment (kidney Qi) is rich and to further speculate life span. Thus, diagnostic knowledge of medicine enters into a mutually interactive relationship with the physiognomy

Fig. 23 The diagnosis monograph *Tongue Differentiation Guide*

theory. Here, it is unnecessary to debate over whether physiognomy is right and wrong or to determine which comes first. All we have to know is that more often than not ancient knowledge is without clear boundaries (Figs. 23 and 24).

Touch as a diagnostic method is also called palpation, and it covers checking by hands the joint movement, fracture, dislocation, intra-abdominal pelvic mass accumulation, skin humidity, etc. However, the most commonly used and most important content is examination of patients' pulse manifestations. The method of

Fig. 24 Illustration from *Tongue Differentiation Guide*, which betrays influence of modern anatomy

pulse-taking stems from the understanding by physicians of beating "pulses" in the human body. In the classic era, pulse refers to long stretches of "meridians"—"Meridian of Hand Taiying" and "Meridian of Foot Yang-ming"—while in the early stage, it often refers to the pulse of a certain location, i.e., the specific places for diagnosing the troubles. Therefore, the most primitive pulse-taking involves multiple places to diagnose the troubles. When the meridian concept took shape, it became "pulse-taking according to different vessels." To connect the beating pulse to the state of human health and disease diagnosis, physicians built a variety of specific theories—for instance, one theory spans several levels from light to heavy, for diagnosing diseases in the viscera, and is thus called "light and heavy pulse diagnostic method." In another theory, the floating pulse is a phenomenon of spring (liver, wood), and the surging pulse (heart, fire) is a phenomenon of summer. This theory is called "pulse with four seasons." In a third theory, a total of nine arterial pulses are taken at the head, foot, and hand (heaven, earth, and people), with three pulses at each part, to examine the Qi and blood at the upper, middle, and lower sections of the human body. This method is called the method of "three body parts and nine pulse-taking sites." However, the one most closely related to modern pulse-taking method takes the pulse at Renying (carotid artery) to learn the status of "yang," and at Cunkou (wrist radial artery) to learn that of the "yin." Comparison of the changes in magnitude of the pulses at the two sites to determine whether yin and yang are in balance is called "Renying–Cunkou pulse method." Later, this approach was simplified by dividing Cunkou into two parts, one yin and the other yang. And the middle finger is used as the boundary (hence the name "pass"), with the place one cun (1/3 decimeter) to the wrist crease (hence the name "cun") for deciding the status of yang and the place one chi (1/3 m) to the elbow (hence the name "chi") for deciding that of yin. However, the first problem proposed at the onset of *The Classic on Medical Problems* is as follows: Of all the arteries in the twelve meridians, why is Cunkou which belongs to Taiyin meridian and which is on the wrist being used for diagnosis? Therefore, according to the existing information, this important change of diagnosis by taking pulses can only be traced back to the era when *The Classic on Medical Problems* was compiled. However, in the "The Yellow Emperor's Classic of Internal Medicine," "diagnosis chi" is mentioned, but to mean "check the conditions of the forearm skin." Although the pulse-taking method has been changed from "Renkou–Cunkou" to "Cunkou alone," the underlying theory remains the yin–yang theory. On the other hand, with those changes, the yin–yang theory underwent changes in its use in medicine—its essence of "loop" circulation gradually faded away, and its characteristics of "opposition" became highlighted.

Subsequently, in the book *Pulse Classic* compiled by the minister of imperial medical affairs Wang Shuhe of Western Jin Dynasty, it can be seen that pulse-taking had undergone another important change, that is, the middle finger which is taken as the "pass" and boundary became a site for taking pulse—and Cunkou is divided into cun, pass, and chi and matched to internal organs. At this time, chi and cun are no longer matched with yin and yang, but correspond to the upper and lower [sections of] human body. From the correspondence of cun, pass, and chi in

the left hand to the heart, liver, and kidney, respectively, and that in the right hand to the lung, spleen, and gate of life, it can be concluded that the attachment relation had been changed to the left (yin, blood) and right (yang, Qi). In addition, the number of "pulse phenomena" reached 24, while "*The Yellow Emperor's Classic of Internal Medicine,*" recorded less than 10. This method of pulse-taking is still in use today.

Due to the fact that both can achieve the effect of "the physicians can learn the pathogeny without the patients opening their mouths," they become not only an important means for physicians to win the trust of patients, but also a major standard for judging the level of the doctors by patients. However, pragmatic doctors should fully use the four diagnostic methods to gather as much and comprehensive information as possible and strive to make an accurate diagnosis. There is no need to hold anything back or to show off. On the other hand, all of the advanced diagnostic techniques and means of modern medicine can be seen as an extension of the sensory functions without exception. It can be said that there is no essential difference between ancient and modern diagnostic methods all over the world. Contemporary practitioners of traditional Chinese medicine not only need to understand the modern diagnostic methods and significance of information acquired, but also strive to organically combine the information obtained through extension of these sensory functions with the theory and the therapies of traditional Chinese medicine. Only in this way can they be described as practitioners of traditional Chinese medicine in the real sense of the word. For example, in pediatric kidney disease ward in the hospital, most of the little patients either suffer from "nephritis" or "nephrotic syndrome." In the urine reports of the former, there are red and white blood cells, while that of the latter has a certain amount of protein. The former are mostly allergic reactions caused by streptococcal infection of the throat. Belonging to "damp heat" diseases according to traditional Chinese medicine, they should be treated with drugs that clear heat and remove dampness. The latter are mostly because of deficiency in natural endowment, which causes the essence—proteins—to leak out instead of staying in the body. "Tonic" treatment should be administered. Actually, diagnoses made on the basis of urine test results are basically consistent with the judgment based on the traditional four diagnostic methods. What makes matters more interesting is a simple empirical test I did on those little patients. According to the theory of traditional Chinese medicine, "kidney has ear as its aperture." I touched the ears of the children and found that those with especially soft ears are basically diagnosed as suffering from nephrotic syndrome, while those with relatively harder ears diagnosed as suffering from "nephritis." This demonstrates that there is no unbridgeable gap between Western and Chinese medicines.

Here, comprehensive judgment based on the information gathered through the four diagnostic methods can be referred to as "diagnosis." This is the "differential" process of the rules of differential treatment. The main issue is to identify the disease with the "eight classes", i.e., yin, yang, exterior, interior, heat, cold, insufficiency, and excess. The main principle of the "eight classes" is nothing but yin and yang. As long as the basic attributes of the disease are determined correctly and

treatment administered accordingly, there would no big mistake. However, it is no easy task to achieve the purpose in practice, given the complex manifestations of diseases. For instance, for a feverish patient suffering from pulmonary circulation disorders caused by right heart failure, which leads to fluid leakage and secondary pulmonary inflammation, the heat-removing and detoxification treatment for colds and pneumonia method is absolutely ineffective. Only after recognizing the nature of "actual cold under disguise of heat" and boldly using cardiac drugs can we hope to see the result of improved circulation, absorbed exudate, subdued inflammation, and quenched fever. In fact, Western doctors will also use cardiac, diuretic, and potassium-reinforcing drugs, aside from antibiotics, in treating such patients. Chinese and Western medicines lead to the same destination by different routes; therefore, there is still no unbridgeable gap between them.

1.6 Internal and External Treatment

1.6.1 Acupuncture

Acupuncture is a treatment unique to traditional Chinese medicine. It has a very long history and has gradually been understood by countries around the world. Regarding the origin of acupuncture, there is an old saying "Shen Nong tasted 100 herbs and Fu Xi fabricated the nine classic needles." However, another theory maintains that the Yellow Emperor invented the art of acupuncture. Therefore, the ancient Chinese medicine is roughly divided into two systems: One is the Shen Nong-Herbal drug treatment system and the other is acupuncture treatment system of "Fu Xi and Yellow Emperor-acupuncture. From this we can see the position and importance of acupuncture and moxibustion in traditional Chinese medicine. However, this unique treatment method does not at birth comply with the definition in the textbooks of modern acupuncture and moxibustion—the application of acupuncture moxibustion methods, to stimulate the meridians and acupoints to adjust the function of blood and Qi in the viscera, and thus achieve therapeutic purposes." (Fig. 25)

It is generally believed that acupuncture originated in the primitive bloodletting and fomentation means and thus can be traced back to the invention of using fire and polish of stone tools by ancient humans. However, in the "*Rites of Zhou,*" a book recording in detail the medical system and therapies practiced in the Western Zhou Dynasty, there is no trace of moxibustion and pricking being used for the treatment of diseases. This shows that although moxibustion and pricking are inseverably connected to the use of fire and manufacture of tools, their time of emergence as a cure for diseases may not be so early. Not until the various medical books are unearthed in the Western Han Dynasty tomb in Mawangdui did we see illustration of moxibustion being used for disorders along with the description of meridians in the human body. However, pricking is still not mentioned (Figs. 26, 27 and 28).

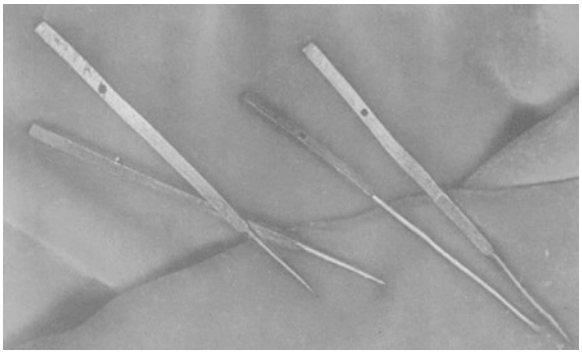


Fig. 25 Golden needles unearthed at a Han Dynasty Tomb in Mancheng, Hebei Province

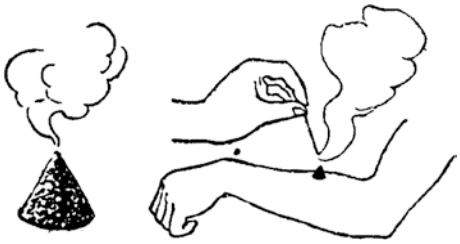


Fig. 26 Moxibustion therapy: that is, stimulation of acupoints directly with lit moxa

Fig. 27 Salt-partitioned moxibustion: that is, salt (or other material) is placed between the lit moxa and the skin, as a medium of heat conduction

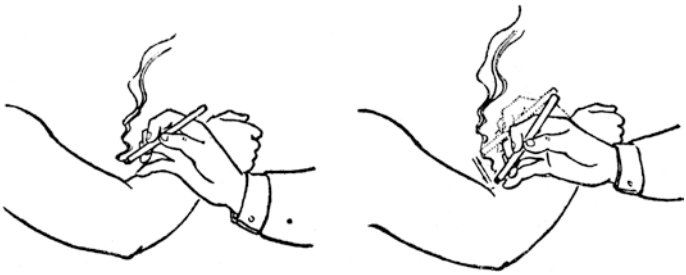


Fig. 28 Mild moxibustion and bird-pecking moxibustion: lit moxa is properly distanced from the skin and kept in motion, so as to prevention burn. Those are soft and comfortable moxibustions

In addition, due to similarity in external form, it is generally accepted that knife-shaped stone needles are the predecessors of metal needles. However, just as mentioned in medical books unearthed at Mawangdui, stone needles of proper size should be used to cut carbuncles and flatten abscesses. On the other hand, "*The Yellow Emperor's Classic of Internal Medicine*" proposed that stone needle therapy originating from the East is suitable for the treatment of carbuncle ulcers, while small needle therapy emerging in the South is suitable for the treatment of limb spasticity, pain and paralysis, and movement disorders. In addition, it also summed up the application of drug, needles, and stone, i.e., the application of drug, as treatment for internal disorders, and that of needles and stone as treatment for external diseases. Therefore, we can conclude that "stone needles" are not the predecessors of metallic needles, but a surgical tool instead. The reason for mentioning needles together with stones is that both are used for the treatment of external disorders—disorders between the skin and the tendons as contrasted to those in the "internal organs," i.e., the five zang and six fu viscera.

Furthermore, even within the family of "needles," there are also different members, which ought to be "surgical tools" and "acupuncture appliances" according to the modern point of view. This family is mentioned in the "*The Yellow Emperor's Classic of Internal Medicine"* as "the Nine Classical Needles." "Stiletto needles" are a surgical tool, and the "filiform needles" are true acupuncture appliances, while the oval-headed pin should be called massage appliances. Therefore, only by including the early art of acupuncture into the scope of external treatment can we truly understand the origin of this therapy and its original appearances (Table 5; Fig. 29).

Early ramification of the "external treatment" is in line with the formation of the existing definition for acupuncture. There should have been a main driving force from the two aspects: first, trend of independent development in use of the "knives and instruments" as treatment technology, although in this area in China is extremely slow; second, the tendency to independence of the "pulse" part of disorders. This is because that "vessels" themselves are not only sufferers of various disorders requiring treatment, but also channels for the circulation of Qi and blood. Moreover, they are connected to each other and to the viscera. Therefore, the theoretical basis is awarded to filiform needles for use in regulating blood and Qi, and unique treatment of internal (visceral) and external (channel) disorders, because of the fact that the needle body is small and its operation is slow and that it has a period of "needle retention time" within the body.

The various organs and most of the acupoints for acupuncture are connected with certain meridians, and various parts of the body are subordinated to meridians in accordance with the aponeurotic system and dermal parts. Therefore, the meridian theory forms a most direct and closest relationship with acupuncture theory. At the same time, the treatment functions of certain acupoints would more often become independent empirical knowledge. Thus, the entire system of acupuncture would always contain the content of these two branches of complementary knowledge. Regarding clinical utility, the latter is often more important—because it is not that acupuncture stimulation administered on a meridian, or one of its

Table 5 The shape and dimensions of "the Nine Needles" in *Lingshu—Nine Classical Needles and Twelve Source Points*

No.	Name	Length (cun)	Shape	Application
1	Shear needle	1.6	Big head, sharp end	Mainly used in discharge of yang-Qi
2	Round needle	1.6	Oval shaped	Massage the divisions, to refraining damage to the muscles, used for discharging the atmolysis
3	Spoon Needle	3.5	Sharp like millet awns	Used to press the meridians without puncturing it to induce the arrival of Qi
4	Ensiform needle	1.6	With three blades	Relieving obstinate illness
5	Stiletto needle	4	2.5 fens in width with tail like sword blade	Used for cutting open purulence
6	Round-sharp needle	1.6	With tip like hair, round and sharp	Used for treating sudden diseases
7	Filiform needles	3.6	Sharp like the rostrum of mosquitoes and gadflies	To be driven into the acupoint slowly, small enough to retain in the human body for longer; recuperation needed after its removal, used for treating arthritis
8	Long needle	7	Sharp and thin	Used for treating pains in locations difficult to reach
9	Big needle	4	Strong like a club, with a slightly round blade	Used for discharging water in the pivots

subordinate acupoints generates the same result, but that a certain acupoint must be taken. For example, "Large Intestine Meridian of Hand-Yangming" crosses the face, so deviation the eyes and mouth (facial paralysis) can be treated by administering acupuncture on this meridian. However, only acupuncture on "Hegu acupoint" belonging to the meridian has a significant therapeutic effect, while that on any other acupoint of the meridian should not be selected. In much the same vein, there is another example involving "Tsusanli" which is the acupuncture point specifically used in the treatment of gastrointestinal disorders. In ancient medical literature, mnemonic rhyme is used to clue on the unique therapeutic efficacy of these two acupoints: "Disorders in the stomach to be treated by acupuncture on Sanli and those in the eyes and face to be treated by acupuncture on Hegu." Modern scientific research has confirmed with infrared camera method that after acupuncture on Hegu, blood flow in the face increases and the temperature rises. Surgical study of acute abdomen reveals that in the case of gastric perforation and intestinal obstruction, long-time stimulation of Tsusanli with electric acupuncture can promote the enwrapping movement of the peritoneum toward the perforation site, or increase bowel movements, thus exempting patients from the ordeal of

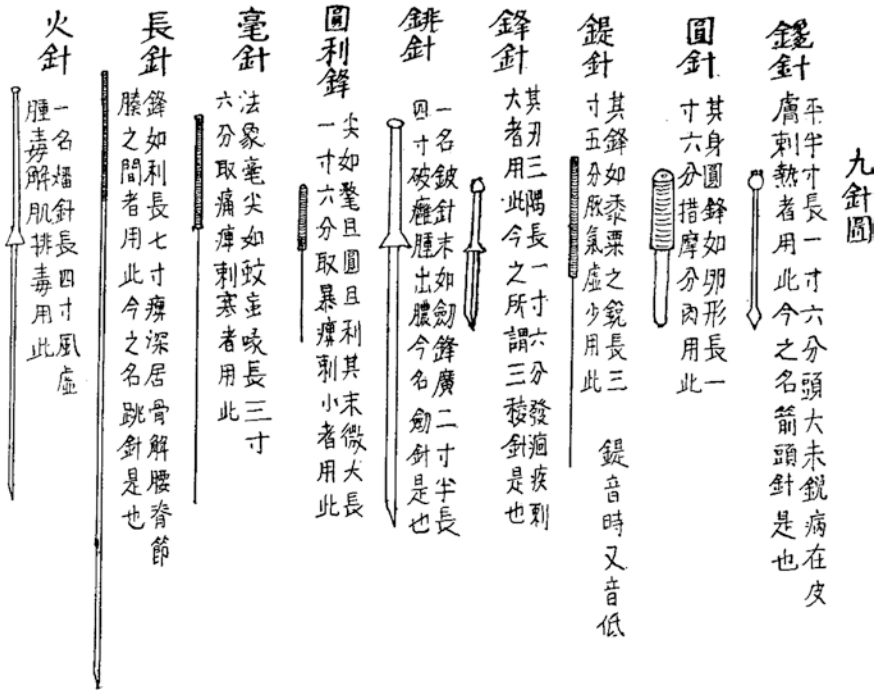


Fig. 29 Figure of the nine classical needles

surgery. However, relevant scientific research still cannot explain why acupuncture on Hegu increases facial blood flow or why acupuncture at Tsusanli causes movement in the gastrointestinal tract.

1.6.2 Prescriptions

Doctors use drugs in treatment of diseases in similar ways generals commanding soldiers to war. Therefore, the ancients have the saying "administering medication is like commanding troops." Both military commanding and medication have fantastic cases of "victory via one single valor," as well as examples of coordinated attacks (and disease conquest). Prescriptions involve multiple drugs have been hailed as "like Han Xin commands soldiers, the more the better." Flexible command is necessary for war, but it contains the basic tricks for formations; physicians need syndrome differentiation in treatment, but prescriptions have also to follow certain rules and guidelines. The formulas of drug combination established in accordance with a certain theory or time-tested experience are known as "prescriptions." Pills, powder, ointment, and balls made in accordance with these for vend are known as "prepared medicines." The list written by physicians via

referring to established formulas with additions and subtractions, according to which the patient goes to the pharmacy to buy the drugs, is called "prescription." Theories on how to combine medication, formulate the principle of prescription, analyze existing prescriptions, and flexibly use prescriptions constitute the medication principle, combined prescription or "Modern Prescriptions of Chinese Materia Medica."

"*The Yellow Emperor's Classic of Internal Medicine"* contains only a dozen simple and completely inapplicable primitive prescriptions (such as hair and bird feces), but harbors the three kinds of "prescription theories" still taught in traditional Chinese medicine today, namely the theory of monarch, minister, assistant and guide, that of seven-component prescription, and that of aroma co-ordination.

The theory of monarch, minister, assistant, and guide means that prescriptions are comprised of the monarch drug, i.e., herbs for the disease and the minister drug, i.e., complement drug and the guide drug, i.e., the drug that conveys the function of the monarch drug. This is related to the seven-component prescriptions, that is, a prescription could be a "small prescription" comprised of one monarch drug and two minister drugs, or a "medium prescription" comprised of one monarch drug, three minister drugs, and five assistant drugs, or a "big prescription" comprised of one monarch drug, three minister drugs, and nine assistant drugs. Because the number of drugs in one-monarch two-minister prescription is odd, there are "odd formulas"; accordingly, because the number of drugs in two-monarch four-minister prescriptions is even, there are "even formulas." There are also "acute prescriptions" with thick odors, "mild prescriptions" with faint odors, and double recipe used together.

These theories are not derived from the experience of actual treatment. For example, "even number of drugs should be avoided in dredging prescriptions," but Dachengqi Decoction, a purgative prescription recorded in "*Treatise on Febrile and Miscellaneous Diseases,*" consists of an even number of drugs. In addition, there is the saying, "where an odd number of drugs do not work, an even number of drugs would succeed." In this case, the differentiation between odd and even becomes meaningless. Moreover, "the drug echoing the minister medicine is called guide," which directs "the monarch drug directly to the site of a disease." In the three sections of citation above, the definition of "guide" is mentioned only once. This is not consistent with the commonly called interpretation. It should also be noted that the application of "guiding medicines" appeared in the Jin and Yuan Dynasties. Therefore, it can be safely concluded that both the theory of "monarch, minister, assistant, and guide" and the numbers of monarch, minister, and assistant drugs in "small, medium, and big prescriptions" or "odd and even formulas" are nothing but analogies of the human society and castles in the air. However, contemporary scholars believe this is the law based upon which *Treatise on Febrile and Miscellaneous Diseases* established the various formulas. For instance, "*Overview of Traditional Chinese Medicine*" has such analyses:

The components of Mahuang Decoction
Monarch—Chinese ephedra, inducing sweat and dispelling exogenous evils

Minister—cassia twig, helping Chinese ephedra induce sweat and dispel exogenous evils
Assistant—almond, helping Chinese ephedra prevent asthma
Guide—Radix liquiritiae, coordinating the various drugs
The components of Tiaowei Chengqi Decoction
Chinese rhubarb, monarch—clearing heat and purgation
Guide—entering the intestine and the stomach
Glauber salt, minister—salty and cold, softening hardness and moisturizing dryness
Radix liquiritiae, assistant, alleviating the purgatory effects of Chinese rhubarb and Glauber salt, boasting the function of adjusting the stomach and moisturizing dryness

In other words, the drugs composing a prescription, regardless how many, will be divided into the four categories of monarch, minister, assistant, and guide, and vice versa, that is, all the four categories must also have corresponding drugs, even it is only two or three drugs. Scholars with great attention to the objective facts of this theory would often refrain from outspoken attacks—that is, they would from directly negating it. In dealing with the development history of prescription theory, they may mention the "monarch, minister, assistant, and guide" in the modern version of "*The Yellow Emperor's Classic of Internal Medicine,"* but basically they acknowledge that real prescription theory and practical application dates back to the era later than the Song Dynasty. Only those with blind respect for ancients can give such a similar evaluation: that is, measured by the modern level of preparation for prescriptions, it is not inferior; in some cases, some modern formulations have not yet reached such a high level. Objectively speaking, the positive significance of this theory is to make people understand that in combined prescriptions, attention must be paid to the differentiation between primary and secondary drugs and mutual complementation.

The early pharmacology book "*Shen Nong's Herbal Classic-Descriptive Catalogue*" put forward the theory of "Harmony between the Seven Emotional Factors," which is often deemed as an important prescription theory. The so-called Harmony between the Seven Emotional Factors means that aside from "going alone" (independent uses), and a drug is usually in "mutual promotion, mutual reinforcement, mutual restraint, mutual inhibition, mutual antagonism, mutual detoxication" relationships with other drugs. Among them, mutual promotion and mutual reinforcement refer to the synergistic relationship between two drugs. Historically, there are some books under the name "*drug pairs"* specialized in research of coordinated use of two drugs. An important undertaking of contemporary prescription is to illustrate with the help of modern pharmacological research results that certain prescriptions are "quality pearls with scientific sense." Take the Peony and Licorice Decoction (or combination of peony and licorice) for example. This prescription first appeared in the "*Treatise on Febrile Diseases,"* and subsequent researches on widely used prescriptions have the following descriptions:

The peoniflorin contained in peony alleviates spasm and analysis has found that spasm alleviation is due to the direct effect on the smooth muscle. … In addition,

it has sedative, analgesic and anticonvulsant effects. It has demonstrated suppression of different parts of the central nervous system to varying degrees. Spasm relief is also found on the vascular smooth muscle, by expanding the peripheral vessels … Thus it slightly decreases the blood pressure. This is consistent with the extensive inhibition of the central nervous hub. It is often fairly effective in treating high blood pressure patients with obvious excitement symptoms due to insufficient ying and excessive yang (it also has coronary artery expanding, platelet aggregation inhibiting, anti-bacterial, anti-inflammatory, and liver function improving functions).

The main components of licorice are glycyrrhizin, glycyrrhetinic acid, a variety of flavonoids, and licorice glucoside. It has the adrenal cortex effect, papaverine-like antispasmodic effect, non-confrontational β receptor-like role, and analgesic, anti-ulcerantitussive, codeine, detoxification effects.

In the prescription for the treatment of musculoskeletal pain, the main components are peony saponins, licorice saponins, and peoniflorigenone, each with a separate mechanism. Studies have shown that this prescription can inhibit the ileum contraction caused by the excited sympathetic nerve, with peony for presynaptic inhibition and licorice postsynaptic inhibition.

Although the author also uses "sour–sweet herbs nourishing yin, nourishing liver and relaxing the tendon, harmonizing the nutrient Qi, and activating meridians" to explain why combined use of peony and licorice relieves spasm and pain, this interpretation is not convincing after all, because if the peony is replaced with ebony which is stronger in acidity, the prescription is suitable for the treatment of biliary ascariasis, or if it is replaced with sugar and vinegar to comply with the sour and sweet tastes, maybe it would be difficult to produce obvious "urgent relief" effects.

Thus, the two aspects of the combination of the basic theory and therapies of traditional Chinese medicine—the meridian theory and acupuncture therapy, drug theory and prescription—are in fact still shrouded in mystery. The research in active ingredients and their pharmacological effects not only illustrates the reason for licorice to be used in treating urgent diseases and various pains, but also clarifies the underlying reasons for the so-called coordinated effects. However, it cannot be explained why this high-quality pearl can be created at a time so ancient.

The main features of prescriptions since the Song Dynasty is classification according to the effectiveness, thus making "treatment methods" an important part of the prescription study, as demonstrated by "prescriptions in eight arrays" of Zhang Jingyue in the Ming Dynasty, and "*Collection of Prescriptions with Notes*" of Wang Ang in the Qing Dynasty. Treatment methods refer to "the eight methods," i.e., sweat, vomit, purge, harmonize, warm, clear, reinforce, and cancel.

1.6.3 Internal and External Treatment

Division is one of the important symbols of medical progress. According to historical records, medical division is first seen in "Rites of Zhou," which remarked that

palace doctors were divided into dietary doctor (in charge of diet), disease doctor (internal medicine), the ulcer medicine (surgery), and veterinary. The division is subdivided into nine in the Song Dynasty, ten in Jin Dynasty, and 13 in Yuan and Ming Dynasties. The medical division of the central government essentially reflects the objective situations of independent progress of the various branches in the certain eras. For instance, bone healing has always fallen under the scope of surgical treatment, but after Lin Daoren, the famed "founder of orthopedics in China," completed "*Secret Recipes of Treating Wounds and Bone Setting Taught by Celestials*" (in about AD 846), the fracture treatment principles including restitution, immobilization, and exercises were basically established. Subsequently, fracture treatment witnessed significant improvement. In the early Song Dynasty, "fracture (department)" can be found in the book "*Taiping Holy Prescriptions for Universal Relief*" edited by Wang Huaiyin. Accordingly, the imperial doctor bureau of the Song Dynasty reassigned ulcer to the "department of ulcer and fracture." In the Yuan Dynasty, it was explicitly stipulated that doctors must be proficient in at least one of the 13 medical divisions; otherwise, they shall not practice medicine.

However, the basic characteristics of the holistic view of the traditional Chinese medicine determine the relativity of the division. For example, internal and external treatments are administered simultaneously in orthopedics, thus accelerating the healing rate of wounds. In cases of the callus growth is slow due to poor physical conditions, the superiority of combining external and internal treatments in the treatment principles of traditional Chinese medicine is even more pronounced.

Second, "the surgical department" of traditional Chinese medicine is in fact mainly engaged in the treatment of sore carbuncle and other skin disorders and is devoid of the connotations of modern Western medicine—featuring surgical methods in treatment of diseases. After the Jin and Yuan Dynasties, the principle of combing external and internal treatments in surgical department is implemented in greater specificity and greater depth. Qi Dezhi, the imperial doctor of the Yuan Dynasty, integrated for the first time in his book *Essence of External Diseases* a variety of pulse phenomenon changes with the treatment of surgical disorders and adopted internal dispersion, internal expression, and other methods. Since then, the three principles of dispersion, expression, and reinforcement were basically established to treat external diseases. In the Qing Dynasty, the "life-saving manual school" represented by *Life-saving Manual of Diagnosis and Treatment of External Diseases* written by Wang Hongxu, and the "experience school" represented by "Experience Gained in Treating External Diseases" written by Gao Jinting has common characteristics, i.e., focusing on dialectical treatment of surgical diseases and combining internal and external treatments.

Thirdly, despite their respective characteristics, gynecology, pediatrics, department of stomatology, department of pharynx and larynx, and other subjects have no clear-cut boundaries with internal medicine. On the plus side, actually, gynecology of the modern Western medicine can only show the strengths of the surgical method in diagnosis and removal of tumors in the reproductive system,

while the traditional Chinese medicine has many advantages in treating functional gynecological diseases caused by autonomic nerve, endocrine system disorders with methods such as acupuncture, medicine, and other holistic therapy–which are diverse, effective, and long-lasting. However, on the other hand, over-reliance on drugs and over-emphasis on internal treatment also hinder the independent development of surgical therapies and obstetrics.

1.7 Knowledge About Drugs

All things used to treat the disease are not drugs. Needle-knife is an example. Items of non-medical purposes can be used as drugs. Gunpowder is an example. The wormwood used for moxibustion is seen as a tool, rather than a drug. However, many animals, plants, and minerals used on the surface of human bodies are called "external drugs." If gemstones are worn for health preservation purposes, should it be referred to as decoration or medicine? If things that are used for defense against diseases and that are wholesome are drugs, should umbrellas, clothing, houses, etc., count as drugs? As for "food" and "drugs," the boundary is even less clear. Therefore, "drug" is actually a very abstract concept which is difficult to define. However, the relatively independent and abstracted concept and knowledge system of "drugs" in common discourses is formed for the purpose of treating and preventing diseases and gradually developed in the process of trying to use a variety of substances.

Precisely because clothing, umbrellas, holding canes, bathing, etc., are wholesome, the ancient medical classics and contemporary traditional medicine of India contain relevant knowledge. Precisely because there is uncertainty in the relationship between "food" and "drug," we have the "food therapy" and "medicated diet." Precisely because in the opinion of the ancients, wearing a variety of substances can expel evils and cure diseases, people need to "orally take" some substances when evil Qi invades the body. Therefore, the Chinese character "服" has two meanings: "wear" and "eat," and "eat medication" is also known as "take in medication."

For example, in the early literature *Classic of Mountains and Rivers*, a book completed in the late Spring and Autumn Period to Han Dynasty, there can be seen many similar records, such as the skin of a certain animal can exempt people from insanity diseases when used for "seats"; "taking" some birds (wear their feathers) can be a protection against thunder. But there are more records such as "take" Shatang Tree, which is light in texture, can help people ride on water without drowning. In most cases, it is very difficult to tell whether "服" means "wear" or "eat." Therefore, a complex relationship was formed between "witchcraft" and "science" in the early process of knowledge development. Only by understanding the anthropological analysis methods can we tell from the theoretical level that theories of medical knowledge originating from "Shen Nong tasted a hundred herbs" are nothing but "legends."

Drugs used in traditional Chinese medicine include animals, plants, and minerals, and among them plants account for the largest proportion. Perhaps this is the reason for most pharmacological books of traditional Chinese medicine to be called "Ben Cao" (Materia Medica)—"Ben" means "root." In other words, the theory of "Ben Cao" is the ancient Chinese pharmacology, which records the name, properties, effects, major functions and origins of various drugs, as well as knowledge of picking, processing, and preservation. In the subsequent works of material medica, examples of application are also attached under the name of "attached prescriptions."

It is recorded in historical books that Zi Yi, a disciple of the famous pre-Qin doctor Bian Que, had written a book "Materia Medica" and that Chun Yuyi, a famous physician of the Western Han Dynasty got the book "Medicine Theory" from his teacher. However, the earliest extant catalog History of Han Dynasty-Yiwen Records does not include any book containing the words "Ben Cao" or any book dedicated to drugs. It is indeed mentioned in the explanation following the bibliography of "Medical Classics" that "Ben Cao" includes "tune one hundred drugs (prescriptions) and combine those complementary to each other." In the "classic prescriptions" like section, there is a record of Shennong and Huangdi Trying Forbidden Plants, and in the subsequent explanation, there is a saying "differentiating the five bitter and six spicy flavors." Obviously, those depictions are related to the knowledge of drugs. However, they are nowhere to be seen in the medical theoretical writings and prescriptions handed down, because the establishment of the "Ben Cao" theory and generation of "knowledge of drugs" are not the same issue. According to the records of the Book of Han, in the late Western Han Dynasty, there appeared posts of "Herbal Officials" and subsequently scholars proficient with Five Classics, calendar, and Materia Medica were summoned to the palace to write books and set up schools of thought. Those incidents indicate that at this time independent herbal medicine theory—pharmacology—has been gradually established.

1.8 Theories of Health Preservation

The purpose of medicine is to maintain health, which is also the objective of health-preserving techniques. Only from the perspective of the "goal congruence" can we find a justifiable reason to include in the scope of "traditional medicine" a variety of health-preserving techniques that are not directly related to the medical knowledge system. For example, the term "Qigong therapy" first appeared in 1934, while the vast majority of Chinese medicine practitioners neither mastered, nor used this therapy, and its theoretical doctrine and practicing ways were also relatively independent; "tea" becomes widely favored by the Chinese people, and one of the world's three major beverages, not because of its health-preserving function. Again, the people embrace the customs of taking red dates and red berries (haws) after giving birth, because those fruits have the function of enriching

the blood and promoting blood circulation. However, the vast majority of Chinese medicine practitioners know nothing about this "two reds decoction." Orthodox knowledge handed down tells them that after child birth, the mother should first drink Shenghua decoction made of Angelica, Chuanxiong, peach kernel, baked ginger, and other drugs, so as to activating blood circulation and dissipate blood stasis.

Therefore, whether it is from the perspective of ideology or that of the source and composition of knowledge and techniques, the "science of health preservation"—with its arsenal of physical and mental improvement methods—is linked to the three religions of Confucianism, Buddhism, and Taoism, and martial arts, cooking, folk, and so on. Of course, its close relationship to medicine is self-evident.

1.8.1 Taoist School and Health Preservation

The word "养生" (meaning health preservation) first appeared in the well-known Taoist classic "*Zhuang Zi.*" However, its original meaning is completely different from "health-preserving techniques aimed at improving health" as we are saying today. Firstly, *Neipian • Yangshengzhu* (Internal Chapter—Health Preserving), Duke WenHui came to be aware of ways of maintaining (governing) Health (people) after listening to Pao Ding, the cook, talking about how he "cut open oxen" for decades without blunting the knife used, by following the gaps between the muscle and bone. *Waipian-Dasheng* (External Chapter—Supreme Life) mentioned that rulers good at "nurturing (harnessing) lives (people)" are like a shepherd, who should always be ready to rush those lagging behind. Other examples include the following: Shan Bao set great store by health preservation but was devoured by a tiger, and Zhang Yi was careful with everything but eventually died of a disease. Those examples are used to illustrate the truth of "equal emphasis should be placed on internal and external factors and going to either extreme should be avoided." Therefore, Taoist "theory of health preservation" is a political theory, instead of commonly said "health-preserving techniques" aimed at the pursuit of health and longevity (Fig. 30).

Interestingly, "*Zhuang Zi*" cited as examples people who "do breathing exercises, exhale the stale and inhale the fresh, and do bio-inspired exercises" in the pursuit of longevity, criticizing them as going against the "natural law" of life and death, and judging their behavior as undesirable and "deliberate." But through the words of criticism, we can learn the fact that "people practice Taoyin and physical training" were an objective social existence back then—those people were pursuing longevity. After the dominance of Confucianism was established in the Han Dynasty, the Taoist political idea of "following the laws of nature" was maintained in the hearts of the rulers as "Confucian for external and Taoism for internal" on the one hand. On the other, it was transformed and interpreted as the pursuit of "health-preserving technique" for pursuit of health and longevity.

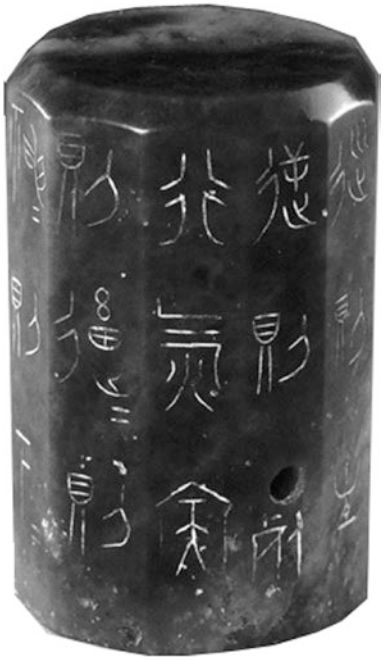


Fig. 30 Ancient Jade inscribed with methods for "Promoting the Circulation of Qi"

This device is a cane head, made of green Jade with gray and black hues. It is a dodecahedral prism 5.2 cm in height and 3.4 cm in width. Hollow but sealed at the top, it is used to sheathe a cane. The top is a circular plane, and the lower part of which is connected to the interior through a hole. All the prismatic surfaces are polished. On each of the twelve surfaces, three intaglio characters are inscribed from the top to the bottom. Plus the repetitious passage characters, the text consists of 45 characters in total, recording the essentials of "promoting the circulation of Qi." This is the earliest record of Qigong ever to be found in China, as well as the relatively early literature on ancient Chinese medical theory. Now, the cane head is kept in Tianjin Museum of History. The text reads as follows: "行气, 深则蓄, 蓄则伸, 伸则下, 下则定, 定则固, 固则萌, 萌则长, 长则退, 退则天 天几春在上, 地几春在下面则生, 逆则死." (While circulating Qi, send it downwards so as to store it. Once it is stored, it will go further downward to become lodged. After that, it will germinate, grow upward, and get free to the heaven, thus completing a cycle. The heavenly mechanism goes upward, while the earth mechanism goes downward. Following the rule will lead to (longer) life, while going against it will lead to death.)

Even Taoism which rises later on is the same. Although the saying "My fate is determined by myself, not by the heaven" from the first Taoist classic "*Taiping Jing*" (The Classic of Great Peace) has often been heralded as the Taoist motto concerning the life and health, in fact, the words are intended to say that Yama will "increase the quota" (elongate their lifespan on the *Life Book*) for people doing good deeds and for people who do bad things Yama will "deduct the quota"

(shorten their life span). Gradually the moral constraints faded, while the representative images of Alchemy Practice and cultivation of active substance in the body took over, accepting Taoist philosophy, upholding Lao Zi as the founder and *Daode Jing* (Moral Classic) as the sustaining classic.

1.8.2 Physical Cultivating Technique

How do people "conducting physical cultivating" mentioned in *Zhuang Zi* drill themselves? Summarize relevant content of medical books unearthed at Mawangdui, we can roughly obtain the following methods:

1. Bigu (abstain from eating cereals), Zhang liang, the prime minister of Han Dynasty, retired into the remote mountains to practice Bigu after helping Liu Bang seize state power. *Eliminating grain and eating vapor* unearthed at Mawangdui introduced the specific method of Bigu and the conditioning method for discomfort resultant from Bigu. The former requires action in accordance with the moon phases, i.e., "refraining from cereal and eating pyrrosia lingua only" from the first day of the lunar month, and gradually increasing the amount of pyrrosia lingua until the full moon, after which decreasing its amount by the day. When feeling "heavy headedness and light footedness," the exerciser should add breathing exercises for cultivation. Because people practicing Bigu still eat a certain plant and conduct "breathing exercises," Bigu also has the features of "eating Qi" and "taking foods."
2. Qi eating refers to respiration in accordance with a certain method to achieve the purpose of health preservation. Its theoretical basis is that the "Qi" is the essence of heaven and earth and people attaining Qi can get their lifespan lengthened although the birth, growth, and culmination of Qi are formless and cannot be observed, while those lose it will dire. Therefore, deep breaths are emphasized so that the essence of heaven and earth can reach every nook and cranny of the entire body.
3. Food taking is richest in content. In the silk texts unearthed in Mawangdui, there are sayings like "eating fresh pine and cypress, and drinking Springs where beasts drink can produce rejuvenating effects and lend luster to the skin," "in the summer months cooking with the sun can make one acute and wise," "Eating Allium bakeri in the spring months can expel diseases and strengthen the bones; thus Allium bakeri are the king of Herbs"; it is advisable to drink mellow wine before bedtime, because it is "the essence of the grains," and so on.
4. Daoyin (literally induction, physical, and breathing exercises) refers to exercise of the body for the purpose of dispelling diseases and improving health. Therefore, it is heralded as a medical sport. The *Daoyin Diagram* unearthed at Mawangdui depicts a variety of human postures, with marginal illustrations of "steering away deafness," "steering away knee ache," "bear stretch," "smoothing ying and yang with the help a cane," etc. The diagram accords

with the record that "people practice Taoyin and physical training" were enthusiastic about bear and bird extensions in *Zhuang Zi · External Articles · Will Tempering* (Fig. 31).

5. Jieyin refers to the achievement by men of longevity through certain sexual practices. "*Ten Questions*" records different schools of theory for obtaining longevity, among which six mentioned Jieyin. From this we can see that great importance is attached to it in the health preservation science. Of the six schools, Peng Zu is the only school advocating complete abstinence to avoid "male essence leakage" which causes diseases. The other five are focused on the relationship between sexual behavior and longevity. The main points are as follows: (1) Do not ejaculate. "Be sure to avoid ejaculation; in this way the diseases cannot emerge, thus leading to longer life span;" (2) In the process of sexual intercourse, "absorption" (intake of yin to reinforce yang) to achieve the purpose of replenishing. The technique of Jieyin is completely different from "ways of foreplay" illustrated in *Conjugation of Yin and Yang* and *The Supreme Way under the Heaven*. In those books, "ways of foreplay" deal with the sexual art, in which men and women are on a completely equal footing, and the coordinated orgasm of the two parties is emphasized. In contrast, in Jieyin, men occupy the central position, while women are only tools. Like the "food" in "food taking" and "Qi" in "Qi eating", women are a resource of replenishing material for men. In addition, in the silk books such as *Health-Preserving Prescriptions* and *Miscellaneous Prescriptions*, there are many treatments for treating "erection dysfunction in the elderly" with drugs, reflecting the close relationship between the concept of "elderly" and sexual function.

Strictly speaking, in dealing with these unearthed materials, we should not only take into consideration the close inheritance relationship between their content and pre-Qin culture, but also their impossibility to include the culture of early Western Han Dynasty due to the fact that they were buried in 168 BC. Even so, there are no traces of influence from Taoist theory of mental convalesce in the various methods of "health preservation." The Taoist name of "physical training" indeed aptly grasped the essence of the method of these health preservation methods. Their theoretical core is aimed taking external materials for the benefit of their own health. Therefore, we can only say that the health science back then was still in the early

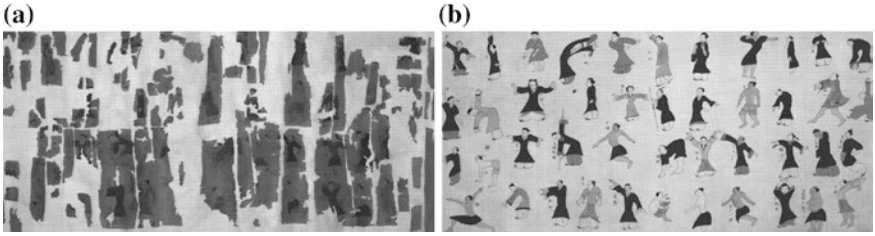


Fig. 31 *Daoyin Diagram* unearthed in Mawangdui. **a** Originally, one of the silk books unearthed at Mawangdui in Changsha, Hunan Province in 1973; the diagram was named by archeologists *Daoyin Diagram* in accordance with its content, **b** is the restituted figure

stage featuring "life" (longevity). However, the method of "Qi eating" is especially worthy of attention: Exhale the stale and inhale the fresh (renewal) are the natural instinct of all lives to maintain survival. As far as humans are concerned, there are two ways of "renewal"—eating and breathing. Invisible "Qi," "Qi" from the heaven and "Qi" encompassing the space between the heaven and the earth are the indispensable "Qi" sustaining life forms. They have given the ancients unlimited reverie. The concept of "Qi" is integrated into the system of philosophical thought, and medicine, as well as health-preserving theories. By inhaling the essence of the Qi between heaven and earth, people learned to enrich their own "vitality," which not only helps them keep fit, but also earn them the super powers of splitting bricks and stones. Though different in form, hard and soft can both be summed up as "Qigong."

In addition, there is one point particularly worth noting: The *Guidance Book*, unearthed in the Han Dynasty Tomb in Zhangjiashan, Jiangling, Hubei Province, is of the same era as the medical books of Mawangdui. In it we can see operational practices like "lower-jaw joint reset." This means that in the minds of people of that time, the exact definition of "guidance" should be the treatment of diseases by movement (including active and passive). *The "Five-animal Play*" created by Hua Tuo in the Three Kingdoms Period are completely in line with the concept of guiding technique.

The so-called five-animal play refers to exercises in imitation of the acts of tigers, deer, bears, apes, and birds to exercise the body, while those activities also betray influences from the theory of five elements (Table 6; Figs. 32 and 33).

1.8.3 Cultivation of Nature and Life

In English, there is a motto "A sound mind in a sound body." It means that a healthy mind can only be contained in a healthy body. From this perspective, attention to physical health is of primary importance. In the process of its development, health preservation in China since ancient times has on the one hand sought physical fitness through the cultivation of "Qi," dietary recuperation, and physical exercises, and on the other hand combined the spiritual realm of Taoism "tranquil nothingness" with the art of "physical training." The result is a health-preserving philosophy of dual cultivation of nature and life. Ji Kang from the Kingdom of Wei during the Three Kingdoms Period remarked in his *On Health Preservation*:

The gentlemen know that the form relies on the spirit to stand, and spirit owes its existence to the form. Therefore, they would cultivate their nature for the subsistence of their spirit and set their mind at peace to achieve physical health. In addition, they conduct respiratory exercises to exhale the stale and inhale the fresh, and eat proper food for health preservation. In this way, they achieve harmony between form and spirit and mutual complementation between the inner and outer self.

Those words can be deemed as a model of clear definition for the term "health preservation." In the subsequent 1,000 years, although the specific pattern of

Table 6 The relation of the five animals to the five elements and the five viscera

The five elements	Wood	Fire	Earth	Metal	Water
The five animals	Deer	Ape	Bear	Crane	Tiger
The five viscera	Liver	Heart	Spleen	Lung	Kidney

Fig. 32 Five-animal play, the physical training method invented by Hua Tuo, is still widely popular as of now

Fig. 33 Physical training

"physical training" was repeatedly changed, and the theory of "spiritual nurturing" took in Buddhist philosophy, the principle of "Cultivation of Nature and Life" remained the ultimate truth.

1.8.4 Qigong and Dietetic Therapy

Traditional health preserving methods acknowledged by contemporary Chinese medicine and incorporated into its own knowledge system, and widely applied are Qigong and dietetic therapy. Qigong: guided circulation of Qi and Zen meditation were integrated to form "Qigong", a means for cultivation of nature and life. Wang Songling, a Qigong history researcher, remarked, "In recent years, we found that some of the larger sects, such as Wudang and Emei, had claimed to have lasted for thousands of years. However, it is quite difficult to explore their history, especially the history of their styles, because they are handed down through oral tradition, without specific written records (including the style and history)."

Zhang Lu, a physician of Qing Dynasty, remarked in his book *Zhang's Clear View of Medicine—Obsession*: There are cases of Buddhist followers becoming obsessed with meditation, and Taoist disciples going to far in practicing Qi exercise, but upon studying all the medicine books and prescriptions I have found no one mentioning ways of treatment. From this remark we can understand the close relationship of Buddhism and Taoism to Qigong. The fact that physicians are ignorant of this tells the alienation between the two. After the 1950s, China has set up three Qigong sanatorium to train Qigong physicians and popularize Qigong therapy through "offering courses". Subsequently, Qi was included in "The Research Plan of Medical Science in the Next 12 Years"; China Association of Traditional Chinese Medicine established Qigong Science Research Council; some hospitals set up Qigong Divisions, and some universities established Qigong Departments, offering post-graduate programs or using modern scientific methods to investigate the "external Qi" phenomenon of Qigong. The most popular among the people is Taijiquan, which combines "external training of the tendons and bone (body movement) and "internally training of breathing" (adjust circulation of Qi).

Dietetic Therapy: Foods and medicines are mainly natural plants and animals, and there is no clear boundary between foods and medicines. Each type of natural materials has the property of being cold and hot, warm and cool, and the function of reinforcing and reducing, lifting, and subduing. Now that "nothing in the world is not a drug," dietetic therapy becomes a matter of course. However, in recent years, dietetic therapy and "healthy diet" knowledge in people's real life are mostly modern scientific knowledge, such as olive oil reduces blood fat; vegetables are rich in vitamins and fiber; wine softens blood vessels; and seafood are beneficial for brain development. On the other hand, traditional "Drug Diet" is more commercial speculation and cultural experience than dietetic therapy. If one of those days, the Beijing roast duck, Simmering Lamb Hotpot, Sichuan hotpot and Cantonese seafood are awarded with introduction of "therapeutic" functions, can we say that traditional medicine has been succeeded and carried forward in an unprecedented degree?

2 Lecture 2 TCM Classics and Celebrated Masters

2.1 Classics Overview

There are a tremendous amount of TCM works, but only a few of them are deemed as classics. When were these classic works completed? It is really a difficult question to answer, because records about the time when these classic works were completed are different, more critically is that the time when the book came out is entirely different from the time when the book became a classic. What is the value of these classics? This question also has completely different answers—someone thinks that classics are always unchangeable rules for learning and using traditional Chinese medicine; but someone else thinks that it is not necessary so and if only one learns textbooks, such as *Essentials of TCM* well, one can grasp

the essentials and become an excellent TCM doctor. As for the general situation of TCM works and relevant classics as well as the above-mentioned different opinions concerning values of classics, I think the followings should be explained (Figs. 34 and 35).

2.1.1 About "Quantity" and "Quality" of TCM Works

Table 7 cited the writing and recording of several bibliographies, from which we can easily see that there are actually quite a lot of ancient medial works; if we check for local chronicles, the so-called medical works compiled and housed by squires and literati of various regions are even too numerous to mention one by one. There are so many medical works completed by literati through copying and recording predecessors' old treatises and selectively compiling prescriptions because medical science is only a practical technique (for treating diseases of all people, including emperor, the relatives of emperor and the destitute, as well as making people healthier), but an important way for Confucians to cognize the nature ("one aspect of studying the phenomena of nature for a thorough inquiry into the innate laws of things"). Meanwhile, it is just because even in terms of records in booklists of history books written in biographical style, although book names and authors are different, there exist a great amount of medical works which contain repeated contents and have no new ideas. Consequently, a few works featuring new ideas and acting as basis for extraction in the history stand out and become classic works acknowledged by people at all times.

2.1.2 How to Think of Disappearance of Ancient Books

It is frequently seen that experts in medical literature lament over disappearance of ancient books. But seeing it from the standpoint of evolutionary historical

Fig. 34 A Glimpse of abundant classics

Fig. 35 Ivory sculpture showing filial piety "Among the three unfilialities, childlessness is supreme." "The filial son should restrain his sorrows so as to ensure a decent funeral for his parents." "The filial son should refrain from climbing high mountains and venturous undertakings." (so as to avoid injury). Those are an incarnation of the initial connotations of filiality—emphasis on the continuity of the family name. Later, they gradually transformed into properly supporting of and obedience to the elder generations. Accordingly, "A filial son knowing medical knowledge" became the ideal and pursuit of intellectuals

perspective, it is another matter. Because disappearance of ancient books is not only a negative outcome of fire, havoc, turmoil caused by war or moths, but also reflects the active aspect that works composed after such books had already absorbed their essences and thus such books became obsolete. For example, although *Sheng Nong's Herbal Classic* of the Han Dynasty disappeared, but its essences had been included in *Annotation of Shen Nong's Herbal Classic*

Table 7 Writing and recording of TCM works

Bibliography works	Medical works	Total volumes
Han Shu · Yi Wen Zhi	36 (schools)	868
Sui Shu · Jing Ji Zhi	256 (books)	4,510
Jiu Tang Shu · Jing Ji Zhi	136 (schools)	3,962
Xin Tang Shu · Yi Wen Zhi	120 (books)	4,416
Song Shi · Yi Wen Zhi	509 (books)	3,327
Ming Shi · Yi Wen Zhi	73 (books)	1,164
Qing Shi Gao · Yi Wen Zhi	251 (books)	1,532
Song Yi Qian Yi Ji Kao	1,883	?
Zhong Guo Yi Ji Kao	2,607	?

compiled by Tao Hung-jing of the Southern Dynasties; later *Annotation of Shen Nong 's Herbal Classic* also disappeared, with essences of its contents being integrated into *Xin Xiu Ben Cao* of the Tang Dynasty; later works concerning Chinese herbal medicine such as *Zheng Lei* of the Song Dynasty and *Gang Mu* of the Ming Dynasty absorbed the essence of old books and supplemented new ideas, seeing increasing large scale. Thus, pervious pharmaceutical knowledge was fully inherited. Therefore, if we look at the phenomenon by regarding traditional Chinese medicine as a science, disappearance of ancient books is not a "loss," but a normal law of knowledge systems enduring constant sublation and innovation. Of course, if we see the issue from a perspective of historical research and desiring to view the original appearance of literature, it should be regarded as another matter (Figs. 36, 37, 38 and 39).

Fig. 36 Remnant paper of annotation of Shen Nong's Herbal Classic unearthed from Dunhuang

Fig. 37 Remnant paper of annotation of Shen Nong ‘s Herbal Classic of Dunhuang Housed by Ryukoku University of Japan

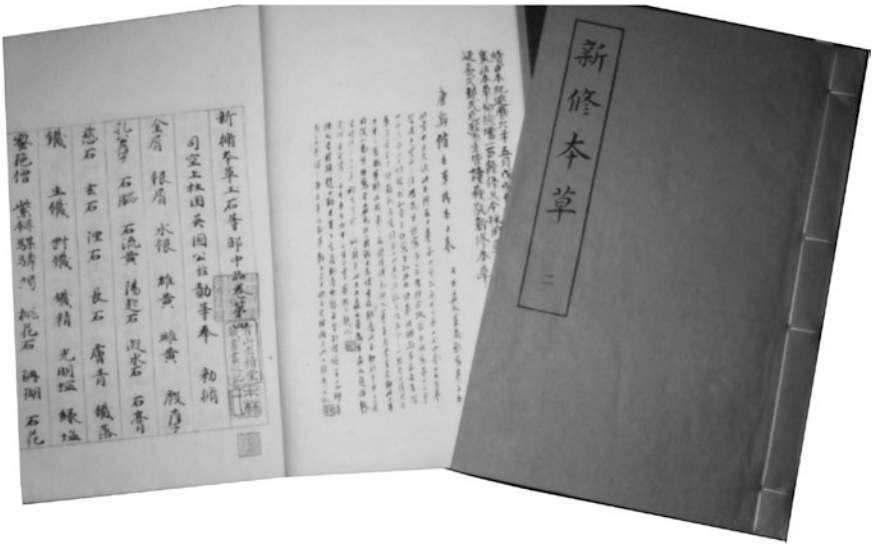


Fig. 38 Xin Xiu Ben Cao (newly revised Materia Medica) of the Tang Dynasty

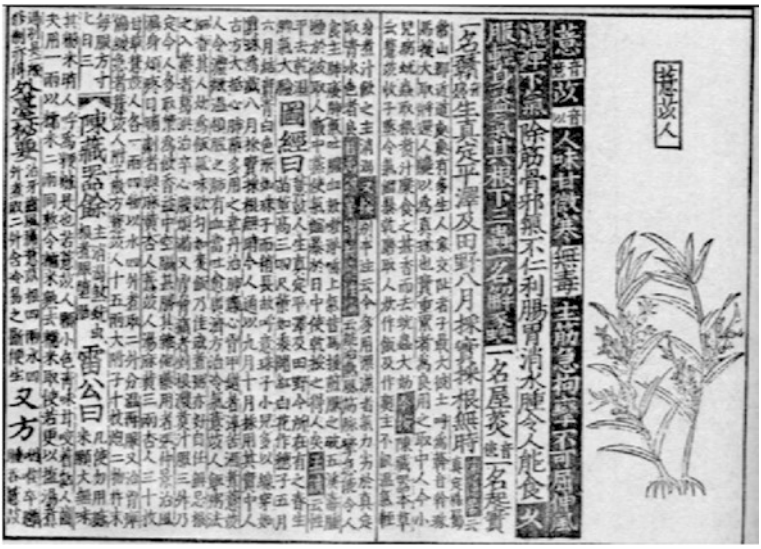


Fig. 39 *Zheng Lei Ben Cao* of the Song Dynasty It features wide adoption of essences of various books and use of different fonts (such as black lettering on white background and white lettering on black background, big character, and small character) for, respectively, indicating different origins of the contents

2.1.3 How to Think of Value of Classics

Classics boast everlasting values. The classics of TCM, first, just like classics in other fields such as literature, religion, and even cultural relics, have everlasting historical and cultural values; second, their unique theories and practical values are still in use up to now, besides, if we do not get ready for thoroughly giving up such medical knowledge and techniques of treatment, we will never be completely disconnected from its unique theoretical frame and treatment style. This is why we hold "learning traditional Chinese medicine should start from classic works."

But on the other hand, those think learning traditional Chinese medicine through textbooks represented by *Essentials of TCM* are also right. Because such textbooks do not deviate from what is said in the classic works, they just delete trivial and repeated contents in form and make the contents more clear and concise in terms of forms. Such work did not exist in ancient times. For example, Huang-fu Mi of the Western Jin Dynasty, the author of *Zhen Jiu Jia Yi Jing* (*Classic of the ABC's of Acupuncture and Moxibustion*), the first extant work dealing exclusively with science of acupuncture and moxibustion recognized by the field of Traditional Chinese Medicine, stated the compiling rules in the preface of this book: due to classics of previous generations such as *The Yellow Emperor's Classic of Internal Medicine* featuring "too much statement and too little know-how," therefore "deleting unnecessary qualifiers and repeated contents, just discussing the essences." Then, why ancient people could do it and people today

can't? What the ancient conducted meant developed, contributed to, and provided meritorious services to the medicine, so why did we consider people doing the same thing today eliminated, broke and committed crime to it? Consequently, if we esteem every word in classics as right and absolute truth without demonstration, then it is safe to say that we are learning knowledge without really understanding them or we are just like frogs in a well.

2.1.4 About Classics and Masterpieces of Later Generations

The idea "four classics" is popular in TCM industry and the reason behind it is yet to be clear. In 1958, the first *Essentials of TCM* Part Two consists of *Introduction to Canon of Internal Medicine*, *Introduction to Treatise On Febrile Diseases*, *Introduction to Jin Kui,* and *Introduction to Epidemic Febrile Disease*. Since its contents belong to "selected readings of classics," so maybe we can call them as "four classics." However, *Treatise on Febrile Diseases* and *Jin Kui Yao Lue* were originally works of Zhang Zhongjing, a famous doctor of Han Dynasty; no works concerning "doctrine of epidemic febrile disease" formed in the late Ming Dynasty and Qing Dynasty was exactly deemed as "a classic." Other works clearly boasting "classic" position were not demonstrated in it. Thus, we often see that the following four works were named as "four great classics": (1)*The Yellow Emperor's Classic of Internal Medicine* is the earliest classic works that has been existed today; (2) It is rumored that *Nan Jing* was composed by Bian Que, a famous doctor of the Pre-Qin Period; (3) *Treatise on Febrile and Miscellaneous Diseases*, composed by Zhang Zhongjing, a well-known doctor in the late Eastern Han Dynasty, is the first works containing theory, method, formula, and herbs; (4) *Sheng Nong's Herbal Classic*, the earliest extant pharmacopoeia in Chinese history, was completed in the Eastern Han Dynasty (Fig. 40).

Besides, there are also some post-Han classic works that cannot be ignored, such as *Mai Jing* (Pulse Classic), the first works concerning sphygmology completed in Western Jin Dynasty and *Zhen Jiu Jia Yi Jing* (Classic of the ABC's of Acupuncture and Moxibustion), a monograph on science of acupuncture and moxibustion, *Zhu Bing Yuan Hou Lun* (*General Treatise on Causes and Manifestations of All Diseases*), a monograph on symptoms completed in the Sui Dynasty, *Qian Jin Fang,* and *Wai Tai Mi Yao* (Medical Secrets of an Official), two medical formularies of the Tang Dynasty as well as representative books of the four famous doctors in Jin and Yuan Dynasties and outstanding doctors of medical school of epidemic febrile disease of Ming and Qing Dynasties. We will respectively discuss the so-called four great classics as follows, and masterpieces of later generations will be introduced together with relevant representatives.

1. Current version of The Yellow Emperor's Classic of Internal Medicine

The Yellow Emperor's Classic of Internal Medicine, the earliest extant and the most important TCM classic in Chinese history, has always been considered that it was completed in pre-Qin period. This final conclusion once again became an

Fig. 40 Cover, content, and first page of body of *Zhu Bing Yuan Hou Lun* (general treatise on causes and manifestations of all diseases)

issue after a great amount of silk manuscripts and bamboo slips concerning medical works were unearthed from Mawangdui, Hunan in 1973. This is because from theories and technical levels, we can judge the medical books unearthed from Mawangdui were completed earlier than The Yellow Emperor's Classic of Internal Medicine, besides, from the direct relevance of certain contents, we can see there is a relation of inheritance and development between them. Therefore, this batch of medical works unearthed from a tomb of Western Han Dynasty of 168 BC becomes the most valuable data and direct evidence for studying the up-limit of era when The Yellow Emperor's Classic of Internal Medicine was completed. Well, can we consider that medical works unearthed from Mawangdui were completed in a period earlier than the pre-Qin period? If such a possibility exists, the historical final conclusion that The Yellow Emperor's Classic of Internal Medicine was completed in the pre-Qin period will not be impacted. To make clear of this issue, I'll have to talk a little more about it (Table 8).

The earliest "bibliography" of China was *Qi Lue* completed by Liu Xiang and Liu Xin (father and son) in the late of Western Han Dynasty. The original version had already disappeared for many years but its basic contents were

Table 8 Classification properties of medical works unearthed from Mawangdui

Qi Lue "Fang Ji Lue"	Medical works unearthed from Mawangdui
Medical classic	Zu Bi Shi Yi Mai Jiu Jing (silk manuscripts) Yin Yang Shi Yi Mai Jiu Jing (silk manuscripts) Mai Fa (silk manuscripts) Yin Yang Mai Si Hou (silk manuscripts)
Classical prescription	Wu Shi Er Bing Fang (silk manuscripts) Tai Chan Shu (silk manuscripts) Za Jin Fang (wood manuscripts)
Sex instruction	Shi Wen (bamboo manuscripts) He Yin Yang (bamboo manuscripts) Tian Xia Zhi Dao Tan (bamboo manuscripts) Que Gu Shi Qi (silk manuscripts)
Immortal	Yin Dao Tu (silk manuscripts) Yang Sheng Fang (silk manuscripts) Za Liao Fang (silk manuscripts)

kept in *Hanshu Yiwenzhi* (History of Han Dynasty—Treatise on Literature). Of which, "Fang Ji Lue" recorded four categories of works concerning medical treatment and longevity—medical classic, classical prescription, immortal, and sex instruction. The so-called medical classics refer to theoretical works concerning medicine. Unearthed medical works named as *Zu Bi Shi Yi Mai Jiu Jing*, *Yin Yang Shi Yi Mai Jiu Jing*, *Mai Fa,* and *Yin Yang Mai Si Hou* by excavators which concern channels and collaterals of human body and methods of diagnosis by feeling the pulse fit into this category; as for *Qi Lue*, it contains *The Yellow Emperor's Classic of Internal Medicine*, *Inner Canon of Bian Que*, and *Inner Canon of Bai Shi*, totaled 216 volumes in 7 categories. "Classical prescription" refers to pharmaceutical formulation for treating diseases. *Wu Shi Er Bing Fang*, a medical book unearthed from Mawangdui, is a classical prescription, while *Qi Lue* included 274 volumes, 11 categories of works of classical prescriptions for treating various diseases such as "Bi," "Shan," and "Dan" of five viscera, and six entrails as well as trauma, gynecology, pediatrics, and dietotherapy. *Shi Wen*, *He Yin Yang*, medical books unearthed from Mawangdui are works belonging to "immortal" and "sexual instructions" called by later generations, which instruct people how to Bigu (not eating food), eating, Daoying, and other methods of for gaining longevity, or "sexual knowledge" which is beneficial to health and love between each other. As human sexuality is no longer only for producing offspring, it acts a part of cultural and spiritual life, constituting one element of harmonious relations between the two genders. Therefore, appearance of works concerning "sex instructions" is also a profile-marking advance in civilization.

It's just because the 14 categories of medical works unearthed from Mawadui buried as funeral objects together with kings, princes, and aristocrats of the Western Han Dynasty covered four aspects of "Fang Ji Lue" of Qi Lue as a whole, it is more appropriate to deem it as a demonstration of actual situations of medicine back then, instead of antiques completed several hundreds of years ago compared to time point back then (Fig. 41).

Besides, the view that *Su Wen* and *Ling Shu,* respectively, contained 9 volumes and 81 articles (formerly known as *Zhen Jing* or *Jiu Juan*) were exactly "eighteen volumes of The *Yellow Emperor's Classic of Internal Medicine*" recorded in *Qi Lue* was just conjecture of Huang-fu Mi of the Western Jin Dynasty. Therefore, we cannot determine when the two works were completed or when was the lower limit of period when The *Yellow Emperor's Classic of Internal Medicine* of the version handed down was completed. Considering that several dozens of medical works recorded in *Qi Lue* have already completely disappeared today, and even seeking for a little direct citation from works of later generations is very difficult, we have no reason to think that "18 Volumes of *The Yellow Emperor's Classic of Internal Medicine*" recorded in it could be perfectly and separately reserved. Actually, other complete works handed down were all completed after Eastern Han Dynasty. Second, by seriously summing up relations of "Articles" and "Volumes" in *Qi Lue*, we can find out that there was no phenomenon of "accumulating articles into volumes" back then; therefore,

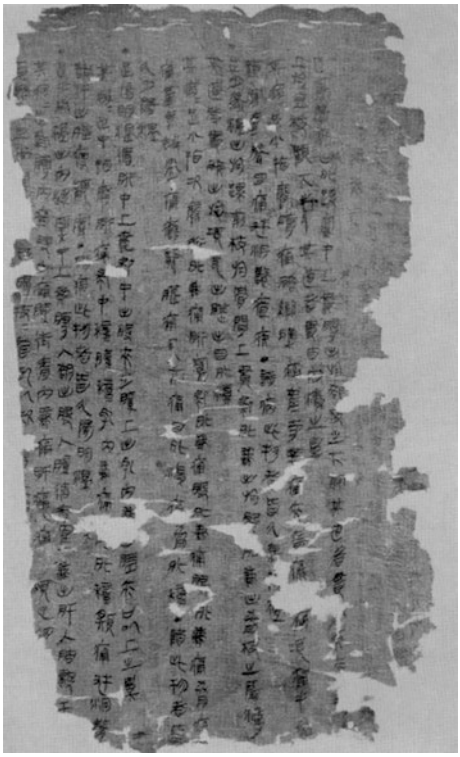


Fig. 41 *Yin Yang Shi Yi Mai Jiu Jing*, a medical works unearthed from Mawangdui

18 volumes of *"The Yellow Emperor's Classic of Internal Medicine"* in *Qi Lue* were actually 18 articles. Bibliographies of past dynasties had always separately recorded *Su Wen* and *Ling Shu* as two separate works; thus, we will find out that conscientious historians had not accepted Huang-fu Mi's ungrounded speculation. All in all, we cannot consider the lower limit of period when the handed down *The Yellow Emperor's Classic of Internal Medicine* was completed later than *Qi Lue* just because *Qi Lue* recorded the name of *The Yellow Emperor's Classic of Internal Medicine*. In the late Western Han Dynasty, Wang Mang seized political power of the Han Dynasty. He had successively for two times widely built houses and recruited scholars boasting professional skills to come to the capital for writing books and establishing theories and demanded them to unify different ideas. From the characteristics that *Su Wen* and *Ling Shu* were both collections of medical thesis and featured obvious tendency of "unifying different ideas", it was highly possible that there existed close relations between them and such historical background. However, considering setting the record straight as well as the ideas that have already been popular around the world, it is best to call *Su Wen* and *Ling Shu* as "Current version of *The Yellow Emperor's Classic of Internal Medicine*" (Fig. 42).

Fig. 42 *Wu Shi Er Bing Fang* unearthed from Mawangdui

Content component and similarity and differences of *Su Wen* and *Ling Shu* may be appropriately generalized into the following points:

(a) The majority of articles and chapters of the two books were written in an answer-and-question format and showed a little difference in academic views due to different responders. For example, people were divided into five categories of Jin, Mu, Shui, Huo, and Tu based on five-element theory, or divided into Tai Yang, Shao Yang, Tai Yin, Shao Yin, and Yin Yang He Ping according to yin–yang theory. Although people were divided into "five categories" by both books, the basis was different, demonstrating their basic property of "thesis compilation."

(b) It is generally acknowledged that words in *Ling Shu* were easy and simple and guessed that *Ling Shu* should have been completed after *Su Wen;* however, the phenomenon can be seen that the latter cited words in the former. This is actually because both of the two books referred to and absorbed some contents of the same original documents. Table 9 takes two paragraphs, respectively, from *Su Wen* and *Ling Shu* as examples to explain how the two books separately

Table 9 Examples of quotation and explanation of original scriptures in *Su Wen* and *Ling Shu*

Original scriptures	*Ling Shu · Xiao Zhen Jie*	*Shu Wen · Zhen Jie Pian*
Any doctors using acupuncture should Xu Ze Shi Zhi, Man Ze Xie Zhi, Yun Chen Ze Chu Zhi, Xie Sheng Ze Xu Zhi, … Yan Shi Yu Xu, Ruo You Ruo Wu	The so-called Xu Ze Shi Zhi means those suffering weak Qikou pulse should be made stronger through reinforcing Qi and blood "Man Ze Xie Zhi" means those suffering strong Qikou pulse should be treated with measures of purging Qi "Yun Chen Ze Chu Zhi" means eliminating blood stasis for dredging the channels and collaterals of Qi and blood vessels "Xie Sheng Ze Xu Zhi" means in case of a vigorous channel, measures of eliminating its pathogenic factors should be adopted …… "Yan Shi Yu Xu, Ruo You Ruo Wu" means appearance of collaterals featuring blood stasis has Qi, while the phenomenon of no collaterals featuring blood stasis has no Qi	"Xu Ze Shi Zhi" means that treating asthenia syndrome with acupuncture should adopt reinforcing method and the surrounding areas of the acupuncture points will have heat effects, because enriched healthy atmosphere will generate heat "Man Er Xie Zhi" means for treating vigorous pathogenic factors, acupuncture reduction manipulation should be adopted. And the surrounding areas of the acupuncture points will have cool effects because pathogenic factors are removed; thus, the surrounding areas of the acupuncture points will be cool "Yun Chen Ze Chu Zhi" means eliminating blood stasis for dredging the channels and collaterals of Qi and blood "Xie Sheng Ze Xu Zhi" means not pressing and closing the pinhole for escape of pathogens after pulling out the needle …… "Yan Shi Yu Xu" means the basis for "excess" and "deficiency" referring to, upon the arrival of Qi, the amount of cool effects and heat effects upon the surrounding areas of the acupuncture points; "Ruo You Ruo Wu" means after adoption of acupuncture method, channel Qi comes quickly without having been detected
……	……	……

gave different explanations to the paragraph of original document concerning "deficiency, excess, and reinforcing and reducing methods" of acupuncture therapy. While this paragraph of "original scriptures" appeared in *Jiu Zhen Shi Er Yuan*, the first article of *Ling Shu* without annotation. However, even this paragraph of elucidated "original scriptures" also featured obvious higher theoretical level than medical works unearthed from Mawangdui due to mentioning "deficiency, excess, reinforcing, and reducing methods," let alone medical works unearthed from Mawangdui talking only about moxibustion without mentioning acupuncture therapy.

(c) In aspect of contents, *Su Wen* deals with more doctrines concerning yin–yang, nourishing of life in four seasons, Zang-Fu, and channels as well as other theories regarding human body's physiology and pathology, while *Ling Shu* mainly deals with acupuncture and moxibustion therapy. Both the books seldom deal with specific methods of pharmacotherapy, just on relations of matching and belonging between Zang-Fu and food and drink as well as drugs based on five-element philosophy.

2. *Huang Di Ba Shi Yi Nan Jing*

Huang Di Ba Shi Yi Nan Jing had different names in historical documents. No matter whether it is called as *Ba Shi Yi Wen*, *Ba Shi Yi Nan*, or named after Huang Di (Yellow Emperor), or "Jing" (scriptures), its actual contents are about "Wen" (questions), and "Nan" (difficult problems). Because this work called as Nan Jing for short was composed in a question-and-answer pattern. It is said in the past that this book was completed by Qin Yueren (Bianque), which was only traced back to the Sui and Tang Dynasties to the earliest time, such as *Huang Di Ba Shi Yi Nan Jing Xu* written by Wang Bo, a talent of the Tang Dynasty, and *Ji Zhu Nan Jing Xu* composed by Doctor Yang Xuancao. Just as the conclusion made by Okanisi Tameto, a famous medical historian, author of *Nan Jing* was considered to be Huang Di by people of pre-Sui period, while to be Qin Yueren by people of post-Tang period. However, it is basically acknowledged in the academic circles that this book was completed in the Eastern Han Dynasty, for which the main basis was that *Qi Lue*, a bibliography completed in the late Western Han Dynasty, did not record it and it was first mentioned in the preface to *Treatise on Febrile and Miscellaneous Diseases* composed by Zhang Zhongjing of Eastern Han Dynasty and Lv Guang of the Three Kingdoms Period had already written comments on it.

The 81 questions designed in *Nan Jing* concern such six aspects as main and collateral channels, Zang-Fu, diseases, acupuncture points, and acupuncture therapy. Although methods of feeling the pulse, properties of diseases, acupuncture therapy were included in the book, such methods did not belong to specific measures for diagnosing or treating a specific disease, but some general cognition and theoretical research concerning such aspects. Apart from inferior length of articles, *Nan Jing* also has the following main difference compared to *The Yellow Emperor's Classic of Internal Medicine*: It does not summarize "yin and yang are the rule of heaven and earth" as in *The Yellow Emperor's Classic of Internal Medicine*; and in it yin–yang and five-element philosophies are not separate;

and it is not a convergence of thesis of many authors. Instead, it combines Yuan Qi, yin–yang, and five-element philosophy to use in pulse diagnosis, channels, Zang-Fu, syndromes, acupuncture points, and acupuncture therapy consistently so as to build a theoretical frame which broke away from experiential knowledge but became more perfect. For example, it talked about that there were 10 changes of pulse because of solid and soft (yin and yang) changes due to impacts of five pathogenic factors (five elements): $5 \times 2 = 10$; in terms of acupuncture points and acupuncture therapy, there were only five acupuncture points for each channel which were, respectively, named as Jing, Xing, Shu, Jing, and He and properties of metal, wood, water, fire, and earth; the five acupuncture points of various channels were arranged in an order of inter-promotion among five elements; channels featuring yin–yang correlation present a relationship of inter-inhibition between their acupuncture points with the same names (Table 10). When treating diseases, it is just choose the acupuncture points according to the theory of inter-promotion and inter-inhibition of five elements. This is "Five Acupuncture Points" which were endowed with such special properties since *Nan Jing* and still occupy an important position in contemporary science of acupuncture and moxibustion (Fig. 43).

3. *Sheng Nong's Herbal Classic*

In China, there is a legend of "Shennong tasted hundreds of plants and met seventy poisonous ones in one day," which originally meant identifying whether the plants are edible, i.e., the reason why "Sheng Nong Shi" was called "Nong." However, since *Huai Nan Zi* of Han Dynasty called it is the origin of knowledge of drugs, Sheng Nong has become the originator of knowledge of drugs. Besides, because we only replace the sage (Sheng Nong) with "the mass of working people," the mode of obtaining experiential knowledge by the process of "tasting poisoned drug awareness" is consistent with historical materialism; therefore, this legend is still widely cited up to now (Figs. 44 and 45).

As this is followed a chapter specially discussing "drugs" in the article, it is OK for us to just know that the classic in this field is *Sheng Nong's Herbal Classic*. Most ancient scholars believed that it is a remainder of book burning conducted in Qin Dynasty. However, according to the fact that many names of places of Eastern Han Dynasty were seen in it and the independent and special time coordinate formed by pharmacology, we can infer that it is completed in Eastern Han Dynasty. The *Sheng Nong's Herbal Classic* seen today is modern edition of the lost version, and the later generations could edit and restore it because most important works concerning Chinese herbal medicine of past dynasties deemed it as a classics passed down from the ancient times and cited a great amount of texts from it. According to these records, we can know that *Sheng Nong's Herbal Classic* records 365 entries on medicaments, which fall into three grades based on quality. Taking the top grade drugs for a long time, one can gain vigor and extend life; drugs of middle grade and lowest grade feature increasing functions of treating diseases and toxicity; thus, it is not inadvisable to take more of them or take them for a long time. The record of each drug generally contains drug name, property and flavor, major functions, place of origin, another name, etc.

Table 10 Relations between "five acupuncture points" and yin–yang and five elements

Five acupuncture points	Jing	Rong	Shu	Jing	He
Properties of five elements	Yang Jing: wood	Fire	Earth	Metal	Water
	Yin Jing: metal	Water	Wood	Fire	Earth
Attachment of "five seasons"	Acupuncturing Jing in spring	Acupuncturing Rong in summer	Acupuncturing Shu in the last month of summer	Acupuncturing Jing in autumn	Acupuncturing He in winter

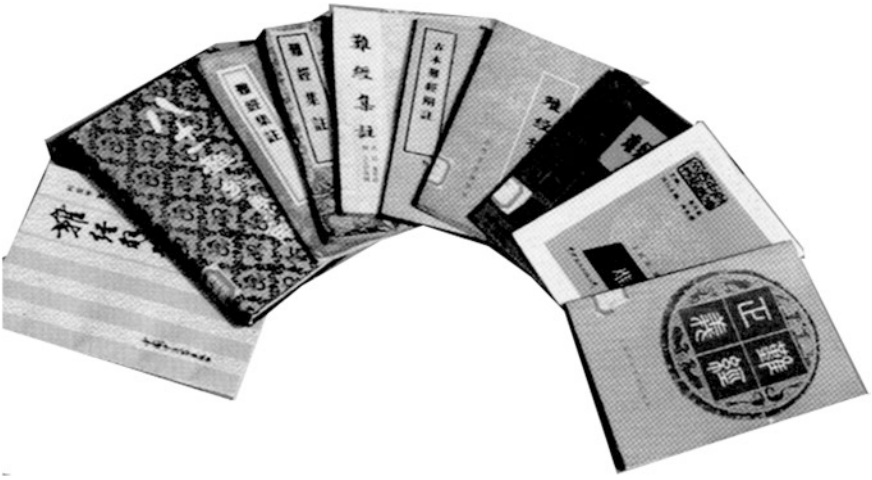


Fig. 43 Several annotated copies of *Nan Jing* of modern carving version

4. *Treatise on Febrile and Miscellaneous Diseases*

"Febrile disease" in terms of traditional Chinese medicine is different from typhoid fever, a modern disease name caused by typhoid bacillus in modern medicine. As a disease name, it can be understand in a broad and a narrow sense, respectively. Febrile disease in a broad sense refers to all exogenous diseases, an example was that "There are five kinds of exogenous diseases" mentioned in *Nan Jing*. This is because ancient TCM theories of disease causation think that "all diseases can be attributed to three reasons"—although diseases appear differently, they are caused by the following three factors: external "six evils" (wind evil, cold evil, summer heat, dampness evil, dryness evil, and fire evil); internal causes, including improper diet, overstrain, and unbalanced seven human emotions (joy, anger, anxiety, thought, sadness, fear, and surprise); or accidental injury caused by weapons, worms, or beasts. While among the five febrile diseases (stroke, typhoid

Fig. 44 Portrait of Sheng Nong

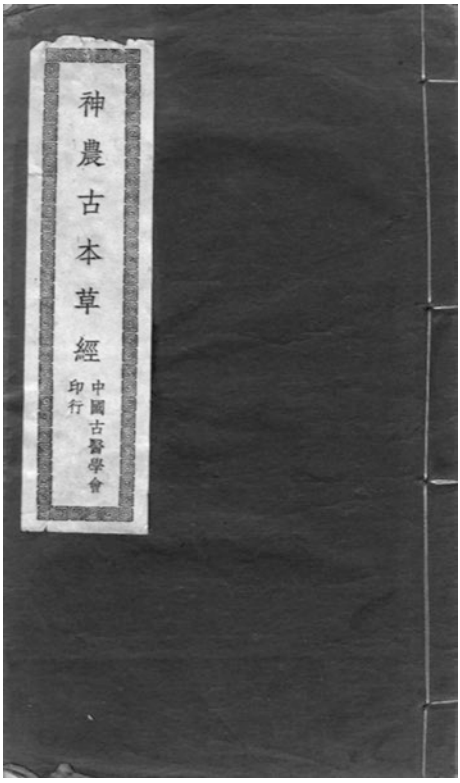


Fig. 45 *Sheng Nong's Herbal Classic*, version of collecting scattered the classic works in the Republic of China

fever, damp-warm syndrome, fever, and warm disease), the one(s) caused by "cold evil" was (were) defined a narrow sense (Fig. 46).

Treatise on Febrile and Miscellaneous Diseases completed in the late Eastern Han Dynasty, just as the title suggests, included drug therapies for diseases caused by external and internal factors. In aspect of treating diseases caused by "external infection" (typhoid fever), this book makes a distinction between progression, property of diseases and corresponding therapeutic principles, and specific prescription based on the six concepts of "three yin and three yang." For example, diseases on the body surface are "Tai Yang disease," their cardinal symptoms are fever, aversion to cold, headache, etc. Patient suffering no sweat should be treated with "ephedra decoction" for sweating. Those sweating patients should take "cassia twig decoction." In some cases, the two prescriptions can be used together; those in poor health may take such prescription with ginseng. After taking the medicine, the patient should eat hot porridge for supporting the efficacy of the medicine. If the patient suffers diseases caused by external infection, but he (she) does not have a fever and has a weak pulse as well as just wants to sleep, then the patient suffers a "Shao Yin disease." Correspondingly, the patient should take ginseng, monkshood, and other drugs for "reviving yang for resuscitation"—saving "yang-Qi" which is going to decrease and extinct. Actually, even Western medicine doctors with certain clinical practical experience will likely to understand such words when reading them. The former is the symptoms of most

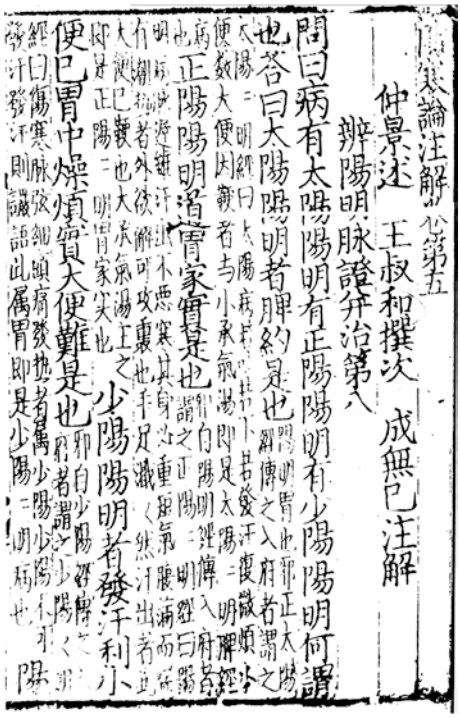


Fig. 46 *Treatise on febrile diseases* of the Yuan Dynasty version

cold sufferers, and they will recover just only by taking aspirin or other antipyretic analgesics, while the latter belongs to "septic shock" suffered by the old and the weak, in such a circumstance, aspirin certainly no longer applies.

It is just because *Treatise on Febrile and Miscellaneous Diseases* includes complete contents from theories to therapeutic principles and prescriptions in aspect of treating exogenous diseases; it is attached great importance by doctors of later generations. Wang Shuhe, an imperial doctor in the Western Jin Dynasty, separated out such contents, which account for 50 % of total contents of the book and compiled them into a book titled *Treatise On Febrile Diseases*; the remaining contents concerning treatment of miscellaneous diseases gradually evolved into *Jin Kui Yao Lue* and were handed down.

5. "Becoming a book" and "becoming a classic"

Through the above basic introduction to TCM classics, we should be able to see that these classics were not completed as early as described by ancient people or modern works on medical history. These books were basically completed in Eastern Han Dynasty based on absorption of medical knowledge of pre-Western Han Dynasty. As a result, when observing development history of Chinese traditional medicine, the first era worthy of special attention should be the period of Western and Eastern Han Dynasties featuring stable society, prosperous culture, medicine, and knowledge of other fields supplementing each other and enjoying common development.

If we think about whether there were only such a few important medical works or there were many of them back then? The answer should be the latter. Then, apart from accidental factors, which inevitable factors had influenced circulation of the few works which finally became classics? First of all, a certain scale was very important. At a certain time point, works reaching the scale and level of "great achievement" will surely have survival advantages and meanwhile makes many original works included by it retreated from their historical stage. For example, *Su Wen* and *Ling Shu* which constitute *The Yellow Emperor's Classic of Internal Medicine* did not meet requirements of "systematization," but they featured gigantic length and rich contents, and we can affirm that they contained works of Bian Que and other doctors recorded in *Qi Lue* as well as contents of *Tang Ye Jing Fa*, *Huang Di Shen Nong Shi Jin,* and other works. It is more evident that "Nine Articles of *Jiu Zhen*" repeatedly mentioned faded from people's memory after having evolved and been noted into 81 articles of *Ling Shu*. Similarly, when Huang-fu Mi of the Western Jin Dynasty adopted the theory of channels related to acupuncture and moxibustion therapy in *The Yellow Emperor's Classic of Internal Medicine* and *Huang Di Ming Tang Jing* detailing locating the acupuncture points, major functions, and depth of acupuncture and compiled them into *Zhen Jiu Jia Yi Jing* (*Classic of the ABC's of Acupuncture and Moxibustion*), the first extant work dealing exclusively with science of acupuncture and moxibustion, later, *Huang Di Ming Jing Tang* completed in the Eastern Han Dynasty lost the possibility of becoming a "classic"; *Sheng Nong's Herbal Classic* also lost its separate existence due to people of later generations including it into their own

herbal works. Looking at the problem from this standpoint, it is completely unnecessary for us to feel pity for disappearance of a great number of medical works of ancient times. The same sentence: Those died surely because there were reasons for them to die.

Second: Theoretical definition and systematization are also very important. *Nan Jing* is not long but it put forward many important theoretical concepts which also became systems. *The Yellow Emperor's Classic of Internal Medicine* holds that "yin–yang" is the philosophy of heaven and earth, parents of changes, essence of living or death; *Nan Jing* put forward that the concept of "Ming Men" was the origin of life vitality, such concepts all provide wide space for role of the later generations. Therefore, the times when *The Yellow Emperor's Classic of Internal Medicine* and *Nan Jing* were completed are not as early as we have ever imaged, but their academic value as classics are not influenced at all. In recent 2,000 years, based on the above two classics, doctors have been learning how Qi and blood run through channels, what kind of functions various Zang-Fu have and other basic theoretical knowledge, understanding yin–yang and five-element philosophy and other philosophical thought's specific application in life knowledge, analyzing pathogeny, pathogenesis, and building new theories based on elucidating sages' sublime words with deep meaning so as to continuously enrich concrete contents of traditional Chinese medicine and make it enjoy development.

Let us look at the question how to "become a classic." The fundamental reason of these works becoming classics is undoubtedly the "potential" they have. But excavation and recognition of the potential has no direct relations with the time when the book was completed. For example, *Wai Tai Mi Yao*, a great works compiled by Doctor Wang Tao of the Tang Dynasty, did not mention Zhang Zhongjing in theories of "Zhu Lun Shang Han Ba Jia" of Volume 1 at all, and we can only see "Zhang Zhongjing's *Treatise On Febrile Diseases*" cited in the part of extracting treatment prescriptions, and it had the same position as *Fan Wang*, *Shen Shi*, *Xiao Pin*, *Lu Yan,* and other medical formularies popular back then; Sun Simiao had the same opinion of him. Therefore, it is said in the preface when medical literature correction office of the Northern Song Dynasty corrected this book that since this book was completed 800 years ago, only Wang Shuhe knew its value. Therefore, the historical appearance of *Treatise on Febrile Diseases* becoming a classic was since the Song Dynasty, with improvement of doctors' theoretical levels, it was increasingly valued by doctors and was studied by them from different perspectives. Through order of arrangement and annotation of articles, and elucidating and discussing step by step basic concepts such as yin–yang, exterior and interior, chill and fever, and deficiency and excess, thus enable the specific methods of differentiating pathological process and disease location based on "three yin and three yang" to be raised to the theoretical altitude of "syndrome differentiation of six channels." Therefore, the position of *Treatise on Febrile Diseases* gradually changed to "Confucian classics" from "medical formulary"; Zhang Zhongjing himself began to be called as "the Second Sage" and was finally addressed respectfully as "medical sage" (Fig. 47).

Fig. 47 Annotated copy of *The Yellow Emperor's Classic of Internal Medicine · Su Wen* composed by Wang Bing, Tang Dynasty

The time when *The Yellow Emperor's Classic of Internal Medicine* was thought highly of by doctors is earlier than the time when *Treatise on Febrile Diseases* was paid attention to. Annotating *Su Wen* started from Quan Yuanqi, living between Qi and Liang of Southern Dynasties, and the most famous was the secondary annotation written by Wang Bing of Tang Dynasty; annotation of *Ling Shu* did not appear until the Ming Dynasty. After the forerunner of Ma Shi, Zhang Zhicong, a doctor of Qing Dynasty, called dozens of people together to discuss knowledge at Lv Shan Tang. It took them 5 years to, respectively, complete the Variorum of the two books, which could be called the creation of collective work. Representative works concerning recompilation of the two books in a form of "books arranged according to subjects" were *Huang Di Nei Jing Tai Su* glossed by Yang Shangshan which was completed before Tang Dynasty and *Lei Jing* by Zhang Jingyue, a great doctor of Ming Dynasty. Both of the books were categorized by She Sheng (absorbing nutrients needed by the life), yin–yang, Zang-Fu, syndrome, etc., demonstrating the pursuit of building systems. Grasping the main contents and deleting trivial contents showed that the author was brave enough to develop the useful and discard the useless of classics, as well as the manifestation of the phenomenon that medicine in Ming Dynasty returning from plenty to briefness and simplicity became a fashion. *Nei Jing Zhi Yao* by Li Zhongzi has only Volume One

and Volume Two, which truly boasts the effect of grasping its main contents and retaining only the essence. Thus, it remains to be a book favored by doctors up to today.

Although *Nan Jing* had annotations long ago, it was called *Ba Shi Yi Wen* yet by some doctors during the period of Sui and Tang Dynasties. Similarly, after Northern Song Dynasty, it enjoyed a sharp promotion of position and became a classic enjoying equal popularity with *The Yellow Emperor's Classic of Internal Medicine*. Later, under the influence of textual criticism and explanations of words in ancient books of Qing Dynasty, in the medical circles, the extreme example that editing and restoring books such as *Sheng Nong's Herbal Classic* which were no longer necessarily exist separately and featured only literature significance (Fig. 48).

From the external factor, completion and becoming classics of these works all have close relations with "Confucian doctors." First, from the author's perspective, 162 papers from different authors contained in *The Yellow Emperor's Classic of Internal Medicine* show that their authors were absolutely not craftsman-type doctors who lived on practical skills in terms of writing levels or cultural literacy, but just the generally called "Confucian doctors." This point is underlined because application and impact of Confucianism could be obviously seen in the process of development and systemization of medical theories of Western and Eastern Han Dynasties. Although in the whole ancient society, "Confucians knowing medicine" is a very common phenomenon, but these Confucian doctor authors were not general Confucians who knew medicine. First, what they concerned was not social order ("courtesy") which constituted knowledge of Confucian learning, but a philosophical cosmology functioning as tools of "arguing" and "reasoning things

Fig. 48 *Huang Di Nei Jing Tai Su* written by Yang Shangshan of Sui Dynasty, in which contents of *The Yellow Emperor's Classic of Internal Medicine* were recompiled in a form of category. It is an important documentary studying contents and texts of early edition of *The Yellow Emperor's Classic of Internal Medicine* that exists today

out." Second, although general Confucians were not strangers to medical theories (including physiology, pathology, therapy, and pharmacology), they always utilized such simple principles known to everyone at the cultural level to comment on politics and national affairs ("Super doctors treat with country"), while on the contrary, Confucian doctors used yin–yang and five elements and other ultimate truth and theory that man is an integral part of nature and even military strategists' doctrines and other major principles to the medicine, which was "looked down upon by gentlemen." In a sense, it is just because of such Confucian doctors, various necromancers' doctrines which "consider themselves always right" and treatment experience described in *The Yellow Emperor's Classic of Internal Medicine* could be integrated into systematized theoretical systems and consequently decided basic nature and characteristics of traditional Chinese medicine. This feature reached extremes in Nan Jing. During the historical period following the Western and Eastern Han Dynasties, the study of medicine was characterized by re-compilation of literature and recollection of books about prescriptions due to different social morals and cultural pursuit. In the Song Dynasty, following popularity of education was naturally crowded official career, and after Song Dynasty, there appeared many "Confucian doctors" who "became excellent doctors instead of being outstanding officials," or actually speaking, they had no hope to become an official and had to work as a doctor, while in the world of ideas, new Confucianism (a Confucian school of idealist philosophy of the Song and Ming Dynasties) integrated speculative features of Taoism and Buddhism was established; therefore, study of medical theories continuously received much attention.

In spite of someone thinking that these books titled with Huang Di, Bian Que, and Shennong also had some impacts on these works becoming classics, but actually it was not very important. Because there were many works named with such names, but such works were not handed down for this reason. Instead, it is worth noting that scholars' psychological need for abstract "academic idol" hidden behind the mentality of "idolizing ancients and *Jing*." Mankind generally has psychological need of "idolizing." All imaginary gods, ancient sages, clay sculpture of Bodhisattva, and alive idols all have functions of meeting mankind's such psychological need. While in the knowledge area of traditional medicine, icons "created" by later generations not only include medical sages such as Bian Que, Hua Tuo, and Zhang Zhongjing, but a most charming abstract icon—"ancient scholarism." However, what is the inevitable outcome of "idolizing the ancient" was that scholars lost self-confidence—they seemed never to be brave enough to image: I'm able to create new and better theoretical doctrines or practical skills. In their view, ancient medicine has been a perfect "completed system" since it was established and had no possibility of development; all new things were nothing but a process of "enlightenment." Realization of this process was either because impartment of "enlightened" ancestors, or due to the person's own power of understanding—understanding "sublime words with deep meaning" of ancient sages, i.e., secrets hidden in the classics and specific application methods. On this track of academic development, although new knowledge constantly emerges, it would not be deemed as critique of old theories and systems, but just "elucidation." With

such realization, we will subsequently realize "idolizing ancients" and "restoring ancient ways" were both just a kind of mentality. Besides, the outcome of the recycling process was continuously increasing brilliance and feature of "ancient academics" that worth worship.

In a word, TCM classics are just like antique porcelain—continuously appreciate with time lapsing; and the reason of appreciation has no relations with "practical values." Just like in real life, what people use are all more beautiful porcelain with better quality made by absorbing ancient technologies, what absorbed by traditional Chinese medicine from classics are actually also some basic nutrients of philosophical thinking. New-style teaching material *Essentials of TCM* revised in 1959 deleted all the original contents "Neijing Overview, Typhoid Fever Overview, Jin Kui Overview, Warm Disease Overview" of the second volume. It is just because the essence of the classics had already been promoted as "Outline." Therefore, TCM classics were not so much quite like antiques "as" they "were" antiques.

2.2 Elegant Demeanor of Famous Doctors

How doctors becoming famous and popular is a very complicated problem. It is always very hard for clinical doctors boasting skills of bringing the dying back to life to make their mark in history. Those mentioned by historians were those wrote books which were handed down, or whose lifetime had relations with politics and influential officials, or whose argumentation concerned other fields. While in modern times, the doctors becoming famous were always because their medical ideas or techniques of treatment contain contents which could be deemed as "elements of science," such as Hua Tuo's "anesthesia and operation," Song Ci's "forensic medicine," and Wang Qingren's "anatomy."

2.2.1 Bian Que and Qin Yueren

While giving accounts of issues concerning treating emperors' diseases and making figures of speech to politics with medicine, various documentaries would naturally mention names of some doctors. But doctors of pre-Qin period accounted in biography were only Bian Que.

Sima Qian considered that Bian Que was the founder of prescription; therefore, he adopted various schools for writing a Biography for him. He said Bian Que's family name was Qin, and his first name was Yueren. When he managed guest houses when he was young, he was imparted knowledge by a person of extraordinary talents. Thus, he could see people through walls and diseases in the human body. Later, he traveled to various places and adapted himself to local customs. In Handan, he heard that people valued women; thus, he became a doctor engaged in gynecology; when he passed Luoyang, he saw local people respect the old; thus,

he mainly treated diseases such as faded eyes and deaf ears; when he entered into Xianyang, he knew that the Qin people paid much attention to children; thus, he called himself a pediatrician. Li Xi, an imperial doctor of Qin, envied his talents and sent someone to assassinate him; thus, the famous doctor died an unnatural death.

For demonstrating Bian Que's advanced medical techniques, Sima Qian recorded the following three cases. The first one was that Zhao Jianzi, a senior official of Jin State, suddenly fell unconscious, when everybody lost their head, Bian Que diagnosed that he would naturally wake up in 3 days, and later, Zhao really woke up in 3 days; the second case was that the prince of Guo State "died of a sudden disease," when all the people were busy with making funeral arrangements, Bian Que recommended himself to treat his illness, which aroused a horse laugh. But after he took measures such as acupuncture and moxibustion and managed to make the prince take medicine, the prince woke up; the third case was that he looked Marquis Qi (a nobleman of Qi State) far into the distance for several times and knew that Marquis Qi was sick and the disease continuously went deep into his body. But Marquis Qi was deaf to his advice, and finally, his disease was not curable and he died (Fig. 49).

Because the three cases occurred from the Spring and Autumn Period to the Warring States with the time spanning over several hundred years, it has always been a problem perplexing historians. The comparatively reasonable explanation should be Bian Que and Qin Yueren were not the same person, the former was living in the late Spring and Autumn Period, and he was a medical official of Zhao Fu (the residence of an noble surnamed Zhao), while the latter was a folk doctor living in the middle Warring States. While Sima Qian was compiling *The*

Fig. 49 Stone relief of Han Dynasty modern scholars explained its content as "Picture of Bian Que Treating Disease with Acupuncture"

Biography of Bian Que, he first adopted the faithful historical account of Bian Que diagnosing Zhao Jianzi recorded by history official of Zhao Jia; remade the two fables of *Looking Disease of Marquis Huan of Cai in a Distance* recorded in *Han Fei Zi · Yu Lao* and *Diagnosing Corpse-like Syncope Suffered by Prince of Guo* in *Han Shi Wai Zhuan* which not only made the time coordinate of the fable story move backward, but made Bian Que of the Spring and Autumn Period link up with Qin Yueren of the Warring States. According to The Biography of Bian Que, "He was a doctor in Qi State or in Zhao State where he was named Bian Que," (Note: not "when in Zhao State") laying bare Sima Qian was quite clear in his heart what he described were actually two Bian Que! (Figs. 50 and 51)

For such a The Biography of Bian Que featuring mixture of true history and story, how should we interpret it? First, the significance of making clear of that Bian Que and Qin Yueren being two persons living in different periods and having different status as an official and a common citizen, respectively, rests with understanding two features of impartment of professional techniques in early times: One was that knowledge demonstrated by different statuses as an official and a folk doctor gradually transited from "academics and education controlled by government" to the folk, which was just the time feature of Spring and Autumn Periods as well as Warring States Periods. The second was inheritance of "name and assumed name," although data of such aspect lacked in Chinese historical records, but similar cases existed in our neighboring countries can inspire our thinking over this problem. For example, some ancient medical books of India were successively completed by the teacher and the pupil, or the pupil continued to use the teacher's name, consequently, later generations had to use twenty-first generation and twenty-second generation for indicating their difference. This tradition was pushed to its full development in Japan, for example, Manase Dousan

Fig. 50 Statue of Bian Que on Yao Wang Mountain in Yao County, Shaanxi

Fig. 51 "Fu Weng," a legendary famous doctor of Han Dynasty It is recorded in *History of the Later Han Dynasty*: "At beginning, an old man, nobody knew where he was from, always fished at Fu Shui (today's Wujiang River), hence the name Fu Weng. He made a living in the countryside. When he saw patients, he would treat the patients with acupuncture and stone needle and it always worked immediately. He composed *Zhen Jing*, *Zhen Mai Fa*, which were handed down. His pupil Cheng Gao looked for and sought for him for many years, and finally Weng imparted medical techniques to him. Cheng Gao also hid his tracks and didn't seek office." Su Wen and Ling Shu both repeatedly mentioned *Zhen Jing* and *Jiu Zhen;* therefore, it is not absurd to consider that before completion of Su Wen and Ling Shu, there was another work called *Zhen Jing*

(1507–1594), a famous doctor of the sixteenth century, gave his family name, first name, style, and assumed name, and "Yuan Hao" unique for the most advanced monk to his son, son-in-law, best student, respectively, for them to separately inherit and use; thus, later generations had no way to judge who wrote the book by the author's name. Therefore, some scholars think that "Bian Que" was a title for excellent doctors back then. Furthermore, the three cases in The Biography of Bian Que all reflected the meaning of "outstanding doctors know the patient's condition when he observes changes of the patient's facial color and gloss (or even observe over the wall)." When Zhao Jianzi was unconscious, Bian Que found he was suffering obliterated operation of blood and channels by observing his condition from his body; when the prince of Guo State "died of a sudden disease," Bian Que discovered that he was just suffering corpse-like syncope by watching him over the palace wall; when Marquis Huan of Cai (or Marquis Huan of Qi) did not feel any discomfort, Bian Que had already observed that he was not only ill, but his disease spread from his "skin" to "blood vessels," "intestines and stomach," and "bone marrow" with passage of time. Han Fei Zi make up the fable that

Marquis Huan of Cai did not take the doctor's advice on treating his disease and Bian Que no longer gave him advice but ran away when he was incurable, his purpose was, just as mentioned in the first part of this book, "explaining the principle of administering state affairs with principles of medical science"—warning key political leaders to listen to expostulation of loyal officials (doctors of the society) for solving problems as early as possible. While in medical domain, miracle and importance of "observing the patient's complexion, tongue, expression, behavior, etc.," had already been mentioned in "diagnosis theory" in this book; *The Yellow Emperor's Classic of Internal Medicine* praised "outstanding doctors know the patient's conditions when they observe changes of the patient's facial color and gloss" are "gods," and those know the patient's conditions by feeling the pulse are only "skilled"; so did Sima Qian. He said Bian Que felt the pulse was just for deceiving the public.

2.2.2 Zhang Zhongjing and Hua Tuo

Western Han Dynasty and Eastern Han Dynasty had lasted for 400 years. There were a total of three doctors in this period for whom we can know their lifetime. One is Chunyu Yi, a doctor of Western Han Dynasty accounted in *Shi Ji · Cang Gong Zhuan*. His clinical data of 25 patients were praised as the earliest "medical cases" existed today; the other two doctors are Zhang Zhongjing and Hua Tuo who lived in the late Eastern Han Dynasty. Chunyu Yi knew medical knowledge, but he was reluctant to treat patients because his master Gongcheng Yangqing was unwilling to let later generations know that he understood medical knowledge; Hua Tuo took pride in knowing multiple Confucian classics and was ashamed of treating diseases; all these were decided by the values that doctors were deemed as one of the "humble occupations." Therefore, if Zhang Zhongjing really "served as the prefecture chief of Changsha," then it is absolutely impossible that he would engage himself in curative activity which would bring disgrace to his reputation and integrity. But in those times, it is very common that officials' home had various medical works titled "housed prescriptions of XXs home." Although Zhang Zhongjing and Hua Tuo were deemed as representatives of physicians and surgeons, respectively, actually, the two of them had many things in common. However, in medical domain, Zhang Zhongjing was reputed as "medical sage," while Hua Tuo was denounced as a heresy who rebelled against orthodoxy; however, among the public, Hua Tuo was more famous than Zhang Zhongjing (Fig. 52).

Zhang Zhongjing was born in Nanyang prefecture (the area it governs is today's Nanyang of Henan), and he approximately lived from the middle of the second century to the beginning of the third century. In documentaries of pre-Tang period, only the name "Zhang Zhongjing" was recorded; until Lin Yi et al. corrected *Treatise on Febrile Diseases* in Song Dynasty, the sentence of *Biography of Famous Doctors* of Tang Dynasty was cited which said that he was named Ji and his first name was "Zhongjing"; also said that he "was elected as Xiao Lian (a

Fig. 52 Modern portrait of Zhang Zhongjing

talent who shows filial obedience to parents and boasts integrity) and served as the prefecture chief of Changsha," etc. According to records in *Yi Shuo* by Zhang Gao of Song Dynasty, Zhang Zhongjing learned medicine from Zhang Bozu who lived in the same prefecture; another version says that after he served as the prefecture chief of Changsha, he was once a famous doctor in the capital. But it is difficult to judge the accuracy of accounts recorded by later generations (Fig. 53).

In addition, in the preface of *Treatise on Febrile and Miscellaneous Diseases,* it says: Zhang's Family originally featured prosperous members, but in several years after Jian'an years, two-thirds of the family members died, mostly of typhoid fever. Therefore, Zhang Zhongjing diligently looked for ancient maxims, learned widely from various prescriptions, and referred to *The Yellow Emperor's Classic of Internal Medicine*, *Nan Jing,* and other medical books. Consequently, he composed 16 volumes of *Treatise on Febrile and Miscellaneous Diseases*. But whether this preface was the original works of Zhang Zhongjing was one of the focus issues discussed by scholars for several hundred years. However, these issues concerning the author's lifetime and process of completing this book do not affect the situation as a whole for academic study of medicine itself. We just need to know that Wang Shuhe, an imperial doctor in the Western Jin Dynasty, separated out the part concerning diseases of "external infection" in it and named it as *Treatise On Febrile Diseases*; its theoretical framework was based on the system of "syndrome differentiation of six channels" of *Su Wen · Re Lun*, but it is a little different; this book was promoted from "medical formulary" to the theoretic "classic" since Song Dynasty and was reputed as the first classic comprehensively containing theory, principle, prescription and drug.

Fig. 53 "Picture of Hua Tuo Treating Guan Yu's Arrow Wound by Scraping His Bones" in Japanese books

Hua Tuo, similarly lived from the end of the second century to the beginning of the third century, styled himself Yuanhua, and his another name was Fu. He was born in Qiao County, Pei State (today's Bo Zhou, An'hui). According to records in *The History of the Three Kingdoms*, Hua Tuo had a good knowledge of how to keep fit and live a long life; therefore, when he was nearly one hundred years old, he still looked very young. He was also sharp at prescriptions. When he was treating a patient, he just selected several drugs all by eyes and hand, without using a balance. After the patient cooked the drugs well and drank the medicine juice, the patient would recover immediately; if he treated patients with acupuncture and moxibustion, he just chose one or two acupuncture point(s). He told patients that feeling would spread to a certain place, when the patient said "the feeling has arrived," he would immediately withdraw the needle (which was the same as "new acupuncture therapy" popular in the 1960s, conduction of needling sensation was obvious because techniques featuring strong stimulation was adopted or the nerves were directly stabbed). If pathology result was in the body, and acupuncture and medicine would not take effect, then he would ask patients to drink "Mafeisan (anesthetic)"; a very short time later, the patient would be as drunk and became unconscious; thus, Hua Tuo might slit the patient's belly and stomach with a drawshave, cut intestines and wash, get rid of the disease. Then, he would sew up the cut, to which ointment was applied; then, the patient would recover in 4 or 5 days and got well in a month. However, "Mafeisan" had already been lost for a long time and nobody knows its composition. On the other hand,

laparotomy was not only involving anesthesia, but also detailed anatomy knowledge, effective hemostasis, disinfection techniques, etc., for Chinese traditional medicine, and it seemed to be a difficult job beyond the reach. But for extraperitoneal diseases such as subcutaneous lipoma and cysts, it is comparatively easy to conduct resection. Therefore, we should consider the possibility that such small operations were exaggerated as laparotomy. The fact that Hua Tuo was deemed as highly skilled surgeon by later generations has a direct relation with rendering of the novel *Romance of the Three Kingdoms*. In the light of cases recorded in *The History of the Three Kingdoms*, Hua Tuo was also a TCM doctor who did not surpass the times and tradition—taking drugs and acupuncture and moxibustion as the main measures for treating patients. But in aspect of treating exogenous diseases, theories supporting Hua Tuo were different from the system of "syndrome differentiation of six channels" of Zhang Zhongjing, but like Bian Que observing facial colors of Marquis Qi—pathogenic factors gradually went deep along skins and blood vessels. Maybe this may be looked as the difference between medical knowledge system of Shandong and that of Jinchu (today's Hubei and Hunan)

2.2.3 Wang Shuhe and Huang-fu Mi

The most well-known doctors of Wei-jin Period of China were Wang Shuhe and Huang-fu Mi. Wang Shuhe compiled *Mai Jing (Pulse Classic)*, the first monograph on pulse diagnosis, and the latter was famous for composing *Zhen Jiu Jia Yi Jing* (Classic of the ABC's of Acupuncture and Moxibustion), the first works dealing exclusively with science of acupuncture and moxibustion and both of the two books have been handed down. So based on the above point, the majority of medical historians thought that the medicine development in this historical period featured "reorganization of documents" (Fig. 54).

It's known that Wang Shuhe was from Gaoping in Western Jin Dynasty and had worked as an imperial doctor. But there are some different opinions of whether he was born in Gaoping of Shanxi or Gaoping of Shandong, worked as an imperial doctor in Wei Kingdom of the Three Kingdoms or in Western Jin Dynasty. In summary, his first contribution to medicine was "gathering and collecting exposition, knacks concerning pulse since Qi Bo to Hua Tuo" and integrating them into 10 volumes of *Mai Jing* (Pulse Classic). The position of this book in diagnostics has already been introduced in "diagnosis theory," the fifth section of First Lecture of *Fundamental Idea* of this book. His second contribution was reorganizing old theories of Zhang Zhongjing and compiled them into *Treatise On Febrile Diseases*. But doctors of different periods had different opinions toward it. Someone thought that this move was "shredding beautiful brocade and making it up with cotton waste," causing later generations unable to see the original appearance of Zhang Zhongjing's works; someone else thought that preserving of Zhang Zhongjing's book should be owed to Shuhe and he had "made the greatest contribution."

Huang-fu Mi edged himself into the list of "recluse" of history books written in biographical style due to his birth in the purple, attainments of literature and

Fig. 54 Cover and preface of *Ming Tang Jing of The Yellow Emperor's Classic of Internal Medicine*. This book was the important origin of knowledge concerning "acupuncture points" in *Jia Yi Jing* (classic of the ABC) compiled by Huang-fu Mi

history reputed as "Shu Yin" (referring to a person addicted to books and diligently learning knowledge) and being aloof from politics and material pursuits as repeatedly refusing being enlisted. Huang-fu Mi (215–282), was named Jing when he was young, styled himself as Shi An and named himself Mr Yuan Yan. He was born in Chaona of Anding (today's Guyuan, Ningxia). He had been weak and sickly for his whole life, which might be one of the important reasons why he was wild about medical research. He became a disabled person that "half of his body suffered numbness and his right foot was a little smaller" when he was 34 years old at the latest; when he was between 42–46 years old, he also suffered "wind" disease and had been deaf for several months. At this time, he began to take "Wu Shi San (powder of five minerals)" (also known as "Han Shi San"). However, the medicine not only could not cure his lingering illness, but made him suffer dryness heat at his chest and belly as well as feel worried and choking cough, to the extent that he also wanted to "be naked and eat ice, fail to fall asleep day and night and shed tears when facing the food" in the winter, he almost wanted to take a knife to stab himself. Even so, he had never doubted "Wu Shi San" itself, but considered that all bad consequences were caused by "Wei Cuo Jie Du" (wrong methods of taking the medicine). Such a tragedy was very common among scholar-bureaucrats back then.

Strictly speaking, no records on Huang-fu Mi treating patients were handed down. He was reputed as a medical scientist mainly because he adopted and

picked contents concerning acupuncture therapy in *The Yellow Emperor's Classic of Internal Medicine* and *Ming Tang Jing* and compiled them into *Zhen Jiu Jia Yi Jing* (*Classic of the ABC's of Acupuncture and Moxibustion*). The historical position and value of this book was detailed in the introduction of "acupuncture and moxibustion" therapy, the Sixth Section, Lecture One of this book. It should be supplemented that Huang-fu Mi's principle for excerption was not taking empty talks such as yin–yang and five elements, which was not common in traditional medical domain.

2.2.4 Sun Simiao

Sun Simiao may be the most famous doctor among those of Tang Dynasty. According to historical records, Sun Simiao had been intelligent and susceptible to diseases since he was very young; therefore, he not only read historical works and hundreds of opinions carefully over and over again as well as liked Chinese herbal medical science. Both Emperor Taizong of Tang and Emperor Gaozong of Tang called up him or granted him title of nobility, but he stubbornly rejected. Although later he once served as a medical official, he quitted office 1 year later and lived in seclusion. When he was one hundred years old, he died. Many persons with a literary reputation back then all respected and worshiped him as a teacher (Fig. 55).

Sun Simiao wrote thirty volumes of *Qian Jin Yao Fang* and *Qian Jin Yi Fang,* respectively. The two books recorded more than 6,500 prescriptions and knowledge concerning health maintenance, acupuncture and moxibustion, drugs, spells, etc. Therefore, *Qian Jin Fang* was not only a works of great achievement in prescriptions, but an encyclopedia of health care. Research on *Qian Jin Fang* conducted by later generations focused on seeking which contents had never been seen before and hereby praised the shining point of "innovation" of Sun's medicine. But for such an encyclopedic works, it is actually very difficult to distinguish specific origins of certain knowledge; therefore, it is best to deem it as a treasury of medical knowledge existing back then (Fig. 56).

The content order of *Qian Jin Fang* was obviously different from that of other works—putting prevention and cure of pregnancy-related diseases and nursing care of newborn at the beginning of the volume. Although most commenters think this reflected Sun Simiao's respect for females, it is really commendable in the feudal society when women were thought to be inferior to men. But it may be more reasonable if we think it is a reflection based on "nurturing life should start from the starting point (embryo, delivering) of the cyclic process from birth, old age, illness, and death." This is just the reason why Sun thought "life is more important than a thousand pieces of gold" and titled his works *Qian Jin Fang*. Apart from specific knowledge concerning health care with medicine, Sun also commented self-cultivation of doctors: Doctors should be knowledgeable and make efforts indefatigably; doctors have deep sympathy and high sense of responsibility to patients and treat the high, low, rich, and poor equally as their own natives; doctors should not consider himself always right and defame other

Fig. 55 Sun Simiao's two great prescription works *Qian Jin Fang* and *Qian Jin Yi Fang*

Fig. 56 The edition of *Qian Jin Fang* in Song Dynasty

doctors etc., thus could they be accounted as "great doctors of the common people," or they would be "giant thieves wriggling with spirits"! This piece of precept of medical ethnics written with the title of *Virtues of Great Physician* had always been deemed as a classic comparable with *The Hippocratic Oath* by Hippocrates (Fig. 57).

Other large works on prescriptions of the same times include *Wai Tai Mi Yao* (medical secrets of an official) compiled by Wang Tao (40 volumes, falling into 1,104 categories and recorded more than 6,000 prescriptions). Valuing prescriptions may be one of the characteristics of medicine of Tang Dynasty.

2.2.5 The Famous Four Doctors in Jin and Yuan Dynasties

Si Ku Quan Shu Zong Mu Ti Yao held that "Confucian schools were divided in Song Dynasty while medical schools were divided in Jin and Yuan dynasties" because during this period, the four schools emerged which were represented, respectively, by Liu Wansu, Zhang Congzheng, Li Gao, and Zhu Zhenheng. The four of them adhered to purport of *The Yellow Emperor's Classic of Internal Medicine*, but they understood and used it differently, thus forming different academic standpoints which had the same origin. They became well-known figures in Chinese medical history for their respective academic ideas, curative activities, and theory works influencing later generations.

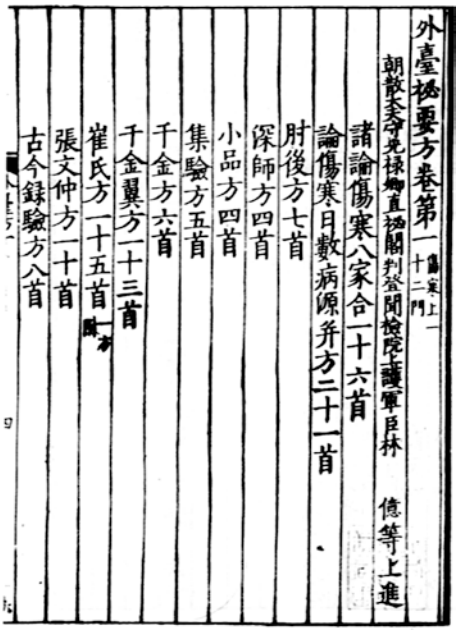

外臺秘要方卷第一傷寒上一 十二門
朝散大夫守光祿卿直秘閣判登聞檢院上護軍臣林億等上進
諸論傷寒八家合一十六首
論傷寒日數病源并方二十一首
肘後方七首
深師方四首
小品方四首
集驗方五首
千金方六首
千金翼方一十三首
崔氏方一十五首 缺方
張文仲方一十首
古今錄驗方八首

Fig. 57 The edition of *Wai Tai Mi Yao* (medical secrets of an official) in Song Dynasty

Liu Wansu lived in the twelfth century. He began to study *The Yellow Emperor's Classic of Internal Medicine* in his twenties to wholeheartedly understand its "profound theories," thought over essence of disease phenomena, consequently, he completed *Su Wen Xuan Ji Yuan Bing Shi* after 40 years' hard work. His uppermost opinion was that essence of all diseases should be attributed to "heat" and he mainly used drugs inclined cold and cool for treating diseases; thus, he was called "heat theory holder" or "cold and cool school." For treating exogenous diseases, he broke the principle of "relieving exterior cold first and then clearing interior heat" adhered since *Treatise On Febrile Diseases*, and held that from the very beginning, the diseases should be treated by "treating exogenous pathogenic factors and internal causes of diseases," "expelling pathogens from both interior and exterior." "Fang Feng Tong Sheng San (Wan)" still on sale today was a representative prescription of such therapy created by him.

Zhang Congzheng, who had received home schooling since he was very young, similarly made great achievements for seriously studying medical classics. He thought that since the disease was not an integral part of human body, treatment was nothing but driving them out of the body; as it was external pathogenic factor, then only treating methods "sweating, vomiting, purgation" should be adopted, while warming method was nothing else than closing the door for keeping invaders. Therefore, he was named as "pathogenic factor theory holder" or "attacking pathogenic factor school." His representative works were 15 volumes of *Ru Men Shi Qin* reorganized by his pupils, from which we can see that Zhang Congzheng was very flexible in practically treating patients. For example, he widely adopted psychotherapy for mental diseases and hooked dead embryo with a steelyard hook, etc. Thus, he was incompatible with other doctors and always sighed "skilled person always feels lonely."

Li Gao was born in a rich family and understood *The Spring and Autumn Annals*, *Book*, *Yi*, and he engaged himself in studying medicine for his mother's disease could not be cured. Although he was a famous doctor in Jin Dynasty together with Liu and Zhang and learned measures from *The Yellow Emperor's Classic of Internal Medicine*, they held quite different theories in terms of medical theories, which had a great relation with the historical environment they were in. Liu Wansu was the oldest of them. Although he was born in turbulent days, he was living in a prosperous society when Emperor Shizong of Jin was in power. The government decree promulgated gave priority to pacification and eliminated the tax in case of disasters; besides, gold and silver resources could be exploited by people freely; and the government would support and helped out the refugees, the old, and the sick. Zhang Congzheng was born a little later and lived in Zhongzhou, and battlefront of Jin and Yuan was far in the northwest; Jin mainly fostered cordial relations with Song Dynasty in the south; thus, he could roam about and avoided fire, havoc, and turmoil caused by war. Li Gao, however, was born in a period when reign of Emperor Aizong of Jin was on the decline, and Jin Dynasty was going to be destroyed when uprisings of war could be seen everywhere. Therefore, when he held that diseases were caused by "internal injury of spleen and stomach" instead of "exterior infection," he always mentioned the

background that cities were stranded and food ran short of and people ate the flesh of human body. In the opinion of later generations, Li Gao highlighted "supporting spleen-Qi and stomach-Qi", extremely stressing "acquired foundation" in theory, hence called him "school of invigorating the spleen," or rather "comments on temporary changes."

Zhu Zhenheng, born in Yuan Dynasty, first learned Confucianism from Xu Qian, pupil of the fourth generation of Zhu Xi, in Bahuashan of Dongyang. He gave up Confucianism to study medicine just because fortune teller said he would not have a bright official career path. He crossed Zhejiang, went to Wuzhong, out of Wanling, arrived at Nanxu, and reached Jianye, but he failed to find an ideal teacher; later, he went to the north and read works of Liu Wansu and Li Gao for the first time; finally, in Hangzhou, he had stood in front of the door of Luo Zhiti, a famous doctor, for 3 months before he was accepted. One year later, he finished learning and returned to hometown; from then on, he made his name. The core of medical ideas of Zhu Zhenheng was "yang-Qi is always superfluous while yin-Qi is insufficient"; therefore, treatment should focus on "nourishing blood"; thus, he was named "nourishing yin school." *Ju Fang Fa Hui*, his representative works, strongly criticized the feature of preferably using spicy and dry drugs in *He Ji Ju Fang* which had become popular since Song Dynasty; thus, *Si Ku Quan Shu Zong Mu Ti Yao* commented: "*Ju Fang Fa Hui* come out and medical science began to change."

Making a general survey of opinions of the four famous doctors, Liu and Zhang's theories of "heat," "attacking pathogenic factors," were "arrogant" medical methods; Li and Zhu's "invigorating the spleen," "nourishing yin" theories, delivering a style of "kingly way." If we describe human body as a "Tai Chi" including yin and yang and deem diseases as imbalance of yin and yang, the so-called arrogance should get rid of the superfluous part; "kingly way" should manage to enlarge the insufficient part, but the ultimate purpose is to seek balance of yin and yang.

2.2.6 Zhang Jingyue and Li Shizhen

Inheriting the tendency of gateway separating and successive emergency of new theories in Jin and Yuan Period, study of medical theory reached a new peak in Ming Dynasty. Compared with the famous four doctors in Jin and Yuan Dynasties who, respectively, attributed diseases to an ultimate cause, Zhang Jingyue, a doctor of Ming Dynasty (1563–1640), universally interpreted medical science with *Yi*, showing the taste of "Tai-Chi—Yin-Yang" was the fundamental truth of creation and development of the universe.

Xue Ji, a doctor of Ming Dynasty (1487–1559), earlier than Zhang Jingyue, based on inheriting Li Gao's treatise on the spleen and stomach, paid more attention to nourishing both kidney and spleen. Liu Wei Di Huang Wan (six-ingredient rehmannia pill) and Ba Wei Di Huang Wan (eight-ingredient rehmannia pill) were both commonly used drugs, especially the method "tonifying middle-Jiao and Qi"

and "Di Huang Wan" were used simultaneously, more fully demonstrated that he attached equal importance to innateness and acquired foundation. Zhao Xianke, working exclusively on *Yi* and particularly valuing Ming Men, commonly used Liu Wei Di Huang Wan and Ba Wei Di Huang Wan for treating various diseases. He said in his *Yi Guan Shui Huo Lun*: "In case doctors can't understand true noumenon of congenital Tai Chi, thoroughly enquire into magical effect of intangible water and fire, not be able to use the prescriptions of Liu Wei Di Huang Wan, Ba Wei Di Huang Wan, the doctor lacks the majority of medical knowledge in terms of theory." Although he had a high regard for Xue Ji, his principles of medical science had already developed into such a phase that only the congenital foundation "kidney" was talked about, while acquired foundation "spleen and stomach" was neglected. In terms of theories, Zhang Jingyue held that "principles of medical science and Yi had the same origin", and treasured kidney-yin and kidney-yang. Accordingly, he created and manufactured "Zuo Gui Wan" (enriching genuine yin of left kidney), "You Gui Wan" (enriching kidney-yang of right kidney). From general characteristics of theories of these doctors, we can know a little about what important impact of Confucian school of idealist philosophy of the Song and Ming Dynasties, which centered on discussing "ontology," had on medical science of Ming Dynasty.

In aspect of botanical knowledge, *Ben Cao Gang Mu*, the last works compiled by following the road of widely adopting contents of various books and pursuing completeness, emerged in Ming Dynasty. Compared with previous works concerning Chinese herbal medicine, Li Shizhen, the author of *Ben Cao Gang Mu*, paid more attention to walking out of his study and visiting those who had practical experience. After that, research of pharmacology stepped on the path of emphasizing theoretical research, demonstrating the generality of the times featuring returning from complicatedness to simplicity (Table 11; Fig. 58).

2.2.7 Ye Tianshi

With increasing population density in the south of the lower reaches of the Yangtze River, influence of increasing convenient transportation and other factors, prevalence of infectious diseases also naturally appeared to be rising. Following Wu Youxing, living beside the Taihu Lake during the late Ming and early Qing

Table 11 Drugs recorded in landmark works concerning Chinese herbal medicine

Master works on pharmacology	Number of drugs
[Han] Sheng Nong's herbal classic	365
[Liang] Annotation of Shen Nong's herbal classic	720
[Tang] Xin Xiu Ben Cao	850
[Song] Zheng Lei Ben Cao	1,748
[Ming] Ben Cao Gang Mu	1,892

Fig. 58 Modern portrait of Li Shizhen and *Ben Cao Gang Mu*

Periods, composed *Wen Yi Lun* that elucidated characteristics of epidemic diseases, therapy should be different from *Treatise On Febrile Diseases*, and some related new theories and therapeutic method also successively appeared in the Jiangsu-Zhejiang region. Their common characteristic was that they considered "fever and warm disease as well as pestilence aren't typhoid fever"; therefore, later generations called them "epidemic febrile disease school" and Ye Tianshi (1667–1746) was one of the representatives. For epidemic diseases with fever as the main clinical manifestation, Ye Tianshi divided its process into four stages "Wei, Qi, Ying, and Xie", no longer following the system of "syndrome differentiation of six channels" of *Treatise On Febrile Diseases*. For those having no TCM clinical experience, it is truly very difficult and unnecessary to gain a clear idea of differences between the system called "Wei-Qi-Ying-Xie syndrome differentiation" and "syndrome differentiation of six channels" of *Treatise On Febrile Diseases*. In conclusion, his feature is using drugs inclined cold and cool; for clinical practice such as febrile convulsions, he adopted some new drugs such as rhinoceros horn and antelope's horn which had never been used in therapeutic system of *Treatise On Febrile Diseases*. Just as Ye Tianshi said: "Although distinguishing Wei, Qi, Ying, Xie is the same as typhoid fever, the therapeutic methods adopted are quite different."

Literary sketches of Ming and Qing Dynasties had many descriptions about Ye Tianshi's experience of learning medical science and characteristics of using drugs without sticking to one pattern. *Wen Zheng Lun Zhi*, Ye Tianshi's masterpiece, was completed by him "travelling to Dongting Mountain," his disciple Gu Jing followed him into the boat and freely wrote down and recorded what Ye Tianshi said at that time. Thus we can also have a glimpse of Ye Tianshi's natural and unrestrained character.

Thenceforward, Wu Jutong (1758–1836) who had no preconceived ideas of schools, based on comprehensively studying relevant theories of *Su Wen*, Zhang

Zhongjing, down to Wu Youxing, Ye Tianshi, put forward that warm diseases should be divided into upper stage, middle stage, and lower stage, i.e., the so-called theoretical system of "Triple-jiao Syndrome differentiation."

Ye Tianshi's "Wei-Qi-Ying-Xie syndrome differentiation" and Wu Jutong's "Triple-jiao Syndrome differentiation" were not only academic purport of epidemic febrile disease school, but the last station of the long development process of traditional Chinese medicine theory system.

2.2.8 Wang Qingren

Wang Qingren died on the eve of Opium War (1768–1831). As he found that ancient people's description of viscera was not quite true, he came up with an idea that he should correct such mistakes; then he thought it over and considered that ancient people must have never seen viscera themselves, thus made mistakes. Therefore, he himself went to the execution ground and cemetery for observing true condition of viscera for many times. For this reason, he is spoken highly of in contemporary China which highlights scientific evidence and is deemed as traditional medicine's last scenery line appeared at the end of feudal society.

However, before Wang Qingren saw viscera with his own eyes, how could he know some description of ancient people was wrong? Thus for his study motive, some one analyzed: As in those times, works concerning anatomy introduced from the West could be seen, his motive of observation should be thoroughly mastering Chinese and Western medicine. But when we read his *Yi Lin Gai Cuo* (Corrections on the Errors of Medical Works) in detail, we cannot see any influence of Western medical science; thus, some one analyzed and considered that: It had rather been deemed as representation of "studying the phenomena of nature for a thorough inquiry into the innate laws of things" in medical domain—spontaneous innovator. Circumstances change with the passage of time. Wang Qingren hurried to cemetery each morning, without keeping away from smelliness and dirtiness, for observing the corpse of foundling residue left by wild dogs; he watched "cut punishment" for several times in order to further fully understand whether heart, liver, spleen, and lung of adults were the same as children's. What is his original motive of "drawing a complete chart after having visited the sites and checked material objects for 42 years and grasped the truth" cannot be accurately known, and we have every reason to believe that it is a result of combined actions of many factors. It is most likely in the times when Western anatomization knowledge had already been introduced into China that Wang Qingren was able to know ancients' description of Zang-Fu was wrong without having "seen" them with his own eyes, because he "heard" Chinese traditional medicine had a problem of being inconsistent with the facts in this aspect, thus stepping on the road of empirical observation.

Wang Qingren's empirical study was also demonstrated by that for testing and verifying the pathway of water metabolism, he designed an animal test: He took two domestic animals as the experimental animal. One was fed as usual, and the other was refused to give any drink or food. Several days later, he paunched the

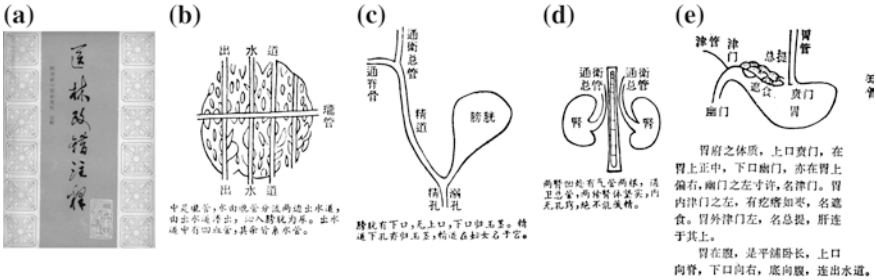


Fig. 59 *Yi Lin Gai Cuo*. **a** Cover. **b** Recognition of "Chu Shui Dao: (tri-jiao)". **c** Recognition of "Urinary System". **d** Recognition of "Kidney". **e** Recognition of "Stomach," "Common Bile Duct"

two animals for comparison. As he saw that the animal without having been given food or drink featured dry and wrinkled epiploon, he considered this was "Chu Shui Dao" (the channel for water flowing out). Thus, it is undoubtedly that water oozed out from Chu Shui Dao." As only after we have understood basic theories of traditional Chinese medicine and modern physiology, can we understand the meaning of this animal experiment; therefore, it is necessary for us to make some explanation: in the times when people had no correct understanding of physiology of renal circulation and urine formation, people always thought that urine seeped into bladder from gastrointestinal tract through "triple-jiao" (Shui Dao, i.e., "the non-flesh part" in abdominal cavity). Therefore, the experiment conducted by Wang Qingren was nothing more than "confirmed" this wrong physiological explanation established by *The Yellow Emperor's Classic of Internal Medicine*. Another example was although he quite carefully observed sphincter of common bile duct at the opening of duodenum: "There is a knot on the left side of Jin Men in the stomach, looking as if a jujube, which is named Zhe Shi," but just as the times when *The Yellow Emperor's Classic of Internal Medicine* was completed, he deemed common bile duct as "a path for stomach discharging bile and water." Therefore, in a sense, Wang Qingren's anatomy empirical observations were nothing but repetition of the processes of such physiological explanation established by doctors of the times when *The Yellow Emperor's Classic of Internal Medicine* came out and actually it did not make any innovation or "corrections" at the level of knowledge (Fig. 59).

3 Lecture 3 Sino-Overseas Exchanges of Medicine

The Chinese civilization, a quite long historical period, has formed and developed in a relatively enclosed environment. However, propaganda of knowledge and techniques and cultural exchanges between China and foreign countries have never been interrupted.

3.1 Similarity and Peculiarity of Sino-Overseas Exchanges of Medicine Before the Late Ming and Early Qing Dynasties

As any traditional medical knowledge has a close relation with its parent's cultural system and features wide social foundations and practicability due to its close relationship with lives of the people, it will inevitably play an important role in cultural exchanges and propaganda of knowledge and techniques and attract attention of researchers engaged in history of cultural exchanges and medical history. Generally speaking, general history books as well as various works of special history such as books on history of cultural exchanges and medical exchanges, all feature loyalty to the basic position of history research—taking collecting historical facts and conducting relevant textual research as the foothold and the goal. Thus, it provides basic guarantee for people hoping to understand relevant history or those who want to take it as a basis for further studying impact of "exchanges" on development and changes of various civilization systems. The followings are academic monographs provided for readers to understand Sino-overseas exchanges history of medicine:

Shi Shiqin *A Brief History of Introduction of Traditional Chinese Medicine into Japan*, Central China Normal University Press, 1991.

Ma Boying et al.: *Sino-overseas Exchange History of Medical Culture*, Wenhui Press, 1993.

Wang Xiaoxian *The Silk Road Medicine Exchange Research* Xinjiang People's Press, 1994.

Li Jingwei: *Sino-overseas Exchange History of Medicine,* Hunan Education Press, 1998.

Song Xian, *Ancient Persian Medicine and China*, Economic Daily Press, 2001.

Chen Ming: *Special Prescription and Medicine, Unearthed Documents and Medicine of Western Regions*, Peking University Press, 2005.

Basically, all nationalities, countries, and regions have their own "traditional medicine." Generally speaking, although medicine knowledge (i.e., the theories and methods for treating disease) in different cultures might be somewhat different, there is no essential difference between them. Scan the historical textual research and studies on several—thousand-long "Sino-overseas exchanges of medicine," the following common points may be generalized (Fig. 60).

First, the ways of propagandizing knowledge and techniques are nothing but "people" and "books." "People," as the carrier for propagandizing medical knowledge and techniques, include immigrants, scholars, officials, monks, and businessmen.

Second, medical knowledge is always introduced into neighboring countries with Confucianism as an integral part of Chinese culture. Those nationalities, countries, and regions featuring undeveloped and immature civilization always fairly comprehensively accepted theories and technologies of Chinese traditional medicine and even the medical system during the process of accepting Chinese traditional civilization, such as countries on Korean Peninsula and Japan (Fig. 61).

Fig. 60 A few research monographs on Sino-overseas exchange history of medicine

Third, medical exchanges between countries boasting mature and developed cultivation were mainly conducted on the level of technologies, e.g., absorbing new drug varieties and treatment techniques. These countries seldom accepted foreign theories in terms of theories. Such examples include absorption of each other's medicine knowledge between China and India, the two ancient civilized countries, and Arabic countries' absorption of Eastern Asia's medicine knowledge.

Fourthly, during this historical period, exchanges of medical knowledge between China and Europe, America, and regions outside Asia were mostly indirect. Commercial activities concerning spices and other goods had played an important role in adding new drug varieties and forming some new treatment methods.

Fifth, due to the essentially same nature of traditional medicine, it is very hard to judge whether a certain same or similar theory, therapeutic method existing in different knowledge systems occurred diversely and independently or was originated from exchanges and propaganda.

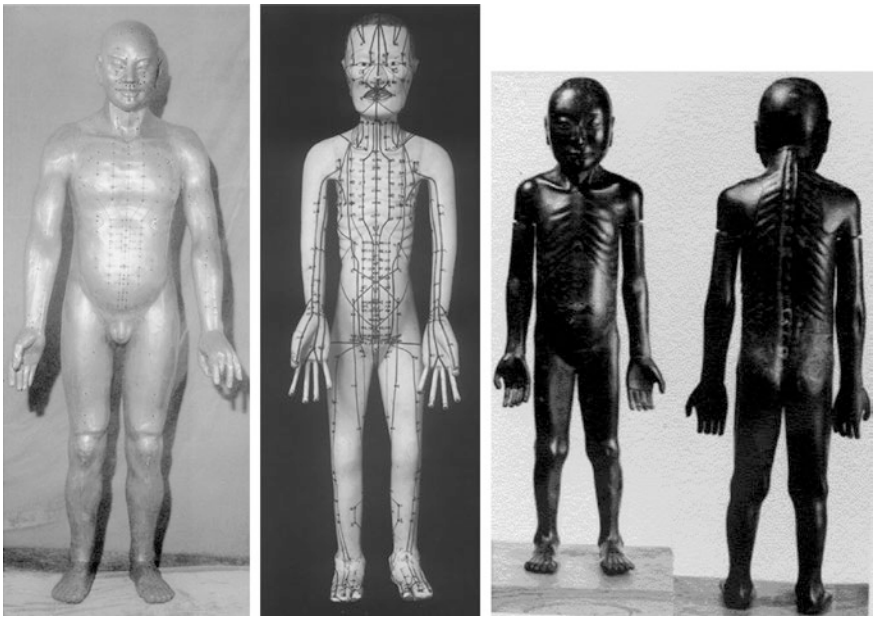


Fig. 61 Acupunture models in the Song Dynasty of China, for the purpose of meeting the needs of acupuncture teaching, a "copper man" engraved with acupuncture points were made (*on the left*, an imitation). Imitation works of Japan (*middle*) and South Korea (*right*)

Sixth, any kind of knowledge, including the medicine, after having been introduced into other regions, will surely see selective absorption and transformation due to influence of different thinking modes and indigenous culture of various nationalities. On the basis of textual research about history facts, it remains a deep-seated pursuit to observe the process of selective absorption, transformation, and even innovation and relevant reasons.

3.2 Taking Indian Medicine as an Example for Observing the Influence of Foreign Medicine

It is often heard that some one says proudly: Traditional Chinese medicine is the only existing traditional medicine. Actually, traditional Indian medicine has also existed up to today.

3.2.1 Research on Traditional Indian Medicine

Two works may be referred for understanding the cultural background of traditional Indian medicine, which are extremely worthy of reading. The first one is

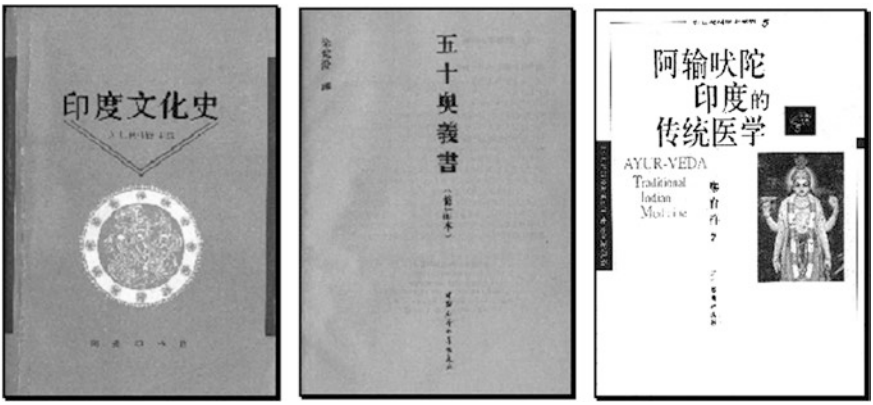


Fig. 62 Works concerning Indian culture and traditional medicine

Cultural History of India[1] compiled with A. L. Basham as the chief editor. This book is composed of articles written by different experts specialized in studying certain issues in the world instead of by one person; therefore, it is concise and compendious as well as deep; the second is *Upanishads*,[2] translated by Xu Fancheng, which can help us understand profound Indian philosophical thinking. As for traditional Indian medicine, *Ayurveda—Traditional Indian Medicine*[3] composed by the author can be used as the primer. However, in the West and Japan, scholars' attention to traditional Indian medicine and relevant research conducted by them has greatly gone far beyond our imagination (Figs. 62, 63 and 64).

3.2.2 Background Introduction

1. India: In a long historical period, "India" always refers to the vast land extending from The Himalayas to the sea instead of a country in the terms of "politics" or "territory." About 4,000 years ago, origin of Indian Civilization, i.e., Indus Civilization, appeared in the northwestern part of South Asia Subcontinent. Aryans, belonging to white race, invaded India in about BC 1500. Thus, "varna" (a caste of India) system, featuring racial overtones and division of social classes, formed in Indian society back then: Brahman

[1] The Commercial Press, Chinese Version, 1997.

[2] China Social Sciences Press, 1995.

[3] Liaoning Education Press, 2002.

Fig. 63 Example works of Japanese scholars studying traditional Indian medicine

Fig. 64 Example works of Western scholars studying traditional Indian medicine

(monopolist of priests and knowledge), Kshatriya (warriors), Vaisya (peasants, herdsmen, merchants), and Sudra (craftsmen etc.).

2. The knowledge systems taken charge of by Brahman in early times were only four Veda samhitas: the Rig Veda, Yajur Veda, Sama Veda and Atharva Veda; and in the late period, the knowledge systems fell into four categories:

Mantra (proverbs, poetry, and creed) constitutes the most ancient part of Veda literature, including the above-mentioned works; *Bhrahmin*: the thesis about prayers and prayer rituals; *Aranyaka*: a kind of teachings imparted in the forest, an appendix of *Bhrahmin*; Upanishads: means "secret and profound dogmata" (Figs. 65 and 66).

Another kind of works is called Veda sub-collection, including phonetics, the rites, grammar, etymology, phonology, and astronomy.

3. Philosophy: India boasts very developed philosophical thought, with the system of philosophy including six orthodox fractions, i.e., Samkhya, Yoga, Nyaya Vaisesika. Mimamsa, Vedanta. The fractions are called "36 Ajivakas," such as "Lokayata" which denies the existence of any soul or pure consciousness;

Fig. 65 Scenic Indus. Indus is the mother river of India which once gave birth to "Indus Civilization"

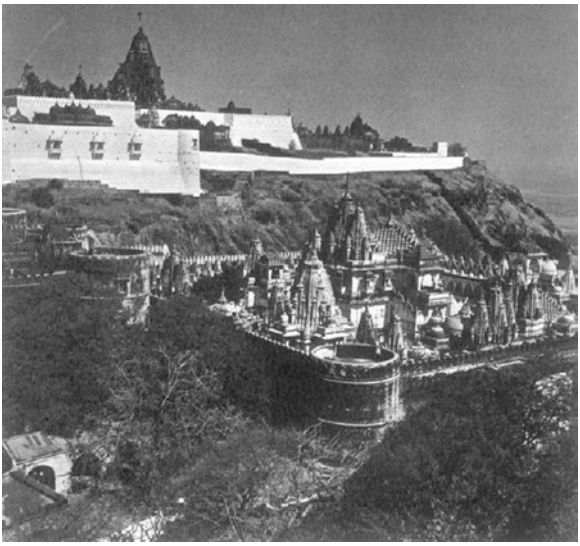


Fig. 66 Jaina Temple. Denominations in India are quite complicated. It is generally acknowledged that there are three main denominations: Hinduism, Jainism, and Buddhism. Documentaries concerning Jainism contain many technological contents

"Buddhism" and "Jainism" which deny the supreme of *Veda*, God-created universe, and Caste System.

4. Geography: India's geographical feature has a close relation with its medical characteristics. For example, monsoon starting from June each year leads to a "rain season" which lasts about 3 months, while it seldom rains in other seasons. Therefore, a year initially fell into three seasons: rain season, winter, and summer. Later, the three seasons were, respectively, subdivided into two seasons. In North India, they are called rain season, autumn, early winter, severe winter, spring, and summer, while in South India, they are called rain season, autumn, early winter, spring, summer, and pre-rain season. As everyone knows, the "Naturalists" appearing in Pre-Qin Period of China divided yin and yang into "Tai and Shao," respectively, for defining the nature of yin and yang of the four seasons (spring: Shao Yang, summer: Tai Yang, autumn: Shao Yin, and winter: Tai Yin), while medicine adopted the method of dividing yin and yang into three parts. For a quite long time, historians have always felt confused

at the origin and connotation of the doctrine of three yin and three yang. But by virtue of India's division of six seasons of a year for thinking about that "three yin and three yang," respectively, last 2 months in *The Yellow Emperor's Classic of Internal Medicine*, or dividing a day–night period into six sections, which separately belong to "three yin and three yang," maybe it is more easy for them to understand the meaning of "three yin and three yang, divided according to the time" in the book. Besides, the characteristics of traditional culture of India and various ancient countries in the Western region also had close relations with these countries' geological locations at the areas between West Asia and East Asia (Fig. 67).

In fact, in terms of ethnology, history, and civilization typology, India actually belongs to the West. But it is located in the East. During the process of its cultural development, it had been tremendously influenced by the oriental nations, leading to an increasing gap between it and the Western culture which has the same origin. When the Westerners discovered India again, they all thought that it is an oriental country. However, with in-depth discovery, more and more scholars have a fairly deep understanding of the cultural nature of India. From an objective perspective, India not only has a persistent Western keynote, but features a distinctively rich oriental flavor; it is different from European and American countries as well as China and Japan. Therefore, it is really a cultural intermediate zone between the East and the West.[4]

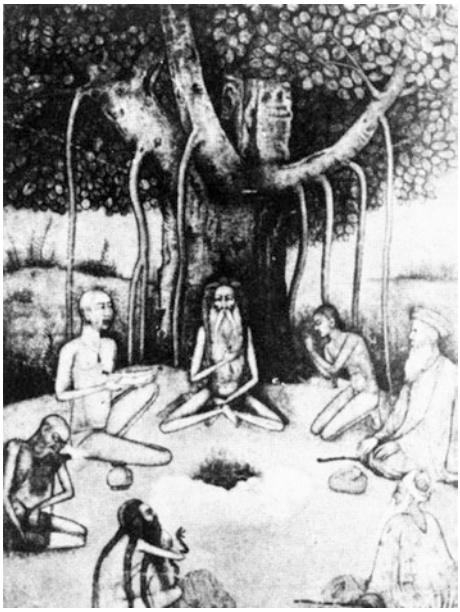


Fig. 67 Talks between Indians and the Hui people—integration of two cultures

[4] Yu Longyu. A Comparison between Chinese Literature and Indian Literature [M]. Lujiang Press, 1996:80–81.

3.2.3 Traditional Indian Medicine

(Unani) Just like China boasts traditional Chinese medicine represented with the Han people's traditional medicine as well as various kinds of medicine of minorities and folk treatment methods, India also has multiple kinds of traditional medicine. Of which, Ayurveda, which is deemed as "created and authorized by the god," and Unani, traditional Arabic medicine introduced in India with invasion of Islamism, have a longest history (Figs. 68 and 69).

"Ayurveda" is the combination of Ayus and Veda in Sanskrit. Therefore, it is safe to say that Ayurveda has a basic meaning of "knowledge of life," it is knowledge about life, or it is transliteration of life guidelines formed based on this kind of knowledge.

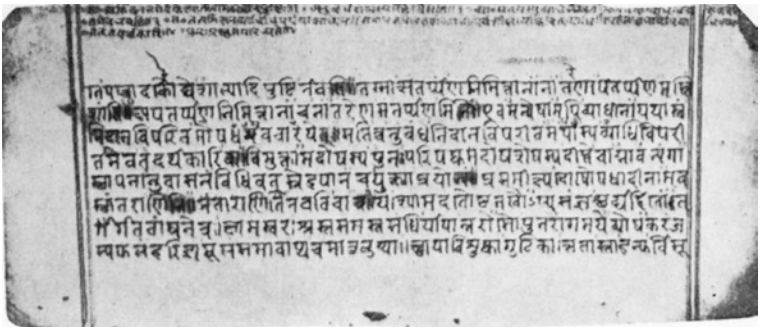


Fig. 68 Ancient manuscript of *Caraka-samhita*. As the oldest classic of traditional Indian medicine, Caraka-samhita has a similar position as *The Yellow Emperor's Classic of Internal Medicine—Plain Questions:* people thought that it was completed during the period from several centuries before Christ to several centuries AD, and the actual time is yet to be determined. The contents are mainly about "internal medicine" treatment, and its relation with *Susruta-samhita* is just like the relation between *Plain Questions* and *Ling Shu*

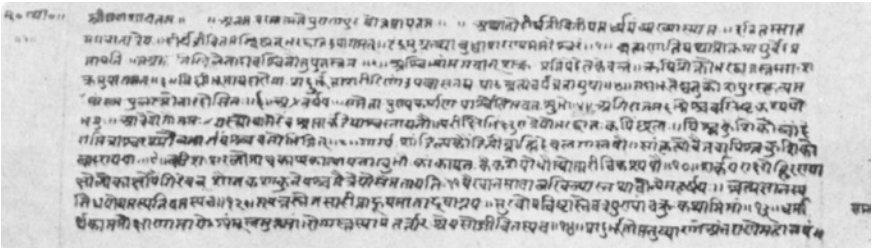


Fig. 69 Susruta-samhita. It is another oldest classic of traditional Indian medicine with its position and characteristics similar with *Ling Shu of The Yellow Emperor's Classic of Internal Medicine,* and it is also uncertain when it was completed. The contents are mainly about "physical" treatment methods. *Susruta-samhita*, *Caraka-samhita,* and *Astangahradaya-samhita*, a book combined contents of the two books featuring comprehensive summary of medicine and surgery, are known as "three elders" of Ayurveda

Although "Ayurveda" has a long history as Chinese traditional medicine and always serves the public's health causes, in the cities and palace during the reign of believers of Islam, however, Unani medicine dominated, while Ayurveda existed in the surrounding regions inhabited by Hindus and poor people. In the twentieth century, with the independent movement, traditional medicine also saw unprecedentedly grand revival. As a result, after India got independence, there was increasing number of universities boasting qualifications of imparting Ayurveda which obtained basically equal position of Western medicine (Fig. 70).

However, while comes to traditional Indian medicine, Chinese scholars tend to call it "Buddhist medicine"; and in their inner heart, they consider the so-called medical and sanitary contents in the Buddhist scriptures as Indian traditional medicine, which is quite inappropriate. In short, the so-called Buddhist medicine is actually as defined by Fukunaga Katsumi: "a colorful cloth woven with Buddhist astrology as the latitude line and Indian medicine as the longitude."[5] As a religious medicine, the Buddhist medicine is the medicine characterized by Buddhism belief and is the medicine featuring self-realization, self-restriction, self-care, and self healing. It is a social phenomenon objectively existing and related to medicine. We cannot simply and one-sidedly consider that Buddhist medicine exists in Buddhism but has nothing to do with Buddhism, regard it as methods for treating

Fig. 70 Sculptures demonstrating "Pulling Teeth"

[5] Fukunaga Katsumi, Buddhism Medical Recipe 2.

Fig. 71 As described in works of history of Western medicine, India can conduct repair surgery for person whose nose is cut off

diseases and drug use[6] which are completely same as those of medicine and just in the charge of temples and monks. This feature can be clearly seen in the introduction of Drinking Tea for Life Cultivation in Figs. 71 and 72.

3.2.4 Exchanges of Chinese Medicine and Indian Medicine

Collecting records of knowledge propaganda from documentaries is undoubtedly an important way for studying "history of exchanges." For example, *Collection of South Asian Historical Materials from Chinese Sources* [7] compiled by Geng Yinceng has widely collected materials related to ancient Indian medicine and other scientific technologies in ancient Chinese literature. However, as influence, absorption and integration of foreign culture always go on unconsciously, we may also expand our horizon for observing mutual influence possibly existing between two knowledge systems from different perspectives (Figs. 73 and 74).

[6] Chen Lin. Attempting Discussing Relations between Buddhism Drugs and Medicine. Li Liangsong and Liu Jianzhong. Treatise on Chinese Medicine [M]. Lujiang Press, 1996:80–81.

[7] Compiled by Peking University South Asia Research Institute, Assembly of Middle-South Asia Historical Data in China's Ancient Books and Records [M]. Shanghai: Shanghai Classics Publishing House, 1994.

Fig. 72 Ayurveda paying attention to "Hygiene." Indian people are used to keeping clean, which is fully demonstrated in religious activities as well as realistic life

1. Footprint of God of Double Horses

In their opening section, *Caraka-samhita* and *Susruta-samhita* both described the process how this knowledge system was created by Brahma and imparted to people on the earth by Asvin. Although the process of imparting Ayurveda knowledge in "God Kingdom" is just a fairy legend, but "Asvin," the God of Double Horses, is quite attractive. It is one of the eldest gods in primitive religious system of Indo-Europeans and was first found in Yamnaya Culture originated at the north coast of Caspian Sea–Black Sea during the period of BC 3200–BC 2200 and had already been eulogized as the god of medicine in the *Rig Veda.* However, it is worth noting that the footprint of the God of Double Horses boasting magic medical techniques not only appeared in primitive religion of Indo-Europeans. As the God of Double Horses is one of gods of polytheism common to Indo-Europeans such as Aryans, Iranians, Scythians, and nomadic people living beyond the Great Wall, its statue can be found in Persian stone carving, graveyards of Kazakhstan people living beyond the Great Wall and bronze ware of Iran. Besides, "statue of the God of Double Horses" was also found in China, such as ancient cliff paintings in Tianshan Mountain and Yinshan Mountain, gold medal unearthed from a Warring States tomb in Inner Mongolia, and eaves tiles unearthed from the tomb of the Lower Capital of the Yan State and even on the family crests made of bronze ware in the late Shang Dynasty (Fig. 75).

Just like the God of Double Horses, born at the north coast of Caspian Sea–Black Sea, came far to India, Persia, Iran, and North China, "Aryan" referring to a race was gradually deemed as a cultural group; the original meaning of "Varna" (a caste of India) differentiating the "color" of different skins gradually downplayed

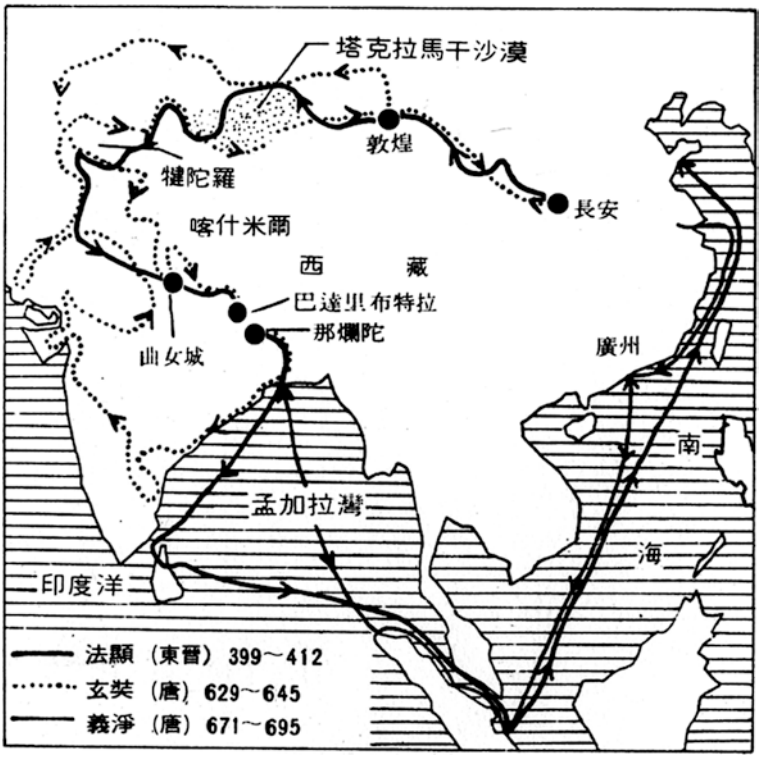


Fig. 73 Sketch map for tour route of Chinese Monks and Priests. For example, Ching, lingering in India during the period from AD 672 to 682, elaborated lives, diseases, and regimen of monks and priests back then in his *Commentaries on Nanhai Jigui Neifa*

Fig. 74 Ancient Tea-Horse Road at the foot of Jade Dragon Snow Mountain. The Ancient Tea-Horse Road with Lijiang, Yunnan as a major transit point is an important channel for propaganda of commerce and culture of the southwest

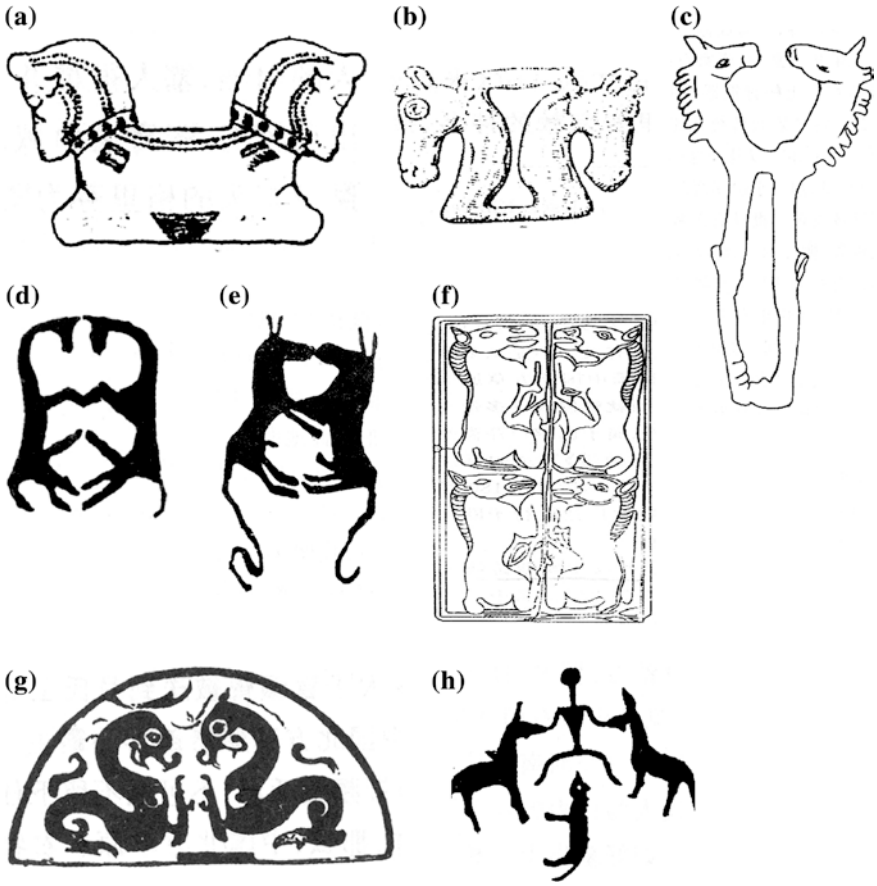


Fig. 75 Statues of the God of Double Horses. **a** Statue of the God of Double Horses in Ancient Persian stone carving. **b** Statue of the God of Double Horses unearthed in graveyard of Kazakhstan people living beyond the Great Wall. **c** Statue of the God of Double Horses on bronze ware of Luristan, Iran. **d** Statue of the God of Double Horses in Ancient Cliff Painting in Tianshan Mountain. **e** Statue of the God of Double Horses in Ancient Cliff Painting in Yinshan Mountain. **f** Gold metal of statue of the God of Double Horses Earthed in a warring states tomb located at the Xigoupan, Inner Mongolia. **g** Statue of the God of Double Horses on eaves tiles unearthed from Tomb No. 30 of the lower capital of the Yan State, Yi County, Hebei. **h** Statue of the God of Double Horses on the family crest made of bronze ware in the late Shang Dynasty

and became a caste; Arabic medicine introduced into India peacefully existed with Ayurveda and had a close relation between them; ancient medicine of India and even the whole Middle Asia had all kinds of interrelationships with Chinese traditional medicine, and Ayurveda, knowledge system of Indian traditional medicine, was not only influenced by the West and the East, but penetrated into other culture with a posture of independent system.

2. Drug Classification

It is safe to say that direct historical materials clarifying a certain prescription or a certain drug coming from India, etc., in the document have already been completely examined by predecessors[8] and have been repeatedly cited as the proof for a long history of Sino-India cultural exchange. Therefore, it is no need to say more about it. However, in consideration of "stimulus diffusion" in cultural exchanges, it may be found that a boundless space exists besides "clear records in documents."

The concept of "stimulus diffusion" was put forward by A.L. Krober in 1940. In his opinion, in each case of stimulus diffusion, a new mode actually emerges which is brand-new for the culture giving birth to it but is not so in the whole human culture. There exists not only historical relation and interdependence, but originality here, because the new mode was created with new materials in different ways.[9] Obviously, stimulus diffusion does not directly inherit from a certain kind of knowledge, but possibly a corresponding creative intention and confidence inspired by a certain hearsay, hence leading to a true invention (in case of false hearsay) or reinvention (in case of true hearsay). For example, while expounding the famous Japanese doctor Hanaoka Seishu (1760–1835) created anesthetics and successfully applied them to breast cancer treatment, Keiji Yamada thought that although it is impossible for Hanaoka Seish to directly obtain Hua Tuo's anesthetic technique, it is related to stimulus diffusion of the story about Hua Tuo.[10] On the other hand, the creative activity created by comparing to "owned by others instead of oneself" can also be deemed as a role of stimulus diffusion, although under such a circumstance, it may possibly completely use new materials and methods for creating a brand-new mode. Indian ancient drug classification may have possibly exerted such an impact on traditional Chinese medicine.

As everyone knows, S*heng Nong's Herbal Classic*, the earliest extant pharmacopoeia in Chinese history, falls into three categories and records 365 entries on medicaments which was completed in the Eastern Han Dynasty (25–220) or so. Till to the Southern Dynasty, Tao Hung-ching, living in the Liang period, by integrating, processing, and sorting out added drugs to "*Fu Jing Wei Shuo*" and additional remarks on the drugs by famous doctors, composed Annotation of Shen Nong 's Herbal Classic which recorded 730 kinds of drugs. What has been repeatedly praised by scholars of medical history was not only the increase of drug amount, but the classification: Tao Hung-ching changed the three-category classification featuring rich fairy arts into "classification based on natural quality," i.e., "differentiating materials according to their nature," hence seven categories: jade and stone, plant, wood, insect and beast, fruit and vegetable, rice and food, etc.

[8] Geng Yinzeng. Assembly of Middle-South Asia Historical Data in China's Ancient Books and Records may be called representative work in this aspect.

[9] See details in Joseph Needham, Science and Civilization in China, Chinese translation Volume 1 [M]. Beijing: Science Press, Shanghai: Shanghai Classics Publishing House, 1990:254–259.

[10] Keiji Yamada. Bird Crying in the Night [M]. Iwanami Shoten Publishing 1990:237.

We should say that making classification in the light of natural quality is the most basic, intuitive, and primitive classification method; therefore, it is quite natural that such a method independently arises in any place. It is really cannot be ignored that, although a believer of Taoism, Tao Hung-ching gave up the three-category classification featuring the fairy arts and changed the original system respected as Sheng Nong's *Herbal Classic* and adopted the natural-quality-based classification method.

Although Tao Hung-ching believes in Taoism, his thought essentially belongs to synthesized Buddhism and gave commandment that after his death, "covering his head and feet with large cassocks … and Taoists stand on the left and on the right[11] etc.," which vividly demonstrates the fact that he integrated Taoism and Buddhism. Besides, in his preface "*Supplement to 'Prescriptions for Emergencies*'" for supplementing Guo Hong's Handbook of *Prescriptions for Emergencies,* citing of medical theories in the Buddhist Scriptures can be found. As a matter of fact, Tao Hung-ching's classification method for medicine was formed by integrating the two systems, i.e., under the natural-quality-based classification, the drugs were subdivided into three categories. As to whether the two "systems" can be expressed as exotic and traditional, Buddhism and Taoism, India or China, it's just a "maybe". If we can realize that during its forming process, Taoism, the native Chinese religion, itself has factors to develop by influenced by foreign Buddhism,[12] even "Mirror"[13] and "Fu"[14] (magic figures drawn by Taoist priests to invoke or expel spirits and bring good or ill fortune), religious and precious objects of Taoism may all have relations with influence of exotic culture, then it will be more natural for us to realize essential of Tao Hung-ching's thought "Taoists stand on the left and on the right". Then, it will become increasingly possible that foreign and Chinese classification methods will be integrated for drug classification.

In addition, in *the Annotation of Shen Nong 's Herbal Classic* compiled by Tao Hung-ching, the contents concerning so-called common medicine for various diseases were added, similar to the practice of categorizing the drugs into 50 categories in the light of treatment effect with examples of 500 drugs in the aforesaid *Caraka-samhita.* The diseases listed by Tao Hung-ching are about 80-plus and 10 of them and relevant drugs are listed as follows for a

---

[11] History of Southern Dynasties, Biography of Tao Yinjing, the Punctuated Text of Zhonghua Publishing House, 1975, p. 1900.

[12] Necromancer was renamed Taoist priest about at the turn of the two Han dynasties. "You have Stupa and I have Yellow Emperor and Laozi" is likely the incentive formed by religious rites of Taoism that caused theories of the Yellow Emperor and Laozi, originally a political philosophy theory, to turn to Huanglao Dao (a branch of Taoism) and Taoism. Besides, Lv Cheng, Tang Yongtong, etc., all gave an account of the influence of Buddhism on Taoism and metaphysics.

[13] *Notes Xijing* recorded that Emperor Xuan of Han wore "a Shenduguobao Mirror," "It's rumored that evil spirits will reveal their true features in this mirror," etc.

[14] Ma Boying et al.: Sino-overseas Exchange History of Medical Culture [M]. Shanghai: Wenhui Press, 1993:146.

demonstration: common drugs for wind evilness (5), drugs for treating Fengxuan (7), drugs for treating Feng suffered by the neck, head, and the face (11), drugs for treating stroke and weak feet (13), drugs for treating long-term rheumatic arthritis (15), drugs for treating pains cased by evil Feng (12), drugs for treating pruritus caed by Baofeng (9), drugs for treating typhoid fever (25), drugs for treating severe heat stroke (18), and drugs for treating overstrain recurrence (4).

Later, the above-mentioned contents were also found in the drug-concerned part of "*Supplement to* '*Precious Prescriptions*'" composed by Sun Simiao in the Tang Dynasty. There are a total of 65 categories from "treating Feng first" to "weak, cold, and pain feet." Since then, the compound classification method was adopted in the several "milestone" works concerning Chinese herbal medicine which also contain the contents of primary drugs for various diseases, which may inherit and pass on Tao Hung-ching's system.

The "doctrine of four ways of birth" for origin of species is also an interesting topic. This doctrine introduced into China belongs to the system undergone transformation of Buddhism. According to Volume 17 of *Ekottara Agama* and Volume 8 of *Abhidharmakosa-Sastra*, there are four forms of birth for realms of existence[15]:

1. Oviparity: birth from an egg, like a chicken, a magpie, and a crow;
2. Viviparity: birth from a womb, "human beings, beasts as well as two-foot insects are born from the womb";
3. Humidogene: also called birth out of causes and birth from moisture, "like maggots appearing in rotting flesh, worms in toilets, and worms born from corpse";
4. Metaplastic: miraculous materialization, like various gods, hungry ghosts, and sufferers in the hell.

The key point of Buddhism's modification of four-form-birth theory lies in replacing "birth from sprout" with "birth by transformation" of "birth via karma." It seems that this theory does not have a great impact on Chinese drug classification. However, in Insect Section of Volume 42 and Volume 391 of *Compendium of Materia Medica* by Li Shizhen, insects fall into three groups which were, respectively, born from an egg, metaplastic, and moisture. Of course, their meanings are different from Buddhist teachings. That means, we should actually take it as a classification method developed by Li Shizhen who thought about the emergence way of insects based on the views of birth from a womb, an egg, and moisture.

It is true that drug classification is only a fairly specific subtopic, but just like a picture, we cannot grasp the whole layout without making clear of each part of it. A question directly related to this issue is that: at the turning point of the two Han Dynasties or even earlier, what was it like that Indian medicine knowledge was

[15] Ren Jiyu, Religion Dictionary [M]. Shanghai: Shanghai Lexicographical Publishing House, 1981:296.

introduced into China? Why were drugs considered as "originated from the West" in "*Plain Questions · Yi Fa Fang Yi Lun* (theory about different disease-treating methods for people living in different regions)"? In Chinese traditional medicine, pharmacology formed an independent system, i.e., the concept of "Chinese herbal medicine" and the publication of special works all appeared not earlier than the end of the Western Han Dynasty, which, however, enjoyed a rapid development in a period after it, which is really worth serious studying. All in all, if only understanding Chinese history and Chinese traditional culture, not only we cannot conduct researches on exchanges and comparison, but even for people who only want to study development and evolution of local culture and traditional scientific and technological system based on Chinese traditional culture, it will be a hinder for deepening the study.

3. Story of Everything Being Medicine

A story spreads in traditional Chinese medicine industry: One day, a teacher said to his student: "go and dig a kind of plant which is not medicine and then you can graduate." The student went off to carry out the order and thought that it was very easy. Who would have thought that he returned empty-handed and cried to his teacher: "it seems that I am not able to graduate." His teacher asked: "Why?" The student answered that: "After having looked all the vegetations, although I don't know all of them, I know that all of them are medicine. So I can't complete your task." The teacher said with a smile: "You've finished your school and you can graduate now."

Although it is a widely spreading story in the circle of traditional Chinese medicine and the heroes of the story do not have any identity of foreign people, the story was originated from India. Sun Simiao, the famous doctor in the Tang Dynasty, said in his masterpiece *Supplement to* "*Precious Prescriptions*" that "It's said that JIvaka, the respected doctor from India, said that all the things in the world were effective medicine and nothing under the sun is not a drug."[16] Although we have no idea from which place Sun Simiao got to know the speech of JIvaka, the respected doctor from India, we can find the followings in *Caraka-samhita*: "If we know any thing in the world has a certain 'ynkti' and 'artha,' then it's safe to say that there is no thing other than medicine in the world" (1, 26, 12)[17]; besides: "Nothing but medicine exists in the world (1, 27, 330)".

As there is a close relation between Tibetan medicine and Indian medicine,[18] this view is spreading among Tibetan doctors and has already come into a story:

[16] [Tang] Sun Simiao, Supplement to "Precious Prescriptions" Volume 1 [M]. Beijing: People's Medical Publishing House, 1955. Photocopy Version 2.

[17] Numbers in the brackets successively indicate volume, chapter, and section of this book.

[18] See details in Yongdrol Tsongkha's "Tibetan Medicine Annals from the 6th century BC to 10th century AD" [J]. China Tibetology, 1997:96–111.

One day, the teacher asked the students to get some things which have no medicinal value in the nearby mountains. With the exception of JIvaka, all the students came back with some articles they thought having no medicinal value. But JIvaka returned empty-handed and told the teacher that he didn't find any thing having no medicinal value.[19]

It is worth noting that the view of "everything is medicine" represents another pharmacological theory and we can even say it is another thinking mode of philosophy. The legend of "Shennong tasted hundreds of plants and met seventy poisonous ones in one day" for identifying medicine has been spreading since ancient times in China[20] and modern works on medical history also basically follow this mode in explaining the route of forming knowledge of drugs, i.e., "During the process of clan members turning from long-term collecting plants to growing plants, they'd chewed and swallowed many plants, thus accumulated some experience of treating diseases with plants"[21]; "During this process, they had suffered many pains from poisoning and accumulated quite a lot of knowledge of drugs"[22]; "As they were desperate for food, the people always ate some poisonous plants by mistake and as a result, they suffered vomiting, diarrhea, coma or even death. After countless attempts, people gradually realized that some plants were beneficial to human body while some others were harmful and some could be used for treating diseases. Thus some knowledge about botanical drugs was preliminarily accumulated".[23] Such "theory of getting poisoned and identifying the drugs" reformed from "Shennong tasted hundreds of plants" illustrated an important source of knowledge—experience. Meanwhile, the researchers also pointed out that the modes of thinking such as analogy and association (i.e., the laws of thought called "law of similarity" and "law of contact" by researchers of witchcrafts[24]) are also important ways for explaining the efficacy of drugs. For example, in *Shan Hai Jing* (or Classic of Mountains and Seas), an ancient document about China's early geography, it is recorded that: Shatang (a kind of tree) growing on the hills of the Kunlun Mountains features light and floating body which therefore can be used for defending against the water and people eat its fruits can't be drowned; Yaocao

[19] Yongdrol Tsongkha. Famous Indian Veda Doctor JIvaka, [N]. QingHai Daily 1998-1-1 special editions.

[20] It's important to note that the meaning here in *Huai Nan Zi* is to explain the origin of food-identifying knowledge instead of medicine, i.e., the reason why Sheng Nong was called "nong (meaning agriculture in Chinese)." It is later gradually explained as "identifying drugs."

[21] Kong Jianmin. Chinese Medical History Outline [M]. Beijing: People's Medical Publishing House, 1988:10.

[22] Yu Shenchu. *Brief History of Chinese Medicine* [M]. Fuzhou: Fujian Science and Technology Press, 1983:6.

[23] Beijing College of Traditional Chinese Medicine. Chinese Medical History [M]. Shanghai: Shanghai Science and Technology Press, 1978:2.

[24] See details in Frazer, J. G. *The Golden Bough* (Chinese Folk Literature and Art Publishing House, 1987 Chinese Translation) for specific analysis of witchcraft ideological law.

(legendary fairy plant, such as lucid ganoderma) is the embodiment of the God's daughter, therefore people eating it will be loved by others and will become beautiful; Gurong (a legendary vanilla) features "black flowers and having no fruits", therefore people eating it will suffer infertility etc. Such clues tell us that apart from practical experience, analogical pattern may be called one of the most important ways for establishing the theory of efficacy of drugs in the ancient times. "Induction principle is one of the basic principles for Chinese ways of thinking, "the theory of human-environmental inter relation", in particularly, has constituted an important part of their ideological framework."[25] Zan Ning (919–1001), a well-known monk in the Northern Song Dynasty, summed up various "induction phenomena" discovered by forefathers and composed *Wu Lei Xiang Gan Zhi*. Starting from "magnet magnetizing the needle" and "amber attracting mustard," in the book, the author listed 77 phenomena of "species inducting each other likewise." Then, a total of 448 special phenomena of species mutually inducted were separately recorded on the basis of body, clothes, diet, appliance, drug, disease, study, fruit, vegetable, flower and bamboo, poultry and fish, miscellaneous works, etc. It may be called as having reached the peak of perfection in terms of listing phenomena, from thinking mode; however, it remains "one case one meeting." Comparatively speaking, ancient India enjoyed more developed philosophy and logics so some people commented that "in the country people from the king to the citizens all take studying philosophic theory as the only cause of life." [26] They are more used to deducing an "ultimate truth" to all specific objects. Therefore, in Indian medicine, the worn precious stone, flower rings, handheld umbrellas, and canes are all drugs for they have relations to health of human body and play a role in treating diseases.

4. Traces in Slangs and Folk Customs

"Men are afraid of wearing boots, while women fear wearing hats". It is a saying spreading among common people. It means that swollen feet (wearing boots) for men and swollen head (wearing hat) for women are signs that they will suffer severe diseases which will have a poor outcome. This point of view not only cannot be found in modern medicine, but not the theory of Chinese traditional medicine. However, similar records can be found in India's medical classic *Susruta-samhita.* Chapter 31, Volume 1 of it was named *Abnormality of Color and Appearance,* saying:

Without other complication, swelling feet will kill men; while swelling face or private place will kill women.

"Seven-month premature infant will live while eight-month premature infant will not."

---

[25] Keiji Yamada: Emergency of "Wu Lei Xiang Gan Zhi" and Its Way of Thinking. Jianshi. Ancient Philosophy and Science-technology Culture of East Asia [M]. Shenyang: Liaoning Education Press, 1996:126.

[26] Liang Shuming. Outlines of Indian Philosophy (Version 3) [M]. Commercial Press, 1922.

It is also a well-known saying well known among common people, which was exactly regarded as the experience of lives of people. It means that premature infant has been in the womb for 7 months can survive, while that has stayed in the mother's womb for 8 months cannot. From the perspective of modern medicine, it is easier for premature infants born at a time more approaching the due date to survive; therefore, the opinion that "Seven-month premature infant will live while eight-month premature infant will not" obviously cannot find basis in modern scientific knowledge. Generally speaking, the majority of "theories" violating the common sense and scientific laws can find theoretical basis in traditional culture but description that "Seven-month premature infant will live while eight-month premature infant will not" cannot be found in ancient Chinese medical works. However, in alien civilization, theoretical basis can be found for this argument.

In *The Treasury Book of Astronomy*[27] published in Hongwu Years of the Ming Dynasty, it says that:

In the seventh month the sun (Taiyang) is shining which is beneficial for fetus growing in the womb. When the woman is pregnant and Taiyin is the life pillar (Ming Gong) or strong, meaning that the fetus will be good at agriculture after it's born. The infant will survive if it's born in this month.

The eighth month is shined by Saturn. Saturn features coldness and dryness; therefore, nausea is severe and Qimai of the fetus is drowsy and the embryo is not so energetic as in the seventh month. Therefore, the fetus cannot be alive if it has been in the womb for only 8 months.

Another book of astronomy of the Western regions translated in the Ming Dynasty also has similar reports.[28] According to the research of Michio Yano, the master copy of *Ming Yi Tian Wen Shu* is an Arabian astronomy works. However, ancient Indian Medical classic also discussed this issue:

In the eighth month, Ojas[29] gradually and slowly moves between the mother and the fetus. Therefore, (the mother and the fetus) are healthy sometimes and weak at other times. At this time, even the fetus was born, he can't survive. This is because Ojas is not stable and consequently, the mother is also in an unstable state.

For us, it seems not necessary to study carefully whether the point of view is originated from India or Arab, because the two cultural systems had extremely frequent exchanges and integration with each other from an early time. It is enough for us just to know this idea having come from other regions. It is worth noting

[27] Journal of Beijing Tianhuaguan *The Treasury Book of Astronomy*, see the third part of Four Series issued by Taiwan Commercial Press, with the book named *Ming Yi Tian Wen Shu.*

[28] [Ming] translated by Haidaji. A postscript for 4-Volume Book of Astronomy, block-printed edition.

[29] Ojas is an important concept which is not easy to understand. It is explained in *Caraka-samhita* translated and commented by Michio Yano as existing in the heart and of a colour slightly yellow, and people will die without it. Japanese translated it as "energy element."

that the above two cases are both propagandized by means of existing in slangs and folk customs; thus, it is easy for us to neglect its nature as exotic culture and assume it is a native product of traditional culture. From the preface of the above-mentioned *Ming Yi Tian Wen Shu*: "At this time the western regions have several hundred books and people speak different languages and write different characters", we can slightly know that various cultures of the Western regions widely existed in China back then.

5. The Blood-Sucking Leech Therapy

Achieving the goal of apocenosis and getting rid of slough by means of negative pressure, in Chinese traditional medicine, was first found in Fifty-two Prescriptions for Ailments, a medical book unearthed from Mawangdui, an ancient tomb of the Western Han Dynasty in Changsha, Hunan. As the horns of animals were preliminarily used, it is called "horn law" by later generations. However, in Chinese traditional medicine (including traditional medicine of many minority nationalities), although methods of using "horn" or bamboo bank, porcelain jar, and various utensils for drawing out purulent blood can be found, there were no complete systems or theories regarding different tools having different properties and choosing different sucking tools according to pathogenesis just like Ayurveda. In particular, there is elaborate account that the leech was used as blood-sucking tools in Indian medicine.

Chapter 13, Volume 1 of *Susruta-samhita* was named "Chapter for Leech Application", and it is mainly about the methods how to use leeches to suck extravasated blood. In which, however, another two blood-sucking methods are also slightly mentioned: blood-sucking horn and calabash. This is because the whole Ayurveda takes the three doshas "vata, pitta, and kapha" as the argument basis. Although they are all methods for sucking extravasated blood, different treatment tools were adopted due to different disease pathogenesis. In conclusion, there were three tools for sucking extravasated blood: horn, leech, and calabash. Horn features moisture, appropriate for extravasated blood of "the Vata Dosha"; leeches feature coldness, appropriate for extravasated blood of "the Pitta Dosha," while calabash features dryness, appropriate for extravasated blood of "the Kapha Dosha"; when the three doshas coexist, the three objects will be used simultaneously.

As for blood-sucking by leeches, the record of using leeches for sucking purulent blood from sore and ulcer was first found in medical books of the Tang Dynasty and Chen Ziming in the Song Dynasty called it as "Qi Zheng Treatment Method" in his *Essence of Diagnosis and Treatment of External Diseases*:

For treating the ulcer at its early stage, first use a pen tube and put a leech in it with the mouth of the tube opposing the ulcer so that the leech can suck the purulent blood thus the virus will be eliminated. In case of giant ulcer, three or four leeches will be used.

In terms of time, the time for China adopting this method seems much later than India, and China has no elaborate account as in Ayurveda. As for whether any propaganda existing between the two countries, there are not any historical records (Fig. 76).

Fig. 76 Leeches sucking blood

It is interesting that in the first half of the nineteenth century, advocated by F.J.V. Broussais, a French doctor, an upsurge of using the leech as blood-sucking tools emerged in EuropeIf simply think the emergence of this phenomenon is only a case of original therapies tending to "diversely and independently occur," I'm afraid it's not always compelling enough. Because the leeches used for sucking blood back then were mainly imported: in 1827, 33 million leeches were transported into France, while the number reached 43 million in 1833.[30] Such leeches were called as Hirudo medicinalis,[31] while "Hiru" has same pronunciation as leech in Japanese (ひる, hiru). We only know that Japan's Kampo medicine learned Qi Zheng Treatment Method, and it has yet to know whether someone had been lightened from Japan (Fig. 77).

6. Increase of Drug Varieties

During the 1,000 plus years from *Sheng Nong's Herbal Classic* in the Han Dynasty to *Compendium of Materia Medica* by Li Shizhen in the Ming Dynasty, drugs recorded in works concerning Chinese herbal medicine had increased from 300 plus to nearly 2,000, and undoubtedly, many foreign drugs and experience in using drugs were absorbed. It is very difficult to seriously study which new drugs were originated from foreign culture; maybe many professional have no way to complete the task perfectly even if they devote all their life to it. For example, Lin Meicun, specialized in studying cultural exchanges between China and the

[30] Written by Wen Shimai [German] and translated by Ma Boying. 5000-Year-Long History of World Medicine [M]. Beijing: People's Medical Publishing House, 1985:128.

[31] Book Four of Concise Encyclopedia Britannica [M]. Beijing: Encyclopedia of China Publishing House, 1986:455.

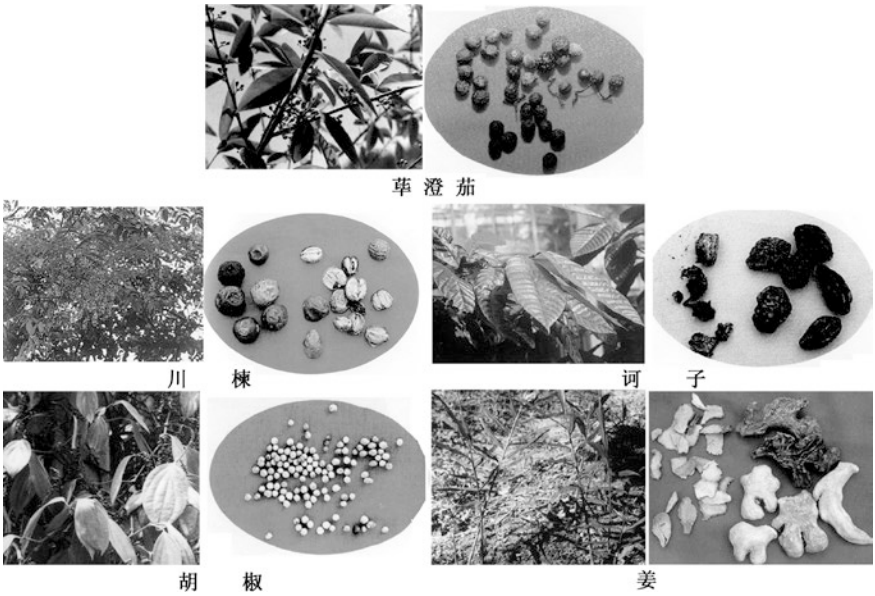


Fig. 77 Drugs favored by ayurveda. Fragrant fruits occupy an important place both in traditional Indian medicine and diet. For example, myrobalan, phyllanthus emblica, and melia toosendan are collectively named "Three Fruits"; long pepper, black pepper, and rhizoma zingiberis are collectively called "Three Pungent Materials"

Mid-Asia, although launched a special topic for discussing "flora and fauna of the Western regions in the City of Chang'an" in *West Wind Blowing the Old Road—Cultural Exchanges between China and the West Demonstrated by New Archeological Discoveries*, the discussed flora, with exception of well-known grapes, only "alfalfa" was determined.[32] Some drugs existed in *Caraka-samhita* and *Susruta-samhita* and later gradually appeared in works concerning Chinese herbal medicine such as *Tang Materia Medica* and *Classified Materia Medica* are given here as examples. At least we can feel that the prosperous Sino-India cultural exchanges in the Tang Dynasty have some relations with the increase of drugs in *Tang Materia Medica* (see Table 12).).

7. Bloodletting by Pricking Meridians of the Nose

Zhang Congzheng, one of the four eminent physicians in the Jin and Yuan Dynasties, once suffered from hot eyes and emergency of slight corneal opacity,

[32] Lin Haicun. Gu Dao Xi Feng—New Discoveries of Archaeology for Chinese and Western Cultural Exchanges [M]. Beijing: Joint Publishing, 2000:184–190

Table 12 Examples of new-increased drugs in the Post-Tang Dynasties

Drugs name in Sanskrit	Formal name	Plant/Drug name in Chinese	The first Materia Medica documents concerned
Eranda	Ricinus communis	蓖麻	Xin Xiu Ben Cao (newly revised herbology)
Aksota	Juglans regia	胡桃	Qian Jin Fang
Hingu	Ferula asafetida	阿魏	Xin Xiu Ben Cao (newly revised herbology)
Aguru	Aquilaria agallocha	沉香	Xin Xiu Ben Cao (newly revised herbology)
Marica	Piper nigrum	胡椒	Xin Xiu Ben Cao (newly revised herbology)
Haridra	Curcuma longa Curcuma aromatica	姜黄 郁金	Xin Xiu Ben Cao (newly revised herbology)
Dadima	Punica granatum	石榴	Xin Xiu Ben Cao (newly revised herbology)
Turuska	Liquidambar orientalis	苏荷香	Xin Xiu Ben Cao (newly revised herbology)
Amalaka	Phyllanthus emblica	庵摩勒	Xin Xiu Ben Cao (newly revised herbology)
Kathinjara	Ocimum sanctum	零陵香	Xin Xiu Ben Cao (newly revised herbology)
Karpura	Dryobalanops aromatica	龙脑香	Xin Xiu Ben Cao (newly revised herbology)
Kramuka	Areca catechu	槟榔	Xin Xiu Ben Cao (newly revised herbology)
Sarsapa	Brassica juncea	芥菜	Xin Xiu Ben Cao (newly revised herbology)
Cirtaka	Plumbago zeylanica	白花腾	Xin Xiu Ben Cao (newly revised herbology)
Harenuka	Piper auranticum	南藤	Xin Xiu Ben Cao (newly revised herbology)
Agnimantha	Premna spinosa	海边小树	Xin Xiu Ben Cao (newly revised herbology)
Ajagandha	Ocimum gratissimum	罗勒	Qian Jin Fang
Sirisa	Albizzia lebbeck	合欢	Xin Xiu Ben Cao (newly revised herbology)
Nirgundi	Vitex negundo	牡荆	Xin Xiu Ben Cao (newly revised herbology)
Haritaki	Terminalia chebula	诃梨勒	Xin Xiu Ben Cao (newly revised herbology)
Punnaga	Calophyllum inophyllum	海棠果、胡桐	Xin Xiu Ben Cao (newly revised herbology)
Musta	Cyperus rotundus	莎草	Xin Xiu Ben Cao (newly revised herbology)

(continued)

Table 12 (continued)

Drugs name in Sanskrit	Formal name	Plant/Drug name in Chinese	The first Materia Medica documents concerned
Rasanjana	Berberis asiatica	小蘖	Xin Xiu Ben Cao (newly revised herbology)
Pippali	Piper longum	荜拨	Zheng Lei Ben Cao
Abhisuka	Pistacia vera	阿月浑子、无名子	Zheng Lei Ben Cao
Amra	Mangifera indica	庵罗(芒果)	Zheng Lei Ben Cao
Kakkola	Piper cubeba	毕澄茄	Zheng Lei Ben Cao
Katphala	Myrica nagi	杨梅	Zheng Lei Ben Cao
Kattrna	Cymbopogon citratus	香茅、茅香	Zheng Lei Ben Cao
Karkotaka	Momordica mixta	木鳖子(木别子)	Zheng Lei Ben Cao
Sallaki	Boswellia sarrata	印度乳香、返魂香	Zheng Lei Ben Cao
Sprikka	Trigonella corniculata	葫卢巴	Zheng Lei Ben Cao
Bhurja	Betula utilis	桦	Zheng Lei Ben Cao
Revata	Cassia fistula	阿勃勒、腊肠树	Zheng Lei Ben Cao
Rohini	Picrorrhiza kurrosa	胡黄连	Zheng Lei Ben Cao
Kasamarda	Cassia sophera	茳芒	Zheng Lei Ben Cao
Simsapa	Dalbergia sissoo	印度黄檀、檀	Compendium of Materia Medica
Susavi	Momordica charantia	苦瓜	Compendium of Materia Medica
Moca-rasa	Bombax malabaricum	木棉、斑枝花	Compendium of Materia Medica
Visamustika	Strychnos Muxvomica	番木鳖、马前子	Compendium of Materia Medica

which attacks sometimes. Each time when it attacks, he suffered from photophobia and obscurity and unappeasable gall, then he visited the eye ophthalmologist Jiang Zhong'an who treated him with acupuncture and then "flipped his two nostrils with grass blade and three places bled, he nearly recovered and completely healed in 3 days." Therefore, he himself sighed: "long-term suffering is finally eliminated. Although I've studied medicine for half of my lifetime, I haven't learned this therapy. Can't I learn it?"[33] Later, he widely used this simple therapy for treating

[33] [Jin] Zhang Congzheng *Ru Men Shi Qin* Volume 1 [M]. Shanghai: Shanghai Science and Technology Press, 1959:31.

people's diseases and recorded it in his book composed when he was old for later generations to study and use.

From Zhang Congzheng's emotional sigh "although I've studied medicine for half of my lifetime, I haven't learned this therapy" and lack of record of acupoints in the nose or bloodletting in the system of science of acupuncture and moxibustion, we can see that such a therapeutic method is not the inherent content of Chinese traditional medicine. However, similar records are found in *Susruta-samhita* in which Chap. 8, Volume 3 was named Therapeutics of Bloodletting, which says:

Eye diseases such as cataracta, blepharitis, head diseases, adhimantha (severe ophthalmia) can be treated by means of puncturing veins around the nose, forehead, and outer canthus.

8. Ophthalmology

Propaganda of Indian ophthalmology-related knowledge into China can be found in many medical history books. The records are basically about in the Tang Dynasty, some Indian monk treated cataracta with acupuncture needle; the booklist included *Longshu's Treatise on Ophthalmology,* and we can see that books named *Longmu Collection on Ophthalmology by Taoist Priest Baoguang*, Secretly-Handed-down Nagajunas Ophthalmology, are passed down. However, the contents of these works are obviously combinations of Chinese and Western elements. As we do not know much about Indian ophthalmology, we have no way to study relevant impacts. Moreover, if we thoroughly understand the contents in "Chap. 19 of Ophthalmology" of Susruta-samhita, it will be possible for us to study the specific impacts.

First of all, both China and India have "Five-wheel" Theory in morphology. As "Five-wheel" Theory in treatise of TCM ophthalmology is mostly based on the five elements (fire, wood, earth, water, and metal), it is generally considered it is "new theoretical summaries of TCM ophthalmology from the late Tang Dynasty to the Song Dynasty instead of being originated from Indian ophthalmology"[34]; "It is derived from the theory of five elements"[35]; even it is taken as the basis for studying the origin and development of contents of ophthalmology works, i.e., such theories named Longmu can be identified as "Combination" of China and India, "non-Indian Books."[36] We should know that, while studying the origin and development of "Five-wheel" Theory, we should pay attention to the following two

[34] Ma Boying et al.: Sino-overseas Exchange History of Medical Culture [M]. Shanghai: Wenhui Press, 1993:153.

[35] Qi Baoyu. "Five Wheels and Eight Regions." Encyclopaedia Sinica · Chinese Traditional Medicine [M]. Beijing: Encyclopedia of China Publishing House, 1992:509. Before studying Indian ophthalmology, I adopted such a point of view in my Treatise.

[36] Ma Boying. History of Chinese Medical Culture [M]. Shanghai: Shanghai People's Publishing House, 1994:78, 2.

points: First, "wheel" of five wheels—mandla—is a word featuring extraordinary characteristics of traditional Indian culture with its original meaning of "circle, ball" and is translated into "Lun" in Chinese; its philosophical meaning is collection of objects and world image (translated into "Zase". "Mandotblw" in Chinese), which obviously has a direct relation with "caksur-indriya"—vision; its religious meaning is the place where Buddha and Bodhisattva gather (paraphrased as 轮圆具足 "Lunyuanjuzu"). Second, although TCM ophthalmology takes "Five-wheel" Theory as its most important theoretical basis, the theory was developed quite late and obvious signs of gradual improvement can be seen. For example, as said in *Longmu Collection on Ophthalmology by Taoist Priest Baoguang*: "it's also said that there are five wheels in the eyes, which are individually called wind wheel, blood wheel, air wheel, water wheel and meat wheel." However, it is also said that the wind wheel was so named not because it has a known shape"; and the blood wheel was not defined as two canthi, just saying that it belongs to heart, blood in red–black. *Longmu Collection*, an appendix of this book published in the Ming Dynasty, also says that "liver governs the wind wheel which is invisible inside; while leukoma in the eye has little red vein, it is the blood wheel that governed by the heart."[37] "Five-wheel" Theory, perfectly matched with the five elements and the five internal organs, was first found in *Yin Hai Jing Wei* composed in Sun Simiao's name[38] and various ophthalmology works in the Ming and Qing Dynasties. However, *Yin Hai Jing Wei* has the famous prescription "Double Resolution Powder" created by Liu Wansu, a doctor in the Jin Dynasty, and has the content "I say: the immortal Sun say …", showing that the book was completed quite late. In summary, construction of TCM ophthalmology and "Five-wheel" Theory matched with the five elements and the five internal organs appeared later than multiple "Longmu Ophthalmology," with no composer noted, passed down in the Song and the Yuan Dynasties, or we can say that it is transformed on this ground.

Second, it is the therapeutic method. Indian ophthalmology mainly considers whether crystalline lens (the fourth patala) are health or not in terms of ocular diseases, which naturally resulted in sound external treatment (including emergency of cataract extraction), but it has no way to get rid of visual disturbance caused by other reasons (such as ocular fundus diseases) and has to blame it on supernatural pathogenesis. Compared with it, traditional Chinese medicine mainly focuses on viscera functions in treating ocular diseases; therefore, although in the same times featuring lacking comprehensive scientific cognition of visual physiology and pathology, the former (India) turned to the supernatural interpretation and put it down as "immedicable"; and the latter established the therapeutic method based on viscera functions. Hence, this is the strong points and shortcomings as well as characteristics of these two eye knowledge systems. After Indian ophthalmology

[37] Taoist Priest Baoguang et al.: Secretly-Handed-down Nagajunas Ophthalmology [M]. Beijing: People's Medical Publishing House, 1958:78, 2.

[38] Wen Yuan Ge Si Ku Quan Shu.

was introduced into China, apart from accepting the therapeutic method of cataract removal with acupuncture needle, traditional Chinese medicine was also greatly influenced in terms of operative treatment such as hooking, cutting, and cauterization. Hooking and cutting therapies found in various books are basically the same as the above-mentioned operative treatment of Indian ophthalmology, and the explanation to use of cauterization therapy, in particular, is completely consistent with the foresaid "burning with the fire and the disease will not reoccur." Just as said in Volume "pterygium" of *Yin Hai Jing Wei*: "using cauterization therapy after cutting it so as to prevent it to reoccur"[39]; It says in *Shen Shi Yao Han* (Precious Book of Ophthalmology) that "After cutting it, cauterization should be used for completely curing it or it will soon reoccur"; it is said in *Mu Jing Da Cheng* (a complete book of ophthalmology) that: "if it grows again after being cut, cauterization therapy should be used for completely curing it."[40]

It is safe to say that after learning from the other's strong points to offset its weakness in operative treatment, TCM ophthalmology started to see fairly obvious development, forming the structure of attaching equal importance to pharmacotherapy (internal and external treatment) and operation. Pharmacotherapy has always been the strong point of traditional Chinese medicine and may have only absorbed some prescriptions of Indian ophthalmology in aspect of eye drops for external use,[41] but it is difficult to indentify which one is traditional and which one is exotic.

As for disease names, it is hard to say whether they are directly influenced by Indian ophthalmologists, back then "all ophthalmologists say there are 72 eye diseases," but "when asking what these eye diseases are, they can hardly speak out half of the famous disease cases."[42] The statement in *Longshu's Treatise on Ophthalmology* may exert a certain indirect stimulation on differences of eye diseases and increase of number of disease names, but more importantly, as the operative treatment such as cataract removal, hooking, cutting, and cauterization has been accepted, naturally, the differentiation of pathological changes would be simultaneously affected, and as a result, various names of cataracta and external oculopathy appeared which did not exist in the past for differentiating symptom characteristics and therapeutic method.

---

[39] [Ming] Fu Renyu. Shen Shi Yao Han (Precious Book of Ophthalmology). Volume 1. "Gou Ge Zhen Lao Yi Jie Shen Lun" [M]. Shanghai: Shanghai People's Publishing House, 1959:29.

[40] [Qing] Huang Tingjing. Mu Jing Da Cheng Book 1 of Volume 1 "Gou Ge Zhen Lao" [M]. Beijing: TCM Ancient Books Publishing House, 1987:46.

[41] Que Ming's Yi Shou Yan Ke "Modification" says: "Famous doctors gathered for giving treatment, the disease was not cured; a Taoist was recruited to treat the eyes with drugs and the disease was cured in half a month (with the middle part omitted), the Taoist then granted this book and asked Zhenwu to make such drugs for treating patients, and numerous blind people far and near can see again." (See Cao Bingzhang. Great Achievements of Chinese Medicine Vol. 23, Shanghai Science and Technology Press, 1990).

[42] Taoist Priest Baoguang et al: Secretly-Handed-down Nagajunas Ophthalmology [M]. Beijing: People's Medical Publishing House, 1958:78, 1.

From the ophthalmology works passed down, although various direct and indirect impacts of Indian ophthalmology can be found, all these were absorbed after having been restructured. All ophthalmology works named with Longmu are not translated ones. It can be perceived that propaganda of medical knowledge is quite different from that of Buddhist Sutra translation, which may mainly be propagandized by means of oral instruction and demonstration. Moreover, mentality of considering a certain knowledge as inherent in local nationality also existed back then. For example, when discussing hooking, cutting, acupuncturing, and cauterization in *Mu Jing Da Cheng* (A complete book of ophthalmology), it says: "the original method of hooking, cutting, acupuncturing and cauterization were formed by imitating nine needles of Huangdi (the Yellow Emperor, a legendary Chinese ruler), it's heard that it's obtained from Mr. Hua Tuo in the Han Dynasty or Longshu Shan Ren, yet it's unknown which one is true"[43]; it clearly describes in *Shen Shi Yao Han* (Precious Book of Ophthalmology) after having elaborated cataract removal method that "highlighting therapy of cataract removal with acupuncture needle in Longmu Lun (Nagajunas Ophthalmology)," and then, it says that "therapies of hooking, cutting, acupuncturing, cauterization were all originated from H ua Tuo," "The needle is not flint needle but needle for acupuncturing pupil." In addition, there is another category of works thoroughly rejecting accepted operative treatment, such as *Yi Cao Ting Mu Ke Quan Shu, Yi Shou Yan Ke*, and *Yin Hai Zhi Nan*. Cao Bingzhang (1877–1956) in the Republic of China, while compiling *Great Compendium of Chinese Medicine*, only included the above-mentioned three books concerning ophthalmology. If it is not for satisfying the psychological need of maintaining purity of national culture, he might consider those contents are not rational knowledge of "traditional Chinese medicine."

It seems that the exotic things cannot be soundly circulated until they are transformed without any traces. However, whatever happens, we should say that the history of integration of Indian ophthalmology into traditional Chinese medicine took positive factors, i.e., digestion, absorption, transformation, and restructure as the main forms.

9. Tibetan medicine and traditional Mongolian medicine under the Bodhi tree

The Tri-doshas of "vata, pitta, and kapha" of Ayurveda were nearly intactly "duplicated" into China's Tibetan medicine theories. By means of the following introduction of "the Tri-doshas" in Tibetan medicine,[44] it is believed that we cannot only understand the close relations between the two systems of medicine, but further deepen the cognition of "the Tri-doshas" by virtue of relevant explanations in Tibetan medicine.

---

[43] [Qing] Huang Tingjing. Mu Jing Da Cheng (A complete book of ophthalmology) Volume 1 "Gou Ge Zhen Lao Yi Jie Shen Lun (The View of Hooking Cutting, Acupuncturing and Cauterization Methods Should Be Used Careful)" [M]. Shanghai: Shanghai People's Publishing House, 1959:29.

[44] The following introduction concerning Tibetan Medicine is all cited from Chinese Traditional Medicine Overview compiled by Chen Shikui, Cai Jingfeng [M]. Beijing: China Press of Traditional Chinese Medicine, 1997:108–112.

Tibetan medicine thinks that the three primary elements of rLung, mKhris-pa, and Badkan are the material basis for human body and also the energy and basis indispensable for life activities. In the normal physiological state, the three elements maintain a coordinated and balanced relation in human body; therefore, it is physiological. Whenever any element or a few elements of the three is/are too prosperous or weak due to some reasons, they will become pathological; thus, rLung pathosis, mKhris-pa pathosis and Badkan pathosis will appear. Therefore, when treating the diseases, the three elements need to be adjusted to restore them to the coordinated state and reach the healthy level.

RLung is the force driving human body's vital functions, closely related to various functions of life activities. Its functions are somewhat similar to "Qi" in Han People's traditional Chinese medicine, but not totally the same. In the light of different functions and locations, RLung falls into the following five categories (see Table 13 for the comparison between five categories of RLung and Ayurveda's "five types of Vata").

mKhris-pa is characterized by the quantitative and qualitative characteristics of heat and is the source of many splanchnic functions of human body, featuring the nature of "fire" of traditional Chinese medicine. This is a kind of fire or heat necessary for physiological activity, different from fire-pathogen concerned with diseases. MKhris-pa falls into five distinct subcategories based on specific locations and functions (relevant comparison is omitted).

Badkan is characterized by the characteristics of water and soil, keeping a close relation with substance and functions of body fluid, grume, and other fluid in human body. Someone translated Badkan as sputum or grume. "Phlegm" here means the normal matter existing under normal physiologic condition, instead of sputum appearing under the pathological conditions. Badkan falls into five distinct subcategories in the light of their locations and functions (Relevant comparison is omitted).

Besides, Tibetan medicine considers that human body has seven "basic substances" and "three filths." The seven substances are food nutrient, blood, muscle, fat, skeleton, marrow, and semen; the three filths are excrement, urine, and sweat. Actually, this statement is also originated from Indian medicine.

"Since the sixteenth century, *The Four Medical Tantras*, a classic of Tibetan medicine, has been widely, systematically and comprehensively introduced into the Mongolia regions in the form of the monastic education with Tibetan Buddhism. In the middle period of the seventeenth century, Zayabanzhida·Namuhaizamusu, a Mongolian and a Junggar scholar, translated *The Four Medical Tantras* from Tibetan to Mongolian. And it was published by means of wood engraving. In the eighteenth century, the wood engraving version of Beijing, the Qing Dynasty translated by Nao erjigexi · Minzhuerdaoerjimeng of yellow flag, was published, becoming a must-read reference book for Mongolian doctors."[45]

[45] Su Nuo. Tibetan Medicine and Mongolian Medicine under Bodhi Tree [M]. Beijing: The Ethnic Publishing House, 2001:78.

Table 13 Comparison of "Five Types of Vata" and "Five Categories of RLung"

Name		Location		Function	
Ayurveda	Tibetan medicine	Ayurveda	Tibetan medicine	Ayurveda	Tibetan medicine
Prana Vayu	Srog-'Dzin rLüng	Heart, encephalon, face, chest, ear, nose, tongue	The top of the head (moving between the throat and the chest)	"The giver of life"; breathing, swallowing; maintaining heart, spirit, sense organs, rationality; normal functions of arteries, veins and nerves	Governing swallowing, respiratory movement, salivary secretion, sneezing, burping, jogging and increasing the memory, making the sense smart and keen, maintaining normal mental state
Udana Vayu	Gyen-rgyu rlung	Throat, lung, navel Up to neck and nose; down to navel	Chest (moving between nose, tongue and throat)	Sound production; language, singing; upward tendency; maintaining physical strength; strengthening spirit, memory, and rationality	Governing sound production, keeping the face rosy, radiant and energetic, making people in high spirits and think well
Samanasamana	Me-mnyam rlung	Heart	Heart (moving through the whole body)	Regulating functions of blood vessels and circulatory system; distributing nutrients and blood to the whole body	Governing limb movement, flexion and extension and walking, opening and closing of eyes and mouth, governing language and thinking
Apana Vayu	Khyab-Byed rLüng	Large intestine and viscera in internal pelvimetry	Anus (moving in the lower part of the body; large intestine, bladder, perineum, inner side of the thigh etc.)	Relieving the bowels, excretion of menstruation, maintaining of 9-month gestation period	Governing excretion of semen, menstruation and bowels-relieving, and control of defecation and delivery process etc.
Vyana vayu	Thur-Sel rLüng	Stomach, small intestine, naval Activity and the whole intestinal tract	Gastral cavity (moving between various Zang-Fu organs)	Accelerating the role of digestive ferment; accelerating gastric secretion; assimilation and transportation of digestion; transportation of dross	Governing digestion support, secreting and separating essence and dross, accelerating development and maturity of blood

Mongolian medicine's "Three-Element Theory" and division of the "three elements", i.e., "Heyi, Xila, and Badagan," respectively, into five subcategories, are undoubtedly the copy of "rLung, nKhris-pa, and Badkan" of Tibetan medicine and their origin can be traced back to the "three elements" of Indian medicine. Besides, "seven essences" of Mongolian medicine (nutrient, blood, muscle, fat, skeleton, marrow, and semen) and "three filths" are also the same, and it is unnecessary to go into details (Figs. 78 and 79).

3.3 From "Chinese Prescription" to Know Acceptance, Transformation, and Innovation of Chinese Medicine in Foreign Countries

Japan has traditional medicine called "Chinese prescription." However, is "Chinese prescription" the copy of Chinese traditional medicine or traditional medicine unique to Japan? Out of question, the parent of "Chinese prescription" is Chinese traditional medical knowledge, but "Chinese prescription", featuring same origin and different branches with Chinese medicine, is an innovation product undergone selective absorption and transformation. *Overlooking Kan bo the Japanese Traditional Medicine* is a book I wrote in recent years which studies and introduces Kampo medicine history, published by Taiwan Eastern Great Book Company in 2007 (Fig. 80). If you have interest in knowing more and researching development history of Japan's "Kampo medicine," you can find it and have a look. The followings are some contents of this book.

Fig. 78 Visual image of "Four-tower" theory of traditional Dai medicine. Seeing from its "earth, water, fire, and wind," it is obviously influenced by the "four-element theory" of Buddhism

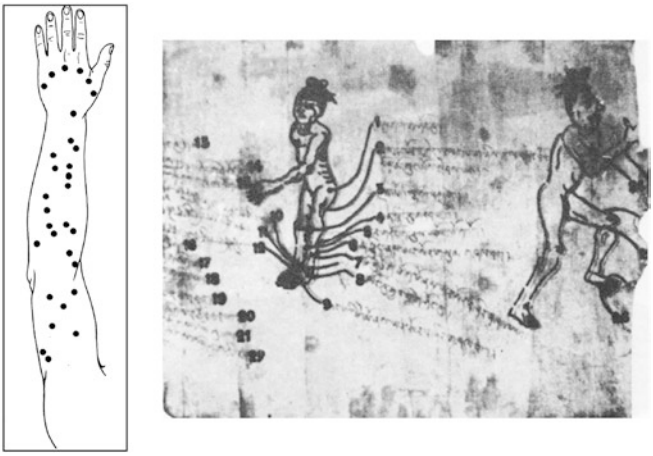


Fig. 79 India's "Marmans" and relevant records in Tibetan. Medicine ayurveda thinks that there are a hundred-plus "marmans" (*left*) in human body, any damages to them will lead to death. Similar records are also found in documents of Tibetan medicine (*right*). The "acupoint" and "vital point" translated in Chinese are different from "acupuncture point" of traditional Chinese medicine

Fig. 80 Overlooking Kan bo the Japanese traditional medicine

3.3.1 Ways of Absorbing Chinese Culture

Introduction of Chinese culture into Japan had different characteristics in different historical periods which were divided into the following four phrases by Mr Yan Shaodang:

1. Form of communication featuring communications between different races as the natural channel (Asuka Period and Nara Period, the sixth to the eighth century);
2. Form of communication featuring nobles, intellectuals as the main body (Heian Period, end of the eighth century to the twelfth century);
3. Form of communication featuring Zen monks as the main body (Gozan Period, the thirteenth century to the sixteenth century);
4. Form of communication featuring business as the main channel (Edo Period, the seventeenth to the nineteenth century).[46]

As for the first phase featuring communications between different races as the natural channel, first, the time for its emergence was much earlier than Asuka Period and Nara Period. It is said that at an early time, some people from the mainland of China successively moved to Japan for different reasons. For example, Emperor Qin dispatched Xu Shi (having similar pronunciation as Fu and mostly written as Fu today) to go to Japan with virgin boys and virgin girls for panacea; however, Xu Shi did not return and the tomb of Xu Shi still remains in Japan up to now. Ancestors of Japanese developed "Jomon culture" featuring gathering fruits and fishing to agricultural production period, featuring agricultural farming as the main production, and people generally think that the direct reason is the migrants from Korean Peninsula. But for the question whether there are Chinese people in these migrants and whether there is any China-based composition in culture, advanced technologies brought by migrants, the answer is naturally positive. Second, although at a certain phase, there is a certain communication method specially worth noting, there are some other forms coexisting. Mode of cultural communication with human beings as the carrier, in particular, has always been existed at any times.

The communication method featuring nobles, intellectuals as the main body, serves as a link between past and future. "The primary members of Japanese missions to the Sui Dynasty were descendants of Chinese; and Japanese missions to the Tang Dynasty also put Chinese in an important position; the ruling class of Yamato Imperial Court was mainly composed of eight clans, i.e., Chen, Lian, Gong, Zhi, Zhao, Shou, Shi, and Chunzhu which all have blood relationship of Chinese."[47] The most well-known Danbo Family in Japanese medicine development history is also descendants of Chinese.

---

[46] Yan Shaodang. Research on Dissemination of Hanji (classics of the Han Dynasty) in Japan [M]. Nanjing: Jiangsu Classics Publishing House, 1992.

[47] See Yan Xixiong's Judging the Far-reaching Influence of Sino-Japan-Korea Exchanges from Various Historical Facts. Including Historical Trace of Japanese Culture by Wang Yong, Wang Baoping[M]. Hangzhou: Hangzhou University Press, 1991:1–12.

Although people and books have always been the main media for cultural communication, people of different identities will communicate different cultural contents. At the age of monks serving as media for cultural communication, books brought back to Japan were mainly Buddhist sutras (called "Inner Classics"), while "Outer Classics" concerning politics, history, literature, natural science, and other aspects were quite limited. In Volume 55 "Content Part" of Taisho Shinshu Daizokyo, there are *Changxiao Heshang Qing Lai Shu Mu*, *Huiyun Lv Shi Shu Mu Lu*, *Xin Shu Xie Qing Lai Fa Men Deng Mu Lu*, *Fuzhou, Wenzhou, Taizhou Qiu De Jing Lv Lun Shu Ji Wai Shu Deng Mu Lu,* etc., but there were seldom books concerning technologies, only a few of them, such as *Wu Zang Liu Fu Tu* (internal organs internal organs diagram), *Qi Yao Li* and *Mi Lu Yao Fang*. According to statistics of Zheng Pengnian, during the 20 years of Tempyo Period (729–748), there were only 43 "Outer Classics" introduced into Japan, of which only 3 are medical books:[48]

Jing Dian Shi Wen, Xin Xiu Ben Cao (Newly Revised Herbology), Tai Zong Huang Di Ji (Collection of Emperor Tai Zong), Tian Guan Mu Lu Zhong Wai Guan Bu Fen,

*Xu Jing zong Ji, Jun Chen Ji Yao Chao, Shi Shi Xing Guan Bu Zan, Yao Fang(*Prescription*), Wen Gui,*

Zheng Lun (political comments), *Di De Lu* (Records of Emperor's Virtue), *Shi Er Jie* (Twelve Warnings), *An Guo Bing Fa* (An Guo State's Warcrafts), *Rang Guan Biao, Nei Gong Shang Zhan*,

Yao Lan, Zhi Yong Ju Fang (Prescriptions for treating ulcer), *Hui Bei Zhan* (Divining According to Comet), *Jun Lun Dou Zhong Ji, Di Li Bing Shi Ji Mu Lu*,

Qun Zhong Ji, Ming Hang Lun (statements of Emperor Ming of Tang), *Di De Song* (Ode to Emperor's Virtue), *Zhi Guan Yao Lu, Tian Wen Yao Ji Sui Xing Zhan*,

Rui Biao Lu, Qing Rui Biao, Dun Jia Yao, Jun Tian Zhi Le, Shang Jin Hai Biao, Bu Zan,

Sheng Xian (sage), *Tai Yi Jue, Yu Li* (Jade Calendar), *Shi Lun, Yu Xin Ji* (Yu Xin's Collection), *Gu Jin Guan Mian Tu,*

Dong Lin, Chuan Zan Xing Jing, Jiu Gong, Tui Jiu Gong Fa, Huang Di Tai Yi Tian Mu Jing, *Tian Wen Yao Ji* (Figs. 81 and 82).

However, it is quite different in Edo Period featuring commerce and trade as the main channel of communication and a great number of pragmatic works related to the people's livelihood were quickly introduced into Japan. According to research conducted by Mayanagi Makoto, Chinese medical books introduced in Japan

[48] Zheng Pengnian. History of Japan Borrowing Chinese Culture [M]. Hang Zhou: Hangzhou University Press, 1999:58–59.

Fig. 81 Zheng Cang Yuan treasure house

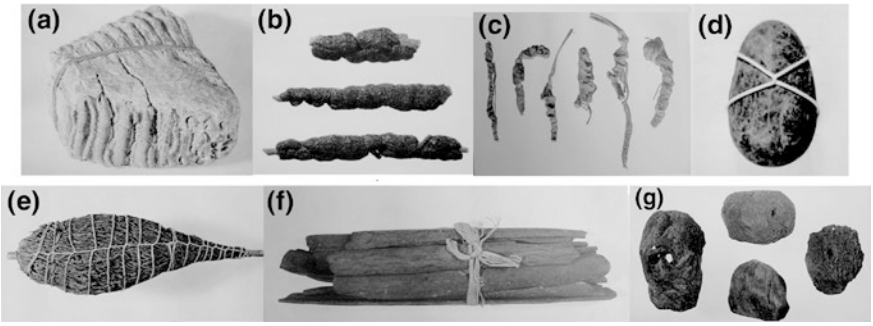


Fig. 82 Pictures of some drugs housed in Zheng Cang Yuan. **a** Five-color Long Chi. **b** Purple. **c** Ginseng. **d** Realgar. **e** Polygala root. **f** Cortex cinnamomi. **g** Rheum officinale

during the Edo Period were up to 980.[49] Take Ji Lai Shu Mu[50] of No. 29 Nanjing Ship in Xiangbao's 4-year reign (1719) as an example, books brought to Japan one time reached up to 52 categories and 198 volumes. Of which, one-third are

[49] Mayanagi Makoto, Tomobe Kazuhiro. General Catalogue of Years in Which Chinese Medical Books Were Introduced (Edo Period)[J]. Japan Research Series 7, 1989:151–183.

[50] In Edo Period, for taking strict precautions against introduction of books on Catholicism and own needs of trade business, ships entered into the port just needed to present the list detailing the carried books; therefore, they left "booklists obtained for many times" which are the so-called first-hand original documents. After sorted by Osamu ooba, they were included into Research Periodical Series for the Institute of Oriental and Occidental Studies, Kansai University (I) (1967, not for sale).

Fig. 83 Ancient pictures describing treating disease with acupuncture

medical books, totaled 18 categories and 70 volumes (the number behind the name of the book refers to the amount of the volume):

Ben Cao Hui Yan 5, *Ben Cao Bei Yao* 3, *Jing Yue Quan Shu* 6, *Shang Han Zhi Jie* 2, *Plain QuestionsLing Shu* 2,
Jing Nang Mi Lu 3, *Ben Cao Hui Zuan* 5, *Shi Shi Mi Lu* 5, *Yi Fang Ji Jie* 10, *Zheng Zhi Da Huan* 3,
Zhang Shi Yi Tong 1, X*ue Shi Yi An* 1, *Jin Kui Yao Lue* 5, *Yi Zong Bi Du* 10, *Compendium of Materia Medica* 5,
Qian Jin Fang (Thousand Pieces of Gold Formulae) 1, *Ben Cao Zeng Bei Yao* 1, *Plain QuestionsLing Shu Lei Zuan Yue* 2 (Figs. 83 and 84).

3.3.2 Relations Between Medical Schools and Traditional Chinese Medicine in Modern Times

Due to the geographical convenience, Japan first obtained general medical knowledge originated from the mainland by means of Korean Peninsula, i.e., the so-called Korean Prescription in works concerning Japanese medical history. Around the fifth century, when members of Japan's imperial family were ill, most of them went to see doctors in Silla and Baekje, etc., situated on Korean Peninsula back then. For example, in 414, Komu-ha-chimu-kamu-ki-mu from Silla was invited to go to Japan for treating Emperor Ingy; later, Delai, Wangyoulengtuo, Panliangfeng, and Dingyoutuo from Baekje successively came to Japan for serving as doctors.[51] Introduction of "Korean Prescription" enabled residents on Japanese islands to look at diseases and therapeutic action in a new way—realized that diseases may arise from residence and diet, internal causes such as pleasure, anger, sorrow and joy and external causes based on climate changes; and their

[51] Fujikawa Yū. Japanese Medical History [M]:17.

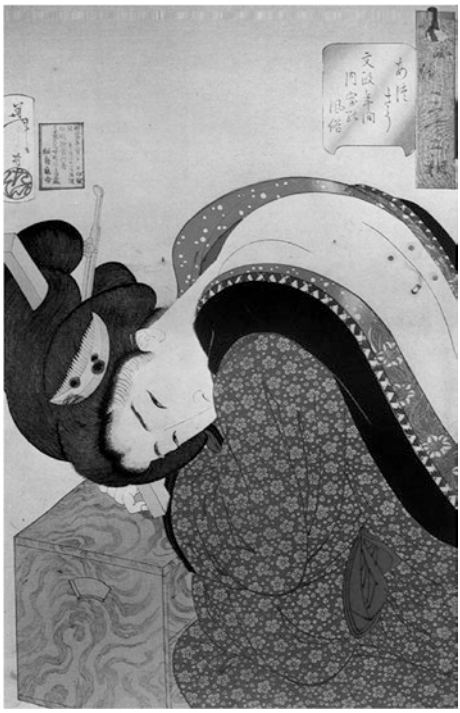


Fig. 84 Ancient pictures describing treating disease with Moxibustion therapy

therapies also became eating cakes, drugs, etc., taking the first step from witchcraft to scientific medical treatment (Figs. 85 and 86).

It is generally acknowledged direct introduction of Chinese medicine into Japan started from 562, when Zhicong, from Wu State, brought 160 volumes of books concerning ancient Chinese prescriptions, medical herbs, and acupuncture

Fig. 85 National Treasure "Monk Jianzhen's Statue" famous sitting statue of Jianzhen made of dried paint which describes Jianzhen's posture when he was alive Jianzhen reached Japan on December 20, 753

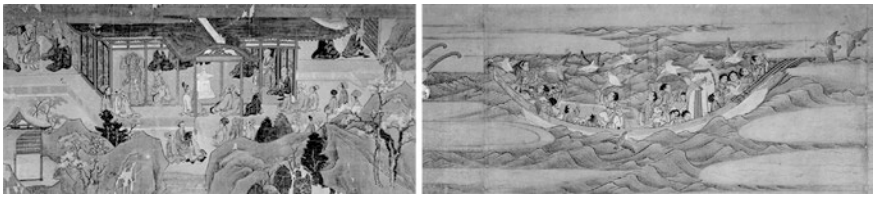


Fig. 86 "Dong Zheng Hui Zhuan." Works of Kamakura Period (the thirteenth century) housed by Toshodaiji famous for panorama describing Jianzhen's life. The *left picture* describes Jianzhen giving a lecture in Daming Monastery, Yangzhou; the *right one* describes the scene of various birds welcoming Jianzhen during his journey to Japan

and moxibustion. Most works on Japanese medical history regard it is the beginning of introducing foreign medical books, especially books on acupuncture and moxibustion, into Japan. In fact, Emperor Wen Di of the Liang Dynasty previously presented a set of Zhen Jing (an acupuncture classic) to Emperor of Japan in 552. Later, this set of books was granted to Jihebian Duotumi, who was also sent to Silla for specially learning acupuncture and returned to Japan in 642 (the first year of the reign of Kogyoku), becoming the first Japanese doctor of acupuncture.[52] During the Sui and Tang Dynasties, Japanese officials and monks were not afraid of hard work and risked their lives to sail across the sea for learning advanced political national policies and technological culture. In 608, Japanese Ono no Imoko was sent to the Sui Dynasty on a diplomatic mission, accompanied by pharmacist Kusushi Enichi and Kusushi no Enichi. Kusushi Enichi and Kusushi no Enichi had learned medicine in China for 15 years and then returned to Japan; and Kusushi no Enichi had stayed in China for learning medicine for 31 years.[53] Later, Kusushi Enichi visited China again in 630 and 654. Meanwhile, Chinese monks represented by Jianzhen also visited Japan for spreading medical knowledge. During the Tempyo Period when Emperor Uda ruled over Japan, Fujiwara no Sukeyo, upon the emperor's command, compiled *Catalog of Books Extant in Japan*, recording 1309 volumes of Chinese medical books existing in the palace back then.[54] Tanba Yasuyori, doctor of medicine, compiled the most important medical works 30-volume *Yi-shin-hou* back then in 984 just based on these medical books (Fig. 87).[55]

---

[52] Fujii, Naohisa. Medical Culture Chronology [M]. 14, 7.

[53] Wu Yuechang et al. Brief History of Sino-Japanese Medical Exchange[J]. Fujian Traditional Chinese Medicine, 1982(1):44.

[54] Hattori Toshirō. Study of Japanese Medicine of the Heian Period [M]. Tokyo: Yoshikawa Kōbunkan, 1955:129.

[55] 81 Chinese medical books were cited in *Yi-shin-hou*. However, the historical view considering a book a pure "imitation" by reason of that this book has no personal experience or opinion of Yasuyori has already behind the times. It is because from the contents selected by this book and its difference from compiling style of similar Chinese medical books (for example, "acupuncture and moxibustion" comes before internal medicine, external medicine, gynecology and pediatrics), and it can be seen that they are similar in one aspect but different in other aspects.

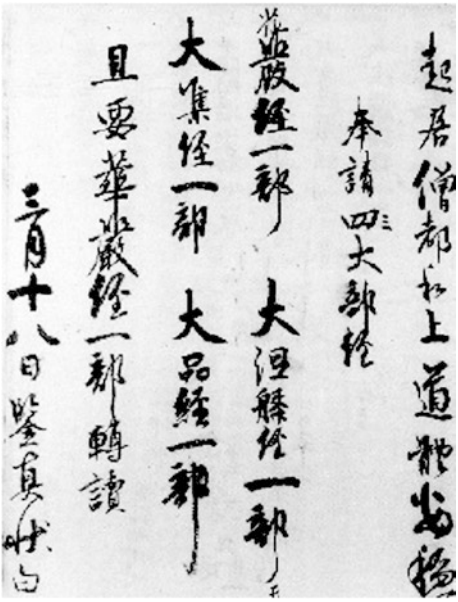


Fig. 87 Zheng Cang Yuan Treasures. Document on borrowing scriptures from Todai-ji temple in 745 (Tenpyō-shōhō 6). Although it is signed by Jianzhen, there are still some questions whether it is signed by himself or not

In addition, establishment of medical system also followed the example of China. *Code of Taiho*, enacted in 701, was the first legal system formulated by Japan through following the example of China, which was revised in 718 (Yōrō 2 during the reign of Empress Gensh) and called *Pension Decree.* Of which, there is a "decree on medicine and disease," including a total of 27 articles, which definitely regulates selection of qualified doctors, especially medical education and examinations; and the teaching materials are all Chinese medical books (Figs. 88, 89, 90 and 91).

When coming to the so-called modern times of historical stages of Japan, Japanese medicine gradually stepped into the stage of localization, which is also the most brilliant phase of Kampo medicine—with knowledge becoming available for common people, three famous medical schools emerged based on selectively absorbing Chinese medicine.

1. Gosei School

The emergence of this medical school can best reflect the characteristic of "lagging behind" of Japanese culture, i.e., a certain issue, system, or thought, and theory tends to emerge in Japan a period later than in its origin place, not because of time required for experiencing the process of self-accumulation and development. As a beginning, Sanki Tashiro went to China in the Ming Dynasty for study in 1487 (Chōkyō gannen) and returned to Japan with various medical works of the Ming Dynasty 12 years later, representing that the state-of-the-art thoughts and treatment technologies of "Medicine in the Song and Ming Dynasties" in China

Fig. 88 Tanba Yasuyori. His ancestor is a Zhi King, great-great-grandson of Emperor Ling of Han, who submitted to the rule of Japan with citizens of seven family names when Japan was under the reign of Emperor Ojin for running away from social upheaval. Later, he lived in Tanba Province and then took Tanba as his surname. Yasuyori (912–955) studied medical skills and was a doctor of medicine, and he was on the scroll of fame for compiling *Yi-shin-hou*

back then were firstly and generally accepted by medical circle of Japan, which became a common practice with promotion of Manase Dousan, a pupil of Sanki Tashiro. Meanwhile, more and more doctors, headed by Dousan, resumed secular life, forming a new group of doctors called "Confucian physician" in the society. Japanese academia, however, does not speak highly of Gosei School and thinks that it is the "outcome of following Chinese medicine" (Figs. 92, 93, 94 and 95).

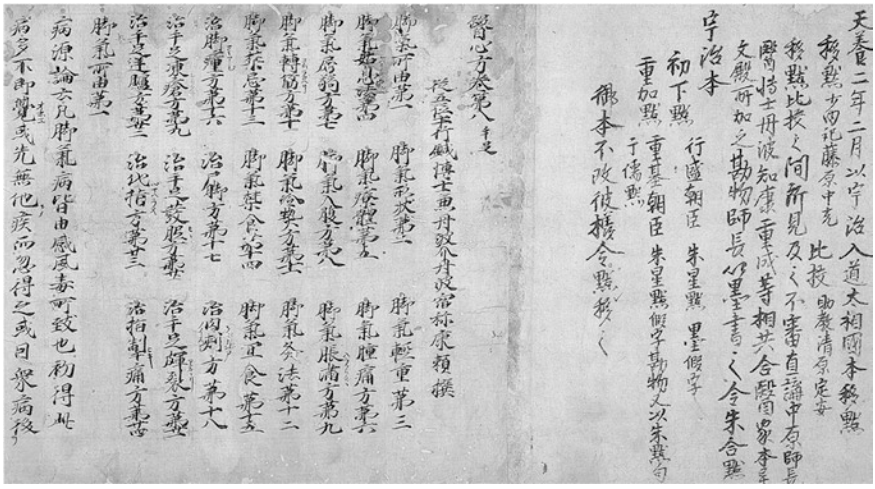


Fig. 89 Illustration in Yi-shin-hou

Fig. 90 It is composed by Tanba Yasuyori, doctor of medicine, completely on the basis of Chinese medical works in 984

Fig. 91 Wooden Statue of Sanki Tashiro. *Ben Chao Yi Tan* by Nasu: "Though there are many famous doctors in our country, only statues of Jianzhen and Sanki Tashiro were made and worshiped since the ancient time"

2. Koho School

"Koho School" refers to a group of doctors who thoroughly denied all basic theories of Chinese medicine such as yin–yang and five-element philosophy, channels, and viscera and opposed the Song–Ming medicine, respecting exclusively *Treatise*

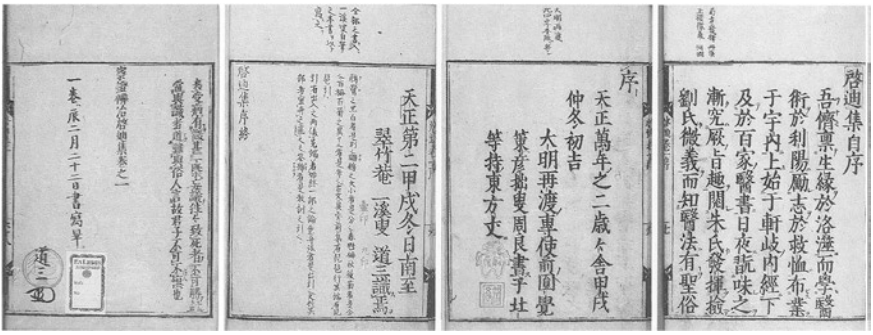


Fig. 92 *He Ji Ji*, magnum opus of Sanki Tashiro (in 1225). It can be seen that name of his drugs used hidden numbers

Fig. 93 Manase Dousan (1507–1594), began to learn from Sanki Tashiro, who studied abroad in China and returned to Japan, since 1531 and then engaged himself in diagnosis and treatment and disseminating Li-Zhu medicine in Kanto, greatly boosted his reputation. In 1546, he opened an "Enlightenment School" in Kyoto in order to recruit students for giving lectures. During the 20 plus years, he fostered a total of more than 800 students, widely disseminating Li-Zhu medicine and his personal academic opinions

on Cold-induced Febrile and Miscellaneous Diseases composed by Zhang Zhongjing of the Han Dynasty. No doubt the emergency of this school has close relations with "back to the ancients" trend of Confucianism, but since the ancient times, many innovations were conducted in the name of restoring ancient ways—Koho School of Japan also aimed at establishing new medicine not limited to

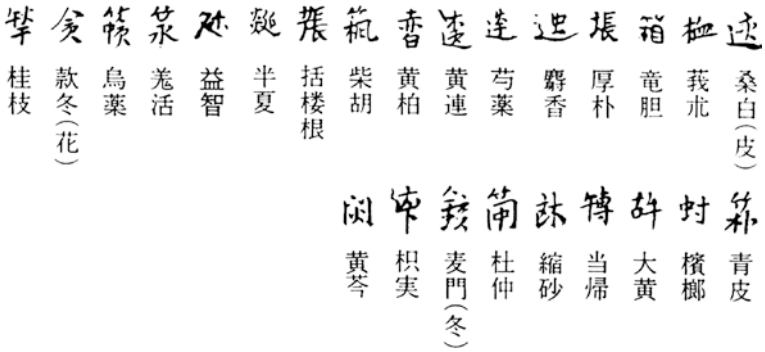


Fig. 94 *Enlightenment collection*. The contents of the main academic works of Manase Dousan can be traced back to *The Yellow Emperor's Classic of Internal Medicine* and medical books of various schools, which especially highlights theories and therapeutic methods in medical works of the Song, Yuan, and Ming Dynasties such as *Pi Wei Lun* (Treatise on Spleen and Stomach), *Ge Zhi Yu Lun*, *Dan Xi Xin Fa*, and *Yi Xue Zheng Zhuan*

Zhang Zhongjing under the name of returning to empirical medical spirit of Zhang Zhongjing.[56] As Koho School has two fundamental characteristics, "scientificity" highlighting empirical experience and "originality" of Japanese medicine, it was spoken highly of by Japanese historians.

The theory "stagnation of Qi" created by Gotou Konzan, the founder of Koho School, had a direct relation with relevant arguments in *Spring and Autumn Annals of Master Lü Buwei,* while the argument of the first representative figure Todo Yoshimasu that "the only source of all illness is poison" was also exactly the same as "Gong Xie Lun", composed by Zhang Congzheng, one of the famous four doctors in Jin and Yuan Dynasties (i.e., Liu Wansu, Zhang Congzheng, Li Gao, and Zhu Zhenheng)

3. The School of Compromising

Nakagawa Shutei (1771–1850), living in the late Edo Period, described comments of people on "Koho School" and "Gosei School" back then:

If someone has diseases, just as there is a thief in the house. Koho School only seeks to drive the thief away without considering whether the house survives or perishes; while Gosei School holds to guard its house without daring to ask whether the thief is gone or not (Fig. 96).[57]

Therefore, it is inevitable and natural that "School of Compromising" emerged which adopted strong points of the two above-mentioned schools both in terms

[56] Comprehensive Books on Kampo medicine in Modern Times [M]. Tokyo: Masterpiece Publication, 1979–1984: Volume 13. "Commentary" written by OTSUKA Yasuo.

[57] Yi Fang Xin Gu Bian. Volume 1, see Book 112, Comprehensive Books on Kampo medicine in Modern Times.

Fig. 95 Todo Yoshimasu (1702–1773). Among the famous doctors of Koho School, Todo Yoshimasu is the one worth most attention and understanding for he has academically reached the peak of perfection, set up a new banner and aimed at revitalizing "doctrine of general medicine." The so-called general medicine was originated from *Rites of Zhou*, which records medicine and doctors back then in four categories—general medicine, ulcer medicine, diet medicine, and animal medicine. "General medicine" is equivalent to internal medicine today. Todo Yoshimasu took the position of adopting "sages' opinions of history" and restoring ancient ways, thinking that doctor Bian Que (a famous doctor in ancient China) in the pre-Qin period was the representative of general medicine and his successor was Doctor Zhang Zhongjing in the Han Dynasty. Thereafter, due to prosperity of yin–yang and five-element philosophy, fairy arts of Taoism, the doctrine of general medicine became extinct. Therefore, the goal for which Todo Yoshimasu had struggled with the pursuit for all his life can be summarized into a sentence, reviving the doctrine of "general medicine," which had a history of more than 2,000 years but became extinct since the death of Zhang Zhongjing, the writer of *Cold-induced Febrile Diseases*, and enabling the medicine to go back to its own way! In aspects of "learning" and "skills," Todo Yoshimasu showed unique characteristics, so he was the representative figure boasting the most influence and bearing the most bouquets and brickbats in the Koho School. Wu Xiusan, chairman of Yibei Medical Association and doctor of medicine, said when evaluating various celebrities of Koho School: "The one stands out among various famous figures is Mr. Todo Yoshimasu"

of theories and clinical practical treatment. It is generally acknowledged that the forerunner of School of Compromising who intended to learn from the two abovementioned schools' strong points to offset its weakness so as to perfect therapeutic methods was Mochizuki. Later, there were famous scholars such as Sūrankan and Taijun Wada from Kyoto and Yamada Seichin, Taki Genkan from Tokyo who attached great importance to literature textual criticism and research. However, in

Fig. 96 Hanaoka Seishu (1760–1835)

my opinion, Hanaoka Seishu (1760–1835), in particular, was worth noting for he had sought for Hua Tuo's Mafeisan (anesthetic) for all his life and was famous for successfully operating excision of breast cancer under anesthesia, which was the first case in the world.

Hanaoka Seishu's key idea was "combination of internal and external causes into one with a thorough inquiry into the innate laws of things"; besides esteemed traditional Chinese medicine, he absorbed medical skills of the Netherlands, hence becoming "Hanaoka Branchu" of "School of Compromising" of traditional Japanese medicine. His student Honma Sôken's "Lectures on Skills of Doctors" indicated judgment on basic medical value (living things), ways of pursuing studies (thorough inquiry into the innate laws of things, widely learning others' strong points, experiment), body and function [valuing Xuan Qi (Yellow Emperor and his official Qibo), without excluding techniques of Manmo (backward tribes around the world)], and other various basic ideas:

I stand for "a thorough inquiry into the innate laws of things", valuing Xuan Qi while not believing all of their books, hating Manmo but not rejecting all their techniques, widely learning others' strong points all around the world, always conducting experiments so as to save people's lives, this is skills of doctors of the Divine Land (a poetic name for China) (Figs. 97 and 98).

Doctors sitting on the hedge between Koho School and Gosei School belonged to "the school of textual analyses"; this is because they attached great importance

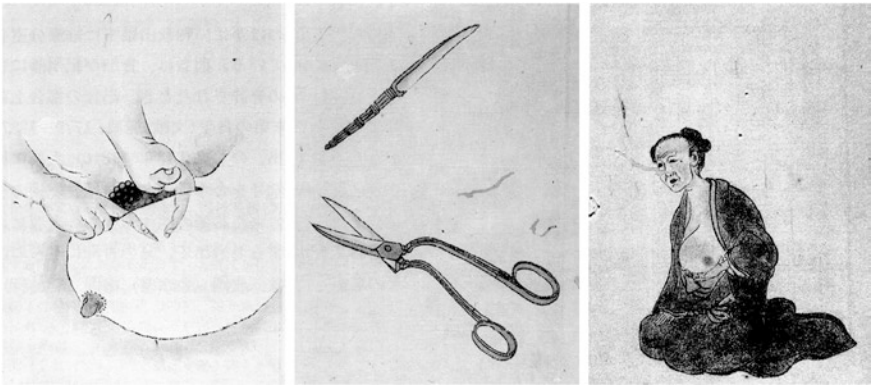


Fig. 97 Beast Cancer Atlas describing Lumpectomy

Fig. 98 Lower Limb truncation surgery for gangrene suffer of Sôken

to document research and could equally treat various medical theories and therapeutic methods for the only purpose of "treating diseases." For example, many doctors of the school of textual analyses conducted research on weights and measures for fully understanding drug measurement in *Cold-induced Febrile Diseases.* Their researches on ancient medical literature were highly praised by Chinese doctors.

3.3.3 From the Theories of Tai Ji, Yin–Yang to the Method of "Abdominal Palpation Diagnosis"

As systematic abdominal palpation diagnosis contents cannot be found in Chinese traditional medicine, Japanese scholars always proudly highlighted that "abdominal palpation diagnosis method" was born (invented) in Japan and developed (systematized) in Japan and we can boast the essence of Japanese unique diagnostic

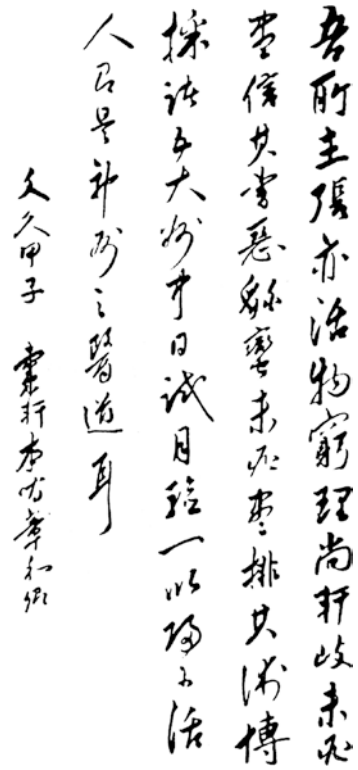


Fig. 99 Honma Sôken

method to the world (Figs. 99, 100 and 101).[58] And they think that the method of adopting abdominal palpation diagnosis instead of pulse-taking for diagnosing diseases throughout the body were created by those doctors who were skilled but knew little theories. However, through studying various early works on abdominal palpation diagnosis, we found that they not only had respective theoretical frames, but were full of ultimate origins of Tai Ji, vitality, theories concerning yin–yang, spleen, and kidney, and essence function of congenital factors, and acquired disposition. If compared with other medical works of Gosei School which highlighted theories, early works on abdominal palpation diagnosis were by no means weaker, but rather even better in terms of theories. The impressive one was exactly the specific process of freely using abstract conceptions such as Tai Ji and yin–yang for establishing theoretical framework and diagnosis principles of abdominal palpation diagnosis. In other words, the forming of abdominal

[58] See Volume 1 of Traditional Japanese Medicine Abdominal palpation diagnosis Series, Osaka: オリエント Publishing House, 1994 “Commentary” of Kazuo Matsumoto carried on the frontispiece.

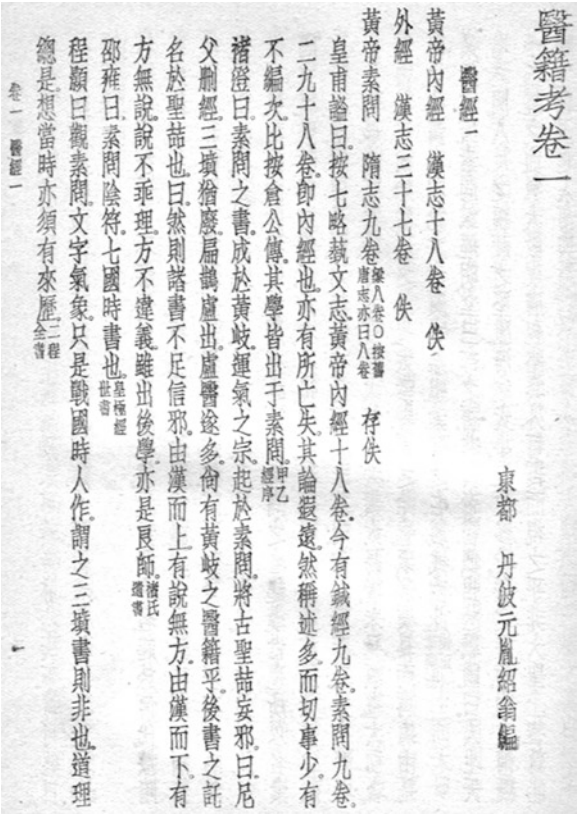
Fig. 100 Taki Genkan (1755–1810). Descendants of Tanba family changed their surname as "Taki." Therefore, they had been doctors for generations. Genkan and his son Yuanjian, Yuanyin were all writers with prolific works. Thus, in a sense, when it comes to the school of textual analyses emerged in Japanese traditional medicine during the mid-Edo Period and lasted to early days of Meiji Period, we nearly talk about the achievements and history of Taki Family in this period

Fig. 101 Daogui (knife-shaped medicine measuring vessel) of ancient style restored by Taki Yuanjian. He aimed at precisely measuring the so-called medicine of one Daogui in the ancient time so as to use the ancient prescriptions in *Treatise on Cold-induced Febrile and Miscellaneous Diseases*

palpation diagnosis is actually a process of actualizing these virtual ultimate truths on the "abdomen" (Figs. 102, 103, 104, 105 and 106).

3.3.4 Typical Cases of Religious Medicine Integrating Chinese and Indian Medicine and Buddhism

Eisai (1141–1215), a monk living in Kamakura Period, became immortalized by writing *Drinking Tea for Life Cultivation* and reputed Monk Doctor. On the other hand, among various works on "tea culture," comments concerning Eisai and his important historical status and role can be found, he was not only the disseminator of Chinese tea culture, but the forerunner of Japanese "tea ceremony." Treating diseases with tea was interpreted by Eisai as follows:


醫籍考卷一

東都 丹波元胤紹翁編

醫經一

黃帝內經 漢志十八卷 佚

外經 漢志三十七卷 佚

黃帝素問 隋志九卷 發八卷○按舊唐志亦曰八卷 存佚

皇甫謐曰。按七略藝文志。黃帝內經十八卷。今有鍼經九卷。素問九卷。二九十八卷。卽內經也。亦有所亡矣。其論遐遠。然稱述多而切事少。有不編次。比按倉公傳。其學皆出于素問。甲乙經序

褚澄曰。素問之書。成於黃岐。運氣之宗。起於素問。將古聖喆妄邪。曰。尼父刪經。三墳猶廢。扁鵲盧出。盧醫遂多。尙有黃岐之醫籍乎。後書之託名於聖喆也。曰。然則諸書不足信邪。由漢而上有說無方。由漢而下有方無說。說不乖理。方不違義。雖出後學。亦是良師。褚氏遺書

邵雍曰。素問陰符。七國時書也。皇極經世書

程顥曰。觀素問。文字氣象。只是戰國時人作。謂之三墳書則非也。道理總是。想當時亦須有來歷。二程全書

卷一 醫經一 一

Fig. 102 *Yi Ji Kao* (textual research on medical books) by Taki Yuanyin, included in *Medical Series of Han People* in 1936, which was printed in single version successively for two times later in the name of *Zhong Guo Yi Ji Kao* (textual research on Chinese medical books) by People's Medical Publishing House, hence becoming a must reference book for Chinese researchers

1. Heart dominates among five zang viscera; and all diseases originate from heart;
2. The five flavors enter into five zang viscera and heart favors bitter. However, pungent, sour, sweet, and salty are always found in diet, while bitter lacks;
3. Therefore, if heart becomes weak, the five zang viscera will become ill;
4. Bitter is necessary for treating heart disease, while tea is the top choice of bitter; therefore, we should drink tea;
5. Always drink tea for getting bitter so that heart will become strong and five zang viscera will become strong, hence energetic and strong (Figs. 107, 108 and 109).

This is the logic of "Drinking Tea for Life Cultivation" expounded by Eisai. It is not hard to see that thoughts and comments of Eisai integrated Buddhist astrology and worldly medical theories and "heart" of the religion with "heart" of the human body. The "Xin" (meaning core, heart in Chinese) referred in "All diseases

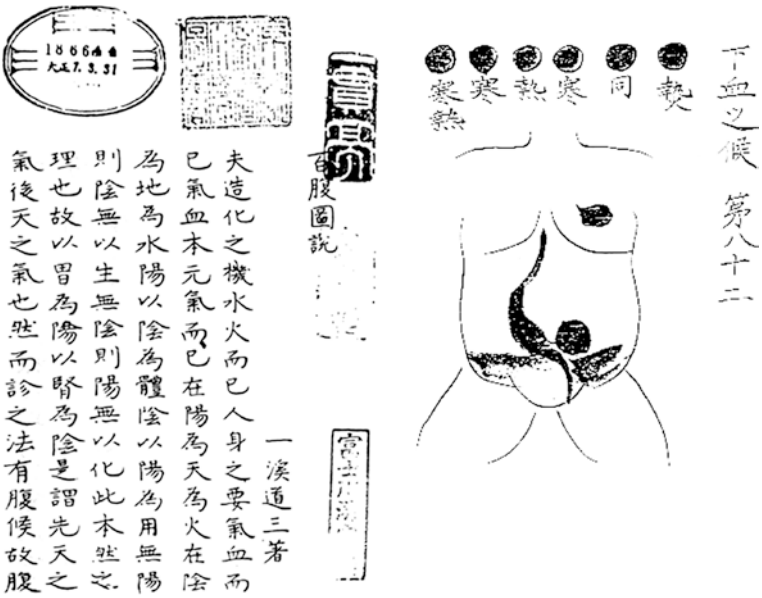


Fig. 103 "Front Page" and "Abdominal palpation diagnosis Picture" of *Bai Fu Tu Shuo,* the earliest abdominal palpation diagnosis works

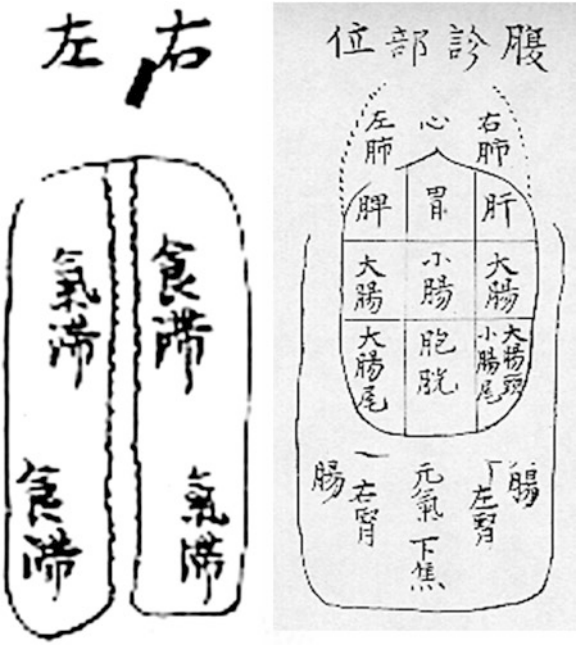


Fig. 104 Pictures on Wu Yun Zi diagnosing back and abdomen. A story of abdominal palpation diagnosis originated from Wu Yun Zi was circulated in Japan, and this is because the works named *Wu Yun Zi Abdominal Palpation Diagnosis* was handed down in the world. Wu Yun Zi was surnamed Wang with Ning as his first name, who submitted to the rule of Japan in Keian (1648–1651) and died in Japan in 1660

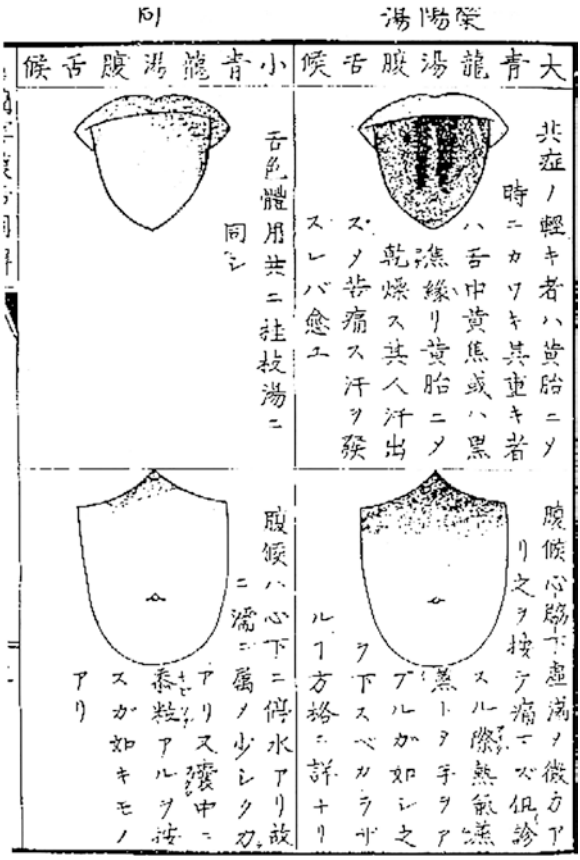


Fig. 105 Works concerning abdominal palpation diagnosis and tongue diagnosis, indicating the integration of the two diagnosis methods of China and Japan

were related to Xin" was obviously not the "heart" of the human body, besides, the "Xin" treated with bitter was obviously not the "Xin" of religion, origin of all diseases—soul. Anyhow, medical theories of this structure were partly originated from Chinese medicine.

3.4 Influence of Introduction of Western Medicine on Traditional Medicine

The historical facts that modern Western medicine was introduced into China since the late Ming and early Qing periods had already been repeatedly stated in many works, and it will not be detailed here. However, what kind of influence did the introduction of another medical system exert on traditional Chinese medicine? Recalling well-known comments on this issue, they are mainly bitter hatred toward how traditional Chinese medicine was destroyed and suppressed,

Fig. 106 "Abdominal Palpation Diagnosis Picture" in *Rare Cases of Abdomen Diseases*

Fig. 107 Eisai Statue (housed by Jufukuji Temple)

Fig. 108 Printed matter of *Drinking Tea for Life Cultivation* (housed by Buddha Tooth Relic Temple and Museum)

how Western medicine censured traditional Chinese medicine with mechanical materialism of "natural science" and how current systems on education, test, and health care go against existence and development of traditional Chinese medicine. Although I quite understand and respect the feelings of all Chinese cultural quintessence defender, I hope they can objectively and deeply think about what kind of impacts had been exerted on traditional Chinese medicine by "science" and how long such impacts will last. Because only with such attitude is rational and scientific and true love for the quintessence of Chinese culture (Figs. 110, 111 and 112).

3.4.1 Positive Influence in Logical Thinking and System Arrangement

Since introduction of modern western logics, "Mohism," famous doctrine in pre-Qin Period but having been forgotten by countrymen for many years for their ignorance, has been attached great importance again, someone began to explain its logical proposition. Introduction of Western medicine similarly had analogical potential influence. As long as we seriously have a look at publications and works on traditional Chinese medicine of the Republic of China, we can find that how people engaged in traditional Chinese medicine built the complete systems of traditional Chinese medicine from theories to etiology, pathology, acology, and pharmacology by imitating stylistic rules and layout of Western medicine. From imitation of compiling style, we can see that doctors of traditional Chinese medicine were actually and unconsciously learning logicality of Western medicine's thinking and learned how to look at the problems and logical arrangement thinking as a doctor. Is not this "impact of science on traditional Chinese medicine"? Is this a kind of impact beneficial?

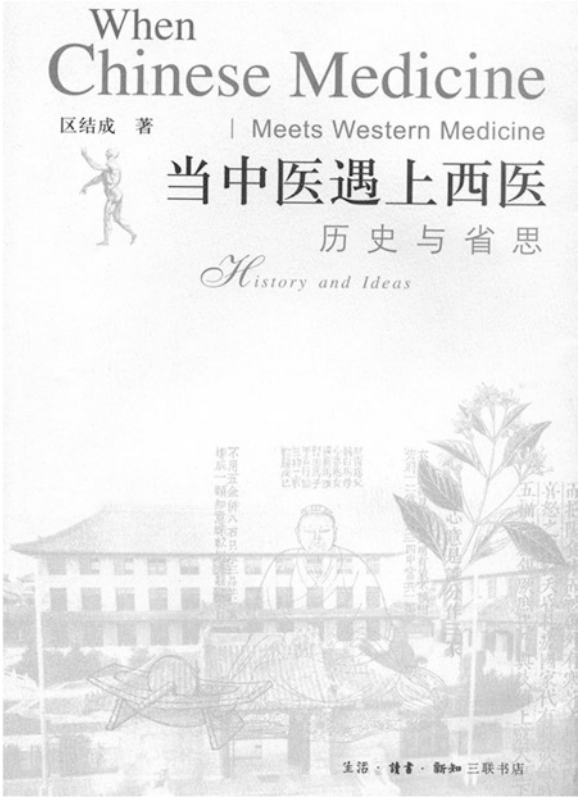


Fig. 109 *When Traditional Chinese medicine meeting with Western medicine*, composed by Qu Jiecheng, a Hong Kong doctor, in which many opinions attracted wide attention of scholars in the mainland

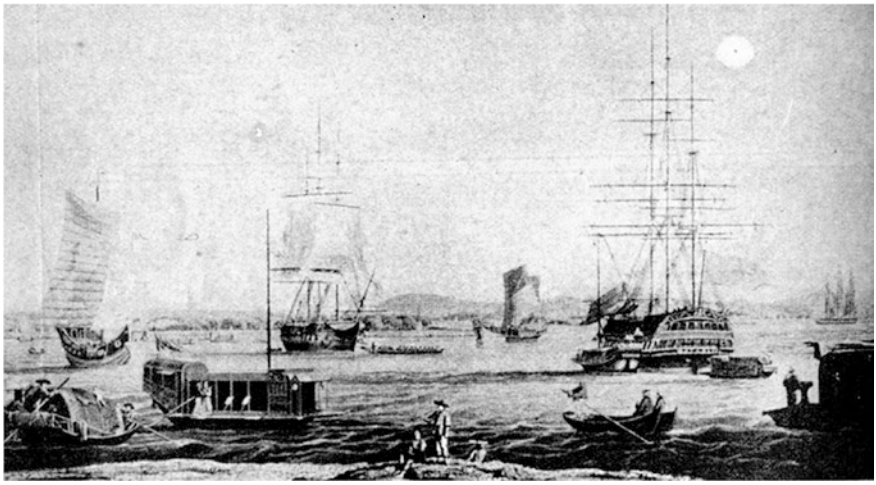


Fig. 110 India company ships at East dock of Huangpu in 1807. Smallpox vaccination was introduced into Macao, China by doctors on the ship of this company in 1805

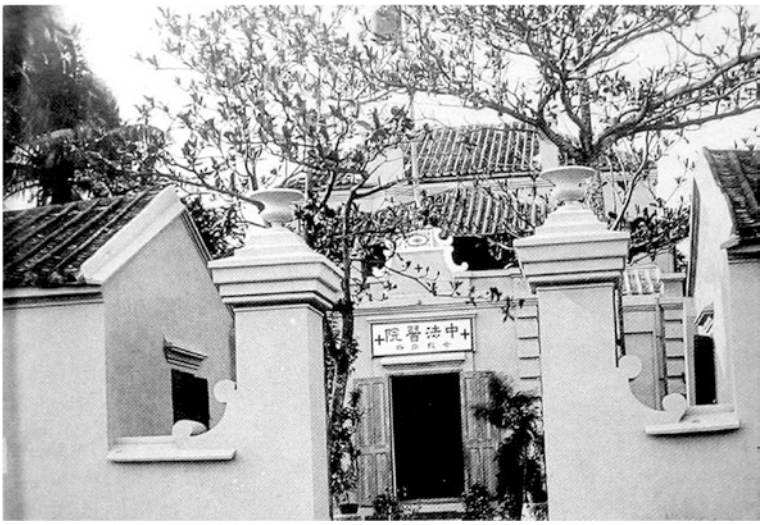


Fig. 111 Sino-French hospital in Mengzi County of Yunnan Province, photographed in 1923

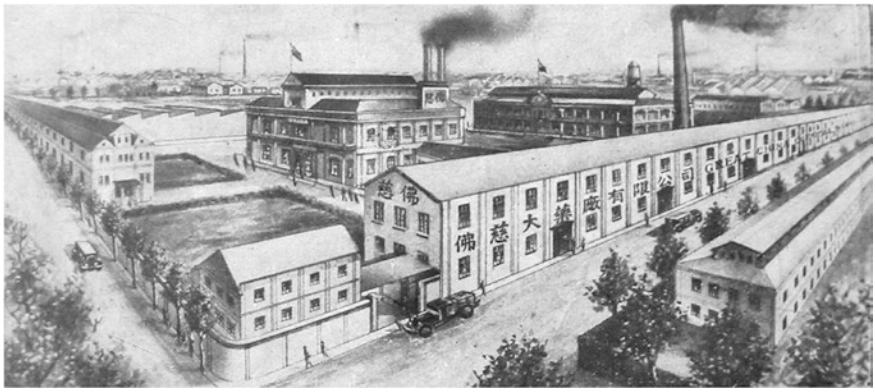
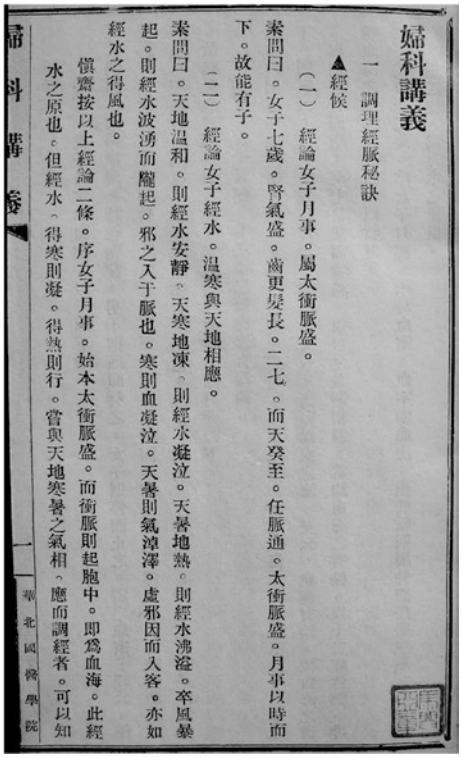


Fig. 112 Pharmaceutical factory of modern China: panorama of first factory of Foci Pharmaceutical Factory

3.4.2 Positive Influence of Basic Physiological Knowledge

Introduction of Western medicine enabled all doctors of traditional Chinese medicine conscientiously or unwittingly to have obtained a great deal of basic life science knowledge (Fig. 113). For example, before introduction of modern scientific knowledge, doctors of traditional Chinese medicine did not know that heart will beat, but explain the apex beat which can be touched at the left breast as "beating of large gastric collateral will slightly stir clothes, named as Xu Li" (see *The Yellow Emperor's Classic of Internal Medicine*). This is because back then, in the


婦科講義

一 調理經脈秘訣

▲經候

（一） 經論女子月事。屬太衝脈盛。

素問曰。女子七歲。腎氣盛。齒更髮長。二七。而天癸至。任脈通。太衝脈盛。月事以時而下。故能有子。

（二） 經論女子經水。溫寒與天地相應。

素問曰。天地溫和。則經水安靜。天寒地凍。則經水凝泣。天暑地熱。則經水沸溢。卒風暴起。則經水波湧而隴起。邪之入于脈也。寒則血凝泣。天暑則氣滓濁。虛邪因而入客。亦如經水之得風也。

儀齋按以上經論二條。序女子月事。始本太衝脈盛。而衝脈則起胞中。即爲血海。此經水之原也。但經水。得寒則凝。得熱則行。嘗與天地寒暑之氣相。應而調經者。可以知

婦科講義 一 華北國醫學院

Fig. 113 *Gynecology Teaching Materials* of North China College of Chinese Medicine

Qi–blood circulation physiology constructed on the basis of imagination, energy produced by diet sent to the stomach and digested was regarded as source of life power. Therefore, meridian theory of traditional Chinese medicine thought that starting point of channels is stomach instead of heart; as a result, in the aspect of judging life or death, all ancient works hold that body temperature and breath are key criteria and never mention to touch the heart whether it is beating (So was Song Ci, the greatest medicolegist). As another example, Wang Qingren, a doctor in the Qing Dynasty who was showered with praise for engaged himself in anatomy, also did not know the relations between the kidney and uropoiesis, just like doctors in the Qin and Han Dynasties, he thought that urine seeped from small intestine into neighboring bladder. Up to today, doctors of traditional Chinese medicine, no matter boasting how pure they are, they have owned such basic knowledge; and all of them are unconsciously using disease names which did not exist and could not exist in the past such as hepatitis, nephritis, and hypertension. The reason I highlight importance of "disease names" is that disease names conceal the different cognition of nature of disease and etiology. The knowledge structure of doctors of traditional Chinese medicine has changed significantly, which was undoubtedly the consequence of science's subtly influence on doctors of traditional Chinese medicine (Fig. 114).

Fig. 114 Two kinds of works of Ding Fu Bao, a famous scholar

3.4.3 Introspection and Cognition of One's Own Characteristics

Only after the introduction of Western medicine, vasculature of human body (including arteries and veins, lymphatic vessel), complete picture of nervous system, and argumentation on functions of five viscera and six entrails, could doctors of traditional Chinese medicine understand their own meridian doctrine was not about blood vessels and further think about what were main and collateral channels and what were viscera in traditional Chinese medicine; and on that basis, they built the so-called fundamental theory frame of traditional Chinese medicine that is different from modern medicine, including meridian-collateral theory and viscera-state doctrine. For example, in 1958, Ministry of Public Health entrusted Nanjing University of Traditional Chinese Medicine and other units to compile *Essentials of TCM*, which explains the problem of what is five viscera and six entrails as follows (Fig. 115):

Although viscera generally mentioned in books on traditional Chinese medicine have the modern meanings of internal organs of the body in some aspects, they mainly refer to various phenomena externally demonstrated by internal organs. In other words, various physiological and pathological phenomena on the surface of the human body can be incorporated into the reach of various internal organs according to their characteristics"; "It's just because names of internal organs generally referred to by traditional Chinese medicine don't always refer to various internal organs themselves, but mainly refer to the phenomena of internal

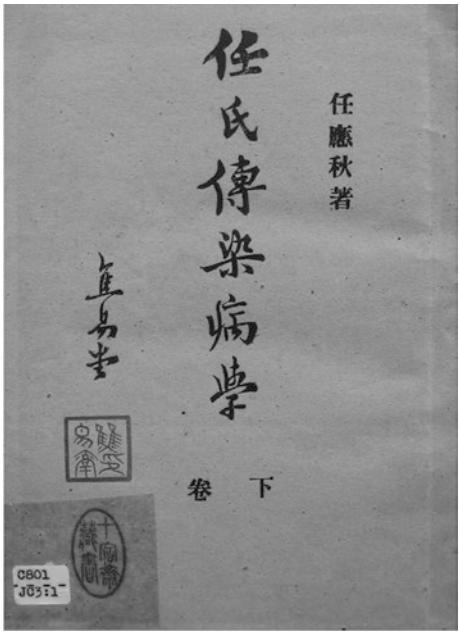


Fig. 115 *Lemology* by Ren Yingqiu, educator of traditional Chinese medicine in modern times

organs; therefore, we cannot judge it with the concept of internal organs in modern sense.[59]

As another example, although doctors of traditional Chinese medicine like to say that their most prominent characteristic and biggest difference with doctors of Western medicine are "diagnosis and treatment based on an overall analysis of the illness and the patient's condition"—i.e., determining the therapeutic method based on "symptom (such as deficiency, excess, coldness, and heat) abstracted by comprehensively considering various disease manifestations, physical quality, and conditions such as being wifeless, having no husband, poorness, or richness, instead of taking stopgap measures and say that it is the therapeutic principle established by Zhang Zhongjing, a well-known doctor in the Han Dynasty. However, actually, this concept was explicitly raised in the foresaid *Essentials of TCM*. In other words, without the introduction of Western medicine, there would be no concept of diagnosis and treatment based on an overall analysis of the illness and the patient's condition" with such connotation. Because in Chinese, the Chinese character "Zheng (evidence)" originally had the same meaning as "Zheng (symptom)"; besides, doctors did not have the consciousness of differentiating the two of them—whether deficiency, excess, coldness and heat, or stomachache, dizziness all are disease names coexisted in medical books. Meridian theory no

[59] Nanjing University of Traditional Chinese Medicine. Introduction to Chinese Medicine[M]. Beijing: People's Medical Publishing House, 1959:53.

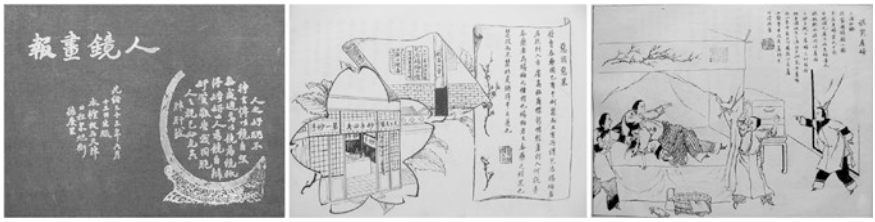


Fig. 116 Critical descriptions of "Doctors in the past" in modern pictorials

longer includes contents such as "collaterals are visible from body surface and channels are deep in the body," "the blue of arteries and veins indicates coldness and red indicates heat" described in *The Yellow Emperor's Classic of Internal Medicine*; five viscera and six entrails, respectively, become "a physiological unit"; the summary of concept of "diagnosis and treatment based on an overall analysis of the illness and the patient's condition" which can best demonstrate characteristics of traditional Chinese medicine is exactly the impact of science on traditional Chinese medicine (Fig. 116).

3.4.4 Pressure is Also a Driving Force

Although introduction of Western medicine had truly exerted a certain pressure on doctors of traditional Chinese medicine, who, for the purpose of safeguarding their own survival and seeking for countering through development, they actively opened various schools, focusing on talent cultivation, created various publications and academic groups for studying academia, translated works on Japanese Kampo medicine, developed national medicine, etc., demonstrating unprecedentedly

Fig. 117 Product of the times: "New Traditional Chinese Medicine"

aggressive self-improvement situation in "solemn and stirring" feelings. If we have enough space to detail these impacts and analyze corresponding results, and the opinion of "destroying traditional Chinese medicine" will inevitably be collapse of itself (Fig. 117).

References

1. Yamagiwa K (1898) On Dermatophytosis. Houbunsha, Tokyo
2. Yu F (1941) History of medicine in Japan. Nisshin Shoin, Tokyo
3. Yu F (1979) Outline of medicine in Japan. Heibonsha, Tokyo
4. Anzai Y (1942) Story of Famous Doctors in the Meiji era[M]. Ryuginsha, Tokyo
5. Anzai Y (1943) Study of Confucian Doctor in Japan[M]. Ryuginsha, Tokyo
6. Fujii N (1942) A chronology of medical culture. Nisshin Shoin, Tokyo
7. Hattori T (1945) Study of Japanese medicine of the Nara period. Yoshikawa kobunkan , Tokyo
8. Hattori T (1955) Study of Japanese medicine of the Heian period. Yoshikawa kobunkan, Tokyo
9. Hattori T (1964) Study of Japanese medicine of the Kamakura period. Yoshikawa kobunkan, Tokyo
10. Hattori T (1971) Study of Japanese medicine of the Muromachi-Azuchi-Momoyama period. Yoshikawa kobunkan, Tokyo
11. Hattori T (1978) Study of Japanese medicine of the Edo period. Yoshikawa kobunkan, Tokyo
12. Hattori T (1981) Study of Japanese medicine: other words. Kagaku shoin, Tokyo
13. Ishihara (1963) Medicine of Japan: origin and development. Shibundo, Akira Tokyo
14. Nagahama (1964) Outline of medicine in Japan. Sogensha, Okasama
15. The History of Science Society of Japan (eds.) (1965) Complete history of science and technology in Japan, vol 24 "Medicine"(1). Daiichi Hoki Shuppan Kabushishi Kaisha, Tokyo
16. Geibi Medicine Society (1970) Complete Works of Yoshimasu Todo. Shibunkaku Shuppan, Kyoto (re-engraved version of 1970)
17. Japan Society of Medical History (1978) Illustrated catalog of medical culture history in Japan. San'ichi Shobo, Tokyo
18. Yakazu D (1979) Ebb and flow in publication of books and magazines on Kampo Medicine in Meiji, vol 110. Shunyodo, Tokyo
19. Yamada S (1980) History of imperial doctors. Shibunkaku Shuppan, Kyoto
20. Shizu S (1982) History of medical treatment in Japan. Shoseki Kabushiki Kaisha, Tokyo
21. Seizo Y (1983) The history of dermatophytosis: before the invention of vitamin. University of Tokyo Press, Tokyo
22. Taku S (1983) Study of medical specialist appointment in ancient times. Hosei Daigaku Shuppankyoku, Tokyo
23. Taku Shinmura (1985) Study of history of medical treatment and society: civilian life and medicare from ancient times to middle ages. Hosei Daigaku Shuppankyoku, Tokyo
24. Mori J (1985) Story of Taki family. Shibunkaku Shuppan, Kyoto
25. Yoichiro N (1988) History of disease in Japan. Yûzankaku shuppan, Tokyo
26. Soda H (1989) Illustrated history of medical culture in Japan. Shibunkaku Shuppan, Kyoto
27. Haruo K (1993) Sexual diseases in Edo period. San'ichi Shobo, Tokyo
28. Pan G, Fan Z (1994) Kampo medicine. China Press of Traditional Chinese Medicine, Beijing
29. Kure S (1923) Series of doctor sages. Shibunkaku Shuppan, Kyoto
30. This series consists of 7 volumes, including 18 titles of monographs on medicine and miscellanies, starting from the perspective of "broadest interpretation of the so-called psychiatry"
31. Chen C (ed) (1936) Imperial Chinese medicine series. World Journal Book Store, Shanghai

32. This series includes 14 volumes, and each volume includes several writings in Chinese of Japanese physicians from modern times. The 14th volume mainly includes monographs and theses of modern scientific research in medicine. Its compilation and publication concurred with the promulgation of Traditional Chinese Medicine Ordinance by the National Government of Republic of China in the 25th year. Therefore, it is "intended as a translation of overseas research for reference and a necessary step for carrying forward Chinese medicine"
33. The Japan Academy (ed) (1978) History of medicine in Japan before Meiji. Information Center for Ancient Japanese Medical Literatures, Tokyo (updated and re-engraved version of 1978)
34. This book consists of five volumes, with each volume independently published by the Japan Society for the Promotion of Science in the 1955–1964 period, and subsequently updated and re-engraved in 1978 by Information Center for Ancient Japanese Medical Literatures. The book includes 19 monographs of: introduction, anatomy, disease, physiology, pathology, internal medicine, surgery, trauma, treatment, gynecology, ophthalmology, mouth and teeth, ENT, forensic medicine, biography, chronology and other special histories. Otsuka K, Yakazu D (eds) Complete Collection of Current Books on Kampo Medicine. Meicho Shuppan, 1979–1984. This series was published in four phases. The first phase: volume 1–30, published from 1979 to 1980; The second phase: volume 31–60, published from 1980 and 1981; The third phase: volume 61–100, published from 1981 to 1983; The fourth phase: volume 101–103, published from 1983 to 1984. The series contains about 180 books by 53 physicians in all
35. Series on Kampo abdominal diagnosis. Orient Shuppansha, Osaka (1994)
36. The series consists of 5 volumes, 41 titles on abdominal diagnosis
37. Series on Kampo clinical diagnostics. Orient Shuppansha, Osaka (1994)
38. The series consists of 24 volumes, 98 titles on diagnostics
39. Daichi Haramakotogen (tr.) (1971) Suśruta-samhita. Rinsen Book Co., Kyoto
40. Yano M (tr.) (1988) Introduce to Indian Medicine, i.e., the 30-chapter Japanese translation of Charaka Samhita. Asahi Shuppansha
41. Mukhopadhyaya g (1926) History of Indian Medicine, vol 2. Calcutta University Press
42. Sir Bhagwat Sint Jee HH (1978) A short history of aryan medical science. New Asian Publishers, Nai Sarak
43. Ben H, Efes A (tr.) (1980) Ancient Indian medicine. Shuppan Kagaku Sogo Kenkyujo
44. Tamotsu S (tr.) (1985) Ancient Indian Science and Society, Douhousya
45. Inamura H (tr.) (1987) Ayurveda: Health preserving in daily life. Heiwa Publishing Inc
46. Tamotsu S (1988) Scientific thoughts in Ancient India. Tokyo Shoseki Co. Ltd., Tokyo
47. Fukunaga K (1990) Buddhist Medical Encyclopedia. Yuzankaku
48. Ben H et al (tr) (1990) A hand book of Ayurveda by Vaidya Bhagwan Dash and Acarya Manfred M. Junius. New Delhi, 1983; Heiwa Publishing Inc., 1990
49. Hiroshi M (1993) The way of Ayurveda. Toho Publishing Inc
50. Zysk KG (1993) Asceticism and healing in Ancient India: medicine in the Buddhist Monastery. Akira Kajita (tr.) Jiku Shuppan
51. Liang S (1922) Overview of Indian philosophy. Commercial Press, Shanghai
52. Takakusu J, Kimura T (1935) History of philosophy and religion in India [Gao Guanlu (tr)] Commercial Press, Shanghai
53. Majumdar RC, Raychaudhuri HC, Kalikinkar D (1986) An advanced history of India [Zhang S et al (tr)]. Commercial Press, Shanghai
54. Zhang B (tr) (1989) Bhagavad Gītā. China Social Sciences Press, Beijing
55. Ji X (1990) Buddhism and Sino-India cultural exchange. Jiangxi People's Publishing House, Nanchang
56. Chattopadhyaya D (1992) Lokayatika. Wang Shi'an (tr). Commercial Press
57. Xu F (tr) Mukhya Upanishads. China Social Sciences Press, Beijing
58. Basham AL (ed) (1997) History of Indian Culture. Commercial Press

Author Biography

Yuqun Liao born in Beijing in 1953, a native of Xingshan County, Hubei Province, employed since 1982 by the Institute for the History of Natural Sciences (IHNS), Chinese Academy of Science, made fellow in 1996, and successively Director Assistant, Vice Director, and Director (2005–2009), and Director General of Chinese Society for the History of Science and Technology (2008–2012). He was exposed to traditional Chinese medicine education since childhood, started reciting prescriptions for medical decoctions together with Tang Poems at 5 or 6 years of age, recitations extended to *Drug Properties in Verse*, twelve regular meridians and acupuncture acupoints, and eventually ended with study of *Treatise on Febrile Diseases*, *The Yellow Emperor's Classic of Internal Medicine*, and other classics of traditional Chinese medicine. He graduated from primary school in 1966, participated in "The Down to the Countryside Movement" 3 years later, and accepted training in Western medicine as a medical corpsman of Production-construction Legion, accepted regular education in medical schools after the "Cultural Revolution" ended in 1977, and henceforth started the "collision and convergence of Chinese and Western Medicines" on a new platform. Accidentally took to the path of "science and technology history" research after graduation from college.

He mainly engaged in research of the history of medicine, monographs include *Ways of Traditional Chinese Medicine, The History of Chinese Science and Technology-Medicine Volume* (Co-author), *Ayurveda—Traditional Indian Medicine, Medicine Is Intention—Understanding Traditional Medicine in China, Overlooking Kan bo the Japanese Traditional Medicine*, etc.

The Four Great Inventions

Jialu Fan, Qi Han, Zhaochun Wang and Nianzu Dai

1 Lecture 1 Invention, Development, and Influences of Papermaking Technology

The invention of papermaking technology is one of the most outstanding contributions made by the Chinese people to the world civilization. It is not only a revolution in writing materials, but also a perquisite for the subsequent invention of typography.

1.1 Character Carriers Before the Invention of Papermaking Technology

Over its long history, the Chinese nation has created brilliant ancient cultures. In the early ages, the ancient Chinese successively used the ancient Chinese character system in animal shells and bones, bronze, pottery, stones, bamboo, wood, silk, and other materials to extensively record incidents in their life. After exploration for more than centuries, the Chinese finally invented "paper," a character carrier of good quality and low cost. To trace the origin and development of papermaking technology, first it is necessary to briefly introduce the major writing materials previously used in China and the regions of other ancient civilizations.

1.1.1 Shell and Bone Inscriptions

So far, archaeological discovery of the earliest documented data is the shell and bone inscriptions of Shang Dynasty. Bone and shell inscriptions derive their name from the carriers: Shell refers to tortoise shells and bone refers to animal bones.

J. Fan (✉) · Q. Han · Z. Wang · N. Dai
University of Science and Technology of China, Hefei, Anhui Province,
People's Republic of China

© Shanghai Jiao Tong University Press,
Shanghai and Springer-Verlag Berlin Heidelberg 2015

Y. Lu (ed.), *A History of Chinese Science and Technology*,
DOI 10.1007/978-3-662-44166-4_2

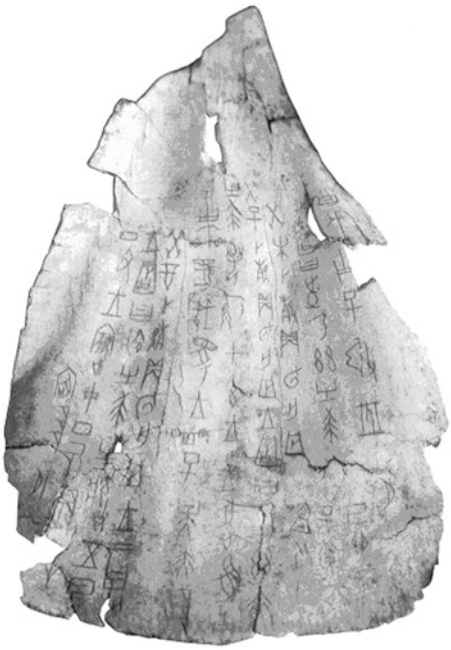


Fig. 1 Shell and bone relics from Yin Ruins

Therefore, shell and bone inscriptions are characters engraved on tortoise shells and animal bones. Shell and bone inscriptions are in use from about fourteenth century BC to twelfth century BC, current for about two centuries.

In the late Shang Dynasty, Yin the capital was subjected to the warfare of Duke Wu of Zhou Dynasty crusaded against Emperor Zhou of Shang Dynasty, and turned into ruins. This incident in history was recorded on shells and bones, was buried for about 3,000 years, and was known to few in the while. In late nineteenth century, farmers from Anyang, Henan Province, accidentally bumped into shell and bone fragments (see Fig. 1) while working in the field. In 1899, Wang Yirong, an epigrapher from Fushan, Shandong Province, recognized for the first time that shell and bone inscriptions were characters used in the Shang Dynasty.[1] From then on, shell and bone relics became the subject of antique collectors, and research in shell and bone inscriptions gradually attracts people's attention.

Aside from Yin Ruins, shell and bone relics are successively unearthed in Qijia of Fufeng, Fengxi of Xi'an, and Fengchu of Qishan in Shaanxi Province; shell and bone relics of the Western Zhou Period are also unearthed at Fangdui Village, Hongzhao County, Shanxi Province, as well as Changping District in Beijing, since the 1950s. Some inscriptions on shell and bone relics of the Western Zhou Period are as small as millets and can only be intelligible with the help of magnifying glass.

[1] Bai Shouli (General Chief Editor), Xu Xichen, Si Weizhi, Yang Zhao (Chief Editor). General History of China Volume 3 [M]. Shanghai: Shanghai People's Publishing House, 1994:116.

Shell and bone inscriptions are mainly oracle texts, interspersed with independent records of historical facts. According to the "*Book of Rites-A Token*," "The rulers of Yin hold the deities in high esteem; they [always] lead the people to wait upon the gods, and put the ghost [of deceased ancestors] before rites." In the Shang Dynasty, people believed in gods and put the gods before rites in the order of obedience. Whenever an important event occurs, they would practice divination to ask for the opinion of the gods and record the divining results. Most of the texts in the bones or shells are directly engraved without writing first, but there are also texts engraved after they were written.

1.1.2 Bronze and Pottery Inscriptions

With the invention and application of pottery making and metal smelting technologies, some ceramic wares and metal utensils were made carriers of characters.

Previously known as bell and tripod scripts, bronze inscriptions refer to epigraphs engraved on ancient bronze objects or other bronze utensils. Archaeological findings show that ancient Chinese had mastered bronze-founding technology back in as early as 3000 BC to 2300 BC. The Shang and Zhou Dynasties mark a period of considerable development of bronze ware in China. The earliest bronze ware unearthed with epigraphs can be traced back to the Shang Dynasty, concurring with shell and bone inscriptions. Statistics has found that about 6,000–7,000 bronze ware unearthed prior to 1950 are with epigraphs, among which 1,000 are made in Qin and Han Dynasties, 1,000 are made in Shang Dynasty, while the rest 4,000 odd pieces are from the Zhou Dynasty.[2] This betrays the fact that bronze wares are the most common character carriers in the Zhou Dynasty.

Epigraphs of the Shang and Western Zhou Dynasties were mainly cast on bronze ware, while it was being made, while later epigraphs were engraved after the ware took shape. It is noteworthy that some epigraphs on bronze ware of Zhou Dynasty adopt molds pieced together, with each mold consisting of one or several characters. This is very similar to the movable types used later on and thus can be deemed as ushering in the application of movable types.

Although concise, epigraphs are greater in length and complete, when compared with shell and bone inscriptions. The longest bronze epigraph in existence is the Maogong Tripod (see Fig. 2) unearthed in Qishan, Shaanxi Province, during Daoguang Era (1821–1850) of the Qing Dynasty. Manufactured in the reign of Emperor Xuan of Western Zhou Dynasty, the tripod has a 499-character epigraph, which can be termed a masterpiece among epigraphs of Western Zhou Dynasty.

In addition to the bronze inscriptions, the seal which appeared in the Shang and Zhou Dynasties has a special significance. The use of the seal is essentially

[2] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988.

Fig. 2 Maogong tripod currently kept in "National Palace Museum" in Taipei

mechanic replication of characters, thus the engraving and use of seal technology, especially the use of bulk seal, can be seen as the forerunner of woodblock printing.

Epigraphs engraved on pottery ware fired from clay are called pottery inscriptions. Pottery ware with epigraphs falls into three categories, i.e., pottery utensils, brick and tiles, and mud caps. Pottery inscriptions have a lot in common with bronze inscriptions. However, pottery utensils are fragile and unfit for long-term preservation, while bronze utensils are strong and durable. Therefore, pottery inscriptions are not used for recording long historic facts like bronze inscriptions are. Instead, they are mainly short texts.

Early pottery ware in China, like painted pottery unearthed in northeast China and north China, emerged approximately in late Neolithic period. There are decoration patterns, pictures, and character-like signs on those potteries.

1.1.3 Boulder Inscriptions

Fabrication of bronze inscriptions requires a complicated casting procedure, while engraving on stones has proven more convenient in comparison. The above-mentioned stone inscriptions of ancient times show that the use of stones as character carries has a long history. However, so far we know that the use of boulders to record feats and recall the ancestors first started in the Qin Dynasty.

It is generally acknowledged in the academia that the 10 stone drums are as the earliest stone engravings extant in the real sense of the word (see Fig. 3). Originally located in Tianxing (now Fengxiang County of Shaanxi Province), those stone drums were rediscovered in the Tang Dynasty, and men of letters like Du Fu, Wei Yingwu, and Han Yu had poems or odes in praise of them. Externally

Fig. 3 Stone drum "*Luanche*" of the warring states period currently kept in the palace museum in Beijng

drum-shaped, the stone drums are irregular in shape and size. The rocks used have a dull color but high rigidity, ranging from 45 to 90 cm in height, and averaging 210 cm in the circumference of cross sections. With wide and flat bottoms, and round yet slightly smaller tops, they look very much alike sections of a cylinder. Texts are engraved around them, in the style of the seal, or Zhou Wen, which is used before Qin Shi Huang unified character. The content is singing praise of the emperors of Qin hunting, and thus, they are also known as "hunting stone tablet." Due to long-term natural erosion and artificial destruction, most of the texts have become obscure, while the text on one of the drums has already vanished completely.

Investigations by modern scholars in the style of the characters and the place of excavation have lead to different opinions regarding the specific time of their engraving: Duke Wen, Duke Mu, Duke Xiang, Duke Xian, and etc. However, it can be basically determined that those stone inscriptions are made in the Kingdom of Qin in eighth century BC to seventh century BC in the Spring and Autumn Period.

After annexing, the six kingdoms of Qi, Chu, Zhao, Wei, Han, and Yan, Emperor Qinshihuang made many visits eastward between 219 BC and 211 BC and established seven stone tablets in Mountain Yishan, Mountain Taishan, etc. in Shandong Province in extolment of his achievements. After his death, his son Qin Ershi circumambulated the country and added "Complementary Remarks" to the stone tablets, to sing eulogy to his virtuous policies.[3]

[3] Sima Qian of the Han Dynasty, Records of the Grand Historian-Biographic Sketch of Emperor Qinshihuang.

After the Han Dynasty, inscribed stones turned into rectangular *bei* from cylindrical *jie*. Usually, rectangular in shape, *bei,* is polished in the exterior to facilitate inscription and thus is far more elaborate than *jie* with its coarse surfaces.

Aside from *bei* and *jie*, the poems of personages and literati, as well as the tribute of visitors, are also carved on the cliffs of famous mountains or places of interest, resulting in cliff carvings. In the fifth and sixth centuries, when Buddhism prevailed in China, cliff carving became so popular that Buddhist gashes and segment of Buddhist classics could be found on cliffs everywhere. The characters were usually large to show the stateliness of the religion. In addition, characters are also carved on the stone materials of various architectures.

Stone classics are another type of stone inscription with great importance after the Han Dynasty. After the Emperor Wu of the Han Dynasty adopted Dong Zhongshu's proposal of "respecting Confucianism as the only doctrine," Confucian classics became the major courses studied by scholars and to be handed down generations after generations. However, "It has been a long time since the emergence of Confucian classics, and mistakes abound. Worse still, worldly scholars tend to give farfetched interpretations, thus misleading future scholars." To avoid mistakes stemming from manual transcription, all Confucian classics were engraved onto stone tablets as the definitive edition. From Xiping Era of the Eastern Han Dynasty to the Wei Dynasty established by Cao Cao, to the Qing Dynasty, Confucian classics were inscribed on stones for seven times. Inscribing on stones has considerable influence on the subsequent invention of typography.

1.1.4 Bamboo Slips and Wooden Tablets

Mo Di (BC 486–BC 367), an important thinker of the Warring States Period, listed in his book *Mo Zi* many character carriers used in ancient times. It is said in *Mo Zi-Ming Gui Xia* that "The wise kings of ancient times customarily consider serving ghosts and gods as their duties and hold ghosts and gods in high respect. Afraid that later generations would fail to observe this custom, they wrote it down on bamboo and silk so as to hand it down. However, the worry over the loss of record due to the corrosion of bamboo and silk caused them to engrave it on boulders and jars or carve it on bronze ware and rocks for assurance."[4]

"Bamboo and silk" mentioned by Mo Zi are bamboo slips and fine silks, which are used as a major writing material in the long era between the Warring States Period and Qin and Han Dynasties, even after the emergence of paper. The characters on the above-mentioned shells and bones, and bronze and boulders are "engraved," instead of being "written" with pens. Strictly speaking, those materials are not "writing" materials. The earliest writing material in China is bamboo slips, and the earliest books are bamboo slips strung together with ropes, also called strung bamboo slips.

[4] Mo Zi. Volume 8. *The Twenty-two Masters*. Shanghai: Shanghai Classics Publishing House, 1986: 249.

It is now difficult to determine the exact time of origin for bamboo slips. The Chinese character "册" in the oracles on the Shang Dynasty shells and bones looks very much like a bunch of bamboo slips strung together with two strings, while the character "典," which is relevant to "册," denotes a book on the table. It is also seen in the bronze inscriptions of Western and Eastern Zhou Dynasties. Therefore, it is believed that the use of bamboo slips began back in the Shang Dynasty. Slips made of animal bones can still be found now. For instance, a tiger bone is kept at the Royal Ontario Museum of Canada. About 22 cm in length and containing 22 characters, the bone slip is made in the third year (1152 BC) of Dixin (i.e., Emperor Zhou of Shang Dynasty). Another bone slip fragment dates back to twelfth century BC. Both of the two can be seen as the beginning of using slips for writing. So far the earliest bamboo slips discovered are the Warring States bamboo slips unearthed in the Tomb of Zenghou Yi of the early Warring States Period (443 BC) in Sui County, Hubei Province, in 1978. The slips are about 72–75 cm in length and 1 cm in width, and characters are written on both sides. The form of the characters is the same as the characters on other utensils of the Warring States Period. The time for bamboo slips to come into use should be earlier than this slip.

"简" (slip) is a collective name for "bamboo slips" and "wooden slips," which are collectively referred to as "bamboo and wooden slips." The emergence of wooden slips may be later than the bamboo slips, probably as their replacement. Wooden slips appeared in the Han Dynasty and became the prevalent writing material during the years before and after the Christian era.[5] First, both bamboo and wooden slips are usually narrow slips straight in form to contain one row of characters from top to bottom only. This shows that in bamboo slips, the material determines its long and narrow shape; after wood replaced bamboo in making slips, the long and narrow shape is naturally preserved. Second, the word "简" has a radical of "竹" (bamboo); concurrence of Bamboo and Silk is often found in the pre-Qin classics, while the use of "wooden slips" in the literature did not appear until the Han Dynasty. Third, just as in literature records, books of the Warring States and early Han Dynasty unearthed in recent years are all bamboo slips, while wooden slips unearthed over the years are from around the Eastern Han Dynasty, mostly in remote regions in the northwest where no bamboo was available.

Slip is the basic unit of ancient books, equivalent to one page of a modern book. Slips sequentially bound together with a string form a book, equivalent to the modern forms of a book. In some cases, characters are written on the slips which are then strung together into a book; in other cases, empty slips are bound into a book, and then, characters are written. In "*Yongyuan Military Materials Register*" unearthed in Dunhuang, some characters are covered by the string, pointing to the fact that characters were written on the slips which are then bound together. In "*Etiquette*" of Han Dynasty unearthed in Wuwei, there were no characters in places covered by the string, showing that the book was made before

[5] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988:60.

any characters were written on the slips. Bamboo slips, unearthed in Zenghou Yi Tombs in Sui County, Hubei Province, are bound with two strings, and the characters immediately above and under the strings are wider spaced, bespeaking the fact that binding comes before writing.

Hemp strings are the most commonly used in binding slips, while silk sash and hide stripes are also used. Liu Xiang mentioned in his book Bie Lu (Abstracts): "Sun Zi's book is written on dried bamboo slips which are bound together with light blue silk cord," referring to the use of "light blue silk cord." Sima Qian remarked in "Records of the Great Historian—the Confucius Family" that elderly Confucius "had read the Book of Changes to such extent that he wore out the cowhide string for three times." This indicates that the Book of Changes read by Confucius had been bound with cowhide cords.

1.1.5 Silk

While it is much easier writing on slips than engraving on stones and metals, the writing space is limited, especially for drawing which requires much greater space. About from 7 BC to 6 BC, the Chinese people began to use silk as a writing material. Silk is light in weight and smooth in texture and can be cut into various shapes and sizes. Therefore, it can be used not only as a text carrier, but also as the solution to the problem rising from the limited spaces of bamboo slips in certain cases of special uses.

It is now impossible to trace when silk was first used as a writing material. In 1934, a silk book ("Chu Zeng book") was unearthed in a Chu Tomb in Changsha. 47 cm in wide and 38.7 cm in length, the book contains characters written with black ink and brush. The characters are flat in font, resembling those on the slips of the Warring States. Research found that it belonged to the Kingdom of Chu during the Warring States Period.[6] Silk manuscripts of the Warring States period are also unearthed in many other places, while those from periods after the Qin and Han Dynasties are even greater in number. No. 3 Han Tomb of Mawangdui, Changsha unearthed in 1973 a large number of silk manuscripts, which were written on full sheets of silk 48 cm in width, or on half sheets 24 cm in width. At the time of excavation, all of them have been severely damaged (see Fig. 4). After restoration, collation and examination, the batch was found to contain a total of 28 books, encompassing 120,000 characters. According to research, earliest of these silk manuscripts was replicated in the 25th year of Qinzheng (222 BC), while the latest was made in the burial time in the 12th year of Emperor Wen of Han Dynasty (167 BC). The transcription years of most of the silk manuscripts should be between Emperor Gaozu and the early years of Emperor Wen of Han Dynasty, i.e., in the 30 years around the beginning of the second century BC.[7]

[6] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988:81–82.

[7] Encyclopedia of China (Volume of Archaeology) [M] Beijing: Encyclopedia of China Publishing House, 1986:307.

Fig. 4 Silk book *Book of Warring-States Strategic Advisors* (partial), unearthed in No. 3 Tomb at Mawangdui

In the Qin and Han Dynasties, both slips and silks were used. Due to the fact that slips are relatively inexpensive and allow easier modification, drafts were often made on slips before final versions were copied onto silk while writing important documents. In addition, silk is greater in width and is often used to draw the illustrations and other figures for bamboo slips.

The silk manuscripts were stored mainly in two ways. One way is to fold and store them in a pouch or wooden box. For example, silk manuscripts found in Changsha Mawangdui were folded and put in lacquer boxes. The other is to roll them on round sticks made of wood or other materials in the fashion of silk reels. Later, the reels are inherited by paper books. The trend of writing material change can also be seen from the directory of history books from the ancient Chinese dynasties: The nearer the era, the greater the use of "volume," a unit denoting silk and paper, and the less the use of "chapter," a unit denoting bamboo slips.

When used as a writing material, silk is clearly superior over slips. It is not only light, soft, easy to carry, but also "easily tailor-made in accordance with the length

Fig. 5 Parchment manuscript, from the monograph of Dard Hunter

of the book."[8] In addition, being white and clear in surface, and awarded with good ink absorption properties, silk is the ideal writing material. Even in Tang Dynasty when papermaking was well developed, people were still writing on silk. Paintings before the Tang Dynasty mostly used silk rather than paper. However, silk is expensive and thus is difficult to popularize.

1.1.6 Writing Materials Used in Other Countries Before Papermaking

Ancient Egyptians and some other peoples of the world carved texts in stone tablets. In ancient Assyria, Babylonia and the Middle East people engrave texts in clay billets, which were then fired to become a hard bricks. In ancient Rome and other European nations, people casted words in brass, bronze, lead plates, and other metal materials. Westerners had also used wood in writing chronicles. All these materials are not different from the writing materials used by the Chinese before the invention of papermaking.

In ancient times, some countries had also used other writing materials, which were not used or popularized in China. Among them, the most noteworthy ones are as follows:

First are animal hides, mainly parchment (see Fig. 5) and vellum. Made of sheep skins and calf hides, those thin sheets were the writing materials in Western countries for a long time.

Second is papyrus. In the Nile basin, there grows a perennial cyperaceous herb (Cyperus papyrus). Egyptians cut of the stem, removed the roots and top, segmented the middle part into two-foot pieces, cleaved the pieces into halves, and flattened them. Then, the flattened sedge stalks were laid out in two layers on a plank, with the upper and lower layer vertically staggered, and vinegar was dropped onto them. After that, they were pounded until completely flat, resulting in the so-called papyrus sheet.

[8] Tang Xu Jian. Initial Learning. Volume 21.

Third, leaves. India, Pakistan, and other countries in ancient times used broad leafs of palm trees for writing, after which two holes were punched in each leaf and then a cord was used to string it together with other leaves. Buddhist scriptures written in such leaves were introduced during the Tang Dynasty to China and called by the Chinese people "Pattra." India had also used in writing the large leaves of fan coconut trees of the Palmae family. Use of leaves as writing material is also found in other regions in ancient times.

Fourth, bark felt. Long before the Europeans arrived in the Americas, the Mayans and Aztecs used thin slices made of bark for writing and painting. Its production method is as follows: removing the colored outer layer of the epidermis from the bark stripped off, tear the endothelial torn into one inch wide strips, put the stripes into a pot, add plant ash, and heat to boil. Then, like production of papyrus piece, lay the boiled bark crisscross on a plank, hammer them into thin slices, dry the slices, and hammer with polished stones. Indigenous peoples on many Pacific islands beat barks to make tapa or kapa. Seen from the principle and production process, the product also belongs to the scope of bark felt.

It is worth noting that the above writing material can be used as text carriers. Some looks like paper externally, while others are dubbed "paper." However, seen from production principles none of them is real paper made through recombination of broken fiber. Yet application of these written materials has continually promoted the development of the writing systems of various nationalities. The writing systems, in turn, put forward higher requirements for writing materials, laying the basis for the invention of paper, a better writing material. About the era before Christ, the Chinese first made a breakthrough. Back then, the widely used writing materials were slips and fine silk, which had major defects as writing materials, although they were far more suitable than stone and other materials for the purpose. Slips are bulky. "*Records of the Great Historian • Imperial Biographies of Qin Shi Huang*" said, "All things in the world of things, big and small, are judged by the emperor himself. Slips are submitted continuously to the emperor, day and night. The slips submitted amount to hundreds of kilograms each day. The emperor cannot take a break unless [officials] stopped submitting." In other words, the bamboo slips marked by Qin Shi Huang during his reign are often weighed in Dan (60 kg). Had these submissions been written on paper, 1 kg of paper might have been more than enough. Silk is expensive, and only a handful of the rich and powerful aristocracy can afford to it. Therefore, silk cannot meet the needs of a rapidly developing society. It was in this context that papermaking came into being.

1.2 Invention and Development of Papermaking

1.2.1 Invention of Papermaking

It is still a controversial issue regarding when papermaking was invented. For a long time, people think that it is Cai Lun (?~AD 121) of the Eastern Han Dynasty that invented papermaking according to the following record from "*Book of Eastern Han Dynasty •The Legend of Cai Lun.*"

Since ancient times, books and documents have been written on slips, and later silk came into use, under the name of paper. Neither silk nor slips are convenient because the former is expensive and the latter cumbersome. Cai Lun creatively used bark, hemp, rags, and used fish nets in producing quality paper, and submitted his invention to the emperor in the first year of Yuanxing (AD 105). The emperor spoke highly of Cai's talents. From then on, people followed suit and began to use the paper invented by Cai Lun, hence the name CaiHou Paper.[9]

In this regard, doubts rose as early as the Tang and Song Dynasties. Some believed that there had been paper before the invention of Cai Lun, who was just proficient in the art handed down by predecessors, just as Zhang Huaiguan of the Tang Dynasty said in Volume 2 "Judgment of Calligraphy," "With the rise of the Han Dynasty, paper began to be used as a substitute for slips. During the reign of Emperor He, Cai Lun dedicated himself to papermaking and improved it."[10]

The above view did not attract much attention until the twentieth century, when archaeologists in China successively discovered some ancient papers ascertained to be made before Cai Lun, such as the Lop Nur Paper, the Baqiao Paper, Jinguan Paper, Fufeng Zhongyan Paper, Majuanwan Paper, Fangmatan Paper, and Xuanquan Paper, which were found to be relics of the Western Han Dynasty. After that, the situation began to change for the better.[11] Now, a growing number of scholars believe that papermaking craft began before Cailun, who was the first to use bark, hemp offal and rags, fishing nets and other raw materials to make paper. Cai also revolutionized papermaking technology and significantly improved the quality of the paper, playing an irreplaceable position in the history of papermaking.

1.2.2 Development of Papermaking in the Early Stages

Shortly after the advent of the "Caihou paper," people moved toward to began to use paper in writing documents and letters. Yu Shinan of the Sui Dynasty (AD 630) remarked in the Volume 104 *Beitang Shuchao* that Cui Yuan (78–143), a scholar of Eastern Han Dynasty, wrote in a letter to his close friend Ge Gong (styled Yuan Fu, 73–143) "I am sending you ten volumes of *Xuzi Shu*, in paper, because I'm too poor to afford to even plain silk," meaning that he could not afford plain silk paper and had no choice but to write on paper. Yu also remarked that Yan Du said in replying to a letter from Zhang Huan, "I thought about you a lot since we parted 3 years ago. Last month I received your letter in care of Boying. Reading the four pages time and again gave me such delight." Boying is the style of Zhang Zhi, who lived from 117 to 192.

---

[9] Book of the Later Han. Volume 108. Biography of Cai Lun. The Twenty-five Histories. Book 2 [M]. Shanghai: Shanghai Classics Publishing House, 1986:1022.

[10] Tang • Zhang Huaiguan. Judgment of Calligraphy. Volume 1. On Three Kinds of Fu's. Volume 87: 4016.

[11] Collection of Traditional Chinese Crafts • Papermaking and Printing [M]. Zhengzhou: Elephant Press, 2005.

In the late Eastern Han Dynasty, with the gradually expansion of papermaking places, paper technology witnessed continuous improvement and development. In Donglai Shandong (now Huangxian County Shandong), there appeared a famous papermaker Zuobo (styled Ziyi, 165–226). Zhang Huaiguan said in *Shu Duan*, "Ziyi is exceedingly proficient in papermaking,"[12] praising that Zuobo Paper was superior to Caihou Paper. Historically, there are many men of letters full of praise for Zuobo Paper. For example, "*Xiao Ziliang's Reply to Wang Sengqian's Letter*" said: "Ziyi's paper is smooth and glossy. Characters written on it with Zhongjiang's ink are readily intelligible. One can keep Boyin's brush dancing on the paper until his thoughts are exhausted. However, now the three are gone forever, never to return." One more example: *Sanfu Juelu* recorded: Wei Dan wrote in a memorial submitted to the emperor: "… Artisans should hone their instruments first if they want to do a good job. Zhang Zhi Brush, Zuobo Paper and my ink, are established classics. With the three combined, I can write thousands of words at one sitting."[13] Wei Dan (179–253), styled Zhongjiang, noted calligrapher of the Three Kingdoms Period, the fame of the ink made by him. The ink, pitch black in color, had a fame on a par with Zhang Zhi Brush and Zuobo Paper. It is not difficult to see that extensive use of paper promoted the advances in brush and ink production technology, which went on to promote the development of calligraphy and painting.

Ode to Paper by Fu Xian (234–294) of Jin Dynasty is the earliest essay existing in praise of paper. The original text goes in Chinese classical style of writing.

It says to the effect that in various historical periods, characters have different carriers. First, inscriptions on turtle shells, bones, metals, and stones were used in place of making rope knots for recording incidents. Later, paper replaced slips. Paper is not only suitable for writing, but also low in price, white in color, pure in texture, and exquisite in form. Men of letters are fond of paper and have written many a fabulous essay. Brand-new paper is made from rags and old ropes. Papers can be folded and unfolded, allowing convenient use. Those away from their hometown can use paper to write letters home and convey their feelings.[14]

Although the use of paper had become increasingly common in as early as the Three Kingdoms Period, silk and bamboo as the old writing materials were not fully replaced. A variety of writing materials were used at the same period. After the Jin Dynasty, with the continuous improvement in the quality of paper, people got gradually accustomed to the use of paper and no longer wanted to use expensive silk or cumbersome bamboo slips. In conformity with the historical trend, the government banned use of bamboo slips in the palace. For example, in the later

---

[12] Tang Zhang Huaiguan. Judgment of Calligraphy. Volume 1. On Three Kinds of Fu's. Volume 87: 4016.

[13] Song Su Yijian. Notes on the Four [Tools] of the Study. (Volume 4). Collection of Series. Book 1493: 50.

[14] Jin Fu Xian. Ode to Paper. In Qing Yan Kejun (eds.) Anthology of Ancient, The Three Dynasties, Qin, Han, Three Kingdoms and Six Dynasties Anthology of Jin (Volume 51) Beijing: China Book Store, 1985:5.

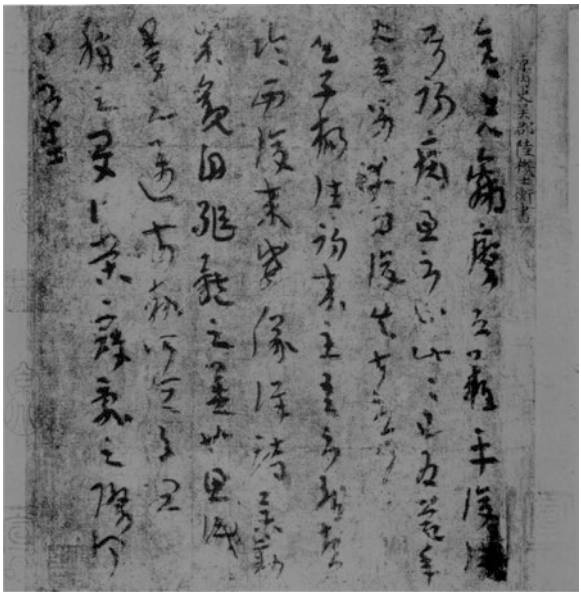


Fig. 6 Pingfu Tie (the calligraphy model)

Eastern Jin Dynasty, Huan Xuan (369–404) dethroned Emperor An of Jin Dynasty and styled himself emperor. After ascended the throne, he ordered that yellow paper be used in the palace, instead of bamboo slips. Volume 605 *Tianping YuLan* cited "*Huan Xuan Usurpation*" "In ancient times, there was no paper, so bamboo slips were used for writing. There was no element of showing respect to predecessors. Now all those who use slips should switch to yellow paper instead."

During this period, papermaking spread to all places in the south and north. The north was dominated by Luoyang, Chang'an, Shanxi, Hebei, Shandong, etc. Papermaking centers in the south were located in Jiangning, Kuaiji, Yangzhou, south Anhui, Guangzhou, etc. Gaochang (now Turpan, Xinjiang) probably started making hemp papers in the 16 Kingdoms Period (304–349). With expanded production areas, paper turnout continued to increase, satisfying social demands to some extent.

The extensive use of the paper also promoted the progress of writing art for Chinese characters and changes in the font. Chinese character fonts changed from the official script and Xiaozhuan popular in the Han Dynasty to Kaili with the features of both official script and regular script, both of which formed in the Period of Wei, Jin and Southern and Northern Dynasties, and Kaili gradually evolved into the regular script. Meanwhile, Caoli (Zhangcao), rising in the later Han Dynasty, continued in use until the Wei and Jin Dynasties and became more characteristic. For example, Pingfu Tie, the Calligraphy Model on hemp paper written by Lu Ji (261–303) of the Western Jin Dynasty and kept in the Beijing Palace Museum (as shown in Fig. 6) is a representative masterpiece. Since then, the cursive Kaili gradually developed into Xingcao, and then to cursive style. Without paper, all those transition would be hard to imagine.

On the other hand, ever new requirements for paper supply spurred by social and cultural developments, and extensive use of paper in official documents, school textbooks, Buddhist, and Taoist classics greatly promoted the prosperity of paper industry and development of papermaking. After Buddhism was introduced to China, in order to meet the needs for the spread of Buddhism, the monks came up with a fast book replication method, at the time when woodblock printing was not yet invented, that is, by encouraging believers to extensively copy Buddhist scriptures, or to buy from monasteries scriptures copied by professional Buddhist scripture transcribers, saying that copying and buying Buddhist scriptures can earn bless of the deities, or afterlife salvation according to the wish of the believers. A large number of Buddhist scriptures found in the Dunhuang Grottoes were handed down by believers who bought and stored them in the temple grotto for worship.

1.2.3 Emergence of Bark Paper in the Tang Dynasty

Sui and Tang Dynasties witnessed considerable prosperity in science and technology, culture and art, and religion. Social demand for paper soared, promoting the vigorous development of papermaking technology, ushering in the first peak mainly featuring the rapid rise of bark paper.

Bark paper first appeared in Cai Lun's period. However, seen from the unearthed material objects, turnout of bark paper before the Tang Dynasty was far less than that of hemp paper, and this scenario did not change until the Northern and Southern Dynasties. Since the Tang Dynasty, bark paper gradually prevailed to become the most important kind of paper, with three main strains, i.e., rattan paper, mulberry bark paper, and mulberry paper.

Rattan paper appeared in the Jin Dynasty and reached its peak in the Tang Dynasty. Wuzhou, and Yuhang County, Xinzhou, and Quzhou of Hangzhou submit rattan paper to the royal palace.

Rattan paper of the Tang Dynasty boasts high quality. Li Zhao of the Tang Dynasty put "Yanxi Rattan paper of Yue first," while listing quality papers at that time in *Guoshi Bu* (Supplementary National History). Rattan paper was used as the high-class paper for official documents and was privileged for the royal family and the royal Taoist temples.

After reaching its peak in the Tang Dynasty, rattan paper soon declined. Rattan was limited in growing areas, slow in growth and long in regeneration cycle, overharvesting inevitably lead to its depletion. Shu Yuanyu, a scholar of Tang Dynasty, indignantly wrote the article *Obituary to the Ancient Rattans in Yanxi*,[15] warning people that moderation should be exerted in development and utilization of natural resources and objective law should be followed, and that sole demand for immediate benefits should be avoided; otherwise, sustainable development would be impossible.

[15] Song Gao Sisun. Yan Records. Volume 5.

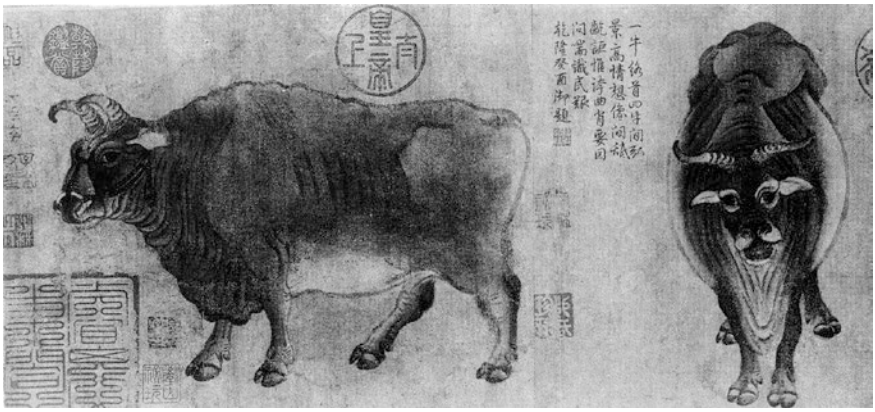


Fig. 7 Wuniu Tu (Five Ox Painting) painted by Han Huang (partial) this is the earliest painting in existence on paper by famous painters. Taken from *Collected Pictures of Ancient Chinese Civilization*

The sudden plummet in rattan paper production put a higher demand for other types of bark paper production. The mulberry bark paper and mulberry paper developed very quickly during this period. Many a bark paper work produced in the Sui and Tang Dynasties has been handed down. The well-known "*Lanting Xu*" copied by Feng Chengsu of the Tang Dynasty is on mulberry bark paper. Wuniu Tu (Five Ox Painting) (Fig. 7) painted by Han Huang (723–787), a painter of the Tang Dynasty, and now kept in Palace Museum, used mulberry bark paper.[16]

Based on the heritage of technology in Tang Dynasty, bark paper production reached a second peak in the Five Dynasties and Ten Kingdoms Period, witnessing the appearance of the most prestigious paper in history—the Chengxintang (Clear Heart House) Paper. According to the records of *Houshan Tancong*, a book by Chen Shidao (1053–1103) of the Northern Song Dynasty, Chengxintang was originally the hall name of Li Lei (888–943) the founding father of Southern Tang. During the reign of Emperor Li Yu in the Southern Tang (961–975), an official bureau was set to make quality paper exclusively for imperial use, and the paper was named the Chengxintang Paper.

The Chengxintang Paper was solely intended for imperial use and occasionally presented to the courtiers. Therefore, it was rarely seen by the outside. After the demise of the Southern Tang Dynasty, the Northern Song Dynasty literati obtained some from the imperial warehouse through palace attendants of the Southern Tang Dynasty and began to chant poetry in its praise, thus making it known and valued by the public. Liu Chang (styled Yuanfu), a scholar of Song Dynasty, presented ten sheets of the Chengxintang Paper he had got to Ouyang Xiu (styled Yongshu, 1007–1068). On seeing the paper, Ouyang Xiu could not hold his praise and made

[16] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M] Beijing: Science Press, 1998:143.

the poem "In Gratitude to Liu Yuanfu for Chengxintang Paper": "Don't you see that talents like Manqing and Zimei had been long-buried in the earth? … Since the departure of those two talents, the mountains have taken a gloomy appearance and low morale. Even if I have Chengxintang Paper, whose praise should I sing for?" Ouyang gasped in admiration, "from where to did you get this paper, so pure, so shiny, so elaborate, so smooth, and so elastic?"[17]

Chengxintang Paper rose to fame, with repeatedly praise from the thinkers of the Northern Song Dynasty. Due to the rarity of original pieces, Chengxintang Paper became very precious and plainly unattainable for ordinary literati. Therefore, imitations kept appearing from the Northern Song Dynasty to the reign of Emperor Qianlong of Qing Dynasty. Only five types of Chengxintang Paper mentioned in the literature of subsequent generations are genuine, while the majority are more likely to be later imitations.

1.2.4 Technical Achievement in Fine Letter Paper in the Tang Dynasty

Tang Dynasty also attained high achievements in letter-paper craftsmanship. The so-called letter-paper refinement techniques refer to finishing process of the original paper through calendering, applying glue, applying wax, dyeing, etc. to make it more elaborate or to meet specific needs.

Refined letter paper appeared only slightly later than the invention of papermaking. The previously mentioned Zuobo Paper with "elaborate glow" is the result of calendering. By the Jin and Southern and Northern Dynasties, dyed paper became generally used in writing edict and documents, and the five classics and Zi Shi, due to rapid development in paper-dying technology. In the Eastern Jin Dynasty, there were multiple colored papers, including blue, red, light blue, and pink, reflecting significant increase over the previous era in the variety of dyed paper.

After the Tang Dynasty, refined letter-paper skills saw all round development, as witnessed by the appearance of surface wax application, gold sprinkling, and other methods. Various methods combined to create a number of new varieties of letter paper.

Hardened yellow paper of the Tang Dynasty is the most valuable. Also known as "Yellow Hard" it is often referred by subsequent generations as "Yellow Wax Letter Paper" (as shown in Fig. 8). This kind of paper assumes a yellow or light yellow appearance, has a hard and smooth texture, and gives off a crisp sound while being shaken. Based on the wax letter-paper production process, people of the Tang Dynasty combined the coating and powdering techniques of the Wei, Jin and Southern and Northern Dynasties with wax application technique to make flour wax letter paper: At first, white mineral fine powder is coated on the paper; wax is applied, before the final process of calendering. The resultant paper has the advantages of both letter paper and waxes letter paper. People from later generations applied gilt on the powder wax paper to produce gilt wax paper.

[17] Northern Song Ouyang Xiu. Complete Works of Ouyang Xiu. Volume 5.

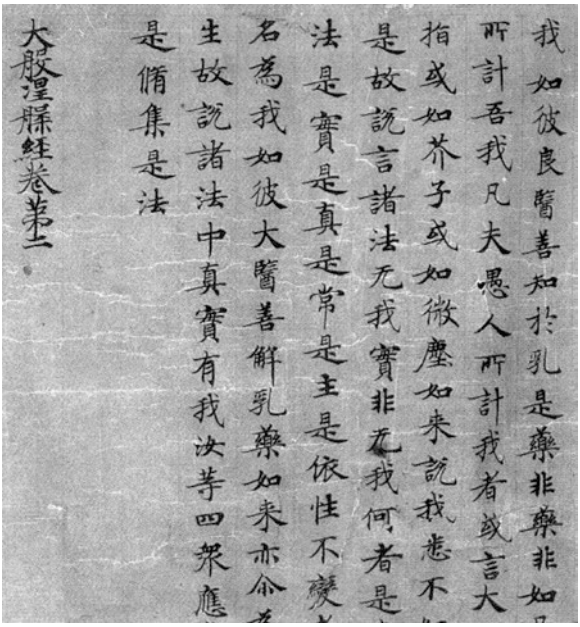


Fig. 8 Hardened yellow thin paper of Tang Dynasty

Among the dyed papers of the Tang Dynasty, Xue Tao paper is the most famous. The paper was named after its maker Xue Tao (styled Hongdu, about 781–832). Xue was good at writing short poems, so she specifically asked the paper technician to make smaller-sized papers in order to solve the problem of unduly waste in normal-sized paper. The resultant paper was well received by people, partly because of its pleasant color. Li Shangyin (ca. 813–ca. 858) of the late Tang Dynasty wrote in her poem *Seeing Cui Jue off to Xichuan,* "Huanhua letter paper has the color of peach blossoms, and deserves good inscriptions in praise of the crescent moon."[18]

1.2.5 The Sudden Emergence of Bamboo Paper in the Song Dynasty

With the continuous development of papermaking technology, the quality of paper was continuously improved and the consumption of paper also incessantly increased. The original linens and barks could not meet the needs of the paper industry for materials, and the development of new raw materials became urgent. The maturity of hemp paper and bark paper manufacturing technology also made the technical preparations for the development and use of new raw materials, and the production of new kinds of paper. It is under such conditions that bamboo paper, which uses bamboo fiber as raw material, came into being.

[18] Complete Poems of Tang Dynasty. Book 2[M] Shanghai: Shanghai Classics Publishing House, 1986: 1361.

Fig. 9 Bamboo paper version of calligraphy of "Coral Note" by Mi Fu

Techniques for making bamboo paper was invented in a time no later than the Tang Dynasty and came to maturity in the Song Dynsty. Mi Fu said in "*History of Books,*" "I once processed bamboo [paper] of Yuezhou by hammering, and found it smooth as the gold plates, and better than Youquan Paper. I resized it to make scrolls, which were stored in a book case. The process was repeated and I could make dozens of scrolls a day." Mi Fu added in his *Paper Assessment Note*, "After processed via innumerous hammering the bamboo paper from Yue became lovely tight and thin, and better than Youquan Paper. I began to make this paper at the age of fifty, and named it gold version." Mi believes that bamboo paper of Yuezhou is superior to Youquan Paper of Hangzhou.

Mi Fu's Coral Note (as shown in Fig. 9) is now kept in the Palace Museum in Beijing. Examination has found that it had used bamboo paper, which is yellow, contains many fiber bundles, and its smooth surface bespeaks processing though calendering.[19] In the Southern Song Dynasty, bamboo paper manufacturing technology became greatly improved, and refined bamboo paper was gradually able to compete with rattan paper and bark paper for its low price.

Shi Su recorded in *Jiatai Kuaiji Annals*, "Now bamboo paper becomes the only paper with worldwide fame, and no imitation has succeeded so far. Thus it has eclipsed rattan paper. There are three types of superior bamboo papers, i.e., Yaohuang, Xueshi, and Shaogong—the three are equal." Shi also summed up the five advantages of Kuaiji bamboo paper as "first, smooth; second, displaying the advantages of ink; third, suitable for stunts with the tip of writing brush; fourth, maintaining the ink well despite repeated folding and unfolding; fifth, resistant to worms."[20] Chen You in "*Fuxuan Yelu*" (1210) also spoke highly of bamboo paper from Zhejiang "Currently, the bamboo paper of Yue is superior to that of other places."[21]

---

[19] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M] Beijing: Science Press, 1998:187.

[20] Southern Song Shi Su. Jiatai Kuaiji Records. Volume 17, Records of Produce. Complete Library in Four Branches of Literature.

[21] Southern Song Dynasty Chen You. Fuxuan Yelu. Volume 2. Complete Library in Four Branches of Literature.

In the Song Dynasty, book printing industry was well developed, and there were five book printing centers of Hangzhou Jianyang, Meishan, Kaifeng, and Pingyang (Now Linfen, Shanxi). "Jianben" (also known as "Mashaben") engraved in Jianyang Fujian won out and became most popular due to its lower price, just as recorded in Volume 11 of *Fangyu Shenglan* by Zhu Mu of the Southern Song Dynasty, "Masha and Chonghua are book producers and known as the House of Books." Jianben primarily used bamboo paper. Later, Zhejiang, Jiangxi, and other areas with developed book printing industry became main producing areas of bamboo paper, and block-printed books often used locally manufactured paper.

1.2.6 Achievement of Bark Paper in Song, Yuan, Ming, and Qing Dynasties

The masterpiece of bark paper craft in the Song and Yuan Dynasties is Pizhi. "*Wenfang Sipu*" recorded that "Yi and Xi produce many varieties of quality paper, including Ningshuang, Chengxin, and etc. In some cases the large-sized paper can reach 50 Chi (1 Chi = 33.33 cm) in length." Manufacturing paper of such size not only requires special papermaking facilities, but also superb operating skills. Precision is required in each step. Before the advent of papermaking machines in the nineteenth century, Western countries never mastered the technology for production of large-size paper.

Mulberry paper still developed after the Song, Jin, and Yuan Dynasties. During Jin and Yuan period, it was continued to use the system of Song Dynasty for issuing paper money, which uses mulberry paper from the north (as shown in Fig. 10). According to "*The History of the Jin • Shihuozhi*" recorded, "In May the system of paper money repeatedly changed—new systems became invalid soon after they were promulgated. The mulberry bark and old paper used in papermaking were levied on the people, and the levy became very difficult. So the government ordered to have mulberry bark and old paper priced, on used this as a basis to collect Mulberry-bark-and-old-paper tax in the form of Weibaoquan and Tongbao, on the ground that such a tax can free people from the ordeal of transporting and save costs."[22] Paper money has high requirements on the quality of the paper, so the fact that mulberry bark paper in north China was used in the Jin and Yuan Dynasties to make money reflects its superior quality at that time.

Ming and Qing Dynasties epitomized papermaking technologies and is the third peak of the development of bark paper technology. The highest achievement of bark paper in the Ming Dynasty is Xuande Paper produced in Xuande years (1426–1435). The Xuande Paper is the general term for a series of refined letter papers, whose main varieties include white letter paper, gold-sprinkled letter paper, five-toner pink letter paper, five-toner letter paper with golden flowers, five-toner curtain paper, and porcelain green paper. These papers were submitted for imperial use for their superior quality and thus the name Xuande Paper.

[22] History of Jin. Volume 48. A Record of Food and Commodities 3. The Twenty-five Histories. Book 9: 7036.

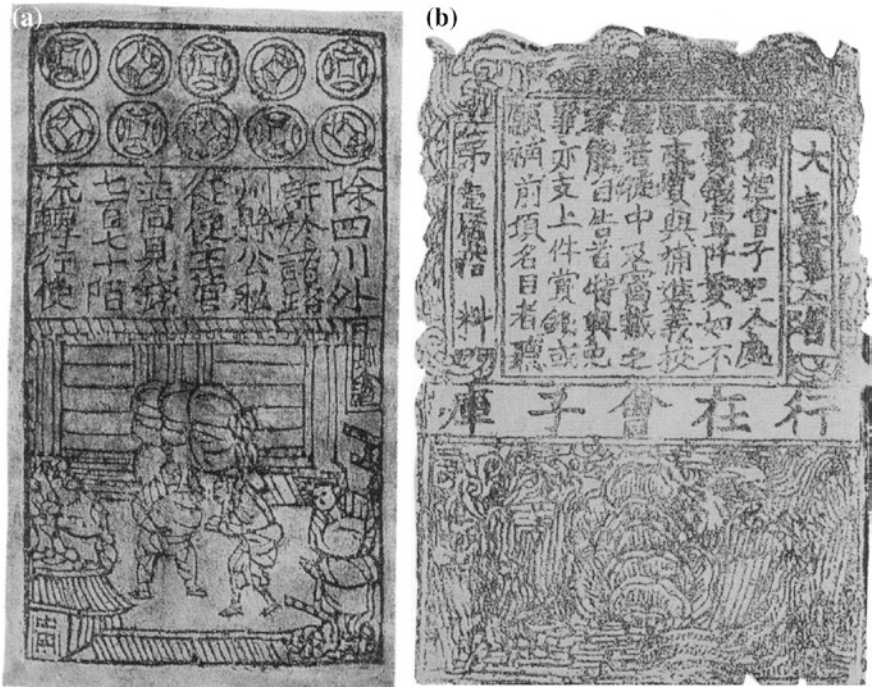


Fig. 10 Paper money of the Song Dynasties. **a** Jiaozi of the Northern Song Dynasty, **b** Huizi of the Southern Song Dynasty

The last peak in development for bark paper is the advent of Rice Paper Era. The term "Xuanzhi" (rice paper) is first seen in Volume III of *Famous Paintings of All Periods* compiled by Zhang Yanyuan of the Tang Dynasty, "Good families should set aside hundreds of Xuanzhi sheets, and wax them for counter-drawing." "Xuanzhi" is the abbreviation for "Xuanzhou Gongzhi" (the tribute papers from Xuanzhou). From the Tang Dynasty to the Qing Dynasty, making technique for Xuanzhi witnessed a series of development stages, with changes in raw materials, production process, and even product name. "Xuanzhi" is the general term for the tribute papers produced in Xuanzhou, and the name derived from "Xuanzhou Gongzhi" of the Tang Dynasty. In its development process, Xuanzhi inherited the bark paper manufacturing technology of Wannan—as represented by Chengxintang Paper—in the Song Dynasty and the advanced technology of Xuande Paper, with continuous improvement in the long period of Yuan and Ming Dynasties. By the middle and late Ming Dynasty, Xuanzhi had become perfected and the outstanding representative of handmade paper in China.[23] In compilation of *Complete Library in Four Branches of Literature* in the Qing Dynasty (as

[23] Fan Xilu, Zhang Binglun and Fang Xiaoyang, Connotations of Xuanzhi Concept from the Perspective of Its Technological Origin [J]. Historical Research in Auhui, 2009: 2.

Fig. 11 *Complete library in four branches of literature* compiled in the Qing Dynasty

shown in Fig. 11), Xuanzhi was used. Just as Hu Yunyu (styled Pu'an, 1879–1947), the scholar from Jing County in late Qing Dynasty had remarked in "*On Papers • Xuanzhi,*" "Jing County was known as Xuanzhou in ancient times. Across the country produces the largest amount of papers, called Xuanzhi, which is produced in Xuancheng, Ningguo Jingxian and Taiping, hence the name Xuanzhi. The paper produced in Jing County is especially elaborate. Now Xuanzhi is produced in Jing County only, and thus is also known as Jingxian paper."[24]

1.2.7 Manual Papermaking Since the Late Qing Dynasty

After the Opium War, the influx of Western machine-made paper into market had an impact on sales of handmade paper. Since the late Qing Dynasty the papermaking equipment began to be introduced for production of machine-made paper, efforts were made to imitate Lianshi Paper and MaoBian Paper in response to market demands. A variety of papers including Yanglianshi and Jilianshi were produced, resulting in increasingly serious impact on handmade paper. With the continued development of the paper industry, the handmade paper production was generally in the state of contraction. In addition, there were war and chaos, so papermaking shops in many areas had to shut down or turn away.

During the Anti-Japanese War, material supply in the rear was in shortage. Some manual papermaking workshops restored production to meet the demand for paper, and traditional paper industry flourished once again. For instance, bamboo paper production in Jiajiang, Sichuan made considerable progress in this period.

After the founding of the People's Republic of China, manual bamboo papermaking in other war-torn areas soon revived and developed, aside from Jiajiang which continued the development of bamboo paper. In the early days of the nation, the paper industry was still relatively backward. And with economic blockade,

[24] Hu Yunyu. On Paper. Puxuezhai Series, Volume. 4.

China's import of wood pulp was once cut off, and machine-made paper could not meet the needs of the society. Paper-producing areas took active measure of self-help production, not only furnishing an important supplement to the paper market, but also contributed to the rapid rise papermaking industry in China by turning many workshop of lower-class bamboo paper into bamboo pulp boards for machine paper factories in the context of originally backward domestic paper industry suffering shortage of raw materials.[25]

After the 1980s, the Chinese government adopted the policy of reform and opening. Traditional calligraphy and Chinese painting picked up vitality. With the revival of the ancient classics printing industry, the demand for handmade paper increased, lending vitality to handmade paper production. According to our investigation in recent years, Jingxian County of Anhui Province, Jiajiang of Sichuan Province, and Fuyang of Zhejiang Province are still major producing areas for handmade papers with relatively larger numbers of workshops and greater turnout. In addition, there are many manual papermaking workshops of varying scales in places in Yunnan, Guizhou, Guangxi, Anhui, Hebei, Shaanxi, Shandong, Shanxi, and other provinces.

1.3 Dissemination of Papermaking and Its Influences on Modern Papermaking Technology

1.3.1 Dissemination of Papermaking in Countries Adjacent to China

Dissemination of papermaking overseas started with regions adjacent to China.

Korean Peninsula adjoins China. Lelang County (now the Pyongyang area) in the north was established in the 3rd year (108 BC) of Yuamfeng during reign of Emperor Wu of Han Dynasty, under the jurisdiction of Department of Youzhou Prefectural Governor of Western Han Dynasty. Since the Western Han Dynasty, many Chinese had settled down here and in the Eastern Han Dynasty, and Wei and Jin Dynasties, Lelang County was governed by the Han ethnic group, who not only used paper made in China, but also brought the papermaking technology there. In about third century AD to fourth century AD, artisans from northern China began making paper there. Goguryeo, bordering Lelang and Liaodong, started making paper roughly at the same time. Baekje and Silla might be a little later in papermaking, but no later than the fifth century AD.[26]

In the early states, the Korean peninsula produced hemp paper, which were thick in texture and which had the characteristics of paper from north China. In the later half ninth century, Wang's Koryo Dynasty rose, overthrew Silla in 935 AD,

[25] Wang Shiwen. Historical Review of Traditional Chinese Bamboo Paper and Treat of the Features of Its Manufacturing Technology [J]. Paper History Research: (15).

[26] Pan Jixing. The Four Ancient Great Inventions in China—Origin, Dissemination Overseas and Global Influences [M]. Beijing: University of Science and Technology of China Press, 2002:361–367.

and established a unified peninsula feudal dynasty. Papermaking skills of Korea witnessed further development, with the progress in bark papermaking especially significant. After the Song Dynasty, Koryo paper entered China as a tribute paper and was appreciated by the literati. Han Ju, a poet of the Song Dynasty (ca. 1086–1153), had the expression of "The Koryo paper you sent me are white like tallow and moonlight sprinkled on the tea table,"[27] and so on in his poem "*Gratitude to Qian Xunzhong for the Koryo Ink.*" In the late fourteenth century, Koryo Dynasty came to an end, ushering in the era of Li Dynasty, under the title of Korea. Li Dynasty and its Chinese contemporary Ming and Qing Dynasties continued to maintain friendly relations and cultural exchanges. Chinese still inappropriately called the Korean paper "Koryo paper." Like China, Korea entered a period of outstanding papermaking technology during this period, further improving the quality of the paper. Shen Defu (1578–1642) of the Ming Dynasty even remarked that "Among all papers currently in use around the world, Koryo paper is the best."[28] Despite the partiality in Shen's comment, the quality of Koryo paper is evident.

Japan, overlooking China across the sea, started economic and cultural exchanges with China early on. According to the research of Pan Jixing, the starting time of Japanese papermaking should be the fifth century when Wang Ren, Gong Yuejun, Azhi Shizhu, and many other Chinese people came to settle down in Japan from the Korean peninsula. This era is equivalent to the Jin and the Sixteen Kingdoms period in China. After entering the Nara Dynasty (710–794), Japan enjoyed social stability, economic prosperity, and booming cultural and educational undertakings. All those brought about a surge in the demand for paper, and the fast increasing demand greatly stimulated the development of local paper industry. Mino, Musashi, and many places in Honshu Island and Awa of Shikoku Island were sending paper as tribute to central government. Broken burlap, mulberry bark, and gampi were the main raw materials. Over time, papermaking in Japan gradually formed its own characteristics in process.

Bordering China in the south, Vietnam and Chinese mainland were under the reign of the same government in the 1,000 years between the Han Dynasty and Song Dynasty and used the same reign title and characters. Papermaking in Vietnam started in about the early third century, when Shi Xie (137–226) was in office of the prefect of Cochin.

Despite the fact that India borders with China and started direct economic and cultural exchanges with it since the Western Han Dynasty, and the fact that Buddhism was introduced from India to China in as early as the first century, we can see from currently available information that papermaking entered India might not be earlier than the seventh century. The route was probably from Xinjiang via Kashmir, or from Tibet via Nepal. Pakistan and Bangladesh started making paper slightly later than India, but reached a high level in no later than the thirteenth century to fourteenth century.

---

[27] Song Han Ju. Collected Poems of Lingyang.

[28] Ming Shen Defu. Feifu Yulüe. Collected Series. Book 1559. Shanghai: Commercial press, 1937.

1.3.2 Dissemination of Papermaking to Europe

It is in the Tianbao years (AD 751) during the reign of emperor Xuanzong in the Tang Dynasty that the Chinese papermaking was introduced to the West and Arab. Prior to this, "in early eighth century, the Arabs ruled the region equivalent to Turkestan of the former Soviet Union. This situation is well documented in the Arab history books. Back then Turkic civil war broke out, and one of the leaders asked for assistance from China, while another sought help from the Arabs. Arabs defeated the Chinese army and drove the latter to the frontier of China. Among the captives there were paper workers who later teach papermaking art in Samarkand."[29]

Dissemination of papermaking to Europe can be divided into two phases: the first phase is from twelfth century to thirteenth century, when papermaking was introduced to Europe by the Arabs from the Tang Dynasty. The second phase is from the eighteenth century to the nineteenth century, when the Chinese papermaking technology was directly introduced to Europe by Europeans and eventually led to revolution in the papermaking technology. In Europe, Spain is the earliest to make paper locally, and one of the reasons is that it was once under rule of the Arabs. Previously, European had to import paper mainly from Arabia for use. The Arabian paper was transported from Damascus via the Byzantine Constantinople to Europe. An alternative route is from Egypt and Morocco in North Africa via Sicily in the Mediterranean. Introduction of papermaking to Italy might have been achieved via the same two sea routes. The first paper workshop in Italy was established in 1276 in Monte Fano in central Italy, and it produced hemp paper.

Since then, France introduced papermaking from bordering Spain in the mid-fourteenth century, while Germany established a paper workshop in the latter half of the fourteenth century with several Italian paper workers brought to the country by a businessman named Strom back to his hometown Nuremberg. Nuremberg later became famous for papermaking, and the center of the printing industry in Germany. Since then, Switzerland, the Netherlands, the United Kingdom, Denmark, Norway, and other European countries successively imported technology from neighboring countries to establish paper factories.

In the New World in America, the Spaniards established in 1575 the first papermaking field in Mexico. More than one century later, that is, in 1690, Rit House an immigrant from Germany built the first-hand paper company in Germantown, a city near Philadelphia within the boundary of the USA. By 1776 when the USA became independent, paper factories had been widely distributed in many states.

In the eighth century, it was papermaking process of the Tang Dynasty that got introduced from China to the West. When Europe and the USA successively established their own paper factories, papermaking in China continued to develop. After

[29] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West [M]. Beijing: Commercial press, 1957: 112.

development over the 1,000-odd years spanning the Song, Yuan, Ming, and Qing Dynasties, the overall level of papermaking had exceeded that in the Tang Dynasty. Although Europe also contributed to the development of the traditional papermaking artistry—for example, the Dutch invented the beater in 1680, and the Germans first started using a screw press in the sixteenth century—the overall level lagged far behind China. This is especially true in variety of paper materials, use of paper drugs (viscous additives used in papermaking), and manufacturing of large-format papers where Europe had a significant gap to bridge in order to catch up with China. Learning the situation from Jesuits sent to China, Europeans began introducing paper technology from China for the second time from the middle of the eighteenth century.[30]

1.3.3 Influences of Traditional Papermaking Techniques on Mechanical Papermaking

Modern paper machine was invented in 1798 by French named Robert. Originally, it was just a small-sized machine established in Eisenach paper mill, with a lot to be improved. After many years, a really practical machine was set up by Gerber and Don King in England. From then on, papermaking entered the modern mechanized process.

The modern paper machine is composed of three main parts, i.e., the wire section, the press section, and the dryer section, all of which adopt the principles of papermaking in China. Therefore, just as Carter put it, "it is a most irrefutable and absolute truth that papermaking has been invented by the Chinese. Other countries might be able to contend with China for being the originator of other discoveries. They might be justified in arguing that those discoveries germinated in China but depended on the West for development and utilization. However, the Chinese papermaking spread abroad as a well developed process. Actually there is no substantial difference between the paper used today and the paper back then. Even in today, China still wants further improvements in papermaking. The thin printing paper and tough paper we used now spread from China to the West in the nineteenth century."[31]

Papermaking made unparalleled contributions to world civilization. It not only provides mankind with a new and convenient textual and graphic carrier, promotes the spread and development of human culture, but also lays the foundation for the invention of printing. It can be said that without papermaking, there would be no printing, because without paper as the cheap material, printing would lose its meaning of existence. In addition, it also created painting and calligraphy unique to the Chinese. At this point, mechanical papermaking so far has not completely replaced the traditional papermaking technique.

---

[30] Pan Jixing. The Four Ancient Great Inventions in China—Origin, Dissemination Overseas and Global Influences [M]. Beijing: University of Science and Technology of China Press, 2002:392–397.

[31] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West. [M] Beijing: Commercial press, 1957:17.

1.4 Evolution of Traditional Papermaking from the Perspective of Dongba Paper of Naxi Ethnic Groups

The time of papermaking origin has been a hot topic in research of papermaking history. However, research in the evolution of the papermaking process is still insufficient. The current academia cannot give definite answers to many problems, including which process was used in the early stages of papermaking, when it began to use paper drugs, and when was papermaking process used. The reason is lack of sufficient evidence. In recent years, more and more data gradually emerge with the deepening of survey in intangible cultural heritage, making it possible for us to further explore these issues. According to the information available, we had questioned the view of Cai Lun inventing paper drug and put forward a new view.[32] Recently, we find that traditional papermaking processes in some places carry important information, which can help us construct the evolutionary process of paper craft.

1.4.1 Production Technique for Dongba Paper of Naxi Ethnic Group

Naxi Ethnic Groups in Daju of Yulong County and Baidi, Shangri-La County, Diqing Tibetan Autonomous Prefecture, Lijiang City, Yunnan Province still retain the original Dongba paper production process. In recent years, Li Xiaocen, Zhu Xia, Chen Dengyu, and many other scholars have successively been to the place of origin for fieldwork. According to the investigation report, the bark of a shrub in the family of Wikstroemia Thymelaeaceae is used as the materials for production of Dongba Paper. The production process includes acquiring raw materials, drying materials, soaking, cooking, rinsing, pulping, making paper, drying the paper, calendering the paper. Compared with the process of mulberry bark paper and mulberry paper, the set of processes have many features, but the most noteworthy is the process of making paper.

The uniqueness of the finishing technique for Dongba paper lies in that the technique is not only different from ordinary papermaking, but also different from pouring paper. Therefore, it can be seen as a third technique. To facilitate discussion, we will briefly introduce this process.

Papermaking tool used in Chinese mainland is shown in Fig. 12. It is constituted by two parts: the bamboo curtain and curtain frame. Similarly, Dongba paper papermaking tool is composed of two parts: the curtain and frame (as shown in Fig. 13). The curtain "is made of rows of thin bamboo strips connected with twines." Curtain frame "is shaped after the drawer and its inner space is spacious enough to contain the paper curtain. Thus, its size matches that of the paper curtain. On the bottom, there are two to three horizontal rungs used to support the

[32] Jialu Fan, Fang Xiaoyang. Several Issues Relevant to Paper Drug Invention [J]. Journal of Nanchang University (Humanities and Social Sciences), 2000(2) 132–136.

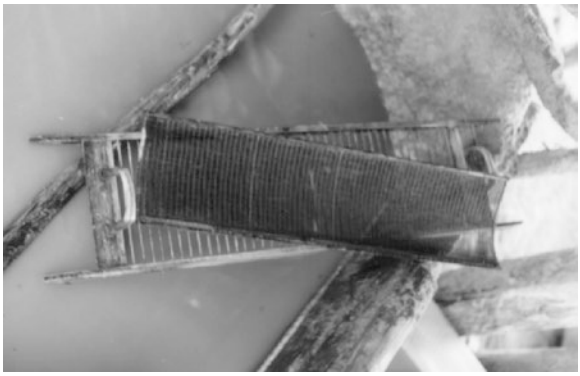


Fig. 12 Paper curtain and curtain support for papermaking in Chinese mainland

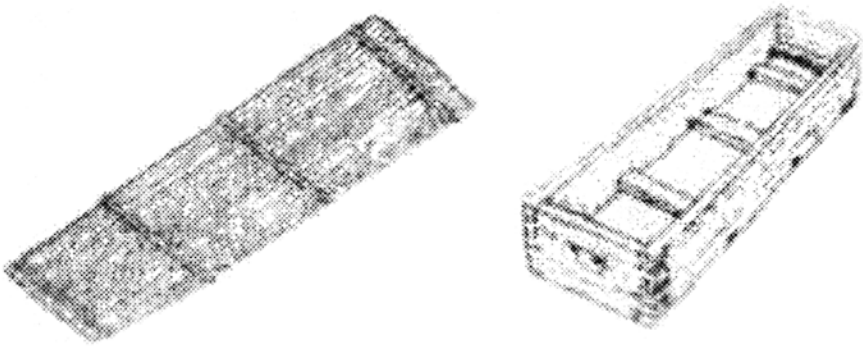


Fig. 13 Tools for making Dongba paper by Naxi ethnic groups

paper curtain." We have noticed that there are significant differences between the curtain used in Dongba and that in the Chinese mainland. First, the latter can be rolled up, and unfolded, while former is like a fixed bamboo fence which cannot be rolled up. Second, the wires in the latter are very thin, generally below 1 mm in diameter. In some cases, they are only 0.3 mm. In comparison, those in the former are much thicker. There is also a significant difference in curtain frame between the two. The curtain frame used in papermaking in Chinese mainland is thin, equivalent to a screen for fixating papers. Smaller curtain frames are no thicker than 3 cm, and those used for 4-Chi (1 Chi = 33.33 cm) rice papers are normally no thicker than 6 cm. Here, the curtain frame "is shaped like a drawer" and can reach 20 cm in thickness.

In fact, the differences in tool reflect that in process. The papermaking process in Chinese mainland is as follows: secure curtain on the curtain frame, hold both ends of the curtain frame with hands, plug the curtain into the groove, lift the pulp and make it evenly distributed on the paper screen, and then peel the curtain off from

Fig. 14 Lift the curtain after putting the lift paper upside down on the paper stack

the frame and turn it over on the paper stack, lift the curtain (as shown in Fig. 14). The process can be repeated again to make thousands of sheets of paper as drain the paper stack, lift the paper sheet by sheet, and then begin the drying treatment.

For Dongba paper, the process is different. The first step is to put curtain into the curtain frame, immerse it in water, place the beaten pulp on the curtain, and shake the curtain to make the pulp even. Then take out the paper curtain, directly flip it over on the wall or board for drying paper, pat the wet paper slightly so that the wet paper can get stuck to the wall or board, and then remove the curtain, and make the second sheet.

Although in making Dongba paper, removable curtain is used, which is similar to the tool used in papermaking method. However, seen from the above procedure, it has much in common with pouring paper.

Pouring papermaking method is a process different from papermaking, in that the curtain is stationary, i.e., the curtain and the curtain frame are combined into one, and that homespun rather than bamboo filament is used in the curtain. While pouring paper, sprinkle the pulp on the paper curtain, and shake the curtain so that the pulp becomes evenly distributed. Lift the curtain, dry the paper in the sun, and peel it off. The Tibetan manual papermaking technique currently kept in Dege Sutra Printing House in Sichuan is the pouring method. In addition, pouring method is still in existence in Mannzhaozhai, Mengkun Township, Menghai County, Yunnan Province, etc.

Removable bamboo curtain and independent curtain are repeatedly used in Dongba paper, similar to the papermaking process. However, the process of making Dongba paper shares some common ground with pouring method in that its curtain cannot be rolled up and the pulp is poured instead of being lift up. So it is a paper manufacturing process between pouring paper and papermaking.

1.4.2 Technical Origins of Dongba Paper Process

The fact that the manufacturing technique of Dongba paper between pouring paper and papermaking carries important historical information, which attracts the attention of researchers far and wide.

Most of the relevant research that the author has learnt believe that it results from the merge of pouring paper method and papermaking process. For instance, Mr. Chen Dengyu believed that The Naxi ethnic group absorbed the strengths of papermaking method and pouring paper method to create a unique Dongba paper during their exchanges with the adjacent Bai ethnic groups and Tibetan ethnic group.[33]

The reason for them to come to this conclusion is that "in China, there are two distinct systems in traditional paper manufacturing technique: one is the traditional papermaking system, and the other is pouring paper." Seen from the existing situation, this is an objective fact. However, different understandings of the fact will lead to very different inferences.

Li Xiaoceng and Zhu Xia believe that the birthplaces of papermaking method and pouring paper method are different. The reasons are as follows: Firstly, the two methods have significantly different characteristics: the papermaking process is mainly found in the East Asian continent, while pouring paper method is mainly seen in the Indo-Pakistan subcontinent and Southeast Asia; papermaking process is mainly used in the Chinese cultural area for production of papers for cultural purposes and sanitary paper, while pouring paper method is mainly used in Buddhist cultural district in India for the production of papers for Buddhist scriptures; technically both are two distinct systems; Secondly, some literatures have relevant records. For instance, the *Condition of Plants in the South* recorded "Honey-scent paper" as "tough handmade paper produced in ancient India using daphne bark as the raw material via pouring paper method." The final conclusion is the papermaking process originated in Chinese mainland and is related to silk whitening by the ancient Chinese; pouring paper may have originated in areas beyond Chinese mainland, including the vast areas of the Indo-Pakistan subcontinent and Southeast Asia, and is related to clothing and bark cloth, while its dissemination and use is closely related to the Buddhist culture of India.[34]

Although this argument is not entirely unfounded, the evidence is far from being able to necessarily lead to this conclusion. In fact, now there is no direct evidence showing which is used at the beginning of the invention of papermaking—the pouring paper method, the papermaking method, or another method. The question is, how we understand the several different processes we see today? You can think of each process as having its own unique origin. You can also believe

---

[33] Chen Dengyu. Exploration of New Methods in Dongba Paper of Naxi Ethnic Group [J] Ethnic Art Studies, 2004(6):70–78.

[34] Li Xiaocen, Zhuxia. Manual Papermaking in Ethnic Groups in Yunnan Province [M]. Kunming: Yunnan Fine Arts Press, 1999:88–94.

that the various processes are not mutually independent; instead, they are the remains of the same process in different evolutionary stages. Changes result in diversity, just as the case of evolution of animals. When we say that man evolved from apes, we mean that only some of the apes evolved into human beings, not that all the apes evolved into human beings. As a result, there are the two species of human and ape. If we say that humans and apes have always been two species with their respective origins, logically there is no problem. Otherwise, people would not have believed so before Darwin.

It stands to reason that all kinds of process are evolving in varying degrees. It is hard to imagine people from the time of Cai Lun can produce paper so uniformed and so thin with the thin curtain see today. It is equally difficult to imagine that a certain process would stay constant without improvement in the long years. The manual papermaking processes that we see at different places are different. Can we say that these processes have their own respective origins? If the papermaking process did not exist in Cai Lun's era, how did people make paper? Mr. Pan Jixing in the early 1970s proposed that the first paper should have been produced by pouring paper.[35] The reason for him to think so is that he only knew these two methods and that pouring paper is more backward than the papermaking method. We believe that, if there were no more primitive method, then the inference is correct. Of course, if Cai Lun really used pouring paper method, the method should be far more primitive than what we see today. Since it is considered that the papermaking method comes from pouring paper method, how exactly does the evolution occur? Which intermediate forms are involved? Before we see the papermaking skills in Dongba, we have been confused by these issues.

While undertaking review at the Ministry of Culture in the first session of intangible cultural heritage projects, the author had access to data of Dongba paper production technology in Yunnan Province. In videotapes, the author clearly saw the entire production process of Dongba paper. Seeing the paper worker lifting (strictly speaking, should be "pouring") the paper curtain with wet paper and securing on the drying wall, and then softly sticking the paper to the wall, I cannot help but exclaim, isn't it the transition between pouring paper and papermaking process that I've been looking for?

The repeated use of one curtain in Dongba paper craft, rather than preparation of hundred of curtains as does the pouring paper method, helped saving costs. But compared to the papermaking process, it puts one sheet to dry every time it lifts one—i.e., the two processes of lifting and drying are not separated—and productivity is lower. Therefore, it should be an intermediate form in transition from pouring paper method to the papermaking process. If the case were like what Mr. Chen Dengyu said, i.e., absorption of the advantages of pouring paper and papermaking method, it is clearly difficult to understand from the perspective of technology evolution.

---

[35] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M]. Beijing: Cultural Relics Publishing House 1979:47–51.

1.4.3 Relevant Deductions

Following this line of thoughts, we can reach a series of deductions.

First, if the earlier paper is manufactured by pouring paper method, then, the early paper should not be so uniformly thin and with curtain pattern, as the paper from later generations are. Instead, there should be no curtain patterns and might also be thicker. The era of pouring paper method in common use should be the Wei and Jin Dynasties. Approximately in the middle and late stages of Northern and Southern Dynasties, transition to the papermaking process began in the Central Plains, and the transition basically completed in the Sui and Tang Dynasties. Papermaking methods adopted by the transition period should be an intermediate form like that for Dongba paper—the paper produced should have curtain patterns, but should not be so thin as that produced by later generations of papermaking.

Second, since the craft of Dongba paper of the Naxi Ethnic Groups is an intermediate form during the transition from pouring paper to the mature papermaking method, it could not have been introduced from Tibet, but from the cultural circles of the Central Plains instead. The level of the craft is equivalent to that in the Central Plains region in the early Tang Dynasty. Admittedly, the Naxi manual paper craft as we see today is not necessarily the same as what it was initially.

Third, the time of pouring paper introduced to Tibet should be earlier than the appearance of the papermaking process, at least earlier than the popularization of papermaking method in the Central Plains region. Judged temporally it should be before the Tang Dynasty. The academia mostly agrees with the conclusion of the American scholar Carter, i.e., Chinese papermaking was introduced to the West and Arab in the 10th year of Tianbao (AD 751) during the reign of Xuanzong of the Tang Dynasty. In a battle with the Chinese army, Arabs captured some paper workers who later began to teach papermaking process in Samarkand.[36] Now the manual paper craft at the same stage of evolution as the Dongba paper craft is still preserved in the West. The American scholar Hunt made quite a comprehensive study of handmade papers around the world in the first half of the twentieth century. In his book, Hunt introduced manual paper production in England at that time: paper drugs were not used and the curtain used could not be rolled up. Instead, felts were used to separate the wet papers (as shown in Fig. 15), in a way somewhat like making tofu skin.[37] Like Dongba paper craft, this set of process does not use paper drugs and thus can be considered to be at the same stage. Upon further comparison, it is found to be more advanced than Dongba paper, in that it directly attaches the wet paper to felts instead of the wall, improving work efficiency, and product quality. Now that pouring paper is the more primitive method,

[36] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West [M]. Beijing: Commercial press, 1957:112.

[37] Dard Hunter, Papermaking: The History and Technique of an Ancient Craft, 1949, Alfred A. Knopf, New York, p. 441.

Fig. 15 Papermaking without paper drugs, from Dard Hunter's *the history and technique of an ancient craft*

its widespread use should have happened before this craft. Therefore, we believe that the time for pouring paper to be introduced into Tibet should be before the Tianbao years of the Tang Dynasty, probably before the Tang Dynasty or in early Tang Dynasty.

Fourth is on the issue of time and route for papermaking to be introduced to India. Mr. Ji Xianlin has conducted in-depth explorations on the issue in the 1950s. According to his research, in the middle of the second century AD, papermaking already entered China's western region, and Indians living in the Ancient Xinjiang region may have accessed paper at that time. There is evidence in literature that in no later than the seventh century there were people using paper in the mainland of India.[38] As for the time of papermaking introduced to India, Mr. Ji did not give any specific conclusion. We believe that it should be at roughly the same time when papermaking spread to Tibet, that is, before the Tang Dynasty. This, of course, is a corollary of this article, without much direct evidence.

[38] Ji Xianlin. On the Time and Location for Introduction of Chinese Paper and Papermaking from China to India. Wang Shuying (eds.) Ji Xianlin on Cultural Exchanges between China and India [M]. Beijing: New World Press, 2006-1. The book also included two other relevant theses, i.e., Was Chinese Paper and Papermaking Introduced to India via Maritime Routes, and Supplemented Studies of the Introduction of Chinese Paper and Papermaking to India.

Finally, about why pouring paper method persisted in the region for a long period of time, we believe that religious use is a relevant factor. In accordance with the Mr. Li Xiaocen's theory, products of papermaking process were mainly used for cultural purposes and sanitary paper, and those of pouring paper method mainly for Buddhist scriptures. He treated the differences in product use as the essential difference between the two processes. Thus, his theory does not make sense logically. However, we can find the answer to a question through it. The reason for those regions to preserve the relatively backward production technology is perhaps the religious culture has more stringent requirements on inheritance. The paper made by pouring paper method is used to write Buddhist scriptures, and paper used for Buddhist scripts over generations has been made this way. So this method can go on and on. Although there were other methods for making paper, the paper had not been used for scriptures. Therefore, they were not worth learning. Much like the Tibetan Ethnic Groups managed to preserve the process of pouring paper method, the Naxi Ethnic Group was able to save the original process, probably because of its direct relationship with the unique Dongba cultural traditions. In fact, after the modern times, pouring paper method was still in use in many areas. D • Hunt's book recorded pouring paper scenarios he had seen in Guangdong Province, China in the mid-twentieth century.

Of course, there may be other reasons. For example, while surveying the manual paper-producing areas in Jiajiang, we found that in Macun Tonwship, which is not far from the county seat, manual paper craft had evolved very quickly over recent years. All the paper mills basically produced calligraphy paper, but it was impossible to find throughout the township a mill still using traditional methods for making pulps. In relatively secluded Huatou Village, whose average elevation exceeds 1,000 meters, many papermaking households solely using the original process had been preserved. This shows that the evolution of the process is not synchronized in slightly larger ranges. There are always some places to stick with the original process. Naxi papermaking process may not have been directly introduced from the Central Plains and is likely to have arrived at a later period from an adjacent place which happened to have retained the original process.

2 Lecture 2 Printing

Qi Han

Printing, gunpowder, and compass are known to the Westerners as the three great inventions of China. The British Francis Bacon once said in the seventeenth century, "Printing, gunpowder and the compass: These three have changed the whole face and state of things throughout the world; the first in literature, the second in warfare, the third in navigation; and they have all played significant roles, whence have followed innumerable changes, in so much that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries." We now know very clearly that those inventions are from China. Add papermaking, and we will have what is well known today as the four

great inventions of ancient China, which are great contributions to human society made by the Chinese nation, and which has also had extremely far-reaching impact.

Printing is called "a sacred art" and also known as "the mother of civilization." Its importance is well known. It is often said that "knowledge is power," and one of the sources of this power is printed books. Woodblock printing was invented during the Zhenguan years, the early of the Tang Dynasty in the seventh century, about 700 years earlier than that in Europe. During the Qingli years of Northern Song Dynasty in the eleventh century, Bisheng invented movable type, about 400 years ahead of Gutenburg from Germany. Over the 1,300 years, due to the widespread adoption of printing, the Chinese civilization has managed to continue in a continuous line, making an indelible contribution to the world.

2.1 Block Printing

2.1.1 Origin and Development of Block Printing During the Tang and Song Dynasties

The time of invention of woodblock printing is an old issue of controversy over hundreds of years. There are many theories proposed by scholars from home and abroad, ancient and modern and those theories can be divided into seven categories, namely the Han Dynasty Theory, Eastern Jin Dynasty Theory, Six Dynasties Theory, Sui Dynasty Theory, Tang Dynasty Theory, Five Dynasties Theory, and the Northern Song Dynasty Theory. According to archaeological data currently available, the Han Dynasty Theory, the Eastern Jin Dynasty Theory, and the Six Dynasty Theory are faulty in that they are too premature, while Northern Song Dynasty Theory is feeble in for being too late. The Five Dynasties Theory, though popular in the Qing Dynasty, has been overthrown by Xiantong-version "*Vajracchedikapra-jnaparamitaSutra*" of the Tang Dynasty found in Dunhuang. The Sui Dynasty Theory has few followers due to its misunderstanding of literature. Therefore, the only theory with relatively higher credibility is the Tang Dynasty Theory. Since the Tang Dynasty ruled for about 300 years (618–907), there are a variety of different arguments for the specific era of invention of printing, including the early Tang Dynasty Theory, middle Tang Dynasty Theory, and late Tang Dynasty Theory, with the third theory having the most followers. Some have proposed the Zhenguan Theory (early Tang Dynasty Theory) in the seventh century, according to the "*Hong Jian Lu*" by Shao Jingbang (1491–1565) a historian from Hangzhou in the Ming Dynasty. These data first appeared in "*Collected Essays of Reading in Shizhuzha*i" a book written by Zheng Ji (died in ca. 1880) of the Qing Dynasty. The original text in Volume 46 of *Hong Jian Lu* says: "太宗后长孙氏，洛阳人。……遂崩,年三十六。上为之恸。及宫司上其所撰《女则》十篇,采古妇人善事。……帝览而嘉叹,以后此书足垂后代,令梓行之" (Empress Zhangsun, wife of Emperor Taizong of the Tang Dynasty, is a native of Luoyang, passed away at the age of 36, and the emperor grieved her death. The

Inner Palace Secretary relegated the ten essays of "*Important Principles for Girls*" which recorded the virtuous deeds of ancient women… The Emperor read them and sighed in admiration. Convinced that the book by the empress sets an example for future generations, the emperor ordered to have it printed).

"梓行" is equivalent to engraving and printing, thus the meaning is very clear. The Empress Zhangsun died in the 10th year of Zhenguan (636). Therefore, the book should have been published in the same year or slightly later. At that time, there might have been civil print of the book, before Emperor Taizong wanted to have it published. The problem is that Shao Jingbang is a historian of the sixteenth century, and his book is second-hand historical data. However, the sentence "令梓行之" (ordered to have it printed) is nowhere to be found in *The Old Book of Tang, New Book of Tang*, *Comprehensive Mirror for Aid in Government* or *The Imperial Readings of the Taiping Era*. Yet "*Hong Jian Lu*" is an official general history, which was proclaimed by Shao to be comparable to *Tongzhi* (General Records) by Zheng Qiao of the Song Dynasty, and which took 15 years of his effort, and underwent four drafts. From this, we can see how cautious and careful Shao had been. In addition, Shao also proclaimed "I transmit but do not innovate." Therefore, his record should not have been concocted out of thin air.

Buddhist disciple Xuanzang of the Tang Dynasty once printed and distributed images of the Budda, providing circumstantial evidence to the Zhenguan Theory. In his "*Yunxian Sanlu*" (Random Record of Immortals), Feng Zhi of Tang Dynasty cited "*Sengyuan Yilu*" (Anecdotes of Monk) as saying "Xuanzang printed images of Samantabhadra on Huifeng Paper, for distribution across the nation, exhausting five camel loads each year." Xuanzang made a journey westward to the India in the 3rd year of Zhenguan (629 AD), returned in 645, and passed away in the first year (664 AD) of Linde. Therefore, printing of Buddha images should have occurred after his return. He produced five camel loads of images of Samantabhadra each year—that is a large quantity—yet unfortunately none has been handed down. The single width large images of Samantabhadra with Monju and Avalokitesvara of the Five Dynasties found in Dunhuang may be similar to the image printed by Xuanzang.

Lu Shen, the scholar of Hongzhi-Zhengde Era in Ming Dynasty, is the first one to propose that book printing began in Kaihuang years of Sui Dynasty. Lu's "*Hefenyan Xianlu*" (Idle Record of Hefenyan) recorded, "On December 8 of 13th Year (January 5th, 594) of Kaihuang during reign of Emperor Wen of Sui Dynasty, edict came requesting complete restoring or recarving of shelved Buddha statues and remaining Buddhist scriptures, thus marking the beginning of printed book. This happened before Emperor Feng Yingwang."

The material cited by Lu is seen in "*Chronicles of The Three Treasures Over Generations*": because the Northern Zhou Dynasty abolished Buddhism, "destroying statues and damaging Buddhist scriptures, treating monks with scorn and smashing temples," "Buddhist towers and other buildings were ruined and scriptures and images plunged into degeneration." Yang Jian, Emperor Wen of Sui Dynasty, strongly advocated Buddhism soon after he acceded to the throne and promulgated in the first year of Kaihuang (581) a decree, ordering that everyone

in the country should be free to choose to become a monk or nun and that money should be levied on the basis of population for the restoration of Buddhist scriptures and statues. In the 13th year of Kaiwang, he "Respectfully donated one hundred and twenty thousand rolls of silk for renovation of all damaged statues and images" "to re-solemnize the true images of Buddha, to make the destroyed facilities more stately, and to restore all the ruined statues and scriptures." However, the article mentioned "the ruined statues and scriptures," which includes scriptures and statues, and the two are obviously different. Therefore, "restore all the ruined statues and scriptures 'means' carving the statues that have been destroyed, and gathering and collating remnant Buddhist scriptures." Wang Shizhen of the early Qing Dynasty said "Upon detailed study of the context, I found that carving applies to the statures, while gathering and collating applies to Buddhist scriptures. This is a slip of tongue on the part of Yanshan (i.e., Lu Shen)." Hence, the theory of Kaihang in Sui Dynasty rose from Lu's misunderstood of the context. Later generations in quoting Lu Shen changed "悉令雕撰" to "悉令雕版," or even to "雕造," inevitably resulting in repeated baseless assertions, which has now few believers.

Based on existing literature and archaeological objects, we cannot prove it is a historical fact that block printing appeared in the Eastern Han Dynasty, the Six Dynasties, Later Zhao Dynasty, Northern Qi and Sui Dynasties. Actually only a few of them can be as the corroboration of the Zhenguan (early Tang) Theory. Of course, the final settlement of this issue is pending on the discovery of new historical and archaeological objects.

Verifiable book-carving locations in the Tang Dynasty including Chang'an the capital, and Luoyang the eastern capital, Yuezhou, Yangzhou, Jiangdong, Jiangxi, and with Yizhou (Chengdu) were well developed. Bookshops appeared in the eighth century in Chang'an. In the Dunhuang Photo of Tang Dynasty manuscript *New Compendium of Works on Moxibustion for Emergencies* in the collections of the National Library of China, there is a note "京中李家于东市印" (printed by the Li Family of the Capital City in the East Market). On the back of photograph, we can see the yin and yang scripts written in the 2nd year of Xiantong (861AD). From the prescription written 3 years before that we can conclude that the book had been printed before Xiantong, and this "*Moxibustion*" manuscript had been copied from a printed version. In addition, Dadiao Fmaily of East Market of Shangdu printed "*Almanac*." Xi'an is now in possession of a printed version of *Dharani Mantra* unearthed in a late Tang Dynasty tomb in the western suburbs of Chang'an, which features a seemingly colored Buddha in the middle, surrounded spell texts in Chinese in a square. It is similar to the spell book sold by the Bian Family of Chengdu in the Tang Dynasty, thus is probably a product of Chang'an. The printed book is originally kept in a copper box, with inscription of Xiantong reign of the Tang Dynasty. Therefore, it must have been printed in Xiantong years or before that and thus is the oldest existing printed book of the Tang Dynasty.

"*Vajracchedikapra-jnaparamita Sutra*" found in Dunhuang has a line of remark "Reverently printed and distributed by Wang Jie for his parents on April 15, the 9th year of Xiantong (868)." This volume of the sutras is acknowledged to be the world's most ancient printed book in existence. Wang Jie, an ordinary folk-turned

Fig. 16 Picture of Sakyamuni preaching in frontispiece of "Vajracchedikapra-jnaparamita Sutras"

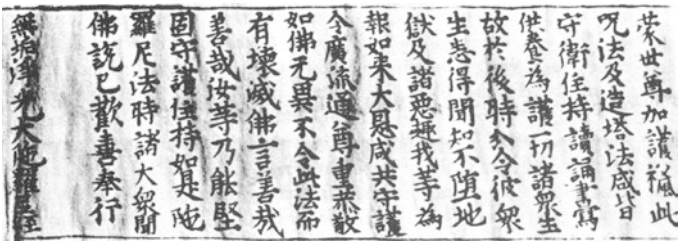


Fig. 17 *Spotless pure light Dharani Sutra* found in Bulguksa temple, South Korea

Buddhist disciple, funded printing of sutras. And the motivation is to pray for his parents and repel misfortunes, thus the expression "printed and distributed… for his parents." In the frontispiece, there is a picture of Sakyamuni preaching Buddhism (as shown in Fig. 16). The image is solemn and stately, and the carvings elaborate. It is a mature work and the crown of printing history in the world. Now it is kept in London.

In 1966, woodblock print *Spotless Pure Light Dharani Sutra* (as shown in Fig. 17) was found in the stone spire of Sakya Tower, in Bulguksa Temple in Gyeongju, South Korea. Upon examination and collation, scholars believed that it had been printed between 704 AD and 751 AD (the third year of King Seongdeok—the 10th year of King Gyeongdeok, equivalent to the 4th year of Changan in the reign of Empress Wu Zetian–10th year of Tianbao in the reign of Xuanzong during the Tang Dynasty). The volume of the sutras is four feet longer than the Xiantong-version Vajracchedikapra-jnaparamita Sutra, about one hundred years earlier, and decades older than the Hoki versions of *Spotless Pure Light Dharani Sutra,* and three others published in 770 AD. Thus, it is known as the treasures of the world's oldest surviving woodblock printing. This sutras used four characters made by Empress Wu Zetian (i.e., 证、授、地、初). However, those

new characters made by Empress Wu cannot prove that it to be a Silla printing, but can prove it to be engraved in the Tang Dynasty. In the first year (689 AD) of Zaichu, Empress Wu created a dozen new characters, which were used by translators and engravers in compliance with her decree or because they have become popular in the society. Even if they reached Silla, those characters could only be used by a few men of letters and were unlikely to be very popular, because Silla had no reason to comply with the decree of Empress Wu. As for the general writing or book engraving, commonly used characters were naturally preferred over complicated hieroglyphics with multiple strokes causing difficulty in engraving.

Tang Dynasty had frequent cultural exchanges with Silla. In the 13th year of Zhenguan (639 AD), Silla, Goguryeo, Baekje each dispatched students into national schools of Tang for study. Over a decade, the Silla adopted the dress of Tang. The Silla monk Chajang took over four hundred copies of the "*Sanzo*" from the Tang Dynasty and won nationwide welcome. Monk Hong Kyung brought home a set of the *Tripitaka* from Fuzhow of Tang. Since the entire voluminous "*Tripitaka*" was brought to Korea several times by monks, it is only naturally reasonable for rolls of printed copies of Buddhist scriptures to be taken with them. Therefore, scholars believe that *Spotless Pure Light Dharani Sutra* is the printed version of the Tang Dynasty in the early eighth century, not published by Silla. Decades after this, there in Japan emerged the Hoki-version dharani. Said to have been hidden in millions of small wooden pagodas, they may have been Japan's own creation because of the large number, but the influences from engraving in China are irrefutable.

After the Tang Dynasty, China entered the period of the Five Dynasties and Ten Kingdoms. During this short period of only 50–60 years, the alteration of dynasties was frequent. Separatist warlords seized their won strongholds, leading to the formation of a dozen local regimes. Coupled with massacre and looting from the Khitan and tribes, hundreds of square miles surrounding the Central Plains including Kaifeng and Luoyang became deserted. Sovereignty was retained in the more remote areas such as Sichuan, Southern Tang, Wu and Yue, and Kingdom of Min, which became cultural centers, with economic prosperity, and relatively developed printing industry. The government published official version of the scriptures, marking the beginning of official versions. Therefore, those scriptures occupy an important position in printing of this period. Book engraving locations in the Five Dynasties include Kaifeng, Jiangning, Hangzhou, Qingzhou, Guazhou, Shazhou, Fujian, and Sichuan, among which Kaifeng, Chengdu, and Hangzhou are most active.

After the establishment of the Song Dynasty, the government became not only eager to supplement the collection of the National Library, but also more strongly advocated book engraving. Imperial Colleges engraved Confucian classics, history, philosophy, and medical books, which were distributed around the country and licensed them for sale. The monarch of the Song Dynasty followed Buddhism and Daoism therefore is also engraved scriptures of the two religions. In this situation, the private interest in books engraving and compiling witnessed significant increase, and it became a trend among local officials of the Southern

Song Dynasty to get engaged in book engraving. Lu You said: "Modern scholars are obsessed with book carving." Wang Mingqing said: "most of the county seats I visited in recent years took to book carving." Over 100 scholars, including Lu You and his son, Fan Chengda, Yang Wanli, Zhu Xi and Zhang Shi, took book engraving with them wherever they took an official post. Via carving, they published their own writings, or those of their ancestors, or those of local personages and celebrities. As for scholars publishing the writing of their mentors and friends, or rare books in their family collection, they are simply too numerous to mention.

Local governmental agencies of the Song Dynasty, including the Military Commission, Tea and Salt Commission, Judicial Commission, Transportation Commission, Provincial Official Residence, County Official Residence, Provincial School, Prefectural School, County School, Academies, Colleges, all took to books engraving, making them the official books. Among the agencies, Provincial Official Residence and District Schools were more productive. In addition, there were envoy bursaries: Song set envoy bursaries in all counties to provide board and lodging for officials going to the capital. Envoy bursaries have envoy expenditure, bursary vinegar tax, and funds under other names. The money was used for catering to the officials, and the balance for engraving books. Some bursaries also set up book printing bureaus. Local officials sometimes also use public funds to engrave books.

The books engraved were printed and sold at a profit, thus Kaifeng, Lin'an, Wuzhou, Quzhou, Jianning, Zhangzhou, Changsha, Chengdu, and Meishan successively set up bookshops, just as in the saying "All the common folks followed suit and started carving books (so as to make money), for food and clothing." Private schools, as well as temples, all took to book engraving, creating an unprecedented prosperity in official and private engraving in the Song Dynasty, marking the golden age in the history of woodblock printing. In the Song Dynasty, engraved versions replaced manual copying, offering great convenience to the reader, and enabling the substantial scientific and technological culture development. The book engraving of Song Dynasty has three characteristics: First, the government attaches importance to and local officials advocate book carving. Second, block-printed books are rich in content, complete in category, and exquisite in outlook, which are beyond the reach of future generations. Third, book engraving places gradually increase. In the Northern Song Dynasty, the number of book-carving centers does not exceed three dozen, while that in the Southern Song Dynasty reaches nearly two hundred. In the Southern Song Dynasty virtually all the 15 routes (equivalent to present-day provinces) were engaged in book carving, with Zhejiang, Fujian, and Sichuan particularly representative.

Hangzhou already boasted bookstores in the Northern Song Dynasty. After the court fled south, the number of private book houses mushroomed, under the name of classics shop, classics mill or classics workshop, shop for classics, book shop or characters shop. Twenty of those can ascertained, some of which were moved to Hangzhou from Bianjing. Books engraved in Hangzhou are sophisticated, with renown at home and abroad. Ye Mengde, the bibliophile of Song Dynasty, said: "in

the world printed books of Hangzhou are supreme, followed by those of Sichuan, while those of Fujian are inferior."

Jianyang County and Jian'an County which shares an outer city wall with Jianning Mansion are one of the centers of the publishing industry in the Southern Song Dynasty. Block-printed editions of Fujian were called "Min Edition," "Jian Edition" or "Jian'an Edition," and those of Masha Township Jianyang were called "Masha Edition." Masha Editions were shoddy products designed to speed sale; containing many errors they almost become synonymous with inferior or notorious editions. In addition, because soft wood was used in carving, the calligraphy and painting were prone to blurring and damages; locally produced bamboo papers were mostly used for printing, and the papers were crisp and thin in texture and the yellow black in color. Neither the content nor the material was good, and they gave a bad impression. But because "Fujian Editions almost swept the nation" for their rich variety and low cost, books currently handed down from the Song Dynasty are mostly Jian Editions. Admittedly, there are also works with elaborate design and academic values. In the Southern Song Dynasty, even the remote Qiongzhou also published a medical book. It can be said that in the Southern Song Dynasty woodblock printing had spread to almost all parts of the country.

Most of the books before the Tang Dynasty have succumbed to generations of warfare, while many books of the Song Dynasty are handed down, and even some ancient works have been handed down in the form of printed copies made in the Song Dynasty. Therefore, the block printing of Song Dynasties has been meritorious in preservation of ancient Chinese culture. The Song Dynasty not only for the first time engraved the philosophical works of thinkers in the pre-Qin and Han Dynasties, but also published a lot of science and technology books. Due to the government's attention, medicine witnessed particularly development, and official and private medical books published were greatest in number. Books of the ancient times and present day have multiple versions; books of entertainment and fun also appeared.

In Kaibao 4 years (971 AD), Emperor Songtaizu sent people to Chengdu to carve *Buddha Treasure*. This is the first time for China to engrave *Tripitaka*, which is also the ancestral version of a variety of domestic and foreign versions of *Buddha Treasures*, and which known as "the Yizhou Edition." Due to the fact that publication started in Kaibao years, it is also called *Kaibao Treasure*. Later monks and common folks in Fujian carved a set of *Tripitaka* blocks in Dongchan Dengjueyuan in Fuzhou, called "*Chongning Wanshou Tripitaka*" or "Dongchan Temple Edition." In Kaiyuan Monastery within Fuzhou city carved a version of *Pilu Tripitaka*, called Kaiyuan Temple Edition. Starting his path on officialdom as Observation Missionary of Mizhou in Guian County, Huzhou, Liangzhe Xilu Route in the middle of Xuanhe Era, Wang Yongcong donated his family wealth in the 2nd year of Shaoxing (1132) for engraving "*Tripitaka*" in Yuanjue Monastery in Sixi, and the resultant sutras was called "*Sixi Yuanjue Tripitaka.*" In the third year of Jiaxi, Fabao Zifu Monastery in Sixi Anjizhou (Huzhou) published a Buddhist scripture, called "*Sixi Zifu Tripitaka.*" Monks and common

folks from Jiangsu Region set up a Tripitaka Bureau in Qisha Yanshengyuan, in Chenhuzhong, Pingjiang government mansion. The bureau started carving in July, the 4th year of Shaoding during the reign of Emperor Lizong of the Song Dynasty, and completed the undertaking successfully in the 2nd year of Emperor Yingzong of the Yuan Dynasty. The resultant work is called *Qisha Tripitaka*.

In the Liao Dynasty, two sets of *Khitan Tripitaka* were also carved. In the Jin and Western Xia Dynasties, there were many carved books. Book carving in the Yuan Dynasty gradually declined, in comparison with the Song Dynasty, but it prospered again in the Ming Dynasty. In the Qing Dynasty, woodblock printing took a downward turn, and wood type became popular. After the Daoguang Era, Western printing was introduced to China, and woodblock printing was gradually eliminated.

2.1.2 Overprint, Woodblock Print, and Color Print

The earliest extant overprint object should be of the "*Annotations on the Vajracchedikapra-jnaparamita Sutra*" (as shown in Fig. 18) published by Zifu Temple in Zhongxing Route (present-day Hubei Jiangling) in the Yuan Dynasty. In the frontispiece, there sits Wuwen the senior monk annotating the sutras,

Fig. 18 *Annotations on the Vajracchedikapra-jnaparamita Sutra* published by Zifu Temple in the Yuan Dynasty

waited upon by a boy. Beside the boy there stands a third person. The book case, square table, clouds, and Ganoderma are all red, while the pine nearby is black. The body of the text and the notes are red and black, respectively, while the title "*Vajracchedikapra-jnaparamita Sutra*" is red. The printing time should be between 1,340 and 1,341. The engraving creatively adopted for the first time two colors, marking a major event in the history of printing.

1. Overprint in Huzhou

In late Ming Dynasty, the two families of Min and Ling in Huzhou managed to carry forward the overprint technology, developing by the two colors, three colors, four colors, and even five colors on the basis of two colors, marking a big step forward in the history of color printing. Overprint in Huzhou began in approximately the 9th year (1581) of Wanli, represented by Ling Yingchu's publication of "*A New Account of Tales of the World*". Another theory believed that it began in the 44th year (1616) of Wanli, represented by Min Qi Ji's publication of "*Mr. Zuo's Spring and Autumn Annals.*" Both of the books are products of Wanli, Tianqi and Chongzhen Eras. Hu Yinglin of the Ming Dynasty said "Like engraving in Huzhou, engraving in Xi witnessed rapid progress" adding "In printing, the color red, black and indigo are used, sometimes independently, sometimes combination of two. Two-color printing would be more precious if red is used." The reason for Huzhou engraving to be exquisite is the adoption of two-color printing, i.e., overprinting. Min Qiji was a scholar of a wealthy family in Wucheng County. He engraved Lao Zi, Zhuang Zi, Lie Zi, the collected poems of various schools and *Chu Ci* (Songs of the South). His brothers and nephews were also engaged in book engraving. The Ling Family had Ling Yingchu and Ling Mengchu as the representatives. Ling Mengchu engraved "*The Collected Poems of Meng Haoran,*" and his family engraved many books which have been handed down.

Overprint edition put a variety of bright colors on the snow-white Liansi paper, producing pleasant and satiating books to attract the reader's affection. The craft is most suitable for works and maps with commentaries and a variety of punctuation marks in that it can make them clear. Criticism is recorded above the body of the text and annotations and punctuation marks are placed between lines to make the meaning of each word readily intelligible and all paragraphs clearly separated so as to make the books easier to read for beginners. The characters in each line are widely spaced to facilitate overprint, and there are no lines within the box for text on each page. Each box normally contains 8 or 9 lines, to embrace 19 characters each. Such printed copies, particularly the three- or four-colored copies, are costly and time-consuming, since each of them would require the cost of several ordinary books. In addition, subject certain printing techniques are required, so that the colors will not get mixed. The Min and Ling Families turned out 144 overprint books in total, and most of them are red and black, 13 three-colored, 4 four-colored, and 1 five-colored.

2. Woodblock Print

One of the features of printing in the Ming Dynasty is well developed woodblock print. The number of pictures in illustrated books ranges from several or dozens in the least to one or two hundred in the most. Woodblock print of the period is not only great in quantity but superior to Song and Yuan Dynasties in quality, marking a peak of graphic art. Illustrations can either be placed under the diagrams to form comic books, or inserted in the middle of the body or a section, while in most cases, they are attached to the frontispiece. After the Chenghua and Honghua Eras of the Ming Dynasty, folk rap, poetry, fiction, and drama became widely popular. To cater to the preferences of the reader and to promote sales, the publishing houses started everything they print with pictures, just as the saying "All of the legends, ancient and modern, are illustrated with pictures." Illustrations can increase the taste of books, facilitate understanding of the texts, enhance the reader interests, and appeal to both the vulgar and refined. Therefore, illustrated books became a momentary fashion in the Ming Dynasty. The woodblocks are so elaborately carved and intricate that they make the viewers mesmerized, thus catering to the preference of the time and invite a broader scope of buyers. Woodblock print is most popular in Wanli, Tianqi, and Chongzhen years, attaining full flourish. Woodblock print can be roughly divided into four schools: Beijing, Nanjing, Jianyang (the three factions feature bold and simple lines, and abundant antiquity), and Huizhou. Huizhou prints are elaborate and meticulous, gorgeous, and inviting. The figures carved are vivid and lifelike, while the curtain patterns carved are reflective of all nuances. Reflecting arts and techniques to the extreme, they deserve the name of embroidered images. Open the book and the reader is bound to be pleased and fascinated. Most of the workers come from Qiu Village (or as Qiuchuan Village) in She County. Surnamed Huang, they claim themselves to be the Huangs of Xinan, or the Huangs of ancient She. "At that time, people would certainly seek workers from She for engraving undertakings." Those workers were often invited to carve books away from their hometown, and sometimes moved houses to facilitate life and work.

3. Color Print

After the Wanli years of the Ming Dynasty, Huizhou woodblock printing technology reached its peak, with the popularization of common fiction and drama. So some people came up with the idea of adding colors to the pictures. "*Moyuan*" (Collection of Chinese Ink Stick Images, ca.1605), engraved by Zilantang of the Cheng Family from Shexian Anhui, has nearly 50 colored images, most of which are four- or five-colored. All colors were applied to the engraved block and then printed out on paper. Each block contains a number of colors, presenting a rich and luxuriant appearance, and grabbing the eyes of the onlooker. In "*Tianlao Duiting Tu*" (Picture of Heavenly Elders in the Court, as shown in Fig. 19) in *Moyuan*, there are red and yellow phoenixes and green bamboos. Using colored ink, the block

Fig. 19 *Tianlao Duiting Tu* in *Moyuan*

can be used to print dozens of pictures at one sitting. In the following year, the Xin'an Huang Yiming carved "*Fengliu Juechang Tu*" (Picture of Perfectly Matched Merriness and Smoothness), turning out ink-printed copies, as well as color-printed copies, in which character's clothing and footwear, and their skin color and eyes, and window curtains are extraordinarily printed. In *Huashi* (History of Flowers) printed in about 1600, there are red lotuses and green leaves. Originally, several colors were applied to the corresponding sections of the block, for instance, red to the flowers, green to leaves, and ocher to the branches. However, the resultant prints are easily confused. Therefore, a further step was taken: each color was engraved on a separate woodblock, and woodblocks were used in the order of colors to be printed. Because smaller blocks were engraved first and then used in different combinations, like Douding the assorted snacks, therefore it was called "Douban" (assorted block) by the people of the Ming Dynasty.

The Douban is a very delicate and complex job. At first, the worker has to sketch the outlines of the entire picture and then divided it into several units according to the painting itself. This step is called "Zhaitao" (frame-removing). A picture often requires the engraving of three dozen to four dozen smaller blocks, and sixty to seventy times of printing of varying shades. To commit to paper the different shades and position and direction of a flower or a leaf is like

the boneless painting used by artists of the Northern Song Dynasty. Paintings produced this way are best at maintaining the character and spirit of Chinese painting, because the pigment and rice paper used are identical to those in the original painting, with the same features of Chinese national art. Douban color printing, a great leap forward in the printing history, had become very successful in the early years of the seventeenth century. The most prominent representative work is "*Luoxuan Biangu Jianpu*" (Trumpetvine Pavilion's stationery catalogue) carved by Wu Faxiang of Jiangning. The landscapes, plants, and animals in the book are printed using Douban and Gonghua overprinting. Yanji Zu of Zhangzhou commented in the Foreword "My friend Wu Faxiang told me that the slightest detail has been completed meticulously and ingenuously. Therefore, it is wonder among imperial scholars and the ultimate treasure of the study." *Luoxuan Biangu Jianpu* was printed in the 6th year of Tianqi (1626), 19 years earlier than Hu Zhengyan's "*Shizhuzhai Jianpu*" ("Ten Bamboo Decorated Album," but only 1 year earlier "*Shizhuzhai Shuhua Pu*" ("Ten Bamboo Studio Manual of Painting and Calligraphy"), which was completed in the 7th year of Tianqi.

Hu Zheng Yan, of Xiuning Anhui origin, moved house to the side of Jilongshan Mountain in Nanjing to live together with his wife Wu and work together in engaged album engraving and printing. With more than 10 bamboos in front of his house Nanjingzhai, he named it "Ten Bamboo Studio," and styled himself "Master of Ten Bamboo Studio." He was well versed in the six categories of Chinese characters and unrivaled in calligraphy such as seal script, official script, cursive script, and running hand. He could also make quality paper and quality ink. In addition, he was skilled in engraving and good at painting. "*Shizhuzhai Shuhua Pu*" printed by Hu consists of 16 books and 8 albums, including bamboo album, ink book, stone album, feather album, plum album, orchid album, fruit album. "*Shizhuzhai Jianpu*" includes 32 categories, like ancient utensils, figures, flowers, and stones (as shown in Fig. 20). The originals are well painted and engraving vivid, aptly reproducing the spirit of the originals. While printing a palm brush is used instead of a writing brush, the motions are applied appropriately and to the point. Hu discussed day and night with skilled workers for a long time without getting tired. Finally, he was able to carry ingenious designs and became equally proficient with painting, engraving, and printing. Flowers and plants, feathers, and worms—they all come to life under the brush of Hu. No wonder his friend Yang Longyou would say that Hu "has dexterous hands and a clever mind far beyond the previous generations… and is unprecedented." His works were immediately warmly received by people to the north and south of the Changjiang River. Beginners in painting used them as templates for copying. Thus, Hu has played an important role in painting education.

Wu and Hu used Gonghua craft (blanked stamping), i.e., pressing the engraved block on white paper to produce protruding patterns (see Fig. 21), in the same way we use the stamp now. It can be said to be a colorless printing, used to set off the water, white clouds, mosaic veins in the leaves and flowers to make them simpler yet more elegant.

Color printing of Douban of the Ming Dynasty was also imitated in the Qing Dynasty. For instance, two drawings in "*Compendium of Materia Medica,*"

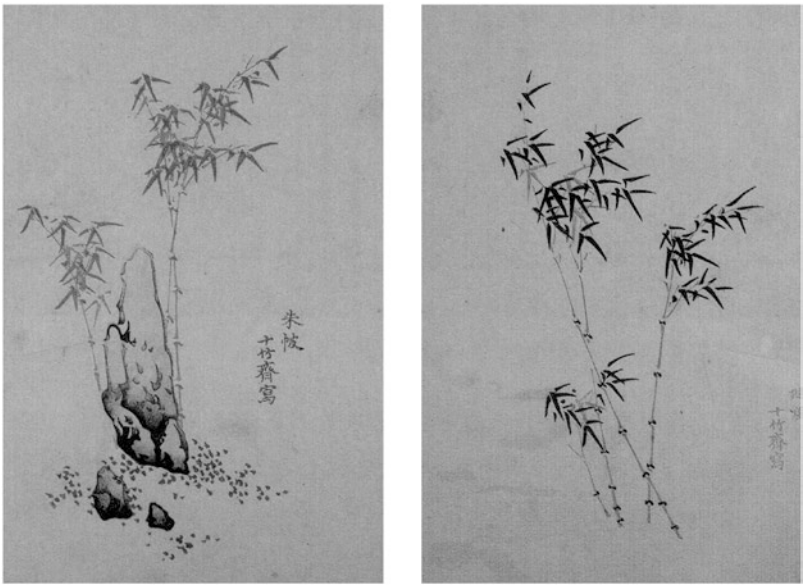


Fig. 20 "*Shizhuzhai Jianpu*" printed by Hu Zhengyan

Fig. 21 Gonghua printing of Hu's

Peach Garden Oath picture in "*Romance of the Three Kingdoms*" and Emperor Kangxi's "*Ploughing-weaving Picture*" carved in Suzhou had been produced via color overprint. The full landscape of Westlake and the ten scenic spots of Westlake in "*Stories of the West Lake*" published by Wang Ya in Jinling during Emperor Kangxi's Reign and "*Mountains and Rivers in Ancient She*" Volume One

published by Wu Yi during Emperor Qianlong's reign were produced via multicolored overprint. Qing Zaitang imitated Hu's *Ten Bamboo Studio* in drawing flowers, plants, and feathers. "*Shizhuzhai Shuhua Pu*" was recommitted to engraving in the 22nd year of Jiaqing (1817) by Jie Ziyuan (Mustard Seed Garden), and in Guangxu Years, Jiao Jing Shan Fang (studio for collation of classics) had yet another engraving. However, the verve and color of that color overprint were inferior to those of the original. Multicolored "*Painted History of Jieziyuan*" was painted by Wang Gai and his two brothers in Jiaxing; and the first episode was color-printed using Douban in the 18th year of Kangxi (1679). Three more episodes were printed in the fortieth year of Kangxi (1701), to be followed by four more episodes printed in the 20th year of Jiaqing (1818). Gorgeous and pleasing to the eye, the book underwent repeated re-carving after the Jiaqing years and was made textbook for beginner painters. Therefore, it was more popular and more influential than the "*Shizhuzhai Shuhua Pu.*"

During the reign of Emperor Qianlong, Ding Liangxian and Ding Yingzong from Suzhou printed many flower-and-bird paintings (as shown in Fig. 22) by using Douban. Using exquisitely carved blocks and Gonghua technology, the prints used white paper and presented a dazzling colorful appearance. They are of rare quality in chromatic printing. Ding Liangxian was a Catholic living in the middle of Qianlong's reign. Constantly rubbing shoulders with European missionaries in regions south of the Yangtze River, Ding was engaged not only in printing, but also trading of foreign paintings. His works might have been sold to Europe through the missionaries. In Suzhou during the reign of Emperor Qianlong, there were people imitating Western perspective in making New Year pictures and printed materials of other literature, some of which are still kept in the museums of Europe and Japan.

In the 28th year (1848) of Daoguang, Yingying Shuwu (photocopying house) edition of "*Goldfish Album*" was published, including paintings of 56 different types of goldfish, each with a protruding belly and goggling eyes and a vivid posture. The original color of each type was painted, and the margins of each paper were decorated with pale green patterns of pines, bamboos, and plum blossoms. "*Zhedong Zhenhai Desheng Quantu*" (Panorama of Victorious Zhenhai Zhedong) was the result of color printing. In the 7th year of Guangxu, "*No. 1 Genius Book*

Fig. 22 Flower-and-bird painting printed by Ding Liangxian in Qianlong years using Douban

Romance of the Three Kingdoms" was printed in Shanghai, with each frontispiece illustration colored, setting an example of woodcut overprint combining the new method of letterpress.

2.1.3 Wax Block Printing and Movable Tin Type

In the Song Dynasty, people not only used various woodblocks and copperplates as printing tools but also invented application of wax in printing. In the first year (1094) of Shaosheng, the messenger in Kaifeng the capital was so eager to publicize the list of new No.1 Scholar and the Runner-up Scholar that he could not wait to carve a woodblock. Instead, he used wax blocks. Records of this incident can be found in Volume II of "*Chunzhu Jiwen*" (News from the Water's Edge on a Spring Day) written in the Song Dynasty by He Yuan: "Bi Jian was the No. 1 Scholar and Zhao Shen the runner-up." Soon after the list was announced, the messenger in the capital was eager to spread the news. So he carved a wax block for printing. There was water on the radical of the character "澌" and ink failed to adhere. As a result, "澌" became "斩" (meaning "behead"). The messenger shouted the erroneous message at the top of his lungs "状元毕斩第二人赵谂" (literally, No. 1 Scholar will in the end behead the runner-up Zhao Shen. The correct message should be No. 1 Scholar Bi Jian; Runner-up Zhao Shen.—translator), those who heard the news considered it ominous. Later, Zhao Shen was killed for rebellion, echoing to the message of "in the end the runner-up will be beheaded." At that time, the No. 1 Scholar was Bi Jian. However, since the oily wax could not mix with water, the radical "氵" denoting three drops of water did not accept ink and failed to come out in the print. The messenger shouted "状元毕斩第二人赵谂." Eventually Zhao Shen was beheaded. This wax printing is suitable for works urgently needed and demanded at short notice. There is no record whether it was used in the Yuan and Ming Dynasties. However in the Qing Dynasty, it was commonly used to print newspapers (as shown in Fig. 23).

In the early Ming Dynasty, tin type was used to print counterfeit notes and the perpetrator was subjected to capital punishment. In the 52nd year (1787) of Qianlong in the Qing Dynasty, Cheng Dunwei from Shexian printed a volume

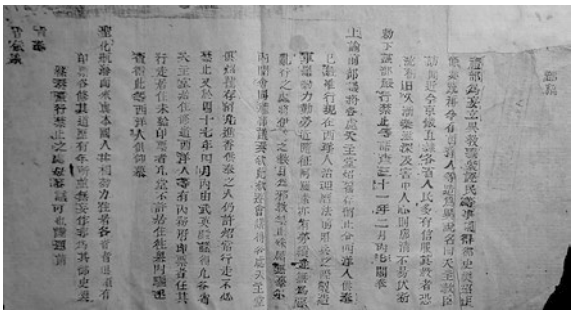


Fig. 23 Wax-printed newspaper in the Qing Dynasty

of "*Texts on the Eaves Tiles in Qin and Han Dynasties*": "In the beginning data wood was used for carving. However, upon proofreading against the original mistakes persist. Later seal casting and foundry method used by the Hans was applied: molten tin was poured into the tile-turned mould to produce tin types." Cheng opened a new chapter in printing by using molten pewter to cast mold for reprographic printing.

2.2 Movable-Type Printing

2.2.1 Invention of Movable-Type Printing by Bi Sheng and Its Use in the Song Dynasty

The invention of movable-type printing is a great technical revolution in the history of printing. The world's first inventor of movable type is Bi Sheng, a civilian in the Song Dynasty, specifically in the Qingli reign of Emperor Renzong (1041–1048) in the Northern Song Dynasty. Bi's invention is four hundred years earlier than the first use of movable type in Europe by Gutenburg to print the Bible. The fact of Bi Sheng's invention is recorded in "MengXi Bitan" (*Brush Discussions of the Dream Creek*) (Fig. 24) by Shen Kuo (1031–1095, or 1030–1094) and is irrefutable. "MengXi Bitan" said in Volume 18:

Woodblock printing had yet to become prevalent in the Tang Dynasty. After Feng Yingwang printed the Five Classics, woodblock came into use for printing by subsequent generations of classics. During Qingli reign Bi Sheng created movable type.

便是八除者增二便是但一位一因之若
位數少則頗簡捷位數多則愈繁不若乘
除之有常然筭術不患多學見簡即用見
繁即變不膠一法乃爲通術也
版印書籍唐人尚未盛爲之自馮瀛王始印
五經已後典籍皆爲版本慶曆中有布衣
畢昇又爲活版其法用膠泥刻字薄如錢
脣每字爲一印火燒令堅先設一鐵版其
上以松脂臘和紙灰之類冒之欲印則以
一鐵範置鐵板上乃密布字印滿鐵範爲
沈括十八
一板持就火煬之藥稍鎔則以一平板按
其面則字平如砥若止印三二本未爲簡
易若印數十百千本則極爲神速常作二
鐵板一板印刷一板已自布字此印者纔
畢則第二板已具更互用之瞬息可就每
一字皆有數印如之也等字每字有二十
餘印以備一板內有重複者不用則以紙
貼之每韻爲一貼木格貯之有奇字素無
備者旋刻之以草火燒瞬息可成不以木
爲之者木理有疎密沾水則高下不平兼

Fig. 24 The dream pool essays

The method: carve characters out of clay, as thin as a coin and each character occupies one block; set fire to the clay characters and hardern them. Set up an iron block, and cover it with pine resin, wax, paper ash or the like. While printing, place an iron frame on the iron block, and arrange the fired clay characters on it as necessary. After the frame is filled with characters, heat it until the pine resin slightly melts, and place a lithographic on their surface and the printed characters are as smooth as a whetstone. It would not be convenient if only several copies are printed. If dozens of or hundreds of thousands copies are printed, the speed is unrivaled. Often, two iron frames are used, so that while one is used in printing, characters can be set on the other. When the first block is printed, the second block is ready. Such an alteration occurs in virtually the split of a second. Each character has several spare copies. Characters like '之'and'也' have more than 20 spare copies each, so as to meet the demand of repetition in one block. Characters left idle are stuck with paper and stored in a wooden grid in the order of rhyme. Rare characters are usually not carved beforehand, but are improvised on the spot, fired with straw, and presently prepared for use. The reason for using clay in stead of wood is that wood has different degrees of grain density, and water is likely to make wooden characters uneven in height. In addition, wood characters are undesirable in that they get stuck with paper drugs. In comparison, clay type is easily recovered after use, by heating the paper drug until it melts. After that, whisk the clay type with hand and it will come off by itself, without catching any impurities. After death of Bi Sheng, his clay type is obtained by my cousins and nephews and kept to this day.

In Bi Sheng's method, clay types were hardened through firing and then arranged in an iron frame for printing though primitive; it fundamentally shares the same principle as the prevailing type typography, just like Shen Kuo said "It would not be convenient if only several copies are printed. If dozens of or hundreds of thousands copies are printed, the speed is unrivaled." From Shen Kuo's comment, we can see that it is very efficient. Shen Kuo was only a teenager when Bi Sheng invented movable type. Bi Sheng occupies such an important position in the history of printing in the world, but his invention did not receive much attention at the time. His name is not seen in the history books. Shen Kuo was the only one to know the importance of this invention and to have it recorded.

In addition to Bi Sheng, Shen Kuo, and Shen's nephews, did anyone else in the Northern Song Dynasty know the method of book printing by using mud movable type? This has been a problem bewildering the academia. Fortunately, "*Binglv Xiansheng Wenji*" (Collected Works of Master Palm) by Deng Su (1091–1132) has been found to contain a poem, which helps prove that there were people with a certain degree of understanding of movable-type printing in late Northern Song Dynasty and early Southern Song Dynasty (no later than 1132 AD). The poem reads:

Friendship should be based on mutual understanding; common interests will make it long lasting. Lo, behold Qiuhou and Xiegong, they have a friendship seamlessly strong. In his ordinary comment on people, Qiuhou details what Xiegong likes and hates. The moment Qiuhou finishes a new poem he lends it to others; long have I heard of its praises, and now I have seen it to be true. Visitors come in an endless flow, regardless of the shabbiness of the hut. This scenario is

inevitable even though the poem is circulated the moment it is completed; only if the two iron blocks of Bi Sheng were at hand.

This poem is written in echoing the "rhyme of 铁" initiated by Xie Libu, a native of Shaowu people. It is said in the poem that "new poetry" became widely disseminated soon after its completion, and manual copying alone cannot meet the demand. So the author sighed, "only if the two iron blocks of Bi Sheng were at hand." The expression "two iron blocks" is used here to refer to the description in "*Mengxi Bitan*": "Often, two iron frames are used, so that while one is used in printing, characters can be set on the other. When the first block is printed, the second block is ready. Such an alteration occurs in virtually the split of a second." Deng Su, styled Bing Lv, was a native of Nanjiansha County, Fujian, and an official in the capital Kaifeng. From his poem, we can see that Bi Sheng's method had attained certain reputation at the time.

Books printed in the Song Dynasty with clay type also include "*Yutang Zaji*" (Notes of The Jade Hall), which was written and printed by Zhou Bida in the 4th year (1193) of Shaoxi in the reign of Emperor Guangzong. The works of Zhou were gathered in "*The Collected Works of Zhou Bida*" or "The Grand Collection of the Works of Zhou Bida." In Volume 198, there is a commission letter written to Cheng Yuancheng in the fourth year of Shaoxi, saying "I have been shallow, and become absurd in my old age. I was troubled by stomach trouble time and again, and had to put off printing my books. Recently, I followed Shen Kuo's method, using clay copperplates in alteration for printing and completing a '*Yutang Zaji*' containing 28 articles. And I am sending one of them to you for your advice. There are ten-odd articles more in waiting. Soon after their completion, I will send them to you. I thought reading them can help me remember the good old days, while sighing over the flitting time."

In the article "Shen Kuo's method" is used, because the author has learnt the method in Shen Kuo's book "*Mengxi Bitan*"—which records the clay type printing of Bi Sheng—and mistaken it for the invention of Shen Kuo. In fact, it is nothing but Bi Sheng's method. Zhou claimed "using clay copperplates in alteration for printing," probably to mean that he arranged clay types on cooper blocks or plates—hence the name clay copperplates, to be used in alteration for printing. This operation fully shows the characteristics of movable-type printing—alignment and readjustment of types is required to form a layout prior to printing. Zhou first printed his won book *Yutang Zaji* containing 28 articles. From this, we can see that people in the south in the Southern Song Dynasty were still imitating Bi Sheng in printing books. Publication of Zhou's *Yutang Zaji* marks the advent of the first movable-type print in the world, and it can fill the blank between the Northern Song Dynasty and the early Yuan Dynasty ruled by the Mongolian ethnic group.

2.2.2 Movable Type in Western Xia

In 1991, relics of Buddhist sutras "*Auspicious Tantra of All-Reaching Union Continued*" in Tangut script were found in the ruins of Baisigou Square Pagoda, in Helan Mountain, Ningxia (as shown in Fig. 25). Without frontispiece, ending or

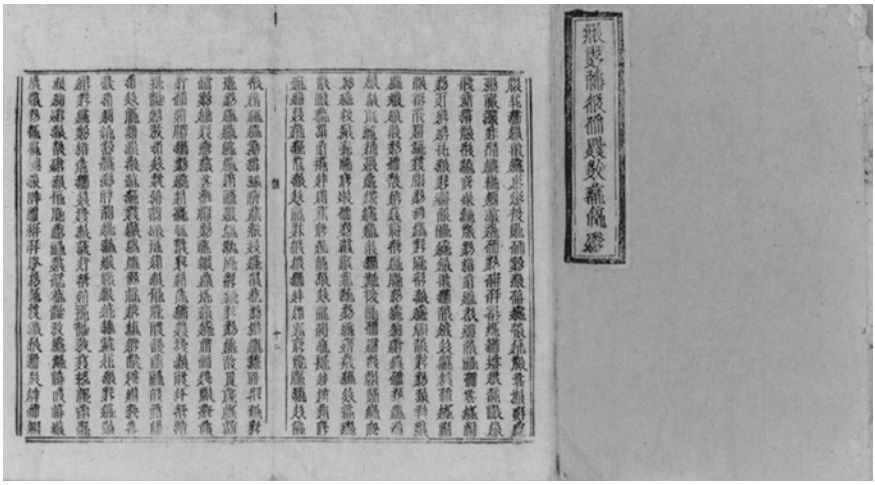


Fig. 25 Remains of *Auspicious Tantra of all-reaching union continued*

epilogue, the age of the print is untraceable. Wooden tablets inscribed with Tangut characters of ChongZong Zhen'guan, Western Xia (1102–1114) and two vows of the 11th year of Qianyou in Renzong reign (1180) were also found. "*Auspicious Tantra of All-Reaching Union Continued*" is a tantric classic of the Tibetan Buddhism, while late Western Xia is a period dissemination and development of Tibetan Buddhism in the Western Xia. It was presumed to be the result of movable-type printing in late Western Xia, because it bears the features of movable type: (1) Bar lines of the page frame do not converge in the four corners or measure the same length. (2) The shade of ink varies. (3) A few characters were printed upside down. (4) There are traces of interlaced lines. According to Volume 22 of the book *Agricultural Treatise* by Wang Zhen, "in methods for creating movable type for printing" "the character blocks are arranged in lines and each line is spaced with bamboo slips. However, Shen Kuo's "*Mengxi Bitan*" doesn't include an interlacing process. Therefore, it is concluded that this book had been the result of wooden type printing. However, interlaced lines are not a distinctive feature of wooden type; they are also found in metal type. In addition, some prints are produced through the wooden type, but are identical to woodblock prints. Some books of Wuyingdian Juzhen Ban (Treasure Editions Collected by Hall of Military Eminence) made via wooden type printing are a case in point. Therefore, there is insufficient justification to use interlaced lines for differentiation of the wooden movable type from the other types.

Japanese is in possession of ten volumes of "*Avatamsaka Sutra*" in Tangut script. In the vow, there is the sentence "vow to carve individual characters, which has been taken by Japanese scholars upon research as corroboration of the book being printed via movable wood type." And the sutra is believed to be the earliest known example of a book printed using wooden movable type. Among the Buddhist scriptures kept in the National Library of China, *Avatamsaka Sutra* is the greatest in number, accounting for 2/3 of the entire *sutra*.

In Volume 40 of *Avatamsaka Sutra* in Tangu script, there are two lines of inscriptions in Tangu scripts, whose Chinese translation are as follows: “实勾管作选字出力者盛律美能慧共复愿一切随喜者皆当共成佛道.” (Those engaged in typesetting are virtuous and can expect to have all their wishes granted and attain the Buddhist Tao.)

The five characters “选字出力者” (those engaged in typesetting) means that a typesetting process is required for printing.

In addition, *Avatamsaka Sutra* contains two lines of commendations inscribed on wood in Volume 5, reading “都行愿令雕碎字勾管做印者都罗慧性 又共行愿一切助随喜者共同皆成佛道.” (It is vowed that those engaged in carving characters and printing are intelligent and can expect to have their wishes fulfilled and attain the Buddhist Tao.) In the sentence, “碎字” refers to movable type. The wooden inscription means that the sutra had been printed with movable type.

In the remaining volumes of *Avatamsaka Sutra* in Tangut, the lines are uneven and askew; the ink shades in the front and back of the papers are different; there are many signs of correction by reprinting, and incorrect characters directly overlaid with the correct ones, as well as smaller characters written with writing brush. Some people believe that these are the signs of movable type. Others think that the Tangut script “*Avatamsaka Sutra*” during Renzong reign (1125–1193) had been printed with wood type carved in Hangzhou during the Yuan Dynasty.

In 1987, Buddhist classic “*Vimalakirti Nirdesa Sutra*” (as shown in Fig. 26) in Tangut script was found in Wuwei, Gansu. Initial studies have concluded that it had been a print of Renzong reign and identified it as having used clay movable type according to hollowness in the strokes, deformed or broken strokes. If the above works in Tangut script have been printed using movable type, then they should be the earliest extant examples of movable-type printing.

2.2.3 Movable Type in the Yuan Dynasty

1. Clay Type (Yang Gu)

Yao Shu, an adviser of Kublai in the early Yuan Dynasty, “was engrossed with influencing the people and forming moral customs, printed the primary school textbooks including *Analects*, *Mengzi*, *Alternative Questions*, *Family Rite*, Yang

Fig. 26 A glimpse of *Vimalakirti Nirdesa Sutra*

Zhongshu-version Four Books, Minister Tian Heqing-version "*Collection of Shengshi Poetry,*" "*The Biography of Yi Cheng,*" "*The Biography of Shucai,*" and "*The Annals of Spring and Autumn*"—all were printed in Yanjing. When he found that primary school books were not widely distributed, he instructed his disciple Yang Gu to use Shen's mobile (note: should be "movable") type to print *Thought about Nearness*, *Classics and History Books of Donglai*, and so on, for distribution across the country." (see Volume 15 "*Stele of the Left Prime Minister Yao Wenxian,*" *Mu'an collection* by Yuan Yaosui.)

Shen's movable type is Bi Sheng's movable type recorded in the work of Shen Kuo. The time of the above-mentioned activity is between the 13th year of Taizong of Mongolia and the 3rd year of Queen Regent of Ogul Gaimysh (1241–1250), exactly 200 years later than Bi Sheng's invention. The article failed to detail whether the printing occurred in Huixian or Yanjing, or what kind of movable type had been used.

As for Yao Shu, Su Tianjue (1294–1352), native of Zhending, also wrote in "*Records of Famous Courtiers in the Yuan Dynasty*": "printed the primary school textbooks including *Analects*, *Mengzi*, *Alternative Questions*, *Family Rite*, Yang Zhongshu-version Four Books, Minister Tian Heqing-version '*Collection of Shengshi Poetry*,' '*The Biography of Yi Cheng*,' '*The Biography of Shucai*' and '*The Annals of Spring and Autumn*'—all were printed in Yanjing. When he found that primary school books were not widely distributed, he instructed his disciple Yang Gu to use Shen's mobile (note: should be 'movable') type to print *Thought about Nearness*, *Classics and History Books of Donglai*, and so on, for distribution across the country." "*Records of Famous Courtiers in the Yuan Dynasty*" is based on tombstone inscriptions written by Yao Sui, but the text is slightly modified. Later, Xu Youren (1287–1364) also introduced the activities of Yaoshu in Volume VI, "R*ecords of Snowy Book House,*" "*Guitang Xiaogao*" and mentioned "teaching disciple Yang Gu to Shen's movable type in printing." "*List of Celebrities in Zhongzhou*" written by Liu Chang of the Ming Dynasty cited from "*Records of Snowy Book House,*" making Yang Gu's use of ancient movable type in printing books widely known.

In the fifteenth century, the famous North Korean scholar Kim Jong-jik remarked in the postscript to "*Pak Anthology,*" a movable-type print in Korea: "Movable type printing was invented by Shen Kuo, and reached its peak through the promotion of Yang Weizhong, who made all the books, ancient and present, printable. The benefits were enormous. However, Yang's movable types were made of fired clay, and easily broken, thus could not last long." Kim said that the movable types prevalent in Yang Weizhong's time were fired clay. However, according to the original record in "*Mu An Ji,*" books published in Yanjing by Yang Weizhong still used engraving. The reason for Kim to make the mistakes may be that he confused "Secretary Yang" (Yang Weizhong) with Yang Gu and erroneously attributed movable-type printing to Yang Weizhong. In addition, in the postscript to the Korean version of "*Chen Yuyi's Poems*" "Movable type printing was invented by Shen Kuo, and reached its peak through the promotion of Yang Chong, who made all the books, ancient and present, printable. However, Yang's

movable types were made of fired clay, and easily broken, thus could not last long." Domestically, no record has been found of Yang Weizhong or Yang Chong using movable clay types in printing books. The claims of Korean scholars might be supported by otherwise facts. Although Yang Gu printed Zhu Xi's books and Lv Zuqian's books in a time later than Zhou Bida did, those books are still earlier movable-type printed copies.

Seen from the Song and Yuan literature above, movable type invented by Bi Sheng was not only recorded by Shen Kuo, but also made in late Northern Song Dynasty. In the Southern Song Dynasty, it was used by Zhou Bida to print his own anthology, and in the Yuan Dynasty, by Yang Gu to print textbooks. In the fifteenth century, these records spread to Korea and became also familiar to the locals. Therefore, popularization and application of Bi Sheng's movable-type printing in the Song and Yuan Dynasties were quite extensive.

2. Wooden Type (Wang Zhen, Ma Chengde)

Before making clay type, Bisheng also experimented with wooden movable type, but he believed that difference in the texture and density of wood would make the characters uneven once they got wet. In addition, wood easily got stuck with the paper drug. Those drawbacks made wood an undesirable material. On the other hand, fired clay did not get smeared easily. Therefore, clay, instead of wood, was chosen. The first one to formally printing books with wood type was Wang Zhen of the Yuan Dynasty, in a time a bit later than Yang Gu using movable clay type. Wang Zhen, a native of Dongping, Shandong, was a famous agronomist and mechanical scientist with important contributions to the printing history. From the first year of Yuanzhen (1295), he had assumed the post of prefecture governor of Jingde, Anhui for 6 years. Within his tenure, he lived a simple life, donated his salaries to building schools, bridges and roads, taught farmers arboriculture, and doled out drugs to rescue people. In the fourth year of Dade (1300), Wang was made prefecture governor of Yongfeng, Xinzhou (now Guangfeng county in Jiangxi), where he advocated cotton and mulberry cultivation. Thus, people from those two prefectures were full of praise for him.

Wang Zhen's biggest contribution was undoubtedly the "*Agricultural Book.*" During his tenure in Jingde County, Wang Zhen had begun writing this book and planned to publish it. Fearing that this book would be too long and thus engraving too difficult, he hired artisans to carve out more than 30,000 characters in 2 years. The carving took the following steps: write on paper the characters, stick the paper on a woodblock, and engrave the characters, after engraving separate the characters one by one with a fine saw, and then finish with a knife the characters to the same size. Arrange the characters row by row, separated with a bamboo slip. After the box is full of wooden characters, flatten the characters with bamboo mats, and secure them with wooden wedges so that they would not move. Coat the characters with ink, spread out a paper on top, and print with a palm brush. Wang Zhen had a technical innovation in typesetting. Sensing it would be inconvenient for the typesetter to around looking for the characters, he created two large wooden

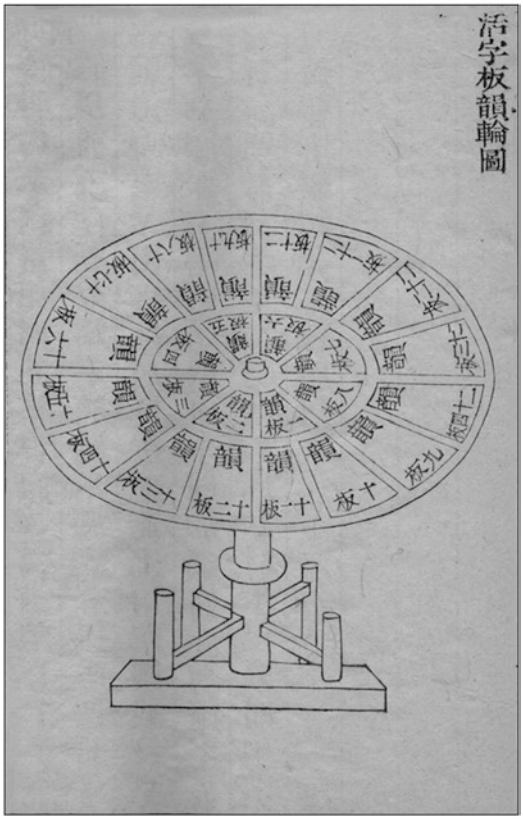


Fig. 27 The master wooden wheel made by Wang Zhen

wheels (as shown in Fig. 27) in which wooden characters were placed according to numbers. During typesetting, a person would sit in the middle and push the wheels with both hands. This method is called "bringing the characters to the people." Compared to looking for characters, it reduced labor and increased efficiency. Titled "Book Printing with Movable Type," the part of "*Agricultural Book*" after Volume 22 recorded movable-type printing, systematically documenting the entire process of writing according to rhymes, engraving, sawing, finishing, making the wheels for picking characters, securing the characters, and printing system. This made *Agricultural Book* a very precious literature in the history of printing.

Wang Zhen had originally planned to use his movable type for printing his own work "*Agricultural Book.*" So when he was transferred to Jiangxi, he took the new set of printing tool with him. However, officials in Jiangxi had already engraved the entire book on wooden blocks, and Wang's invention was laid idle. During his tenure in Jingde, he only printed "*Jingde County Annals*" compiled by himself, in about the second year of Dade (1298). The book had over 60,000 words, and it took less than a month to print one hundred copies, reflecting the high efficiency of moveable type. This book is also the earliest regional chronicles printed via movable wood type.

20 years after Wang Zhen, Ma Chengde also used movable type to print books. Ma, a native of Guangping, Hebei, was made state governor of Fenghua in the sixth year of Yanyou (1319). In the following 3 years, Ma dredged rivers and built dames, constructed irrigation facilities, reclaimed 13-Qin of land (=214.3 acre), launched large-scale afforestation, set up schools, and constructed library buildings. During his tenure, he also "carved as many as 100,000 movable characters," three times more than Wang Zhen. In the second of Zhizhi (1322), books like "Da Xue Yan Yi" were printed with movable type. *Fenghua State Annals* compiled by Ma Chengde may have also been printed with the new movable type. We have no idea whether Ma imitated Wang in printing books; however, we do know that in the Yuan Dynasty, movable wooden type was popular in southern Anhui and eastern Zhejiang regions.

The movable wooden type also spread to the Uighurs in the Yuan Dynasty. In 1908, French sinologist Paul Pelliot found in Dunhuang wooden movable type in Uighur of the Yuan Dynasty. The movable type is now kept in Musée Guimet in Paris. Later, additional findings were made in Dunhuang, and those are now in the possession of the Dunhuang Academy. Uighurs played a very important role in the process of spreading printing from China to the West.

3. Tin Type

Tin type was first mentioned by Wang Zhen in "*Book Printing with Movable Type,*" which said: "Nowadays tin is cast to make characters, which are then strung together with iron bars to form lines. The lines are then embedded in a frame and separated with boundary lines for printing books. However, because tin type does not absorb ink well, misprints are widespread. Therefore, tin type does not last long." "Nowadays" in the passage refers to early Yuan Dynasty or late Song Dynasty, almost two centuries earlier than use of metal movable type in book printing in the West. Since Wang explicitly mentioned casting tin for movable type, it is obvious that tin type had been made after modeling and casting, rather than directly carved on the tin blocks. The tin characters could be strung together with a wire, presumably because there was a small hole in each of them. After typesetting, they could be used for printing. The transition from non-metallic movable type to metal tin type is a big step forward in type-making technology. However, bad printing repeatedly occurred because there was no quality printing ink to support it. Therefore, this new invention becomes just a flash in the pan and failed to be popular for a long time. Regarding the inventor of tin type, its place of invention, and books printed using it, Wang gave no detail.

2.2.4 Movable Type in the Ming Dynasty

1. Wooden Type

With socioeconomic and cultural development wooden movable-type printing was more popular in the Ming Dynasty than the Yuan Dynasty. Prints in the

Wanli Years (1573–1620) were especially numerous. Hu Ying-lin (1551–1602) remarked: "At present, people in a rush to print can use movable type, which originated in the Song Dynasty. However, without mud drug, they have to make do with wooden movable type." Gong Xian of the Qing Dynasty once remarked: "People in the Ming Dynasty used wooden movable type in printing books, and book printing thus became popular." Seen from the actual prints handed down, wood type was indeed quite common in the Ming Dynasty. Some copies can be ascertained for movable-type prints the moment they are open, but some were indistinguishable from engraved printing. As for the differentiation between wooden movable type and copper movable type, the difficulty is even greater. Many copperplate-printed books had been marked as such, while those printed with wooden type rarely labeled the use of wooden type. Therefore, it is common for A to claim a print as the result of wooden type printing, and B to claim it a result of copperplate-plating. There are divergent views, and an agreement is impossible.

There is no record of the Ming Dynasty government using movable type in printing books, while the tetrarchs distributed across the country used movable type, in addition to carving extensively for printing books so as to show their respect for literature and scholarly pursuits or to pose lovers of culture. Mostly, they had made wooden movable type, instead of metal movable type. In the Song and Yuan Dynasties, many colleges engraved books, but application of movable type in colleges began in the Ming Dynasty. In the Ming Dynasty, there were also private use of movable type in printing books, and Hu Min, a scholar of the Imperial College, was one of them. In the Jiading years of the Qing Dynasty, Xu Zhaoji borrowed movable type from someone else to publish his father Xu Xuemo's work "*Shi Miao Shi Yu Lu*" (Records of Temples), which recorded anecdotes and historical facts in the reign of Emperor Jiajing in the Qing Dynasty. The work contained twenty-six volumes, and one hundred books. Movable type can be intended for personal use, as well as lent to others. This is where it eclipses woodblock printing.

There are about 100 kinds of books with verifiable titles printed in the Ming Dynasty using wooden movable type. Mostly, they were printed in the Wanli years, and printed copies before Hongzhi years were rare. Printing places ascertainable include Jiangsu, Zhejiang, Fujian, Jiangxi, and Yunnan, aside from Chengdu, Jianchang, and Nanjing.

A famous wooden movable-type print from the Ming Dynasty is "*Heguanzi*" (The Comb of a Fighting Bird). In the center of the type area, there are the characters "活字版" (movable-type versioni)、"弘治年(Hongzhi Years), or "碧云馆" (Green Pavilion Studio), and the host of the studio remains to be verified. On the cover, there is a large red seal reading "两淮盐政李质颖送到马裕家藏《鹖冠子》壹部计书壹本" (Salt Policy Li Zhi presents One Copy of '*Heguanzi*' to Ma Yu's Home for Private Collection) dated April the 38th year of Qianlong's reign. At the beginning, there is a poem written by Emperor Qianlong in Kuisi year (1773). Because Qianlong repeatedly mentioned the book, and because "*Complete Library in Four Branches of Literature*" had a master copy of "*Heguanzi,*" this book became quite prestigious among movable-type prints. In late Ming Dynasty, people in the south started using the wooden type for printing genealogy.

2. Copper Type

In history, the most popular metal movable type in China is not tin type or type, but copper type.

2.1 Wu Xi (the Hua's and the An's)

The earliest authentic copper movable-type printing in China should be that implemented by Huasui Huitong Studio in the Ming Dynasty. Hua Sui (1439–1513), also known as Wenhui and styled Huitong, was a native of Wuxi, Jiangsu. "In his early years, Hua read extensively in classics and history. In his middle years, he took a fancy to collation and proofreading, and recorded his findings based upon deliberation and investigation. He fashioned copperplate and tin type so that when he came across rare books that had been hard to come by, he would collate and print them, saying 'Now I have learned and mastered the art of printing.'"

Shao Bao's "*Collection of Rongchuntang Biography of Huitong*" recorded "Later, [he] followed up with copper type, saying 'Now I have learned and mastered the art of printing8.' Thus he named his printing house Huitong Studio." Hua Sui made his copper type in the third year of Hongzhi (1490), because in his own account: "I am obliged to spread civilization, and the copper type is like a godsend." His initial motivation was just to reduce the trouble of manual transcription, but later his invention became popular across the country. At that time, there was a plan to re-engrave the book "*Song Zhuchen Zouyi*" (Memorials of Courtiers in the Song Dynasty), but the vast cost had been daunting. So Huitong Studio was commissioned to typeset it in copper type and print it, so as to popularize it. Finally in the third year of Hongzhi, Huitong Studio succeeded in printing fifty copies. Back then only one set of movable type was used, so the body and the notes were of the same size. Each line had two rows of type, making the print uneven, and only one half of some words came out. The ink was fuzzy and sloppy and left the hand black. In addition, insufficient care was executed in collation, passage loss, and mistaken characters occurred in each and every volume. In some cases, even one or two entire pages were left out, making the text incoherent and severing the meaning of passages. However, despite the shoddy printing quality, those books are the first metal movable-type prints known. Later Hua successively printed "*Jizuan Yuanhai*" (Profound Ocean of Records and Compilations) written by Pan Zimu in the Song Dynasty, "*Gujin Hebi Shilei Qianji*" ("Well-prepared Digest of Categorized Matters of the Joint Jade Circles Quoted from Old And New [Literature]") written by Xie Weixin, and "*Jinxiu Wanhua Gu*" (Splendid Flower Valley) by an unknown author. "*Jinxiu Wanhua Gu*" has a big copper version and a small copper version, which refers to big fonts and small fonts, respectively. Books verifiable as being printed by Huitong Studio amount to 19, an unrivaled number in copper-type prints in the Ming Dynasty. These were also the earliest in time. The eight books, i.e., "*Song Zhuchen Zouyi*" (as shown in Fig. 28), "*Jinxiu Wanhua Gu,*" "*Rongzhai Wubi*" (The Fifth Volume of Rongzhai Collections), "*Baichuan Xuehai*" (The Sea of Learning), "*Jiujing Yunlan*" (Rhymes of the

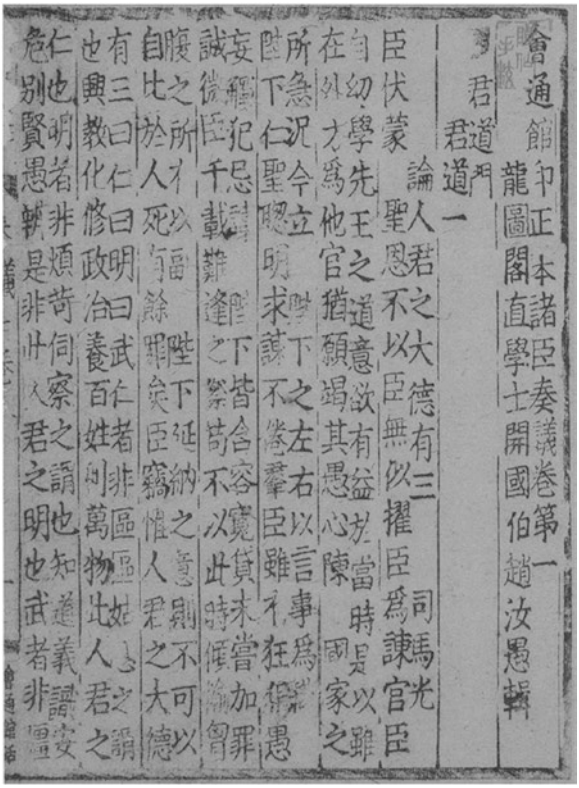


Fig. 28 A glimpse of "*Song Zhuchen Zouyi*"

Nine Classics), "*Wenyuan Yinghua Zuanyao*" (Collected Blossoms of Literature), "*Yinshi Chunqiu*" (Transcription of Spring and Autumn Annals), and "Gujin Hebi Shilei Qianji," printed before the 13th year of Hongzhi (1500) are equivalent to Europe's incunabula and are especially precious.

Hua Cheng, uncle of Hua Sui, a scholar of the 8th year of Chenghua (1472), served as the governor of Guanglu Temple, Beijing. He warehoused vast quantity of millets, reclaimed thousands of Qin of land (1 Qin = 16.5 acre), and collected numerous calligraphy and painting antiques, which he was good at identifying. "*Wuxi County Annals*" of the Kangxi years said that Hua Cheng "Collected various books. He could make very sophisticated letterpress, and could turn the rare books to print he got in merely a few days." Zhu Yunming, a personage of Suzhou said: "Guanglu (Hua Cheng) was over seventy and still as studious as youngsters. He made movable type, chose books urgently needed for studying, and actively printed for the benefit of the learners. Movable type is also the reason for this collection to come into shape easily. After Shen Mengxi (Shen Kuo) described movable-type printing in '*Mengxi Bitan*,' it has recently become popular in Sanwu Region. However, their skills in printing also vary greatly." Although senior to Hua Sui by one generation, Hua Cheng printed Lu You's "*Weinan Wenji*" (Anthology

of Luyou) and "*Collected Poems of Luyou Volume 2*" in the 15th year of Hongzhi (1502), later than Hua Sui's Huitong Studio.

Hua Sui's nephew Hua Jian also printed book in Zhengde years. Most of the books printed by Hua Jian are marked with the label or publisher's words "锡山兰雪堂华坚允刚活字铜版印行" (Printed via copper movable type by Hua Jian (styled Yungang) in Lanxue Studio in Xishan), as well as the circular seal "锡山," and "兰雪堂华坚活字铜版印" (copper movable-type print by Hua Jian of Lanxue Studio) in seal character. Lanxue Studio printed the collected poems and essays of famous writers like Cai Yong of the Han Dynasty, Bai Juyi and Yuan Zhen of the Tang Dynasty; "Yi Lin" by Ma Zong, and "Yiwen Leiju" ("Collection of Literature Arranged by Categories"), a reference book of the Tang Dynasty. "Yiwen Leiju" included an epilog written by Hua Jing, son of Hua Jian, in Zhengde Yihai year (1515). While printing, Lanxue Studio typesets two rows of characters in one line. And the prints are known as Lanxue Studio double-line versions, and very few have been handed down. Thus, they draw much praise from bibliophiles. However, "*The Collected Works of Cai Zhonglang*" is also "abound in mistakes on almost every single page." Most of the books printed by Lanxue Studio are labeled with "刊字芦宽" (typeset by Lu Kuan), which seems to have been engraved for printing.

Apart from the above-mentioned Hua Cheng, there were three millionaires in Wuxi in mid-Ming Dynasty, who were mentioned in the balladry of the time as: "An Guo, Zou Wang and Hua Linxiang, the three millionaire whose gold and silver are measured by buckets." Among the three, An Guo (1481–1534) was especially rich. With enough wealth to match a state, he was called "millionaire An." An boasted 20,000 mu fields in Songjiang Prefecture alone. An planted over 1 km of sweet-scented osmanthus in Jiaoshan Mountain in Wuxi where he lived, and thus styled himself "Osmanthus slope." Rising from a commoner to prominence through commerce, An had built the city proper of Changzhou, and doled out relief in case of famines. Therefore, he was known as "a high-minded person." He liked to buy old books and famous paintings. Whenever he heard of a masterpiece, he would buy it at a cost, filling his house with books. After he got the book, he would "cast copper movable type and printed it to spread its distribution.

An Guo started making movable-type and printing books in about the 7th year of Zhengde (1512). Liao Jixiu, then Ministry of Personnel in Nanjing Shangshu, commissioned An Guo to print his six volumes of "*Dongguang County Annals*" when he heard An Guo had copper movable type. An completed printing in the 16th year of Zhengde and sent them to Liao. This "*Dongguang County Annals*" printed in Zhengde years can be seen as the only local annals printed with copper movable type. In books printed by An, the months and years were generally left out. And the only exception is "*Wuzhong Water Conservancy Annals,*" which has the label "嘉靖甲申 (1524年) 安国活字铜版刊行" (printed by An Guo with copper movable type in Jiashen Year (1524) of Emperor Jiajing). Yu Tai of the Ming Dynasty remarked in an epilogue to "*Record of Initial Learning*": "[An] collected and printed over 20 years the classics, history books, philosophical works and miscellaneous works to benefit students of later generations. The books printed

amounted to thousands of volumes." Currently, 10 books can be verified as prints of An Guo, putting An second to Hua Sui only in number of books handed down. Qian Qianyi of early Qing Dynasty wrote in the epilog to "*Rich Dew of Spring and Autumn*": "Jinling version had multiple misprints and mistakes, and hundreds of words were changed in the movable-type print by An's of Xishan." From this, we can see that An had taken quite seriously his book printing, and there were fewer errors. Qin Jin of the Ming Dynasty wrote in the epitaph to An "cast copper movable type." Since Qin and An were fellow townsmen from the same period, this saying should be credible. However, An Guo's offspring An Ji said that An Guo "had engraved type copperplate" for printing the "*The Collected Works of Yan Lugong,*" Xu Jian's "*Record of Initial Learning*" and other books. What had been cast with or engraved in metal should be the movable type, rather than the copperplate or copper-disk character shelf for placing the movable type. An Guo made movable type in about the Zhengde years, about 20 years after Huitong Studio. Then, he was about 30 years old, so whether casting or carving, he should have made his movable type in imitating the Hua's. An Rui of the early Qing Dynasty "while he had time, my ancestor (An Guo) would pick out the less printed ancient books and printed them through copper movable type. Therefore, he was known far and wide. Bibliophiles today have books printed by An's in Jiaoshan Mountain and those books had been printed via copper type." In fact, An Guo used woodblock, aside from copper movable type in printing books. For instance, "*Selected Poems of Shitian*" (in Zhengde Years) by Shen Zhou and "*Zuocui Leizuan*" claimed themselves to have been carved by An Guo in Hongren Studio in Xishan. Both "*Collected Works of Yanlugong*" and "*Record of Initial Learning*" had two versions, one copper movable-type edition and the other woodblock edition. Unfortunately, after the death of An Guo, his copper type was "measured and divided by his six sons." All of the copper type, together with fields and other properties, were carved up by his six sons. And the copper type obtained by each of them was incomplete and turned into useless waste.

In the biography of Hua Sui, there is a sentence "imitating copperplate and tin type." Therefore, it is suspected that Hua's Huitong Studio had cast tin type, aside from copper type. However, we find it difficult to conclude whether the type made by Hua Sui is tin type or copper type, or both, before we find the actual type used back then and more detailed and reliable historical data. So generally, Hua's movable type is still categorized as copper type. As for the movable type of An Guo, due to the record of "measured and divided the copper type," we know for certain that it is copper movable type.

2.2 Changzhou

Changzhou, a place adjacent to Wuxi, also used copperplates, known as "Changzhou copperplate." Only two kinds of Changzhou copperplate prints, i.e., "*Du's Tongdian Zuanyao*" and "*Yiwen Leiju,*" kept in Baowen Studio by Chao Li, native of Kaizhou, the bibliophile in the movable of JiaJing years of the Ming Dynasty. However, details about the printer have been unavailable.

2.3 Suzhou

In the Ming Dynasty, there were Jinlan Studio, Wuyunxi Studio, Wuchuan Jingshe, and Sun Feng from Wu Prefecture and others engaged in book printing, and they were mainly concentrated in the vicinity of Suzhou, just as Zhu Yunming remarked "recently the enthusiasts in Sanwu region have been active." Tang Jin, native of Shanghai, remarked, "Nowadays, the masters mainly engraved movable type for printing on copperplates, for it is easy to use. It originated in the movable of Qingli years invented by the commoner Bi Sheng." Xie Qiyuan of the Ming Dynasty also mentioned in "*Mr. Xie's Miscellanies*": "Nowadays, the masters mainly engraved movable type for printing on copperplates, for it is easy to use. It was invented in the Qingli years of the Song Dynasty, when the commoner Bi Sheng fashioned movable type by engraving characters in clay and harden them by firing. While printing, two iron plates are used. The movable type is arranged on the plate, and when one plate is used in printing, typesetting on the other can begin. Alternate the two plates, and copies can be completed soon. And the cost is lower than copper movable type." Thus, the convenience of copper type has been generally recognized.

In Zhengde years, "*Collected Works of Fifty Poets in the Tang Dynasty*" was printed in Changzhou. In the 5th year of Zhengde (1510), Shu Zhen engraved "*Collected Works of Cao.*" In the preface, Tian Lan remarked: "Shu said: 'One year when I passed Changzhou, I got one hundred copies of '*Collected Works of Zijian*,' and sold them as I went on. They were sold out soon. Now, there are many inquiries for them, but I have none available. This is because limited copies were produced via movable type back then and now they are no longer available" He Liangjun, native of Huating, Songjiang in the Ming Dynasty said in Volume 24 of "*Siyouzhai Series*": "the Xi's in Xuyan printed *Liduan Ji*, the movable-type version of the 'Collected Works of Fifty Poets in the Tang Dynasty.'" Therefore, we know that the book had been printed by Xu Jin.

2.4 Nanjing

In Nanjing, there was a certain Zhang engaged in printing, but his name is unknown. Only one of his prints, i.e., "*Forgotten Tales of the Kaiyuan and Tianbao Periods,*" is handed down. In the first page of Volume 1, there is a line saying "建业张氏铜版印行" (published by Zhang's via copperplate in Jianye)." However, the time of printing is nowhere to be seen. Wen Zhengming, originally an artist in the Ming Dynasty, took to book collections, and he had a book printed by Magnolia Studio. Wen died in the 38th year of Jiajing (1559) at the age of 90. Therefore, the book should have been printed in Hongzheng or Jiajing period.

2.5 Zhejiang

Among copperplate prints in Zhejiang, only "*Zhugeliang's Book of the Mind*" of the Zhengde Years is known. Inscribed with "浙江庆元学教谕琼台韩袭芳铜版

印行" (printed by Han Xifang through copperplate in Qiongtai under instructions from Qing Yuanxue in Zhejiang), the book has a preface by Han Xifang, saying "I hereby reprint the book with movable type for sharing with people wishing to dedicate themselves to military service and also to remind people of danger in times of safety". The end of the preface reads "In April of Dingchou Year (12th year of Zhengde (1517)), by Han Xifang in his bookstore in Qiongtai, eastern Zhejiang. It can be seen that Han's copperplate also used movable type, and the printing was carried out in eastern Zhejiang. In old times, Qingyuan County was the state capital of Zhejiang. Located in the junction between the two provinces of Zhejiang and Fujian, a quite remote region, Qingyuan County, actually had copperplate.

2.6 Zhicheng (Jianning)

Among extant copper-type prints of the Ming Dynasty, the fifteen volumes of *Mo Zi* of Zhicheng are most highly praised by bibliophiles. Printed with blue ink on white papers, it consists of two books. In the middle of the last page in Volume 8, there is a line saying "嘉靖三十一年(1552年)岁次壬子季夏之吉, 芝城铜版活字" (Zhicheng Copper Movable Type in June of 31st year, the year of Renzi (1552) during the reign of Jiajing). In the middle of the last page in Volume 15, there is a line saying "嘉靖壬子岁夷则月中元乙未之吉, 芝城铜版活字" (Zhicheng Copper Movable Type in July in the year of Renzi during the reign of Jiajing). The printing took only 1 month and a half between June to July. Zhicheng, a name derived from Zhishan Mountain, is the alias for Jianning prefectural city—present-day Jian'ou County, Fujian. Therefore, Zhicheng movable type is actually the copper movable type of Jianning prefectural city. On seeing *Mo Zi* printed in the Ming Dynasty, the Master of Tangcekan remarked: "After seeking far and wide, I finally got the transcribed version printed via Zhicheng movable type." Instead of calling the book a copperplate type version, he called it transcribed version via copper type, so it seemed that he believed that what he got had been a transcribed book based on a movable-type print, rather than the print itself. In addition, Zhicheng copper-type prints also include "*Tongshu Lei Jukeze Daquan.*"

2.7 Jianyang

Apart from the prefectural city, Jianning also had copperplate in its subordinate county Jianyang County. Jianyang copperplate prints verifiable include Yourong Productions. In the first year of Wanli reign (1573) in the Ming Dynasty, Mao Kun, a native of Huzhou, printed "*Differentiation of Styles*" written by Xu Shizeng and inscribed the line "建阳游榕活版印行" (printed via Yourong movable type in Jianyang) or "建阳游榕活版印行" (printed via Yourong movable type in Jianyang, Fujian). After the book was published, people scrambled for it, pushing higher the price of paper mulberry. How can we say that the movable type made by Yourong is copper instead of wooden? This can be proved by "*The Imperial*

Readings of the Taiping Era" printed in the following year (1574). Because the characters and annotation scripts in these two books are exactly the same in font, and the surrounding single lines, typographical format, and paper and ink are also mostly the same. In "*The Imperial Readings of the Taiping Era,*" below the type area there is often a line saying "宋版校正, 闽游氏仝版活字印一百余部" (collation of the version published in the Song Dynasty, over 100 copies printed by You's in Fujian with Tong plate). In the content of the fifth volume, there are two lines of characters "宋版校正, 福建游氏梓制活版, 排印一百余部" (collation of the version published in the Song Dynasty, over 100 copies typeset and printed by You's in Fujian with movable type). The so-called 仝版 above is actually simplified edition of "铜版" (copperplate). In some places, it was written as "Rao's Tong plate," like in "宋版校正, 饶氏仝版活字印行壹百余部" (collation of the version published in the Song Dynasty, over 100 copies typeset and printed by Rao's Tong plate). This copperplate was made by You Rong and later came into the hands of You's and Rao's. Therefore, within the same book, it is called You's Tong plate or Rao's p Tong late. Rao refers to Rao Shiren, a bookseller from Fujian. Zhou Tang of Changshu bought half of "*The Imperial Readings of the Taiping Era*" printed in the Song Dynasty from Fujian through the merchant Rao Shiren and borrowed the other half from Gu's and Qin's in Wuxi. Using the combined version as the master copy, Zhou printed over one hundred copies and divided them with Gu's and Qin's. This masterpiece of one thousand volumes and one hundred eighteen books repeatedly labeled itself a collation of the version published in the Song Dynasty, but turned out to be of rather sloppy proofreading, with many mistaken and lost characters. The characters were skew, and some words were typeset erroneously, reflecting a mediocre typesetting technology. The strange thing is that these two books were not printed in Jianyang, but in Jiangsu and Zhejiang, reflecting a high mobility in the job.

The copper type of the Ming Dynasty did not use pure copper, but copper alloy. The literatures only said that Hua Sui made tin type in imitation of copper type and that the movable type made by Hua Cheng was sophisticated. However, there is not enough data to show how the type was made. Tang Jin claimed: "Nowadays, the masters mainly engraved movable type for printing on copperplates." It seems that the type was engraved on copper. Some people think that probably it was made by casting according to models. Although the individual character is not very regular, the most commonly used words may have had more than one model. So the font of the same character might differ. Cast type is very coarse and needs trimming before application. Since there is no clear record, or actual samples handed down for demonstration, it is still hard to know for certain whether the type had been cast or carved.

In total, there are about 62 copper-type prints produced in the Ming Dynasty, with Hua's of Wuxi producing the most and An's the second most, followed by Jianning and Changzhou. Huang Pilie of the Qing Dynasty remarked in an epilogue to "*Copper Type Mo Zi*": "Among ancient books engraved since the Song and Yuan Dynasties, the most trusted is none other than those produced via movable type on copperplates." This is because they are based on earlier editions

produced via woodblock printing. Copper-type prints of the Ming Dynasty have been treasured by generations of bibliophiles since the Qing Dynasty.

3. Lead Movable Type

Chinese-made lead movable type was first seen in late Hongzhi and early Zhengde years (1505–1508) in the Ming Dynasty. Lu Shen remarked in "*Jin Tai Ji Wen*" (Record of Jintai): "recently people in Piling have used copper and lead for making type, making typesetting and printing convenient. However, typesetting is especially susceptible to mistakes." People from Changzhou in the Ming Dynasty not only used copperplate, but also created lead movable type, making remarkable achievements in the manufacture of metal type.

2.2.5 Movable Type in the Qing Dynasty

1. Wooden Movable Type

Wooden movable type was more extensively used in the Qing Dynasty, spreading to almost all provinces. Fang Yizhi said: "Shen Cunzhong once remarked: 'in the reign of Qingli, Bi Sheng created movable type using clay and firing.' Today wooden is used for carving, and carved characters are put together on a copperplate." The so-called put together on a copperplate might refer to typesetting the wooden characters on a copperplate character wheel. Wooden movable-type prints were popular between the early Qing Dynasty and the reign of Emperor Qianlong in regions in the north and south. In Hongzhi, Zhengde, and Jiajing years of the Ming Dynasty, metal movable type was prevalent in book printing. However, Fang Yizhi and Wang Shizhen the early Qing mentioned copperplate printing using wooden type. Thus, use of metal type in book printing had been gradually fading by the early Qing Dynasty.

During the reign of Emperor Qianlong, Zhou Yongnian of Jinan advocated printing "*Scripture of confucianism*" with movable type, in an attempt to award "*Scripture of Confucianism*" the functions of a modern library and publishing institution, and to supply poor readers with diet and salary. All domestic schools and colleges and ancient temples in famous mountains keeping "*Scripture of Confucianism*" were equipped with a set of movable press, for printing rare books for exchanges. After a few decades, circulation of books gradually got started and increased. Zhou tried to use movable type to increase production of books for better exchanges, and he is the first to advocate large-scale use of moveable type.

While compiling "*Complete Library in Four Branches of Literature,*" Emperor Qianlong wanted to include and print the books found to be missing at the time when "*Yongle Encyclopedia*" was compiled. However, the copper movable type and copperplate originally kept in the library of Wu Yingdian had been recast as coins. Therefore, he had a poem saying "destroying the copper type

and copperplate is a regret, it's a shame we have to resort to wood engraving." He appended an annotation to the poem: "if the copper type were available now, wouldn't it be far more efficient to print books now? Nothing can describe my regret." However, this time a number of books required to be printed, making engraving a challenging job. Jin Jian, the manager then of book engraving in Wu Yingdian, and a native of Korea, suggested that movable type made of date wood should make a preferable choice, in that it not only can accelerate book printing, but also save a lot of cost and materials. He made a careful comparison and gave a vivid example to illustrate that the aggregate for carving woodblocks and 150,000 wood characters and purchasing wooden shelves, and boxes require over 1,400 liang(1liang = 37.3 g) of tael. He also found that carving "*Records of the Grand Historian*" by Sima Qian required 1,189,000 characters, 2,675 pear-wood plates, and the aggregated labor cost would amount to more than 1,450 liang of tael. However, one set of date-wood movable type would solve the problem once and for all, as it can be used to typeset and print the various books if necessary. It would be very convenient, while wood block engraving could only produce one book "*Records of the Grand Historian.*" With this detailed calculation, he convinced Emperor Qianlong. Emperor Qianlong looked his memorial and wrote the commented "甚好, 照此办理" (very good, proceed as the instructions herein). In addition, Emperor Qianlong instructed him to add 100,000 characters for standby. In May, the following year (1774), a total of 253,500 date-wood characters were carved, costing 1749 liang 1 qian 5 fen of taels. Addition to alternative date-wood characters, character-holding Phoebe slot, clamp bands, pine wheel for categorizing, holding and picking characters, typesetting lattice, character cabinet, type boxes, and typeset stool put the aggregate cost at 2339 liang 7 qian 5 fen. This set of new movable-type tool was successively used to print a total of 134 kinds of books for the "*The Essential Collections from the Wuying Hall*" series. Each book had two versions: one on Liansi Paper (also known as Lianshi Paper), and the other on bamboo paper. The former, ranging from 5 to 20 copies, were specially intended for display at the palace. The latter, of about 300 copies, were priced for sale. What we see today are almost all the yellow bamboo paper versions. Each book was preceded with the verse by Emperor Qianlong "*A Ten-Rhyme on the Essential Collections from the Wuying Hall.*"

In the 42nd year of Qianlong (1777), this series of books was distributed to the five provinces in south and east China and allowed to be replicated for distribution. However, the official presses of the five provinces of Jiangsu, Zhejiang, Fujian, Jiangxi, and Guangdong still used woodblock printing in reproducing the book, instead of movable-type printing. Therefore, the cover of those reprints had the cover inscription "乾隆丁酉九月颁发, 奉敕重锓" (re-engraved under imperial decree based on the copy distributed in Sep. Dingyou Year in the Reign of Qianlong). In later period of Qianlong's Reign and during Jiaqing's Reign, eight more books were typeset and printed, including "*A Sequel to Survey of Ryukyu,*" "*Qianlong Otogenarian Festival for Longevity,*" and "*Board of Civil Rules.*" Different from "*The Essential Collections from the Wuying Hall*" in line space, they are known as offprint.

Wooden movable type for "*The Essential Collections from the Wuying Hall*" was made in Internal *Affairs* office of Qing Dynasty and is large in scale. It is a development and improvement at the method invented by Wang Zhen in the Yuan Dynasty. For instance, Wang first carved the characters in a wooden board and then separate them with a fine saw. In the case of "*The Essential Collections from the Wuying Hall,*" individual wooden cubes were made first and the written characters were stuck to them for engraving. Wang cut bamboo slices as the boundary line, and here type in the style of an authentic book was carved on pear wood first. On each block, 18 lines were carved, and this was called "Taoban." In printing, the format of 18 lattices was printed first, and then, the characters were printed within the lattice. Therefore, the four margins of each page did not have any gap, as found in other prints using movable type. Wang used small bamboo slips to support the plate, but this time folded paper bars were used. Wang used a turning wheel for choosing characters for typesetting so as to bring the characters to the typesetter, but this time character cabinets were used—characters were stored in 12 large cabinets in accordance with The 12 Earthly Branches like Zi Chou, Yin, Mao, as used in the format of *Kang Xi Dictionary*. Each cabinet consisted of 200 drawers and each draw 8 large grids and 8 small ones, which stored 4 large characters and 4 small ones. All the characters were labeled with section number, name, and stroke number and were easily located. For people familiar with the arrangement system, each character could be found instantly. The typesetter just shouted the characters needed to the keeper, who can gave them to him presently after he was heard. Back then, it was believed that "in this way, convenient checking and fast typesetting are guaranteed." Roughly two plates of large characters or one plate of small characters could be typeset per person per day. However, it was feared that simultaneous typesetting of the same book would result in insufficiency of a certain type of characters due to repetition. Thus, a daily rotation was created. That is, typesetting of other books should temporarily replace that of the present book, and when the movable type was recovered, its typesetting should resume. In the weather happened to be hot, and the wooden movable type expanded due to increased ink infiltration, the work would be stopped for a while, to let the plate become dry before printing was continued. Jin Jian wrote a summary of his experience handling the printing of the book, illustrating one by one the processes of making wooden characters, engraving, making character cabinet, making the slot, making clamp bands, making top wood, making the central piece, making the categorization disk, setting grid, typesetting and supporting, proofreading and printing, classifying, daily rotation approach, and clauses for separation, namely instructions were illustrated one by one drawing instructions. The typesetting format of the book, called "*The Imperial-endorsed Format for The Essential Collections from the Wuying Hall*" (as shown in Fig. 29), was more detailed and specific than Wang Zhen's "*Method of Book Printing with Movable Type.*" It is an important literature in history of movable-type printing. The essential collections from the Wuying Hall were once kept in Wuying Hall in the Forbidden City, accessible through Xihua Gate. The large number of precious wood type was stored in Wuying Hall for a long time, without full application. Later, it was used by the guards as firewood and was long gone.

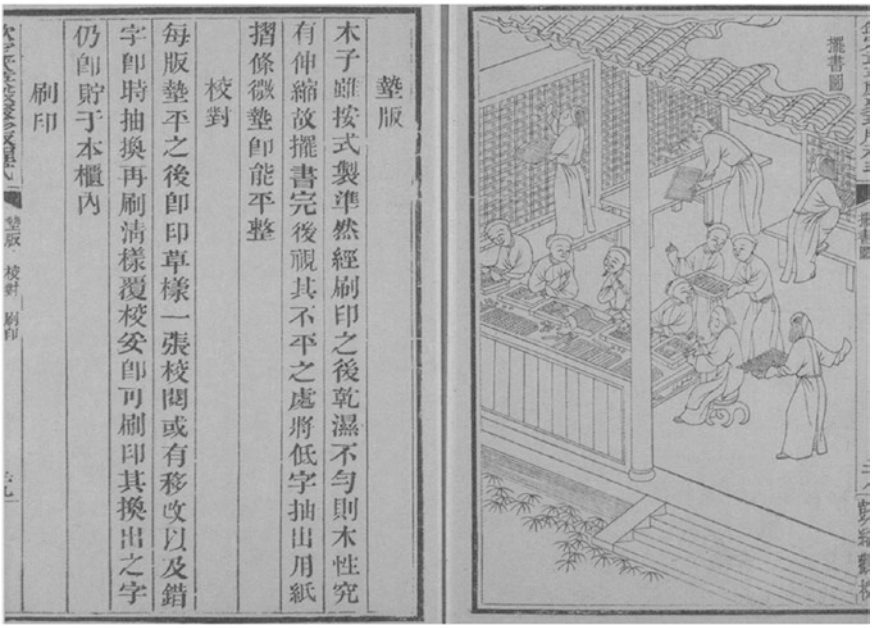


Fig. 29 A glimpse of "*The Imperial-endorsed Format for The Essential Collections from the Wuying Hall*"

The simple and easily implemented book printing method introduced in "The *Imperial-endorsed Format for The Essential Collections from the Wuying Hall*" was imitated by official and private printers from various places. All local governmental offices used movable type in book printing, but the number of copies was limited. Between Emperor Tongzhi and Emperor Guangxu, official bookstores were successively set up in all the provinces, for engraving and printing classics and history books, and those productive ones printed hundreds of books each. Some people think that all the books were result of woodblock printing, but actually there were many movable-type prints. Colleges of the Qing Dynasty were like those of the Ming Dynasty, in that some of them used movable type to print books. The privately carved wooden movable type was more prevalent in the Qing Dynasty. The literati often chose to produce movable type on their own, or borrow or purchase movable type to print the writings of their own and their ancestor's writings or local literatures, so as to expand their fames, to give prestige to their parents, and to sing praise to the preceding sages. In addition, there were many business-oriented bookshops using wooden characters in book printing.

In short, in the Qing Dynasty, fourteen provinces, i.e., Zhili (now Hebei), Shandong, Henan, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Fujian, Guangdong, Shaanxi, and Gansu had movable-type prints.

In addition to genealogy, wooden movable-type prints in the Qing Dynasty are far behind woodblock prints. In addition, the number of movable-type prints

is generally smaller than engraved prints. In some cases, only a few copies were printed, and in others, only dozens or a little over one hundred were printed. In the Qing Dynasty, wooden type was used in printing newspapers, following the precedent set in the 11th year of Chongzhen (1638) in the Ming Dynasty. Yuan Dong said, "Recently Di Bao is often printed with movable type in order to meet the needs of repeated changes. This is the last resort. Even if there are mistakes, they can be forgiven." It was the case in the early years of Qianlong reign and remained so in late Qing Dynasty. In the nineteenth century, wooden movable type was used to print "Jingbao" (literally, The Jing Newpaper). In August, 21st year of Guangxu (1895), reformers in Beijing used wooden movable type to publish a newspaper under the name of "*Multi-national Communique,*" which was renamed later to "*Records of Incidents at Home and Abroad.*" Also known as "*Chinese and Foreign Communique,*" it was issued every other day, in a form similar to "*Jingbao.*" In each issue, there was only one essay. And one to two thousand copies were printed for each issue. The paper was sent to the princes, dukes, and ministers. However, in the winter of 1895, it was banned by the Qing government.

Genealogy Printed with Wooden Movable Type

The ancient Chinese attach great importance to patriarch, so the science of genealogy was prevalent. Genealogy re-emerged in the Yuan and Ming Dynasty and prevailed in the Qing Dynasty. The most prevalent were family tree and genealogy, which were printed using wooden movable type. Family tree and chronicle are two main streams in the Chinese historiography. The former concerns family history and the latter local history.

In the Qing Dynasty, wooden type genealogies were found in Jiangsu, Zhejiang, Anhui, Jiangxi, Hunan, Hubei, Sichuan, Fujian, and other provinces. The wooden movable-type genealogy in the Qing Dynasty was most prevalent in the two provinces of Jiangsu Zhejiang, especially in Shaoxing state and Changzhou state. In those regions, people of the same clan often lived together in the same area. Thus, the clan power was developed, and almost every village had ancestral halls, and each surnames genealogy. All the eight counties under Shaoxing state had chronicles. In Shaoxing, there were workers specializing in genealogy printing, commonly known as "genealogy artisans" or "genealogy masters." Shengxian alone boasted over 100 genealogy masters in late Qing Dynasty. Every time after the autumnal harvest, they would shoulder type stalls on a pole and go to townships in Shaoxing or Ningbo to make genealogy. Wooden type in their stalls was also known as wooden seals and usually amounted to a little more than twenty thousand in number. Consisting of big and small sizes, the wooden characters in Song Ti were made of pear wood. In case of missing characters, the genealogy masters could presently carve them out. The type trays are made of fir and padded with bamboo slips.

In the long-term practice, genealogy artisans of Shengxian County divided the type trays into common type trays and rare type trays, also known as internal trays and external trays, respectively, so as to facilitate typesetting. The internal trays contained characters related to emperor reigns and the Chinese era, as well as "年" "月" "日" "时" "长" "次" "幼" "男" "女" "讳" "字" "号" "行" "娶" "配" "适"

"葬" "一" "二" "三" "四" and other Chinese numbers, as well as function words like "之" "乎" "者" "也." To facilitate memorization, the external tray contained words classified into categories describable with a poem of 28 lines with 5 characters for each line, like "君王立殿堂" and "朝辅尽纯良."

Wooden characters with the head, feet, or radical were grouped under each line, for example, "君(群)王(弄理圣王)立(产端)殿(殿殳)堂(尚掌)." Once the line was remembered, character-picking would become fast. This is different from the word cabinet used in Wuying Hall, and the turning wheel invented by Wang Zhen. The arrangement of characters broke through the Radical conventions in dictionaries. Such a creative spirit is praiseworthy and desirable. Usually, five to eight people were grouped into a shift, complete with posts of character carving, imaging, typesetting, brushing, and printing and odd jobs, in the charger of a contractor (manager). The time needed in making the genealogy depended on the size of the clan and the amount of data, ranging from a couple of months in the minimum to 4–6 months in the maximum. Genealogy was popular in Yinxian, Cixi, Zhenhai, and Fenghua, four subordinates to Ningbo. Its popularity in Taizhou, Jinhua, and Quzhou diminished, and that in Western Zhejiang diminished further.

In Jiangsu, genealogy was most popular in the Changzhou and Wuxi area. Typographical workers from Changzhou were the most prestigious in the Qing Dynasty. Bao Shichen remarked: "movable type in Changzhou featured great differences in size, and the tidiest craft." In the beginning, it was used only in compiling genealogy, and poetry of the literati in between. Recently, "*Wubei Annals*" typeset in Changzhou movable type has become a spectacle. The matching between pictures and texts and the arrangement are all elaborate. In addition, on the bottom of each wooden character, the character was written, facilitating picking. The typeset characters were aligned with fine soil, making easier recovery and adjustment. Changzhou the wooden type, the character was carved on the top, and written at the bottom. Therefore, character-picking is easy. In addition, the characters were aligned with fine soil on the plate to make it even. Such a printing craft is called "clay tray printing." Because the technology of the Changzhou clay tray printing is ingenious, the official bookstore of Anhui Province–Qushui bookstore—was set up in the temple to worthies of former times in Longcheng College in Changzhou. The bookstore collected money to hire printing workers and purchase rare books. Even people from Sichuan sent their genealogical manuscripts to Changzhou for typesetting and printing. It took printing workers in Changzhou less than fifty days to print "*The Genealogy of Gao's Family in the South Gate of Luzhou.*" Genealogy was also popular in Suzhou and Zhenjiang Prefectures, as well as their subordinating counties, near Changzhou. In Anhui, genealogy was most popular in Jixi, She, Yi, Xiuning, Qimen, and Wuyuan Counties, as well as Tongcheng. Printing of genealogy occasionally occurred in the four states of Anqing, Ningguo, Chizhou, and Luzhou.

Generally, seven or eight to ten, or dozens or even one hundred copies of a genealogy were print and each was labeled with the style of the household that was to keep it. Often, they were print on white Liansi paper. The format was usually large: since the wooden type was large, the prints were accordingly large. Ordinary genealogy measured about 30 cm high and 20 cm wide. Prints in the

vicinity of Shaoxing and Ningbo sometimes measured 46 cm high and 37.5 cm wide. In the 53rd year of Emperor Kangxi (1714), "*The Genealogy of Xu's in Huangbu*" in Yugan Jiangxi was actually 50 cm high and 33 cm wide, much larger than the average printed copies. In genealogies printed with movable type in the Qing Dynasty, there was one printed with clay type and one with copper type, aside from those based on wooden type.

2. Copper Movable Type

The earliest movable type made by the Qing Dynasty government is copper type, about 60 years earlier than wooden type. Copper movable type already appeared in the reign of Emperor Kangxi and the astronomical book "*The Origin of Calendar,*" the mathematic book "*Collected Basic Principles of Mathematics,*" and the musical book "*Standard Interpretation of Tone-system*" were typeset with copper type and printed by the internal affairs office in late Kangxi's reign. Chen Menglei in the official residence of the Prince Ying Chi printed nine volumes of his "*Collected Poems of Chen Menglei*" and twenty volumes of his "*Anthology,*" with movable types borrowed from the internal affairs office. The poetry and anthology used Song Ti characters slightly resembling Yan Ti, and the strokes were coarse, different from the standard fonts with light horizontal stroke and heavy vertical stroke used in "*The Integration of Ancient and Modern Books.*"

Chen Menglei, a successful candidate in the highest imperial examinations in the ninth year of Kangxi, was exiled northeast China for getting involved with Geng Jingzhong the rebel. In the 37th year when Emperor Kangxi embarked a tour east, Chen offered a poem to the Emperor and was pardoned. After his returning to Beijing, he was ordered by the emperor to tutor Yin Chi, the third prince, in reading. In order to repay the gratitude for receiving help and encouragement from the emperor, he did some serious study and research. Using the books kept in the palace of the prince and in his own house, he edited an all-inclusive reference book covering more than 3,600 volumes and called it "*The Collection.*" Beginning from October the 40th year of Kangxi (1701), he hired people to transcribe all the books with sliver tael subsidy from the palace and completed the whole book in April the 45th year of Kangxi. The draft of such a masterpiece was completed in a mere 5 years. The first draft was submitted for imperial approval in the 55th year of Kangxi and was given the name "*The Integration of Ancient and Modern Books.*" In the same year, an institute was established for the 80 compilers led by Chen Menglei to expand the book. The expansion completed in around the 58th year of Kangxi. Chen's "*The Collection*" included more than 3,000 volumes; however, "*The Integration of Ancient and Modern Books*" had 10,000 volumes. There seems to have been an increase of over 6,000 volumes. This magnum opus of 16 million characters is also an important reference book used by scholars from home and abroad. "*The Integration of Ancient and Modern Books,*" typeset and printed using copper types, is the largest printing undertaking by the internal affairs office of the Qing Dynasty. It was printed in the 59th year of Kangxi under imperial decree.

Emperor Qianlong claimed that in the compilation of "*The Integration of Ancient and Modern Books*" during the reign of Emperor Kangxi, "copper characters are carved for movable-type printing." Copper character carvers working in Wuying Hall were paid 2 fen 5 li silver tael for each character carved, almost dozens of times higher than those carving Song Ti (Ming Ti) and soft words (Kai Ti) on wood. Metal is hard and more difficult to carve than woodblock, so the labor price would naturally increase fast. The saying "People carving copper characters" was adopted back then, instead of "people casting copper characters." Thus, we know that the copper characters were carved. After the typography of this masterpiece was completed, the numerous copper types were stored in the copper warehouse in Wuying Hall, without being used to print any other book—at least to our knowledge. A warehouse manager and two warehousing officials were appointed to manage it. Later on, these management personnel stole from the warehouse, and copper money happened to be precious in Beijing. Afraid of punishment, they proposed destroying the copper characters to cast money. In the 9th year of Qianlong's Reign (1744), the remnant copper characters were all destroyed, to cast copper money. Later when Emperor Qianlong wished to publish the lost books categorized during compilation of *Yongle Encyclopedia*, he was full of regret in vain and had to re-carve a large number of types using date wood.

2.1 Jiangsu

The earliest private user of copper movable type in the Qing Dynasty is none other than Chuilige, the master of which might have been from the vicinity of Changshu in south Jiangsu. Its prints include the four volumes of "*Selected Rhymes of the Cream of Literary World.*" On the title page, at the lower section of the content and the last line of Volume IV, there are five characters "吹藜阁同版" (copper movable-type print of Chuilige). "同版" was the shortening for "铜版" and was also written as "仝版" in the Ming Dynasty. The book contains selections made by Qian Lucan from Yushan. In the preface written by Qian himself in the 25th year of Kangxi (1686), he said: "So I chose some articles and printed them via movable types so as to distribute them across the country." The cover said that copperplate had been used, and here, Qian said movable types had been used. Therefore, it is without doubt that copper movable-type printing had been used. However, he did not mention whether copper movable types were his own or borrowed from someone else. "*Selected Rhymes of the Cream of Literary World*" precedes "*The Integration of Ancient and Modern Books*" by four decades. It is the earliest copper-type print of the Qing Dynasty.

2.2 Hangzhou

Verifiable use of copper-type printing in Hangzhou, Zhejiang includes the application of copperplate for "The Essential Collections from the Wuying Hall" by Wu Zhongjun in the 2nd year of Xianfeng (1852) to print the three volumes of "*Miaoxiangge Essays*" and "*Miaoxiangge Poems*" written by his maternal

grandfather Sun Yungui, from Changzhou. Wu said in the postscript: "In this summer, collation was completed. So I began to typeset [those books] with copperplate for 'The Essential Collections from the Wuying Hall' to print and disseminate them." During his tenure as an official in Hangzhou, he would typeset and print any books constituting "Wuyingdian Juzhen Ban" when he got them. Therefore, it is clear that the copper types did not belong to him, but were borrowed from someone else. Another copper-type print from Hangzhou includes the seven books of "*Secret Strategies for Offensive and Defense on Water and Land*" printed by the Manchurian Lin Gui in the following year (1853) when he was an official in Zhejiang. In the last book, there is a line "省城西湖街正文堂承刊印" (printed by Zhengwengtang in Xihu Street, the Provincial Capital). The printing was funded by Lin Gui and exercised by a bookstore in Hangzhou. While the 7th book mentioned movable-type printing, how do we know that copper type was used? Because its font is the same as that of Lin's from Futian Shuhai, this is also the reason for some people to believe that the books were Lin's copperplate prints produced in the 3rd year of Xianfeng. Among the copperplate prints, there was the book "*Essentials of Medicines in the Military,*" which is also found among the series. Comparison has found that the two books are the same in content and identical in font. However, the one in "*Secret Strategies for Offensive and Defense on Water and Land*" series has incomplete lines. Moreover, the numbers of characters are different. Therefore, we can see that they were not typeset at the same time. Because one was printed in Fuzhou and the other in Hangzhou, there are minute differences. Lin's only production is the series of "Essentials of Medicines in the Military." However, the books printed by Lin Gui were preceded with his remarks, instead of Lin's name. In addition, on the covers of the seven books, there is the line "麐月方伯集印" (Collected and printed by Linyue Fangbo). Therefore, there is no doubt for them to have been printed by Lin Gui in Hangzhou. Moreover, the font in "*Secret Strategies for Offensive and Defense on Water and Land*" is almost identical to that in "*Miaoxiangge Essays*" and "*Miaoxiangge Poems.*" While the latter two books are prints based on copper movable types for "The Essential Collections from the Wuying Hall." Therefore, all of them are copper movable-type prints. The copper types used in Hangzhou are probably that used by Lin's of Futian Shuhai in Fuzhou. As for why his copper types reached Hangzhou, we have no way to find out, due to the lack of literatures.

2.3 Fuzhou (Lin Chunqi)

The movable copper type of Futian Shuhai was created by Lin Chunqi in Fuzhou. Chunqi went to Hangzhou and Suzhou for schooling at the age of 20. Following his father's official career, he toured Luoyang and Guangdong. Since childhood, he had heard his grandfather and father talk about copperplate-printed books and often regretted that the lack of copperplates in the society had caused the valuable works of ancient and modern scholars to be lost—because they could not afford it. To realize his grandfather's ambition, he began donating to carving from the age of 18 onwards. After 20 years of hardworking and spending over 200,000 liang

liver tael, he finally completed carving 200,000 large copper types in Kai Ti and as many small ones, according to the strokes in "*Hongwu Rhymes.*" His carving covered various styles and fonts in ancient and his own time. Those types can be used to print all kinds of books, big or small. Lin engraved a total of over 400,000 copper types, and the feat is rarely rivaled in the history of metal movable-type-making in Asia. During manufacture, the difficulties in financial, material, and human resources must have been numerous. No wonder he would say: "To undertake it, is difficult, and to complete it, is even more difficult. In the process, there has been more than one occasion that I wish to discontinue. I have exhausted half my life's energy and effort to achieve the result, however mediocre it may be." He added: "Starting donation to engraving in the year of Yiyou (1825), I was only 18 years old, and I completed it in the year of Bingwu (1846)." After 21 years, Lin was only 40 years old. Lin was a native of Longtian, Fuqing, thus the name of his movable types "Futian Shuhai." Lin printed "*The Five Books of Phonetics*" by Gu Yanwu, but only "*On Phonetics*" and "*Poetry Is Song*" are now seen. In the beginning of "*On Phonetics,*" there is the essay "*About Copper Types*" (as shown in Fig. 30) illustrating that the causes and process of making copper movable types. It is the only literature on copper-type manufacture in China.

On the page reverse to the title page, there were the characters in four rows "福田书海铜活字版,福建侯官林氏珍藏" (printed via the Futian Shuhai copper

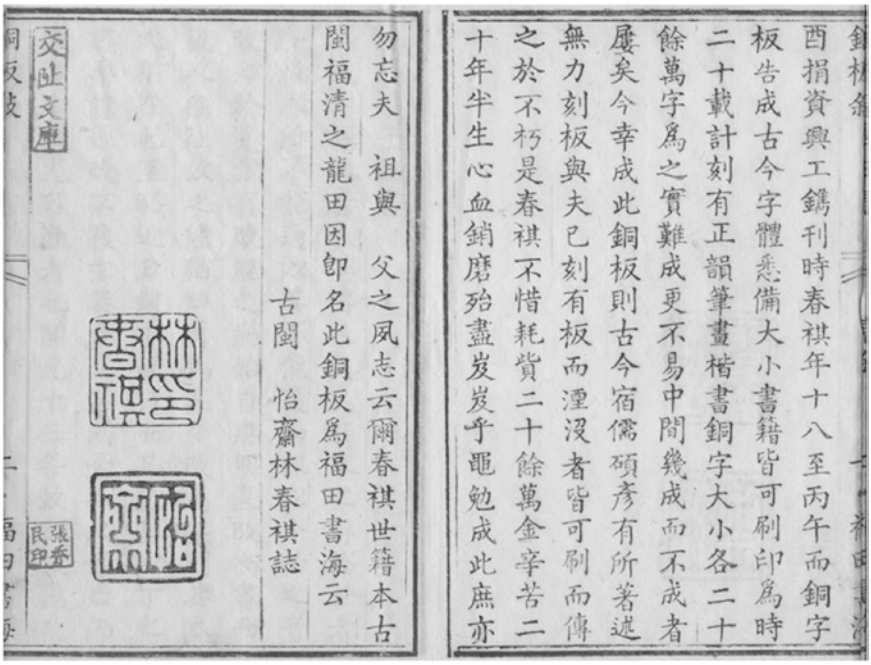

酉捐資興工鐫刊時春祺年十八至丙午而銅字
板告成古今字體悉備大小書籍皆可刷印爲時
二十載計刻有正韻筆畫楷書銅字大小各二十
餘萬字爲之實難成更不易中間幾成而不成者
屢矣今幸成此銅板則古今宿儒碩彥有所著述
無力刻板與夫已刻有板而湮沒者皆可刷而傳
之於不朽是春祺不惜耗貲二十餘萬金辛苦二
十年半生心血銷磨殆盡岌岌乎黽勉成此庶亦
勿忘夫　祖與　父之夙志云爾春祺世籍本古
閩福清之龍田因卽名此銅板爲福田書海云
古閩　怡齋林春祺誌
交趾文庫
張燕民印

Fig. 30 Lin's *about copper types*

movable types, kept by Lin's in Houguan Fujian." At the end of "*Poetry Is Song,*" the type carver's name was inscribed: "古闽三山林春祺怡斋捐镌" (Engraved via donation from Lin Chunqi in Sanshan, Fujian). The movable type in Kai Ti was elaborate, and the paper and ink sophisticated. At the lower section of the type area on each page, there are four characters "福田书海" (Futian Shuhai). In addition, Lin also printed "*Essentials of Medicines in the Military.*" Divided into two booklets, they had the title "侯官林氏铜摆本" (typeset with Lin's Copper Movable Types) on the yellow paper cover. And each of the lines in the two books has the same number of characters as the previous two books. However, they do not contain "福田书海" in the type area, or the date of publication. Lin Chunqi had also printed 14 volumes of "*Four Books on Enlightenment,*" which had "福田书海" in the type area and "考镌铜字侯官林氏珍藏" (printed via copper movable types and kept by Lin's in Houguan) in the title page.

2.4 Taiwan (Wu Long'a)

In the 12th year of Jiaqing (1807), the copper movable-type prints appeared in Taiwan. Back then, there was a Manchuria General Wu Long'a, surnamed Guwalgiya, and a native of the Yellow Banner. He was then the military commander of Taiwan town. He made copper types and printed books, just as Gong Xianzeng remarked in Volume 1, "*Documents of Yiyuan*": "in Taiwan Town, Wu Long'a engraved copper movable types. I have once seen his prints of '*Annotation to 'Dissemination of Imperial Decrees.*'" The calligraphy and illustration were exquisite. Yao Ying, a native of Anhui, during his tenure as an official in Taiwan in Emperor Daoguang's reign in the Qing Dynasty also saw the cooper type prints of Wu's, and he said: "Here in Taiwan, General Wu also cast the cooper types as used for 'The Essential Collections from the Wuying Hall,' also in Song Ti style. However, there were eight rows in each printing and that was not satisfactory to me.

Although books printed using cooper types in Qing Dynasty were not as numerous as those in the Ming Dynasty, printing centers were found in Beijing and Taiwan, aside from Jiangsu, Zhejiang, and Fujian. Thus, copperplate printing was popular in a wider scope. The large scale and exquisite engraving were far better than copperplate printing in the Ming Dynasty.

3. Tin Type (a Printing Worker Surnamed Deng in Foshan)

According to the records of the American Samuel Wells Williams, shortly after the Opium War, the Chinese people not only cast a large number of tin types, but also produced tin type prints. The town of Foshan in Guangdong Province was one of the four major towns in the Qing Dynasty, and its commerce and industry were developed, and gambling particularly prosperous. A printing worker surnamed Deng started casting tin types in the 30th year of Daoguang (1850) in order to print lottery and completed two pairs of movable types in May of the

same year, totaling more than 150,000 characters. He spent 10,000 silver dollars and completed three sets of movable types, amounting to over 200,000 characters in total. The movable types consisted of a set of flat characters, a set of slender large characters, and a set of slender small characters for annotation to the body of the text. While casting, Den first engraved the characters in small pieces of wood, ensuring all the strokes were clear, and printed the engraved character in ultra-fine clay. Next he poured the molten tin liquid into the clay mold and waited for it to cool and solidify. After that, he broke clay molds, removed the movable types, and trimmed them, so that they were all of the same height. The broken mud could be reused to make clay mold. It is said that this method is simpler and more economical than type casting using copper mold in the West. In order to save the metal material, tin types were only four fens (1 fen = 0.33 cm) tall, shorter than the foreign counterpart. At printing, he arranged the movable types in a smooth and sturdy rosewood type tray and secured the four sides to prevent them from moving while printing. Three sides of the tray had ridges, which were of the same height as the movable types. After printing, they became the margins of each page. Pure brass was used for the boundary lines, and 10 lines were contained on half a page. The page was divided in the center by the type area, just like separation of one folio into two pages in woodblock-printed book. When the manuscript was corrected, ink would be applied and printing shall begin, using a brush broom. Later, he almost spent 2 years to complete in the 2nd year of Xianfeng (1852) printing "*Comprehensive Studies in Literary and Documentary Sources,*" by Ma Duanlin, a historian of the Yuan Dynasty. The masterpiece consisted of 348 volumes, 19,348 pages, and 120 books. The font is large and pleasing to the eyes, the papers white and ink clear. This is the first tin movable-type printed copy in the history of printing in the world. He was ingenious in making models and casting types, and successful in typesetting and ink application. He also printed several other books, but the titles have been untraceable.

Woodblock printing was born in the seventh century AD in China, and movable type first invented in the eleventh century by the Chinese. The origins and development are worthy of our pride and commemoration. And the historical suspense also awaits further exploration. Over the 1,300 years, woodblock printing has always been the mainstream in printing and movable-type printing has always been of secondary importance. Movable-type printing again is mostly wooden type-based, and primarily out of private hands. Officially engraved types are relatively rare, including the copper type engraved by the internal affairs office in Emperor Kangxi's reign and wooden type made in Emperor Qianlong's reign, but they failed to become universal. Around the Opium War of the nineteenth century, Western lithography and letterpress printing technology entered China and phased out traditional Chinese printing technology. This phenomenon is also worthy of our careful reflection. With China's rise and its improved international status in the new century, approaches to improve and develop Chinese printing technology in today's environment of information technology and digitization will be our long-sought goal.

3 Lecture 3 The Invention of Gunpowder and Its Influence on the World

Zhaochun Wang

3.1 Invention of Gunpowder

Gunpowder is one of the four great inventions of China (i.e., gunpowder, compass, papermaking, and printing). Historical development has shown that the invention of gunpowder was not achieved by one person at one place in one moment, but by ancient Chinese medical scientists, pharmaceutical scientists (i.e., Materia Medica scientists), and alchemists on the basis of production practices and the accumulation of scientific experiments over about one thousand years in the third year of Xianzong (808 years). This gunpowder was a mixture of saltpeter (potassium nitrate, KNO_3), sulfur(S), and carbon (C) powders. Because it generated a lot of black smoke in combustion, it was called black gunpowder. Saltpeter and sulfur are the key raw materials for preparation of gunpowder, and without saltpeter discovery gunpowder would not have been invented. British historian Joseph Needham arrived at the conclusion that Arab and Western countries could not have invented gunpowder on the fact that they did not know of saltpeter in the late thirteenth century.[39] Engels gave full recognition to this great invention realized in ancient China in "Artilleryman": "Now it is almost universally recognized that gunpowder was invented and used to fire heavy objects toward a certain direction by a country in the east… In China, saltpeter and other pyrophoric agents were blended to make pyrotechnics at a very early period, for use in the military and grand ceremonies."[40]

3.1.1 Scientific Practices Related to Invention of Gunpowder by the Ancient Chinese Before the Tang Dynasties

Saltpeter is a key raw material for gunpowder preparation. From the end of the Spring and Autumn Period to the Tang Dynasty, in-depth recognition and research in the producing area distribution and drug and chemical properties of saltpeter and sulfur had been made, at least 1,200 to 1,500 years earlier than other countries and regions of the world. This is the fundamental reason for gunpowder to be invented in China.

---

[39] Cf. Joseph Needham, Lu Gwei-Djen. A New Perspective on Gunpowder and Firearms within the Realm of Chinese Culture [J]. Journal of Translations in The History of Science and Technology, 1982:2.

[40] Engels. Artilleryman, in Collected Works of K. Marx and F. Engels, Volume 14 [M]. [M]. Beijing: People's Publishing House, 1964:193.

1. Recognition of Producing Areas for Sulfur and Saltpeter

Before being exploited by artificial means, saltpeter follows a pattern of natural distribution and is mostly produced in places with conditions suitable for its generation. In ancient China, production in Gansu on the route of "Long Road" and Sichuan on the route of "Shu Road" was most prominent, to be followed by Qinghai, Shanxi, Hebei, Inner Mongolia, and other places. These origins were gradually learnt and documented by the ancient Chinese. "*Fan zi Ji Ran,*" a book from late Spring and Autumn Period (about the sixth century BC), once said that "消石出陇道" (niter is produced in Long Road) and "石流磺出汉中" (saltpeter and sulfur are produced in Hanzhong).[41] So far there are still different theories regarding the author and publication time of the book, for example, it is claimed that "*Fan Zi Ji Ran*" could have been the pseudo-work of someone from the Qin and Han Dynasties (BC 221–AD 220). Even if it is so, the fact that China already knew of the Long Road and Hanzhong as the origins of saltpeter (niter) and sulfur in the Qin and Han Dynasties at the latest. Long Road was a transportation network in the Qin Dynasty between Gansu and Sichuan, consisting of Yinping Road and Xixia Road in Gansu region and Jinniu Road, Sichuan Section of Yinping Road, and Chencang Road, Baoxie Road, Tangluo Road, Micang Road, etc. in Sichuan Region. Historian referred to it as Long–Shu Road. Classics touching on medicine and materia medica after the Han Dynasty eloquently proved that many places along the Long–Shu Road produced saltpeter.

Tao Hongjing (456–536), a physician of the Southern Liang Dynasty, clearly documented "Niter…is produced in Yizhou and Wudu."[42] in "*Records of Famous Doctors.*"

A team of 23 people led by Su Jing the pharmacologist of Tang Dyansty completed in the fourth year of Xianqing (659) the world's first officially compiled pharmacopoeia "*Newly Compiled Materia Medica.*" The pharmacopoeia listed Yizhou (in ancient times, Yizhou included present-today the majority of Sichuan, part of Yunnan, Guizhou, Shaanxi, Gansu, and Qinghai), Wudu (now part of Gansu), Xiqiang (now Qinghai Datong), and Wenshan County (now the Qiang Autonomous County in Beimao State) as origins of saltpeter.[43]

After the invention of gunpowder and its commission to military use, the study of this issue continued among scholars of the Song, Yuan and Ming Dynasties. "*Kai Bao Materia Medica*" written by Ma Zhi et al. in the Northern Song Dynasty, "*Miscellaneous Anecdotes in the Court and Among the Civilians since Jianyan Reign*" by Li Xinchuan in the Southern Song Dynasty, and "*Compendium of Materia Medica*" by Li Shizhen in the Ming Dynasty dealt in greater detail with

[41] Norther Song Li Fang, et al. The Imperial Readings of the Taiping Era, Volume 988. Medicine (5) Saltpeter, Volume 987, Medicine (4) Sulfur. Cited from "Dialog between Fan Zi and Ji Ran".

[42] Tao Hongjin. Records of Famous Doctors. In Li Shizhen, Compendium of Materia Medica, Volume 11, Stone saltpeter.

[43] Su Jing. New Materia Medica [M]. Shang Zhijun (collate). Hefei: Anhui Science and Technology Publishing House, 1981:94–97.

Fig. 31 Long road, Shu road, and distribution of some saltpeter origins

many origins for saltpeter. Plot on a diagram the saltpeter origins documented before the Ming Dynasty (Fig. 31), and we will have sufficient proof that the records by our ancestors of the saltpeter production are conclusive and credible.

From the Ming Dynasty to the present day, incidents of saltpeter production and application in Longxi and Wudu of the Longshu Region, Gaolanshan in Gansu, and Jiangyou City in Sichuan are seen not only in a lot of literatures, but also in the ruins of ancient saltpeter-mining sites discovered. Some of the sites also made exploration reports. The discovery of ancient saltpeter mine sites in Jiangyou has become a rare historical testimony.

Jiangyou is located in the crossroads of ancient Long and Shu Roads, and the necessary path to Chengdu from Gansu Province. Saltpeter mining in Jiangyou is documented in classics and regional annals after Qianlong years.

Volume 894 of "*Collected Statutes of the Great Qing*" in the 20th year of Qianlong (1755) reads: "There are nitrate mines in Jiangyou County, away from fields and properties, and exploitation is allowed." This record shows that the saltpeter used by the army of the Qing Dynasty in suppressing riots in Big and Small Jinchuan areas was mostly mined in Jiangyou.

"Zitong County Annals" (revised in the 45th year of Qianlong) reads: "Chaoyang Dong in Laojunshan, Jiangyou County produces saltpeter, which was exploited in the 20th year of Qianlong, carried out by Jiangyou City for its adjacency."

Long'an Fu Annals (revised in the 20th year of Daoguang) records, saltpeter were produced in Chaoyang Dong and Daxing Dong, and were annually submitted to Xiaohe Battalion (the barracks in Songpan Town, a Qing garrison town,Sichuan) for use.

The Songpan Wei and Yongning Wei (capital cities in present-day Songpan County and Xuyong County, Sichuan, respectively) set in the early Ming Dynasty

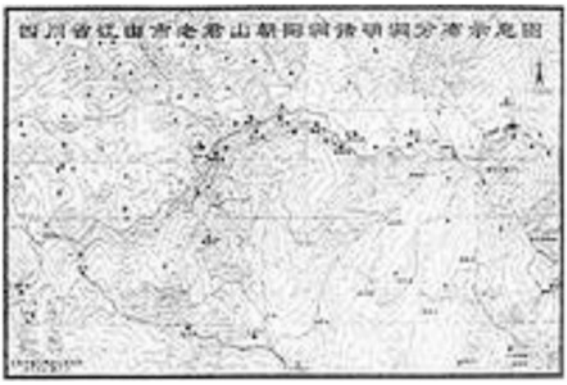


Fig. 32 Diagram of saltpeter cave distribution in Laojunshan Mountain, Jiangyou city

are not far from Jiangyou. And the gunpowder unearthed, which had been used for firearms manufactured by the military bureau of Yongning Wei in the 11th year of Hongwu (1378), is also related to saltpeter produced in saltpeter mines in Jiangyou.

Between 2003 and 2004, delegations of Cultural Heritage workers from Beijing and Mianyang City and Jiangyou City jointly launched investigations for research and found many ancient saltpeter mine sites in Laojunshan Mountain, Zhonghua Township, Jiangyou City, as well as firework crafts that had been circulated for many years. In 2005, the mountain has been approved by the State Administration of Cultural Heritage as a site of natural and cultural heritage under state protection. The above documentations and discovery of the ancient saltpeter-mining sites (as shown in Fig. 32) show that Jiangyou is probably one of the birthplaces of gunpowder in ancient China.

Compared with saltpeter, sulfur has a much broader distribution of origins. Hanzhong (now Shaanxi Nanzheng), the origin of sulfur mentioned in "*The Imperial Readings of the Taiping Era*" is located at the starting point on the northernmost section of Micang Road, a part of the ancient Shu Road. It stretched southward to bazhong (now bazhong County), Sichuan, and sat together with Jiangyou on the traffic network of Long-Shu Road. In addition to the Hanzhong region, Sulfur circulateis also found in many other places. In around the Western Han Dynasty, people found sulfur origins in Hunan, Shanxi, Henan, and other places. "*Huainanzi • Ben Jin Xun*" said, "sulfur appears and auspicious red grass grow." Zhang Heng, the writer and scientist of the Eastern Han Dynasty, also mentioned sulfur in the line "赭垩流黄" (red and white earth and sulfur) in "Ode to the Southern Capital." "*Record of Famous Doctors*" claimed that sulfur was produced in Taihang, Hexi, and Muniushan valleys in Donghai. "*Annotations of Materia Medica*" said that sulfur was produced in North Xuzhou (now Linyi region of Shandong), Jishan (now South Kaifeng, Henan), and Hunan and other places. "*Maps of Materia Medica*" mentioned that sulfur was produced in the remote regions in Nanhai, Guang Nan, Rongzhou (now Sichuan Rongxian and

Weiyuan), etc. "*The Book of Wei*" and Zhang Hua's "*Natural History*" said Bole, Yining, and East Urumqi in Xinjiang also produced sulfur.

2. Research in the Medical Properties of Saltpeter and Sulfur

According to the records of the "Records of the Grand Historian• Biography of Bianque and Duke of Taicang," Chunyu Yi (BC 215–BC140), Duke of Taicang in late Qin and early Han Dynasties said: King of Zichuan (now Shandong Linzi) summoned me for help because one of his concubines encountered difficult labor. I went there … and make the patient drink saltpeter decoction." As a result, the patient was instantly cured and delivered the child safely.

Among the silk book "52 prescriptions" unearthed in 1973 in a Han Tomb, Mawangdui, Changsha, there was a prescription of saltpeter: put (immerse) Xiao (saltpeter) in lukewarm water and sprinkle the water on carbuncles,"[44] indicating that saltpeter can be used to treat ulcers. According to investigation by experts, this prescription appeared during the Warring States, before the completion of "*The Yellow Emperor's Classic of Internal Medicine,*" and transcribed in late Qin and early Han Dynasty. This means that there were doctors using saltpeter as the medicine for treating carbuncle.

In November 1972, a number of medical bamboo slips dating back to the early Eastern Han Dynasty (AD 25–220) were found in Hantan, Wuwei, Gansu Province. Including a total of 92 pieces, the slips recorded more than 30 prescriptions on acupuncture, internal medicine, surgery, pediatrics, gynecology, and over 100 pharmaceuticals in the three categories of animal, plant, and mineral. And saltpeter was used as one of the 16 mineral drugs.[45]

In "*Shennong's Classic of Materia Medica*" the book completed in the Eastern Han Dynasty, 365 kinds of medicines were divided into three categories. In the book, saltpeter was listed as the sixth kinds of top-grade non-toxic drug, respected as the monarch drug responsible for supporting life. Sulfur was classified as the second one of less-toxic drugs and called the minister drug responsible for cultivation. Severely toxic drugs had the lowest ranking and called assistant and guide drugs. There are 125 of them in total, responsible for medical treatment.[46]

Physicians made inflated publicity of the treatment efficacy of prescriptions prepared with saltpeter, claiming that pills made of mercury through alchemy, "can make one young like a boy after 30 years if it were taken together with saltpeter"; and that Sodium Sulfate "dissolves 72 kinds of stones, and can make one

---

[44] Collation panel for silk books unearthed from Han Tombs at Ma Wangdui. Interpretation of Medical Books unearthed from Han Tombs at Ma Wangdu i(2) [J]. Cultural Relics, 1975 (9):36.

[45] Gansu Museum, et al. Brief of Excavation in Han Tombs in Hantan, Wuwei [J]. Cultural Relics: 1973 (12).

[46] The original book is missing, but its content was preserved in materia medica classics through secondary citations. It is generally believed that this book was completed in the Eastern Han Dynasty.

light like the immortals if processed via alchemy and taken," and that "refined saltpeter is like cream and long-term intake can make one light." Such publicity fit in exactly with the wishes of emperors who had been dreaming about longevity and dominating the earth eternally. So they advocated alchemy and became deranged. However, the years of alchemy failed to produce the miracle of immortality by taking elixir. Yet the experimental activities of alchemists were not entirely in vain—it is precisely because they discovered among alchemical disasters the blasting phenomena, which occurred in refining mixtures containing saltpeter and sulfur, and carbonaceous materials, that human beings were able to invent gunpowder.

3. Research in the Chemical Properties of Saltpeter and Sulfur

Thanks to this research, alchemists concluded that saltpeter, lead, mercury, etc. were yin drugs (drugs that were dull in color, inactive in property and not inflammable, and produced in the shaded side of mountains, along the water side and in cold regions) and that sulfur, orpiment, and realgar were yang drugs (red and yellow or green drugs that evaporated when exposed to fire, i.e., were easy to burn and evaporate and that were produced in places exposed to the sun) and invented gunpowder based on the theory of combination between yin and yang (i.e., take the essence of yin and yang for the feat of generation by heaven and earth, complemented by the force of water and fire). A lot of research experiments of this type have been documented.

Wei Boyang the alchemist of Eastern Han Dynasty (active in AD 147–167), recorded in "*Zhou Yi Can Tong Qi*" (The Kinship of the Three According to the Book of Changes) combination of sulfur and mercury to generate red mercury, thus starting involvement of chemical properties of sulfur in people's research. Since then, people found in many experiments that sulfur would start bouncing after catching fire, assuming a very active nature. It was also found in experiments that niter could interact with many substances, and flame phenomena could occur when saltpeter is sprinkled on charcoal. Therefore, alchemists often used saltpeter together with other substances in refining, so as to change and adjust the properties of certain drugs.

Saltpeter generated naturally fall into two categories: "true saltpeter" (i.e., potassium nitrate, also known as fire saltpeter or smoke saltpeter) and "Sodium Sulfate." Both were bitter in taste, white in color like frost and snow, similar to needles in shape, easily soluble in water, and very much alike in appearance. So no scientific method was found to tell the two apart in a very long time. Tao Hongjing (as shown in Fig. 33) is the first person to find this method. He said in "*Annotations of Materia Medica*" that bluish purple smoke rose from saltpeter set to the flame but not from Sodium Sulfate, thus clearly telling saltpeter from Sodium Sulfate, and creating the "flame color method" for identifying potassium nitrate, laying the foundation for refining pure saltpeter for the preparation of gunpowder. This method is still used in modern chemical experiments.

Fig. 33 Tao Hongjing

In the Tang Dynasty, further development of the research in the medical and chemical properties of saltpeter and sulfur drugs, development of alchemy and the developed social economy and science created the conditions for the invention of gunpowder.

3.1.2 Tang Dynasty at Its Peak Laid the Foundation for Invention of Gunpowder

The Tang Dynasty marked the heyday of the civilized society of ancient China. During the period, China became a country with the world's solidest economic basis and most developed science and culture. This situation created directly or indirectly, the conditions for the invention of gunpowder.

1. Solid Socioeconomic Foundation

1.1 Developed Irrigation and Water Conservancy

Waterwheels, cylinder wheel, and other waterwheel irrigation technologies were created, and 219 canals, levees, and ponds were constructed, improving irrigation efficiency. Jiangdong plow and iron plowshare were used to expand the area of reclaimed land, and the country's total households rose rapidly, exceeding the number of 12 million in the Western Han Dynasty.

1.2 Large-scale Handicraft

Governmental and private handicrafts were very impressive. Shaofu Jian, the governmental agency overseeing handicraft, had 19,850 handicraft artisans, and Jiangzuo Jian had 15,000 artisans.

1.3 Fine Division of Labor

In textile and dyeing industry, there were cloth, thin tough silk, damask, soft silk, soft and thin silk, satin and large carpet and blue, yellow, white, black, purple, and

other colors. In ceramics, there was the famous Tang San Cai (tri-color pottery). In metal smelting, there were 168 smelters of silver, copper, tin and iron, and cupellation technology was invented for refining silver.

1.4 Huge Capacity in Shipbuilding Industry

In the 18th year of Zhenguan (644AD) alone, 400 vessels of various types were built and watertight bulkhead technology was invented and the development of vehicle ferry construction technology improved the equipment of warships. Papermaking and other handicraft workshops were found across the country.

1.5 Developed Water and Land Transportation and Active Commerce

Major cities and municipalities in the country were entitled facilitate transportation. On land and seas, there were "Silk Roads" leading to West Asia, Arab, Europe, Africa, Southeast Asia, and neighboring countries from Chang'an, Wuwei, Dunhuang, etc.

All those have created conditions for the development of science and culture.

2. Developed Science and Culture

2.1 Development of Papermaking Technology and Promotion of Engraving Technology

In papermaking industry, world-famous rice paper was created. Promotion of woodblock printing expanded the exchanges of scientific and cultural achievements.

2.2 Astronomy, Calendar, and Arithmetic Obtained Fruitful Results

Improving the armillary sphere, Seng Yixing successfully measured the meridian data, determined Dayan Li the most accurate astronomical calendar of the time and found that the phenomenon of relative movement of satellites (1,000 years earlier than the discovery of Harley the British). Arithmetic colleges were established, and mathematical books like "*The Ten Mathematical Classics*" were compiled.

2.3 One Hundred Schools of Thought Blossomed in Cultural and Historical Works

The greatest achievement in literature was the poetry of the Tang Dynasty. In historical monographs, there were Liu Zhiji's "*General History,*" Du You's "*Classical Records,*" and a number of others. "Huiyao" style was created to in historiography. In geographical works, there were "*Records of the Western Regions in Great Tang*"

dictated by Xuanzang, as well as "*Encyclopedia of Local Annals*" and "*County Annals of Yuanhe Prefecture.*"

2.4 Developed Medical Science

The world's first officially compiled pharmacopoeia "*Newly Compiled Materia Medica*" was completed (the pharmacopoeia collected 844 drugs, made a detailed illustration of the origins, potency, taste, and efficacy of saltpeter and sulfur, and their properties for refining pills and application. It became a symbol of highly developed medical science and provided the basis for alchemists in refining precious medicines.), and medical and pharmaceutical writings, such as *Qian Jin Fang* (Prescriptions Worth a Thousand in Gold) by the famous doctor Sun Simiao and "*The Four Pharmacopoeias*" a Tibetan medicine classic, were published.

2.5 Alchemists of the Tang Dynasty Made Many Achievements in the Ancient Chemical Research

During the ancient chemical experiments (as shown in Fig. 34), they designed and created some chemical instruments and equipment applicable at their time, observed and found a lot of chemical changes, artificially made compounds non-existent in nature, and extracted many chemicals. They explained many phenomena discovered in the alchemy process. In refining "longevity drugs" using the cinnabar, artificial mercuric sulfide, lead and its compounds, lead powder, yellow lead, lithargyrum (lead oxide, PbO), arsenic and arsenic compounds, sulfur, orpiment, realgar, white arsenic and other inorganic materials, metals, and minerals, they sought vegetable "elixir," carried drug research, found many medicines for healing difficult and serious diseases (Famous representatives include Taiyi Shenjing Dan (As_2O_3), a treatment for malaria, Baijiang Medicine, a treatment for skin diseases, and a medicine effective in removing toxicants and pus. Medicines similar to the above drugs were not invented until the mid-nineteenth century in Europe.), and invented the use of

Fig. 34 An alchemist weighing materials

tin, mercury, and silver for making filler in tooth filling. They experimented with smelting of metals, such as copper and copper minerals, iron, and aluminum alloys, as well as other compounds. They made an in-depth research of the doctrine of "transformation and generation of the yin and yang and the five elements." All of these at that time were unique in the world. Therefore, it can be said that the ancient Chinese alchemy is the predecessor of the modern chemistry.

Alchemists of the Tang Dynasty invented gunpowder. They developed "Fuhuo Method" (processing by fire) based on inheritance from their predecessors. The purposes of "Fuhuo Method" are threefold: First, detoxication, that is, reduction of the inherent toxicity of certain drugs by baking in fire. Second, subdue the property of volatility in some drugs when they are exposed to fire; third, tame the explosive nature of drugs including more than one ingredients. In accordance with the third purpose, the alchemists of the Tang Dynasty added an appropriate amount of saltpeter, a yin drug, enhanced the intensity of processing by fire, and avoided alchemy disasters in processing the "four yellow drugs" (sulfur, realgar, orpiment, arsenic trisulfide). Fuhuo Methods related to invention of gunpowder include the following: First, "sulfur processing by fire" in "*Collected Theories on Making Precious medicines*"; second, "vitriol processing by fire" in "*Jiageng Treasure Collection of Lead and Mercury*"; third, "co-refining method for saltpeter, sulfur, realgar, and honey" in *Essentials of the Mysterious Way of the True Origin.*

Among them, Qingxuzi the Taoist disciple in Jinhuadong and the alchemist recorded in "*Secrets to Golden Pills from the Sagacious Ancestor*" completed in the third year of Yuanhe in the Tang Dynasty (later the book was included in Volume II of "*Jiageng Treasure Collection of Lead and Mercury*") that in "vitriol processing by fire," a yin drug, i.e., 2 liang saltpeter, a yang material, i.e., 2 liang sulfur, a carbon-containing substance, i.e., 3.5 liang aristolochic were mixed and refined repeatedly and resulted in an accident with burnt down houses, burnt hands, and faces (as shown in Fig. 35). The earliest gunpowder was invented precisely in such a co-refining process. The reaction process in co-refining accords with the modern chemical reaction in expression of the oxidation and reduction of the above substances (other similar formulation equations will not be dealt with here):

Fig. 35 Alchemist discovered explosion phenomena in refining mixture of saltpeter, sulfur, and charcoal

$$16KNO_3\ (\text{oxidant}) + 3S\ (\text{reducer}) + 21C\ (\text{reducer})$$
$$\rightarrow 5K_2CO_3 \downarrow + 2K_2S \downarrow + K_2SO_4 \downarrow + 13CO_2 \uparrow + 3CO \uparrow + 8N_2 \uparrow \text{reducer}$$

In 1825, the reaction equation proposed by (Xiefulieli) the British chemist was

$$2KNO_3 + S + 3C \rightarrow K_2S \downarrow + 3CO_2 \uparrow + N_2 \uparrow$$

Thus, the gunpowder invented by alchemists in the Tang Dynasty is completely consistent with the scientific truth and reflects the highest level of chemical tests back then.

Since alchemists had simple purposes in alchemy, the restricted experiments in refining immortality pills to prescription of drug materials paid close attention to the phenomena in the test process only without investigating the underlying mechanism. As a result, this important invention did not attract enough attention. Instead, alchemists earnestly warned people against experiments of co-refining saltpeter, sulfur, and charcoal since such tests might incur disasters. The invention of gunpowder was not put to use timely.

3.2 Significance of Gunpowder Invention

Gunpowder invention marked a second revolution following the recognition and use of fire by human beings.

3.2.1 Recognition and Use of Natural Fire by Human Beings Is the First Revolution

Recognition and use of natural fire by human beings ended "barbarian ages" of eating animal flesh raw and drinking its blood and ushered in the period of eating cooked food and disengaging from the animal kingdom. The fire first recognized and used by human beings was resultant from combustion in air of trees and firewood, coal grease, oil, and other carbonaceous materials abundant in nature. Gases such as CO and CO_2 generated in the combustion process slowly dispersed in the air. This slow combustion does not cause explosion, but produces heat and light (as shown in Fig. 36).

3.2.2 Recognition and Use of Fire from Gunpowder Explosion Is the Second Revolution

The oxygen required for combustion of gunpowder is released in the combustion of saltpeter. And gunpowder was thus called a combustion system with self-sufficient oxygen. Such a combustion releases in an instant a large amount of CO, CO_2, and N_2 and other high-temperature and high-pressure oxygen, and

Fig. 36 CO and CO_2 released in the slow combustion of natural fire

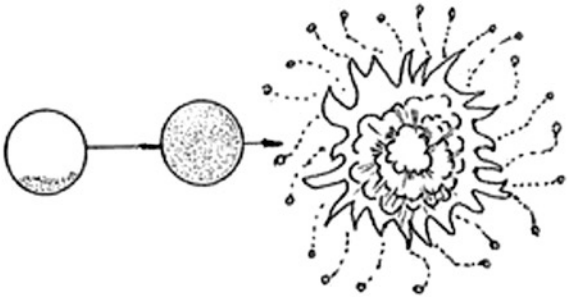


Fig. 37 Huge volumes of CO, CO_2 and N_2 released from gunpowder explosion

the volume is one thousand times larger than the substance used for combustion. It also produces a lot of light, heat, and shock wave; when the amount is large enough, powerful destructive and even lethal forces will be produced: the trees could be snapped, houses tumbled, and stone shattered. If the gunpowder is burned in a sealed container, the container will burst and violent explosion and loud sounds (as shown in Fig. 37) will occur. Utilization of chemical energy from gunpowder combustion brought about unprecedented upgrade and improvement of the human ability to conquer nature and survival conditions, marking a great fundamental contribution by the Chinese nation to the progress of human civilization.

3.2.3 Creation and Development of Firework Culture

In the early Northern Song Dynasty, firework artisans and army generals began to use gunpowder in the manufacture of fireworks and firearms.

1. Use in Manufacture of Fireworks

In late Northern Song Dynasty and early Southern Song Dynasty, Bianliang (now Kaifeng) the eastern capital set up a fireworks workshop, using improved

gunpowder to make firecrackers, pyrotechnics, Qilun, Zouxian, Liuxing, Shuibao, Dilaoshu, shelf fireworks, pyrotechnic barriers, and other products for holidays and festivals.[47] During the Lantern Festival, in the Royal Palace, the official residences and in the streets, lanterns, and festoons were put up everywhere, firecrackers and fireworks were set off, increasing the festive atmosphere. Since then, setting off firecrackers was handed down and became a custom. From the fourteenth century on, pyrotechnic technology has been widely popular in the neighboring and Southeast Asian countries. Today, the pyrotechnics are used by countries and regions all over the world for grand festivals and major events, and fireworks competitions are even held, creating a unique fireworks culture in the world today. Thus, fireworks are also a major contribution made by the Chinese nation.

2. Use in Firework Display

According to records in books such as "*The Dream of Hua in the Eastern Capital • Peking Opera Crafts,*" "*Anecdotes in the Capital • Various Stunts in Washe,*" "*Ancient Affairs of the Martial Arts Circle • Various Artists,*" "*Menglianglu • Chuye,*" there were firework theaters in Kaifeng in the Northern Song Dynasty, and pyrotechnic effects were used for staging "stories using smoke or of ghost, war, and legal cases" and similar shows. In some cases, even the recoil power of the gas generated by gunpowder was used for performing "Zhong Kui Catching Ghosts," "Eight Immortals Crossing the Sea," "Five Ghosts Mock the Judge," and other mythological programs involving images and actions. In addition, the shielding effect of fireworks was also used as objective view of the stage and shift in episodes, to increase the visual effects. Such technology is also widely used in today's movies, TV shows, and all kinds of drama.

3. Use in Military Sports Display

"*The Dream of Hua in the Eastern Capital • Enjoying Military Performance on Baojin Building*" made a more detailed description: after bayonet charge performance by soldiers in 5–7 teams, firecrackers are set off as the sign for changing the stage. After the first batch of firecrackers, huge volumes of smoke and fire rose, and players came onto the stage dressed like ghosts, with masks and unkempt hair and spitting wolf-tooth fire and smoke from their mouths (this fire results from lit rosins)… they went around the stage several times, and set fireworks on the spot. After the second batch, the music department comes into play, and performers staged a show bearing various arms, with faces painted, wearing masks with golden eyes, and decorated with leopard skin, silk, belts and the

[47] Song Zhoumi. Old Affairs of the Martial Grove. Volume 3 "New Year's Eve". Beijing: China Commercial Publishing House, 1982:51.

like. After the third batch, a player in cosplay of Zhong Kui appeared, dancing together with four others dressed as ghosts. After the fourth batch, pyrotechnics gushed out, shrouding the faces of the performers, and among the smoke and fire, seven tattooed people with disheveled hair could be seen fighting each other with real knifes. After the fifth batch, fireworks are set off, and players are dressed in masks and strange clothes, like statues of ghosts in the temple, and this is called a break from the battle. After the sixth batch, players dressed in various clothes came onto the stage, each gripping a boating knife, posing to grab the knife of others and stab. So there are dozens of paired performers, given ten-odd episodes of performance.

4. Use in Naval Drill

According to the description in "*Ancient Affairs of the Martial Arts Circle • Tide Watching,*" the navy of Zhejiang would take advantage of the moment when the tide of Qiantang Jiang River approached to carry out a parade every year. After parade is started, "Hundreds of warships arranged on both sides of the river exercise five arrays of battle, spreading out in one moment and gathering together in the other, speeding up in one instant and jumping into the air in the next. Presently, people on horseback can be seen waving banners and showing their skills with spears and knives. Suddenly yellow smoke sprang up, and people and things became invisible, with only the roar of the water burst to be heard, as if an alpine is collapsing. After a while the smoke clears and the water wave calms, no sign of the ships can be seen, except for the burnt remains of the enemy boats drifting along with the water flow. Hundreds of youngsters from Wu who are good at swimming appear with loose hair and tattoos. Holding ten banners, they struggle upstream, betraying a glimpse now and then amongst the towering waves. The tails of the banners are kept dry, to show their prowess."

3.2.4 Ushering in the Era of Combined Use of Firearms and Cold Weapons in the History of Warfare

After its foundation, the Northern Song Dynasty established a large-scale weapon-manufacturing workshop "Siege Preparation Workshop" for the purpose of unification war and the need for battles with the Western Xia, the Liao Dynasty in the north. The workshop consists of 21sub-workshops for manufacture of various weapons, and the "Gunpowder Sub-workshop" is specialized in manufacturing firearms.

In view of the combating provocations from countries in the North, Zhao Zhen, Emperor Renzong of the Song Dynasty (1010–1063) required civil officials and military ministers and officers and generals to get well versed in the military strategies of previous ages and the Song Dynasty, in order to outwit the opponent in military strategy, aside from proficiency in issues related to military technology, in

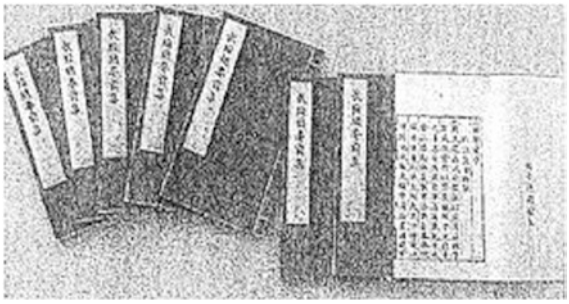


Fig. 38 "*Collection of the Most Important Military Techniques*" published in the Zhengde years of the Ming Dynasty

order to exceed their predecessors technically and tactically, for the purpose to outsmart the opponent, simultaneously "considering the situation" and "using skills." He also required that breakthroughs and innovations be achieved in weapon manufacturing, and the old situation be changed of military commanders "rarely knowing anything about history" and "ignorant of the military technology." He ordered Zeng Gongliang, the Literature Official of Tianzhangge Department, and Ding Du, the assistant minister of the Department of Construction, to compile "*Collection of the Most Important Military Techniques*" (as shown in Fig. 38). When the book was published in the 4th year of Qingli in the Northern Song Dynasty (1044), it completely recorded three formulas for preparing military gunpowder.[48]

1. Preparing the Three Earliest Gunpowder Formulas in the World

Gunpowder prescription for fireball: 14 liang Jinzhou sulfur, 7 liang wohuang (a sulfur), 2.5 catties yanxiao (a saltpeter), 1 liang maru (a carbonaceous material), 1 liang dry paint, 1 liang arsenic trisulfide, 1 liang solidifying powder, 1 liang zhuru (a carbonaceous material), 1 liang lead pills, 0.5 liang yellow wax, 1 fen vegetable oil, 0.5 liang tung oil, 14 liang turpentine, 1 fen thick oil … spin to make them well mixed, wrap the mixture up with five layers of paper, tie the wrap with a hemp string and cover it with additionally molten turpentine. Set if off as cannon.

Gunpowder prescription for caltrop fireball: 1 catty and 4 liang sulfur, 2.5 catties Yanxiao, 5 liang crude charcoal powder, 2.5 liang asphalt, 2.5 liang dry paint (mashed into powder); 1 liang 1 fen shredded zhuru and 1 liang 1 fen shredded maru; 2.5 liang tung oil and 2.5 liang xiaoyou (literally small oil), 2.5 liang wax melted for mixture with the above materials. (Materials used on the outside as wrapper) 12.5 liang paper, 10 liang hemp, 1 liang 1 fen lead pills, 0.5 catties ash,

[48] Northern Song. Zeng Gongliang, Ding Du, recorded in *Collection of the Most Important Military Techniques*, Book 1, Volume 12, *City* Defense Gunpowder, and City Defense Caltrop fire balls, and Volume 11, Fire Attack • Caltrop fire balls (2).

2.5 liang asphalt, 2.5 liang yellow wax to be molten and mixed with the rest materials before being coated on the paper.

Gunpowder prescription for Poisonous Smoke Ball weighing five catties: 15 liang sulfur, 5 liang aconitum, 1 catty 14 liang yanxiao, 5 liang patong beans, 5 liang radix euphorbiae lantu, 2.5 liang tung oil, 2.5 liang Xiaoyou, 5 liang charcoal dust, 2.5 liang asphalt, 2 liang arsenic, 1 liang yellow wax, 1 liang 1 fen zhuru, 1 liang 1 fen maru—mash the ingredients and make a ball, put a hemp rope of 1 zhang 2 chi through the ball, and use it for firing the ball. Materials used on the outside as wrapper include 12.5 liang paper, 10 liang bark, 2.5 liang asphalt, 2.5 liang yellow wax, 1 liang 1 fen lead pills, half a catty of charcoal dust—mix and mash the materials (for coating on the shell of the ball).

The above three military gunpowder formulas were prototypes determined by the military of the Song Dynasty trials and improvement and were distributed across the country as samples for preparation of military gunpowder. Compared with previous embryonic gunpowder used in experiments, the ratio between the saltpeter, sulfur, and charcoal was becoming reasonable and the proportion of saltpeter reached about 50 %. After being lighted, they were thrown to the enemy position with a bow (as shown in Fig. 39), a crossbow (as shown in Fig. 40), and

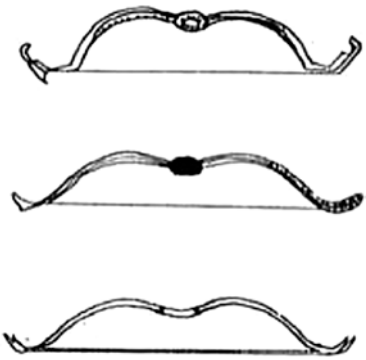


Fig. 39 Bow

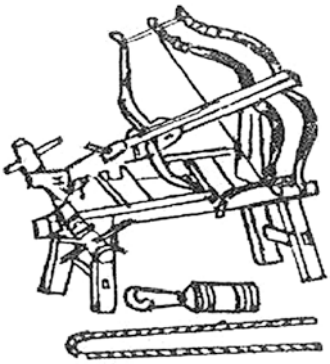


Fig. 40 Cross bow with three bows

Fig. 41 Single-barrel Cannon

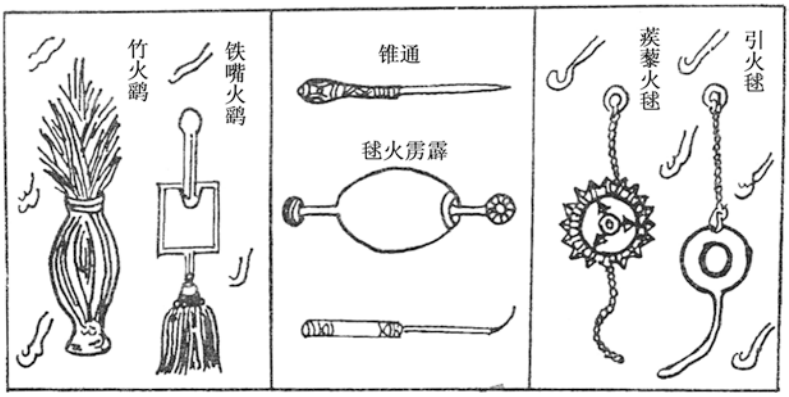


Fig. 42 Fireball made in the early Song Dynasty

trebuchets (as shown in Fig. 41), to produce lethal effects of combustion, explosion, blocking, confusion, poisoning, making military applications of gunpowder a reality. In the preparation process, there had been the transformation from rough processing to fine processing. In product quantity, there was the transformation from scattered production in small amounts to bulk manufacturing, thus creating the conditions for expanded manufacture of firearms and its military use, and opening new areas for improving the destructive and killing powers of weapons. Therefore, Needham said that, so far, "*Collection of the Most Important Military Techniques*" the world's most valuable data recording the first three gunpowder formulas for military purposes.

Based on the three gunpowder formulas, the Northern Song court made the world's first fireball (as shown in Fig. 42) and gunpowder arrows (as shown in Fig. 43) for use in war, ushering the era of concurrent firearms and cold weapons in the history of human warfare. Since then, display of human skills in war was

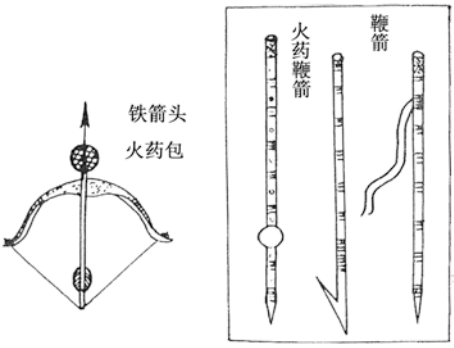


Fig. 43 Gunpowder *arrow* and gunpowder scourge *arrow* made in the early Song Dynasty

elevated to a new level. In the battle field of the glint and flash of cold steel, heavy smoke and loud explosions were added. It was not until the late fourteenth century when gunpowder as a Chinese invention had dominated the world for more than 400 years that Europeans began to realize this magic thing capable of explosion.

Soon after their creation, fireball and gunpowder arrows were used in Kaifeng Battle, Chenjia Island Water Battle between Song and Jin, creating the conditions for transformation in warfare mode.

3.2.5 Creating the Conditions for Subsequent Engineering Blasting

After the gunpowder invented by the Chinese was introduced to Europe, it witnessed improvements over three centuries and was used in engineering. In the beginning of the seventeenth century, the Europeans (another theory says it's the Hungarians) began use gunpowder for the exploitation of mines, replacing manual excavation with the drilling and blasting method, leading to the birth of blasting technology and marking a milestone in the development of mining technology. From the late nineteenth century to the twentieth century, mining explosives were invented, specifically for mining. Roughly in the same period, gunpowder was used in road construction, tunnel excavations, and blasting in other engineering projects.

3.2.6 It is an Irrefutable Fact that Gunpowder Has Been Invented by China

Some Western firearms history researchers proposed in their writings some "theories on gunpowder invention" that could not withstand scrutiny, for the purpose of shaking and denying the history of China inventing gunpowder. These theories have been negated by historical facts and overthrown by the research findings of firearms historians from many countries, but they still need further clarification, so as not to mislead the people.

1. Neither Greek Fire nor Sea Fire Is the Early Gunpowder

Some people say that the "Greek fire" is the predecessor of gunpowder, or it is the early gunpowder. These theories are unfounded.

"Greek fire," also known as "wildfire" and "burning agent," was initially trial manufactured by the Arabs and improved by the Greeks. Between the fifth century and the fourth century BC, it was used in battles, such as the Battle of Delium in 434 BC, the Battle of Rhode in 304 BC, etc. And subsequently, it was used in some countries for more than a thousand years and introduced to the East. Therefore, before invention of gunpowder, "Greek fire" is a major material for fire attack used on the battlefields of Europe. The "Greek fire" has various formulas but all are little known. In 350 BC, the Greece tactician Aeneas once wrote down a formula, including such ingredients as sulfur, pitch, turpentine, and other firelighters, and hemp shavings, and other combustible materials. Burning agent prepared according to this formula was once introduced to Arabian, India, and other countries. It is said that in 326 BC, the Indians had used such an incendiary agent to fight against the invasion of Alexander the Great (356 BC to 323 BC). From the eleventh to the twelfth century when European Crusades invaded Arab in the East, both sides in combat used fire attack appliances made of "Greek fire." However, the major ingredients of the early "Greek fire" are asphalt, honey, sulfur, mignonette, tallow, rosin, naphtha, powdered metal, etc., but not saltpeter.

The first person to call "Greek fire" gunpowder is Robert Valturiuss (1413–1482), who mentioned in his book "*12 Volumes on the Art of War*" in 1450, and the Byzantine emperor Leo VI (866–912) had in his reign ordered his soldiers to use a "fire-projecting equipment" to counterattack the enemy and called it gunpowder arrows. But at that point, Europeans still did not know what saltpeter was. So Valturiuss' theory is nothing but misinformation.

From the nineteenth to the twentieth century, there were still some Western scholars holding the view that Greek Fire was the early gunpowder, including French Oriental scholar Lanoux and artillery colonel Faver in 1845, the French chemical historian Erifee in 1866, the French Maciunas in 1952, the British Ellis in 1932. In the "*Soviet Military Encyclopedia*" completely published in 1980, there is an entry of "Greek Firing Agent" also said that the ingredients for "Greek Firing Agent" probably included saltpeter, sulfur, oil, resin, adding that the Greeks successfully used this firing agent in 673. However, they have forgotten that Fred Gorz, Soviet scholars and their predecessor had rejected this theory, and said: "Greek fire is not a mixture similar to gunpowder, because its ingredients do not include saltpeter, which was discovered by the Chinese."[49]

In addition, Joinville's book "*The History of St. Louis*" said that, it was not until the Seventh Eastward invasion of the European Crusaders (1248–1254) did the Arabs began to use "smoke and fire agent" containing saltpeter, by projecting

[49] [Soviet Union] H.A.Schillinger (ed.), Zheng Ting, et al. (tr.) Course on Gunpowder [M]. Institute of Military Engineering of PLA, 1956.

toward enemy position with long-tail feathered arrows, and that the power of this agent was much greater than the "Greek fire" without saltpeter. The arrows were like fire dragons crossing the air, lightning flitting across the sky, illuminating the night and changing into day, and the crusaders were finally repulsed. Since then, the European Crusaders also used "smoke and fire agent" containing saltpeter in its eighth eastward invasion of Arab (in 1270).

The Arabs and the Europeans did not use saltpeter until the mid-thirteenth century when they prepared the "smoke and fire agent." However, at that time, China had not only long used firearms in wars, but also developed the primary firearms to the stage of tubular shooting firearms. From this, we can see that "smoke and fire agent" containing saltpeter is not the first gunpowder.

Another foundation for Western scholars to take "Greek fire" as the early gunpowder is the "*Book for Fire Attack*" written by someone under the Greek name of Marco between the eighth and ninth century. The book listed some gunpowder formulas. However, research by scholars rejected this view. First, the so-called Greek Marco does not exist as a person, but a pseudonym name; second, the book is not written by one person at a specific time, but by some Arabs through successive additions; third, the book was written in the late thirteenth early fourteenth century, instead of between the eighth and ninth century. Therefore, we can see that the theory of "Greek fire" being the early gunpowder has lost its foothold.

Another burning agent similar to and often confused with "Greek fire" is sea fire, which first appeared between AD 670–AD 680. Thenophanes' "*Chronicle*" (811–815) records that in AD 673, the Syrian technician Kallinikos fled from Heliopolis, Silesia to Constantinople, the capital of the Byzantine empire, and provided the formula and preparation methods of the "sea fire." In AD 674, the Byzantine used "sea fire" in combat, and in 717 used it to attack the Arab fleet, saving Constantinople from the danger of fall. Due to the enormous power sea fire, its formula and preparation method were extremely confidential and known only to the leading figures of the Eastern Roman Empire that used it. It was a strictly guarded secret from other nations, especially the Arabs. Therefore, after the demise of the Eastern Roman Empire, the "sea fire" disappeared along with it.

"Sea fire" is different from "Greek fire." Fire attack devices made of sea fire are mainly used in naval battles to destroying enemy ships, hence the name. "Sea fire" in a battle emits flames from rainbow a fire-breathing pipe and produces a lot of smoke and a loud sound. The Europeans have tried to unlock the mystery of the "sea fire" formula. After several trials, they believe that its main ingredients including sulfur, asphalt and turpentine, but not saltpeter. So it is not the predecessor of gunpowder, or the early gunpowder.

2. India is not the Country that Invented Gunpowder

Someone once took "*Life of Apollononios of Tyana*" written by Flovius Philostratus (170–245) as the evidence to back the theory that India had in the fourth century BC used of gunpowder weapons. It is said in the biography that

in 326 BC, when the Macedonian king Alexander the Great invaded India in the East, he was met with the stubborn resistance of the local Indians between the Hyphasis River and the Ganges basin. It was reported that these Indians fired thunder-like monsters from the city wall to repel intruder's offensive. In addition there is another piece of record: When the Egyptians Hercules and Bacchus led forces to invade India, they also encountered resistance by the Indians in the same place. Legends have it that these Indians also projected a monster over the intruder's head, and the monster created flash of thunder and overwhelming storms, so the intruder was forced to retreat. Later, some people say that the stuff issuing lightning-like light and thunder-like roar was firearms and gunpowder. A lot of historical data have proven that this theory is untenable.

"*Indian History*" written by India historians Sinha and Banerjee documented Indians's resistance against the invasion from the Macedonian army: 326 BC, Alexander's army advanced toward Hyphasis, and annexed on the way some small principalities. Alexander had originally wanted to move on to the Ganges River, but the troops do not want to go eastward anymore, because the Ganges River was being ruled by Nanda King. The Nanda King had a fully prepared army, including 80,000 cavalries, 200,000 infantries, 8,000 chariots, and 6,000 war elephants, waiting to get engaged in war. None of the Macedonians dared to fight him in a battle. Be seen from the above description, the Indian army was mainly reliant on horses, war elephants, chariots, and spears, bows and arrows in combat and did not use firearms. "*World History*" published in the Soviet Union said in the narrative of the war that the assault forces used by the Indian armed forces in combat war elephants, not firearms.

In addition, the "*Manu Code*" also provides more convincing historical data. "*Manu Code,*" written between third century BC and the second century BC, is a compilation of the literature on ancient Indian religion, philosophy, and law. In it there is a provisions saying: "In fighting the enemy, do not use weapons that are not trustworthy or justifiable, use (or) toothed arrows, poisoned arrows, or arrows with red-hot tips to kill your enemies."[50] The provision shows that the arrows used by Indian army in combat were ones with serrated tips, which were coated with poison, fired red-hot and then shot, and there were no firearms based on gunpowder. Engels said in "*Artilleryman*": Greek writers Ellianus, Curtis, Filostrat, and Tamil Christie gave evidence, saying that the Indians seem to at the time of Alexander the Great have used some pyrotechnics in the military, which was by no means gunpowder.[51]

In 1441, the Indian ambassador Saluk said the Indian Army used war elephant-mounted soldiers to fire naphtha throwers toward Muslim soldiers between 1290 and 1300 in besieging Ranthambhore Fort, creating a large volume of

[50] Zhou Yiliang, Wu Yujin (ed.) Selected Historical Data The First Half [M]. Commercial Press, 1964:225.

[51] Engels. *Artilleryman*, in Collected Military Writings of Marx and Engels, Volume 1 [M]. Fighters' Publishing House, 1981:417-419.

sparks. After that, in 1398–1399 in the Batmil war the Indian Army used naphtha throwers to fight the enemy, raining arrows, stones and gunpowder among the invading enemy. Saluk thus believe that the Indian Army in the two combats had used firearms. Japan firearms history researcher Seiho Arima pointed out that naphtha throwers mentioned by Saluk were called Naghribiha in Hindi, meaning "Greek fire" from the west, rather than gunpowder. Seiho Arima concluded that before the invasion of the Portuguese in 1498, the Indians did not know the formula for gunpowder.[52]

The Indian firearms historian Godet also said that gunpowder and rocket were invented in China and spread to India after the fourteenth century, because Sanskrit or Persian manuscripts on firearms found in India were dated later than 1400. It is also said that the earliest firearms found in India were left in North India in 1222 by the Mongolian Army chasing Djelaled-Din, the king of Khwarezmia, instead of being manufactured by India.[53]

3. Roger Bacan is not the Inventor of Gunpowder

There is no exact record of the life of Roger Bacan in British history books, except for the data saying that he was active between 1214 and 1292, and was the inventor of the gunpowder. In 1914, the United Kingdom published his collection of essays. This book is divided into three parts, and the first part includes the letters that Bacan wrote in 1249 to the Bishop of Paris. In the part, Chapter 6, 9, 10, and 11 mentioned gunpowder, and Chapter 10 and 11 listed the gunpowder formula, which states the quantity ratio of saltpeter, sulfur and charcoal as 7:5:5, and the matching ratio as 41.2, 29.4, and 29.4 %. However, textual research by firearms historians has found the chapter harboring the formula flawed, including hypothesis, conjectures, additions, deletion, and revisions by subsequent generations, for example, at the beginning of Chapter 10 and 11, there were, respectively, the two sentences "Transactis annis Arabum Sexcentis et duobus" and "Annis Arabum 630 Transactis." Translated into English, the two sentences are "in 602 of the Arabia year" and "in 630 of the Arabia year." Here, the Arabian year means Muslim year. 602 in the Muslim Calendar is AD 1205 and 630 AD 1233. At this point, the Europeans had no idea of what saltpeter was. How could they say Bacan invented gunpowder? To say the least, even if the gunpowder formula in Bacan's papers was not a patchwork added by people after him. It was over 200 years later than the gunpowder formula published in "Collection of the Most Important Military Techniques." Therefore, the theory of Roger Bacon inventing gunpowder is sheer nonsense.

---

[52] [Japan] Seiho Arima. The Origin of Artillery and Its Dissemination [M]. Tokyo: Yoshikawa Kobunkan. 1962:4–5.

[53] [India] P.K. Gode: The history of firework in India between 1440 and 1900, p. 20.

4. Berthold Schwarz is the Fictional Gunpowder Inventor

Some European, especially German researchers of firearms history, believed that a German monk, Berthold Schwarz, is the inventor of gunpowder. However, there are different theories regarding various data concerning Berthold inventing gunpowder, including his last name, his nationality, his religion, the year, and location of the invention. The earliest German document mentioning him says that he was a Greek engaged in alchemy, rather than a monk. Later, there were theories saying that he was from Denmark, Prague, Cologne, Freiburg, Braunschweig, and Metz. In religious denomination, he was said by some to be a member of Franciscan faction of Christianity, and by others to be of the Dominique faction. No one can say for sure. When it comes to the year of his inventing gunpowder, there are a variety of claims, including 1,250, 1,313, 1,348, 1,354, 1,372, 1,380, and 1,393, with a difference as great as 143 years. German firearms history researcher G Kohler listed a lot of data in his book "*The Development of Military and Strategy in the Era of Knights*" published in 1886 to show that the so-called Schwarz was actually fictional and couldn't have been be considered the inventor of gunpowder. In 1909, the British scholar Clephen pointed out that Schwarz had been an imaginary character fabricated by the Germans, and the objective was to make their nation entitled to priority of invention of gunpowder and artillery. British gunpowder history researcher Partington said after comprehensive research of literatures that Schwarz was a purely legendary figure, fabricated to make people believe that gunpowder and artillery originated in Germany, and that the monument built in 1353 to commemorate his birth had no historical basis.[54] Later, memorial facilities for Schwarz built in the city of Ghent, Belgium, and Metz City, France, were eventually dismantled, due to the fact that he was purely fictional. Therefore, the so-called theory of Schwarz inventing gunpowder was also proved unfounded. In addition, there are some other theories on the invention of gunpowder and firearms, but none is worth refuting.

By recounting the process of China inventing gunpowder and spread of firearms beyond its borders in the Yuan Dynasty, as well as clarifying a variety of gunpowder invention theories, we have proven from both the positive and negative aspect that China is the world's first country to invent gunpowder and use firearms in battles and that it has made outstanding contributions to the widespread use of gunpowder and firearms in all countries around the world.

3.3 Westward Spread of Gunpowder and Its Influence on the Development of European Society

3.3.1 Westward Spread of Gunpowder

From the thirteenth century AD, the invented gunpowder and firearms in China began to spread westward to Arabia, and thereafter to European countries.

[54] J.R. Partington: A history of Greek fire and Gunpowder. p. 96.

1. Learning of Alchemical Technology and Saltpeter-Refining Technology by the Arabs

The Arab Empire was a multi-ethnic country sometimes called Black Tajik in Chinese history books. It created in the eighth to eleventh century extremely prosperous and diverse Arab culture, which includes inherent Arab culture, the culture of the conquered nations, India and Chinese culture, Greek and Roman culture. Medicine and alchemy were particularly well developed, as witnessed by "*Encyclopedia of Single-agent Medicines*" and other medical books. The Arabs used the four elements of air, earth, water, and fire to explain the evolution of all things, similar to the Chinese theory of the Five Elements generating everything. Many Arabs went to China for business and learning, including the Persian alchemist Li Xuan (another theory says it's a Persian chemist also known as Li Silang), who learned alchemy in Sichuan, China, in the middle of eighth century, and obtained remarkable results in refining medicine and herbs, becoming especially learned in the method for refining Prepared Salt created by Liu An, King of Huainan. Later, these alchemists introduced through trade channels, the herbs, the refined immortality pills, and alchemy into Arabia and called alchemy gold refining technology.

The Arab word for alchemy is similar to the Chinese term of 炼丹术. Arabic assigned al-kimiya for alchemy, in which kim was transliteration of the character "金" in the phrase "金液" mentioned in the Chinese alchemy book, "*Bao Pu Zi • Jin Dan Pian*," while the English term is alchemy. In English, the word chemy is derived from the word alchemy by abbreviating the article al. Therefore, we can say that there is a source-development relationship between alchemy in China and modern chemical science.

In the 1340s, China's saltpeter refining technology spread to Arabia, whose saltpeter refining process is similar to that of China. Arabs called the saltpeter and gunpowder coming from China "Barude," "Asian stone," and "Chinese snow."

2. Mongolians Spread Firearms to Arab and Europe in Their Thee Westward Expeditions

Between the 12th year of Jiading and the 1st year of Jingding in the Southern Song Dynasty (1219–1260), the Mongolians spread fireballs, gunpowder arrows, and other firearms to Arab and Europe in their three westward expeditions. The Europeans since learned this magical thing—Firearms. However, at that time, Europe was still in the dark period of the Middle Ages, and the science and technology was extremely backward, so it failed to conduct imitation. While the Arabs had had a considerably solid foundation after learning alchemy and saltpeter, refining technology introduced from China, soon learned the technology for manufacture of gunpowder and firearms, and started to imitate firearms to suit their own needs.

Fig. 44 Madfa

Fig. 45 Arabs using madfa in combat

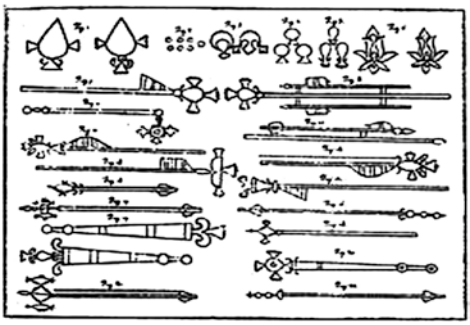


Fig. 46 Gunpowder *arrows* and muskets made by the Arabs

3. The Early Firearm Imitated by the Arabs in Late Thirteenth Century

Arabs did not use the firing agent containing saltpeter until the seventh eastward crusade by the European Crusaders between 1248 and 1254. Neither did them imitate madfa (as shown in Fig. 44), a wooden tubular shooting firearm until the end of the thirteenth century and use it in battles (as shown in Fig. 45). In addition, Arabs also manufactured rocket (as shown in Fig. 46), fireball (as shown in Fig. 47), and other firearms.

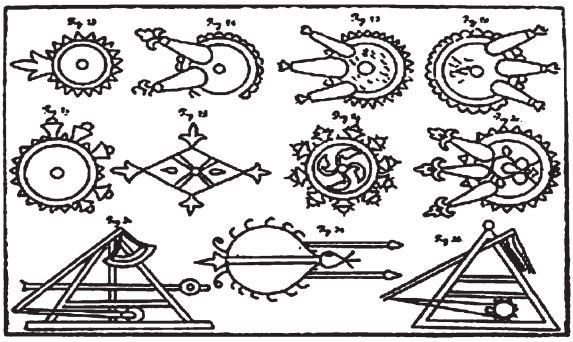


Fig. 47 Fireball and stone-projecting machine made by the Arabs

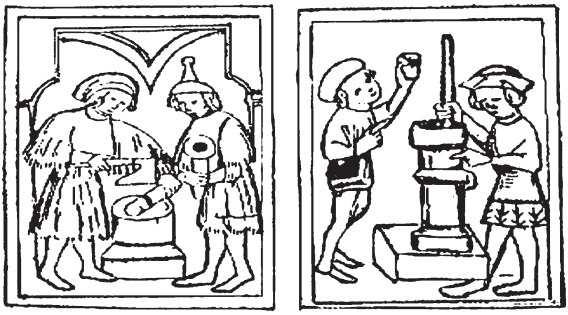


Fig. 48 Manual preparation of gunpowder by Germans in late fourteenth century

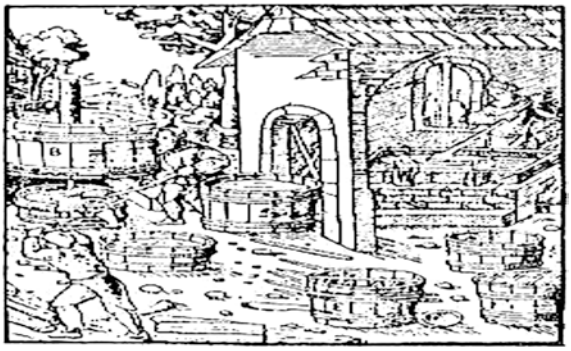


Fig. 49 Workshop for refining saltpeter and sulfur by Europeans in fifteenth century

4. The Arabs Spread Firearms to Spain in the Early Fourteenth Century

Arabs invaded Spain in 711 AD, established a caliphate in 929, and introduced from the eleventh-to-thirteenth-century Chinese silk, porcelain, paper, and printing to Spain. The Spaniards fought many wars to free themselves from the rule of the Arabs. They gradually learnt the firearms manufacturing technology from the Arabs during the wars, opened firearms manufacturing workshops, used manpower to pulverize saltpeter and sulfur for preparation of gunpowder (as shown in Fig. 48) and

Fig. 50 Handguns used by the British troops

Fig. 51 Use of Handguns in attacking a castle painted in Murals of Nili Church, Italy

to select and extract saltpeter and sulfur (as shown in Fig. 49), and successfully imitated the first firearms in the early fourteenth century. Subsequently firearms spread to France, Britain, Italy, Germany, Russia, and other countries.

Europeans imitated the first handguns (also known as fire valve guns), a metal tubular shooting firearm, in the late fourteenth century. According to records of documents in the British royal family, the British army in the mid-fourteenth century began use hand gun (as shown in Fig. 50). In murals in Nili church in Italy, scenes of soldiers holding handguns in combat during siege of a castle were painted (as shown in Fig. 51).

5. The Route of Chinese Gunpowder and Firearms Spreading West

Regarding the route of the gunpowder and firearms spreading from China to the west, the Europeans have many famous assertions.

J. von Romocki the German firearms history researcher said: “between 1225 and 1250, saltpeter first spread from China to Arabia, and then through Arab to

Europe. That is why the British scholar Roger • Bacan was aware of this salt in 1248." [55]

Engels said in "*Troops*": "France and other European countries learned the manufacture and use of gunpowder from Arabs in Spain, while the Arabs learnt it from the people of countries to the east of their country, and those people from the first inventor—Chinese people."

Engels said in "*Artilleryman*": "In the names of saltpeter given by Arabs, two of them mean 'Chinese salt' and 'Chinese Snow' … It seems that Arabs soon enriched the knowledge that got from the Chinese … and knowledge of artillery was passed by the Arabs to the Spaniard in the fourteenth century. The knowledge of artillery use spread from the Spaniards to other European countries."[56]

When the Chinese inventions of gunpowder and firearms were introduced to Europe in the fourteenth century, the Chinese inventions of printing, papermaking, and the compass were also successively brought to Europe through Arab. After their introduction to Europe, these inventions had a huge impact on the development of European society.

3.3.2 The Huge Impact of Gunpowder Introduction to the West on the Social Development in Europe

Over the past few centuries, many great men and celebrities in the world have made a variety of comments on this, and the following ones are the most representative:

Marx said: "Gunpowder, the compass, printing—are the three inventions marking the arrival of the bourgeois society (the original did not mention papermaking). Gunpowder blew the Knight class to atoms, the compass (introduced to Europe in the thirteenth century, making possible ocean voyage) opened the world market and established colonies, while the printing became a tool of the Protestant, and the general means for a scientific renaissance and the most powerful lever to create the necessary preconditions for spiritual development."[57] Engels claimed in "Anti-Dühring • violent Theory (continued)": "Firearms on the outset have been a weapon for emerging monarchy in or relying on cities to fight against the feudal aristocracy. What once have been unassailable stone walls of the castles for the nobility could not withstand the cannon of the public. The public's bullets pierced the armor of the knight, and aristocratic rule died together with aristocratic cavalry donned with armors."[58]

Called by Marx "the true ancestor of modern experimental science," the British materialist philosopher Francis Bacon (1560–1626) said in his famous "*Novum Organum*": "These three (printing, gunpowder and compass) have changed the whole

---

[55] S.J. Lomocki: Geschichte der Explosivestoffe, Bd.I, pp. 37–38 (Berlin, 1895).

[56] Collected Military Writings of Marx and Engels: Volume 1, 365–366.

[57] Collected Military Writings of Marx and Engels: Volume 1, 418–419.

[58] Karl Marx. Machine. Nature Force and the Application of Science (1861–1863). Economic and Philosophical Manuscripts [M]. Beijing: People's Publishing House.

aspect and state of things throughout the world—the first in literature, the second in warfare, the third in navigation - bringing about countless changes; so that there seems to have been no empire, no philosophical system, no star that has exerted greater power and influence in human affairs than these mechanical discoveries."[59]

In May 1982, Yabuuchi Kiyoshi, Honorary Professor of the University of Tokyo, Japan, spoke highly of the historical role of the four great inventions of China after they spread to the West: "The four great inventions of China, i.e., gunpowder, etc., spread to the West before the Renaissance in Europe. Without the introduction to the West of the four great inventions, the Renaissance in Europe would have been impossible. Without renaissance, modernization in Europe would have been impossible. The Europeans themselves admit this."

John Frederick Charles Fuller (1878–1966), the founder of the theory of mechanized warfare believed that the Chinese invention of gunpowder not only brought the Renaissance to life, but also bombarded and toppled the order of the European Middle Ages.

The above comments reflected the following connotations in a concentrated manner.

1. Announcing the Arrival of Capitalism and Starting the Renaissance

The budding capitalism became faintly visible from the fourteenth to fifteenth century in the famous cities of the Mediterranean coast, including Florence, Venice, and Genoa, and the early public culture began to emerge. The emerging urban bourgeoisie called for a campaign against the church and feudal culture in the ideological field to maintain its political and economic interests. It joined hands with farmers, used a new view of the world to overthrow theology, scholasticism, as well as fideism worldview and ushered in a cultural renaissance with "*The Divine Comedy*" published in 1307 by Dante Alighieri (1265–1321) as the prelude. Renaissance is the ideological reflection of transition in Western Europe from feudalism to capitalist society, creating public opinion for capitalism to establish its dominance. Embodied as humanism in scientific and cultural ideology, it nurtured the culture of the Western European bourgeois. At that time, the emerging bourgeoisie seized the opportunity and made use of the favorable situations, pushed the European society toward capitalism, by promoting the socioeconomic, scientific and technological and industrial changes with the assistance of the four great inventions, i.e., gunpowder, the compass, papermaking and printing, introduced from China. Therefore, Marx said that gunpowder, the compass, and printing were the three inventions foretelling the arrival of capitalism.

2. Bombarding and Toppling the Order of Middle Ages in Europe

In political and social revolutions, Italy as the origin of Renaissance did not become the vanguard. Until the sixteenth century, Italy was still a divided country with

[59] F. Bacon. Novum Organum. Tr. Guan Qitong [M]. Shanghai: Commercial Press, 1936:114.

multiple states. To make matters worse, it underwent invasions from France, Spain, and the Holy Roman Empire in 1494–1559. Therefore, the seeds of capitalism only germinated in a few cities, the south, west, and the vast rural areas were still closed in feudalism barriers. However, Portugal and Spain were different from Italy. In the late fifteenth century, the two countries have completed the process of political unification and centralization. They were also two early colonial countries that were supported by the cities and that were becoming increasingly powerful. So they established large fleets for oceanic voyage since the end of the fifteenth century. Guided by compass in navigation, the two countries became maritime hegemonies with matchlocks and cannons, launching overseas expansion and plundering some countries in Africa, Asia, and Latin America, for primitive accumulation of capital. On August 8, 1588, the British fleet defeated the Spanish Armada in the Battle of Gravelines with advanced naval guns and artillery tactics. Afterward, the British fleet controlled the Atlantic sea, consolidating Britain Europe's supremacy at sea. In 1600, the British began to equip all its troops with matchlock guns and sent the longbows which had been in use for a long time to the museum, making it the first country in Europe to enter the firearms era. In 1640, the revolution to establish the rule of the bourgeoisie broke out in Britain. On May 19, 1649 Britain declared it a Republic, tolling for the first time the encoffining of the feudal system and completing the transition from the feudal system to a capitalist society. The world takes this as the sign of the modern society. The success of the bourgeoisie revolution in Britain cleared the road for the development of capitalism and the earliest fruit harvested of social changes in the post-Renaissance era. On July 14, 1789, the people of Paris rose in rebellion, marking the beginning of the French Revolution. In July 1794, the French Revolution overthrew the feudal autocracy and established a capitalist system. Development of large-scale machine industry in the late eighteenth century consolidated the dominance of capitalism in Europe. Since the nineteenth century, the feudal king's crowns of the remainder European countries successively fell to the ground, noble knights wearing armor and aristocracy died together, and the bourgeoisie of the countries showed up singing tunes of victory, establishing within their territory the bourgeois state, and eventually completing the transition from feudal system to capitalism in European society. This is also what the founder of mechanized warfare theory Fuller had said: after its introduction to the West, the gunpowder invented by China bombarded and toppled the European medieval order.

3. Opening of New Routes and Early Colonial Expansion

In the late fifteenth and early sixteenth century, the early European colonial expanders modified the gunpowder and compass introduced from China and equipped them to large ships, making possible the ocean voyages, looting of colonial wealth and primitive accumulation of capital. After the completion of political unification and centralization in Portugal and Spain, the warlike aristocracy attempted to benefit from the voyage adventures and the authoritarian monarchy again took opening up of new routes as an important source of income. All this prompted the two countries'

businessmen and feudal kings to become the first colonists. Thus, Portugal and Spain became two of the earliest foreign countries to engage overseas plundering.

In 1487, King Joao II of Portugal sent the Portuguese Bartolomeu Dias (1450–1500) on a southward voyage along the west coast of Africa in 1487 with an expedition team, who finally reached the southernmost tip of Africa, "Storm Corner" (later renamed to Cape of Good Hope).

In July 1497, King Manuel I of Portugal sent the Portuguese Vasco Da Gama (1460–1524) on a voyage with 170 people. Setting off from Lisbon on November 22, the fleet passed the Cape of Good Hope, reached Mozambique, kilwa, Sofala, and other cities on the Eastern coast of Africa, and established commercial sites.

After the approval of the Spanish State Isabella I, in August 1492, the Italian Cristoforo Colombo (ca. 1451–1506, moved to Portugal and Spain successively) set off from Palos on the southwest coast of Spain, leading three ships spearheaded by the "Santa Maria" and 90 people and discovered Guanahani Island of the Bahamas on October 12 after over 30 days (another theory say over 70 days) of hard sailing, and Columbus renamed the island San Salvador. Then, the fleet discovered northeast coast of the island of Cuba, and later the Haitian Island. After that, it reached the Americas twice, but Columbus insisted that the place he reached was the edge of Asia. It was not until 1499–1504 when the Italian navigator Amerigo Vespucci (1454–1512) made several field trips to South America that people confirmed that what Columbus discovered was not Asia, but the New World–the Americas. And later America was used to name the new continent.

On September 20, 1519, the Portuguese navigator Fernao de Magalhaes (ca. 1480–1521), with support of Spanish King Carlos I (1500–1558, reigned 1516–1556), set off from San Luca (another theory say Sevilla), spain with 5 ships and 265 crew, traversed the Atlantic, entered the Pacific Ocean, and arrived in the Philippines in March 1521. On April 27, Magellan was killed by the local indigenous people. The remaining 18 people embarked the ship "Victoria" and returned to Spain on September 6, 1522.

The new routes opened up by the Portuguese and Spaniards changed the state of the world's continents and oceans being separated and isolated from one another, strengthened worldwide communication, and prepared the conditions for the formation of the world market. However, along with the opening up of new routes, there came the overseas colonial expansion of the Western European countries. This expansion is full of evil and soaked with blood. The matchlocks of Spain and Franks of Portugal were used to shoot and kill innocent people in many Latin American, Asian, and African countries. Matchlocks and Frank also spread to Asian and African countries among this bloody killing.

4. Trumpeting the Horns of Scientific Revolution and Promoting Industrial Revolution

In the field of natural science, the Copernicus' heliocentric theory of the Earth revolving around the sun blew the horn of scientific revolution, freeing natural science from the shackles of theology, and dealt a fatal blow to the banal preaching

of God creating the world. The great geographical discoveries made by Columbus and Magellan are an irrefutable proof of the correctness of round earth theory. The achievements of Galileo in astronomy and physics enabled a new understanding by human beings of the universe. In 1687, Newton's "*Mathematical Principles of Natural Philosophy*" forged the keys for industrial revolution. In the 1760s, the most developed capitalist country Britain ushered in Industrial Revolution. The invention and use of the steam engine in the 1880s made possible further development in the industrial sector. In the late 1830s, the industrial revolution in Britain was basically completed. In the end of the nineteenth century, the USA, France, Germany, Japan, and other countries also completed the Industrial Revolution successively.

The four great inventions of China was timely promoted and used in Europe. The ideological emancipation brought about by the Renaissance, the scientific and technological revolutions and the rapid development of the machinery industry made possible unprecedented improvement in the European military technology. Black powder evolved into smokeless powder. In the invention and manufacture of matchlock guns, flintlock guns, firing guns, Breech-loading rifled guns with firing pins, magazine guns, machine guns, layered guns, built-up guns, and other special guns, many scientific methods were created and used, again under the guidance of the accurate ballistic theory. Sailing ships were replaced by steam ships of large tonnage and high-speed navigation. Universal construction of modern fortresses made ancient castles merely historical monuments for travel and sightseeing. All these shows that modern military technology in Europe and the USA has been walking in the forefront of the world in the sixteenth to nineteenth century after learning the technologies from China for making and using gunpowder and firearms.

Just as Bacon had said, China's three (actually four) inventions have changed the face of the world and the state of things in the world. Nothing has brought about greater impact.

4 Lecture 4 The South-Pointing Needle and Compass

Nianzu Dai

The south-pointing needle, papermaking, printing, and gunpowder are collectively referred to as the four great inventions of ancient China. They had been highly praised by Francis Bacon (1561–1626) and Karl Marx (1818–1883). Marx called those technological inventions as the "necessary preconditions of bourgeois development."[60] The four great inventions have been universally recognized as the creation of the ancient Chinese people. Even though there are some different opinions in the international academic community, there is no conclusive evidence or historical fact to show that other ethnic groups or regions had made earlier inventions or discoveries.

Speaking of the south-pointing needle, the electrostatic and magneto-static knowledge mastered by ancient people will be involved. Due to space limitations,

[60] The Complete Works of Marx and Engels. Volume 30 [M]. Beijing: People's Publishing House, 1975:318.

we can only mention the part relevant to the compass. To learn more about the ancient Chinese people, you may refer to my book "*The History of Physics in China*" or "*A History of Static Electricity and Static Magnetism.*"

Correspondence between the South-Pointing Needle as a technical invention and magnetism knowledge

Level	Knowledge	Technological invention and its era
1	Magnetic polarity	Brawl chess game, the late warring states to the Han Dynasty
2	Magnetic polarity of pointing needle	Sinan (south-indicating ladle), the late warring states to the Han Dynasty
3	Declination	The south-pointing needle, compass, Tang Dynasty
4	The earth is a giant magnetic body	Terrella, 1600, W. Gilbert

4.1 Sinan (South-Indicating Ladle)

"Sinan is a magnetic direction pointer polished from natural magnets (Fe_3O_4). The compass cart in history is a mechanical pointer created by Ma Jun (dates of birth and death unknown) in the Three Kingdoms Period. In historical literature, especially the classics since the Wei and Jin Dynasties, mixed use of "司南" and "指南" results in today's objections and doubts in academia about related scientific knowledge and technological processes. Half a century ago, Museology scientist Wang Zhenduo (1913–1992) launched a comprehensive research of Sinan and the compass and laid the foundation of today's cognition of Sinan as a magnetic pointer (as shown in Fig. 52).

The earliest record of Sinan in writing is seen in *Hanfeizi Youdu*, a philosophical classic of the late Warring States Period

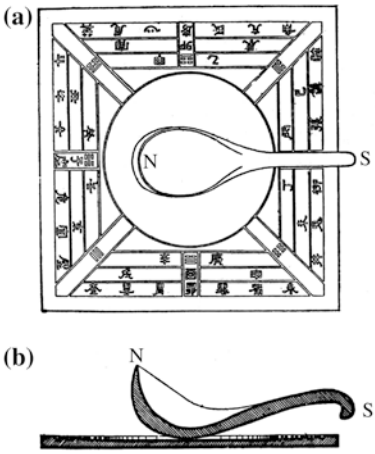


Fig. 52 Sinan restored by Wang Zhenduo **a***top view*; **b***side view*

> In infringing upon his king, a courtier has to get close from far off, much in the same way as one walks, so as to make the king lose his bearings. It would be dangerous for the king to remain ignorant of the change in directions. Therefore, the late older king set up a south-indicating instrument to make them right.

Here, the character "端" has two meanings: first, the "starting" and "front" of things, implying directions. The first "端" in the citations should be interpreted this way; second, "端" as a verb, meaning "to make right," as is the case in the second instance of the character. "朝夕" here was borrowed to mean the directions of "east and west." "端朝夕" means making right the directions of east and west. The citation says to the effect that: Traitors attempting to harm his king by change his governing ideas or guidelines always take actions step by step and bit by bit. In this way, they hope to make the monarch lose his directions and transform his route without knowing it. Therefore, the late older king created "Sinan" in order to help telling the east-west direction.

Is "Sinan" a political principle or utensil? It is not until the Eastern Han Dyansty that Wang Chong (27-ca. 97) described its shape and physical characteristics. He wrote "*Lun Heng • Shiyingpian*":

The grass Quyi may have been fabricated or actually in existence but with fabricated capability of pointing at people. If it can point at people, the reason might be that it can move at the sight of human beings. The ancients were simple in thought, and when they saw it moving, they believed that it could pointing at people, specifically, at the sycophants. When put on the ground, the ladle of Sinan points south. Worms feeding on rotten fish gather and crawl northward when they fell to the ground. That is the nature of such worms. When the grass can point at people, it is also the nature of such grass.

The whole text describes three "objects": grass named Quyi, ladle of Sinan, and worms feeding on rotten fish. The first is a plant, the last a small animal, and the intervening an ordinary object. They have the same nature of indicating directions. According to Wang Zhenduo's research: in the citation, "地" refers to the lower half of the Han Dynasty divination tool "Shi Pan," known as the "Earth Disc" (literally earth plate); "柢" originally referred to the root of the tree, and is used here to refer to the handle of the ladle. The Sinan is similar to the household object "ladle." When it is placed on the divination utensil "Earth Disc," its handle (柢) points to the south. Based on the records in "*Han Feizi*" and "*Lun Heng,*" Wang concludes that the utensil for indicating directions must have been a ladle-type pointing device made of lodestone and restores it as shown in Fig. 52. The original Sinan must have been created in the late Warring States period.

Inner beauty of the curved Sinan in Fig. 52 has been accepted and appreciated by the academia and has become a symbol of scientific and technological artifact of China in the media today.

However, there are individual different opinions: one believes that Sinan is the constellation of the Big Dipper; another believes that Sinan was an official position in the Western Zhou Dynasty. In fact, the former was subconsciously influenced by the similarity between the curved form of the restored Sinan and the shape of the Big Dipper constellation; as for the latter, no evidence has been found, and the Western Zhou Dynasty did not have the official post of "Sinan."

The crux of the matter still consists in science. The curved bar magnet, especially the inward bend of the dipper handle end, greatly weakened the polarity of Sinan as a magnet bar and weakened its induction intensity with the weak magnetic field.

Therefore, even magnetic dipper made of tungsten steel in a strong magnetic field would shortly become completely demagnetized and stop rotating. It is very simple to solve this problem. Wang Zhenduo painted in his masterpiece "*Sinan, the South-Pointing Needle, and Compass*" 14 species of dippers in the Han Dynasty. Among them, only one or two shaped like that shown in Fig. 52, while up to 11 have straight shanks (as shown in Fig. 53). In restoration of Sinan, a dipper with straight shank is used: the dipper has a handle with a sharp tip and the dipper body is not hollowed out (as shown in Fig. 54), such as a magnetic dipper is actually a bar magnet, in full compliance with the physical law "a bar magnet hanging free point to the north–south direction" (as shown in Fig. 55). A Sinan dipper placed on a smooth flat surface with minimal frictional resistance enjoys the same physical conditions as a bar magnet hanging free. To reduce the frictional resistance, the restored Sinan should not be too big (as shown in Fig. 56). The impression of Sinan dipper being rather like the big dipper of the kitchen should be changed.

Others question, why has not archeology found any such object? As for this question, firstly we have to ask our ancestors whether they had buried such objects together with their masters; and secondly, we have to ask modern archaeologists whether they had the awareness for Sinan in their excavations. As we all know, a lodestone scoop in the ground for over a thousand years is more easily prone to rust and peeling. Without the awareness of "Sinan," even if the handed touched it ten times, one could still not recognize it.

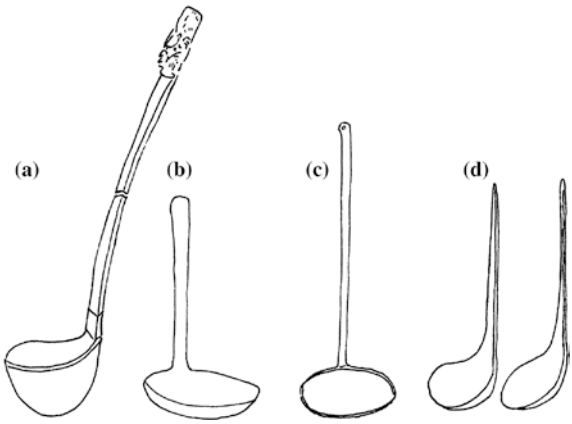


Fig. 53 Four straight shank ladles used in the Han Dynasty. **a** Jianyuan Dragon ladle; **b** Luoyang copper ladle; **c** Shibei ladle; **d** Gourd-bowled ladle

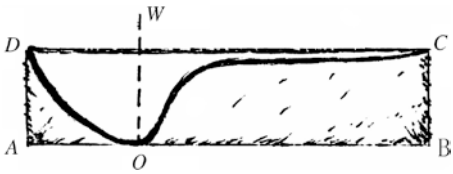


Fig. 54 Sketch of the restored Sinan ladle ABCD is a bar of natural magnet, WO is the center of gravity perpendicular to DOC

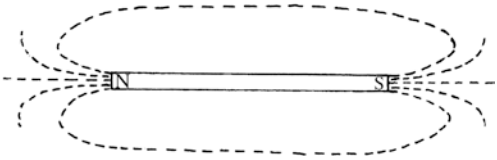


Fig. 55 Polarity and magnetic lineation of a bar magnet

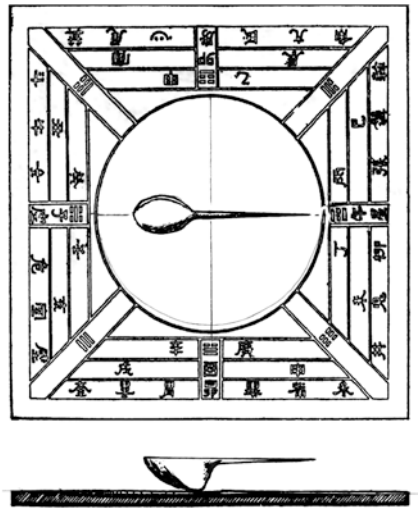


Fig. 56 Picture of the newly restored Sinan and "Earth Disc". **a***Top view*; **b***side view*

The present author believes that Sinan existed in history, and before the invention of the south-pointing needle in the Tang Dynasty, there must had been people "fiddling with" Sinan. In "*Ode to Mysterious Views,*" Xiao Yi, Emperor Yuandi of Liang (508–554) described his glory ancestors, expressed his reflections on affairs ancient and present, spoke of his own power and prestige and his enjoyment, and occasionally even thought about the Yuezhi Tribe rushed by the Huns to the remote areas in the northwest. This time he pinned his hopes on divination, saying "See the divination on Xun by the spiritual bird and observe the turning of Sinan to Li." In the verse, both "Xun" and "Li" are directions in the Eight Diagrams. In the Tang Dynasty, Weizhao (766–779 as Court Secretary) in its "*Ode to Gourd Ladle*" praised the elegance and simplicity of gourd ladles and compared them with the "Big Dipper" and "Sinan," writing "The gourd ladle is different from the Big Dipper Constellation in that it can be used to scoop wine, and from Sinan in applicability."

People also feared that the ancients might cause demagnetization due to beating in carving lodestones into Sinan and worried about whether they had had the appropriate processing tools. Just think about the jade articles (jade bird, jade turtle, jade fish, jade cong, jade hat, and ornaments) of 2500 BC unearthed in Liangzhu, Fanshan, Yuhang County, Zhejiang, as shown in Fig. 57), and these concerns can be dispelled. See the following Moh's hardness scale (as shown in Table 1).

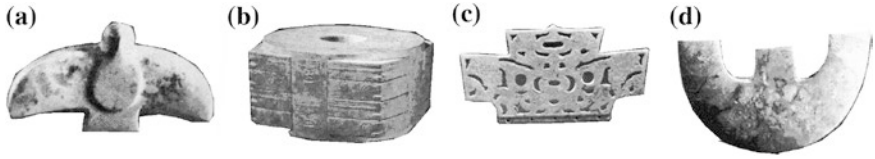


Fig. 57 Jade articles of Liangzhu, Fanshan jade bird, jade cong, jade ornaments, jade token

Table 1 Moh's hardness scale (relative value)

Material	Moh's hardness
Iron, natural lodestone	5–6
Steel	6–7
Jade (nephrite)	6.5
Corundum (emerald)	9
Diamond	10

Now that several thousand years before the Han Dynasty, people could process jade ornaments with complex patterns by using line cutting and other methods, why couldn't the people of Han Dynasty process lodestones which are much softer than jade? Slow and steady wins the race. Among the ancients, the must have been some who know that battering with hammer should be avoided in processing.

It is worth noting that a bar magnet dating back to about BC 1400–BC 1000 was unearthed in the Mexican city of San Lorenzo a few years before 1975. The American physicist Carlson (John B. Carlson) published an article in "*Science,*" saying that it had been over 1,000 years older than the Sinan discovered by the Chinese" (Science, Vol. 189, 1975, p. 753). So far, however, this discovery

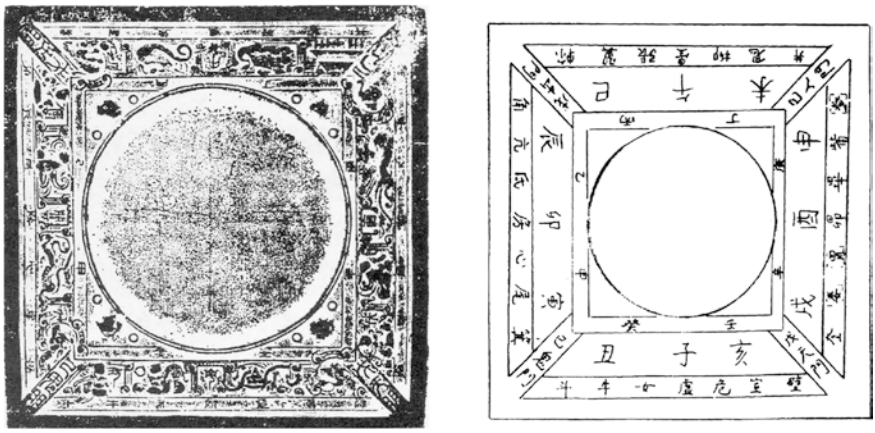


Fig. 58 Han Dynasty copper diviner's board found in the Qing Dynasty. **a** Overall effect diagram, **b** orientation sketch

remains uncorroborated evidence. Moreover, there is no textual or relevant legend in the Olmec Culture to prove it. Sinan from China is still the earliest magnetic pointer with written record by the human race.

Earth Disc (present-day azimuth card), on which the Sinan is placed, is part of "Shi Pan," a divination tool of the Han Dynasty. At the end of the Qing Dynasty, the Han Dynasty copper Shi Pan (as shown in Fig. 58) was also found. In the 1970s, Han Dynasty lacquered wooden diviner's board (as Fig. 59 shows) was unearthed in Mojuzi, Wuwei County, Gansu Province, and Ruyinhou's Tomb in Fuyang City, Anhui Province. The upper half of "Shi Pan" is called "the heavenly disc" in which the names of the 28 stars are inscribed; lower half is called "earth

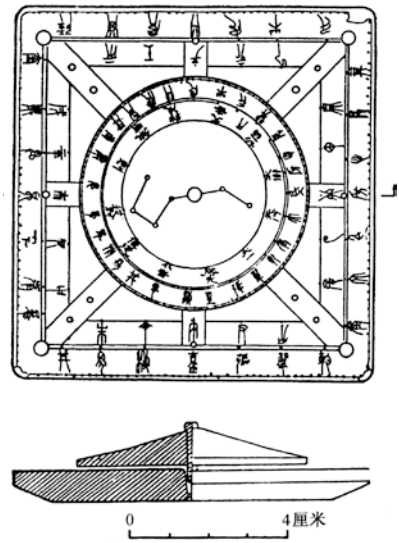


Fig. 59 Han Dynasty lacquered wooden diviner's board unearthed in Mojuzi, Wuwei

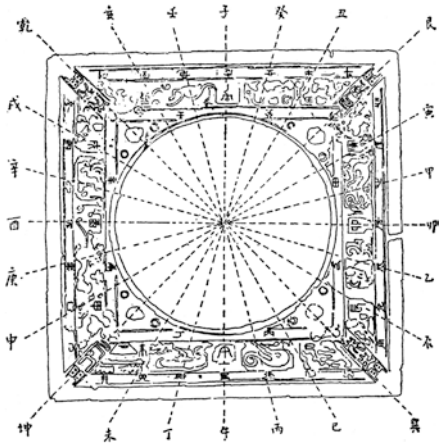


Fig. 60 The 24 directions on a Shi Pan

disc," including 24 directions. The heavenly disc is round; and the earth disc is square, denoting directions of east, south, west, north, etc., with some characters of the heavenly stems and earthly branches and eight diagrams. Among them, "子" (Zi) and "午" (Wu) denote due north and due south, respectively (as shown in Fig. 60). Interestingly, from the Ming and Qing Dynasties to the beginning of the twentieth century, Anhui was a rich land of compasses, which were referred to as the "Anhui Compasses." It is truly amazing for a local tradition to last so long!

4.2 The Sociocultural and Scientific Backgrounds for Appearance of Sinan

Appearance of Sinan in Qin and Han Dynasties is related to the social culture of that time: states merged and geographical concept expanded; a unified China and the germination of large geographic concepts; diversification of divination forms and divination tools; and academic contention of the philosophers.

Those schemas are known to the reader, but we are going to focus the scientific and knowledge background prompting the creation of Sinan.

From a technical point of view, mining and iron metallurgy technology witnessed considerable development between the Warring States Period and the Han Dynasty, leading to the emergence of a large number of magnetite ore. Some places were even named for its production of magnetite ore, for example Cizhou, Cixian, and Cishan. Magnetic stone was widely used in medical treatment (magnetic stone is one Materia Medica drug), construction (Qin Shi Huang built Epang Palace using magnetic stones as the material), alchemy (alchemists' belief in magnetic stones exceeds that of any other school of thought), and ceramic manufacturing (magnetic stone was used to remove iron impurities from the glaze compound). Some physical characteristics of the magnetic stones are documented in a variety of classics.

Initially, "磁铁石" (the Chinese for magnet stone) was written as " 慈石" ("*Guanzi • Dishu*"), as seen in "慈石召铁, 或引之地" (a magnetic stone attracts iron and can pull it up from the ground) (*Lü's Spring and Autumn Annals • JI Qiu Ji • Articles on Proficiency*), and "慈石为铁之母" (the magnetic stone is the mother of iron), thus it attracts iron. The three expressions of 慈, 石慈, and 磁 were used in accordance with change of the times. In the early Han Dynasty, the School of Liu An (BC 179–BC 122), King of Huainan, made much contribution to the magnetic studies and laid the foundation for ancient knowledge on magnetism.

Liu supported almost one thousand spongers in his mansion. Under the auspices of Liu An, they co-edited "*Huai Nanzi,*" "*Complete Craftsmanship of Huainan,*" and other books. In the books, various magnet experiments they did were recorded. They not only knew that the magnet attracts iron by nature, for example, they said "the magnetic stone attracts iron ("*Huainanzi Lan Min Xun*"), "the magnet stone flies upward" (*Huainanzi • Di Xing Xun*"). The latter refers to

the phenomenon of iron chunks pulling magnet fragments up from the ground, showing that magnetic interaction can occur at a spatial distance. They used rectangular magnets to make pawns and also clearly knew that bar magnets having different polarities, as seen from their remarks "magnetic stone pulls the pawns" and "magnetic stone repels the pawns." "Pull" suggests attraction, and "repel" "rejection." Although they did not describe the physical property "Magnets of the same polarity will repel each other, while those of different polarity will attract each other," they used "pull" and "repel" to vividly portray this property. Beyond that, they also made experiments of using a magnet to attract copper and pottery, clay, tiles, and stones, and concluded: "A magnetic stone can attract iron, but not copper" ("*Huainanzi • Shuo Shan Xun*"), and "using a magnetic stone to attract iron is easy, but using it to attract pottery is difficult indeed" ("*Huainanzi • Lan Min Xun*"). These words appear ordinary, but they are invaluable! They show the curiosity of King Huainan School in natural knowledge. Interpretation of those experimental results is possible only after the birth of the modern magnetism. This is the concept of magnetic permeability μ depicting the magnetism of substances in modern magnetism:

略大	Slightly larger
负值	Negative value
铁磁性物质	Ferromagnetic substances
顺磁性物质	Paramagnetic substances
弱磁性物质	Weakly magnetic substances
抗磁性物质	Diamagnetic substances
μ	Magnetic permeability

Copper is diamagnetic substance, and it is not attracted by magnets; tile, stone, and soil are weak magnetic substances, and it is hard for them to be attracted to magnets.

A fact not to be overlooked is that Liu An and his spongers found the pole-pointing property of bar magnets. "Pole-pointing property" refers to the phenomenon of magnet in free rotation pointing to the earth's north and south poles when it comes to a rest, because the Earth is a huge magnet. Liu An's findings not only provided or explained the scientific knowledge foundation for manufacturing Sinan, but also made complete the correspondence table between knowledge and technologies in the beginning of this chapter. "*Complete Craftsmanship in Huainan*" wrote: "hang a magnetic stone in the well (or "room"), and spirit of the missing will find his way home."

In the Han Dynasty, Gao You annotated: "Take clothing of the missing person, wrap a magnetic stone in it, and hang it in the house (or "well" or "room"), and the missing person shall return of his own accord.

The individual words within the brackets are different due to different versions of the saying. Both "亡人" and "亡者" refer to the missing person. When a person

is missing from home, a magnet is hung in the house so as to guide the missing person home safely. This is perhaps the belief of the Taoist art practitioners among Liu An's spongers. The key here is that only a bar magnet suspended-free can point the right direction, not a polygonal magnet of irregular shape as usually imagined. Wrap a long magnet in clothes and then suspended it in the air—this is a typical example of the ancient science donned in the coat of witchcraft. After the Han Dynasty, a large number of magnetic illusions (or magnetic games) were developed, and probably, they were of the same nature.

What is most surprising is that Liu An School discovered the earliest method for making a magnet in the history: "Take some chicken blood and iron filings. Mix them, and coat the mixture on the pawns. Put the pawns on the chess board, insert the iron stick in between and the paws repel or attract each other." ("*Complete Craftsmanship in Huainan*"). Gao You annotated: "take some chicken blood and iron needle filings, mix them to form a magnetic stone, coat the pawns with the mixture, and exposure the pawns to dry. Put the pawns on a chess set, and they repel or attract each other incessantly."

In these two citations, the "杂磨针铁杵" or "针磨" refers the filings resultant from honing steel needles. As the saying goes, "As long as one sets his mind to it, he can hone an iron stick into an iron needle." "Chicken blood" serves as the coagulant. The character "和" in "和磁石" should be pronounced as "huò," meaning "mix," as in "和灰浆" (preparing mortar) and "和药" (mixing medicines). When on keeps filing the needle tip in one direction, the filings will become magnetic naturally, due to the influence of geomagnetic field. Mix this powder with chicken blood to make a magnet, coating the mixture on both ends of the pawns, and the pawns becomes magnetic. So they would repel or attract each other on the chessboard. In the original text, "抵" means "attract mutually" and "击" means "repel mutually."

Making pawns of magnet or making artificially magnetic pawns was once popular in the early days of the Han Dynasty. Compositions set with such pawns are called "Brawling Chess Games." The outcomes of "Brawling Chess Games" are dependent on the magnetic strength of pawns. Those with stronger magnetic strength can pull the pawns of the other side over or push them away and thus lead to victory. Emperor Wudi of the Han Dynasty had on several occasions called the alchemist Luan Da to the palace, to perform "Brawling Chess Games." Liu An, King of Huainan, was the grandson of Emperor Gaozu in the Han Dynasty and uncle of Emperor Wudi of Han. Since he was "good at debate and diction," Emperor Wu "held him in high respect" and "would discuss with him the gains and losses in chess games and make odes on them until dusk." ("*Biography of King of Han Huainan*"). He probably had told Emperor Wudi the artificial magnetic pawns, and "Brawling Chess Games." From Han Feizi to Liu An and Wang Chong, the Chinese created Sinan and were aware of the polarity in long bar magnets, building the complete knowledge of magnetism of a whole era. Since then, another major development of magnetism was to be obtained in the Tang and Song Dynasties, with the advent of a large number of geomancers.

4.3 The South-Pointing Needle

Magnetization of ordinary needles is a contribution of herbalists. Further, the use of magnetized needles as direction indicators and naming them the south-pointing needle is the joint masterpiece of Taoists and geomancer. In turn, the geomancers improved and developed orientation disk, making the compass sophisticated.

Magnet is a Chinese medicine for soothing the nerves and refreshing the mind, and its property has been recognized early by the Materia Medica specialists. The method for telling their quality is by observing the amount of needles that it can attract. Tao Hongjing (456–536) of Xiao's Liang Dynasty said in "*Record of Famous Doctors*": "good magnets can attract needles when hung up, and those capable of attracting three or four (needles) to form a line are better." In the Liang Dynasty or early Sui Dynasty, the Taoist Su Yuan Lang also said in "*Records from the Stone Wall of Great Clarity*": "magnets capable of attracting five or six needles in one continuous line are good; the more needles attracted, the better their quality." In the Tang Dynasty, Su Gong pointed out in "*Annotation to Materia Medica of Tang Dynasty,*" "When first carved, good magnets can link ten needles."

This method of appraising magnet leads to the discovery of ordinary needle magnetization through magnetic induction. And the subsequent discovery of the needle pointing directions is a matter of course in the history of science. According to present-day discovery, the earliest person to describe the south-pointing needle is Duan Chengshi in the late Tang Dynasty (803–863). Duan Chengshi once assumed the official posts of Collator of the Secretary Department and Vice Minister of the Ancestral Temple. In the 3rd year of Huichang (843), Duan invited several colleagues and Taoist "Sheng Shang Ren" (the exalted) to tour the temples in Changan. At the height of fun, they started a game of composing a poem together with each one contributing one line alternatively, and Sheng Shang Ren wrote "勇带磁针石, 危防丘井藤" (I have brought a needle and magnet stone, in case we get lost somehow), while Duan Chengshi submitted "有松堪系马, 遇钵更投针" (there are pines for tying horses, and iron bowls for casting needles.) ("*Miscellaneous Morsels of Youyang*" Volume 5 "*Record of Temples and Pagodas*"). Obviously, they have brought with them a magnet, a needle, and tried to put the needle in the bowl used by monks to hold water so as to observe the direction. This is the earliest record of water-floating compass.

About 200 years after Duan Chengshi, i.e., in the 1040s, like the explosion of knowledge, the south-pointing needle, more precisely, the compass, was almost simultaneously recorded in the following three books:

1. Annotation of "*Guan's Introduction to Geography*" by Wang Ji. The book was a collection of geomancy writings in the Tang and Song Dynasties. Wang Ji (ca. 988–1058) the annotator was styled Zhaoqing. He annotated the book from about 1030–1040, leaving a poem "*Interpretation of Needle Directions*":

Clearly, the needle points at somewhere between Xu and Wei, and its direction to the south is slightly tilted;

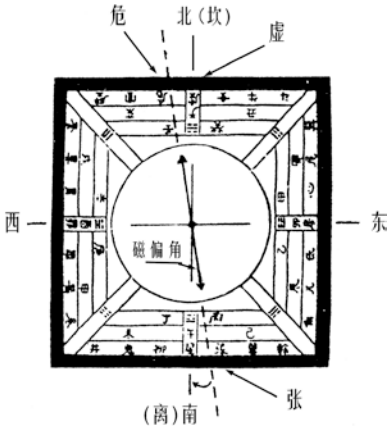


Fig. 61 Graphic expression of a compass and declination (the board is a Shi Pan of Han Dynasty)

If one cannot recognize the deviation from Kan and Li, the minute difference might make the needle useless.

In the poem, "虚," "危," "坎," "离," and "张" are directions on the compass referring to the due north, north by west, due north, due south, south by east (as shown in Fig. 61), respectively. In the poem, there is another direction "南" (south). The poem clearly point out that the two ends of the south-pointing needle, one indicates a direction between "虚" and "危," i.e., north by west, and the other "南方张度," i.e., south by east. The angle between the needle direction and the geographic north–south direction is called magnetic declination. The magnetic declination varies with the location and the specific year. From Fig. 60 we can see that the declination described in "*Interpretation of Needle Directions*" is about 7.5° (where Bianjing, the capital of Northern Song States was located). The box and needle and the magnetic declination are expressed in the same poem.

Wang Ji was a geomancer with widespread fame in Fujian and Jiangxi. His father Wang Xiyuan (961–1081) and grandfather Wang Chune (915–982) were both recorded in "*The History of Song*" as proficient with ephemeris and astrology. Wang Ji's geomancy skills have been a family tradition.

2. "*Total Record of Graves,*" a book on appraisal of tombs, completed by Yang Weide in the Northern Song Dynasty. The book was completed in the 1st year of Qingli (1041) during reign of Emperor Renzong. The book wrote in Volume I "Mountains":

In choosing the site, it is best to follow the four directions without deviation. The method: Take the Bingwu direction according to the compass needle. And then take the other directions by drawing a vertical line through it. The direction between Bingwu and Renzi is along the central line of the earth, and ensure the directions of due south and due north. However, the direction between Bingwu and Renzi is only approximate. If you need more precise data, you might as well use a compass and dangle a rope…

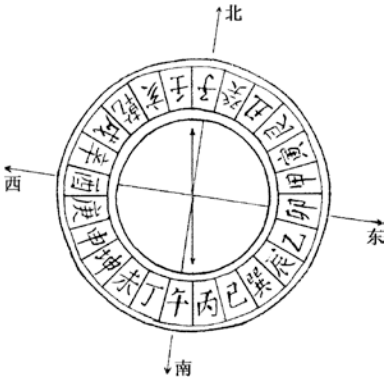


Fig. 62 Bingwu direction on the compass

The character "的" cited in the first sentence refers to the target, and "四正" to the four directions, i.e., east, west, south and north. "当取丙午针" refers the direction indicated by the compass needle (as shown in Fig. 62). Yang Weide knew that the north and south (magnetic north and south poles) are not completely consistent with the geographic north and south. So "约而大概"—only approximate bearings are taken. To obtain the geographic due north and due south, Gui, Gao and other instruments should be used to judge the direction by exposing to sunlight and make calculations based on the shadows. The whole text shows that Yang Weide was familiar with the compass and magnetic declination. The so-called "Bingwu" and "Direction between Bingwu and Renzi" also shows that the magnetic declination of Jingdu in the Northern Song Dynasty was about 7.5°.

Yang Weide, an important astronomer in the Song Dynasty, was the assistant to Han Xianfu (940–1013) in making copper armillary sphere. He was first made "Almanac Secretary" and then "Astronomical Secretary." He became known in the first year of Jingyou (1034) for formulating the table of stars and joined Yan Su (961–1040), an astronomical mechanic in inspecting the Lotus Glass. He was also one of the discoverers and faithful observer and recorder of the 1054 supernova which is world-famous today. He is a naturalist who wrote books on "fate prediction and symbols." In his old age, he used yin and yang theory in geomancy and wrote the book "Total Record of Graves." "茔" is the graveyard.

3. Zeng Gongliang, the Military strategist of the Northern Song Dynasty (999–1078), wrote "*Collection of the Most Important Military Techniques*" (completed between 1040 and 1044). The aforementioned Taoists and geomancers used the magnetic induction method to manufacture the south-pointing needles, while Zeng Gongliang discovered another method, which can be expressed in modern scientific language as: via transformation of magnetic domain from disorder to order in the process of cooling red-hot steel. He wrote:

Method for making the Guide Fish: cut a thin iron leaf into a fish shape, two Cun's in length and two fen's in width, and with a sharp head and tail. Fire it with charcoal, wait until it is red throughout. Pincer it out of the fire, adjust the tail to face

north, dip it in water basin, until several fen's of the tail is submerged. Store the Fish in an airtight container. In use, set a water bowl in a windless place, lay the fish flat so that it floats on the water. And the head of the fish constantly points south. ("*Collection of the Most Important Military Techniques*: Part I" Volume 15).

This approach needs some interpretation from the perspective of modern magnetism: carve out a fish-shaped steel piece, i.e., a common strip of sheet iron with sharp tips at both ends. Expose it to a high temperature of about 700 °C (this temperature is called the Curie point where the magnetic domain of the magnet reaches a state of confusion), so that the magnetic order is completely disrupted. Then adjust the steel piece so that it follows the geomagnetic field direction (tail facing the Zi position, i.e., north and south) and dip it in water, waiting it to cooling. After that, the magnetic domain of the steel gets reordered, thus generating magnetism. The Fishtail facing the North becomes the southern pole and the head facing south becomes the north pole. Therefore, the fish-shaped south-pointing needle "always points to the south with its head." The description of "Points to the south," instead of "due south," shows the presence of the magnetic declination.

Seen from the above, we can know that people had discovered two methods for magnetizing steel. Compass and magnetic declination were also recognized by them.

Later, Shen Kuo summarized in "*Brush Talks From Dream Brook*" and "*Supplement toBrush Talks From Dream Brook*" prior knowledge about the south-pointing needle and magnetic declination. He said: "After polishing a needle with a magnetic stone, specialists can make the needle point to the south. However, the needle often deviates slightly to the east, instead of point due south." "Among needles in my collection, there are some pointing to the south as well as some pointing to the north." "Polish a needle with a magnetic stone, the tip often points to the south, and sometimes to the north." Shen Kuo also proposed various methods for installing the compass. In addition to water floating, he especially dealt with thread suspension method (as shown in Fig. 63), that is, hanging the magnetic needle up with silk thread. In 1777, the French scientist C.A. de Coulomb (1736–1806) used this method to design a marine compass and was awarded first prize by the French Academy of Science. Coulomb balance invented by him also used Shen Kuo's method.

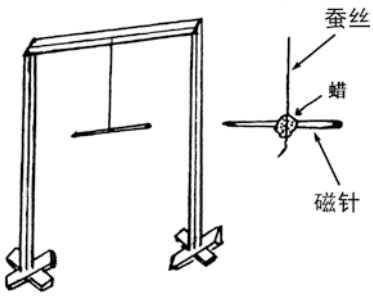


Fig. 63 Thread suspension method of Shen Kuo

As for water-floating south-pointing needle, so long as there is no wind and the needle is carefully put onto water, a copper needle or iron plate could stay afloat on the water for some time, due to surface tension of water. However, the ancients "pierced the needle through a wick (grass) to make it float on water" (Kou Zongshi "*Augmented Materia Medica,*" Volume 5 "*Magnet*"). Water compass is often used this way.

The compass and the south-pointing needle are repeatedly seen in literatures since the Song Dynasty. So is the use of the compass and needle in nautical navigation. Since the third year of Huichang (843), when Duan Chengshi documented the compass, to the time when Shen Kuo completed his book "*Brush Talks From Dream Brook*" (in about 1090), the compass and the box and needle had witnessed great development.

4.4 Compass and Geomancy

The board of the compass is undoubtedly from the earth plate of the earliest Shi Pan. The Fig. 64 shows an earth plate in "*The Residential Classic of the Yellow Emperor,*" a book completed in the Sui and Tang Dynasties. Previously cited Fig. 61 is based on an imitation of Han Dynasty Shi Pan. In the middle, there is a square or circular smooth plane, and the needle placed on this surface will rotate freely due to the influence of the geomagnetic field and become stationary in the north–south direction. This is the onset of drought compass. If a pool (geomancers call it "Heavenly Pool") is mounted to accept the needle, the device becomes a water compass. The square compass makes inconvenient observation, so they are reshaped round. In the early Song Dynasty, Xu Dong (980–1011) started writing the book "*The Classic of the Tiger Seal,*" completed it in the first year of Jingde (Jiachen year, 1004) during the reign of Emperor Zhenzong, and presented it as tribute to the court in the second year of Jingde (1005). In Chapter "*Bird Divination,*" two kinds of direction-guiding plates are painted (as shown in Fig. 65), of which the twelve-direction azimuth circular board is used in transition from square compass to round compass. Transition from square to round also marked a revolution in the history of instrument. Xu Dong pointed out in "*Preface to the Classic of the Tiger Seal*" that the book, "either reflects my own opinions or describes those of the ancients," "Six Ren, Dun Jia, stars the sun and the moon, winds and clouds and the climate, wind angle and birds, although they are not close to world affairs, I dared not leaving any one out." Those two forms of compass must have been made by people before Xu Dong.

Once a geomancer holds a compass, his belief must be included in it. In "*Green Satchel and Cape Classic by Xuan Nü of the Ninth Heaven,*" a book written in the Song Dynasty by pooling writings on geomancy, there is a water compass (as shown in Fig. 66) called "floating needle Indicating Directions": in the center, there is Tianchi for placing the needle; the second and third tiers are the twelve azimuth circles (also called twelve directions); the fourth and fifth tiers are the twenty-four directions. Yang Yunsong (also known as Yang Jiupin), a geomancer of the Tang

Fig. 64 The earth plate drawn in "*The residential classic of the yellow emperor*"

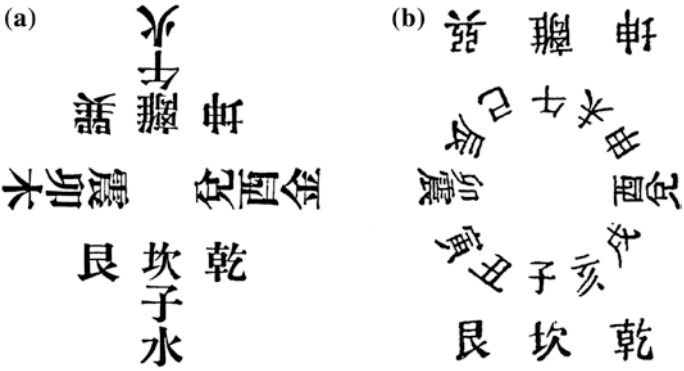


Fig. 65 The classic of the tiger seal. **a** Painted square board of eight diagrams, **b** round board of twelve earthly branches

Dynasty heralded as immortal in the Ming and Qing Dynasties, "cut his hair and entered Mountain Kunlun after Huang Chao captured the Capital," that is, began to devote himself to geomancy 40 years after Duan Chengshi documented magnetic needles, i.e., the first year of Zhonghe (881 AD) in the reign of Emperor Tang Xizong. Yang said in "*Esoteric Pronouncements of the Green Satchel*": "The natural conditions should be measured with the twelve directions on the compass and the artificial complementation should be made with the heavenly stems and earthly branches." Figure 66 gave the historical relics of compass directions gradually becoming more and more specific. Wu Wanggang of the Ming Dynasty painted a compass in "*Interpretation of Compass Classics*" and called it "The General Figure of the Three Needles" of a compass (as shown in Fig. 67). It expanded the five tiers

Fig. 66 Floating needle indicating directions

Fig. 67 The general figure of the three needles

of Fig. 66 to seven tiers, with each layer having a name. Obviously, the directions in the second and fourth tiers are the same as those of Fig. 65; the 24 directions of tier 3 are called "original needles," and as the same as those in tier 5 of Fig. 66; the 24 directions of tier 5 are called "Master Yang's Needles" (Master Yang is Yang Yunsong), and they are the same as those in the fourth layer of Fig. 66; the sixth tier, added by geomancers between the Song and Ming Dynasties, uses stars to indicate directions; the seventh layer is called "Master Lai's Needles." "Master Lai," named Lai Taisu or Lai Wenjun, was from the early years of the Southern Song Dynasty and active in the twelfth century. The indication of three needles (original needles, Master Yang's Needles and Master Lai's Needles) in a compass painting indicates that the purposes and means for geomancy are becoming more complicated and changed. Deviation in meridian of Master Yang's Needles and Master Lai's Needles from the original needle may have been associated with related changes in the geomagnetic pole and magnetic declination.

Since the Song Dynasty, geomancy compass became mystified and complicated by masters of feng shui and geography. Eight trigrams, heavenly stems and earthly branches, heavenly stars, and divinations of good and bad fortunes, and terminology were painted on the board (as shown in Figs. 68, 69, and 70).

Fig. 68 Copper geomancy compass used in the Yuan Dynasty

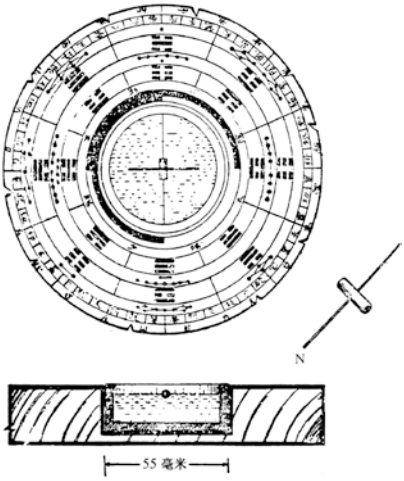


Fig. 69 Geomancy compass of the Qing Dynasty

Fig. 70 Modern geomancy compass

Fig. 71 Porcelain figurine of immortal Zhang unearthed in a Song Tomb in Lin Chuan, Jiangxi Province

The above are water compasses for geomancy purposes. It is worth noting that the dry compass is also first invented and put to use in geomancy by the Chinese. In the 1980s, a "Porcelain Figurine of Immortal Zhang" was unearthed in a Song Dynasty Tomb in Linchuan County, Jiangxi Province (as shown in Fig. 71). The figurines held vertically a compass in the right hand which is placed before the left chest, and the pivot jack can be seen in the middle of the needle. The one buried in the tomb is Zhu Jinan, governor of Shaowu Military Prefecture (in present-day Fujian) in the Southern Song Dynasty. Zhu died in the 3rd year of Qingyuan (1197) and buried in the fourth year of Qingyuan (1198). Therefore, it is irrefutable that the dry compass was popular in the latter half of the twelfth century in Fujian and Jiangxi.

4.5 Compass and Navigation

In the turn of the eleventh or twelfth century, there were texts describing sailing-oriented compasses. In the Song Dynasty, Zhu Yu described boatmen "observing the stars at night and the sun during day time, and used the compass when it is cloudy" in "*Pingzhou Table Talks*." The book was finalized in the first year of Xuanhe (1119). However, Zhu Fu, the father of Zhu Yu served as Marshal of Guangzhou between the second year of Yuanfu (1099) and the first year of Chongning (1102); thus, the book mainly recorded Zhu Fu's experience. Therefore, we can say that use

of compass in navigation should have begun in the latter half of the eleventh century. Four years after Zhu Yu completed his book, Xu Jing was dispatched as an envoy to Korea in the fifth year of Xuanhe (1123), and he mentioned that on the day of crossing the Ocean "if it is obscure south-pointing floating needle is used to tell north and south" ("Record of Envoys to Korea in Xuanhe Years" Volume 34). The so-called south-pointing needle for tell directions has to be no other but a compass.

The reason for south-pointing floating needles or water compass to be used on obscure days is that on sunny days "Astronomy Technology" can still be used to distinguish the directions. "Astronomy Technology" is the observation of the height of Polaris with some simple tools. In maritime navigation over many dynasties, steersmen have accumulated much knowledge. Relevant experience and knowledge of the compass, as a new instrument for navigation, naturally need accumulation. In the beginning of the thirteenth century, compass navigation finally came into all-weather use. Zhao Rushi (1170–1231) mentioned "*Annals of Foreign States*" complete in the first year of Baoqing (1225), "On the boundless sea, the water and sky merges in the distance. Incoming and outgoing boats have to rely on the south-pointing needle, and observe it day and night, since even the slightest deviation would make the difference between life and death." Zhao Rushi, member of the Song imperial clan, ascended through official ranks to Grand Master for Closing Court. Starting from 17th year of Jiading (1224), he was made chief of Quanzhou Customs, Fujian Route. "*Annals of Foreign States*" results from his collection of navigation incidents during his tenure there. Half a century after Zhao Rushi, Wu Zimu documented in "*Record of the Splendors of the Capital City*" (completed in the 10th year of Xianchun, i.e., 1274) sea merchants from Lin'an (now Hangzhou) in the Song Dynasty. In the book, there were similar records of south-pointing needles similar to *"Annals of Foreign States.*" The pointer "had to be watched day and night," and even the slightest difference should be avoided. This documentation undoubtedly refers to a compass. The compass set a direction with the 24 orientations on its board; if the partition between two adjacent orientations (also known as the "Master Yang's Needles") were included, there should be actually 48 orientations (as shown in Fig. 72). Therefore, it could tell the difference of heading within 7.5°.

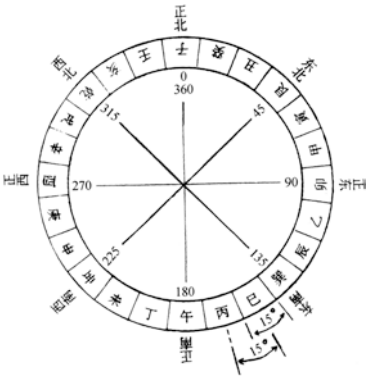


Fig. 72 Correspondence between compass directions and degrees

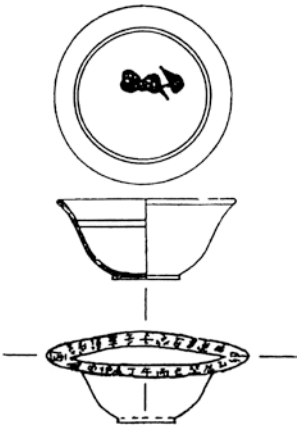


Fig. 73 Needle bowl—nautical water compass

The above geomancy compasses can naturally be used for sailing, but the nautical compass orientation needs only one layer (or circle). A nautical compass needs to be simple, straightforward, easy to identify, and easy to distinguish. In initial stages, the nautical compass may have been a porcelain bowl or plate, with an azimuth circle fitted to the rime or orientations painted in the inner bottom glaze. If one bowl (or plate) was broken, fetch another. Such a bowl was also known as the "needle bowl." In the recent decades, numerous needle bowls of Jin and Yuan Dynasties were unearthed in Lushun, Dalian, Jiangsu, Dantu County, and other coastal areas, even in a Yuan Dynasty wooden boat in Kaihe Village Cixian County, Hebei. In the inner bottoms of those bowls, there is a pattern of a float needle pierced through the lamp wick. In some cases, on the outer bottom there is the glaze character "针" (as shown in Fig. 73). In the Ming Dynasty, Huanan Yao (south China kiln) fired specifically porcelain plates to be used as marine compasses (as shown in Fig. 74). These are the water compass used in the early days of navigation.

Figures 75 and 76 show the nautical compasses of the Ming and Qing Dynasties. Numerous pictures of them can be found in literatures, and material objects of the Ming and Qing Dynasties are kept in museums

Accumulation of sailing experience prompted people to know the compass directions of various points on the navigation route (such as islands, reefs, or other signs on the sea). Ancients call this "needle path," "guide," or "needle through," "needle spectrum" or "needle book." To reach the destination, one has to use the needle path simultaneously with the sailing time (or distance). The unit for calculating the length of the voyage is "geng"; roughly one day and one night can be divided into ten geng's, and one geng equals about 60 li. In describing the route from Wenzhou to Japan, the "*Handbook of South-pointing Needle*" of Ming Dynasty wrote "start from Wenzhou, go 5 geng's along Danjia direction, 6 geng's along Jiayin direction, 20 geng's along Danyin direction, 15 geng's along Genyin direction, and you will reach the Mountain of Japanese. So fabulous." See Fig. 72.

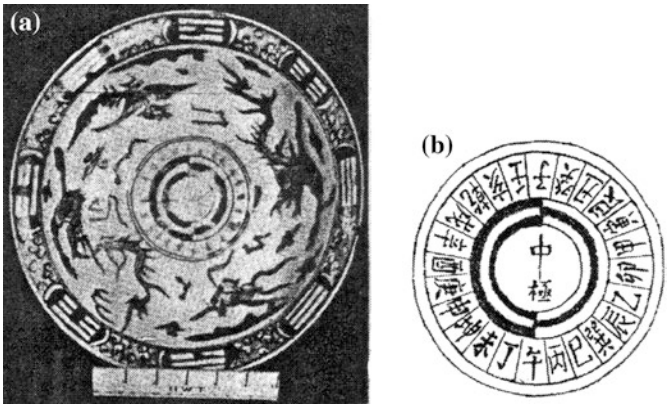


Fig. 74 Eight Trigram Porcelain compass. **a** The overall effect figure, **b** sketch of the magnified central dial board

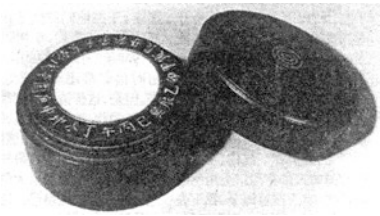


Fig. 75 Water nautical compass of the Ming Dynasty

Fig. 76 Dry nautical compass made in the early Qing Dynasty

Set sail from Wenzhou and take the "Danjia" direction, i.e., the direction of "甲" in the center of the compass, equivalent to 15° east by north; after sailing for "five geng's," change the direction of the ship to "Jiayin," i.e., the direction between "Jia" and "Yin" on the compass, equivalent to 22.5° east by north; sail for six geng's, and switch to "Danyin" direction, i.e., the direction indicated by the center

of the character "寅" on the compass, equivalent to 30° east by north; after going 20 geng's, switch to "Genyin" direction, i.e., the direction between "Gen" and "Yin" on the compass, equivalent to 37.5° east by north. Stick to this direction for 15 geng's and the boat reaches Japan. Calculation based on this direction, the destination is Nagasaki, Japan.

The "*Handbook of South-pointing Needle*" also documented "the needle direction for returning from Japan to Ningbo": "starting from Goto, and follow the direction of Kunshen and go seven geng's, then switch to Gengshen direction and go 15 geng's; switch to Dangeng and Gengyou, and go 25 geng's. You will find yourself in Ningbo." Compare the description with Fig. 72, it is not difficult to see that the compass orientation for returning to Ningbo is basically Japan reverse to that going to Japan.

The above are the so-called needle path of ancient mariners. Textual descriptions of needle paths in many classics and books so far can still be restored into route maps, consistent with present-day routes or route maps. In the Yuan Dynasty, Zhou Daguan (ca. 1275–1346), who was dispatched as envoy to Siem Reap (present-day Cambodia) in the first year of Yuanzhen (1295), wrote "*The Customs of Siem Reap*" and mentioned in its "General Preface" the needle path: "start from Wenzhou, follow the Dingwei direction, pass the ports of Fujian and Guangdong, Seven Islands Sea, and the Cochin Sea to Champa. The favorable wind of Champa can take you to Zhenpu in half a month, that is, the territory of Siem Reap. Start from Zhenpu along the Kunshen direction, pass the Kunlun Sea, and enter the port."

Based on this description, archaeologist Xia Nai plotted the restored chart of the needle path (as shown in Fig. 77). The ancients also painted nautical needle path maps. For example, in the Qing Dynasty, Zhou Huang took imperial orders and visited Ryukyu in the 21st year of Qianlong (1756), and wrote "*A Brief*

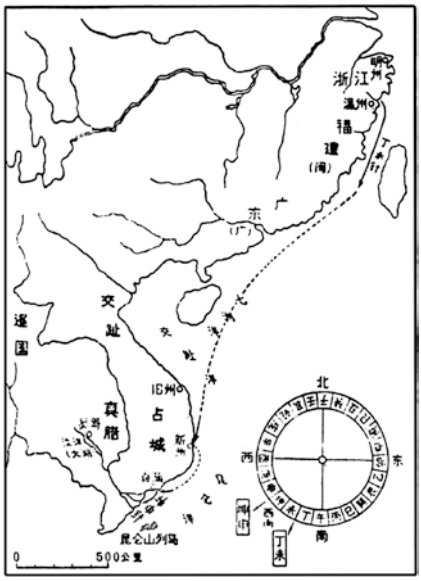


Fig. 77 The needle path from Fuzhou to Cambodia sketched by Xia Nai on the basis of "*The customs of Cambodia*"

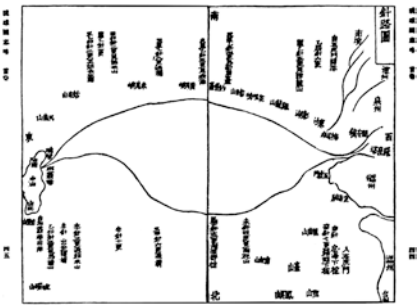


Fig. 78 The needle paths from Fuzhou to Ryukyu (*upper line*) and back (*lower line*)

Fig. 79 Zheng He's nautical chart (part) (The route from the State of Liushan (Maldive Islands) to State of Kezhi (now Kochi) and State of Guli (now Calicut) along the southwest coast of the Indian Peninsula. On the route, the islands, mountains, country names, temples, and pagodas are indicated, and "Astronomy Technology" degrees, as well as the geng's and needle paths to and fro. The latter from right to left reads: 50 geng's along the direction of the Yin is the State of Guli, and 25 geng's along the same direction is the State of Kezhi; 25 geng's along the Yimao direction is the State of Kezhi; 28 geng's along the direction of Jiamao is the State of Li, and 15 geng's along the Mao direction is the State of Guli; and 16 geng's along the direction of Mao is the State of Jiajialiu.) in "*Account of Military Arts and Science*" by Mao Yuanyi

History of Ryukyu." In the book, he painted the needle paths for the route from Fuzhou to Ryukyu and the return trip (as shown in Fig. 78). Next to the routes, mountains and islands, needle position, number of geng's were indicated. In the Yuan Dynasty, Mao Yuanyi (ca. 1570–1637) left an extremely valuable chart of needle path used by Zheng He during his voyages in the book "*Account of Military Arts and Science*" (as shown in Fig. 79).

Combination of compass and needle path made China one of the earliest countries to conduct ocean voyages. After serving in the Yuan Dynasty for 17 years, the Italian Marco Polo (1254–1324) returned home in 1292 on the ship escorting the Mongolian princess Cocachin to Persia. The fleet, including fourteen four-mast ships, and taking more than 600 people, set sail from the port of Quanzhou, Fujian, passed Sumatra, Java, Indian coasts and arrived in Persia. In the Yuan Dynasty, the folk navigator Wang Dayuan set off twice from Quanzhou between 1,330 and 1,339 and reached Southeast Asia, the Indian Ocean, the Arabian Peninsula, and even East Africa. In the early Ming Dynasty, Eunuch Grand Director Sanbao Zheng He made seven expeditions to the Western Ocean between 1,405 and 1,433, reaching as far as Kenya in Africa. The size of his ships, the scale of his fleet, the number of his crew, the vastness of waters sailed, the level of maritime technology, and commanding and management were all unrivaled in ocean voyages around the world back them.

4.6 Spread of the Compass to the West and Its Influences

In Europe or the Arab countries, when was the south-pointing needle or compass documented in literatures? Where were they from? This issue has been of concern to historians of science. Belgian-born American historian G. Sarton (1884–1956), in his famous book "*An Introduction to the History of Science,*" United Kingdom Dr. Joseph Needham in his monumental work "*History of Civilisation in China,*" and even American historian of science F. Cajori in "*History of Physics*" have all involved a large number of related documents and historical materials. Those documents and materials have proven that the Chinese were the earliest people to invent the south-pointing needle, compass, and to discover the magnetic declination.

According to verifiable documentation, the earliest people in Europe to address compass is the English Alexander Neckam (1157–1217). He said in the book "The Nature of Things" completed between 1190 and 1200 that the seafaring sailor "touches the needle with a magnet; the needle starts spinning, and when it stops, its tip points north." In 1205, the French Guyot de Provins said that the sailors "touches a needle with a magnet, fixes the needle to a straw, and floats the straw on the water, and the needle points north." Although there are similar descriptions between the two theories, the earliest account by Neckam is 100 years later than that by Shen Kuo in "Brush Talks From Dream Brook," which is not the earliest Chinese literature on the south-pointing needing and compass.

A significant progress in magnetism knowledge and compass in Europe was written in a letter by the French Petrus Peregrinus (or Perre de Maricourt) on August 12, 1269. Petrus Peregrinus knew the magnet polarity and that a strong magnetic body could inverse the polarity of a weaker one, and invented a compass with scale and a pivot needle. He was an engineer in the army of Louis IX, as well as one of the

few scholars engaged in experiments in the Middle Ages, but he was not yet aware of the magnetic declination. His compass was over 200 years later than that of the geomancer Wang Ji and Yang Weide, 170 years later than that of the nautical south-pointing needle or compass seen by Zhu Fu and his son Zhu Yu in Guangzhou, and even 70 years later than the dry compass (pivot compass) model resultant from the archaeological excavations of "Porcelain Figurine of Immortal Zhang."

Arab literatures on south-pointing needle or compass appeared later than their European counterparts. It is not until the thirteenth century that was south-pointing needle or compass mentioned in several documents. One literature is "*Collection of Anecdotes*" written by Muhammad al-Awfi in about 1,232 in Persian; it mentioned sailors rubbing fish-shaped iron sheet against a magnet. The other literature is "*Complete Gems*" written by Bailak al-Qabajagi in 1,282; the book dealt with the scene of a sailor using a water compass that he had seen with his own eyes, and the south-pointing needle was also a floating fish-shaped iron piece.

In view of above, some historians pointed out that the south-pointing needle or compass may have been introduced by land to Europe via Russia, and the earliest disseminators may have been interested in astronomy, geography, or magic. In the beginning of the thirteenth century, it spread by sea to Arabia. In the fifteenth century, the compass was used as a navigation instrument, to make it possible for the European adventurers, pirates and navigators to cross the oceans and reach Asia.

It should be noted in transportation history that Zheng He crossed the Indian Ocean and arrived in East Africa, and Bartolomeu Dias passed the Cape of Good Hope. Therefore, it can be said that half of traffic route between East and West has been opened up by the Chinese and half by the Europeans.

It should still be pointed out in the history of science that after the compass was introduced to Europe, the Europeans carried out improvements to make it better. A particularly important innovation is putting the compass into the gyro ring (also known as gimbals, i.e., "the censer to be used in bed" invented by the ancient Chinese). Such a compass is known as the "Cardan Ring." The Italian mathematician Jerome Cardan (or Jerome Cardano, or Hieronymus Cardanus, 1501–1576) did not claim the rights of this invention. The gimbals were not originally intended for the compass, but for the carriage seats, to ease the discomfort resultant from bumpy roads when he saw a Tibetan "lamp" (the lamp fitted within the incense burner to be used in bed). Both the compass and the censer to be used in bed (as shown in Figs. 80 and 81, respectively) were invented by the Chinese. Unfortunately, the Chinese people seemed never to have thought of putting those two inventions together.

The compass mounted in the gyro ring (as shown in Fig. 82) is free from impacts of wind and waves in navigation, and this is the biggest advantage of the modern compass. In the early stages of space exploration, in 1910s, the liquid compass was mounted on the gyro ring, as an important instrument of aerospace. Aside from use in determining the direction of flight, the compass was also used to determine the flight altitude by using the magnetic inclination of its needle.

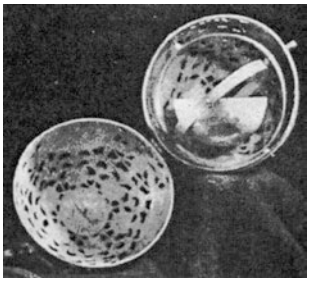


Fig. 80 Tang Dynasty silver censing balls unearthed in Shapo village, Southern Suburbs of Xi'an

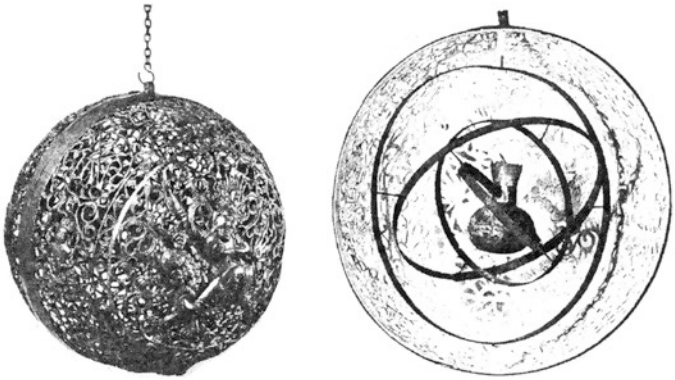


Fig. 81 The shell and internal structure of copper lamp ball in Tibet in the Qing Dynasty

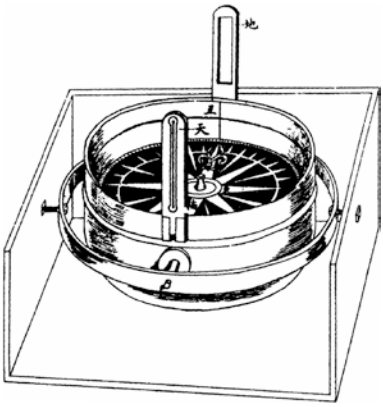


Fig. 82 Nautical compass in Europe in the nineteenth century

The application of compass in horizons, mappers, and other instruments makes it an important instrument of modern science. The initial orientation board and needle has become the ancestors of instruments and meters designed for modern industrial technology and scientific tests.

Author Biography

Jialu Fan was born in February 1964, a native of Jinzhai, Anhui Province; he awarded PhD in history of science and technology; he is vice-president of Huangshan University; part-time professor of University of Science and Technology of China; guest researcher of the Institute for the History of Natural Sciences, Chinese Academy of Science; and member of the National expert panel for protection of intangible cultural heritages under the Ministry of Culture. Fan Jialu's research fields are field investigation of traditional workmanships, and theories for protecting intangible cultural heritages; and his monographs include *Complete Traditional Workmanships in China—Paper Making* and *Chinese Handicraft—The Scholar's Four Jewels*.

Qi Han born in 1963, graduated in 1988 from University of Science and Technology of China, and awarded PhD of Science in 1991 from the Institute for the History of Natural Sciences, Chinese Academy of Science; he was named as research fellow in 1999; he was a former director of Research Office for Modern and Contemporary Chinese and World History of Science, currently as member of the academic committee of the Institute for the History of Natural Sciences, Chinese Academy of Science; he was a PhD candidate supervisor, professor of archaeology in Department for the History of Science and Scientific Archaeology and also a part-time professor of the History Department of Zhejiang University, member of the Academic Committee of the Christian Research Center of the Chinese Academy of Social Sciences; member of Academic Committee of Religion and Chinese Society Research Center of Chung Chi College of the Chinese University of Hong Kong; member of the Academic Committee of the Ricci Institute for the History of Chinese and Western Cultures, University of San Francisco. Qi Han was a Vice Chairman of International Society for the History of East Asian Science, Technology, and Medicine (1999–2002), vice chairman of the Chinese Society for the History of Mathematics (2002–2006), editorial board member of the History of Natural Science, the editorial board member of the History of Science and Technology of China, the editorial board member of the French Sinology, specially invited editorial board member of "Jinan Historians," and invited to visit the USA, Japan, France, Britain, Germany, Portugal, Italy, and other countries. From 1999 to 2000, he was a member of Institute for Advanced Study in Princeton; USA published over 60 papers (in Chinese, English, French, Japanese); he won the Outstanding Paper Prize of Liqing Award for Young

Scholars of History of Science in China, in 1998; in 1999, the first prize in Elephant Award for Outstanding Papers in "Scientific and Technological History" from 1999 to 2001, he awarded project support by the National Natural Science Foundation of "Chinese Astronomy in Europe." He was the winner of the 12th Session of Academic Research Scholarship from the Cultural Affairs Bureau of the Macao Special Administrative Region Government (2004–2005). He was the host of Science and Technology Records in the Institution Panel of National "History of the Qing Dynasty" Compilation Project (2005–2009).

Zhaochun Wang Researcher at the Academy of Military Sciences. With native of Gaoyou, Jiangsu Province, he was born in Shanghai in 1937. In July 1963, he graduated as a major of Nuclear Physics from Department of Physics, Nanjing University. From 1963 to 1973, he engaged in defense-related research, and participated in the projects of "the two bombs and one satellite." Since 1974, he engaged in research into Chinese firearms history, Chinese military technology history, Ming Dynasty military history at the Academy of Military Sciences; he published 13 monographs including "*Chinese Firearms History,*" "*World Firearms History,*" "*History of Chinese Science • Military Technology Volume*" "*History of Ancient Chinese Military Engineering* (*Song, Yuan, Ming and Qing*)," "*General History of Chinese Military Technology,*" "*Introduction of Gunpowder and Firearms to the West and Its Historical Influence,*" "*Ancient Weapons in China,*" "*A Glimpse of Ancient Chinese Books on the Art of War*" and "*Ancient Chinese Books on the Art of War*" (an updated version), "*Generations of Famous Generals in China.*" Being as a Co-author of "*The History of Modern Warfare,*" "*General History of Chinese Military • Military History of the Ming Dynasty* (*Book 1*)," and five in all. In addition, he also participated in the preparation of more than 10 of "*biographies*" such as books and over 10 dictionaries. He submitted over 60 entries for "*Encyclopedia of China • the Military Volume*" and "*Chinese Military Encyclopedia,*" including "ancient weapons." Published more than 40 papers, he granted special allowance certificate in 1992 by the State Council. He was hired in 2007 by the Chinese Academy of Sciences as the consultant of Terminology Committee for Ancient Chinese History of Science and Technology. He was selected to the roster of the Academy of Military Sciences (military history expert) in April 2008 and earned twice Merit Citation Class III.

Nianzu Dai a native of Changting, Fujian Province he graduated from Department of Physics, Xiamen University, in 1964. He has since been engaged in the study of the history of science at the Institute for the History of Natural Science, Chinese Academy of Sciences and he is one of the founders of the discipline of the history of physics. He was named the advanced worker of the Chinese Academy of Sciences in 1978, made researcher in 1990, entitled to special government allowances since 1992. He was awarded the title of Young and Middle-aged Expert with Outstanding Contributions in 1996. He is an incumbent chair Professor of Capital Normal University. He published more than 100 papers on the history of physics. The major works include the "*History of Mechanics in China,*" "*History of Acoustics in China*", "*History of Optical Study in China,*" "*History of Electricity and Magnetic Studies in China,*" "*History of Physics in China*", "*Zhu Zaiyu–the Star of Science and Art in the Ming Dynasty,*" "Zhu Zaiyu the Immortal Royal Descendant," "*Cultural Relics and Physics,*" and "*Records of Physics and Mechanics*"; editor of the "*Collected Papers in Physics in China During the First Half of the 20th Century,*" co-author of Essentials of Physics (via cooperation with Professor Lin Qingliang of National Taiwan University), proceedings of "*Physics under Close Scrutiny*" (edited by Wang Shiping, LI Yanping, etc.).

Ceramics Technology

Wenjie Li

1 Preface

Historic periods of ancient China can be divided into the Paleolithic Age, the Neolithic Age, the Chalcolithic Age, the Bronze Age, and the Iron Age based on means of production. In the Paleolithic Age, there were only chipped stone tools; apart from chipped stone tools, polished stone implements also emerged in the Neolithic Age, which falls into the early, middle, and late periods; the Chalcolithic Age saw stone implements and copper ware, while stone implements dominated. Currently, there are not many discovered copper ware and places where they were found. For example, a copper bell was unearthed from Taosi Site in Xiangfen County, Shanxi Province, which was made of copper; besides, six pieces of small copper knives were unearthed from Dourong Mausoleum Site, Wuwei, Gansu. The Chalcolithic Age falls into the early and late periods; the Bronze Age lasted from Xia Dynasty to Zhou Dynasty, and iron ware emerged in the Warring States Period; starting from Qin and Han dynasties, China entered its Iron Age.

What's archaeological culture? Archaeological culture is the general term for ancient remains and relics left over by human communities in activities of production, living, military affairs, and religion in history. Due to differences in ages and regions, a lot of archaeological cultures were formed which have different characteristics. The reason behind different archaeological cultures is actually the existence of different human communities. Human communities refer to organizations such as tribes or alliance of tribes. Archaeological culture must have a group of typical ancient remains and relics featuring common characteristics by which it can be obviously differentiated from other archaeological cultures. Archaeological culture was named after the place where it was first discovered. For instance, Yangshao Culture was named after Yangshao Village of Mianchi County, Henan Province, Longshan Culture after Longshan Township, Zhangqiu of Shandong

W. Li (✉)
National Museum of China, Dongcheng, Beijing, People's Republic of China

© Shanghai Jiao Tong University Press,
Shanghai and Springer-Verlag Berlin Heidelberg 2015

Y. Lu (ed.), *A History of Chinese Science and Technology*,
DOI 10.1007/978-3-662-44166-4_3

Province, and Daxi Culture after Daxi Site of Wushan County, Sichuan Province. Cultural relics left over by Chinese ancestors include relics and remains. Relics include houses, cellars or caves, pottery kilns, and tombs. Remains include pottery, porcelain, stone implements, bone implements, copper ware, and iron ware. Of unearthed remains, pottery features the largest number for it was a daily life utensil for people. Pottery has the following characteristics: First, it is easy to be made. Second, it tends to be broken. Third, it sees easy replacement. New handicraft, new model, and new decorative patterns would all be reflected on pottery for it is the utensil featuring the most obvious features of times and cultural characteristics, and pottery groups are always used for differentiating archaeological culture. Fourthly, pottery is easy for preservation because pottery became corrosion resisting after having undergone firing. Even if the utensil is broken, the clips can be glued and restored to its former form.

Ceramics is the general term for pottery and porcelain, and history of technologies for making ceramics includes history of pottery-making technologies and history of porcelain-making technologies. History of pottery-making technologies and history of porcelain-making technologies in ancient China are separately discussed as follows.

2 Lecture 1 History of Pottery-Making Technologies in Ancient China

Before the invention of pottery, the implements used by human beings were all made of natural substances, such as stone instruments, wood instruments, and bone instruments. However, unlike stone instruments, wood instruments, and bone instruments, pottery is a kind of instrument manufactured by mankind through firing clay existing in nature, i.e., adding water to clay and kneading them into pug which was then used for making body by capitalizing on its plasticity. After the body was dry, it would be fired so as to make it undergo physical and chemical changes, thus became the first man-made new substance nonexisting in nature—pottery.

As for the question how pottery was invented, archaeologists have yet to find the answer. Up to now, pottery of the original stages has not been discovered yet. The author guessed that at the end of the Paleolithic Age which is 15,000 years away from today, people kneaded clay into clay sheets or clay strips, which became the primitive clay sculptures after dried; when people grilled food on the clay ground and saw the ground turn into burnt kitchen surface, they were enlightened to invent pottery. Once people placed clay sculptures on the kitchen surface, such sculptures would become the most primitive pottery after having been fired. The process of invention of pottery should be as follows: Clay sculptures came first, and then pottery burned on kitchen surfaces; piece-shaped or strip-shaped pottery came before pottery utensils such as bowls, earthen bowls, and kettles.

With pottery, people could cook food so that nutrients of food could be more easily absorbed by people, hence strengthened mankind's physique and boosted mental development of human beings. With pottery utensils, people could lead a long-term settlement life, thus benefited development of gathering economy, primitive agriculture, and animal husbandry. Later technologies for firing pottery appeared, and then the techniques for smelting metal with fire emerged so that tiles could be fired, which was followed by civil engineering technologies taking tiles as the building material; thus, pottery-making technologies could develop into technologies for porcelain manufacture.

History of pottery-making technologies in ancient China can be divided into 12 periods (see Table 1), and main achievements of each period are introduced as follows.

2.1 The Early Neolithic Age

There are 10-plus relics of the Early Neolithic Age (13000 BC–7000BC) (see Table 2): Miaoyan of Guilin City, Guangxi; Yuchanyan of Dao County, Hunan; Xianrendong and Diaotonghuan of Wannian County, Jiangxi; (Liyuzui) in Dalongtan Park of Liuzhou, Guangxi; Hutouliang of Yangyuan County, Hebei; Nanzhuangtou of Xushui County, Hebei; Zhuannian of Huairou District, Beijing; Donghulin of Mentougou District, Beijing; Zengpiyan of Guilin City, Guangxi; Dayan of Lingui County, Guangxi and Niulandong of Yingde City, Guangdong, etc. From these relics, pottery was unearthed.

2.1.1 Raw Materials for Making Pottery

Minor ingredients in the body of pottery kettle unearthed from Yuchanyan Site of Dao County include natural rounded and polished river sand, and angular quartz particles artificially smashed. This shows that pottery unearthed from this historical site was not the most primitively invented. Pottery-making technologies had already surmounted the phase of "obtaining clay at the site" and entered into "selecting clay at the site," because clay obtained at the former phase did not contain artificially smashed quartz particles.

2.1.2 Modeling Methods for the Body

Pottery kettle unearthed from Zengpiyan Site of Guilin (see Fig. 1) adopted clay-sheet sticking method for modeling, and clay sheets were stuck from the bottom to the mouth. It is conjectured that the method of making pottery by filling up leaves was used, in which leaves served as the isolating layer between the body and the ground for preventing conglutination.

Table 1 Table for periods and types of pottery-making technologies in ancient China

Time	Period		Northern Type			
			Cultural Region of Gansu and Qinghai	Cultural Region of Central Plains	Cultural Region of Shandong	Cultural Region of Yanliao
BC	The Neolithic Age	Early Period				
12000						
11000						
10000						
9000				Hutouliang		
8000				Nanzhuangtou		
7000		Middle Period		zhuannian		
6000			Laoguantai	Jiahu, Peiligang, Cishan	Houli	Xinglongwa
5000		Late Period	First Phase of Shizhaocun		Beixin	Zhaobaogou
4000			Yangshao			
3000			Majiayao	Second Phase of Miaodi	Dawenkou	Hongshan
2000	The Chalcolithic Age	Early Period	Caiyuan	Taosi, Henan Longshan		Xiaoheyan
		Late Period	Qijia		Shandong Longshan	
1000	Xia and Shang Dynasties					
	Western Zhou Dynasty and the Spring & Autumn Period					
AD	The Warring States Period and Qin Dynasty					
	Han Dynasty					
1000	The Three Kingdoms and Sui Dynasty					
	Tang Dynasty					
	Five Dynasties- Qing Dynasty					

(continued)

Table 1 (continued)

Time	Period		Southern Type			
			Cultural Region of the Middle Reaches of the Yangtze River		Cultural Region of Jiangsu and Zhejiang	Cultural Region of South China
BC 12000	The Neolithic Age	Early Period				Miaoyan
11000						Yuchanyan
10000			Xianrendong			Liyuzui
9000						
8000						Zhenpiyan
7000						
6000		Middle Period		Pengtoushan		
5000			Chengbeixi	Lower Layer of Zaoshi		
4000		Late Period			Majiabang	Hemudu
3000			Daxi			
2000	The Chalcolithic Age	Early Period	Qujialing		Songze	
		Late Period	Shijiahe		Liangzhu	
1000	Xia and Shang Dynasties					
	Western Zhou Dynasty and the Spring & Autumn Period					
AD	The Warring States Period and Qin Dynasty					
	Han Dynasty					
1000	The Three Kingdoms and Sui Dynasty					
	Tang Dynasty					
	Five Dynasties- Qing					

Table 2 Sheet of age data determined by using 14C dating for the Early Neolithic Age

Number of laboratory	Name of historical site	Substance for determination	Actual age determined by using 14C dating (based on the half-life of 5,730 years)	
			BP	BC
	Miaoyan of Guilin, Guangxi	Pottery shreds	15,660 ± 260	13,710 ± 260
		Pottery shreds	15,560 ± 500	13,610 ± 500
	Yuchanyan of Dao County, Hunan	Matrix of pottery shreds	14,810 ± 230	12,860 ± 230
		Charcoal	14,490 ± 230	12,540 ± 230
		Humic acid on pottery shreds	12,320 ± 120	10,370 ± 120
	Xianrendong of Wannian County, Jiangxi	Charcoal	12,430 ± 80	10,480 ± 80
PV0402	(Liyuzui) in Dalongtan Park, Liuzhou, Guangxi	Human bones of lower layer	11,785 ± 150	9,835 ± 150
PV0401			10,505 ± 150	8,555 ± 150
PV0156	Hutouliang of Yangyuan County, Hebei	Fossil of bones of rhinoceros	11,000 ± 210	9,050 ± 210
BK87088	Nanzhuangtou of Xushui County, Hebei	Sludge	10,815 ± 140	8,865 ± 140
BK87075		Charcoal	10,510 ± 100	8,560 ± 100
BK87086		Sludge	9,980 ± 100	8,030 ± 100
BK86120		Wood	9,875 ± 160	7,925 ± 160
BK89064		Wood	9,850 ± 90	7,900 ± 90
BK87093		Wood	9,810 ± 100	7,860 ± 100
BK121		Wood	9,690 ± 95	7,740 ± 95
BK92056	Zhuannian of Huairou District, Beijing	Charcoal	9,210 ± 100	7,260 ± 100

Data of Miaoyan and Xianrendong were quoted from Zhang Chi's *Relics of Early Pottery and Oryza Phytolith of Ten-thousand Years Ago in Jiangxi*, while data of Yuchanyan were taken from Yuan Jiarong's *Yuchanyan of Dao County, Hunan—Rice and Pottery of Ten Thousand Years Ago*; both the articles were published in *Origins of Rice Agriculture, Pottery and Cities* compiled by Yan Wenming, Yoshinori, Yasuda, Cultural Relics Publishing House, 2000 version. Data of Hutouliang and (Liyuzui) of Dalongtan were cited from *Radiocarbon C14 Data in Chinese Archaeology* (1965–1991), Cultural Relics Publishing House. Data of Nanzhuangtou were quoted from *Archaeology*, page 965 of issue 11, 1992. Data of Zhuannian were quoted from *Historical Relics*, page 91 of issue 6, 1996

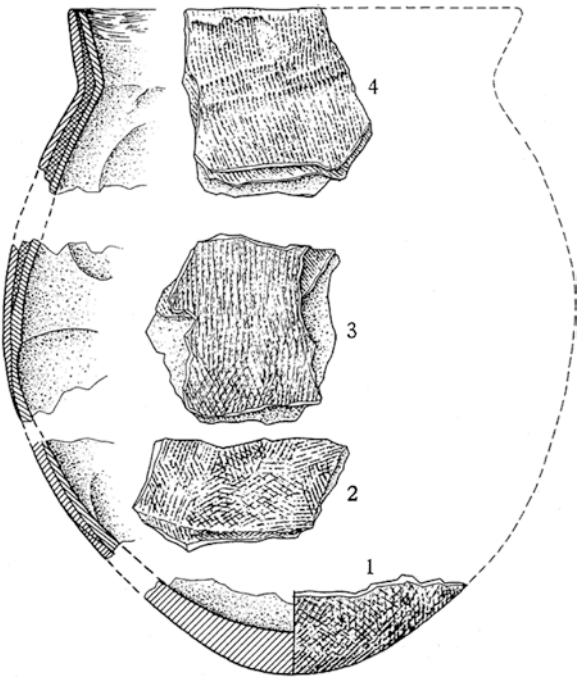


Fig. 1 Pottery kettle unearthed from Zengpiyan Site of Guilin, Guangxi

2.1.3 Firing of Pottery

Pottery of the Early Neolithic Age features low firing temperature, uneven color, soft ceramic, and proneness to crush. For example, pottery shreds of Zengpiyan Site of Guilin featured a firing temperature of 680 ± 20 °C (all firing temperatures are thereinafter expressed in °C) according to the measurement. It is presumed that at first, pottery was fired on the flat ground in the open air without kiln, and later, pottery was fired with lute on the flat ground, which was an intermediate form of firing pottery without kiln to the form of firing pottery with kiln, and the two methods were collectively called pile firing on the flat ground.

2.1.4 The Origins of Pottery in the World Are Diversified

It is said that pottery shreds of 13000 BC–14000 BC were unearthed in Japan and some of them featured firing temperature of only 400–500 °C which had not completely become pottery. Pottery shreds of 10000 BC were unearthed in Far East regions of Russia and those of around 10000 BC were also discovered in Mongolia and pottery of 9000 BC–8000 BC was also found in India, and pottery found in West Asia was not earlier than 7000 BC. Potteries of early times in various regions around the world have different shapes and decorations, indicating that the origins of pottery in the world are diversified. From existing data, pottery

appeared quite early in China, and pottery unearthed from Miaoyan Site of Guilin, Guangxi, was made the earliest in China, as early as in 13610 ± 500 BC and 13710 ± 260 BC.

2.2 Pottery-Making Technologies of the Middle Period of the Neolithic Age

Cultural relics of the middle period of the Neolithic Age (7000 BC–5000 BC) include Chengbeixi Culture of Hubei, Jiahu Culture and Peiligang Culture of Henan, Laoguantai Culture of Shaanxi and Gansu (Dadiwan Culture), Pengtoushan Culture, Gaomiao Culture, Lower Layer Culture of Zaoshi in Hunan, Cishan Culture of Hebei, Xinglongwa Culture of Inner Mongolia, Houli Culture of Shandong, and Culture of First Phase of Zhenjiangying, Beijing.

2.2.1 Raw Materials for Making Pottery

Gaomiao Culture and Lower Layer Culture of Zaoshi in Hunan and Chengbeixi Culture in Hubei all left over white pottery which has two kinds of raw materials: One is high-alumina refractory clay (kaolin) and the other one is high-magnesium fusible clay (talc clay).

2.2.2 Making Pottery with Base Plate

It is inferred that boards appeared in the middle period of the Neolithic Age. Potters cut trunks into boards with stone axes and put the boards on the ground and then made pottery on the boards by means of clay-sheet sticking method and clay-strip building method. With the boards, people could stay where they were and turn the boards with hands, and then the body would rotate accordingly; thus, the boards had already become a tool for making pottery. As the base plate had no shaft and it is unstable during rotation and several bodies would appear skew, such as kettle-shaped pot unearthed from Jiahu Site of Wuyang County, Henan (see Fig. 2) which was made by adopting the top-bottom clay-sheet sticking method for modeling with 17 clay sheets. The bottom plane and the plane at the mouth are not parallel. According to measurement, the included angle formed by vertical line of the bottom and central axis of the body reached 4.5°; therefore, the body of the pottery is obviously skew. Round-abdomen pot unearthed from Jiahu Site (see Fig. 3) adopted clay-strip building method for modeling, and there were traces of clay strips both on the inner wall and on the bottom. Pottery found from Jiahu Site shows that back then, clay-sheet sticking method was gradually less used and clay-strip building method was increasingly more used and it had a trend that clay-strip building method gradually replaced clay-sheet sticking method.

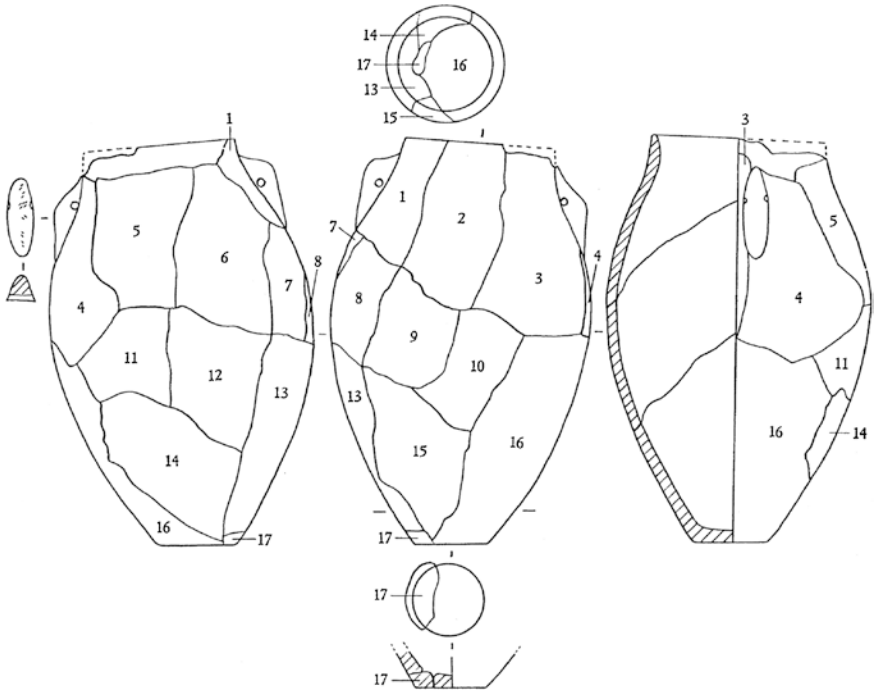


Fig. 2 Kettle-shaped pot unearthed from Jiahu Site of Wuyang County, Henan

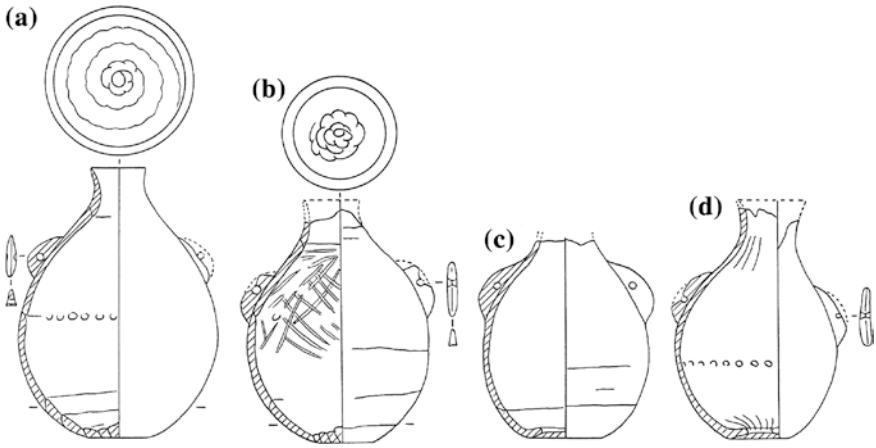


Fig. 3 Round-abdomen pot unearthed from Jiahu Site of Wuyang County, Henan

2.2.3 Origin of Making Pottery with Slow Jigger Wheels

During the long-term process of making pottery with base plate, potters found that placing the center of the base plate on the stump and stirring the base plate, it would revolve. Later, they also found that chiseling a round hole in the center of the base plate with stone chisel and inserting a stump on the ground and then putting the base plate on the stump, it would be more convenient for the base plate to revolve; thus, the base plate and stump became the most primitive slow jigger wheel and the base plate became wheel disk and the stump the pile. Later, potters found that revolving of slow jigger wheel was quite instable and rims of the wheel disk would move up and down, and then they installed a shaft tube under the wheel disk, at the center of it. At first, they might possibly use bamboo tube, and then they resorted to wood tube and covered the shaft tube on the shaft; thus, the slow jigger wheel revolved comparatively stable because the shaft tube was with a certain length and could keep vertical against the wheel disk. At first, pottery was directly made on wooden wheel disk, and then it was found that wooden wheel disk was water funk; thus, pottery turn plate was specially fired and was upside down on the wooden wheel disk for acting as the isolating layer between the body and the wooden wheel disk; thus, pottery was made on the flattop of the pottery turn plate. It has been a long process for making pottery with base plate evolving into producing pottery with slow jigger wheel.

Jiahu Site may fall into three phases, and pottery of the first phase to the third phase was all made on the base plate. Dagang Site is 6 km away from Jiahu Site, and it is later than the third phase of Jiahu Site in terms of time, belonging to the late period of Jiahu Culture. Cap-shaped pottery turn plate, a constructional element on slow jigger wheel, was unearthed from Dagang Site (see Fig. 4a). It is clay red pottery, which was the earliest cap-shaped pottery turn plate that has been discovered in China now. As for the wooden slow jigger wheel itself, it should have been consisted of wheel disk, shaft tube, and shaft; however, all of them have been rotten and have not been discovered yet. It should be stressed here that making pottery with slow jigger wheel, clay-strip building method was followed for the key process of body modeling; therefore, pottery was still handmade, and we could not say that pottery made with slow jigger wheel was made by quick jigger wheels. However, the method of trimming body had already changed, and the technique of trimming body with slow jigger wheel was adopted. The method was as follows: Revolve the wheel disk with hand or foot, and trim the body with hand or scraper blade at the same time. The body had regular shape after having been trimmed with slow jigger wheel, various parts of the body became comparatively even in thickness, and the plane at the mouth appeared parallel with that at the bottom; consequently, the phenomenon of skew body obviously dropped, with traces of trimming the body with slow jigger wheel, fine wheel lines, left over on the surface of the pottery. An example is Basin of Dagang Site (see Fig. 4b), with fine wheel lines left over on the inner wall at the mouth rim and the surface as well as interior wall above the middle abdomen of the body, which is the earliest pottery undergone trimming with slow jigger wheel that has been discovered in China up to now. Painted pottery was discovered at Dagang Site, such as painted pottery kettle (see Fig. 4c), which was made as follows: revolving the pottery by

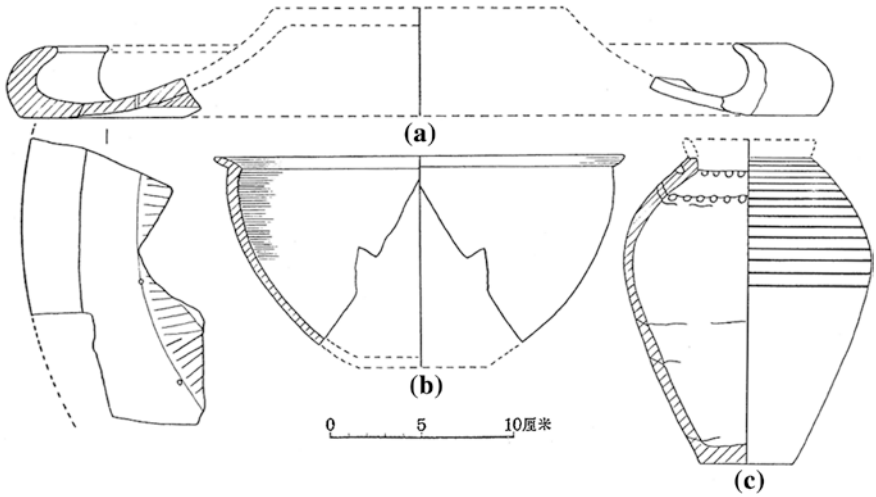


Fig. 4 Pottery unearthed from Dagang Site of Wuyang County, Henan. **a** Cap-shaped pottery turn plate; **b** pottery basin; **c** painted pottery kettle

capitalizing on slow jigger wheel and painting 15 rounds of red parallel stripes on the appearance above the middle abdomen. This kettle was the earliest painted pottery made with wheel painting that has ever been discovered in China so far.

The above-mentioned cap-shaped pottery turn plate and pottery basin trimmed with slow jigger wheel and painted pottery made with wheel painting emerged simultaneously, showing that at the last stage of the middle period of the Neolithic Age, China had already saw the method of making pottery with slow jigger wheel, hence entering the period in which pottery was mechanically made with wheel axle.

2.2.4 Appearance of Pottery Kiln

As mentioned above, pottery of the Early Neolithic Age was made by adopting the method of pile firing on the flat ground, including firing pottery on the flat ground in the open air and firing pottery with lute on the flat ground. Up to the middle period of the Neolithic Age, both Jiahu Culture and Peiligang Culture saw emergence of pottery kilns, hence approaching of the period of firing pottery in kilns. For example, two kinds of kilns were discovered at Jiahu Site: One is cave-shaped kiln (see Fig. 5), which was used for firing pottery as follows: digging a cave in the ground and covering the cave with firewood, then putting the body in the cave and covering the body with firewood, sealing it with mud, and last igniting to fire the body from a side; the other kind is horizontal cave kiln (see Fig. 6), for which the pottery-firing process was as follows: setting up a fire platform in the center of the cave and putting the body on the platform with flame paths established at both sides of the fire platform, at one end of the cave there was fire door and fire chamber with flue set up at the other end. Igniting the fire at the fire door and flames

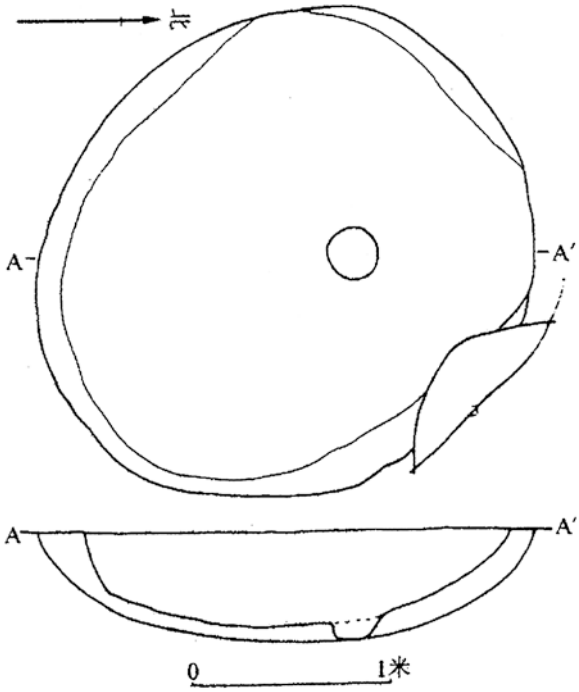


Fig. 5 Cave-shaped kiln at Jiahu Site of Wuyang County, Henan

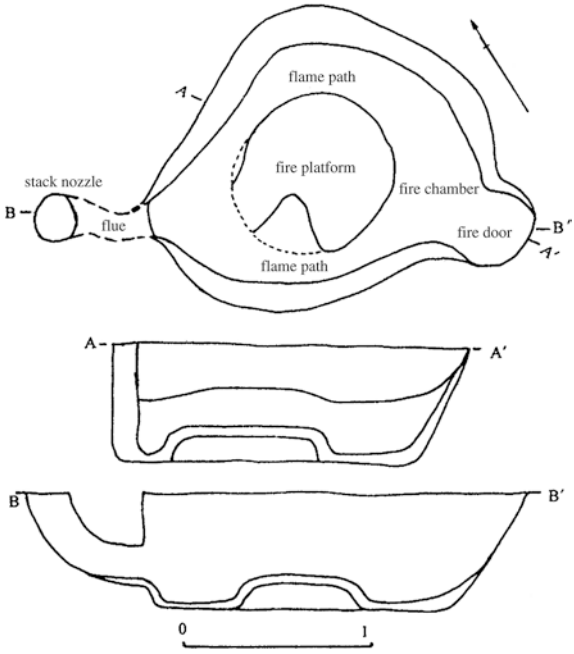


Fig. 6 Horizontal cave kiln at Jiahu Site of Wuyang County, Henan

in the fire chamber would move along the flame paths, bypassing the bodies and transferring heat to the bodies, and the waste smoke was discharged out of the kiln through the flue. Cave-shaped kiln should be the intermediate form of firing pottery with lute on the flat ground to fire pottery in horizontal cave kilns. Cave wall of the two kinds of kilns was underground, making for heat preservation of the kilns, and hence increased the firing temperature of the pottery. For instance, two hard pottery shreds unearthed from Jiahu Site, after measurement, featured firing temperature of 920 °C and 960 °C, respectively.

2.3 Pottery-Making Technologies of the Late Period of the Neolithic Age

Cultural relics of the late period of the Neolithic Age (5000 BC–3000 BC) include Beixin Culture of Shandong, Dawenkou Culture of Shandong and Anhui, First Phase Culture of Shizhao Village in Gansu and Shaanxi (equivalent to Lower Layer Culture of Beishouling), Yangshao Culture of Henan, Shaanxi and Shanxi, Tangjiagang Culture of Hunan, Xiantouling Culture of Guangdong, Daxi Culture of Sichuan, Hubei and Hunan, Hemudu Culture of Zhejiang, Majiabang Culture of Zhejiang and Jiangsu, Songze Culture of Shanghai and Jiangsu, Zhaobaogou Culture of Inner Mongolia, and Hongshan Culture of Inner Mongolia and Liaoning. The late period of the Neolithic Age was called "Yangshao Age" by the archeology world.

2.3.1 Hunan Region Had Become the Center of Technologies for Making White Pottery

Hunan teemed with high-alumina refractory clay and high-magnesium fusible clay, and such advantageous resources made Hunan become the center and birthplace of technologies for making white pottery. High-alumina refractory clay features low silicon oxide, high aluminum oxide, and low fluxing agent; while high-magnesium fusible clay is characterized by low silicon oxide, poor aluminum oxide, and rich magnesium oxide. The common ground of the two kinds of clay is low content of iron oxide; therefore, the produced pottery was white. White pottery featured complicated decoration technologies, for example, white pottery circular-legged plate of Tangjiagang Culture, Tangjiagang Site, Anxiang County, Hunan (see Fig. 7a), decorated with fine-toothed comb patterns and the exterior bottom presenting elephant-foot design. Fine-toothed comb patterns refer to the patterns made by pricking and stamping on the body with comb made of bamboo chips. According to measurement conducted by the author, there are five to seven small square-shaped pits in each square centimeter. Besides, white and red pottery circular-legged plate was also found, which was made by brushing

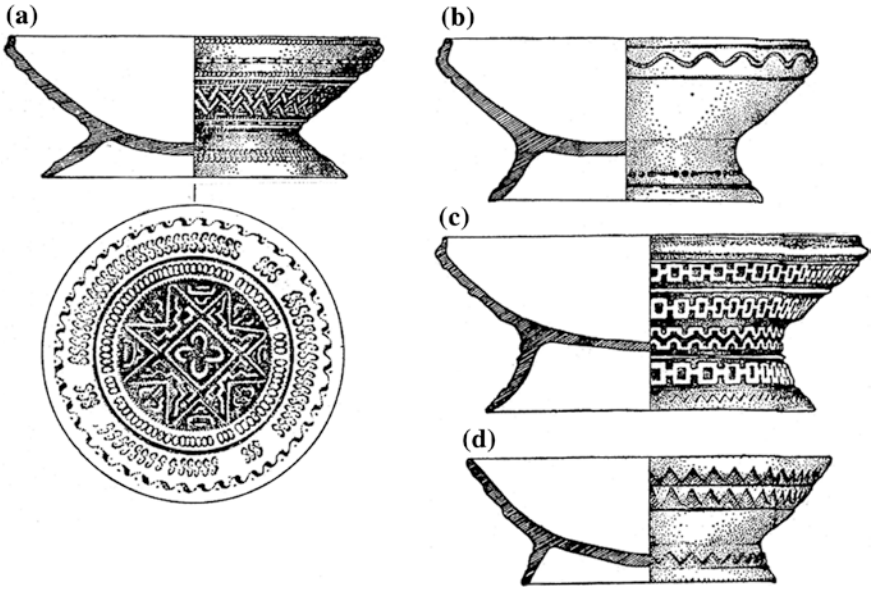


Fig. 7 White pottery circular-legged plate and *white* and *red* pottery circular-legged plate unearthed from Tangjiagang Site, An'xiang County, Hunan

white slurry on the red body. Technologies for making white pottery in Hunan had an extensive influence, and traces of them can be found in Yangshao Culture at Longgangshi Site, Nanzheng County, Shaanxi in the north and Xiantouling Culture at Xiantouling Site of Shenzhen, Guangdong in the south, Majiabang Culture at Luojiajiao Site of Tongxiang County, and Zhejiang in the east.

2.3.2 Origins of Making Pottery with Quick Jigger Wheels

Making pottery with slow jigger wheels was quite popular at the late period of the Neolithic Age, and clay-strip building method had already replaced clay-sheet sticking method. For instance, cap-shaped pottery turn plate of Yangshao Culture at Bancun Village, Mianchi County, Henan (see Fig. 8e), is a component put upside down on the pottery wheel for use; small-mouthed bottom-pointed bottle (see Fig. 9) has traces of clay strips on the inner wall. On the basis of long-term use of slow jigger wheels, potters gradually improved the structure of slow jigger wheels for increasing the wheel disk's revolving speed, and finally, quick jigger wheels for making pottery appeared at the last stage of the Late Neolithic Age. Making pottery with quick jigger wheels was called wheel-throwing pottery for short, referring to the process during which the pub placed on the center of the wheel disk and on the flattop of the pottery turn plate was directly lift and pulled

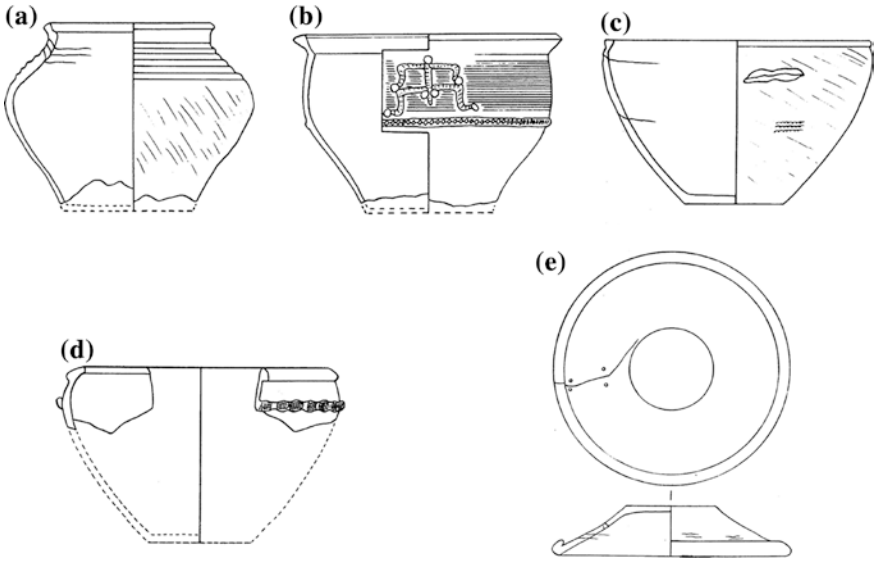


Fig. 8 Pottery of Yangshao Culture at Bancun Village, Mianchi County, Henan

into the body of a desired shape by capitalizing on the inertial force produced by rapid revolving of the wheel disk. It should be stressed here that there are qualitative differences between making pottery with quick jigger wheels and trimming pottery body with slow jigger wheels. If the body was not finely processed, spiral body-throwing finger marks would be left on the inner wall or even over the appearance, and the exterior bottom would see eccentric swirls formed by cutting with cotton rope.

Available data suggest that in China, making pottery with quick jigger wheels has diversified origins, and to be specific, it is originated from three regions and cultures: One is the mid-to-late period of Dawenkou Culture of the lower reaches of the Yellow River, such as lower-layer tomb and upper-layer tomb at Xixiahou Site, Qufu City, Shandong; another is the late period of Daxi Culture of the middle reaches of the Yangtze River, such as the fourth phase of Daxi Culture at Guanmiaoshan Site, Zhijiang City, Hubei; the other is the late period of Songze Culture of the lower reaches of the Yangtze River, such as the third phase of middle-layer tomb at Songze Site of Qingpu County, Shanghai, and gray black soil layer at Fuquanshan Site of Qingpu County. Actual age for Xixiahou Site was not determined by using 14C dating, while the remaining sites have undergone such determination (see Table 3) and the earliest was 3606 BC–3142 BC and the latest was 3360 BC–2944 BC.

A small amount of small pottery made with quick jigger wheels was discovered in the lower-layer tomb and upper-layer tomb at Xixiahou Site, and some small tripods (see Fig. 10b) have spiral body-throwing finger marks in the inner

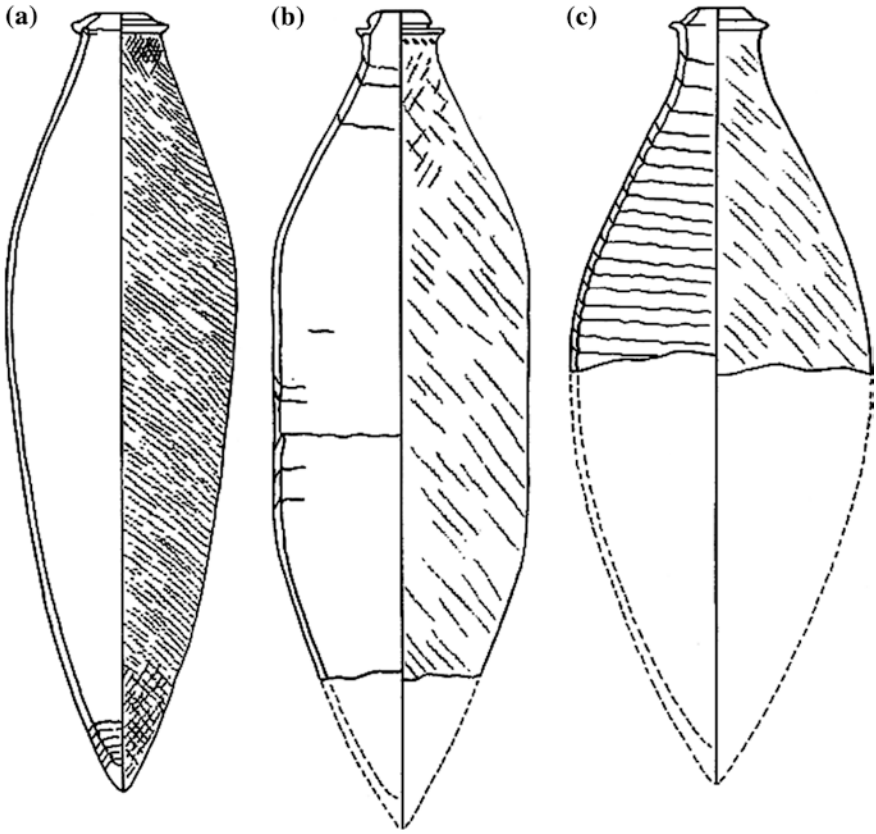


Fig. 9 Small-mouthed bottom-pointed bottle of Yangshao Culture at Bancun Village, Mianchi County, Henan

bottom, which was the traces of throwing the body with quick jigger wheels; some cups with high handle (see Fig. 10c) have fine wheel lines on the inner walls which were the traces of slow trimming the body left by quick jigger wheels; some small stem cups (see Fig. 10a) have eccentric swirls on the bottom which were the traces left by cutting with cotton rope. The above traces reflect the whole processes of making pottery with quick jigger wheels.

Pottery was made with quick jigger wheels at the fourth phase of Daxi Culture at Guanmiaoshan Site, such as bowl-shaped stem cup (see Fig. 10d), which features obvious spiral body-throwing finger marks on the inner wall of the circular leg and faintly visible body-throwing finger marks on the exterior surface of circular leg; bowl-shaped cup (see Fig. 10e) also has body-throwing finger marks on the inner wall of the circular leg.

Table 3 Data table of ages determined by 14C dating for the late period of Daxi Culture and the late period of Songze Culture

No. of laboratory sample	Site	Unit	Nature and phase of culture	Sample	Age determination (based on 5,730, the half-life of 14C)	Age calibrated by tree rings	
						According to Daman meter	High-resolution records
ZK-0382	Guanmiaoshan of Zhijiang, Hubei	T51③	The fourth phase of Daxi Culture	Charcoal	4,760 ± 110	5,330 ± 145	BC 3606–BC 3142
ZK-1250	Fuquanshan of Qingpu County, Shanghai	Gray black soil layer	late period of Songze Culture	Carbonized wood	4,730 ± 80	5,295 ± 120	BC 3499–BC 3142
ZK-0991	Guanmiaoshan of Zhijiang, Hubei	T76③BF30	The fourth phase of Daxi Culture	Charcoal	4,680 ± 80	5,235 ± 120	BC 3371–BC 3101
ZK-437	Songze of Qingpu County, Shanghai	T4M87	The third phase of middle-layer tomb	Human bones	4,635 ± 105	5,180 ± 140	BC 3360–BC 2944

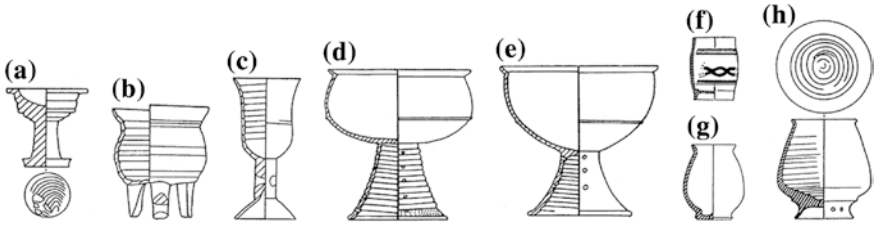


Fig. 10 Pottery made with quick jigger wheels; **a**–**c** were unearthed from Xixiahou Site, **d** and **e** were unearthed from Guanmiaoshan Site, **f** was unearthed from Songze Site, and **g** and **h** were unearthed from Fuquanshan Site

Pottery cup of the third phase of middle-layer tomb at Songze Site (see Fig. 10f) has clear traces of wheel revolving at the inner bottom, and the line graph shows that the inner bottom is concave–convex-shaped. Pottery pot at gray black soil layer at Fuquanshan Site (see Fig. 10g) also has traces of wheel revolving, and the line graph shows that the inner bottom appears concave–convex-shaped; on the pottery kettle (see Fig. 10h) spiral body-throwing finger marks are visible from the inner bottom to the inner wall.

Quick jigger wheel was the most advanced instrument for making bodies in the Late Neolithic Age, and the use of quick jigger wheel obviously increased the productivity of the pottery-making handicraft industry, having a profound impact on ceramic production of later generations.

2.3.3 Development of Technologies for Making Painted Pottery

Arc edge triangle pattern, the typical pattern of Miaodigou-type painted pottery of Yangshao Culture in the middle reaches of the Yellow River, has a wide range of influence. Tubular bottle of Daxi Culture in the middle reaches of the Yangtze River (see Fig. 11a) also has such patterns, reflecting the cultural exchanges between the north and the south.

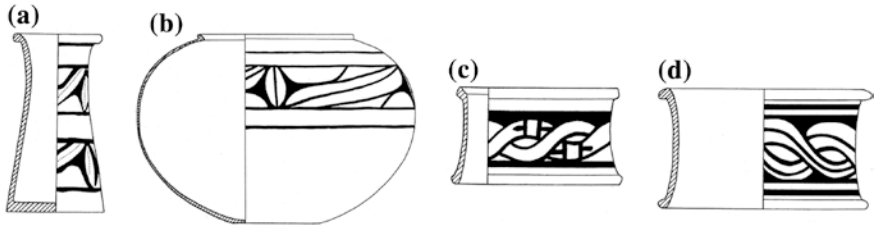


Fig. 11 Painted pottery of Daxi Culture unearthed from Guanmiaoshan Site of Zhijiang, Hubei. **a** Tubular bottle; **b** kettle; and **c** and **d** holder

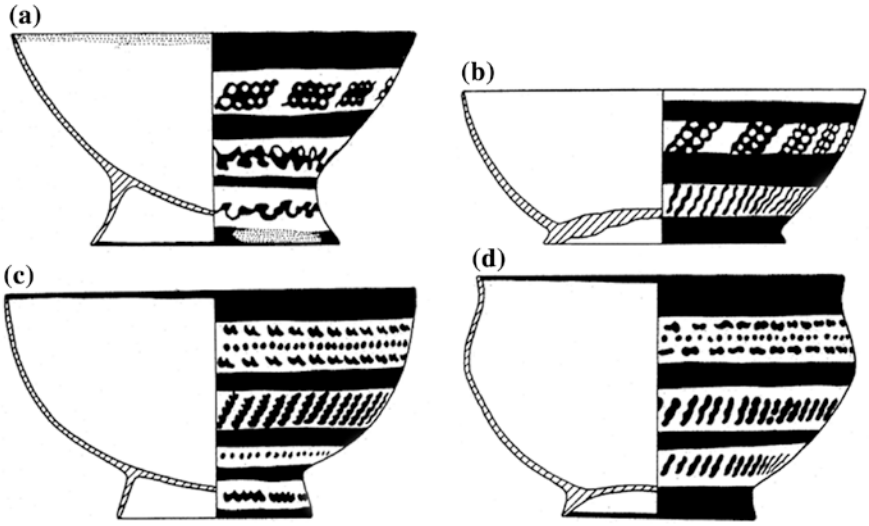


Fig. 12 Painted pottery bowl unearthed from Guanmiaoshan Site of Zhijiang, Hubei; **a**, **c,** and **d** were eggshell painted pottery

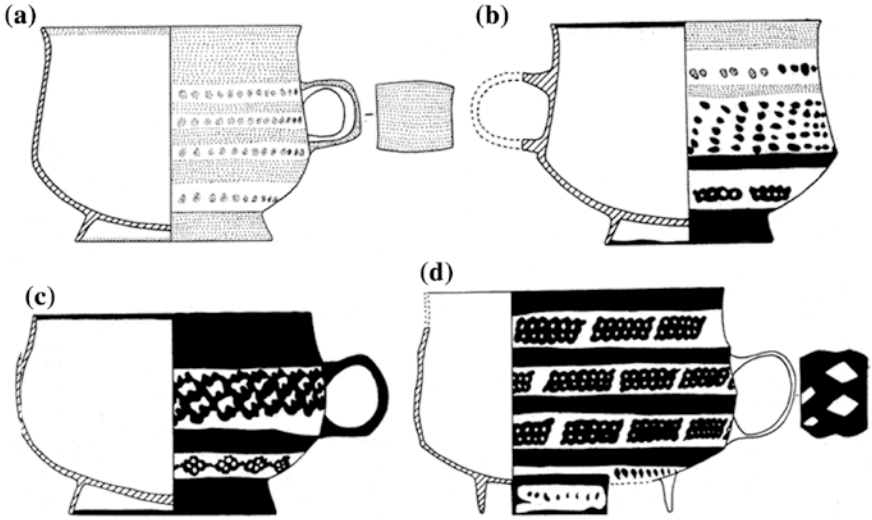


Fig. 13 Eggshell painted pottery single-ear cup unearthed from Guanmiaoshan Site of Zhijiang, Hubei

For both the eggshell painted pottery bowl of Daxi Culture (see Fig. 12a, c, d) and the eggshell Painted Pottery Single-ear Cup (see Fig. 13), the body wall has a thickness of only 0.7–1.5 mm, all modeled by hand and made thin by scraping with tools; besides, the surface was painted with red dot patterns, black dot patterns, curved patterns and curved lattice patterns. These eggshell painted potteries were made 5,940–5,830 years ago, and they are the artistic treasure of Daxi Culture.

2.3.4 Improvement of Updraft Horizontal Cave Kiln

The improvement was demonstrated by the separation of combustion chamber and firing room, such as pottery kiln of Yangshao Culture, Banpo Site of Xi'an, Shaanxi (see Fig. 14), and the fire chamber was in the front part, while kiln chamber is at the rear which was connected by flame path and fire hole. Improvement of pottery kiln enabled the firing temperature of pottery up to around 1,000 °C. Oxidized firing technology of Yangshao Period had already reached the peak; therefore, pottery was mainly red.

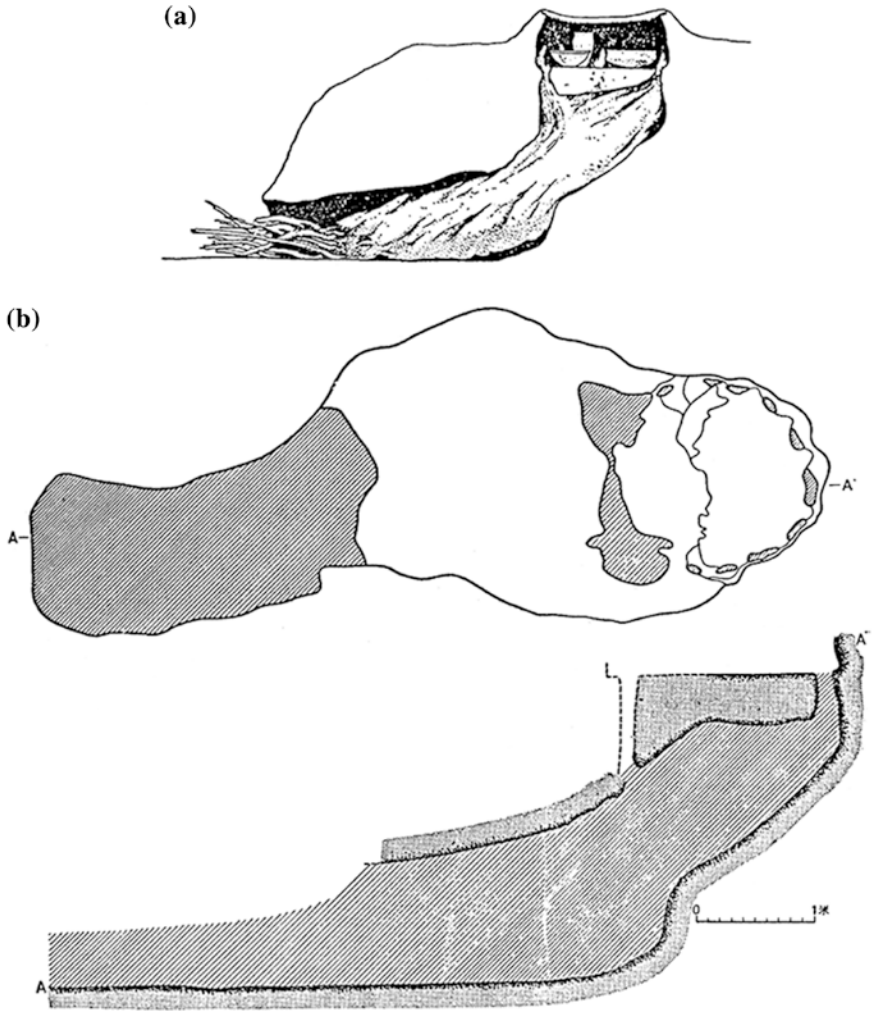


Fig. 14 Pottery kiln of Yangshao Culture at Banpo Site, Xi'an, Shaanxi

2.4 Pottery-Making Technologies in the Early Chalcolithic Period

Cultural relics of the Early Chalcolithic Period (3000 BC–2500 BC) include Majiayao Culture of Gansu and Qinghai, Caiyuan Culture of Ningxia, Culture of Second Phase of Miaodigou in Henan, Shaanxi and Shanxi, and Qujialing Culture of Hubei and Hunan. The Early Chalcolithic Period was a transitional period from "Yangshao Period" to "Longshan Period," reflected in two aspects: One is transition from modeling of the body by hand to modeling with wheeling–throwing and the second is firing of pottery transited from oxidized firing technology to reductive firing technology.

2.4.1 Imbalance of Development of Pottery-Making Technologies with Quick Jigger Wheels

Qujialing Culture of the middle reaches of the Yangtze River took a lead in terms of technologies for making pottery with quick jigger wheels; a small amount of pottery made with quick jigger wheels just appeared at the Second Phase of Miaodigou Culture of the middle reaches of the Yellow River. It can be seen that development of technologies for making pottery in the north and the south was imbalanced.

2.4.2 Molding was Originated at the Second Phase of Miaodigou Culture

This is a new modeling method, i.e., making pouched legs of Jia (a type of ancient Chinese ritual bronze vessel) with pottery inner mold. For example, Jia of the Second Phase of Miaodigou Culture from Guchengdongguan Site of Yuanqu County, Shanxi (see Fig. 15b), its body was handmade, adopting clay-strip building method, and the pouched legs were modeled by molding method, with vertical reverse blue grains (internal grains) on the inner wall of the pouched leg, which were reprinted from blue grains of the inner mold (external grains).

2.4.3 The Upper Reaches of the Yellow River Saw Highly Developed Technologies for Making Painted Pottery

Majiayao Culture falls into four types as Shilingxia, Majiayao, Banshan, and Machang. Majiayao Culture features highly developed technologies for making painted pottery. For example, painted pottery jar of Majiayao type unearthed from Sanping of Yongjing County, Gansu, which is as tall as 49.3 cm, generally known

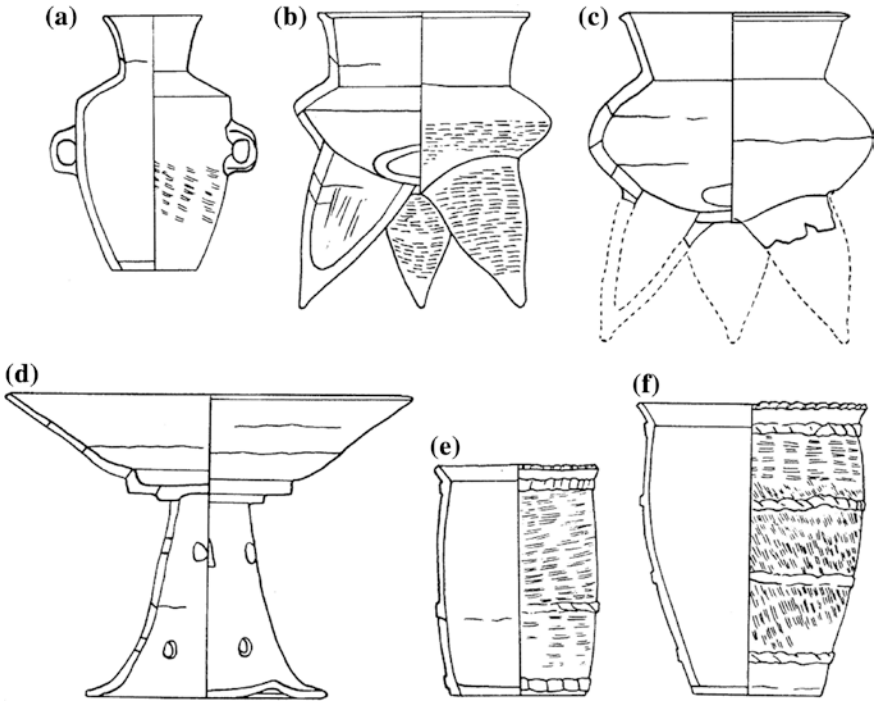


Fig. 15 Pottery of the Second Phase of Miaodigou Culture of Guchengdongguan Site, Yuanqu County, Shanxi

as "King of Painted Pottery," features paintings of black spiral patterns. Painted pottery jar of Machang type unearthed from Tugutai, Lanzhou, Gansu, was painted with black and red frog patterns.

2.4.4 Reductive Firing Pottery by Means of Vertical Cave updraft Kiln

It was an innovation of firing technology.

For example, two pottery kilns of the Second Phase of Miaodigou Culture of Guchengningjiapo Site, Yuanqu County, Shanxi (see Figs. 16 and 17), were all built on the bluff beside the big ditch, consisting of fire chamber, flame path, kiln chamber, kiln door, and outlets for water and smoke. After bodies were filled into the kiln, the kiln door was basically closed and only a hole was left for observing the fire.

Such kind of pottery kiln could use oxidizing flame as well as reducing flame. It is conjectured that the method for burning reducing flame was as follows: After oxidized firing, cover the majority of the fire mouth, leaving only a small hole for adding firewood, ventilating, and drawing out ash; close the outlets of water and smoke with slate or pottery and cover them with mixture of grass and earth and

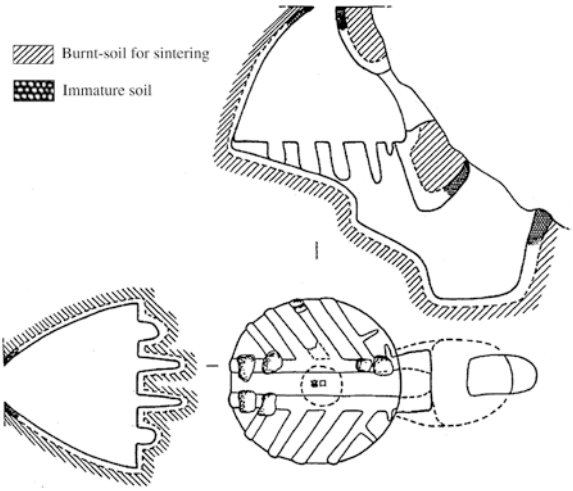


Fig. 16 Pottery kiln of the Second Phase of Miaodigou Culture from Guchengningjiapo Site, Yuanqu County, Shanxi

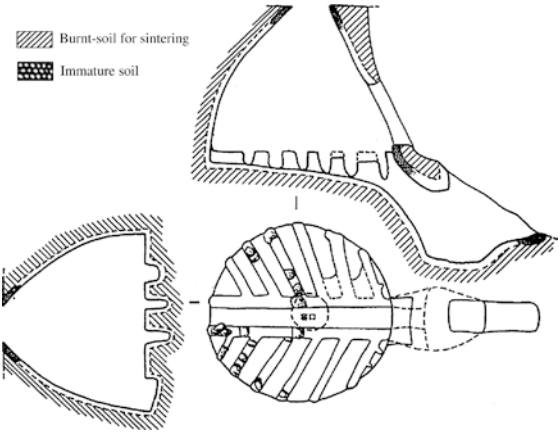


Fig. 17 Pottery Kiln of the Second Phase of Miaodigou Culture from Guchengningjiapo Site, Yuanqu County, Shanxi

then enclose them with low bank of earth into a basement pool; later, reductive firing was conducted and the hole for observing fire on the kiln door became temporary stack nozzle, and flame in the kiln actually became half inverse flame and the flame would reverse when rising to the closed roof of the kiln; after having transferred heat to the bodies, waste smoke and gas would be exhausted out of the kiln from the hole for observing fire. After having undergone reductive firing, the majority of iron in the pottery body has already been reduced from red iron oxide to gray ferrous oxide. And then close the hole for observing fire and fire mouth completely and slowly pour water in the basement pool, and the water gradually penetrates into the kiln through the covering layer and immediately becomes steam when meeting high temperature, appearing misty and separating the pottery from the outside world, for preventing reoxygenation; consequently, gray pottery and taupe pottery were made, and the latter was produced for inadequate reduction.

2.5 *Pottery-Making Technologies of the Late Chalcolithic Period*

Cultural relics of the Late Chalcolithic Period (2500 BC–2070 BC) include Taoshi Culture of Shanxi, Longshan Culture of Henan, Longshan Culture of Shandong, Shijiahe Culture of Hubei, Liangzhu Culture of Zhejiang, the Second Phase of Keshengzhuang Culture of Shaanxi, and Qijia Culture of Gansu, Qinghai and Ningxia. The archeology world called the Late Chalcolithic Period as "Longshan Period."

2.5.1 The First Climax of Technologies for Pottery-Making with Quick Jigger Wheels

The first climax of technologies for making pottery with quick jigger wheels was universally observed in the middle and the lower reaches of the Yellow River and the Yangtze River, and coastal areas of Shandong had seen the most developed technologies for making pottery with quick jigger wheels. For example, Gui Pot (see Fig. 18a, b) and Yan (an ancient cooking utensil) (see Fig. 18c, d) of the late period of Longshan Culture of Shandong, whose three pouched legs were separately made with quick jigger wheels, with the body modeled by reversely throwing and spiral body-throwing finger mark are visible from the inner wall and the exterior surface. The three pouched legs were combined into the lower part of the body, and the upper part was separately made with quick jigger wheels and then connected with the lower part. Thin-body cup with high handle was also called eggshell black pottery cup with high handle, representing the highest level of technologies for making pottery with quick jigger wheels of Longshan Culture of Shandong.

Thirty-one thin-body cups with high handle (see Fig. 19) unearthed from Sanlihe Tomb of Jiaozhou City have the following characteristics:

First, in terms of structure, these cups fall into three categories: Cups of the first category feature bottom of the cup body connected with the upper end of the handle (see Fig. 19a–d), totaled five pieces, accounting for 13 % of the total cups (31 pieces); cups of the second category are characterized by lower part of the cup body drooped into the handle and becoming the gut (see Fig. 19e–h, j–l), totaled

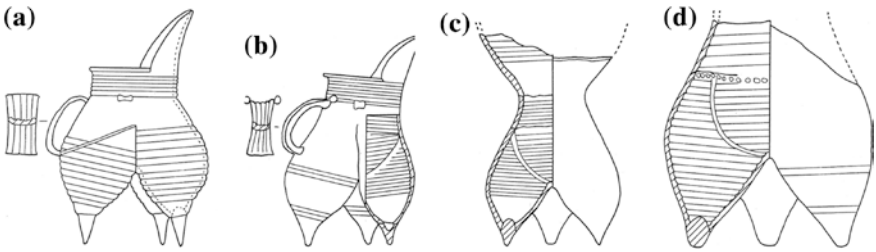


Fig. 18 Pottery made with quick jigger wheels of Longshan Culture of Shandong

24 pieces, accounting for 77.42 % of the total pieces; and cups of the third category have the characteristics of cup body completely drooped into the handle and becoming a typical gut (see Fig. 19i), totaled two pieces, accounting for 6.45 %. Putting cups of the second and the third categories together, there are 26 double-layer cups with gut and shell, accounting for 83.87 %. Double-layer cups were innovation of pottery in terms of structure. Various parts of the cup were separately made with quick jigger wheels and the gut was formed by reversely throwing the pug into bodies and then various parts were spliced for perfectly fitting each other.

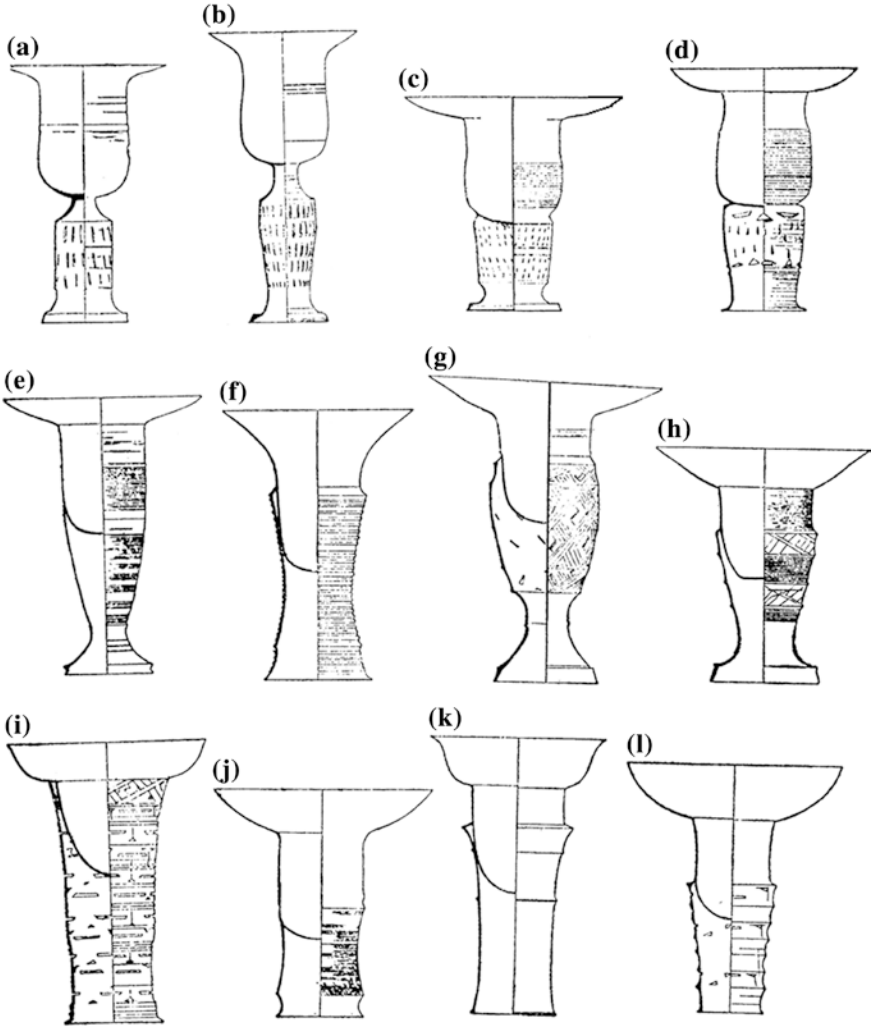


Fig. 19 Thin-body cups with high handles from Tomb of Shandong Longshan Culture, Shanlihe, Jiaozhou, Shandong

Second, from ornamentation, some cup bodies have string patterns and the majority of handles feature string patterns or bamboo joint patterns. All these ornaments were formed during the process of trimming the body slowly with quick jigger wheels. Some handles have incised patterns or engraved holes, all of which were made after the bodies had been trimmed by quick jigger wheels. Hence, it can be seen that thin-body cups with high handle are handicraft articles boasting complicated ornaments.

Thirdly, in terms of thickness of the body, caliber, height, and weight of the pottery, the caliber is between 9 and 15.3 cm, averaged 12.43 cm; the height of the pottery is between 12 and 22.7 cm, averaged 16.60 cm; and thickness of the body is between 0.3 and 1.5 mm, with an average of 0.72 mm. The most representative piece is shown in Fig. 19g; the caliber is 14.2 cm, the body is as thick as 0.3 mm, and the pottery has a weight less than 40 g. Thus, it can be seen that caliber and height of thin-body cups with high handle were moderate, and the bodies were as thin as eggshell and very light. When making such cups, quick jigger wheels were required to be very precise and the wheel disk should revolve quickly and stably. The technologies for making such pottery with quick jigger wheels were quite exquisite, which was unique in the history of technologies for making pottery with quick jigger wheels.

2.5.2 Molding Popular in the Middle Reaches of the Yellow River

In fat-leg Tripod Li (an ancient cooking tripod with hollow legs) of Taosi Culture at Taosi Site (see Fig. 20), the body was modeled by hand with the inner wall full of disordered dot patterns, which were reprinted from the pottery pad. The three pouched legs were modeled by molding, and the inner wall was full of orderly dot patterns which were reprinted from the inner mold. Attach the three pouched legs to the bottom of the body, and cut the inner wall of the body into three big round holes so that the inside of the body opens onto the inside of the pouched legs. Another example is thin-leg Tripod Li (see Figs. 21b–e and 22), which was made by utilizing three-leg internal mold (see Fig. 21a), and the three pouched legs were co-manufactured and de-molded as a whole.

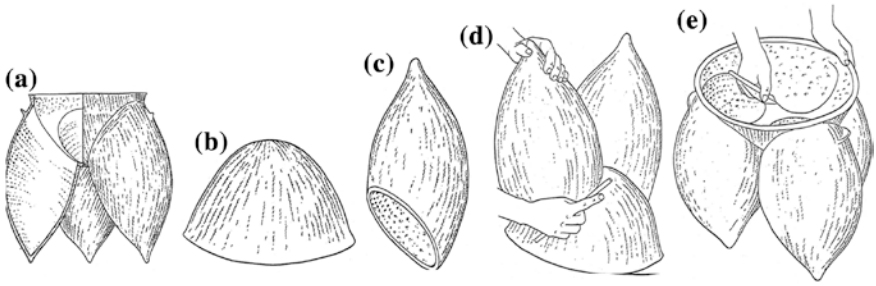


Fig. 20 Fat-leg Tripod Li of Taosi Culture at Taosi Site of Xiangfen County, Shanxi

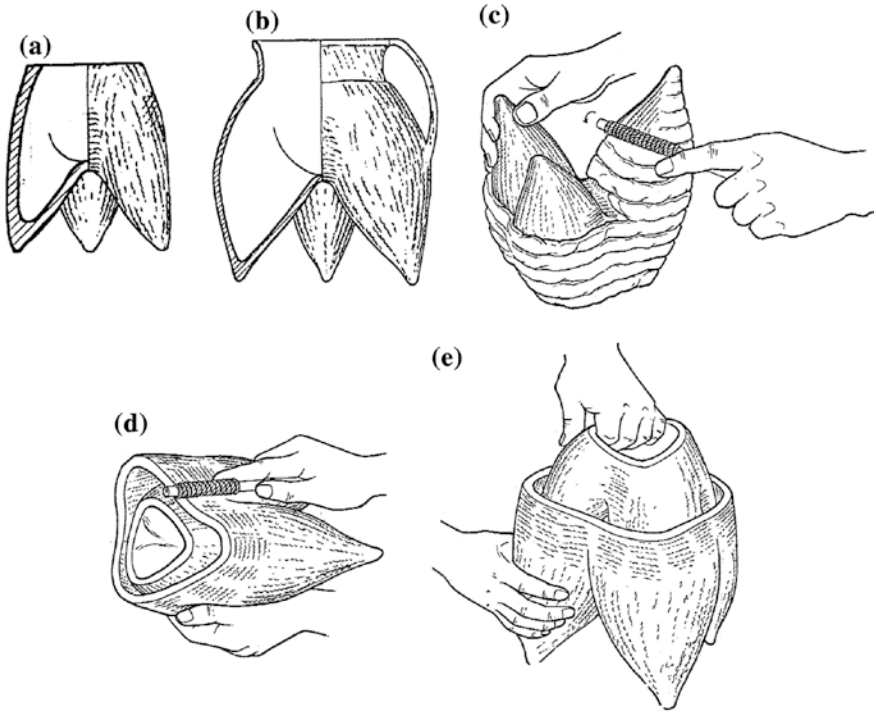


Fig. 21 Thin-leg Tripod Li of Taosi Culture at Taosi Site of Xiangfen County, Shanxi

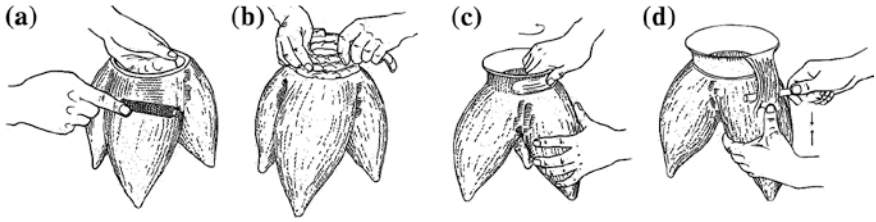


Fig. 22 Thin-leg Tripod Li of Taosi Culture at Taosi Site of Xiangfen County, Shanxi

2.5.3 Maturity of Reductive Firing Technology and Carburization Technology

Due to popularity and maturity of reductive firing technology, a great batch of pure gray pottery was fired. Compared with red pottery made by oxidized firing, gray pottery produced by reductive firing features fairly strong properties of resisting acid–base corrosion; therefore, the quality of pottery was obviously improved and that is why maturity of reductive firing technology is so important. Shandong's coastal areas became the region enjoying the most developed carburization technology, and eggshell black pottery cups with high handle feature

thorough carburization, representing the highest level of carburization technology. Carburization refers to tiny carbon granules penetrating into the holes of pottery bodies for blocking the holes, so as to prevent leakage of fluid in the pottery. Therefore, maturity of carburization technology is also of great significance.

2.5.4 Technologies for Painted Pottery Enjoyed Some Development

Painted pottery was pottery made by painting fired pottery with color pigments for decoration. For example, painted pottery plate unearthed from Taosi Tomb of Xiangfen County, Shanxi, was made by painting red dragon patterns on the carburized black pottery with cinnabar; painted pottery pot was made by painting red- and white-variant animal patterns on black pottery with cinnabar and calcite.

2.6 Pottery-Making Technologies of the Xia and Shang Dynasties

The Xia Dynasty (2070 BC–1600 BC), the early Shang Dynasty (1600 BC–1300 BC), and the late Shang Dynasty (1300 BC–1046 BC) had lasted more than 1,000 years in total. China entered slave society with the founding of the Xia Dynasty. The cultural center of the Xia Dynasty and Shang Dynasty was Henan, and typical cultural relics are Erlitou Site of Yanshi, Shangcheng (city of the Shang Dynasty) of Yanshi, and Shangcheng of Zhengzhou and Yinxu (Yin Dynasty ruins) of Anyang. In addition, other cultural relics include Zhengyao Site of Mianchi County, Henan, Tomb of Lower Layer of Xiajiadian Culture, Dadianzi, Aohan Banner, Chifeng, Inner Mongolia, Yuanqu Shangcheng of Shanxi, Panlongcheng, Huangbei, Hubei, and stamped hard pottery of areas such as Jiangxi.

2.6.1 Technologies for Making Pottery with Quick Jigger Wheels Obviously Backed up

Technologies for making pottery with quick jigger wheels in the Xia Dynasty and Shang Dynasty entered into a low ebb, and making pottery with slow jigger wheels and clay-strip building method once again ascended to the main place. For instance, pottery of Zhengyao Site, Mianchi County (see Fig. 23), has obvious traces of clay strips on the inner wall.

2.6.2 Pottery Tripod Li Made by Molding Enjoyed Development

For example, for Tripod Li discovered at Erlitou Site of Yanshi County (see Fig. 24b), the three pouched legs were separately made by molding and joined together for becoming the lower part of the body. The upper party was handmade and jointed with the lower part.

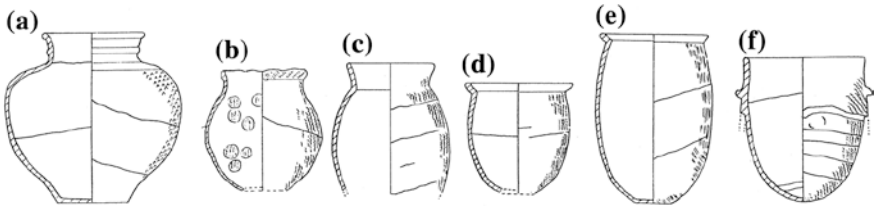


Fig. 23 Pottery made by twisting clay strips discovered at Zhengyao Site, Mianchi County, Henan

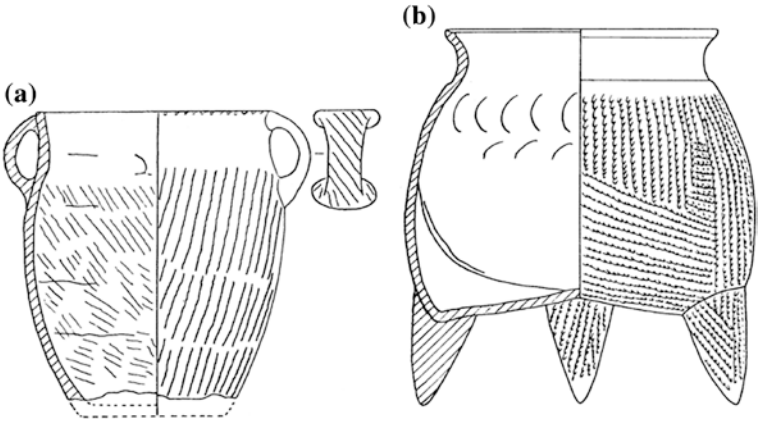


Fig. 24 Pottery made by molding of Erlitou Culture at Erlitou Site, Yanshi County, Henan

2.6.3 Stamped Hard Pottery and Proto-Porcelain Successively Emerged

Stamped hard pottery appeared in the Xia Dynasty, and proto-porcelain emerged in the Shang Dynasty. Since then, pottery-making technologies transited to technologies for making porcelain. And the whole transition period lasted more than 2,000 years from the Xia Dynasty to the Han Dynasty.

Stamped hard pottery refers to hard pottery featuring ornamentation made by tap-stamping or roll-printing. For instance, stamped hard pottery stem cup of the Shang Dynasty unearthed from Huangtulun Site of Minhou County, Fujian, features lightening design made with tap-stamping. Hard pottery jar of the Shang Dynasty unearthed from Panlongcheng of Huangbei (see Fig. 25a) also has lightening patterns made with tap-stamping.

The raw material used for stamped hard pottery is high-silica clay, featuring high silicon oxide, low fluxing agent, coarse texture, and high degree of fire resistance. As the texture is quite coarse, it is not suitable for adopting the method of modeling by throwing the pug into bodies with quick jigger wheel pulling, and clay-strip building method had to be used; besides, the body should be carefully

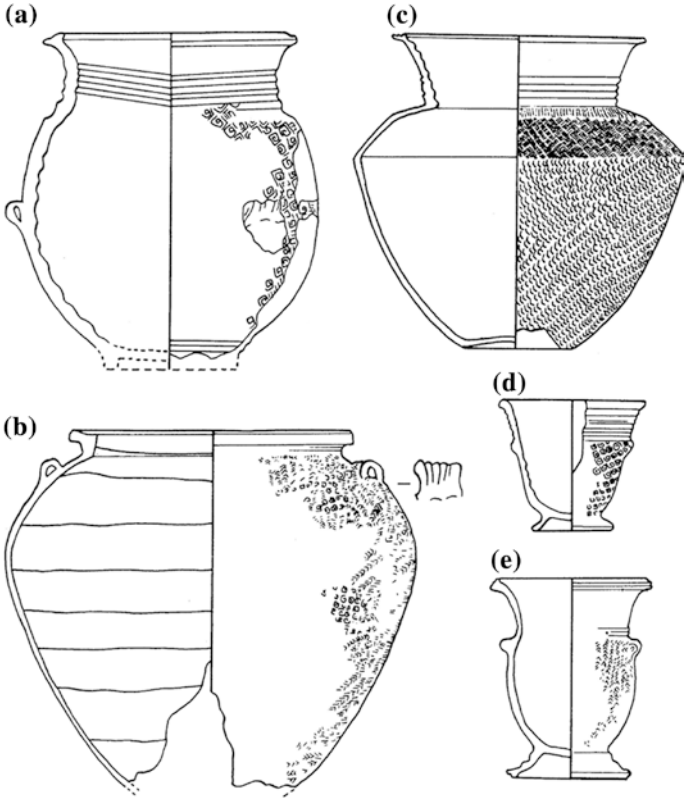


Fig. 25 Hard pottery and glazed pottery of the Shang Dynasty unearthed from Panlongcheng of Huangbei, Hubei

patted or rolled for consolidation. Patterns produced on the body by patting or rolling the body were the stamped patterns. Due to fairly high degree of fire resistance (the internal cause), and firing the body in the flat flame kiln featuring fairly high temperature (the external cause), the fired pottery became stamped hard pottery featuring high firing temperature (up to 1,150 °C), hard texture, and low water absorption. Pottery pat (see Fig. 26b) and pottery sticks (see Fig. 26a, c) of the Shang Dynasty unearthed from Jiaoshan Kiln Site of Yingtan, Jiangxi, were tools used for patting or rolling patterns on the bodies. While patting the exterior surface, pottery pad (see Fig. 26d, e) would be used for supporting the inner wall.

2.6.4 Emergence of Horizontal Flame Kiln

Horizontal flame kiln was commonly known as dragon kiln. For example, horizontal flame kiln of the Shang Dynasty at Wucheng, Qingjiang County (Zhangshu City today), Jiangxi (see Fig. 27c), is strip-shaped. The kiln has nine

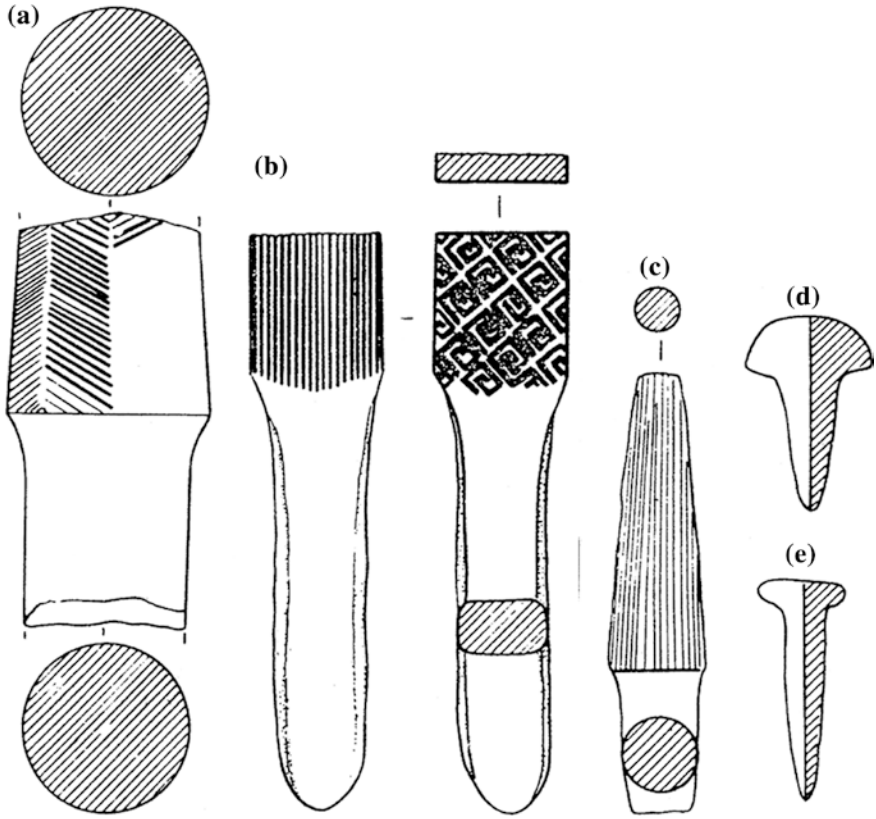


Fig. 26 Pottery-making tools unearthed from Jiaoshan Kiln Site of Yingtan, Jiangxi. **a**, **c** Pottery sticks; **b** pottery pat; and **d**, **e** pottery pad

firewood-filling holes at one side which separated the combustion chambers so as to make bodies at various parts of the kiln to be evenly heated. Horizontal flame kiln of the Shang Dynasty at Lijiashan, Shangyu County, Zhejiang (see Fig. 27d), is also strip-shaped with the kiln bottom having a gradient of 16; therefore, its force for pumping the air is quite strong, and the speed of rising temperature is quite quick. Horizontal flame kiln can easily maintain the reducing atmosphere, conducive to improving quality of pottery.

2.6.5 Technologies for Painted Pottery Enjoyed Rapid Development

Tomb of Lower Layer of Xiajiadian Culture at Dadianzi, Aohan Banner, was built at the time of alternations of the Xia Dynasty and the Shang Dynasty, from where a total of 420 pieces of painted pottery were unearthed (see Fig. 28), approximately accounting for 25 % of the total amount of pottery buried with

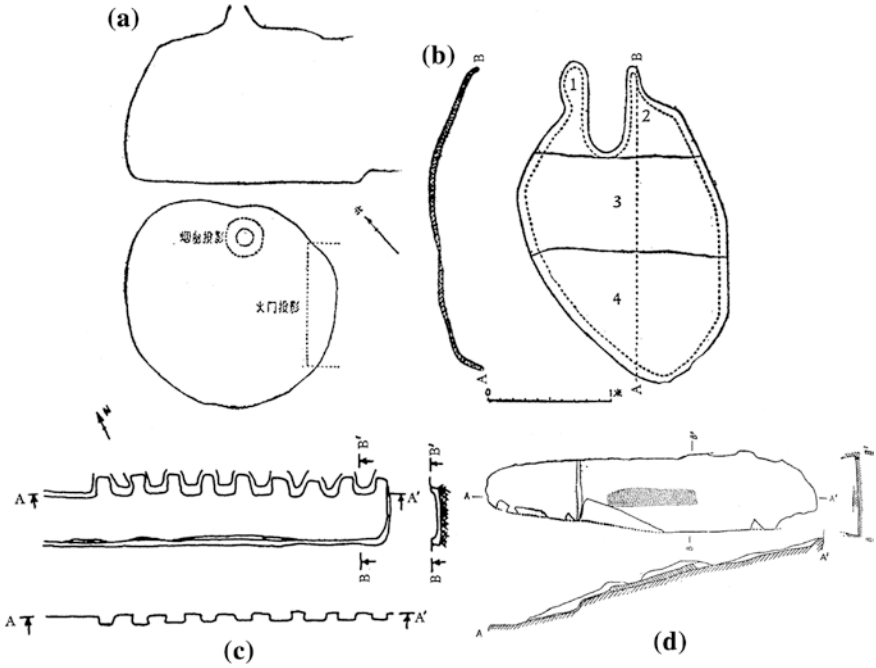


Fig. 27 Kiln sites of the Shang Dynasty

the dead (1,683 pieces). The pigments used for painting pottery include cinnabar and ground hematite, and the drawing tools should be brush which was used for painting complicated patterns on the exterior surface of carburized black pottery. Technologies for making painted pottery were meticulous, while the techniques for firing were quite casual and the firing temperature was mostly 600–700 °C; consequently, the pottery features low hardness and proneness to crush and is funerary ware specially produced to be buried with the dead, also known as burial objects.

2.7 Pottery-Making Technologies of the Western Zhou Dynasty and the Spring and Autumn Period

The Western Zhou Dynasty (1046 BC–771 BC) and the Spring and Autumn Period (770 BC–476 BC) were still slave society. Cultural relics of this period include Western Zhou Graveyard at Zhangjiapo, Chang'an County, Shaanxi, Residence and Graveyard of Tianma-Qucun in Quwo County and Yicheng County of Shanxi, and Shangma Graveyard of Houma, Shanxi. King Wen of the Western Zhou Dynasty built Fengyi and King Wu built Haojing and Zhangjiapo Graveyard was located in Fengyi and Haojing sites. Tianma-Qucun was the capital of the early Jin Dynasty, and Shangma Graveyard was the graveyard of the capital of the late Jin Dynasty.

Fig. 28 Painted pottery of Lower Layer of Xiajiadian Culture at Dadianzi, Aohan banner of Inner Mongolia

2.7.1 Pottery Modeling Technologies

Clay-strip building method still dominated in this period. For example, pottery kettles unearthed in Tianma-Qucun (see Fig. 29) have traces of clay strips on the inner wall. Pottery Tripod Li unearthed from Zhangjiapo Graveyard of the Western Zhou Dynasty was handmade. Pottery Tripod Li unearthed from Shangma Graveyard (see Fig. 30) has traces of clay strips on the inner wall, and

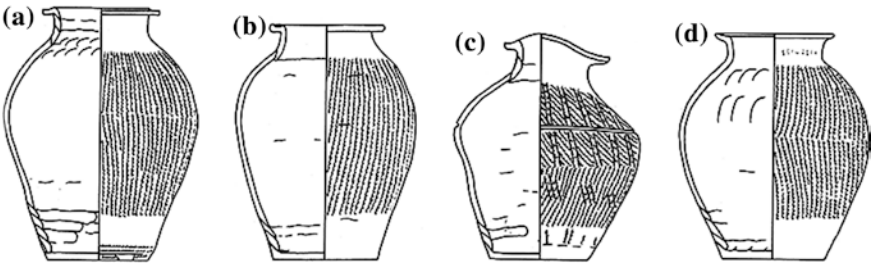


Fig. 29 Pottery kettles unearthed from Tianma-Qucun Residence Site of Spring and Autumn Period in Quwo County and Yicheng County of Shanxi

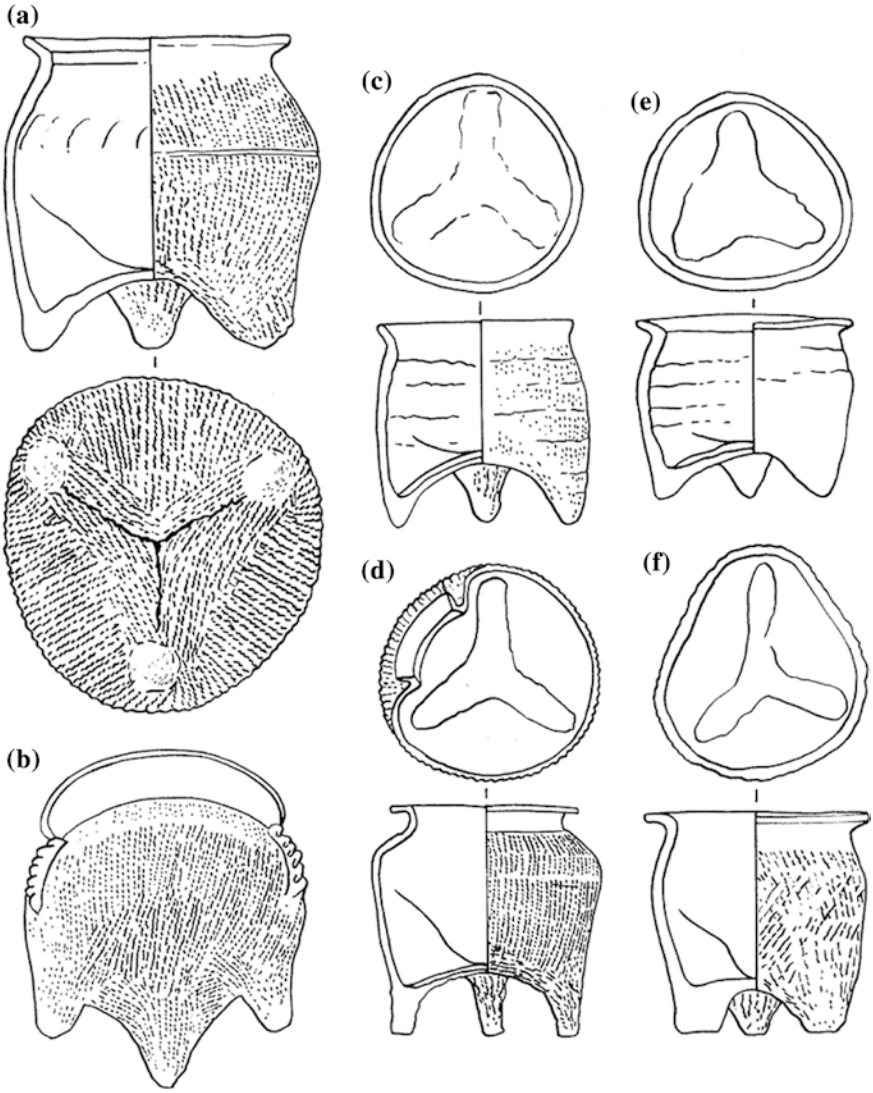


Fig. 30 Pottery Tripod Li made with clay-strip building method unearthed from Shangma Graveyard of the Zhou Dynasty, Houma City, Shanxi

the modeling method was as follows: Pour clay for building the clay drum, and then shut the drum for modeling crotch. The Zhou clan vigorously promoted handmade pottery Tripod Li; thus, handmade pottery Tripod Li became the most representative implement in the Zhou Dynasty. A total of 877 pieces of pottery Tripod Li were unearthed from Shangma Graveyard, accounting for 90.88 % of the total amount of 965 pieces of pottery buried with the dead, and this graveyard was simply an underground museum of pottery Tripod Li.

Technologies for making pottery with quick jigger wheels were still at a low ebb. A small amount of pottery stem cups with thin handle of the late Spring and Autumn Period were unearthed from Tianma-Qucun Residence Site of the Spring and Autumn Period (see Fig. 31), which have spiral body-throwing finger marks on the inner wall. Besides, inner wall of the stem cup and exterior surface of the handle were decorated with dark fringes.

2.7.2 Stamped Hard Pottery was Popular in the Western Zhou Dynasty

For example, stamped hard pottery jar unearthed from Fushanguoyuan Tomb of Western Zhou Dynasty in Jurong County, Jiangsu, features check designs made by tap-stamping; stamped hard pottery vase features curved patterns on the exterior surface made by tap-stamping.

2.7.3 Half Up-and-Down Draft Kiln Basically Came into Being

For example, half up-and-down draft bread-shaped kiln (see Fig. 32) of the middle of the Spring and Autumn Period at Tianma-Qucun Residence Site of the Spring and Autumn Period, consisting of kiln entrance, fire chamber, kiln floor, completely closed kiln crown, and vertical heating flue on the back wall, is a kind of same cave kiln, i.e., fire chamber and kiln chamber were in the same cave. It is easy for half up-and-down draft kiln to maintain reducing atmosphere. Therefore, pottery fired with it boasted obvious better quality compared with pottery fired with updraft kiln.

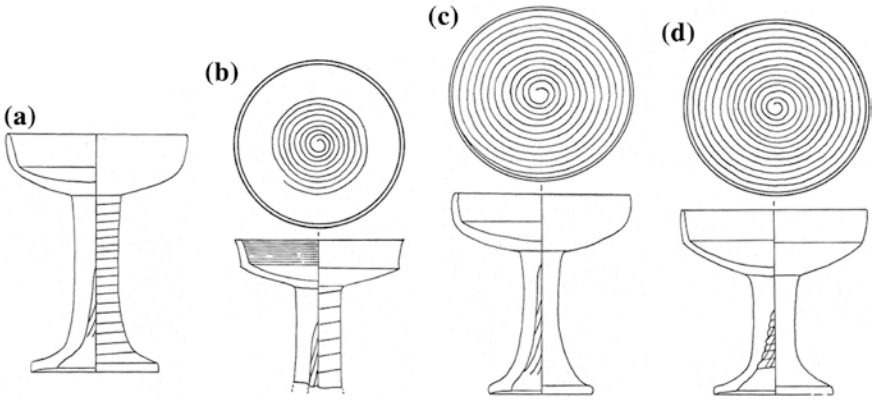


Fig. 31 Pottery stem cup made with quick jigger wheels in the late Spring and Autumn Period, unearthed from Tianma-Qucun Residence Site of Spring and Autumn Period in Quwo County and Yicheng County of Shanxi

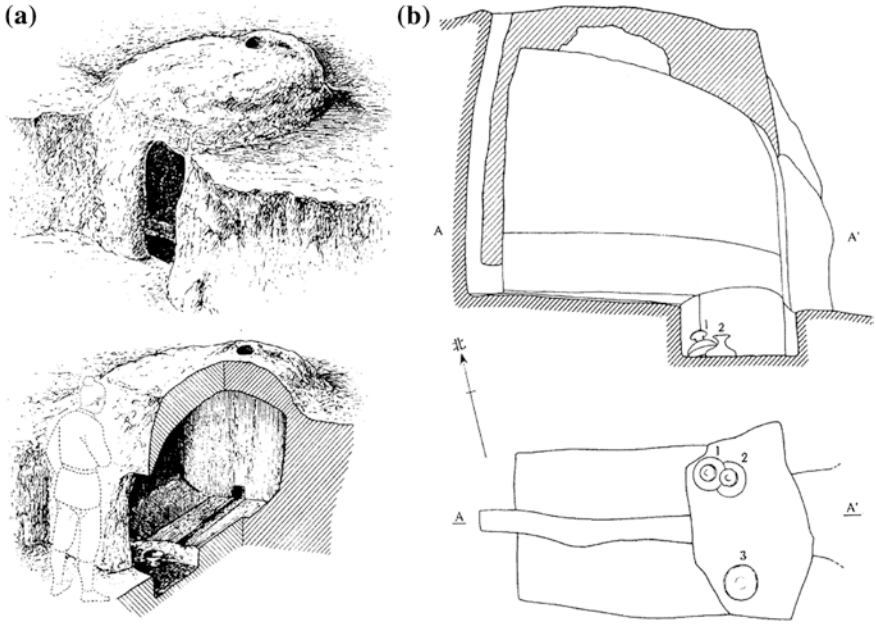


Fig. 32 Pottery kiln of Spring and Autumn Period at Tianma-Qucun Residence Site of Spring and Autumn Period in Quwo County and Yicheng County of Shanxi

2.8 Pottery-Making Technologies of the Warring States Period and Qin Dynasty

China entered feudal society from the Warring States Period (475 BC–221 BC). Emperor Qin Shi Huang annexed the other six states Han, Zhao, Wei, Chu, Yan, and Qi with force, hence ending the history of feudal nobles dividing the country, and established Empire Qin, i.e., the Qin Dynasty (221 BC–207 BC), the first united centralized feudal state of China. Numerous terra-cotta soldiers and horses were unearthed from the three pits on east side of Qin Shi Huang Mausoleum in Lintong County, Shaanxi, which are parts of buildings of Qin Shi Huang Mausoleum and from where a total of 1,179 pieces of pottery figurines and 132 pottery horses were unearthed.

2.8.1 Terra-Cotta Warriors and Horses in Qin Shi Huang's Mausoleum Were a Comprehensive Expression of Pottery-Making Technologies of the Qin Dynasty

Terra-cotta warriors and horses were generally made with two-layer bodies, the inner layer of which was sand-mixed pottery and the exterior layer of which was clay pottery. Two-layer bodies feature advantages of solidness and beauty,

which was an innovation in using materials. Generally, clay-strip building method and modeling with external molding were adopted. For example, traces of clay strips can be obviously seen on the inner wall of the body of pottery figurines (see Fig. 33), and the head of the figurines was modeled by front–back mold clamping (see Fig. 34); body and head of pottery horses were made by bringing many clay pieces together, and horse legs were formed by left–right mold clamping (see Fig. 35). Terra-cotta warriors and horses were painted pottery and were painted red, green, purple, blue, yellow, white, black, and reddish brown after having been fired.

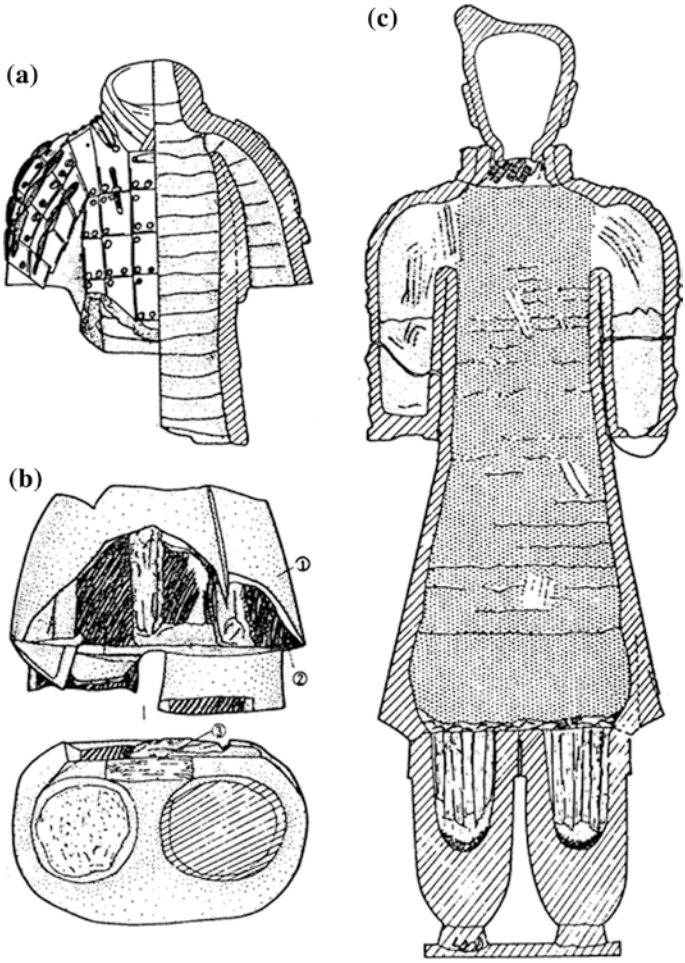


Fig. 33 Pottery figurine unearthed from pits of terra-cotta warriors and horses of Qin Shi Huang's Mausoleum in Lintong County, Shaanxi

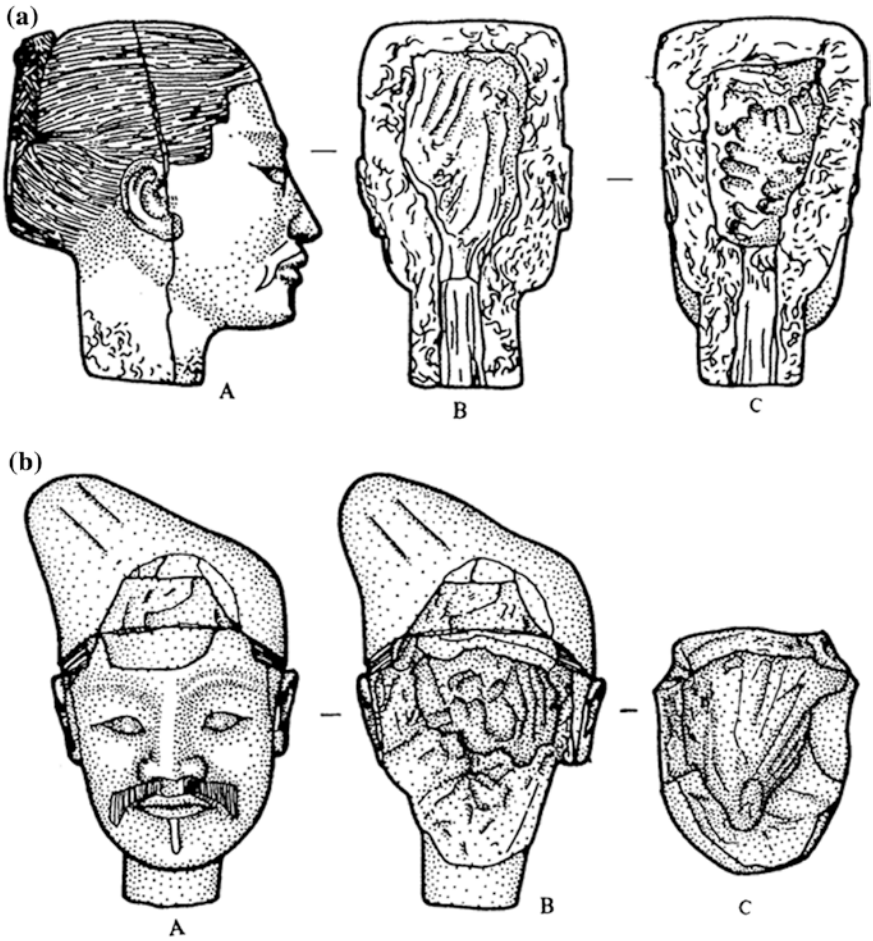


Fig. 34 Heads of pottery figurines unearthed from pits of terra-cotta warriors and horses of Qin Shi Huang's Mausoleum in Lintong County, Shaanxi

2.8.2 Social Causes for Unprecedented Development of Technologies for Making Pottery Terra-Cotta Warriors and Horses of Qin Shi Huang's Mausoleum

There are two social causes: One is the beneficial social conditions. Unity of the country accelerated the development of social productive forces, and concentration of capital and resources around the country was conducive to large-scale building of mausoleums. It is thus clear that strengthened comprehensive national power was the most important social cause for firing and making terra-cotta warriors and horses. With transformation of social system from slavery to feudalism, social morality that burying the alive with the dead was replaced with pottery figurines

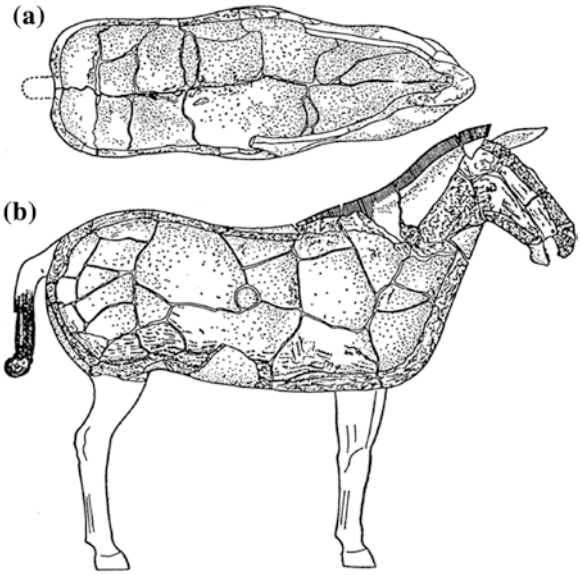


Fig. 35 Pottery horse unearthed from pits of terra-cotta warriors and horses of Qin Shi Huang's Mausoleum in Lintong County, Shaanxi

became increasingly popular, it thus can be seen that Terra-Cotta Warriors and Horses were the products of changed of social system and funeral customs. The ruling class, managers of pottery-making handicraft industry and pottery-making artisans all deemed pottery figurines and pottery horses as humans and real horses and praised Emperor Qin Shi Huang's achievements of uniting China by force in array of terra-cotta warriors and horses, so it is very clear that terra-cotta warriors and horses were products of popular thinking of the Qin Dynasty. The second one was effective management system. According to *Spring and Autumn Annals of Master Lü*, in the Qin Dynasty, management system of "Carving Names on Utensils" was adopted for handicraft industry, especially governmental handicrafts, i.e., carving names of the artisans on the utensils they made for testing whether the artisans were sincere or not. In case of any inappropriateness in their work, relevant personnel would be investigated and held accountable or even convicted. Thus, it can be seen that "carving names on utensils" was actually a kind of responsibility system. Currently, 249 names of artisans have been found on pottery figurines and pottery horses, and there are actually 80, without taking account of the repeated ones. The facts show that the management system of "carving names on utensils" effectively guaranteed the quality of terra-cotta warriors and horses.

2.8.3 Modeling of Hollow Bricks

Hollow bricks were pottery used for large-scale buildings. As they were rectangle-shaped and hollow inside, they were called "hollow bricks." Such bricks were used for building steps of palace buildings or building coffin pit of tombs for replacing wooden coffin pit. Hollow bricks were a kind of innovation of pottery-making

artisans in the middle and late of the Warring States Period. They objectively complied with the principle of pressure that can be borne by hollow object equals that can be borne by solid objects; therefore, they attracted the attention of domestic and foreign scholars.

Hollow bricks were originated from Qin State of the Warring States Period, and later, they were made in other places. For example, hollow bricks of former cities of Zheng State and Han State in the late Warring States Period in Xinzheng City, Henan (see Fig. 36), were formed by matching each clay tablet, belonging to molding method. Clay tablet was the intermediate link from pug to body, and the clay tablet was matched one by one; besides, the tools used for molding should be woody groined boxlike external mold and twin-H supporting board (see Fig. 37). It is conjectured that external mold consists of base plate, toe part, heel part, left block, and right block, and it is convenient for assembling and dismantling; the supporting board is comprised of the upper and lower rectangular boards (the top plate and bottom plate) and two square timbers (backbone) in the middle, which is actually an internal mode that can be dismantled and moved. Emergence of twin-H internal mode dissolved the key problem that how to make the internal part of the brick body be hollow.

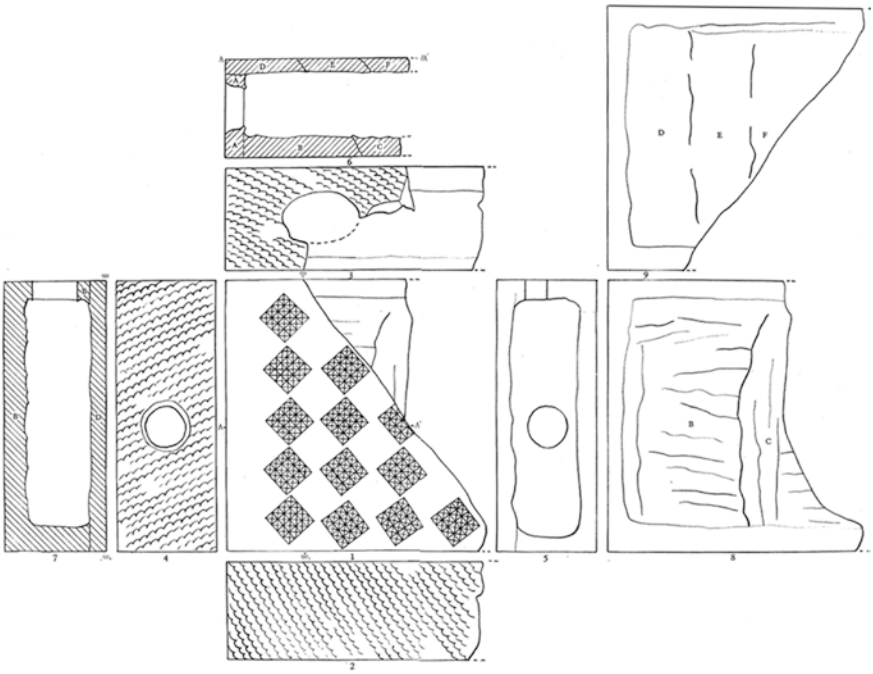


Fig. 36 Hollow bricks of former cities of Zheng State and Han State in the late Warring States Period in Xinzheng City, Henan

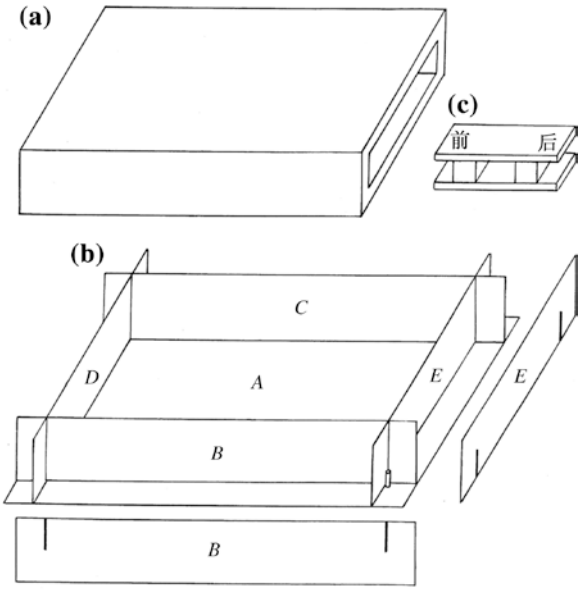


Fig. 37 Diagrammatic map for restoration of hollow brick, external mold, and supporting board

2.9 Pottery-Making Technologies of the Han Dynasty

The Han Dynasty includes the Western Han Dynasty (206 BC–25 AD) and the Eastern Han Dynasty (25 AD–220 AD). It is the historical period when the feudal society gradually became thriving. Cultural relics of this period include Tomb of Han Dynasty in Shaogou of Luoyang, Henan, Tomb of Han Dynasty in Pingshuo, Shanxi, and Kiln Site of Chang'an City of Han Dynasty in Xi'an, Shaanxi.

2.9.1 Technologies for Making Pottery with Quick Jigger Wheels Presented the Second Climax

In the Han Dynasty, pottery-making industry had already become a kind of commodity production and was one of the three handicraft industries (iron smelting, painting, and pottery-making). Some workshops for making pottery were privately operated, and some were government-managed. Development of the commodity economy boosted emergence of the second climax of technologies for making pottery with quick jigger wheels. A great number of potteries were made with quick jigger wheels and they commonly featured large volume and fairly high firing temperature and even funerary ware also featured a firing temperature of around 1,000 °C, which is obviously different from that previously produced because they were mostly fired with reducing flame and hence became pure-colored gray

pottery. The scale of the second climax of technologies for making pottery with quick jigger wheels was far larger than the first climax in the Late Chalcolithic Period (Longshan Period), which can be demonstrated by the magnificent scene of more than 12,000 pieces of pottery of the Han Dynasty made with quick jigger wheels put together in Museum of Shuozhou City, Shanxi.

2.9.2 Method of Making Pottery with Internal Mode was Basically Replaced by that with External Mode

Some pottery container (such as pottery cup with handle) or parts of pottery (such as pottery cover, double handles, and three legs) were formed by adopting external mode. The method of making pottery with external mode includes pottery-making method with single mold and pottery-making method with die assembly, with their advantages lying in automatic de-molding by capitalizing on the body's property of shrinking when becoming dry. Method of pottery-making with external mold in Han Dynasty had already realized part standardization (see Fig. 38), outstandingly shown in the making of Boshan Lid (see Fig. 38b). Back then, it is widely rumored that there were three divine mountains in the East China Sea, including Penglai; therefore, vessel's lid was mountain-shaped, symbolizing exceptionally charming scenery of Penglai. Part standardization refers to a part made with external mold that can work closely with different utensils or be installed on different utensils as an accessory. The method for making Boshan Lid was as follows: The master model was made first and then fired and used for making external mold which was also fired; later, clay was filled in the external mold for making the body of Boshan Lid. Thus, a master model could be used for reproducing multiple external molds, and an external mold could also be used for duplicating multiple pieces of products. Due to part standardization, Boshan Lid, a kind of utensil with complex shape, could be produced in batch and used in common as well as exchanged in use and thus greatly reduced the production costs and raised labor productivity.

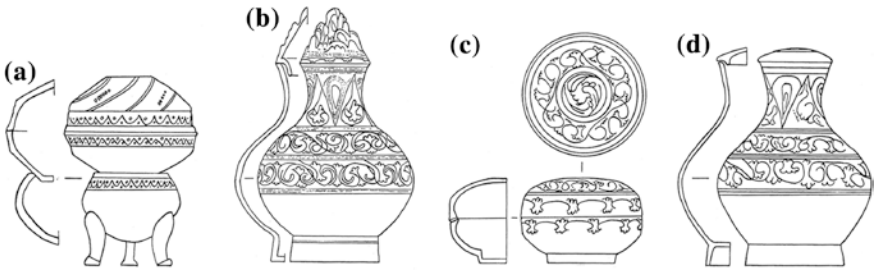


Fig. 38 Painted pottery unearthed from Pingshuo Tomb of the Han Dynasty of Shuozhou City, Shanxi

2.9.3 Painted Pottery Had Become the Distinguishing Feature of Decoration Technologies of the Han Dynasty

Including pottery pot painted with dragon pattern unearthed from Tomb of Han Dynasty in Shaogou of Luoyang and painted pottery unearthed from Tomb of Han Dynasty in Pingshuo, with the number reached more than 800 pieces (see Fig. 38), accounting for over 6 % of the total of pottery (12,000-plus pieces), and they were colored white, black, gray, red, yellow, green, and blue, showing that decoration technologies for painted pottery in the Han Dynasty reached the peak.

2.9.4 Low-Temperature Plumbic-Glazed Pottery Appeared in the Western Han Dynasty

Like the green-glazed owl-shaped Zun (an ancient wine vessel) of the Han Dynasty unearthed in Sanmenxia City, Henan, brownish red-glazed and colored pot of the late Western Han Dynasty were unearthed from No 4 Tomb of Han Dynasty at Tanjiacun of Baoji City, Shaanxi. Low-temperature plumbic-glazed pottery was made by once firing in oxidizing atmosphere with lead oxide as the fluxing agent and copper as the coloring element at a firing temperature of around 900 °C.

2.9.5 Half Up-and-Down Draft Kiln Enjoyed Obvious Improvement

For example, pottery kiln of Chang'an City of Han Dynasty (see Fig. 39) has the following characteristics: Fire division wall was established in the kiln for enabling flame to evenly enter into the kiln chamber through the fire inlet in the wall; besides, a partition was also established for separating the flame, which divided the chamber into the left and right parts, so that flame could freely and evenly flow through the fire-passing hole in the wall; at the joint of kiln walls and the kiln floor, three smoke inlets were set up which were connected with the three flues behind them and all of them converged to form a main smoke flue which was used for exhausting the waste smoke out of the kiln. All of these measures could make the temperature at various parts in the chamber be even so as to prevent the phenomenon of overfiring or underfiring of some parts and thus improved the qualification rate and quality of the finished pottery.

2.10 Pottery-Making Technologies of the Northern Wei Dynasty

There are few reports about pottery-making technologies of the Northern Wei Dynasty (386 AD–534 AD). Tuoba family of the Xianbeis was a clan of the Xianbei ethnic minority. In 398 AD, Tubagui, an emperor of the Northern Wei

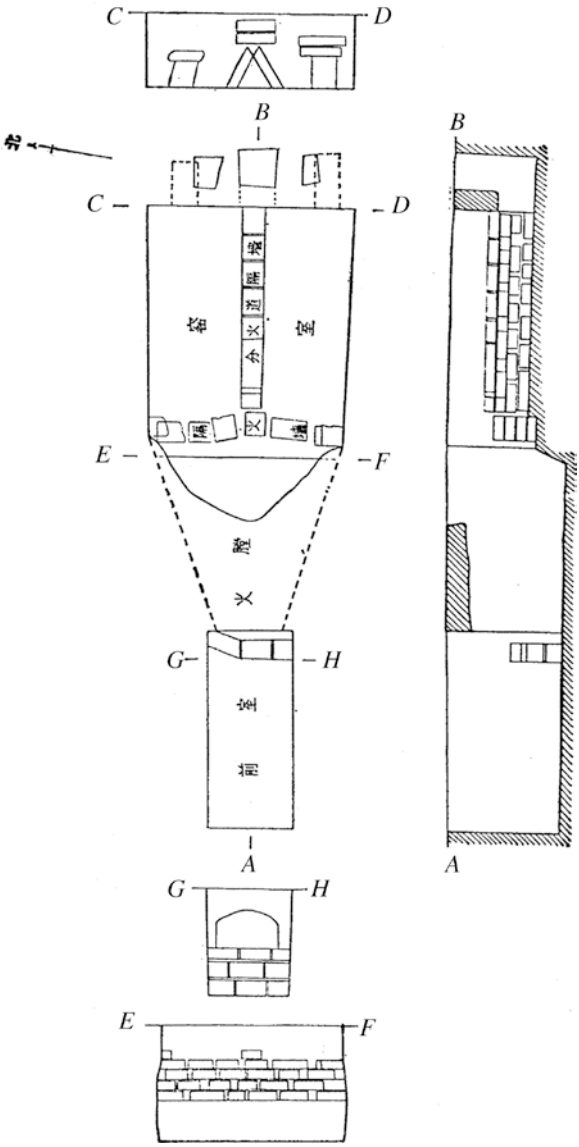


Fig. 39 Pottery Kiln of Chang'an City of Han Dynasty in Xi'an City, Shaanxi

Dynasty moved the capital Shengle (today's Heringer County, Inner Mongolia) to Pingcheng (today's Datong City, Shanxi), which had been the capital of the Northern Wei Dynasty for nearly 100 years before Xiaowen Emperor of the Northern Wei Dynasty moved the capital to Luoyang in 494 AD. Tombs of the Northern Wei Dynasty at the southern suburbs of Datong were the cultural relics of Tuoba Xianbei. One hundred and sixty-seven tombs were excavated, and a total of 754 pieces of pottery were unearthed, of which 93.37 % were common pottery (see Figs. 40, 42 and 43), and glazed pottery accounted for 6.63 % (see Figs. 44 and 45).

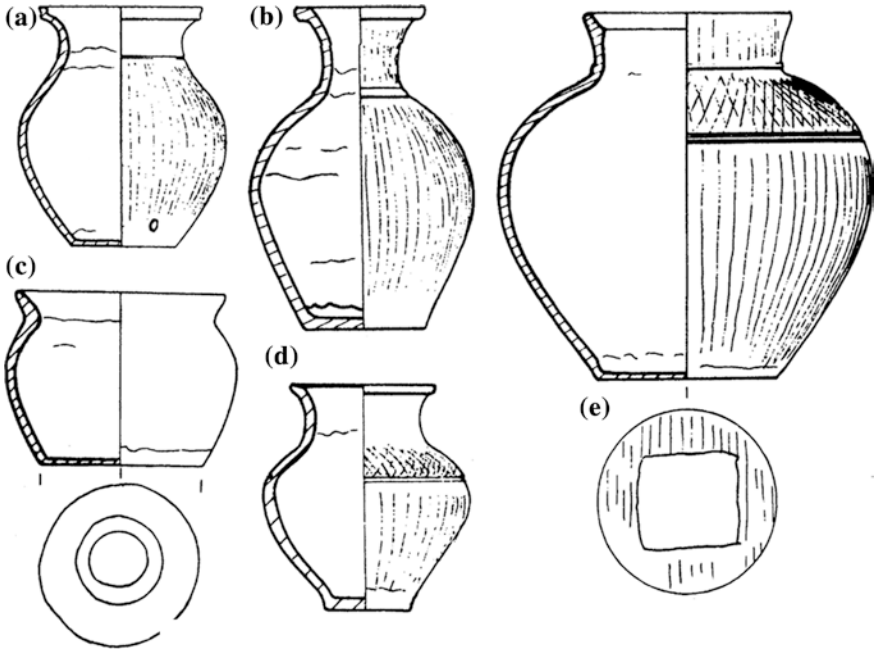


Fig. 40 Handmade pottery unearthed from Tombs of the Northern Wei Dynasty at the Southern Suburbs of Datong City, Shanxi

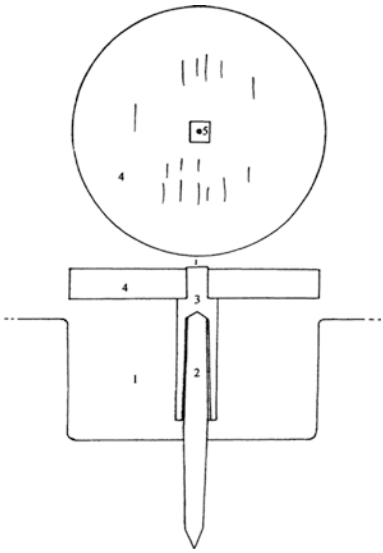


Fig. 41 Diagrammatic map for restoration of slow jigger wheel of the Northern Wei Dynasty

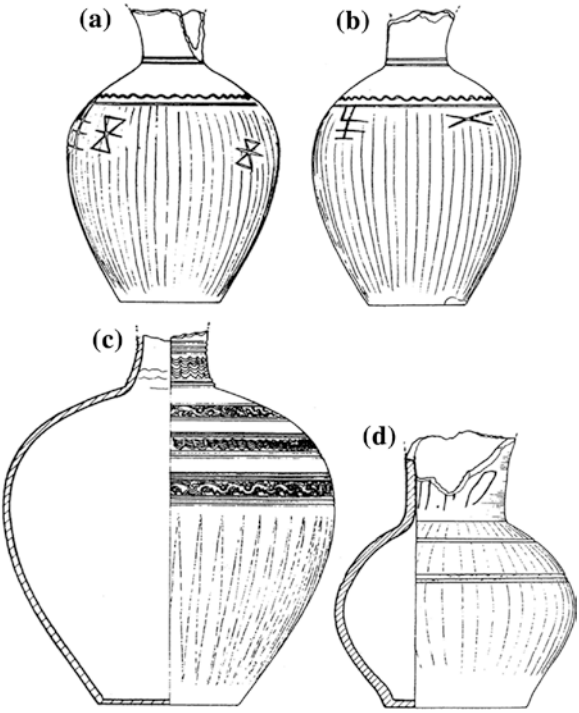


Fig. 42 Handmade pottery unearthed from Tombs of the Northern Wei Dynasty in the Southern Suburbs of Datong City, Shanxi

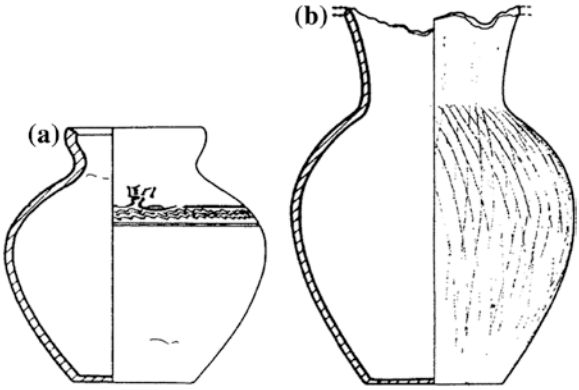


Fig. 43 Handmade pottery unearthed from Tombs of the Northern Wei Dynasty in the Southern Suburbs of Datong City, Shanxi

2.10.1 Restoration of Slow Jigger Wheel

Jigger wheels used by Xianbei ethnic group for making pottery were mainly slow jigger wheels and supplemented by quick jigger wheels. When using slow jigger wheels, generally, isolation layer was not established between the bottom of the utensil and the wheel disk. Bodies were directly made on the wheel disk, which was different from pottery-making technologies of the Han people living in the

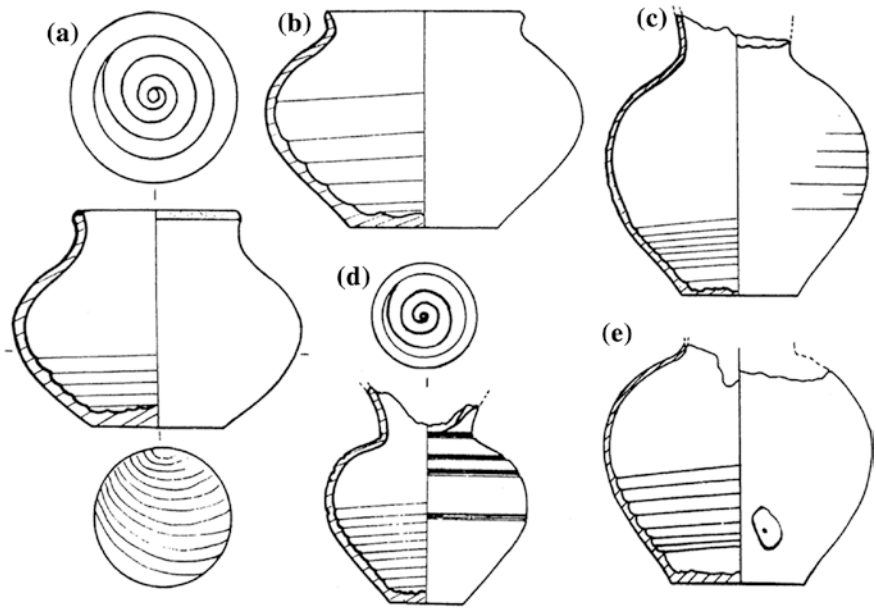


Fig. 44 Glazed pottery made with quick jigger wheel unearthed from Tombs of the Northern Wei Dynasty in the Southern Suburbs of Datong City, Shanxi

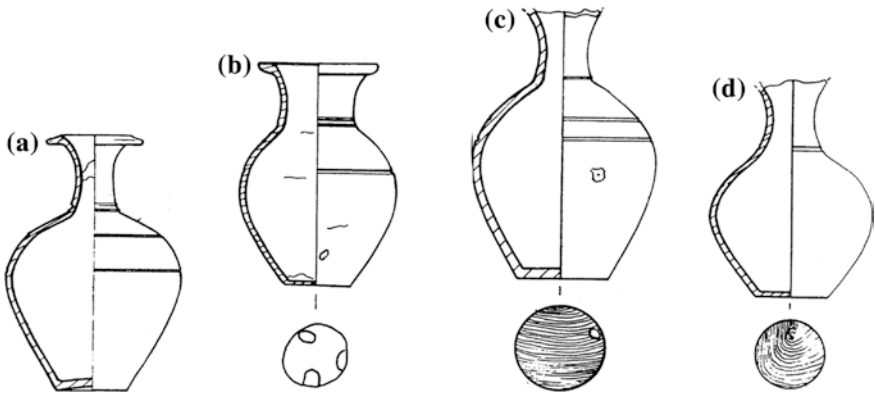


Fig. 45 Handmade glazed pottery unearthed from Tombs of the Northern Wei Dynasty in the Southern Suburbs of Datong City, Shanxi

same region. When the pug had low water content, traces of slow jigger wheel would be left on the bottom of the utensil, including marks of rabbet of cart tub and chock, marks of locating point of the center of wheel disk, and marks of the board of wheel disk, all of which provide basis for restoring slow jigger wheel of the Northern Wei Dynasty. Slow jigger wheel was restored as follows (see Fig. 41): The wheel was comprised of wheel disk, cart tub, pile, and pit of the

instrument, and a pit was set up at the center of rabbet of the tub to be used as the locating point of the center of wheel disk. Compared with quick jigger wheel, slow jigger wheel has the following shortcomings: As internal wall of the tub directly contacts with the pile, and the contact surface is large, the friction is also high, increase of revolving speed of wheel disk was limited, and therefore, pug could not be directly thrown into bodies by means of slow jigger wheel.

2.10.2 Common Decoration of Dark Fringes was the Ethnic Characteristics of Pottery of the Northern Wei Dynasty

Dark fringes were linelike patterns made by sliding and pressing the body with tools featuring solid, round, and blunt as well as smooth front tip (such as bone implement) under the condition that the body had very low moisture content, which will appear when they are exposed to the light. Dark fringes were the most common, varying decoration on common handmade pottery of the Northern Wei Dynasty, featuring the most ethnic characteristics of Xianbei ethnic minority, and reflecting bold and unconstrained national character of these people. Of 682 pieces of handmade common pottery, 419 pieces were decorated with dark fringes, accounting for 61.44 %.

2.10.3 National Amalgamation was Reflected in Pottery-Making Technologies

Some pottery features engraved Chinese characters on their exterior surface. For example, pots (see Figs. 42a, b) were inscribed with two Chinese characters "生" (meaning "alive" in English); kettle (see Fig. 43a) was engraved with a Chinese character "儿" (meaning "Son" in English), and two more crosses were written in the middle of the character "儿," hence a wrongly written character. Engraving Chinese characters on pottery shows that while learning technologies for making pottery of the Han people, potters of Xianbei ethnic minority were also learning Han Chinese culture.

2.10.4 Twice-Firing Process for Low-Temperature Plumbic-Glazed Pottery was Initiated by Xianbei Ethnic Group

From the raw materials and modeling method of making the bodies, all the unearthed 49 pieces of glazed pottery were locally made by potters of Xianbei ethnic group. Of all the glazed pottery, 95.92 % are reddish brown or yellowish brown, which were colored with iron as the coloring element; pottery presenting greenish or turquoise accounts for 4.08 %, which used copper as the coloring element.

There are two firing processes for glazed pottery: One is once-firing process, i.e., glaze was directly applied to the bodies, which were then fired. For example, some glazed pottery (see Fig. 44e) saw walls of the body and enamel layer simultaneously shed off due to calcareous concretion (commonly known as Liaojiangshi in Chinese),

forming a pitlike scar, and correspondingly exposing parts of the body where there is no glaze, which are the proof of adoption of once-firing process. The other is twice-firing process. At first, biscuit fire the bodies with a temperature at around 1,000 °C. The biscuit fired bodies were called bisque, and then glaze the bisque which would be fired again at a temperature of around 900–950 °C. For example, some glazed pottery (see Fig. 45b, c) saw walls of the body shed off due to calcareous concretion contained in it, forming pitlike scar, and then glaze was applied to both the exterior surface and the scar. After having been fired again, glazed layer could be found on the exterior surface of the utensil and in the scar which exists up to date. The glazed layer in the scar was the proof of twice-firing process.

In the development history of low-temperature plumbic-glazed pottery of ancient China, only once-firing process was adopted in the Han Dynasty; while once-firing process and twice-firing process were both used in the Northern Wei Dynasty; Sancai of Tang Dynasty, Sancai of Song Dynasty, and Sancai of Liao Dynasty all adopted twice-firing process. The Northern Wei Dynasty was the key period for transition from once-firing process to twice-firing process. Compared with once-firing process, the advantages of twice-firing process are as follows: At first, weed out wastes produced in the (first) biscuit firing and apply glaze on the sound bisque, and then twice firing was carried out so as to save expensive glaze and increase the qualification rate of finished glazed pottery. And this is the importance of twice-firing process for low-temperature plumbic-glazed pottery originated by Xianbei ethnic group.

2.11 Technologies for Making Sancai of Tang Dynasty

The Tang Dynasty (618 AD–907 AD) was the golden age of feudal society. One low-temperature plumbic-glazed pottery utensil of the Han Dynasty and the Northern Wei Dynasty only used one glaze (green glaze or yellow glaze); however, Sancai of Tang Dynasty used multiple glazes, such as yellow glaze, green glaze, white glaze, or blue glaze, of which yellow, green, and white dominated and hence the name "Tangsancai" (Sancai of Tang Dynasty). Sancai of Tang Dynasty was mainly found in Shaanxi and Henan, especially in tombs of Tang Dynasty in Xi'an and Luoyang, and the majority of them were the funerary ware buried with the dead. Although lead glaze is poisonous, but since these potteries were generally not used as articles for daily use, they did not have much influence on people's health. Such pottery are exampled by Sancai horse-riding figurine unearthed from Li Hui's Tomb at Mijiaya Village, Majiawan Township, Gaoling County, Shaanxi (689 AD), Sancai camel-riding musician figurine unearthed from Xianyutinghui's tomb in Xi'an (723 AD), Sancai stem cup, Sancai bottle and Sancai camel unearthed from tombs of the Tang Dynasty in Luoyang, and Sancai tower-type covered kettle unearthed from the tombs of the Tang Dynasty at Beiyaowan, Gongyi City, Henan. Kiln sites for Sancai of Tang Dynasty currently found include Dahuangye Kiln Site and Xiaohuangye Kiln Site in Gongyi City and Huangbao Kiln Site of the Tang Dynasty in Tongchuan City, Shaanxi.

2.11.1 Quick Jigger Wheel in Workshop of Sancai of Tang Dynasty

A Sancai workshop was found in Huangbao Kiln Site of the Tang Dynasty which consisted of seven-hole cave house, and each hole was rectangle-shaped. Quick jigger wheel was the most important instrument in the cave house. According to relevant information in the report on the excavation, quick jigger wheel can be restored as follows (see Fig. 46): Quick jigger wheel consisted of wooden round

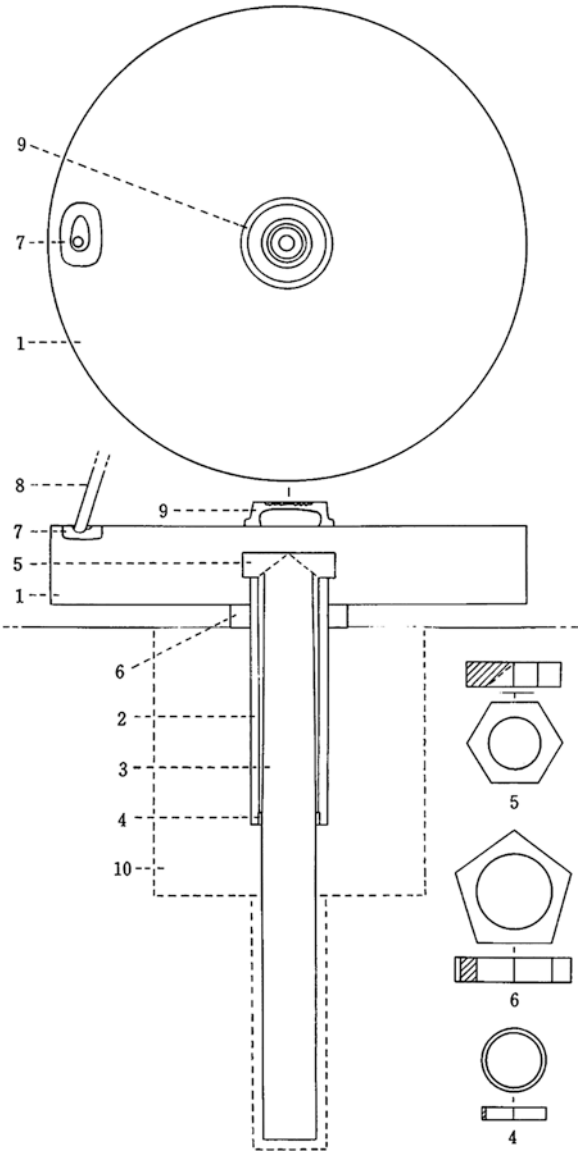


Fig. 46 Diagrammatic map for restoration of quick jigger wheel at Huangbao Kiln Site of the Tang Dynasty in Tongchuan City, Shaanxi

turn plate, wooden cart tub, wooden shaft, iron Danggu (oscillation hoop), iron shaft-top bowl, iron turn plate accessory, porcelain turn plate agitator, wooden stirring stick, porcelain pan head, and pit of the instrument. When throwing the body, pug was placed on the center of the pan head; insert the stirring stick in agitator of the turn plate, and vigorously stir to make the turn plate quickly revolve. Compared with slow jigger wheel, the strong points of quick jigger wheel are as follows: As only Danggu installed on the inner wall of cart tub and shaft-top bowl on the upper inner wall contact with the pile, the contact surface is small, and the friction produced due to the revolving wheel is also little; consequently, the inertial force is strong and the revolving speed is quick and the wheel can revolve around 90–100 circles a minute. While the wheel is rapidly revolving, the pug enjoys rapid shape-changing and good efficiency due to the exogenic action; therefore, clay can be directly thrown into bodies by utilizing quick jigger wheel.

2.11.2 Raw Materials for Making Body of Sancai of Tang Dynasty

The majority of bodies of Sancai of Tang Dynasty took high-alumina refractory clay (kaolin) as the raw material, and a small number of them were made from common fusible clay and a layer of white engobe (elutriated slurry of kaolin) was applied to the exterior surface of the latter utensils.

2.11.3 Twisted-Colored Body Molding was Originated by Potters of the Tang Dynasty

Modeling of Sancai of Tang Dynasty includes molding, making the body with quick jigger wheel, and carving. Of which, twisted-colored body molding, a kind of molding, is a unique modeling method, and twisted-colored body instrument is a rare new variety of glazed pottery. For example, twisted-colored body-glazed covered pottery Yu-Basin features a height of 5 cm, a caliber of 2.2 cm, and varying shades of brown wood-grain-like decorative patterns all over the pottery. The cover of the pottery was separately made. The grains of the twisted-colored body were formed by alternate arranging of red and white pug, and the grains were actually the bedding between the two kinds of pug. The exterior surface of the utensil was applied with colorless transparent low-temperature and lead glaze, and grains of the twisted-colored body can be seen through the glaze layer. The author modeled on the twisted-colored body-glazed covered pottery Yu-Basin.

2.11.4 Glaze for Sancai of Tang Dynasty

Basic glaze was formulated with silica flour, kaolin, miniumite, or slags of smelting lead, and then basic glaze was applied to the bisque which would undergo glaze firing again, and the glaze would become white glaze; yellow glaze was

formulated by adding iron oxide into basic glaze; green glaze was made by adding copper oxide; and blue glaze was made by adding cobalt oxide. Of which, blue glaze was invented by ceramic artisans of the Tang Dynasty.

2.11.5 Twice-Firing Process for Sancai of Tang Dynasty

The first firing was biscuit firing and conducted in large-scale half up-and-down draft kiln at a temperature of 1,150 °C. The second was glaze firing, which was conducted in small-scale half up-and-down draft kiln (see Fig. 47) at a temperature of 950 °C in the oxidizing atmosphere.

2.12 Pottery-Making Technologies of Song, Yuan, Ming, and Qing Dynasties

Sancai glazed pottery produced in the Northern Song Dynasty (960 AD–1127 AD) and the Liao Dynasty (916 AD–1125 AD) was, respectively, called Sancai of Song Dynasty and Sancai of Liao Dynasty. Liao was the local authority established by Qidan ethnic group in the north. Body and circle legs of Sancai Bottle of Song Dynasty were separately made and then joined together. Sancai tray of Liao Dynasty,

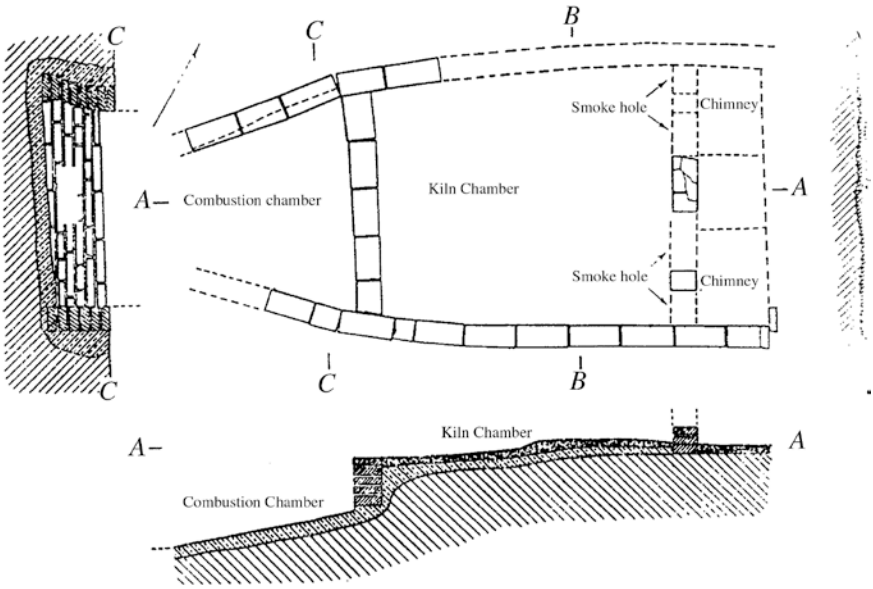


Fig. 47 Small-scale half up-and-down draft kiln at Huangbao Kiln Site of the Tang Dynasty in Tongchuan City, Shaanxi

modeled with inner mold, features a shape originated from wooden products, hence a kind of utensil-boasting characteristics of Qidan ethnic group. Sancai of Song Dynasty and Sancai of Liao Dynasty both had no blue glaze, which was distinctly different from Sancai of Tang Dynasty. Gangwa Kiln in Chifeng, Inner Mongolia (see Fig. 48a), adopted firewood as the fuel for firing Sancai of Liao Dynasty; Daguantun Kiln in Fushun City, Liaoning (see Fig. 48b) used coal as the fuel for firing Sancai of Liao Dynasty. Yaozhou Kiln of Song Dynasty in Tongchuan City, Shaanxi, also adopted coal as the fuel for firing porcelain. Dynasties before Song and Liao all only used firewood as the fuel for firing pottery and porcelains. Although people began to use coal as the fuel in the Song Dynasty and Liao Dynasty, the phenomenon of using firewood as the fuel remained. For example, Jun Kiln and Jingdezhen Kiln of the Song Dynasty all used firewood as the fuel for firing porcelains.

Pottery-making technologies of the Yuan, Ming, and Qing dynasties came to an end, and only technologies for making violet sand earthenware, glazed pottery, Fahua pottery, and Shiwan pottery still enjoyed development. Violet sand earthenware was uniquely produced in Yixing, Jiangsu, which was made by using local purple clay and was first fired in the Song Dynasty and well known for violet sand pot in the Ming Dynasty, such as Gongchun violet sand pot. Gongchun was a master of making pot in Yixing. Violet sand pot boasts sound air permeability, and tea made with it in the previous night will not become sour. Glazed pottery was a new variety of low-temperature plumbic-glazed pottery derived from Sancai of Tang Dynasty, mainly used for building. According to the literature, glazed pottery was first used on palace buildings in Pingcheng (today's Datong City, Shanxi) in the Northern Wei Dynasty. Archaeological discovery showed that the earliest glazed pottery was made in the Tang Dynasty, such as glazed brick and tile unearthed from Huangbao Kiln Site of Tang Dynasty in Tongchuan City, Shaanxi. Glazed pottery of Yuan Dynasty was mainly made in the southern part of Shanxi. In the Ming Dynasty, glazed pottery was also produced in Nanjing and Beijing. For example, Colored Glaze Plant of Beijing produced glazed tiles, and later, the plant was moved to Liuliqu Village of Mentougou District for continuous

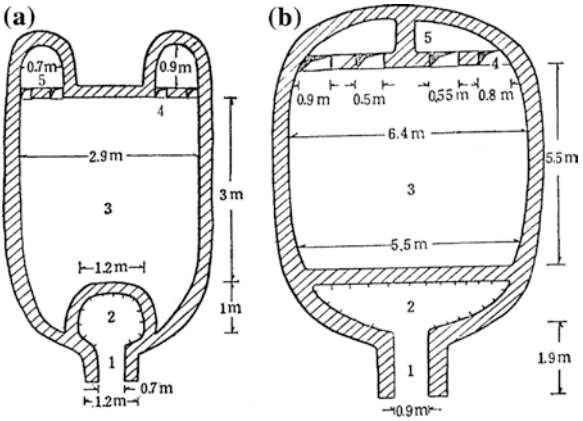


Fig. 48 Half up-and-down draft kiln of the Liao Dynasty. **a** Gangwa Kiln in Chifeng City, Inner Mongolia; **b** Daguantun Kiln in Fushun City, Liaoning

production. The Ming and Qing dynasties were the golden age for making and using glazed pottery, and glazed products were used for architectures such as palaces, royal gardens, houses of the highest nobles, and temples. Jiulongbi (nine-dragon wall) in Datong City, Shanxi, is 45.5 m long, 8 m high, and 2.02 m thick, and it was completed in 1392 (the 25th year of the reign of Emperor Hongwu of Ming Dynasty). It was completely built with glazed products and was the best preserved, oldest, and largest glazed Zhaobi (a kind of screen wall facing the gate of the house) in China. Forbidden City of Beijing was the imperial palace in the Ming Dynasty and Qing Dynasty, and group of buildings of Forbidden City typically and delicately combined technologies for firing glazed pottery and building technology. Fahua pottery was mainly produced in the southern part of Shanxi, emerging in the Yuan Dynasty and abundant in the Ming Dynasty. It is a new variety derived from glazed pottery. Fahua pottery and glazed pottery commonly took iron, copper, cobalt, and manganese as the coloring elements; the difference between them was that Fahua pottery completely or partly used potassium nitrate as fluxing agent for replacing lead oxide. Products of Fahua pottery include flower vase, censer, and animal. Shiwan pottery, made in Shiwan Kiln of Foshan City, Guangdong, was first fired in the Yuan Dynasty. It is a kind of low-temperature plumbic-glazed pottery, taking copper and iron as coloring element. The Ming Dynasty mainly saw production of Shiwan pottery bowls and kettles, and the Qing Dynasty was famous for making Shiwan pottery figures, immortals, melons, fruits, and implements.

3 Lecture 2 History of Porcelain-Making Technology in Ancient China

Porcelain was evolved from pottery but is qualitatively different from pottery. Since the birth of porcelain, porcelain-making technology and pottery-making technology have become two different systems.

History of porcelain-making technology in ancient China can be divided into six periods, and main achievements of each period are introduced as follows.

3.1 Proto-Porcelain of Shang and Zhou Dynasties

Proto-porcelain appeared in the Shang Dynasty. For example, proto-porcelain was found in the First Phase of Wucheng of Qingjiang County, Jiangxi (today's Zhangshu City), with its age equivalent to the early Shang Dynasty in Central Plains (1600 BC–1300 BC). Proto-porcelain enjoyed development in the Zhou Dynasty, such as proto-porcelain stem cup of the Western Zhou Dynasty unearthed from Tawan, Luoyang City, Henan, and celadon four-loop-handled pot of the Western Zhou Dynasty unearthed from No. 6 Tomb at Liutaizi Village, Jiangji

Township, Jiyang County, Shandong. Proto-porcelain was mainly produced in the southern part of China, mostly in Jiangxi and Zhejiang.

3.1.1 Raw Materials for Making Body of Proto-Porcelain

The raw materials for making proto-porcelain were china clay or kaolin. China clay was adduct of kaolin, quartz, and feldspar. The main chemical composition of china clay and kaolin was aluminum silicate. Proto-porcelain can only be fired at high temperature with a firing temperature mostly between 1,100 and 1,200 °C.

3.1.2 Glaze of Proto-Porcelain

Glaze of proto-porcelain was vitric high-temperature calcareous glaze with calcium oxide as the fluxing agent. The method for formulating glaze is as follows: Mix an appropriate amount of calcite powder or plant ash in common fusible clay, hence the thick lime glaze fluid. Then, apply thick lime glaze fluid to the surface of the body. As glaze contains iron oxide, and was fired in the reducing atmosphere, iron oxide became ferrous iron oxide and porcelain glaze appeared light greenish blue.

3.1.3 Difference Between Proto-Porcelain and Pottery

Proto-porcelain featured three elements: First, it took china clay or kaolin as the raw materials; second, there was a layer of vitric glaze on the surface of the utensils; and third, the firing temperature was mostly between 1,100 and 1,200 °C. All these elements are qualitatively different from those of pottery.

3.1.4 Difference Between Proto-Porcelain and Mature Porcelain

Compared with mature porcelain of the late periods, primitiveness of proto-porcelain shows up in three aspects: First, the raw materials of the body had not undergone fine process and had quite high content of iron; second, the glaze layer was uneven in thickness, besides glaze, and the body was not firmly joined and the glaze layer tended to fall off; and third, the firing temperature was not high enough; consequently, glaze and the body were not firmly combined together.

3.2 Celadon of the Southern Part of China in the Han and Jin Dynasties

In the Han and Jin dynasties (206 BC–420 AD), mature porcelain was invented in China, and since then, porcelain existed in the world.

In the late Eastern Han Dynasty (25 AD–220 AD), celadon ware from Yue Kilns was successfully fired, such as green-glazed stamped rampart tiles of the late Eastern Han Dynasty unearthed from Xiaoxiantan, Shangyu, Zhejiang, and celadon four-loop-handled kettle of the Eastern Han Dynasty unearthed from Zhongzhou Road, Luoyang City, Henan.

Yue Kilns were distributed in Shaoxing, Shangyu, Yuyao, Cixi, Ningbo, and Yinxian of the northeast part of Zhejiang (see Fig. 49). It is in the Eastern

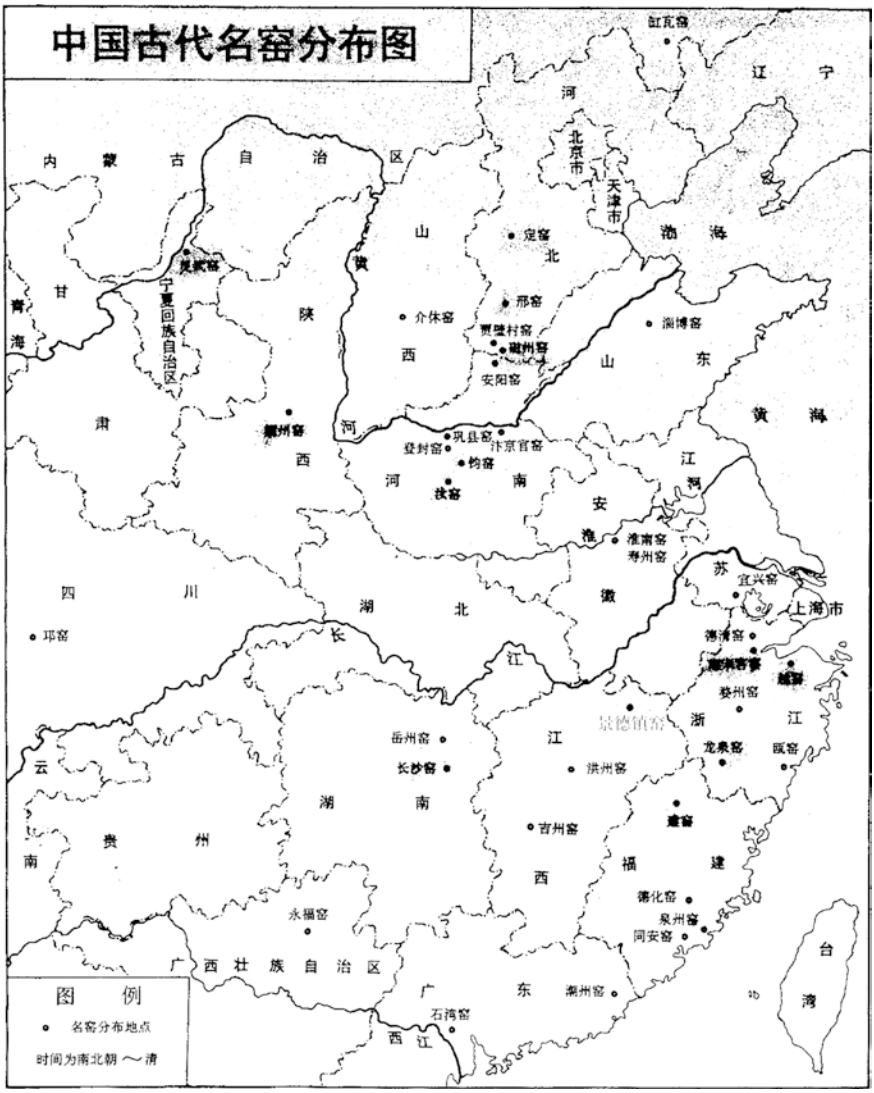


Fig. 49 Distribution of famous kilns in ancient China

Han Dynasty that porcelain was first fired in Yue Kilns which flourished in Tang Dynasty and the Five Dynasties as well as declined in the Song Dynasty.

3.2.1 Body of Yue Kiln Celadon

As for celadon tiles unearthed from Xiaoxiantan of Shangyu, iron oxide, the colorant in their body only accounted for 1.64 % in content, and the content of titanium oxide accounted for only 0.97 %; therefore, the color of the body was fairly light; the firing temperature was quite high, reaching 1,310 °C. Consequently, the body of the porcelain featured quite high strength and fairly low water absorption, which had already reached the standards for mature porcelain.

3.2.2 Glaze of Yue Kiln Celadon

As a kind of utensil, porcelain has to be applied a layer of glass glaze. The glaze on Yue Kiln celadon was calcareous glaze, using calcium oxide as the main fluxing agent. As the glaze contains a certain amount of iron oxide and titanium oxide, it appeared sallow or caesious with change of firing atmosphere.

3.2.3 Kilns for Firing Yue Kiln Celadon

Dragon kiln of Eastern Han Dynasty was discovered at the Kiln Site of Zhangzishan, Shangyu (see Fig. 50), which had a total length of around 10 meters, and the kiln bottom featured a steep slope which was 28 degree for the front section and 21 degree for the back section. Due to steep slope, its force for pumping the air was quite strong, beneficial to increasing firing temperature and improving porcelain quality. Successful firing of Yue Kiln celadon had a close relation with improvement of the kiln.

3.3 Porcelain of the Northern and Southern Dynasties

It is quite common for firing celadon in the Northern and Southern dynasties. White porcelain appeared in the north.

3.3.1 Celadon of the Southern Part of China

Zhejiang and Jiangsu saw the most rapid development of celadon production. For instance, in green-glazed covered kettle with lotus petal design of the Eastern Jin to Southern dynasties unearthed from Subei Motor Factory of Hailing District, Taizhou City, Jiangsu (see Fig. 51), the body was griege and the interior and

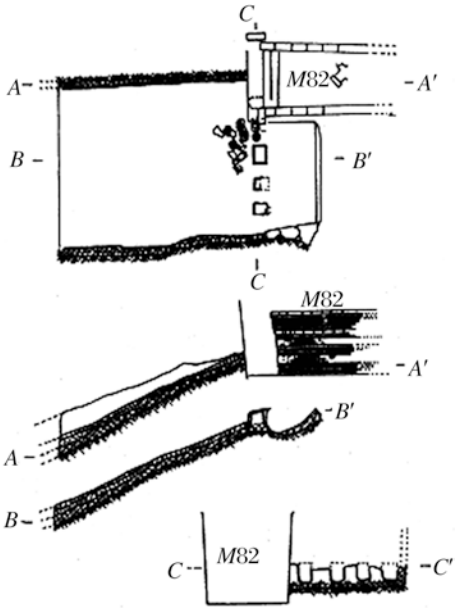


Fig. 50 Dragon kiln of Eastern Han Dynasty at Zhangzishan, Shangyu, Zhejiang

Fig. 51 Green-glazed covered kettle with lotus petal design of the Eastern Jin to Southern dynasties unearthed from Subei Motor Factory of Hailing District, Taizhou City, Jiangsu

exterior were both fully applied with greenish yellow glaze; besides, the glaze was quite thin, featuring fine-cracked glaze which was also called cracked ice pattern.

3.3.2 Celadon of the Northern China

A batch of celadon was unearthed from Fengdai Tomb in Jingxian County, Hebei. After chemical examination, the celadon was fired with china clay of the northern part. For instance, celadon Zun vessel decorated with lotus pattern was the quality product of celadon made in northern China. Another example was celadon

six-loop-handled vase with dish-shaped mouth of the Northern Zhou unearthed from Duguzang Tomb of Xi'an, Shaanxi. It features a white body, and bottom externally applied with dark green glaze.

3.3.3 White Porcelain of Northern China

It is one of the landmarks that white porcelain appeared in the porcelain series made in northern China because white porcelain was the basis and precondition for later generations creating painted porcelain (underglazed, onglazed, blue and white, Doucai, Wucai, Sancai without red, famille rose, etc.). White porcelain refers to porcelain made by applying a layer of colorless transparent glaze on the white body or applying a layer of colorless transparent glaze on the white engobe. The early white porcelain was mostly engobe white porcelain. For instance, white porcelain was discovered in the remains of the Northern Dynasty from Xing Kiln Site in Neiqiu County, Hebei. Another example is that a batch of white porcelain green-glazed vases of 575 AD (the sixth year of the reign of Emperor Wuping of Northern Qi) from Fancui's Tomb in Anyang City, Henan. Its body was white, and its glaze appeared milky white and green, only place with thick glaze appeared green. It is the earliest white porcelain that has been discovered currently.

3.4 Porcelain of the Sui and Tang Dynasties

In the Sui and Tang dynasties (581 AD–907 AD), raw materials of porcelain in southern China and northern China were quite different: The southern China was rich in china stone which has quite high contents of iron oxide and titanium oxide; therefore, it saw green-glazed porcelain quite early, while kaolin was abundant in northern China which has quite low contents of iron oxide and titanium oxide; consequently, white porcelain appeared there early. Hence the situation green-glazed porcelain in the southern China, represented by Yue Kiln and white porcelain in northern China, represented by Xing Kiln.

3.4.1 Celadon from Yue Kiln of the Tang Dynasty

Yue Kilns of the Tang Dynasty were centered at Shanglin Lake of Cixi County. The late Tang Dynasty saw celadon from Yue Kiln made with exquisite techniques, which became the treasure of imperial family, called "olive green porcelain." In 1987, 13 olive green porcelain products consecrated in 874 AD (the 15th year of the reign of Emperor Yizong of Tang Dynasty) were unearthed from underground palace of Famen Temple Tower of Tang Dynasty in Fufeng County, Shaaxi, such as olive green porcelain plate painted with sunflower petals. According to records in County Annals of Yu Yao: "When olive-green porcelain first appeared in Shanglin Lake,

officials were designated to monitor the kilns in the Tang and Song Dynasties," that is to say, "olive green porcelain" was made at Shanglin Lake of Cixi County. "Olive green porcelain" is elaborate celadon product. "Olive green" refers to turquoise, a rare and mysterious color. Porcelain glaze containing high levels of iron oxide and titanium oxide could only be fired into turquoise only in very strong reducing atmosphere in dragon kiln. Therefore, olive green porcelain was very difficult to be fired.

3.4.2 White Porcelain of Xing Kiln of the Tang Dynasty

Xing Kiln was located in the border area between Lincheng County and Neiqiu County, Hebei, and the central kiln was situated in the area just outside the city gate of Neiqiu County. From the late Northern Qi, Xing Kiln began to produce green-glazed porcelain and white porcelain as well. In the Sui and Tang dynasties, white porcelain prevailed, becoming the representative of white porcelain in northern China and declined in the Song Dynasty.

The Tang Dynasty had already seen mature firing technologies for white porcelain. For example, firing temperature of white porcelain from Xing Kiln reached 1,260–1,370 °C. White porcelain long-necked vase unearthed from Houchuan, Shanxian County, Henan, and white porcelain floor lamp decorated with lotus petal both featured fine body, thin glaze layer, and pure white glaze.

3.4.3 Blue-and-White Porcelain from Gongxian Kiln of the Tang Dynasty

Blue-and-white porcelain is the most characteristic variety of porcelain in the history of Chinese porcelain. In 1975, a piece of debris of blue-and-white porcelain pillow was unearthed from Tangcheng Site of Yangzhou, Jiangsu, and a copper coin inscribed with Chinese characters "Kai Yuan Tong Bao" was discovered in the same layer. Kai Yuan is 713 AD. This blue-and-white porcelain debris features white body and gray bottom, blue-and-white porcelain features slight blue on the right side, and the blue floral patterns were scattered shredded leaves with water chestnut. In 1983, 12 pieces of blue-and-white porcelain debris were found at Tangcheng Site of Yangzhou (see Fig. 52). All

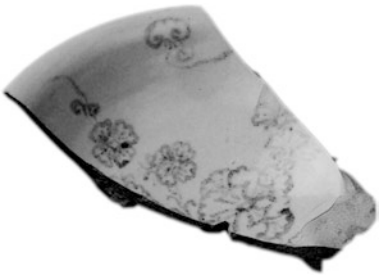


Fig. 52 Blue-and-white porcelain tile unearthed from Tangcheng Site, Yangzhou, Jiangsu

the above-mentioned pieces of blue-and-white porcelain debris were the earliest ones that have been discovered so far. Lots of blue-and-white porcelain debris were also discovered in Gongxian Kiln Site of Henan. Gongxian Kiln Site was located in Dahuangye Village and Xiaohuangye Village of Gongxian County (today's Gongyi City), etc. According to chemical analysis, blue-and-white porcelain debris unearthed from Tangcheng of Yangzhou was produced in Gongxian Kiln. Blue-and-white porcelain belongs to underglazed porcelain, featuring decorative patterns painted on the body with cobalt oxide as the pigment, to which a layer of transparent glaze was applied and then the body underwent once firing at a high temperature of 1,200 °C. As the porcelain features blue decorative patterns under the transparent glaze layer of the vessel, it is called "blue-and-white porcelain."

3.4.4 Underglazed Porcelain from Changsha Kiln of Tang Dynasty

Changsha Kiln, also known as Changsha Tongguan Kiln, was located at Tongguan Township, Wangcheng County, Changsha City, Hunan. It first fired porcelain in the middle of Tang Dynasty, prevailed in the late of Tang Dynasty and declined in the Five Dynasties. Underglazed painted porcelain from Changsha Kiln featured brown and green pigments as seen in the greenish yellow-glazed porcelain plate painted with fragrant thoroughwort with brown glaze unearthed from Tongguan Kiln Site. The raw material of brown glaze was iron oxide which will not wander about and scatter under high temperature. Therefore, brown glaze was used for drawing the outline; the raw material of green glaze was copper oxide which tends to flow away under high temperature; therefore, it is used for filling colors. As pigments were protected by the layer of glass glaze on it, they boasted everlasting colorful appearance.

3.5 Porcelain of the Song Dynasty

About porcelain kilns of the Song Dynasty, people always hold that there were five kinds of kilns, i.e., Ru Kiln, Jun Kiln, Guan Kiln, Ge Kiln, and Ding Kiln. However, actually, there were Cizhou Kiln, Yaozhou Kiln, Jingdezhen Kiln, Jian Kiln and Jizhou Kiln and Lingwu Kiln of the Western Xia Dynasty. The main achievements of various kilns are listed as follows:

3.5.1 Porcelain from Ding Kiln of the Song Dynasty

The central kiln of Ding Kiln was located at Jianci Village and Eastern and Western Yanshan Village of Quyang County, Hebei Province. Ding Kiln first fired porcelain in the Tang Dynasty, flourished in the Song Dynasty, and was on the wane after the Yuan Dynasty. Ding Kiln mainly fired porcelain for folks and

also fired porcelain used by the palace or government in the late Northern Song Dynasty. White porcelain dominated in the varieties. Examples include earthen bowl carved with lotus petals from Ding Kiln of the Northern Song Dynasty, white-glazed tray carved with official seal and couples of cicadas of 977 AD (the second year of Taipingxingguo under the reign of Emperor Taizong of Northern Song Dynasty) unearthed from Dingzhou; white-glazed incense burner with round tray and five feet of Northern Song Dynasty, black-and-white-glazed porcelain sedan decorated with flowers of Northern Song Dynasty, white-glazed long-necked bottle decorated with lotus patterns and white-glazed bottle with designs of lotus and dragon head of Northern Song Dynasty unearthed from south to Murong's Tomb in Dingzhou City. Porcelain from Ding Kiln featured exquisite and white body with the glaze appearing white and yellow.

In Northern Song Dynasty, Ding Kiln adopted upside down firing process for making porcelain, i.e., put utensils inversely into the saggar; therefore, the bowl bottom was full of glaze, while the glaze at the mouth appeared acerbity edge, commonly known as unglazed rim. For making up for the deficiency of unglazed rim, rims of gold, silver, or copper were inlaid at the unglazed rim. For instance, bowl carved with dragon and cloud with flower-shaped mouth from Ding Kiln of Northern Song Dynasty. Its full body was applied with white glaze, and the mouth was inlaid with copper rim of Song Dynasty.

3.5.2 Porcelain from Cizhou Kiln of Song Dynasty

Cizhou Kiln was located in Cixian County, Handan City, Hebei, with the central kiln located at Guantai Township and Pengcheng Township. Cizhou Kiln began firing porcelain in the early Northern Dynasty and had been prosperous to the Ming and Qing dynasties. Cizhou Kiln series also include Dengfeng Kiln of Henan, etc. Its products were utensils specially designed for folks' daily life, dominated by white porcelain and white-glazed porcelain with black decorative patterns as the most characteristic product.

The raw materials for making porcelain from Cizhou Kiln were inferior in quality, containing fairly much carbon, and the majority of bodies appeared gray and coarse and became white by application of a layer of engobe which was white slurry obtained through elutriating kaolin. The glaze was calcium–alkali glaze, and the colorant for black pigment or black glaze was a kind of limonite called "Banhua Stone" which contains a small amount of hematite. The firing temperature was between 1,160 and 1,260 °C, and the firing atmosphere was mainly oxidizing flame.

The decorative techniques of Cizhou Kiln fell into two categories: The first one was technique featuring "iron rust decoration" on white ground. "Iron rust decoration" on white background was a background glaze. For example, for white ground black design vase painted with flower patterns and white-glazed porcelain plum vase decorated with underglazed black floral design, the decoration procedures are: apply a layer white engobe on the body first; and then paint patterns on

the engobe layer with "Banhua Stone"; and at last apply a transparent glaze on it. The porcelain was made by once firing under high temperature. Due to varying content of iron of "Banhua Stone," or different firing temperature, the porcelain appeared black floral design over white ground or brown floral design over white ground. The other category was process of Tihua (getting rid of parts of glaze on the body other than those with decorative patterns). The decoration procedures are as follows: Apply a layer of white engobe on the body and then apply a layer of "Banhua Stone" glaze on the layer of engobe and then carve patterns on the glaze layer and at last conduct Tihua. As Tihua was conducted at different locations, and after this process, two kinds of floral patterns were formed: One was black flowers. For instance, black-glazed kettle carved with flowers of Northern Song Dynasty, which was made by getting rid of the part of "Banhua Stone" glaze layer without flower patterns for exposing the white engobe layer, and then applying a layer of transparent glaze on the surface of the utensil which was once fired under high temperature. Black flowers appeared in Yangwen (convex pattern); the other pattern was white flowers, such as ewer carved with flowers from Dengfeng Kiln of Northern Dynasty, which was made by getting rid of the parts in the decorative pattern, i.e., the "Banhua Stone" glaze layer of the decorative pattern for exposing the white engobe and then applying a layer of transparent glaze to the surface of the utensil and once firing the utensil under high temperature. The white flowers appeared Yinwen (sunken pattern).

Besides, technique of incised decoration on pearl ground from Cizhou Kiln was also characteristic. For instance, pearl ground vase was carved with double tigers from Dengfeng Kiln of Northern Song Dynasty. The vase was made by carving double tiger patterns on the body first and then grass patterns around the tiger patterns, later in the blank, stamping densely arranged small circle patterns with tubular tool which look like strings of peals. Therefore, this decoration technique was called "carving flower pattern on pearl ground". At last, a layer of transparent glaze was applied on the body which to be once fired under high temperature.

3.5.3 Porcelain from Yaozhou Kiln of Song Dynasty

Yaozhou Kiln took Huangbao Township of Tongchuan, Shaanxi, as the central kiln which started firing porcelain in Tang Dynasty and enjoyed rapid development in Song Dynasty. It continuously produced porcelain in Jin and Yuan dynasties. The products were mainly green-glazed porcelain, and the glaze appeared olive, i.e., yellowish green, in case of oxidizing firing atmosphere inclining to oxidation, the product would appear ginger or ochen.

Yaozhou Kiln boasted two decoration techniques: One was engraving technique. For instance, celadon plum vase unearthed from Yaozhou Kiln Site of Song Dynasty features engraving patterns with olive-colored green glaze; Zun vessel was carved with brocade turnip from Yaozhou Kiln of Song Dynasty features engraving patterns and ginger-colored glaze; the other one was impressing technique. For example, bowl model with impressed chrysanthemum patterns

from Yaozhou Kiln of Northern Dynasty was an internal model used for making bowls. The internal model was engraved with chrysanthemum patterns. Pressing the chrysanthemum patterns on the inner wall of bowls was called impressing; green-glazed bowl with impressed patterns of fishes swimming in the water from Yaozhou Kiln of Northern Dynasty features impressed patterns of water waves and four swimming fish on the inner wall and olive-colored green glaze.

3.5.4 Porcelain from Ru Kiln and Royal Ru Kiln of the Song Dynasty

Ru Kiln was also known as Linru Kiln, scattered in Linru County, Henan, and represented by Yanhedian Kiln. It was a kind of folk kiln. Ru Kiln began firing porcelain in the middle of Northern Song Dynasty and had been prosperous until Jin Dynasty. Qingliang Temple Kiln of Baofeng County, Henan, was a "Royal Ru Kiln" for firing celadon used by the emperor.

Both Ru Kiln and Royal Ru Kiln used a kind of opalescence glaze, also known as opacifying glaze, featuring opacity. The dark-colored glaze was called sky blue glaze, while the light-colored glaze was named azure glaze and the lighter was called bluish white glaze, of which the azure glaze was the most expensive. Royal Ru Kiln featured decoration of fine-cracked glaze, i.e., cracked ice pattern. For example, goose neck Ru porcelain vase was carved with flowers of the middle or late Northern Song Dynasty, featured engraved lotus with folding branches, applied with sky blue glaze, and fully covered by cracked glaze; small-mouthed and fine-necked Ru porcelain bottle of the late Northern Song Dynasty, applied with azure glaze and densely decorated by cracked glaze; bluish white-glazed water lily-mouthed Ru porcelain bowl of the early and middle of Northern Song Dynasty; sky blue-and-red-glazed Ru porcelain bowl of the late Northern Song Dynasty; azure glazed Ru porcelain bowl of the late Northern Song Dynasty; porcelain Xi (a kind of stationery accessory) from Ru Kiln of Northern Song Dynasty, applied with azure glaze and fully covered with cracked glaze.

Glaze applied to Ru porcelain was usually feldspar containing quite high level of sodium (Na), which was a kind of flux raw material. Glaze used for Royal Ru Kiln once used agate powder as raw material, using it for replacing quartz, so as to demonstrate official kiln to be nobler than folk kiln. Reduction reaction occurred for iron oxide in sky blue blaze of Ru porcelain at a high temperature of 1,000 °C, blue color of the glaze would appear with increasing reducing atmosphere and rise of temperature, and the color would become darker with rising temperature. Firing temperature of Ru porcelain was above 1,250 °C.

3.5.5 Porcelain from Jun Kiln of the Song Dynasty

Jun Kiln was located in Yuxian County, Henan, and the most representative porcelain was that which is fired by Juntai Baguadong Kiln. Jun Kiln began firing

porcelain in Tang Dynasty and was in a period of great prosperity in late Northern Song Dynasty, and it continuously fired porcelain in Jin and Yuan dynasties. Jun Kiln first enjoyed development in the area of Shengou Township, Yuxian County. After successful firing of copper-red glaze porcelain, the palace took a fancy to it. During the reign of Huizong Emperor in the late Northern Song Dynasty (AD 1101–AD 1125), a royal kiln for firing appliance for the palace was established at Baguadong inside of Northern City Gate of Yuxian County. Apart from celadon ware with sky blue glaze, azure glaze, and bluish white glaze, the royal kiln also fired bronze red glaze porcelain of purple tone, represented by "rose violet glaze" and "begonia red glaze." Utensils included porcelain flowerpots and flowerpot bases which were used as furnishings for the palace. For example, rose violet begonia-shaped flowerpot from Jun Kiln in Northern Song Dynasty featured rose violet as the dominant hue, punctuated by red, and bright in color.

Glaze used for Jun porcelain was calcium–alkali glaze formulated with feldspar, limestone, china stone, quartz, and plant ash, containing oxidizing materials such as copper, iron, tin, and phosphorus. Copper-red glaze took copper cuttings as colorant.

Kiln of Jun Kiln included round single kiln and oblong connected double kiln: The example for single kiln was half up-and-down draft horse hoof-shaped kiln of early Northern Song Dynasty in Yuxian County (see Fig. 53); connected double kiln was exampled by double-combustor chamber half up-and-down draft kiln of late Northern Song Dynasty in Yuxian County (see Fig. 54). The two kinds of kilns were earthen kilns dug in the earth, boasting advantages of sound thermal insulation property, easy forming of reducing atmosphere. And both took firewood as fuel, and featured long flame, stable atmosphere and no pollution of sulfide. Both the kinds of kilns adopted double-firing process: The first was bisque firing at low temperature, and glaze was applied to the body for multiple times with the glaze layer as thick as 3 mm, and the second was glaze firing at high temperature.

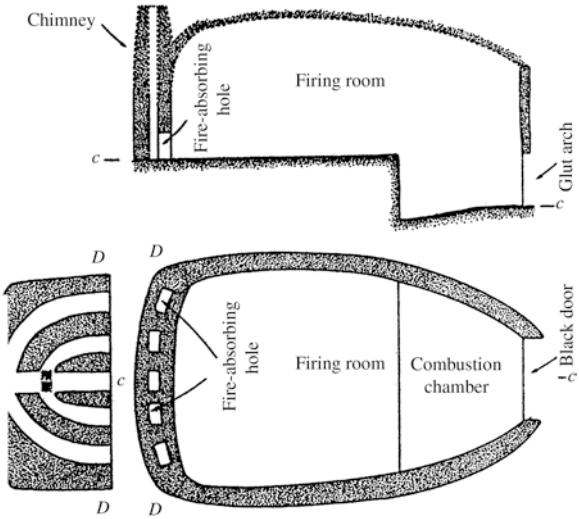


Fig. 53 Single kiln of early Northern Song Dynasty, Yuxian County, Henan

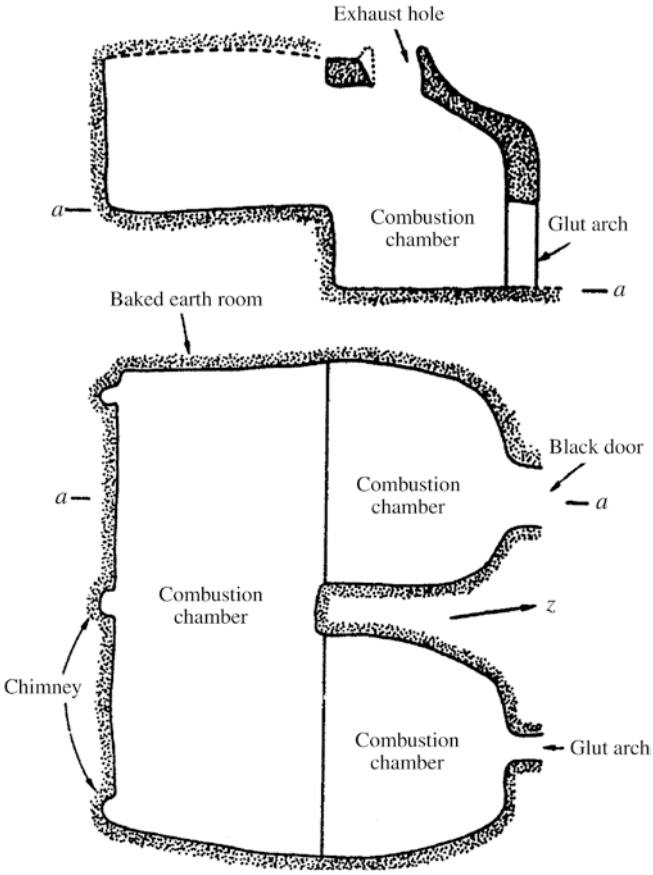


Fig. 54 Connected double kiln of late Northern Song Dynasty, Yuxian, County, Henan

Jun porcelain glaze had three features: First, Jun porcelain glaze was high-temperature glaze, with the glaze firing temperature reaching 1,300 °C; second, Jun porcelain glaze was opalescence glaze, featuring opacity; and third, Jun porcelain was also a kiln transmutation glaze, and it refers glazing color changing in the kiln. Utensils applied with glaze were in the same color before placed into kiln, but they became colorful at the time out of the kiln after being fired. The ancients had sung high praise of the endless variations and fantastic charms of porcelain from Jun Kiln. For example, "one color before entering kiln and various colors after coming out of kiln," "Jun Kiln is matchless, featuring unparalleled kiln transmutation," "the richest color and endless mood," etc.

The causes of kiln transmutation were as follows: Copper in the glaze was a kind of metal with variable valence, which was quite sensitive to firing atmosphere. Once atmosphere in the kiln changed, existential state of copper in porcelain glaze would immediately change, and there might be three existential states: One is ionic condition, including bivalent copper and univalent copper; bivalent

copper appears blue, while univalent copper is colorless; another is particle of copper metal; and the other is particle of copper compound, for example, cuprite renders red color, while tenorite presents an appearance of black. Therefore, a slight change of atmosphere in the kiln would lead to disappearance of a color or several colors and simultaneously emergence of a color or a few different colors. Thus, it can be seen that when atmosphere in the kiln changed, valence of copper would immediately alter, which was the primary cause leading to variation of glazing colors. This kind of variation of glazing color taking place accidently in the kiln had already been grasped by porcelain-maker of Song Dynasty.

By the way, today some scholars think that Jun Kiln began producing porcelain for furnishings at the turning of Yuan and Ming dynasties, and even some were products made in the middle of Ming Dynasty. So we can see that for the issue of when Jun Kiln began producing ornamental porcelain, the academic circles have different opinions and are still discussing it.

3.5.6 Porcelain from Longquan Kiln of the Song Dynasty

Longquan Kiln was located in Longquan County, Zhejiang, with porcelain fired in Dayao and Jincun featuring the best quality. Longquan Kiln began firing porcelain in early Northern Song Dynasty and reached its peak after the middle of Southern Song Dynasty, and it gradually declined after the middle of Ming Dynasty. Its products were mainly daily-use celadon, which were sold well all over the country as well as exported to overseas. Plum green glaze and lavender gray glaze of the late of Southern Song Dynasty reached the peak of glaze color beauty of celadon.

Plum green glaze and lavender gray glaze were made by adding plant ash in calcareous glaze, resulting in high viscosity under high temperature, thus the glaze would not easily flow, and glaze and thick glaze could be applied for many times. The porcelain was fired by adopting strong reducing flame to make the glaze look as verdant as green plum and render semitransparent jadelike quality. For example, green-glazed vase with pierced handles and Li-jar-shaped Furnace, Longquan Kiln, Southern Song Dynasty unearthed from Suining City, Sichuan, celadon stove with double fish-shaped handles, Longquan Kiln, Southern Song Dynasty unearthed from Wuxing County, Zhejiang—all were applied plum green glaze, featuring jadelike quality. Ladle-shaped vase painted with peony and tangled branches, Longquan Kiln, Southern Song Dynasty, used lavender gray glaze.

Celadon glaze surface of celadon from Longquan Kiln cracked to form cracked ice pattern, rendering "gold wire grains pattern" after having been polluted or having undergone artificial dye. People call the porcelain featuring "gold wire patterns" as "Ge ware," such as Ge Ware porcelain furnace with fish-shaped ears of Song Dynasty, featuring yellow glaze, and "gold wire patterns." The reason for glaze surface cracking was that there existed difference between expansion coefficients between the body and glaze. When the difference was large, crackles were dense and formed small pieces; when the difference was little, crackles were sparse and formed large pieces.

3.5.7 Porcelain from Royal Kiln of the Song Dynasty

Royal kiln was porcelain kiln directly established and operated by the government. Its products were mainly daily-use porcelain and ornamental porcelain and specially for the palace. Currently, only royal kiln of Southern Song Dynasty was extravagated on Wugui Mountain at southern suburbs, Hangzhou, named "Jiaotan royal kiln." In the late Southern Song Dynasty, celadon from royal kiln pursued jadelike quality. Double-firing process was adopted: First bisque firing the body at low temperature and then apply three or four layers of glaze on the biscuit for forming thick glaze with glaze layers generally above 2 mm and then fire the biscuit at high temperature. As the body of celadon from royal kiln had fairly high content of iron oxide, mouth and rims of the ware featuring thin glaze appeared gray or gray purple, and the body at the bottom where glaze was scratched off was exposed, rendering black brown color or dark gray color, hence forming characteristics of "purple mouth and iron foot." For example, porcelain bottle with pierced handles from royal kiln of the Southern Song Dynasty featured "purple mouth and iron foot" as well as cracked glaze surface.

3.5.8 Porcelain from Jingdezhen Kiln of Song Dynasty

Jingdezhen Kiln was situated at the southeast of Jingdezhen City, Jiangxi, represented by Hutian Kiln with the largest scale. It started firing porcelain in the Tang Dynasty and its products sold throughout the country as well as overseas in the Southern Song Dynasty. A large amount of products belong to daily-use porcelain, which were primarily bluish white porcelain, featuring pure white fine and smooth body. The glaze color fell between blue and white, bluish white, or whitish blue, and the glaze was so clear as lake water that people's shadow can be reflected in it. Thus, such porcelain was called "light blue porcelain" by later generations. For example, bluish white-glazed plum vase carved with peonies and tangled branches, Jingdezhen Kiln, Southern Song Dynasty unearthed from Jinyu Village, Suining City, Sichuan, featured white body, bluish white glaze presenting white suffused with green and the ring foot exposing the body without glaze. Light blue porcelain Avalokitesvara sitting statue, Jingdezhen Kiln, Southern Song Dynasty unearthed from Songjing, Changzhou City, Jiangsu, features light blue-glazed outerwear and seat with cracked ice patterns, but the remaining parts of body left exposed. Forty-five kilometers away from the northeast of Jingdezhen, there is a mountain named Gaolin Mountain, at the foot of which there is a village called Gaolin Village. Gaolin Mountain abounds in a kind of heat-resisting clay which can be used as the raw material of porcelain. Villagers called such clay as Gaolin.

Porcelain from Jingdezhen Kiln in Song Dynasty was made from only two kinds of raw materials: The first one was china stone. This kind of rock mainly contains quartz and sericite. It is hard and could not be used until it had been broken with water-powered trip hammer and undergone several elutriation. Jingdezhen Kiln of Song Dynasty had not used Gaolin yet and only used china stone as the raw material for making the body, which was called "unitary

formula." The second kind of raw material was glaze stone and glaze ash. Glaze stone was a kind of unweathered or slightly weathered china stone, featuring a high content of fluxing agents—potassium oxide and sodium oxide. Glaze ash was produced by steaming and simmering fairly pure limestone and Langqicao (a kind of pteridophyte), which was mainly composed of calcium carbonate. As white glaze was prepared by adding glaze ash to glaze stone, taking calcium oxide as the main fluxing agent, it was called calcium glaze, also known as calcareous glaze.

Jingdezhen had always fired porcelain with masson pine firewood as the fuel which was called by potters as "kiln firewood."

3.5.9 Porcelain from Jianyang Shuiji Kiln of Song Dynasty

Jianyang Shuiji Kiln, called Jian Kiln for short, was situated at Shuiji Township of Jianyang County, Fujian. It was a folk kiln. Jian Kiln started firing porcelain from Tang Dynasty and began rolling out black-glazed teacups at the beginning of Song Dynasty and stopped firing porcelain at the end of Yuan Dynasty. Black-glazed teacups with black body from Jian Kiln were genuine black porcelain. Teacups with black glaze presenting yellow stripes in the shape of hare's hair were called Tuhao Zhan (teacup with rabbit's hair pattern). For example, Tuhao Zhan unearthed from Jian Kiln of Song Dynasty had patterns of hare hair stripe on its interior wall and exterior surface, which were crystalline glaze. Brown-glazed bowls from Jian Kiln of Song Dynasty had patterns of hare hair stripe on the interior wall and exterior surface, which were also crystalline glaze.

Body and glaze of products from Jian Kiln both contained a high level of iron oxide. Glaze was applied as follows: Shake glaze to the interior wall and glaze the exterior surface by immersing the body, which was called half-glazing or incomplete glazing.

The patterns of hare hair stripe from Jian Kiln were formed as follows: Glaze of Jian Kiln was generally fired in the reducing atmosphere at 1,300–1,350 °C. Iron trioxide from raw materials was partly regenerated to ferriferrous oxide, and oxygen was released, leaving small bubbles in the glaze fluid. While bubbles were rushing out toward the glazed surface, they brought iron trioxide particles to the glaze layer. When the temperature reached above 1,300 °C, glaze layer flowed, causing the part abounding in iron to become stripes. After the stripes cooled down, small crystals of hematite were separated out from them, hence the yellow patterns of hare hair stripe. In terms of porcelain-making technique, such glaze in the shape of hare hair stripe naturally formed during the firing process in the kiln was called "crystal glaze."

3.5.10 Porcelain from Jizhou Kiln of Song Dynasty

Jizhou Kiln was located at Yonghe Township, Ji'an City, Jiangxi. It started firing porcelain in the late Tang Dynasty, developed in Northern Song Dynasty,

flourished in Southern Song Dynasty and gradually fell into decay after Yuan Dynasty. It was a folk kiln, and its most characteristic product was black porcelain. Its master work was made with blending of black and yellow glaze, similar to a turtle in color; besides, it originated tree leaf decoration. Black glaze was the general term of dark glazes, and Japanese called black glaze as "temmoku glaze." Black glaze had various glazing colors, such as black and brown, with iron oxide as the main coloring agent. For example, black-glazed bowl in a shape of bamboo hat and black-glazed pot with angular shoulder from Jizhou Kiln in Song Dynasty both used black glaze.

Black glaze from Jizhou Kiln contained high levels of alkali metals (potassium, sodium) and alkaline earth metals (calcium, magnesium); however, it had low contents of aluminum oxide and iron oxide. Consequently, it is not easy to separate out crystals (small hematite crystals were naturally separated out during the firing process), that is to say, it is not easy to form crystal glaze in the kiln, showing that black glaze from Jizhou Kiln was obviously different from that from Jian Kiln. Under such a circumstance, craftsmen making porcelain from Jizhou Kiln had to adopt twice-glazing process: First, apply a layer of black glaze; second, on the black glaze, adopt methods such as paper-cutting and appliquéing as well as other methods for applying white or yellow glaze. After the body was fired, speckled glaze, turtle-shell glaze, and hare hair glaze were formed.

Spraying glaze means sprinkling milky white glaze of different concentrations on black glaze, and milky white speckles would form after the body had been fired, such as black ground glaze-spraying bowl and bluish yellow ground glaze-spraying bowl with tadpole pattern from Jizhou Kiln of Song Dynasty. Black-glazed bowl with turtle-shell patterns of Song Dynasty was made by spraying some yellow glaze on black glaze and using black ground and yellow speckles for imitating speckles on turtle-shell. Turtle, a kind of reptile found in tropical and subtropical seas, is shaped as a tortoise with its shell presenting yellowish brown and featuring black speckles. Today, there are some turtles displayed in the zoo of Haikou City.

Paper-cutting and sprinkling glaze means sticking paper-cutting on the black glaze for keeping off sprayed glaze. After fired, black patterns were formed at the place stuck with paper-cut had no white or yellowish brown glaze. For example, hare hair ground paper-cut bowl with water chestnut flower pattern from Jizhou Kiln of Song Dynasty was made by sticking paper-cut on the black glaze on the interior wall and then spraying yellowish brown glaze; thus, black water chestnut flower patterns were formed at the place where paper-cut was stuck, and yellowish brown hare hair patterns of radical shape were formed at other places. It should be noted that such hare hair patterns were caused by spraying glaze, different from crystal glaze from Jian Kiln. If such hare hair patterns were crystal glaze, then crystal glaze would also be formed on the place of the interior wall where paper-cut was stuck as well as on the exterior surface.

Tree leaf decoration was a kind of glazing technique originated by Jizhou Kiln. Since Southern Song Dynasty, tree leaf black teacup had become a precious new variety of black glaze. The glazing technique was as follows: Ferment tree leaf to

make it rotten so that only leaf vein is left, dip it into white glaze or transparent yellow glaze, then fling off excess glaze in the tree leaf network, and later stick it on black glaze and fire it at high temperature; thus, black-glazed tree leaf patterns are formed. For example, black-glazed bowl with tree leaf patterns from Jizhou Kiln of Song Dynasty had clearly visible patterns of tree leaf and traces of leaf veins on the interior wall, with transparent yellow glaze on the tree leaf.

3.5.11 Porcelain from Lingwu Kiln of Western Xia Dynasty

Western Xia Dynasty (1038 AD–1227 AD) was a local authority established by Tangut, a branch of the Qiang ethnic minority group, in the northwest and coexisted successively with Song (960 AD–1279 AD), Liao, and Jin dynasties. Lingwu Kiln was located at Ciyaobao of Lingwu County, Ningxia. White glaze was prepared with limestone and clay; black glaze was made with a kind of local black slip with iron oxide as the coloring agent. It was fired with oxidizing flame, and the firing temperature was at around 1,260 °C. White glaze was mostly yellowing white.

The majority of utensils from Lingwu Kiln were decorated with Tihua decoration, and the process was as follows: Apply a layer of white engobe to the body, later apply a layer of black glaze or brown glaze on it, then engrave flower patterns, and later remove black glaze or brown glaze on the parts other than those with flower patterns to expose the white engobe, so that the black-glazed or brown-glazed flowers appear in Yangwen (convex pattern). For example, brown-glazed Tihua porcelain flattened pot of Western Xia Dynasty had peonies presented in Yangwen. Tihua vase with engraved patterns of Western Xia Dynasty unearthed from Lingwu Kiln Site featured black glaze and engraved patterns of peony with folding branches in Kaiguang. Kaiguang means window. Jiang glazed roll-mouthed vase with engraved peony of Western Xia Dynasty had two groups of windows at the stomach and a brown-glazed peony in each group of windows apart from engraved brown-glazed wave patterns at other places.

3.6 Porcelain of Yuan, Ming, and Qing Dynasties

During Yuan, Ming, and Qing dynasties (1271 AD–1911 AD), Jingdezhen Kiln in Jiangxi reflected the achievements in porcelain-making technologies of various kilns around the country, well known for making colorful glazed porcelain and painted porcelain. In Yuan Dynasty, Porcelain Bureau was established at Jingdezhen, obviously improved crafts of white porcelain; in Ming Dynasty, porcelain factories were set up at Zhushan, Jingdezhen, called “Royal Kiln,” which fired porcelain for the palace. Since then, Jingdezhen became the center of porcelain production of China and even around the world. Starting from Yongle Years of the reign of Zhuli, Chengzu of Ming Dynasty (1403 AD–1424 AD), porcelain produced

in royal kilns all carried inscription of reign title of the emperor back then; in Qing Dynasty, an imperial utensil plant was established in Jingdezhen where porcelain for the palace was produced. In the period ruled by emperors Kangxi, Yongzhen, and Qianlong, porcelain-making technologies reached the peak, which later gradually declined. As stated above, in Song Dynasty, porcelain from Jingdezhen Kiln was generally made by adopting "unitary formula" for raw materials of bodies, i.e., only used china stone and Gaolin had not been used yet. From Yuan and Ming dynasties, porcelain from Jingdezhen Kiln was produced by adopting "binary formula" for raw materials of bodies: In Yuan and Ming dynasties, porcelain was made mainly with china stone mixed with a little Gaolin and the firing temperature reached around 1,250 °C; in Qing Dynasty, a little more Gaolin was used for producing porcelain with the firing temperature reaching around 1,300 °C. Compared with "unitary formula," "binary formula" boasted the following strong points: In aspect of chemical components, the content of silicon oxide was becoming less and less, while aluminum oxide was becoming more and more; in microstructure of the body, content of quartz became increasingly less while mullite–crystal generated from aluminum and silicon under high temperature, gradually increased, which functioned as the framework in the body. Consequently, porcelain body from Jingdezhen Kiln gradually reached modern standards for hard porcelain. In Yuan and Ming dynasties, potassium oxide and sodium oxide in the glaze of white-glazed porcelain from Jingdezhen Kiln had already functioned as fluxing agents together with calcium oxide, and such glaze was called calcium–alkali glaze; sometimes, the contained potassium oxide and sodium oxide even played a larger role than calcium oxide, and the glaze was named alkali–calcium glaze.

Now the main achievements of various porcelain made in Yuan, Ming, and Qing dynasties are introduced as follows.

3.6.1 White-Glazed Porcelain Painted with Black or Brown Flowers

Underglazed porcelain with black or brown flower patterns was made by painting white engobe with iron-bearing minerals as the pigments and then applying transparent glaze before firing the body. The examples are white-glazed porcelain kettle with patterns of black flowers and baby-playing from Cizhou Kiln and white ground porcelain pot painted with dragon and phoenix patterns with pigments containing iron oxide from Cizhou Kiln. Those have been discovered near shipwrecks of Yuan Dynasty in sea area of Sandaogang, Suizhong County, Liaoning. Another example is white-glazed pear-shaped vase with brown flower patterns, Cizhou Kiln, Yuan Dynasty.

3.6.2 Blue-and-White Porcelain

It is also a kind of underglazed porcelain which was made by painting patterns on the body with "blue cobalt (Co) material," i.e., asbolane, and then applying

transparent glaze before once firing the body into porcelain at 1,350 °C. Cobalt looks blue, hence the name of blue-and-white. Asbolane includes those domestically produced and imported from foreign countries or regions. Asbolane produced in Yunnan was called "Zhumingliao," which consists of manganese oxide, cobalt oxide, and other minerals. Imported asbolane was originated from the western regions, called "Su Ma Li Qing" and "Hui Qing Liao."

Examples of blue-and-white porcelain of Yuan Dynasty include blue-and-white covered octagonal plum vase with patterns of waves and dragons, blue-and-white octagonal covered pear-shaped vase with patterns of double lions playing with a ball, and blue-and-white flattened ewer with patterns of double dragons unearthed from South Road of Yonghua, Baoding City, Hebei.

Blue-and-white porcelain of Ming Dynasty, such as blue-and-white dish with patterns of interlocked branches and flowers, was the premium product of the Yongle Period. Blue-and-white plate with lotus patterns was a product from Jingdezhen Royal Ke Period. Blue-and-white flattened vase with patterns of dragons striking through clouds and seawater of the Xuande Period and blue-and-white plate with patterns of phoenix flying through lotus of the Jiajing Period both used "Hui Qing Liao" imported from the western regions for making the blue-and-white colors. Blue-and-white covered kettle with design of double dragons and "Shou" character (Chinese character "shou" means longevity in English) of the Jiajing Period was premium large-scale blue-and-white porcelain of Ming Dynasty. Blue-and-white urn with patterns of dragons and clouds of the Longqing Period also used "Hui Qing Liao" from the western regions for making blue-and-white colors. Blue-and-white brush pot with patterns of figures was the representative work of the Chongzhen Period of the late Ming Dynasty.

A great deal of blue-and-white porcelain was fired in Qing Dynasty, and asbolane produced in Zhejiang was mainly used. An example is blue-and-white bowl with full inscriptions of Qian Chibi Fu of the Kangxi Period. *Qian Chibi Fu* is an ode to Cibi written by Su Shi, a poet of Northern Song Dynasty.

3.6.3 Underglaze Red Porcelain

Underglaze red porcelain refers to porcelain whose underglaze color presents red patterns, which was firstly fired in Jingdezhen Kiln in Yuan Dynasty. The coloring pigment for underglaze red porcelain was produced by processing "copper flower," which was the copper crumb, i.e., the surface layer shed from red bronze when it oxidized by heating, featuring thin and crisp. The processing method was as follows: Grind "copper flower" into powder, and then add water to the mixture and grind the mixture into paste, hence the copper-red pigment. At first, paint patterns on the body with copper-red pigment and then apply transparent glaze and finally once fire body into porcelain in the reducing atmosphere at a temperature of 1,350 °C. Copper-red pigment was very sensitive to atmosphere, which could only be fired into pure bright red in a fairly strong reducing atmosphere; therefore, the output was quite low, and products handed down were quite few,

such as underglaze red pear-shaped vase with patterns of chrysanthemum of Yuan Dynasty, underglaze red plate with patterns of lotus of Ming Dynasty, and underglaze red gourd-shaped vase with patterns meaning happiness and longevity of the Qianlong Period, Qing Dynasty.

3.6.4 Doucai Porcelain

Doucai was a kind of colorful porcelain combining underglaze blue-and-white decoration as well as onglaze decoration, with blue and white as the main color. It was a kind of precious colorful porcelain fired by imperial utensil plant at Jingdezhen during Ming and Qing dynasties, and the products produced in the Chenghua Period of Ming Dynasty were the best. The process was as follows: On the fired blue-and-white porcelain, first use pigment containing iron oxide red and copper to paint the patterns, and then twice fire the product in oxidizing atmosphere at low temperature. Iron oxide red is also called red from iron oxide, produced by calcining and rinsing "iron vitriol," with iron oxide as the coloring agent. Appropriate amount of lead powder and glue was necessary for painting the body. Examples of Doucai porcelain include Doucai Tianqiu vase with patterns of seawater, rivers, and mountains of the Yongzheng Period, Qing Dynasty, and Doucai plate with patterns of flowers of the Yongzheng Period.

3.6.5 Wucai Porcelain

Wucai means multiple colors, and it does not necessarily mean five colors. As a matter of fact, all colorful porcelain featuring above three colors (including red) was called Wucai. The process for making it was as follows: At first, paint complete tableau on the fired porcelain with red pigment, green pigment, yellow pigment, blue pigment, and purple pigment, and then twice fire the body in oxidizing atmosphere at a low firing temperature of around 800 °C.

Wucai porcelain fell into two categories: One was blue-and-white Wucai porcelain, which was made by painting patterns on fired underglaze blue-and-white porcelain, and then twice firing the porcelain at low temperature, such as Wucai covered porcelain pot with fish and alga patterns of the Jiajing Period, Ming Dynasty; the other category was onglaze Wucai porcelain, which was made by painting patterns on fired white glaze porcelain, and then twice firing the porcelain at low temperature, such as Wucai club-shaped vase painted with figures of Qing Dynasty and Wucai plate with patterns of birds and flowers of the Kangxi Period. The latter features four small windows at the rim, separately written with four Chinese seal characters "Wan," "Shou," "Wu," and "Jiang," which means longevity; on the exterior surface, five bats were painted, meaning "having great luck." White ground Wucai plate with dragon patterns of Qing Dynasty is a premium product of Wucai porcelain.

3.6.6 Su Sancai Porcelain

In ancient China, joyous events such as wedding celebration and birthday congratulations were called Yunshi and red was always used; events such as funeral were named Sushi, and red was forbidden to be used. Therefore, porcelain featuring above three colors without red was called Su Sancai. For example, Su Sancai brush pot with patterns of seawater and dragon only adopted white, green, and yellow. It is a premium product among Su Sancai porcelain of the Kangxi Period.

3.6.7 Famille Rose Porcelain

In the late Kangxi Period of Qing Dynasty, famille rose porcelain was created and fired with imported pigments. When it came to the Yongzheng Period, famille rose porcelain saw increasing maturity, and later supplanted Wucai porcelain, hence becoming the mainstream of onglaze porcelain of Qing Dynasty. Famille rose porcelain got its name because its glaze had "glass white"—a kind of white pigment containing arsenic (arsenic trioxide). On porcelain fired at high temperature, firstly painted patterns with famille rose and then twice fired the porcelain at a low temperature of around 750 °C. As arsenic oxide played a role of opacification, it made red pigment into pink, green pigment into light green, and blue pigment into light blue as well as made each color featuring rich levels. Temperature for twice-firing famille rose was lower than that for Wucai; therefore, it had a softer color, hence the name "soft pigment." After the body was fired, arsenic oxide in the glaze would be basically volatilized; therefore, its toxicity fundamentally vanished, and thus, it had little impact on mankind's health. Famille rose porcelain, such as famille rose wine vessel with patterns of many deer of the Qianlong Period, featured various colors of rich levels. Another example was famille rose plate with patterns of flowers and butterflies of the Yongzheng Period, which was an excellent product of famille rose porcelain; famille rose plate with patterns of maidens playing with babies of the Yongzheng Period was a representative works of famille rose porcelain; famille rose plate painted with Guozhi peaches of the Yongzheng Period was a premium product of famille rose porcelain from royal kilns. The picture extending from the exterior of the porcelain to the interior was called "Guozhi Picture"; famille rose lantern-shaped wine vessel painted with chrysanthemum of the Qianlong Period was an excellent work among famille rose porcelain; famille rose Weijiao flowerpot painted with various flowers of the Qianlong Period represented technological level of famille rose. Weijiao is a roundabout angle.

Porcelain was one of the greatest inventions of ancient China. However, there are only a few of historical documents concerning porcelain-making technologies. The earliest one is *A Record of Pottery* written by Jiang Qi in the Southern Song Dynasty (1127–1279), which was later included in *Fuliang County Annals* published in the 21st year of the reign of Emperor Kangxi (1682). *The Exploitation of the Works of Nature* written by Song Yingxing in the tenth year of the reign of Emperor Chongzhen of Ming Dynasty (1637) is another document

concerning porcelain-making technologies. All these works present accounts of porcelain-making technologies of Jingdezhen, which were later translated into foreign languages and introduced to the West. In the fifteenth and sixteenth centuries, Chinese workers and technicians engaged in porcelain-making also went to foreign countries for firing porcelain; thus, porcelain-making technologies of Jingdezhen were also introduced to foreign countries.

4 Conclusion

Main achievements in technologies for making pottery and porcelain in ancient China may be summed up in the following two aspects:

1. Five Milestones in History of Technologies for Making Pottery and Porcelain in Ancient China
   (a) In the Late Paleolithic Age, mankind invented pottery, which was the first substance made by mankind that did not exist in the nature. Invention of pottery led to great changes to mankind's life and production;
   (b) The Xia Dynasty saw emergence of stamped hard pottery, and Shang Dynasty saw appearance of proto-porcelain. Since then, pottery-making technologies transited to porcelain-making technologies;
   (c) The Eastern Han Dynasty saw the emergence of mature porcelain—Yue Kiln celadon, hence China entered into the era of making porcelain.
   (d) The Northern Qi Dynasty saw the emergence of white porcelain, and the Tang Dynasty saw mature firing technologies for firing white porcelain, hence the situation of "blue-glazed porcelain in the southern China and white porcelain in the northern China." White porcelain was the basis and prerequisite condition for the later generations to create painted porcelain.
   (e) Brilliant achievements were made in colorful glazed porcelain and painted porcelain from the Song Dynasty to the Qing Dynasty: Colorful glazed porcelain includes copper-red-glazed porcelain from Jun Kiln of the Song Dynasty, black-glazed porcelain from Jian Kiln, Jizhou Kiln, and Lingwu Kiln of Western Xia Dynasty, and red glaze (including shiny red, ruby red, and coralito), yellow glaze, and green glaze after the Ming Dynasty; painted porcelain includes white-glazed porcelain with patterns of black flowers, blue and white, underglaze red, Doucai, Wucai, Su Sancai, and famille rose of Yuan, Ming, and Qing dynasties.
2. Four Great Breakthroughs in Technologies for Making Pottery and Porcelain in Ancient China
   (a) Breakthrough in the selection of raw materials of the body. In the past, pottery was mainly made from common fusible clay, consequently limiting rise of firing temperature. Starting from the proto-porcelain, heat-resisting raw materials were adopted and china clay was used for making proto-porcelain in Shang and Zhou dynasties. In the Song Dynasty, Gaolin was used as raw

material in kilns of the northern part of the country and kilns in south China used china stone as raw material, called "unitary formula." In the Yuan, Ming, and Qing dynasties, china stone and Gaolin were used as raw materials in Jingdezhen Kiln, which was called "binary formula," causing porcelain body to gradually approach the standards for modern hard porcelain.

(b) Breakthrough in body-modeling methods. The breakthrough was demonstrated in making pottery with quick jigger wheels and molding: On the one hand, making pottery with quick jigger wheels appeared at the last stage of the Late Neolithic Age. The Late Chalcolithic Age saw the first climax of pottery-making technologies with quick jigger wheels, and the Han Dynasty saw the second climax of pottery-making technologies with quick jigger wheels; on the other hand, method of making pottery with internal mode appeared in the Early Chalcolithic Age and that with external mode appeared in the Warring States. The Han Dynasty saw standardized parts made with this method. Due to adoption of methods of making pottery with quick jigger wheels and molding, productivity of pottery-making handicraft industry enjoyed rapid improvement.

(c) Breakthrough in building kilns and firing temperature. Breakthrough made in building kilns started from emergence of half up-and-down draft kiln and horizontal flame kiln in Shang Dynasty, and both the kinds of kilns enjoyed improvement and development from Zhou Dynasty to Han Dynasty. Breakthrough in firing temperature began from proto-porcelain of the Shang and Zhou dynasties, reaching 1,100–1,200 °C; in the Eastern Han Dynasty, the firing temperature for celadon from Yue Kiln reached 1,310 °C; thus, celadon became mature porcelain; in the Tang Dynasty, firing temperature for white porcelain from Xing Kiln reached 1,260–1,370 °C. With rise of firing temperature, hardness, strength, and compactness of porcelain also correspondingly increased.

(d) Breakthrough made in the formation and development of glaze. The breakthrough was demonstrated in high-temperature glaze and low-temperature glaze. On the one hand, high-temperature calcareous glaze appeared on the proto-porcelain of Shang and Zhou dynasties; on the other hand, low-temperature lead glaze emerged in Western Han Dynasty. Ceramic artisans added various pigments of metallic oxides into the glaze, hence forming colorful glazed porcelain; besides, they also painted under or on the glaze with various metallic mineral pigments for making painted porcelain.

References

1. Li W (1996) A study of the pottery-making technologies in ancient China. Science Press, Beijing
2. Li J (1998) History of science and technology in China—ceramic volume. Science Press, Beijing
3. Kuanghua Z, Jiahua Z (1998) History of science and technology in China—chemistry volume. Science Press, Beijing

Author Biography

Wenjie Li a male, and a researcher of National Museum of China, was born in Jinyun County, Zhejiang Province, in November 1935. In 1955, he graduated from Experimental Middle School of Liaoning Province and from History Department of Peking University, majoring in Archaeology in 1960. Before July, 1987, he engaged himself with work concerning archaeology of field of the Neolithic Age in Institute of Archaeology, Chinese Academy of Social Sciences, and later, he was transferred to a post on archaeological excavation and study in Department of Archaeology, National Museum of Chinese History. From 1980 to today, he has been engaged in studying history of technologies for making pottery in ancient China. So far, he has already published 48 reports and articles on archaeological excavation. *A Study of Pottery-making Technologies in Ancient China*, as his master work, is China's first monograph studying technologies for pottery manufacture in ancient times. He has seven works and treatises to publish, with *History of Pottery-making Engineering Technologies in Ancient China* as his master work, which systematically summarizes major achievements made in the Yellow River Valley, Yangtze Valley, and other regions in the period from the Early Neolithic Age to Qing Dynasty by dividing the book in chapters based on periods and dividing it into sections according to technological processes.

Weaving Technology

Feng Zhao

1 Lecture 1 Overview of Weaving Technology in China

Clothes, food, house and transportation are basic necessities of life whenever or wherever humans are. Textile industry just provides basic safeguard for satisfying such needs of humans, thus textile has consequently become one of the most important component in the technology history of human beings. As in the whole world, textile technology also occupies an important position in Chinese history of science and technology, especially silk technology made an extremely important contribution to the whole world' history of science and technology, and exerted significant impacts on development of the world' technology as well as culture.

1.1 Structure of Textile Industry in Early Times

Cotton, wool, Ma (a general term for hemp, flax, jute, etc.) and silk are the four main and pervasive kinds of raw materials of natural fibers. Ancient civilizations in different regions had all created rich textile cultures according to specialties of their own natural environments. In the course of history, the textile cultural circles gradually took their shapes with distinctive traits. Roughly speaking, the four great ancient civilizations in the Old World just had obvious corresponding relations with four textile fiber raw materials. Egyptians mainly used flax; India mainly saw rich outputs of cotton; ancient Babylon primarily produced wool, while China dominantly produced silk.

Flax was originated from the Near East, but seemingly it's earliest utilized in textile in Egypt. Flax braided fabrics of 5000 BC were found in Fayum and Badari, which were however quite crude. Besides, sites of the Neolithic Period of 3750 BC were found along the banks of various lakes of Alps located at the border

F. Zhao (✉)
Donghua University, Shanghai, China

© Shanghai Jiao Tong University Press,
Shanghai and Springer-Verlag Berlin Heidelberg 2015

Y. Lu (ed.), *A History of Chinese Science and Technology*,
DOI 10.1007/978-3-662-44166-4_4

of Switzerland and Italy, and a massive volume of flax yarn and fabrics were found at the earliest site in Robenhausen.

Sheep and goats should have been earliest domesticated in the middle and lowest reaches of Tigris and Euphrates of West Asia, but wool was widely used in textile. It can be seen that wool was used in the whole West Asia, Central Asia, North Asia and Europe in an early period. However, wool textile in Central Asia might be introduced from West Asia.

In India, an old country, cotton textile was originated and developed in an extremely early time. Cotton fibers and cotton textiles of 5,500 years before were unearthed at Mohenjo-Daro Site located in the valley of Indus River in today's Pakistan. These cotton fibers were identified as fibers of cultivated cotton, demonstrating that cotton was the main textile raw material in Indian textile cultural circle. But shortly thereafter, cotton textile technology was gradually introduced into Persia and into Europe and Africa before the Christian era as well as into the northwestern areas of China around the Christian era.

While China, a country located in the east, mainly used silk as the main textile raw material. From the data of archaeology, silk was exactly originated from the Yellow and Yangtze River Valleys in China more than 5,000 years ago. The earliest known solid evidence of using silk was found in 1926, when Li Ji, an archaeologist of the first generation of China, excavated a site of Yangshao Culture at Xiyin Village, Xia County, Shan Xi, where half of a silkworm cocoon was unearthed. After verification of many scholars, this half of a silkworm cocoon was deemed as the important material evidence of the fact that silkworm cocoons and silk were used in ancient China. Currently, this silk worm cocoon was kept in Taipei's Palace Museum. In 1958, persons engaged in archaeological studies of Zhejiang found a bamboo basket at Liangzhu Culture Site at Qianshanyang in Huzhou. There were some textiles and strip lines and other material objects in the bamboo basket, which were identified as tough silk sheets, silk thread and ribbons etc. by Zhejiang Textile Institute back then and Zhejiang Technology University later. Later, Archaeological Institute of Zhejiang also found some silk ribbons at this site which were made around 4,000 years ago. The third material evidence was debris of silk and Ma fabrics of around 5,500 years before unearthed at the Neolithic Site at Qingtai Village, Xingyang City in 1980s, which was the most explicit material evidence of ancient Chinese producing and using silk 5,000 years ago. According to the above findings, we can see that Chinese silk had a history of at least 5,000 years Later, China's silk was also introduced to Japan, South Korea etc. becoming a key feature of textile cultural circle of East Asia.

While featuring silk, China's textile raw material in early time also included a great amount of wool and hemp-fiber.

The place where the majority of wool fabrics were found was Xinjiang, where was closely linked with textile cultural circles of Central Asia and West Asia. A large sum of wool fabrics were found at sites of early Bronze Age (around 3,000 years ago) in Xinjiang discovered by archaeological studies, such as Xiaohe Cemetery in Lopnor region, Wubao and Yanghai Cemeteries in Turpan Prefecture, Zagunluke Cemetery in Qiemo, etc. and there were also many kinds of wool, which have yet to be identified comprehensively.

Cellulose fibers of plants were also widely used in China in early times and there were many choices. For example, kudzu fabrics of around 5,000 years ago were unearthed at Caoxieshan Site in Wuxian County, Jiangsu, as said in *Shi Jing*, · *Zhou Nan* · *Ge Qin*:

Kudzu vines are soft and long, spreading in the valley.

The leaves are flourishing, which are cut off and cooked,

for making fine and coarse kudzu-hemp cloth and once you put on clothes made of the cloth, you'd never detest them.

Kudzu in the poem was just kudzu vine, its scientific name is Pueraria lobata (Willdenow) Ohwi. It's a kind of perennial herbaceous liana of leguminosae, featuring thick and long stems. Besides, it's a type of sarmentous plant, always spreading on the ground or winding on other plants. "Cutting off and cooking" are the processes of extracting kudzu fibers, "Chi" (fine cloth) and "Xi" (coarse cloth) are all fabrics made from kudzu fibers.

In addition, among Hemp-fibers, North China mainly used hemp, which has a scientific name of *Cannabis sativa* L. As an annual herbaceous plant, it's dioecious. South China, however, used ramie with the scientific name of Boehmeria nivea (Linn.) Gaudich. As said in Shi Jing · Chen Feng · Dong Men:

The city moat outside of East Gate can be used for soaking Ma (cannabis sativa)
I can sing with the tender and beautiful girl.
The city moat outside of East Gate can be used for soaking Zhu (ramie).
I can talk with the tender and beautiful girl.
The city moat outside of East Gate can be used for soaking Jian (sedge).
I can talk with the tender and beautiful girl about intimate things.

The "Ma" and "Zhu" in the poem refer to hemp and ramie respectively and "Ou" means a process of soaking skin of cannabis sativa in the water for obtaining fibers. "Jian" in the last paragraph means sedge, a kind of cogongrass, which was used for making rope back then.

1.2 Cultural Opportunity of Origin of Silk

However, the most characteristic fiber in textile industry in early China was silk fiber. The main silkworm species in Chinese textile history were *Bombyx mori* L. which was a kind of economic insect featuring eating leaves of mulberry trees and spinning their cocoons, also called mulberry silkworm. This is a kind of insect of complete metamorphosis. It will go through four development stages in its life-cycle: silkworm egg, silkworm, chrysalis and silk moth which feature completely different forms and physiological functions (see Fig. 1). Silk egg is the stage when embryo develops and grows into a tiny silkworm. Tiny silkworm is the growth stage when the silkworm absorbs food nutrition, generally called silkworm, commonly known as "Can'er". In the silkworm stage, or caterpillar stage, the silkworm will go through four skin molts. When it sheds its old skin, it will not eat, hence the name of dormancy. After four

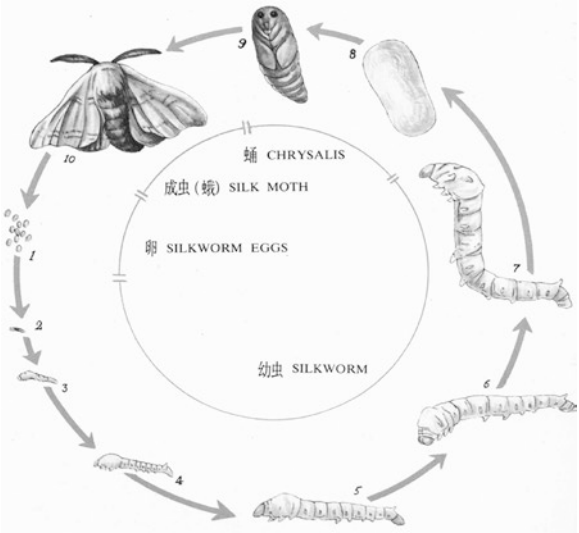


Fig. 1 Pictures of four forms of silkworm growing and changing

times of dormancy, the silkworm is called a matured silkworm, whose body becomes completely transparent and it stops eating and begins to spin itself in a silk cocoon. After the silkworm spins its cocoon, it sheds its skin and becomes a chrysalis and around seven days later, the silkworm moth, also called adult silkworm, emerges from the cocoon, which is the stage male silk moths and female silk moths mate and female moths lay eggs for reproducing offspring. Female silk moths lay eggs after having mated with male moths. A female moth generally can lay around 500 eggs. Cocoon silk span by the silkworm is used by people for producing silk fabrics.

The legend of silk origin spread very far and there were also many kinds of silkworm gods worshipped by folk people. The most famous official legend was Leizu, Yuan Fei of Yellow Emperor, invented rearing silkworms while the best known folk one was the story about Silkworm Horse Maiden (Matouniang).

The legend about Leizu earliest rearing silkworm was first found in *Lu Shi* by Luo Mi of Song Dynasty: Xilingshi, Concubine Yuan of the Yellow Emperor, was named Leizu. She was the first one rearing silkworms and therefore people worship her as the silkworm goddess." It's also recorded in *Tong Jian Gang Mu Qian Bian · Wai Ji* by Zhang Lvxiang of Jin Dynasty that: "The Xilingshis' daughter Leizu married Yellow Emperor, titled Concubine Yuan. She first taught people to rear silkworms for getting silk from the cocoon for making clothes, thus people under the sun needn't worry about suffering from cracked skin and chilblain, consequently, later generations deified her as the silkworm goddess." Leizu was also called Xilingshi and her clan was originated from near the Xiling Gorge in Sichuan, therefore someone predicted that Leizu's technology of breeding silkworms might have come from Sichuan.

There are many legends about origin of breeding silkworms among the people, but the best known one was the one about Silkworm Horse Maiden. Many scholars also called it silkworm-horse story, which was first found in *Sou Shen Ji by Gan Bao of Jin Dynasty*:

According to a very ancient myth, there was a father who spent his days traveling far away and left his daughter at home. There was also a white stallion and the girl took care of the horse by herself. The girl lived a hard and lonely life, missing her father very much, so she joked with the horse: I will marry you if you would bring my father home. After heard the words, the horse broke the reins and ran away and directly ran to the place where her father was. When her father saw the horse, he felt pleasantly surprised, therefore pulled the horse and rode on it. The horse looked at the direction where it came from, keeping crying. Father said: this horse cries, is there anything happens at my home! Thus he urgently rode the horse back home. He thought that the horse had unusual feeling and thus gave it more hay. The horse refused to eat it. Each time when the girl came in or went out, it would spare no efforts to happily and angrily attack her, which happened not only one time. The father felt quite surprised and secretly asked his daughter. The girl told her father all the things: "It must be for this reason". The father said: "Don't speak it out or it may bring disgrace to the family and you'd better not come out." Then he sneakingly killed the horse with bow and arrow and dried the horse skin in the yard. After the father was again off on his travels, with a neighbor girl, the girl was playing with the horse skin, pressing the skin with her feet and mockingly said: "You're just an animal and you want a human for a wife? You are killed and peeled for this reason. Why did you distress yourself!" Before she finished her words, the horse skin suddenly engulfed her and whisked her away. The neighbor girl was very afraid and dared not to save her. She ran to tell the girl's father. The father returned and searched for his daughter, but his daughter had lost. Several days later, he finally found that his daughter and the horse had already changed into a big white silkworm (with a horse-shaped head) that was spinning silk threads in a large tree. The silk cocoon was much stronger and more abundant than that of an ordinary silkworm. A neighbor woman took the silkworm and bred it and obtained several times of income. Thus the big tree was named mulberry. The Chinese character "sang (mulberry) is pronounced the same as "Sang (mourning)". Thus people ran to plant this kind of trees, and bred silkworms which are reared today.

As a matter of fact, silk industry occurred in China was because multiple basic conditions appeared in China. First of all, it's because of existence of resources. There were numerous wild mulberries and wild silkworms in China which produced various wild silkworm cocoons. Secondly, China enjoyed developed ancient culture. 5,000–7,000 years ago, our ancestors who lived in the Neolithic Period had created relatively complete cultures in terms of clothes, food, housing, travel, production, religion, art, war, providing soil for producing silk. The other condition was opportunity. From tremendous data of archaeology, ethnonymics, anthropology, we can see that invention of silkworm-rearing technologies or silk industry originating in China was actually based on China's peculiar cultural background.

Mulberry silkworm was a kind of creature featuring the most magical changes in the nature, amazing people in all ages. Silkworms go through four changes of form: silkworm egg, silkworm, chrysalis and silk moth. People always associate the transformation between motion and station (including dormancy and waking up) of silkworms with the most important issue back then—the heaven, the earth,

the life and the death. Silkworm egg is the beginning of life. Hatching of silkworm is just like the birth of life, the few times of dormancy just like a few stages of life. Chrysalis can be regarded as a kind of death, death of the original life, while chrysalis changing into moth for flying is the direction of soul after death happens that is pursued by people. Just as said in *Bo Wu Zhi*: "Chrysalis, with another name of soul", has the same meaning. It's recorded in LiJi·Tangongxia: "Confucius said those using figures and horses made of couch grass as burial objects are kind while those using tomb figures are heartless." Tomb figures refer to wood figures, mud figures etc. Its original meaning might have a relation to chrysalis. In tombs of Yangshao Culture, around half of the dead were buried in urn coffins near the foundations. Holes were left for the urn which was conjectured to let the dead's soul freely going up to heaven. This might also be originated from association with chrysalis changing into moth and breaking through the cocoon after having been dead for seven days. As urn coffins were mostly used for burying dead children who are weak in strength, it's necessary to punch holes in advance. Later, one of the approaches for people to become immortals was called Yu Hua (ascending to heaven and becoming immortal), which was just originated from association of observing a chrysalis becoming a moth.

Since changes of silkworms are so magical and important, the mulberry relied on by silkworms for survival appeared quite sacred. From legends in ancient history, the mulberry forest is habitat of silkworms, and had a close relation with folk activities. Of which there were two categories of activities: one was men and women trysting each other in the mulberry forest, offering a sacrifice to Gaomei God (who is in charge of marriage and childbearing) for praying for children; the second was offering sacrifice to the god for praying for rain in mulberry trees. Praying for children was for descendants multiplied, and praying for rain was for harvesting abundant grains. The two most important activities conducted by humans in ancient times were held in the mulberry forest, showing that the importance of mulberry to our ancestors. The mulberry forest was the place where man and women trysted with each other, which can be demonstrated by many historical data, among which the records in *The Book of Songs* were most abundant. For example, it's said in *Wei Feng · Shi Mu Zhi Jian*:

> Ten acres of field is the mulberry field, girls harvesting mulberry leaves are very leisure, and will return with her companions.
> Outside of ten acres of field is the mulberry forest, girls harvesting mulberry leaves are smiling, and will go back home with her companions.
> While the most obvious evidence is records in *Yong Feng · Sang Zhong*:
> Where should I pick dodder? In the outer suburbs of Muye (north of today's Qi County, Henan).
> Who am I missing? The beautiful and charming unmarried young woman of the Jiangs.

Such a kind of customs was also reflected in some artistic works of back then. Pictures of picking mulberry leaves can be found on a large number of bronze wares of the Warring States, describing the very scene of men dating women in the

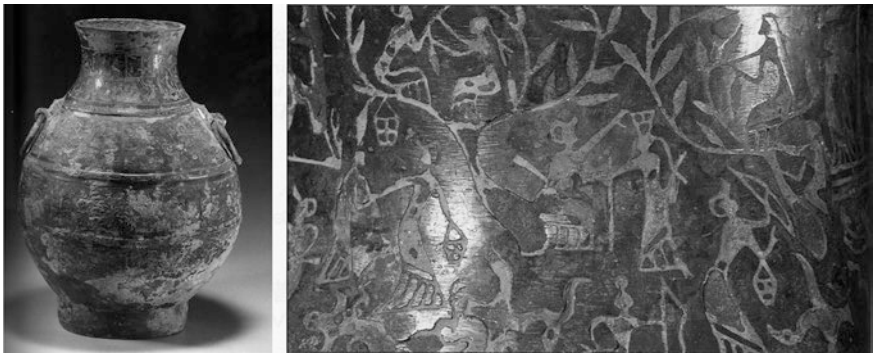


Fig. 2 Picture of Mulberry leaf harvest on Bronze Wares

mulberry forest and offering sacrifice to Gaomei God (see Fig. 2). All these stories seemly indicate that in the mulberry forest, it's especially easy for gods to communicate with humans, therefore in Zhou Dynasty, when men dated women in forests of mulberry trees, they would always offer sacrifice to Gaomei God (i.e., the god in charge of childbearing). The most famous example of the mulberry forest being the place for praying for rain was King Tang of Shang praying for rain in forests of mulberry trees. Many documents recorded this story. For instance, it's recorded in *Lv Shi Chun Qiu Shun Min* that: "In the past, Tang defeated Xia Dynasty and dominated China. The nation had been suffering drought and crops were lost in successive five years. Then Tang prayed to God by providing his own body as the guarantee in a forest of mulberry trees." It's annotated in *Huai Nan Zi* by Gao You that: "The mulberry forest was the place where people offered sacrifice for praying for rain. "

Due to importance of the mulberry forest, people further imaged a kind of sacred tree from mulberry trees which was called Fu Sang (a large mulberry), a place for the suns to rest. It's said in *Shan Hai Jing · Hai Wai Dong Jing*: "There is Fu Sang in Tanggu (where the sun rises) and the ten suns rest on Fu Sang." The concept of sacred tree Fu Sang had already formed at least in the period from Pangeng to Wuding of Shang Dynasty. One of the bronze trees unearthed from Sanxingdui Site of Shang Dynasty in Guanghan, Sichuan was confirmed as Fu Sang. Under the bron ze tree is a trumpet-shaped base and the tree trunk is perfectly straight with nine branches. On the nine branches and the top of the tree there is a bird respectively and hanging decorations of bronze dragon, ring, flower, leaves etc. Later, the image of Fu Sang was commonly seen in artworks of Warring States, Qin and Han dynasties. The image of Fu Sang was also found on the painted box unearthed from Zeng Hou Yi Tomb in Leigudun, Hubei and the Fu Sang is a giant tree, featuring four opposite branches on whose tops there is a sun respectively, and a sun is on the top of the trunk, another sun was shot by Hou Yi and changed into a bird, totally ten suns. Appearance of image of Hou Yi shooting the sun more strongly demonstrated it's the image of Fu Sang imaged by people back then (see Fig. 3).

Fig. 3 Image of Hou Yi Shooting the Sun on Lacquer wares unearthed from Zeng Hou Yi Tomb

Thus the silk obtained was not common fabrics, using silk for clothes will surely facilitate communications between humans and the god. Therefore, it's not always a bad thing for spinning itself a cocoon, but the only way for soul ascending to the heaven. Therefore, the death was wrapped with silk fabrics or silk floss, same as using silk materials for making an artificial cocoon, conducive to the death's soul ascending to the heaven. The earliest known silk fabrics up to now was from an urn coffin of Yangshao Culture Site at Qingtai Village, Xingyang, Henan, which was used for wrapping a child's corpse. Relevant records concerning burial customs of later generations also demonstrated this point. It's recorded in *Li Ji · Ji Yun* that: "Weave Hemp-fibers into cloth, and weave silk into silks for nourishing the alive and burying the dead, serving the ghosts and gods, hence origin of all things." Weave the Hemp-fibers into cloth for nourishing the alive and weave silk into silk fabrics for burying the dead are functions of cloth and silk fabric had already been distinguished. Cloth was used for the alive while silk fabric was used for clothing the dead. Against the burial customs unearthed from No. 1 Tomb of Chu State in Mashan, Jiangling, it's basically the same. With gradual development of silk production, more aged gradually wore silk clothes. It's recorded in *Meng Zi · Liang Hui Wang* that: "If a farmland of five mus ($1\mu = 667\ M^2$) is planted with mulberry trees, people over 50 will be able to wear silk clothing", which may possibly mean the same. The sentence not only shows respect for the aged, but also has the meaning of silkworm spinning itself in a cocoon after it gets old.

Apart from being used as clothes for the dead, in early times, silk was also used as sacrificia garment. It's recorded in *Li Ji · Yue Ling* that: "When rearing silkworm is finished, silkworm cocoons should be distributed and achievements should be identified by amount of reeling silk, so as to provide ceremonial robes for people to wear when they offered sacrifice to the god and ancestors at ancestral temple of a ruling house", which shows that the obtained silk by breeding silkworm was mainly used for clothes for people to wear when they offered sacrifices to the god and ancestors at ancestral temple. *Li Ji Ji · Yi* more elaborately recorded the rite of breeding silkworms and offering cocoons and the purpose of making clothes.

At the end of spring, silkworm-breeding women finished their task of rearing silkworms. Thus they showed cocoons to the emperor, and then offered cocoons to the queen. The queen said: "these will be used for making clothes for the emperor." Thus

the queen wore ceremonial dress and accepted such cocoons, and offered sacrifice to gods with hogs and sheep for appreciating their services. The etiquette of presenting cocoons in ancient times probably all followed this way. When a lucky day approached, the queen began to draw out silk. First, the queen put her hands for three times in the basin in which silkworm cocoons were soaked and pulled out a silk head each time. Then she distributed silkworm cocoons to various lucky ladies and women who bred silkworms, to let them bleach the silk. Later, all the silk would be dyed red, green, black, and yellow respectively and made into various ceremonial clothes decorated with various patterns. After the ceremonial clothes were made, the emperor wore them and offered sacrifice to deceased monarchs and ancestors, how reverent he is!

Clothes made of silk were for wearing at the time of offering sacrifice to deceased monarchs and ancestors. Similarly, silk was also used as sacrifice, such as silk manuscripts or paintings on silk, which intended to use silk as a kind of carrier for communicating contents on silk manuscripts or articles wrapped with silk to the other world. The best known silk manuscripts were those unearthed from Zidanku, Changsha, Hunan which featured characters in the center, surrounded with magical pictures (see Fig. 4). However, silk manuscripts were also used for writing covenant of two states. It's recorded in *Zuo Zhuan · Ai Gong Qi Nian* that: "Da Yu held the conference of feudal princes at Tushan, and ten thousand of feudal princes came to offer him jade objects and silk fabrics", Chinese

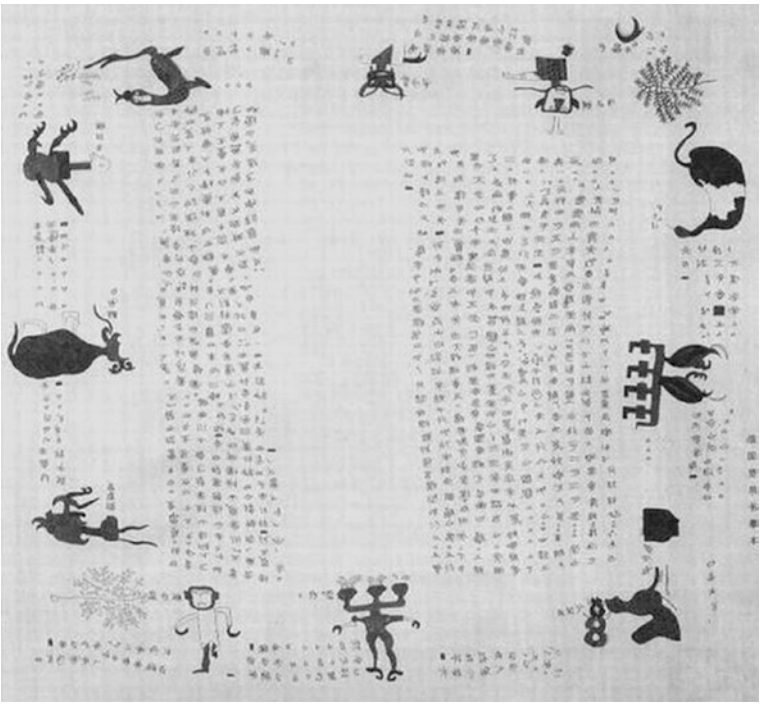


Fig. 4 Silk manuscripts of the Warring States Period

idioms also goes: "Turn swords into ploughshares (put an end to war and have peace)", here jade and silk manuscripts were all materials for writing credentials. After credentials were finished, they would be buried into the ground or burned with fire, showing that they would reach the heaven.

Silkworm is a kind of very delicate creature and is prone to harm of severe natural environment. For making silkworms continuously exist on the earth, our ancestors began to build silkworm rooms for carefully breeding them, hence the beginning of China's mulberry silk industry, and invention of breeding silkworm also began under China's characteristic cultural background. After the Spring and Autumn as well as Warring State Period, silk enjoyed more outputs and people also felt silk less mysterious. Meanwhile, Chinese society also gradually moved towards a feudal society featuring ritual systems from an early magic world featuring unity of heaven and man, thus silk was more used in combination with Chinese society's ritual systems, and became one of the important contents of ancient Chinese society.

1.3 Textile Raw Materials and Property of Defend Against the Cold

Ordinary textile materials, especially cotton, wool, Hemp, are mainly used for making clothes, especially for defending against the cold in winter. Generally speaking, people usually wear cotton coats and cotton trousers in winter and fairly wealthy people may wear lined short gowns and trousers made of silk floss. But before cotton was introduced into China, the materials for clothes wearing by Chinese people in winter were obviously different in different regions. According to documentary records and unearthed material objects, the materials for clothes worn by ancient Chinese people in winter included fur, Maohe (short coat made of animal hair and coarse hemp), Mianyi (clothes stuffed with silk floss or cotton) etc.

Northwest China produces fur and wool. What worn by ancient people of 3,000 years ago unearthed in Xinjiang were basically fur coats or wool fabrics, showing that fur and wool clothes were only clothes for ordinary people. But in inland, fur and wool became very rare and fur coat was particularly precious. People wearing coats made of such material were mostly kinsmen of the emperor and rich families living in the north. *The Book of Songs* always mentioned fur coats used in those days which were mostly made of lambskin and raw fox skin. *Zheng Feng*, *Tang Feng*, *Hui Feng* in *The Book of Songs* all had a poem titled *Gao Qiu* (Lambskin Coat) respectively. *Hui Feng · Gao Qiu* said: "People wear lambskin coats to enjoy comfortable and leisurely time, and wear fox skin coat to go to court." Wen Yiduo's explanation was: "Senior officials usually wore lambskin coats and when they went to court, they wore fox skin coats." Another poem titled *Bin Feng · Qi Yue* says: "Get fox skin for making a fur coat for Gongzi (son of a feudal prince or high official), also talking about a kind of fox skin coat. This kind of fur coat was also depicted in images. On the wall paintings in the tomb of Xu Xianxiu in the Northern Qi Dynasty in Taiyuan, Shanxi, there was an image of the host of the tomb wearing a fur coat.

Maohe was a kind of fairly coarse and thick fabric woven with hair fabrics (the majority of them are wool fabrics), which can also be used for defending against the cold and was very common in tombs unearthed in Xinjiang in early times. Although its effect of defending against the cold was not as good as fur coat, it was used by ordinary people. It's said in *Bin Feng · Qi Yue* that: "There is not even a hemp coat, how to go through the cold winter?" meaning that making clothes with coarse wool fabrics for keeping warm in winter. In southern areas where the weather is not very cold, clothes made of such coarse wool fabrics can also be used for defending against the cold. Today's tweed flannel may also be counted as a kind of Maohe, indicating that people all around the world use Maohe for keeping out the cold. Tao Yuanming lived in Jiangxi and he only relied on drinking wine and covering Maohe for resisting the cold.

Dilapidated house is accompanied by the moaning wind, seeing the court filled with weeds.

Get up with Maohe on the back and sit awake through the night, and it's difficult to wait for the daybreak coming.

(*Yin Jiu* The Sixteenth of the Twenty Poems)

The most common winter clothes for ordinary people were lined clothes, i.e., the clothes were comprised of two layers, and thermal insulation materials were filled between the two layers, which was named double-layer clothes or written as Fuyi. This was the clothes for keeping out the cold invented in areas where no fur or feather were produced, falling into the following categories according to different filling materials or different grades.

The main category of filling materials was silk floss. Back then, silk floss was called Mian, Xu, Kuang etc. possibly according to their quality, but they are difficult to distinguish. The best silk floss was directly made of cocoons, just like rinsing silk floss we make today, and the second grade was silk floss made of leftovers of cocoons which was of a little inferior quality; the third grade was used old silk floss. The clothes stuffed with silk floss we wear today also need to be turned over and stretched again after several years and the silk floss should be filled into the clothes again. If the old silk floss was really of poor quality, then some new silk floss should be added. All these clothes stuffed with silk floss can be called as Mianyi, Xuyi or Kuangyi. Ancient China began to levy silk and silk floss as taxes since Han Dynasty, indicating that in practical clothes, silk floss and silk held the equal position. There are also many records concerning Mianyi in ancient documents. Bai Juyi, a realistic poet of Tang Dynasty, composed a poem with five characters to a line, named *Xin Zhi Bu Qiu*:

Cloth woven with ceiba produced in Guiguan (today's Guangxi) is as white as snow, silk floss produced in Wujun (today's Suzhou) was softer than cloud.

The cloth and silk floss are heavy and thick, keeping fading warmth after they have been made into fur clothes.

Wearing the fur coat, sit from morning to the evening, covered with it, sleep from evening to the next morning.

Who knows in the cold winter, the body feels as warm as in spring.

That is to say, a Mianyi made of silk floss can make the body feel warm in winter. In Tang Dynasty, the central government issued frontier troops with spring clothes and winter clothes. According to records in documents found in Dunhuang, there were three kinds of winter clothes, including long-sleeved clothes, coats, trousers made of silk floss, all of which should be stuffed with silk floss There was also a story about Mianyi of garrison soldiers involved in frontier defense during the reign of Emperor Xuan-Zhong in the Tang Dynasty. It's recorded in *Full Collection of Tang Poems* that: some of the clothes made of silk floss (originally called "Kuang Yi") for frontier troops were made by maids in the imperial palace. A solider unintentionally found a poem in the robe (*Poem in the Robe* by a maid in Kaiyuan, Volume 797, *Full Collection of Tang Poems*:

> Dear soldiers defending the borders, you have worked very hard, are you asleep?
> I don't know who will wear the coat I made with my own hands.
> I deliberately put more silk yarns in it for including all my affection.
> We have no chance to get together this life, I hope we can fall in love with each other in the future life.

This soldier gave this poem to the officer who then handed the poem over to the court. Back then Emperor Xuanzong of Tang showed this poem to the palace for seeking the maid who wrote this poem. Finally a maid admitted her guilt. Emperor Xuanzong suddenly had compassion for her, and he not only didn't punish the maid, but wed her to that soldier. Officers and soldiers of frontier troops all wore Mianyi in the cold northwestern area, indicating that Mianyi was main clothes for people to wear in winter in those days.

However, as it's not easy to breed silkworms and silk floss was expensive, although it was main raw material for winter clothes for people back then, not all people could afford it. The material inferior to silk floss in quality was coarse hamp which was called Yun. As said in *Shuo Wen*: Yun, jumbled mass of silk or hemps, means coarse hemp. Clothes stuffed with coarse hemp were called Yunpao. It's recorded in *Lun Yu · Zi Han* that: "Confucius said: "Only Zi Lu will not feel ashamed when wearing shabby Yunpao and standing together with people wearing robes made of fox fur and raccoon fur. Although it's said in *The Book of Songs* that why no envy and no lust is not good enough? After Zi Lu heard of this, he repeatedly recited this poem. Confucius said again: "How can we say only no envy and no lust is good enough?" Xing Bing said when he explained Yun that: Yunpao was intermingling nettle hemp for making robes". According to Confucius, probably only Zi Lu would not blush when he wore Yunpao and stood together with those wearing fur overcoat. Yunpao mentioned here meant inferior winter coat and also showed that fox fur and raccoon fur were good materials for winter clothes. Tao Yuanming also mentioned Yunpao. He said in *Ji Cong Di Jing Yuan Wen* that "There are no coarse cloth clothes in winter and gourd ladle and rice basket are in urgent need in summer." All these show that the common materials for winter clothes in the south were Yun and He, both of which were inferior in quality and were not very good for keeping warm, but comparatively appropriate for temperature in the south. Jia Sixie of the Northern Wei Dynasty recorded and narrated

oakum keeping warm in the preface to *Qi Min Yao Shu* (Essential Techniques for the Peasantry) that: "Ci Chong held the post of prefecture chief of Guiyang (in today's Hunan). People in those days generally didn't grow mulberry trees and ignored matters on breeding silkworms, growing mulberry trees, weaving, silk, hemp, thus they only wore very simple clothes."

Compared with hemp, the inferior clothes were made by using reed catkins as wadding. This was found in the story about *Lu Yi Shun Mu* by Min Ziqian in "The Twenty Four Filial Exemplars". This may be a special case, but possibility still existed. It's said that Min Ziqian was from Kingdom of Lu in the Spring and Autumn Period and was also a pupil of Confucius. The contents were as follows:

Min Ziqian's father married a second wife, who gave birth to two sons. Min Ziqian supported his parents and was obedient. Although his stepmother didn't like him but he was still very obedient and didn't neglect them. His stepmother envied and hated him and gave her own boys with cotton-padded clothes, but gave Ziqian clothes filled with reed catkins. His father didn't know this condition. In winter, his father asked him to drive the vehicle. Ziqian couldn't stand the cold and lost the bridle for several times. His father therefore scolded him and Ziqian didn't defend himself. His father watched him carefully and found that he was pale in color, thus touched him with hand and found he wore thin clothes. His father tore up his coat and knew that there wasn't cotton fiber in it. But the two sons born by his second wife wore pure cotton coats. His father felt very sad and wanted to drive his wife away. Ziqian burst into tears and went up to persuade his father: if mother stays with us, only one son feels cold; if mother leaves, nobody will take care of the three of us, father, please think it over carefully. His father was moved by his words and didn't divorce his wife. His stepmother corrected her mistakes and equally treated the three sons, feeding and clothing them the same, thus becoming a loving mother. (Dunhuang Version of *Biography of Dutiful Son*)

Therefore, we concluded as follows: in ancient China, before cotton was used in large volume, the majority of them wore clothes filled with silk floss of different quality. Very wealthy people and noblemen would wear fur coats. Coarse Maohe and Yunpao stuffed with coarse hemp were sometimes worn by the poor. Of course, some people even had no clothes and Maohe in winter, especially those in southern regions where no silk was produced.

1.4 Dress and Chinese Traditional Ritual System

About the fairly noble textiles, silk in particular, the more important was its relations with Chinese traditional ritual system. Buyi (cloth gown) was mentioned in China's past dynasties, that is to say, those didn't hold official posts could only wear sackcloth, hence the name of Buyi. But silk was the mark of nobleness and identity. Due to its rich colors and patterns, it can be used as a symbol of rank.

The highest grade was undoubtedly costumes for emperors. Records about twelve patterns on sacrificia garment in early times can be found in *Shang Shu · Yi Ji* and the

Fig. 5 Kesi Gunfu (robes worn by the emperor) with twelve ornaments of Ming dynasty

twelve ornaments could be used in different amounts according to different ranks. In 59 AD (the second year of the reign of Xiaoming Emperor of Eastern Han Dynasty), it's specified that the twelve ornaments concerning the sun, the moon and the star were used for emperors, and three councilors, dukes or princes should use nine ornaments concerning mountains, dragons, and nine ministers and officials with lower ranks should use seven ornaments concerning pheasant. The twelve ornaments in early times were not handed down, the earliest ones we can see today were emperors' pictures on Dunhuang frescoes, but not all the twelve ones can be seen here. Material objects with the twelve ornaments were Kesi (silk tapestry with cut designs) Gunfu of Emperor Wanli of Ming Dynasty unearthed from Dingling, Beijing (see Fig. 5).

Dragon design was also the pattern used only on clothes worn by emperors. According to historical records and archeological findings, dragon design was used on emperors' clothes in Liao Dynasty at the latest (see Fig. 6). By Yuan Dynasty, large dragon with five claws was ear-marked for emperors' clothes while smaller dragon with three claws could still be used for general occasions. Since Ming Dynasty, there were dragons with five claws and boas with four claws and flying fishes, bullfights which were quite similar to dragons. Apart from dragons with five claws, boas, bullfights and flying fishes were all used on clothes granted to officials (see Figs. 7, 8 and 9).

Apart from patterns, color was also an important factor for differentiating grades. It's recorded in history that in Qing Dynasty, sacrificia garments were mainly black, while Western Han valued yellow, and Eastern Han used red. But in Han Dynasty, clothes colors also changed according to seasons. It's recorded in *Hou Han Shu · Yu Fu Zhi* that the five colored court dress for different seasons were blue for spring, scarlet for summer, yellow for the last month of summer, white for autumn, and black for winter. Purple was also used for home and daily living clothes of the nobles while green was always used for daily clothes of civilians. It's said in *Jiu Tang Shu · Yu Fu Zhi* that when Emperor Gaozu of Tang ruled the country, the emperor wore ochre yellow robes and garments, thus forbidding

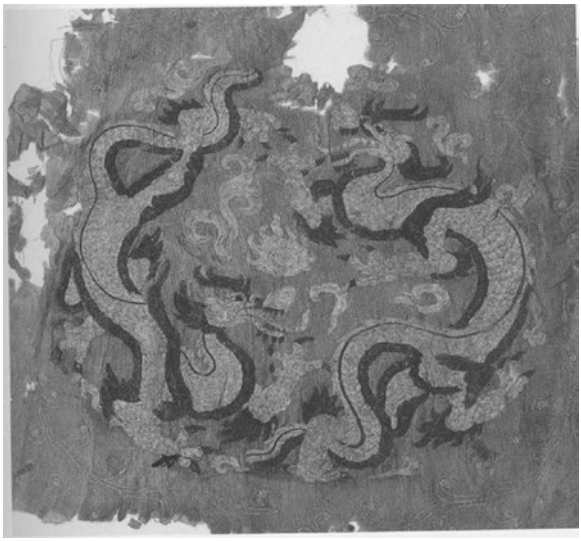


Fig. 6 Dragon robe of Liao dynasty

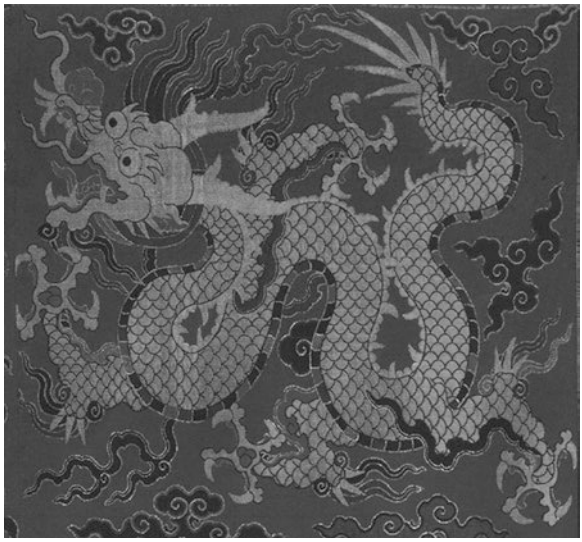


Fig. 7 Boa robe of Ming dynasty

subjects to wear helvolus clothes and specified that princes and officials of the third rank and above should wear purple silk robes and garments with big flower mission; officials of the fifth rank and above should wear vermilion silk robes and garments with small flower mission; officials of the sixth rank and above should wear clothes made of yellow silk and cloth decorated with double-silk ribbon; officials of the sixth and seventh ranks wore green clothes. By the time Tai Zong ruled the country, officials of the seventh rank should wear green dress made of damask silk decorated with tortoise shell and double giant geometry grain silk, while

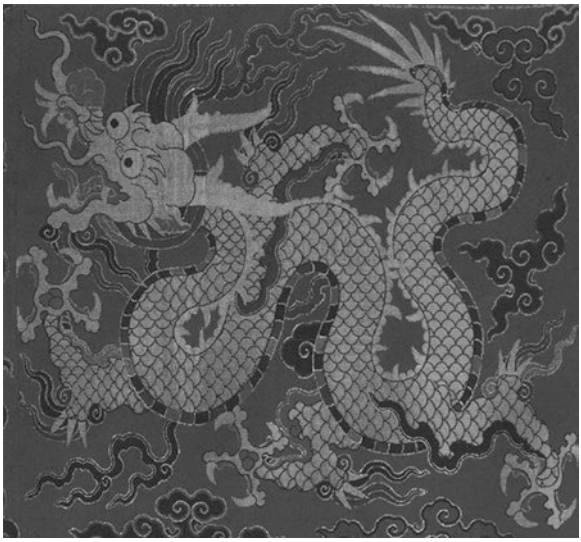


Fig. 8 Bullfight clothes of Ming dynasty

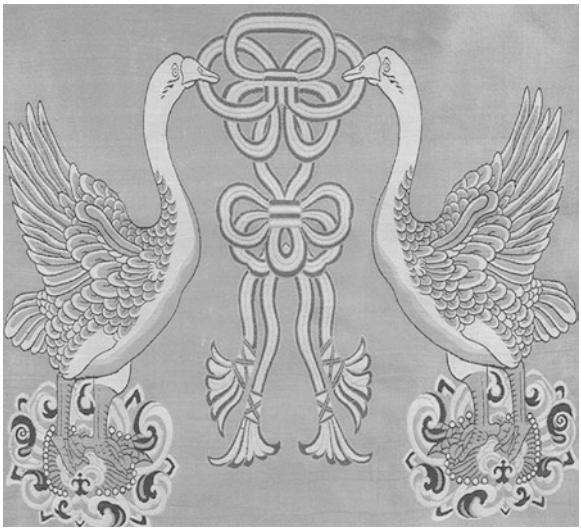


Fig. 9 Flying fish clothes of Ming dynasty

officials of the ninth rank should wear clothes made of mixed damask silk of blue silk and cloth. Generally speaking, the four colors purple, deep red, green and blue used for defining the official ranks started from Sui and Tang dynasties. Since the middle of Tang Dynasty, the emperors also granted brocade decorated with wild goose holding ribbon in the mouth and brocade with decoration of Gu Zhou (a kind of bird mentioned in ancient books) holding Rui Sha in the mouth to senior officials such as surveillance commissioner and Khrom etc. Such pattern of wild goosing holding ribbon on brocade had been handed down in Liao Dynasty and

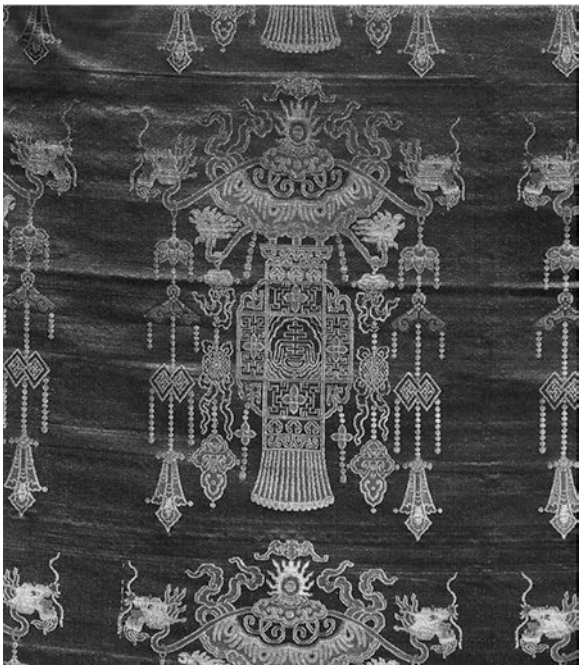


Fig. 10 Pattern of wild goose mouth-holding ribbon brocade in Liao dynasty

was also found in tombs of Niao Dynasty (see Fig. 10). Color grades of official costumes in Song Dynasty were the same as those of Tang Dynasty, but there were some differences in brocade patterns on clothes for different seasons. According to *Song Shi · Yu Fu Zhi*, officials of the first rank were granted with lantern decorative brocade, the second with Cusipandiao thin brocade, the third with yellow lion exquisite brocade, the fourth with Cuimao thin brocade, and the fifth with red brocade and the rest high-ranking officers with narrow brocade gown, including Cuimao, Yinan, Yunyan, lion, lianque, Baozhaoda and Baozhaozhong brocade.

All the civil and military officials of Ming and Qing dynasties used Buzi (Chinese traditional twelve kinds of decorative patterns on ceremonial dress and court dress) for indicating ranks. According to *Ming Shi · Yu Fu Zhi*, in 1391 (the 24th year of the reign of Emperor Hong Wu), Buzi on informal clothes was stipulated as follows:

Duke, marquis, earl, emperor's son-in-law: kylin, Hakutaku;

Civil official: red-crowned crane for officials of the first rank, golden pheasant for officials of the second rand, peacock for officials of the third rank, wild goose for officials of the fourth rank, silver pheasant for officials of the fifth rank, egret for officials of the sixth rank, Xichi (a kind of water bird) for officials of the seventh rank, oriole for officials of the eighth rank and quail for officials of the ninth rank;

Military officer: lion for officials of the first and second ranks, tiger and leopard for officials of the third and fourth ranks, bear for officials of the fifth rank, young tiger for officials of the sixth and seventh ranks, rhinoceros for officials of the eighth ranks, sea horse for officials of the ninth rank.

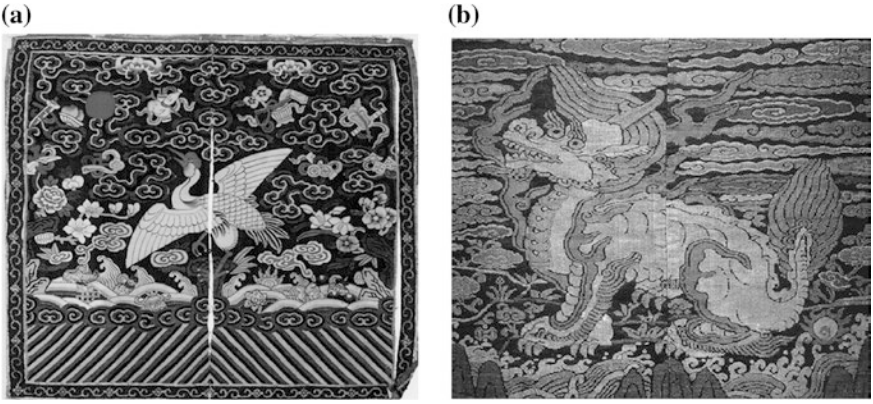


Fig. 11 A group of Buzi of Ming dynasty

Terpsiphone paradisi for clerks other than officials.

Supervisor: Haetae

(see Fig. 11)

Buzi fell into round Buzi and square Buzi, the former mainly included patterns on dragon, boa etc., used for kings, princes and aristocrats; and the latter was used for officials of all ranks and descriptions as follows:

Civil official: crane for officials of the first rank, peacock for officials of the second and third ranks, wild goose for officials of the fourth rank, silver pheasant for officials of the fifth rank, egret for officials of the sixth rank, Xichi for officials of the seventh rank, quail for officials of the eighth rank and terpsiphone paradisi for officials of the ninth rank;

Military officer: kylin for officials of the first rank, lion for officials of the second rank, leopard for officials of the third rank, tiger for officials of the fourth rank, bear for officials of the fifth rank, young tiger for officials of the sixth rank, rhinoceros for officials of the seventh and eighth ranks, sea horse for officials of the ninth rank.

In general silk patterns, silk art also showed changes in its popular and fashion style with changing times. Decorative patterns on bronze ware, pottery, lacquerware, and gold silver ware also followed decorative style of silk or interacted with silk style, demonstrating common era characteristics. For example, since the middle of Bronze Age, small geometry grains such as fret, thunder pattern etc. filled into rims and gaps of animal patterns appeared on various sacrificial vessels, which might possibly be impacted by animal theme embroidery on shadow stitch fabrics featuring geometry grains. After opening of the Silk Road, Chinese silk art was exchanged with western textile art, forming the most magnificent silk patterns of Tang Dynasty, influencing the regions and countries along the Silk Road. From designs appeared after Song and Yuan dynasties, we can always see Jing Di Kai Guang Pattern, grounded with Suo Wen of small geometric shape, such as Qushuiwen, Suojiawen, Qiuluwen etc. on which nest-shaped patterns with

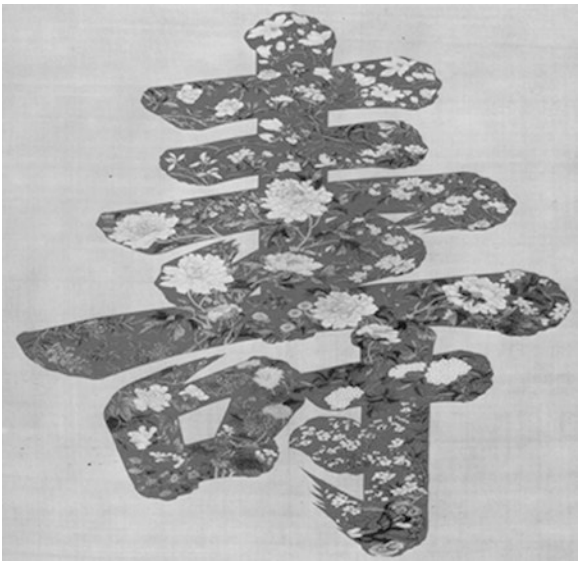


Fig. 12 Auspicious pattern on silk in Qing dynasty

rings were arranged as the theme, which undoubtedly were originated from silk pattern design. A lot of them appeared on pottery, metal ware, lacquer ware and architecture and almost all works of art. In Ming and Qing period, silk patterns even became an important mean for people to express blessings. "A bumper grain harvest", "superabundant auspiciousness", "three durable plants of winter—pine, bamboo and plum blossom", "abundant offspring, felicity and longevity", "Lotus having a hundred of children, Love for all seasons", etc. all became important themes of silk patterns (see Fig. 12).

1.5 Three Main Stages of Development of China's Textile Technologies

From the perspective of technologies for textile production, we can divide the history of Chinese ancient textile industry into two stages: the one from Shang and Zhou period to the middle of Tang Dynasty was called classic system and the one from the middle Tang Dynasty to Song, Yuan, Ming and Qing was called traditional system. If we subdivide the two stages, Shang and Zhou period was the formation phase of classic system, Qin and Han dynasties were the peak of classic system, the period from Wei, Jin and the Southern and Northern dynasties to the middle of Tang Dynasty was the transitional period when classic system gradually broke down and new technical factors were gradually integrated. The period from the late Tang Dynasty to Song Dynasty was the formation phase of traditional system, and some strong points of western textile technologies were once again absorbed in the Yuan Dynasty, Ming–Qing period was the maturity stage of

traditional system. Since the late Qing Dynasty, another impact was exerted by western modern textile technologies and traditional system gradually collapsed and modern technology system of textile production was finally established in the Republic of China which lasted up to today.

1.5.1 Classic System

Textile production generally saw main regional distribution of silk products in the north and Ma products in the south, and areas for silk production also spread towards the northwest and northeast. Back then, the center for silk production was the middle and lower reaches of the Yellow River and the government established official silk production organizations in the capital Chang'an and main areas for producing silk such as Qi, Chu, and Shu etc. Up to the early Tang Dynasty, Central Plains in middle and lower reaches of the Yellow River and Sichuan were still important places for silk production. But silk production in the middle and lower reaches of the Yangtze River, regions south of Yangtze River particularly, enjoyed rapid development after An Lushan Rebellion, thus the situation of tripartite confrontation was basically formed in the late Tang Dynasty.

Textile production was an important part of people's life. In all the places appropriate for breeding silkworms, each household obtained mulberry trees for rearing of silkworms and paid thin silk as taxes, while in those places suitable for growing hemp, hessian cloth would be used as taxes. It's recorded that in Han Dynasty, a total of five million silk fabrics were given to the government as geld in a year. In Cao Wei period, households modulation was officially adopted, which lasted until the early Tang Dynasty when Zu-Yong-Diao System was adopted, i.e., silk fabrics and Ma fabrics were levied. While on general circulation markets, silk was one of the important currency forms for supporting block trades.

The mulberry trees mainly featured tall branches and silkworms were mainly bivoltine. As for silk reeling tools, in Shang and Zhou dynasties, bronze yan was used as silk reeling pot and simple silk reeling tools were invented for reeling silk in hot soup. It's about since Han Dynasty that hand silk reeling machine had been used for reeling silk until Tang Dynasty. Bast fibre manufacturing was conducted mainly by means of retting, twisting, weaving to form twines for weaving.

As late as the Spring and Autumn Period and the Warring States Period, textile production had already seen two kinds of looms and weaving technologies. One was pedal loom, featuring that shedding of the loom was controlled by foot, which was used for weaving silk fabrics and hemp fabrics. The second one was jacquard, characterized by Hua Ben (similar to painting model, made with silk yarn and cotton thread on fabrics according to dermatoglyphic pattern designed on the paper) or heddle controlling lifting pattern of organizes, which was only used for silk manufacturing. Structure of silk fabrics was also an important part of weaving technologies. In this period, plain weave was the basic structure and there had no true twill weave yet. As for leno fabric, a special four-and-complex gauze, also known as chainlike leno was popular back then. Besides, jacquard fabrics, brocade

in particular, were warp-patterned, i.e., colorful organizes were arranged in regular patterns on the surface of fabrics for presenting decorative patterns.

China's traditional dyes were mainly vegetable dyes. From the Shang and Zhou dynasties to the Northern and Southern Dynasties, although some dyes were introduced from the surrounding areas, most dyes were domestic. Red dyes were mainly madder, and zinnober, a kind of mineral dyestuff, was also used in a large amount; as for blue dyes, indigo plant and woad were directly used for dyeing without fermentation; and yellow was dyed with *cotinus coggygria* and cape jasmine. Mordant method was mostly adopted for dyeing and the main mordant was plant ash and iron-bearing materials. Printing technologies were originated from hand painting, and Han Dynasty began to see true printings, which were made with bronze block printing stencil in combination with hand painting. This method had been used until Tang and Song dynasties, but new-type resist printing methods also gradually emerged in Wei and Tang dynasties. Method of embroidery of this period was basically lockstitch, featuring particularity and complexity.

In addition, silk trade on the Silk Road also showed this kind of characteristics of stage. Grassland Silk Road in early times or Zhang Qian's mission to the Western Region in the reign of Emperor Wu Di of the Han Dynasty, the main channel of exchanges between China and the West was the route from China, through Central Asia, West Asia to the Mediterranean regions. Governments on Central Plains operating the western regions during the period of Han and Tang dynasties particularly made the Silk Road in the Northwestern Area linked the desert and oasis had always played an important role. Compared to this silk road, the silk trade with North Korea and Japan by sea although had enjoyed quite a lot of development, it accounted quite a small proportion.

1.5.2 Traditional System

Since An Lushan Rebellion, chaos caused by war in the north made the government attach importance to silk production in the south. Southern migration of Song Dynasty even made the south become the center of silk production and scale of bast fibre manufacturing gradually decreased. Since the Yuan dynasty, cotton cultivation began to become popular around the country and the story about Huang Daopo was exactly the reflection of this historical fact. Silk production further concentrated on the southern areas. Therefore, mulberry silk production of this period was mainly conducted in areas south to the Yangtze River. For example, weaving and dyeing bureaus managed by the government of Ming Dynasty were mostly located in Jiangsu and Zhejiang provinces while fabric manufacture managed by the government of Qing Dynasty was completely carried out in Nanjing, Suzhou and Hangzhou, hence the name of Three Fabric Manufacturing Areas in the southern areas. Massive volumes of silk were produced in the south while palace in the north consumed a great deal of silk. In the private sector, cotton textile industry dominated.

From the relations of textile and social economy, due to two-tax law coming into force in the middle of Tang Dynasty, textile's position in central finance greatly decreased and the role of silk as currency had been much weakened and later generations gradually used money for paying taxes. Silk production in the folk, however, tended to be more commercialized and specialized. Many cities and townships specialized in textile as well as professional markets relying on these cities and townships were formed in the southern areas.

Great changes also occurred in foreign trade of silk. Due to islamization of Central Asia, the Silk Road in the northwestern direction was blocked from time to time, while Maritime Silk Road in the south was very glorious. In Song and Yuan Period, a great number of port cities emerged in the southern coastal regions and silk products were transported to North Korea, Japan and various countries in Southeast Asia and transferred to other countries by sea. Especially magnificent feat of Zheng He leading his fleet to voyage to the Western Sea in Ming Dynasty composed the greatest chapter concerning the Maritime Silk Road.

As for techniques, center of sericulture production moved to regions south of the Yangtze River, thus relevant technologies became more appropriate for environments of the south and the main types of mulberry trees were those with branches of medium and low height, besides, there emerged massive quantities of mulberry fields with dense mulberry trees with branches of medium and low height. The silkworm-breeding technology of "Chu Kou Gan", i.e., increasing the temperature at the time of mounting, which was not only conducive to reliability of reeling silk, but guaranteed the style of thin silk produced in regions south of the Yangtze River. Models of silk-reeling machines also enjoyed considerable improvement. Perfect pedal silk-reeling machine had already emerged by Song Dynasty and experience of "Chu Shui Gan" was also concluded for silk reeling techniques. Although techniques for bast fibre manufacturing basically remained the same, technologies for cotton textile were introduced into China from the North and the South and enjoyed improvement and development in China. Chinese invented multi-spindle pedal spinning wheel and large spinning wheel, greatly improving textile production rate.

Common looms in Song and Yuan period had already widely used two heddles. At first the looms were single-acting double-heddle and double- tread machines and interactive double-heddle and double- tread looms appeared in Yuan Dynasty, taking the place of axile-styled single-heddle looms in early times. As for models of jacquard looms,Shuzong loom began dominated the world in Song Dynasty. Jacquard weave was controlled by Hua Ben made of doubling thread, including small Hua Ben and large Hua Ben jacquard looms, hence one of the marks of highest silk techniques of ancient China.

Great changes also happened to organization structure of fabrics. Twill, satin weave successively appeared in basic organizations, and chainlike leno in leno weave gradually became less and leno featuring fixed doup end organization sprang up, nap cloth used shorn-pile method, double weave used more backed cloth fixed with ground retinervus and special tying-in and the method of

pattern-forming also evolved from warp threads to weft threads, thus lots of fabrics such as Kesi (silk tapestry with cut designs) and Zhuanghua (a kind of colorful jacquard silk fabric) made by adopting shuttle-controlled techniques became popular. All these were the new factors of weaving technologies of this period.

After Tang Dynasty, red dyes mainly used red flowers and hematoxylon, and the dying technique used acid dying method and mordant method. Blue dyes mainly adopted method of preparing indigo blue by fermenting lime and dying through reduction method. Little changes occurred to yellow dyes, only more sophora flowers were used. As for mordant, in most cases, alums was used for replacing plant ash. In Tang and Song dynasties, resist printings prevailed, except a small amount of other printing techniques, grey paste resist printing, wax printing, Hui Xie (similar to today's blue and white printing) and Jia Xie (knock-out printing) became mainstream products. By Ming and Qing period, printing and dying techniques of silk declined, but blue cloth with design in white enjoyed drastic development, becoming the most important mean for decorating cotton textile. Embroidery stitches also experienced material changes in the late Tang Dynasty. Plain stitch and its varied methods were used a lot, consequently, there even appeared a wide range of varied well-known local embroidery techniques, such as Gu Embroidery, Su Embroidery, Jing Embroidery etc. and chain embroidery was extremely rare.

Tang Dynasty was the period seeing most varied artistic styles of silk. Application of precious flower pattern, in particular, made themes of silk decoration transforming from animals to flowers, plants, birds and insects etc. Decoration styles of this period showed more hobbies of scholars in Song Dynasty and painting flowers became the mainstream of silk decoration. Various flowers such as peony, lotus, plum blossom, chrysanthemum, peach blossom, bamboo leaf as well were widely used on silk products on which there were also matching patterns of bee, butterfly, fish, insect, heron, egret, wild goose, magpie, and a modeling style of realism as well. Flower and plant patterns still dominated in decoration style of silk during Ming and Qing period, but the pattern of manifestation tended towards stylization and the themes mainly concerned auspicious patterns, implying auspiciousness with patterns, thus reaching the degree of implying auspiciousness in each word.

1.5.3 Modern Industrial System

In the late Qing Dynasty, advanced textile technologies of the West had exerted great impacts on China. Many businessmen introduced new style power machinery equipment, new-type raw materials and techniques from the West and employed western technicians to establish plants in China, hence Chinese modern mulberry silk industry and cotton textile industry, as well as modern textile industrial system.

China's modern and contemporary silk industry was originated from industry of silk reeling with machine at the end of the nineteenth century. In 1861,

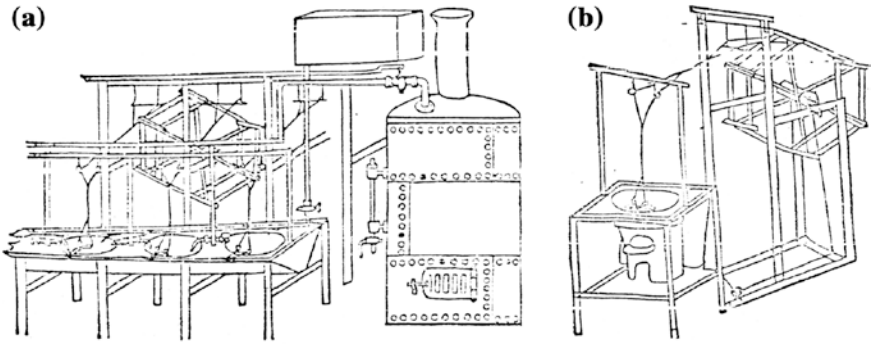


Fig. 13 Silk reeling machines used by Chen Qiyuan. **a** Picture of Ji Qi Da Jie (Chinese silk reeling machine of the first generation). **b** Picture of Ji Qi Dan Che

An British businessman set up Silk Reeling Establishment in Shanghai, which is China's first foreign-founded silk enterprise. In 1872, Chen Qiyuan founded Ji Chang Long Qi Ji Sao Si Chang, China's first silk enterprise of national capital, in Nanhai, Guangdong (see Fig. 13). These enterprises not only adopted advanced industrialized silk production machinery, but operated by imitating forms of production of western factories, bringing China's modern industrialized production system. Later, silk industry and printing and dyeing industry etc. also successively began to adopt industrialized production mode.

Rearing silkworm in a scientific way and reform of silkworm seeds improved species of silkworms and crossbreeding also improved quality of silkworm cocoons. At first, Italian-style and French-style horizontal silk reeling machines were used for reeling silk and later Japanese-style vertical silk reeling machines were adopted, fairly improved silk production and quality. Cotton textile and wool textile industry also enjoyed rapid development, and a great number of modern spinning mills were built around the center of Shanghai, Nantong and Wuxi etc. In addition, various new-style artificial fibers were popular for a time, leading to fairly large changes in structure of raw material production.

As for weaving technology, China introduced flying shuttle machine at the end of the nineteenth century, changing throwing and receiving shuttle with two hands to throwing shuttle and pulling cord with one hand, which not only accelerated the speed but broadened the width of fabrics. Then gear drive was also used to finish pacing of warp and batching. At the beginning of the twentieth century, ironwood weaving machine and power looms were further adopted. Components of weaving machines were most made of iron and the weaving machines were power-driven. As to jacquards, wooden jacquards were introduced and later needles were gradually increased and the machine body was changed into iron. Replacement of these facilities marked the introduction of modern silk weaving technologies. By the second half of the twentieth century, silk reeling machines, spinners and looms etc. further developed into automation until computer-aided intelligent textile manufacturing machines.

Fig. 14 China's Earliest Silkworm Academy

With development of chemical industry, chemical dyes gradually took the place of traditional vegetable dyes. Since the end of the nineteenth century, China has already used massive quantities of chemical dyes for painting. At the beginning of the twentieth century, Chinese national capitalists established plants for dying yarns of various colors first and then cloth with machine. Machine printing appeared in 1930s and roller printing machines were adopted first and then square screen printing machines were used. Printing industry also saw evolvement from watermark to paste-printing, accordingly, techniques of ageing, washing and finishing also were perfected.

The biggest difference between production system of modern textile industry and traditional system was that it had a complete set of systematic scientific research, education and publishing organizations. In 1897, Hangzhou Silkworm Academy founded by Lin Qi, prefecture chief of Hangzhou back then, set the precedent of silk education in modern China (see Fig. 14). After that, silkworm school and silk industry schools were successively opened in various areas, cultivating talents in urgent need for Chinese silk industry. By the twentieth century, various schools, research institutions and promotion institutions engaged in textile industry had been established around the country and monographs and professional journals concerning textile were published and a great number of professional textile talents were cultivated. Shanghai-based East China Institute of Textile technology was once China's most important institution of higher education of textile, which was renamed China Textile University later (today's Donghua University). At the end of the twentieth century, in the important areas of textile production, various textile museums were also built, including Nantong Textile Museum, Suzhou Silk Museum and Hangzhou-based China National Silk Museum (see Fig. 15).

Fig. 15 China National Silk Museum

2 Lecture 2 Looms and Fabric Varieties

The ancient Chinese textile science and technology is a very important part of science and technology system in ancient China. In his book "Science and civilization in China", Needham chose 26 scientific and technological achievements in China that benefited the entire world, with the 26 letters of the alphabet as the headings of the entries. Among them, F the jacquard and level loom, G the reeling machine, spinning machine and doubling winder, are three items related to ancient Chinese textile technology. Chen Weiji and Zhou Qicheng in writing the "History of Textile Science and Technology in China (ancient part)" also mentioned the top ten inventions in the textile industry, and 6 of them are associated with science and technology, including silkworm breeding for silk, vibration and opening, large spinning wheel, contraction twist setting, people control procedures, and special finishing. In 2008, the author participated in organizing "Miraculous Superb Craftsmanship–Cultural Relic Exhibition of Ancient Chinese Inventions and Creations" and proposed top five inventions of silk technology: silkworm domestication, treadle loom, organizational system, Jacquard procedure, stencil textile printing. It can be said that the ancient Chinese textile technology represents the highest level of technology of ancient China.

2.1 Two Paintings: "Silkworm and Weaving" and "Cotton"

About ancient Chinese textile there are many professional writings, and "*The Exploitation of the Works of Nature*" and "*Complete Treatise on Agriculture*" are

outstanding representatives. However, they are often associated with agriculture. Those independently reflecting the entire process of silk production and cotton spinning include "*Silkworm and Weaving*" found in "*Farming and Weaving*", a book in the form of comic strip and the painting, and "*Cotton*", inspired by the picture "*silkworm and Weaving*".

2.1.1 Farming and Weaving: The First Version

The most famous "*Silkworm and Weaving*" was seen in the painting "*Farming and Weaving*" drawn by Lou Shu, the magistrate of Yuqian County in the Southern Song Dynasty. Lou Shu, styled Shouyu, and Guoqi, a native of Yinxian, Zhejiang, is a painter in the Song Dynasty. Lou created the earliest and most complete "Farming and Weaving" during his tenure as magistrate of Yuqian in early year of Shaoxing. And the matter is first seen in "Gongkui Ji" (literally, shame-conquering collection) written by his nephew Lou Yue:

Back then, my Uncle was the magistrate of Yuqian. With his mind set on civil affairs, he sympathized with the hard labor of the farmers and silkworm-breeding women. So after systematic study, he painted two pictures, named "plowing" and "weaving" respectively. "Farming" covered the 21 steps of agricultural production, beginning with seed soaking and ending with warehousing. And Silkworm covered 24 steps of silk production, starting with silkworm egg bathing and ending with silk cutting. Each step was illustrated and complemented with an 8-sentence verse consisting of five words for each line, depicting in detail the undertakings in agriculture and sericulture. Later, by virtue of recommendation from a courtier, the emperor got to know about those paintings, and granted an interview with my uncle, who submitted them to the emperor. The emperor praised and awarded him [for the craftsmanship of those paintings] and ordered to have them hung in the imperial harem for display, with my uncle's name written between the two paintings.

Calculating from the records in "*Annals of Yuqian County*," and "*Annals of Yin County*", we know that the time for Lou Shu to paint those pictures should be no later than the tenth year of Shaoxing (1140). The section of "Silkworm and Weaving" covers a total of 24 steps. However, the original has been missing and only the twenty-four poems remain. Their titles are silkworm egg bathing, silkworm hatching, feeding silkworms, first molting, second molting, third molting, separating silkworms onto screens, gathering mulberry leaves, awakening, choosing the mature silkworms, setting up the trellises, warming the screens, taking down the trellises, harvesting cocoons, storing cocoons, reeling off silk from the cocoons, silkworm moths, offering thanks, spooling, preparing warp threads, preparing the weft threads, weaving silk, weaving patterned silk, and cutting silk. It is said that Lou Shu's "*Farming and Weaving*" had backup copies and stone engravings. The backup copy was left at home, annoted by Lou Yue and an inscribed on a stone by his grandsons Lou Hong and Lou Shen.

2.1.2 The Earliest Existing "Silkworm and Weaving"

At present, the earliest intact surviving scroll of *Silkworm and Weaving* is the "*Silkworm-breeding and Weaving in the Song Dynasty*" originally in the possession of the Palace Museum, now in the possession of the Heilongjiang Provincial Museum. According to legend, there is an annotation made by Empress Wu of Emperor Gaozong of the Song Dynasty, so it is also known as Empress Wu Annotated Version. This painting has been recorded in Song Lian's "*Collection of the Imperial Academy*", Sun Chengze's "*Recording in Passing the Geng Zi Summer in a Leisurely Way*" and Qing-Dynasty "*Treasure Boxes of the Stone Moat*". Seen from the epilog made by Zheng Zulao in the Yuan Dynasty, this painting might be a facsimile by the Imperial Academy of the Southern Song Dynasty, and it is not necessarily loyal to the original painted by Lou Shu. The facsimile is in hand-scroll format, without intervals. And the scenes of bathing silkworm eggs, hatching, tendering the newly hatched silkworms, gathering mulberry leaves, cutting mulberry leaves, feeding, first molting, second molting, third molting, warming the silkworm, final molting, feeding after molting, busy gathering mulberry leaves, setting up the trellises, putting the silkworm onto the trellises, dismantling the trellises, warming the cocoons, collecting cocoons, moths hatched, offering thanks, cleaning cocoons, stripping cocoons, weighing cocoons, salting cocoons, keeping cocoons in an urn, reeling off silk from the cocoons, spooling, preparing warp threads, preparing the weft threads, yarning, weaving patterned silk, taking silk off the loom, and storing silk in the box. Seen from the titles, there are more than 24 steps (as shown in Fig. 16). Also belonging to the Song-Dynasty "*silkworm and Weaving*" there is another version kept in the Cleveland Museum. Also in hand-scroll format, the version is believed to be an authentic work of Liang Kai, but the size is much smaller than the version annotated by Empress Wu. Now there is a version of Song-Dynasty "*Farming and Weaving*" kept in the National Museum. Although it painted scenes of weaving, and occasions of farming, the painting has a straight shaft, and is a far cry from the style and form of the "*Silkworm and Weaving*".

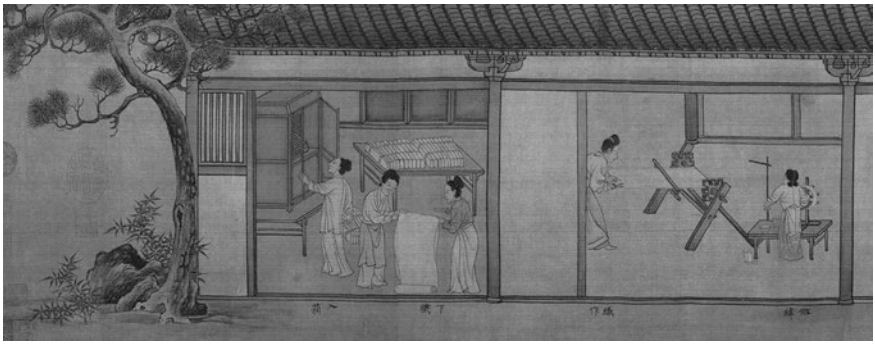


Fig. 16 Farming and weaving in the Song Dynasty

After the Song Dynasty, there are many versions of "*Silkworm and Weaving*". The most famous is the version claimed to be painted by Cheng Qi in the Yuan Dynasty. In this version, all steps are drawn strictly in the order of the 24 poems written by Lou Shu. In addition, there are the 24 poems written by Lou Shu in seal character, and the signature of "刘松年笔" (by Liu Songnian). This illustration set was submitted by Jiang Pu to Emperor Qianlong, who inscribed in the margins 24 new poems. On the picture, there is an epilog mentioning Cheng Qi of the Yuan Dynasty as the painter, so we generally referred to it as Cheng Qi-version "Farming and Weaving". But we know that Qianlong clawed antiques throughout the country, bringing about rampant counterfeiting. The present author doubts that the "*Farming and Weaving*" submitted by Jiang Pu is also one the later works. However, Qianlong immediately ordered to have it inscribed on stones, to be kept in the Summer Palace, which still has a scene called "*Farming and Weaving*". The original *Farming and Weaving* was stored in the Old Summer Palace, and was later lost in the looting of the Eight-Power Allied Forces. The original version of Cheng Qi's "*Farming and Weaving*" is kept in Freer Museum in Washington, and a rubbing version of "*Farming and Weaving*" is kept in the National Library of France. Currently, some of the original inscriptions are still kept in the National Museum, but they have become dilapidated.

2.1.3 Jiao Bingzhen—Version "Farming and Weaving"

In the Qing Dynasty, due to the advocacy of Emperor Kangxi, "*Farming and Weaving*" proliferated, or even flooded, in version. Among the various producers, Jiao Bingzhen was the most influential. A student of Lang Shining, Jiao Bingzhen adopted the focus perspective in Western painting, and completed in the 35th year of Emperor Kangxi (1696) drawing "*Farming and Weaving*". Including 23 pictures for farming and weaving respectively, the painting is somewhat different from the 24 steps of Lou Shu's version. And the largest discrepancy is that Jiao Bingzhen's work is an album and each image is rectangular, annotated with Kangxi's poem (as shown in Fig. 17). This painting has been included in "*Treasure Boxes of the Stone Moat*" and other books, and is currently seen in the United States National Library. Jiao Bingzhen became famous for this painting, which also has a large number of block printed versions, with that by the Peiwen Studio and that by Dianshi Studio most common. In addition, there are also color printed versions by the interior ministry. Later, Emperor Yongzheng and Qianlong followed the example, and transcription and engraving of "*Farming and Weaving*" become rife. "*Farming and Weaving*" was printed on *Book on Agricultures* and *Chronicles*, as well as many rock carvings, wood carvings windows, painted porcelain, New Year pictures, banknotes and inkslabs. The prevalence of "*Farming and Weaving*" also led to the birth of "*Cotton*", a painting of the same type. In addition, in the palace there were also people painting "*Farming and Weaving*" with reference to Jiao Bingzhen's version, including Leng Mei, styled Jichen, and student of Jiao Bingzhen. He had assisted the Jiao in drawing "*Farming and Weaving*", and then independently completed the full set of 46 pictures comprising "*Farming and Weaving*", which is now kept in

Fig. 17 Farming and weaving by Jiao Bingzhen

the National Palace Museum in Taipei. Another is Chen Mei, styled Dian Lun, and called Zaidong. In the 4th year of Qianlong (1739), he painted the 46 pictures of "*Farming and Weaving*", with each piece annotated with Emperor Kangxi's verse, and preceded by a preface by Emperor Qianlong.

2.1.4 Cotton by Fang Guancheng

The popularity of "*Farming and Weaving*" also led to the appearance of the painting "*Cotton*". In the 30th year of Qianlong (1765) in the Qing Dynasty, Zhili Governor Fang Guancheng compiled the painting "*Cotton*" and engraved it on twelve stones. Consisting of sixteen pictures, the painting covers the entire process of cotton textile, from seeding and harvest to weaving and dyeing, including seeding, irrigation, weeding, nipping the tips, picking cotton, selecting and sunning, purchasing and selling, ginning and stoning, fluffing cotton, dividing into sections, spinning, preparing warp threads, administering pulp, putting threads on the machine, weaving cloth and dyeing. Each picture has a text description, and two seven quatrains, one by Emperor Qianlong and the other by Fang Guancheng according to the content of the picture. Because of the poems of Qianlong, the painting was allowed to have "imperially annotated" in its title—"*Imperially Annotated Cotton Album*". This painting can be seen as an authentic record of Fang Guancheng's emphasis on agricultural production and documentation of cotton cultivation during his tenure as Zhili Governor. It played an obvious role in promoting and guiding cotton growing and textile industry development (as shown in Fig. 18).

Fig. 18 Painting of "*Cotton*" by Fang Guancheng

2.2 The Production of Sericulture and Silk-Weaving

Here, we mainly use the version of "*Silkworm and Weaving*" annotated by Empress Wu to deal with the technological achievements in sericulture and silk-weaving back them, with reference to Lou Shu's "*Poems for Farming and Weaving*" and other literature, especially Chen Fu "*Book on Agriculture*" in the Southern Song Dynasty.

2.2.1 Silkworm Egg Bathing

Silkworm egg bathing was originally a ritual handed down since ancient times. In the Song Dynasty, several rounds of bathing were needed. Empress Wu said in her annotation: bathing silkworm eggs in the twelfth lunar month, Qin Guan recorded in the "*Book on Silkworm*": "On the twelfth of December, pool silkworm eggs and put them in cattle urine before bathing them in rivers". Chen Fu's "*Book on Agriculture*" said: "On the twelfth of December, or when snow falls in the twelfth lunar month, spread the silkworm eggs out in the snow, and let them stay on the snow for one day." Obviously bathing silkworm eggs in the twelfth lunar month is equivalent to making them undergo the freezing cold, and the purpose is the same as what we do today, that is, to use the harsh environment "to kill the weak ones, who could not hatch, therefore, the hatched are the strong ones." "*The Exploitation of the Works of Nature*" noted: "The bathing winnows out the unviable ones, and thus saves leaves and ensures good harvest of silk." Even before feeding the silkworms, once more bathing is still needed, as commented by Lou Shu in "*Poem of Farming and Weaving*": "Right after the Qingming Festival…drizzle makes a perfect day for bathing silkworms. Roll up your sleeves and fetch a basin of water

Fig. 19 Silkworm egg bathing in "*silkworm and weaving*" annotated by Empress Wu

from the clear spring." The poem pointed out clearly that in Yuqian where Lou Shu lived, silkworm bathing came before the Qingming Festival, usually indoors. This is consistent with Chen Fu's record in "*Book on Agriculture*": "in spring, when the silkworm eggs were about to hatch, grind some cinnabar into fine powder, and dissolve it in lukewarm water for bathing the silkworm eggs. Make sure the water is about the temperature of the human body, not too cold, or too hot, so as to avoid ominous effects." Obviously, this round of silkworm bathing is mainly intended as an auspicious ritual. That is why cinnabar is used for coloring the water used. The painting for this scene in Empress Wu's version is entirely consistent with the description in Lou Shu's poem. In addition, the tree leaves in the painting are tender and green, indicating that this is silkworm bathing in spring. This consistence indicates that Empress Wu's version of "*Silkworm and Weaving*" has been a transcription of Lou Shu's version with the annotation of "silkworm egg bathing in December" intended as an illustration on the one hand, and that several rounds of silkworm bathing were conducted back then on the other (as shown in Fig. 19).

2.2.2 Accelerating Silkworm Hatching and Collecting Newly Hatched Larvae

"暖种" (warming silkworm eggs) annotated by Empress Wu is the today's accelerating silkworm hatching, and "拂乌儿" (sweeping with whisk) is today's collecting newly hatched larvae. One way for warming the silkworm eggs is heating with the human body temperature. Therefore, the "*The Exploitation of the Works of Nature*" called it "embrace for incubation". Another way is by "warming with chaff smolder (Chen Fu's "Book on Agriculture"). Although Chen Fu recorded a better

Fig. 20 Warming silkworm eggs in "*silkworm and weaving*" annotated by Empress Wu

method in "*Book on Agriculture*" for collecting newly hatched larvae, farmers in the vicinity of Lin'an still use goose feather to gather them. "乌儿" refers to the newly hatched silkworms. Subsequently, this name and this method were consistently used in Zhejiang area. What's noting here is Empress Wu's annotation: "Warm silkworm eggs on Qingming Festival." However, Lou Shu said in his poem "A few days into the solar term of Guyu, silkworms begin to breaking out of shells". There is a difference of over ten days between the two. This can be explained by the modern civil investigation. Nowadays, Yuhang County, to the west of Hangzhou City, is famous origin of silkworm eggs. There incubation occurs extremely early. One of the reasons is that locally a lot of early-sprouting red mulberry trees, and if collecting newly hatched larvae is too late the mulberry leaves will grow old and hard, not only affecting the mulberry trees, but also affecting the harvest. The second reason is there has always been a folk saying "of ten years feeding silkworm early, nine obtain good harvests." Thus silkworm farming starts each year as early as Qingming, while Yuqian might have been unable to meet these conditions. Therefore, there is some difference in the time for warming silkworms (as shown in Fig. 20).

2.2.3 Rearing the Young Silkworms

Rearing young silkworms includes first molting, second molting and third molting. In rearing young silkworms, two things are the most important: first, the supply of mulberry leaves, and second, the regulation of temperature and humidity. In feeding the newly hatched larvae, special care should be exerted on mulberry leaf

supply; only when the leaves are cut into fine strips can they be fed to the silkworms. Empress Wu noted here: "cut the leaves, since the larvae like fine strips of leaves". Lou Shu said in his poem: "pick the soft mulberry leaves that are soft like cicada's wings, and knife them into thin strips." By the first molting, the mulberry leaves can be directly fed to the silkworms without cutting; however, only the tender ones could be used. "When the silkworms first start eating, the mulberry leaves are about the size of coppers. Pick the light yellow leaves, and watch how the larvae gather for a feast." In the entire stage of rearing young silkworms, close attention should be paid to the temperature and humidity control. Chen Fu said in "*Book on Agriculture*": "Silkworms are best reared when fire is used to keep them warm. The method is: prepare a separate furnace and mount it on a trestle which can be conveniently carried about. After the silkworms start eating and crawling onto the leaves, bring the stove into the room. While being brought into the room, the stove must be burning briskly, and be covered with grain shells, so that it won't burst into flame. Presently after the silkworms have finished eating, take the stove away." In the pictures of first, second and third molting of "*Silkworm and Weaving*" annotated by Empress Wu, there are underground braziers to lift the room temperature. In addition, there is a picture dedicated to warming silkworms, and this is absent in the original painting by Lou Shu. This indicates that Empress Wu attached great emphasis to warming silkworms. From the perspective of silkworms' physiology, the small silkworms are far worse in cold-resistance capability than grown silkworms. Therefore, addition of the picture "warming the silkworms" indicates people's understanding of and familiarity with the physiology of silkworms. Utensils used in rearing young silkworms include "Bo" (silkworm rearing tray, called "Fei" in "*Wang Zhen's Agricultural Book*"), "Zhi" (another name for Bo), etc. (as shown in Fig. 21).

Fig. 21 Silkworm nurturing in "*silkworm and weaving*" Annotated by Empress Wu

Fig. 22 Gathering Mulberry leaves in "*silkworm and weaving*" annotated by Empress Wu

2.2.4 Rearing Grown Silkworms

Lou Shu said in his poem: "After the third molting and awakening, the silkworms will find it too crowded to move about freely when they have eaten their fill. Therefore, multiple trays should be prepared so as to separate them. Throughout the days the room is full of trestles supporting silkworm trays." After three rounds of molting, the silkworms increase in size, and are known as the grown silkworms. It is difficult to keep them in the original trays, and large rectangular baskets should be used. This process is known as "separating trays" in Lou Shu's version of "*Silkworm and Weaving*". Although Empress Wu's version does not have this term, its "final molting" picture features two women carrying a tray and separating the silkworms into different baskets. This picture offers a clear illustration for this term. The rearing of grown silkworms is characterized by demands for large amounts of leaves. Therefore, before and after the final molting, one picture of "Busy gathering mulberry leaves" is added. In addition, mulberry leaf-carrying workers are shown bustling about in the silkworm room. At this point, silkworms need a high temperature, but with the days gradually getting warmer, no brazier is needed for heating (as shown in Fig. 22).

2.2.5 Setting up the Trellises

Setting up the Trellises is an important link in silk production, and it is closely related to raw silk quality and unwinding ratio. Trellises are the places where silkworms cocoon. The trellises in the "*Silkworm and Weaving*" by Empress Wu are

today's umbrella trellises, which are widely used in Zhejiang area. Empress Wu called them "山子" (little hills) in her annotation, saying "make little hills out of couch grasses—the process is called Bocu, and put the silkworms onto them for cocooning." The material used here is consistent with the description in Lou Shu's poem, which says: "the grouped couch grasses are uniform in length." The method of setting up the trellises is consistent with that described in "*Essentials of Sericulture*": put the reed curtain on bamboo or wooden columns, mount grass hills on the curtain row by row. Wash your hands, and take the grown silkworms from the large lacquer tray, and spread them on the trellises. In the picture, there are two bunches of trellises below the basket, next to which there is one worker "carefully letting the trellises go after setting them up". Behind him, there is a group of people, and some are holding the tray containing silkworms, while others are spreading the silkworms on the trellises. 上 In setting up the trellises, the mature silkworms should be placed onto the hills so as to make them spin silk earlier. This is called "clever picking for the hills". Empress Wu noted: after about another ten days, the silkworms become slightly wrinkled, transparent and red, measuring about 4 fen in diameter and 2.5 cun in length, with long legs. This is the time for "clever picking for the hills". After that, large numbers of the mature silkworms are put onto the hills, and this process is called "filled the hills". In setting up the trellises, attention should first be paid to the tranquility of the environment, second to temperature, so as to speed up the process of silkworms spinning silk, and to make sure the spit silk can dry quickly, lessen adhesion and improve unwinding ratio. This requirement is reflected in "*Silkworm and Weaving*": Empress Wu annotated it as "heating to facilitate cocooning", and Lou Shu called it "baking the tray" in his poem, saying: "The old farmer meticulously wait upon the fire, and beads of sweat drop from his face." Lou's description is completely consistent with Empress Wu's version of "*Silkworm and Weaving*". This indicates that record of cocoon silk "becoming dry instantly after it is spit out" in "*The Exploitation of the Works of Nature*" by Song Yingxing in the Ming Dynasty has been in existence in the Southern Song Dynasty (as shown in Fig. 23).

2.2.6 Cocoon Picking and Stripping

Back then cocoon picking and stripping are done in the same process. Therefore, Lou Shu mentioned "cocoon picking" in his poem, saying "the large cocoons can include eight silkworms each and small cocoons have one silkworm each". This is the classification and evaluation the cocoons. In addition, there is the verse "cocoon coating is pliant to be wound about the fingers". In Empress Wu's version, there is a picture of "cocoon stripping", in which four people, including men and women, are picking and stripping cocoons. The purpose of cocoon picking is to remove the pierced cocoons, yellow spotted cocoon, cocoon doubles, deformed cocoons, and other cocoons that cannot meet the requirements of the silk reeling. Cocoon stripping is stripping off the loose outer layer of the cocoon and cocoon coating that is poor in strength and denier so as to facilitate reeling (as shown in Fig. 24).

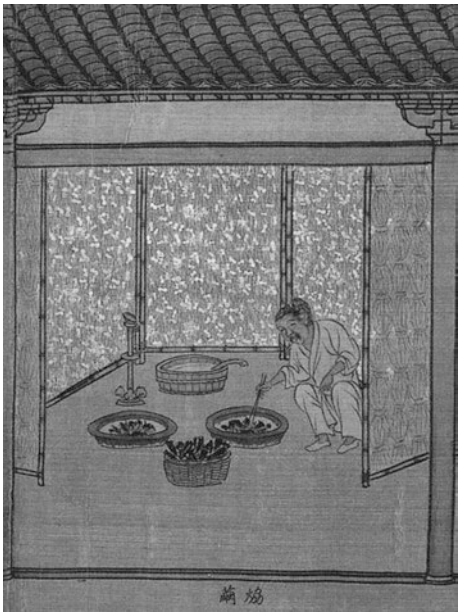


Fig. 23 Setting up the trellises as shown in "*silkworm and weaving*" annotated by Empress Wu

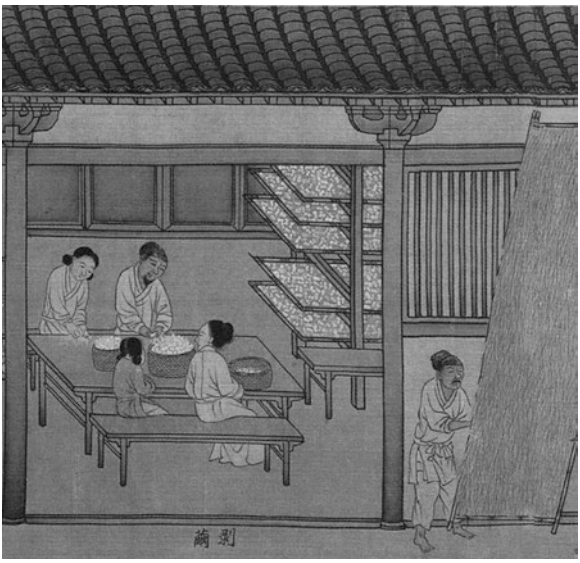


Fig. 24 Cocoon picking in "*silkworm and weaving*" annotated by Empress Wu

2.2.7 Cocoon Storage

At room temperature, silkworm cocoons become moths in seventy or eight days. Therefore, cocoons should be stored so as to extend the deadline of reeling. In ancient China, cocoons could be stored in many ways, liking sunning, baking,

steaming and salting. In Empress Wu's version of "*Silkworm and Weaving*", "salting cocoon" is depicted. Lou Shu's poem "Storing Cocoons in a Vault" says: "put the cocoons together with crystal-like salt and parasol tree leaves into the pottery utensil. Seal tight with mud. Cocoon stored this way can last over ten days." Empress Wu's annotation also mentioned "Cocoon Weighing", indicating a certain proportion between salt added and cocoon. The proportion can be seen in Chen Fu's "*Book on Agriculture*": "In storing the cocoons, expose them to the sun first to make dry. Bury an urn underground, spread out a bamboo curtain on its bottom first and cover with large parasol tree leaves. Then put a layer of cocoons on the leaves. For each ten catties of cocoons, use 2 liang (approximately 75 g) salt. Again cover the cocoons with parasol tree leaves. Repeat until the urn is filled. After that, cover the urn and seal it with mud" (as shown in Fig. 25).

2.2.8 Silk Reeling

In ancient China, silk reeling was divided into raw reeling and ripe reeling. Ripe reeling was conducted after salting, baking and other steps involved in cocoon storage, while raw reeling was carried out right after picking the cocoons. Silk resultant from raw reeling has a bright colour in South China, seen from the picture, it should have been not much different from silk carts currently preserved in Hangzhou, Jiaxing and Huzhou. It is also basically consistent with the description in Qin Guan's "*Book on Silkworms*": The silk cart has a rack, and a reel is mounted on it, to be driven by

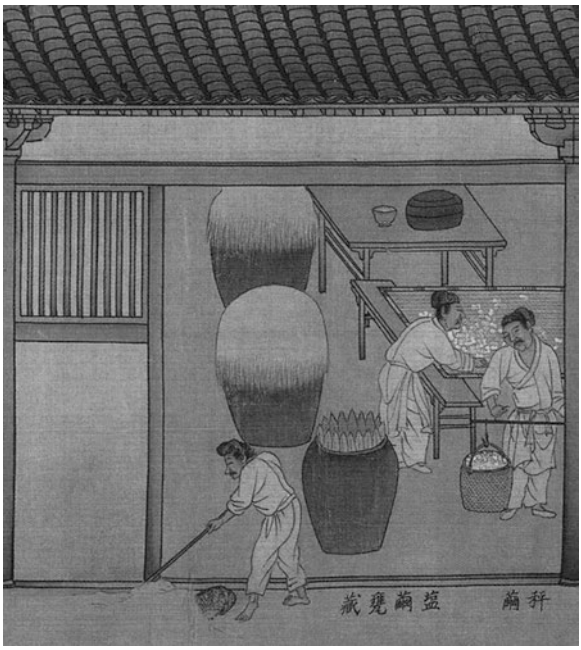


Fig. 25 Cocoon storage in "*silkworm and weaving*" annotated by Empress Wu

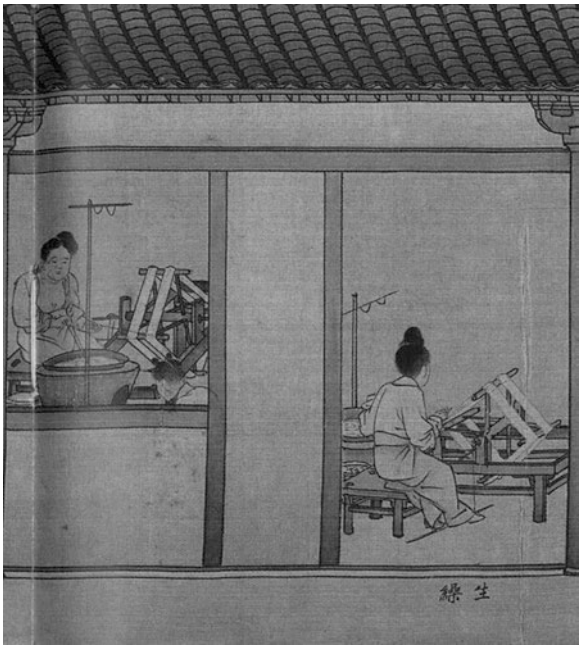


Fig. 26 Silk reeling in "*silkworm and weaving*" annotated by Empress Wu

a treadle crank-link mechanism. The cart also had a traverse gear: "Above the left treadle of the cart, there is a handle one and an inch in length. The handle is connected to a drum, which has a circle to be fitted to a looped rope. The rope moves together with the cart. Since the rope has no ending, the drum can spin. In the drum, a fish-shaped rig is mounted for better quality. Emperor Wu annotated "raw reeling", indicating clear separation between raw reeling and ripe reeling in the Southern Song Dynasty. Regarding the model of the reeling cart alf of it sticks out of the drum. Half one cun from the tip of the rig, a handle is fitted, which is connected to the Tianti (literally feeding ladder)." Tianti is equivalent to today's traverse rod. With this setup, the silk won't be wounded unchangeably in one straight line. Seen from this picture in Empress Wu's version, there is no brazier under the silk crankshaft (perhaps it happened to be blocked). However, Chen Fu's "Book on Agriculture" recorded: when reeling, "the silk should be presently baked dry with fire so that it doesn't lose its luster and become dull." This record indicates that the method of "dried after leaving the water" described in "*The Exploitation of the Works of Nature*" by Song Yingxing had been created in the Southern Song Dynasty (as shown in Fig. 26).

2.2.9 Weaving

This section includes two major processes: preparation and machine operation. Preparation in turn includes spooling, warping and wefting. Spooling involves first taking the silk off the reel of the cart and placing it in a silk stacking pallet,

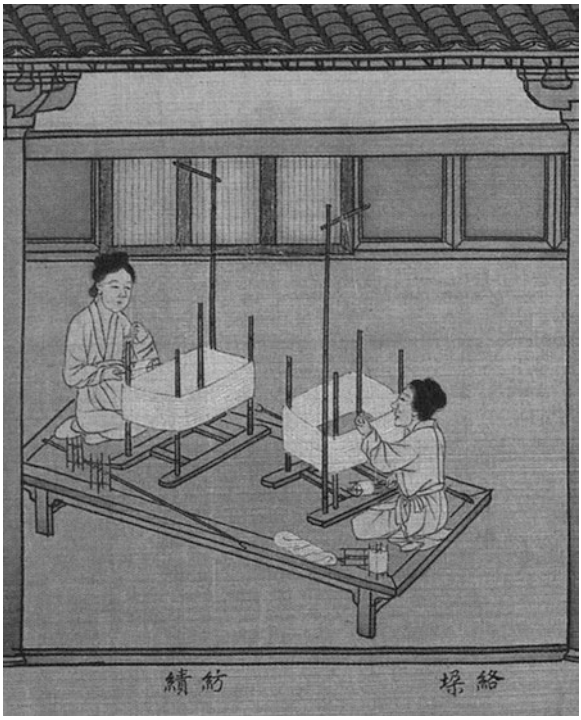


Fig. 27 Spooling in "silkworm and weaving" annotated by Empress Wu

which is called "Luo Du" by Song Yingxing in "*The Exploitation of the Works of Nature*", and hanging a hook, pulling out the end of the silk, and winding the silk onto a reel, for use in warping and wefting. This step is laborious, just as Lou Shu said in his poem: "From dawn I have been busy reeling, and never do I complain that my wrists almost come off" (as shown in Fig. 27). After shaking, the reels can be used in two ways. One is wefting, which involves using a wefting cart for winding the silk on smaller pirns. Lou Shu's description of "thunders heard on a clear day" in his poem describes this step. The other is warping, labeled as "刺丝" (i.e., weaving) in the picture. In warping, the reels are neatly laid out on the ground, with the leads pulled out or directly wound on the warp beam, or coated with starch before being wound on the warp beam. Coating with starch is now called silk starching. *The Exploitation of the Works of Nature*: "in coating [silk], gluten flour is used. For satin it must be used, but for damask it may be spared…. Apply the coating material on the reed curtain, and push the silk above it. Make sure it is well coated and becomes dry after coating." This should be the same as the picture of "Weaving" in Empress Wu's "*Silkworm and Weaving*". Originally I have thought that silk starching was first seen in "*The Exploitation of the Works of Nature*", for the purpose of increasing the various intensities index of warping. Obviously, the satin and damask back then used silk materials with slight denier, and the resulting fabrics are thin (as shown in Fig. 28).

To sum up, "*Silkworm and Weaving*" Annotated by Empress Wu reflects the technology system for sericulture and silk production in Zhejiang and adjacent

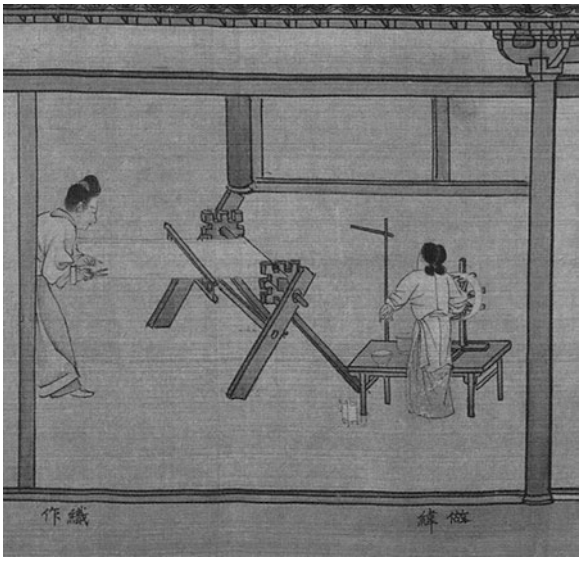


Fig. 28 Starching in "silkworm and weaving" annotated by Empress Wu

regions in the early Southern Song Dynasty. The complete procedures, and advanced equipment indicate that sericulture and silk production technology in ancient China had by then been established, without great changes in the Yuan, Ming and Qing Dynasties. *The Silkworm and Weaving* is an important document in the history of silkworm-rearing and weaving technology, and is only rivaled by "*Treatise on Apparel*" in "*The Exploitation of the Works of Nature*" by Song Yingxing in the Ming Dynasty, but the latter is about 500 years later.

2.3 机 (Loom)—The Consolidation of Ancient Chinese Wisdom

Chinese characters are a pictograph. Traditional Chinese character for "机" is "機", showing the image of a loom. The left part of it is the radical "木" (wood), indicating that loom is made of wood; the right part has the character 戍 in the lower section, depicting the side view of a loom frame, and the radical "幺" in the upper section, symbolizing the warp beam for loading the warp is mounted on the top of the loom. Therefore, the Chinese character 机originally referred to the silk-weaving loom. However, later on, its connotations slowly expanded, first to some other tools, including machinery, equipment, machines, institutions, authorities and etc., and later to phrases indicating wisdom and intelligence, such as 机动 (mobility), 机要 (confidential), 机敏 (alert), 机智 (witty), 机灵 (clever), 机巧 (ingenious) and so on. This shows that, in the eyes of the ancient Chinese, silk-weaving machine was the most complex tool. Use of silk looms to weave silk textiles is the most wonderful part of the ancient Chinese technology, equivalent of today's IT and high-tech industry. After a flash of wit, all kinds of beautiful patterns are woven.

However, the development of loom is not accomplished at one stroke. The improvement and finalization of Chinese silk looms has gone through a history of thousands of years, starting with the primitive back-strap loom, spanning the treadle looms and multi-heddle jacquards in around the Warring States Period, and ending with the integrated-heddle jacquards of the Tang Dynasty jacquard.

2.3.1 Various Primitive Back-Strap Looms

Looms originally used are back-strap looms with heddle-lifting motion operated manually. The so-called primitive back-strap loom refers to a device without rack but capable of completing the basic functions required of the loom. Its most obvious feature is that the weaver's beam is carried on the back or strapped with a belt to the waist of the weaver. It controls the tension of the warps according to the weaver's location, and has no brackets with fixed distance between the warp beam and the weaver's beam. The earliest primitive loom is unearthed in Hemudu ruins in Zhejiang, dating back 7,000 years, but more complete construction of the original loom can be speculated from the 3 pairs, 6 pieces of jade-ornamented loom parts of unearthed from the Fanshan Tombs of Liangzhu Culture in Yuhang, Hangzhou. The configurations of the entire loom can be recovered through the analysis of the cross-section of the jade ornamented parts. The loom mainly consists of cloth-rolling shaft for clamping the fabric, the shed stick for forming openings, and the weaver's beam for securing warp yarn, wherein the shed stick is the most important component of the loom (as shown in Fig. 29).

In China's vast Neolithic cultural relics, there were primitive equipment parts of varying numbers unearthed, for example, Hemudu ruins of Zhejiang, Peiligang site of Cishan, Henan, Liangzhu cultural sites in Hangzhou, Zhejiang and so on, but definition of those original equipment parts as the belonging to the primitive back-strap loom is indeed reliant on surveys and comparative studies of modern ethnology. Weaving technology for primitive back-strap looms have been preserved in the ethnic minority areas in China, involving two models of looms: one is the treadle

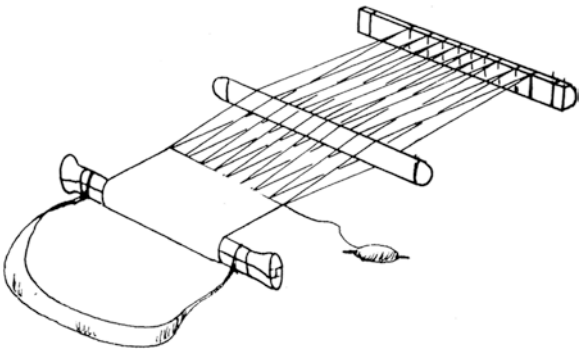


Fig. 29 Restored Liangzhu loom

Fig. 30 Scene of weaving on a Shizhaishan Bronze cowrie container

back-strap loom whose warp beam is secured by the feet; the other is the hanging-shaft back-strap loom with a simple wooden frame to fix the warp beam.

The foot treadle back-strap loom is widely used in regions where Li, Yi, Gaoshan ethnic groups live. The characters on the Han-Dynasty cowrie container unearthed in Shizhaishan, Jinning, Yunnan can also be taken as an instance of weavers operating foot-treadle back-strap loom (as shown in Fig. 30). hanging-shaft back-strap loom is also widely used among ethnic groups, but it is slightly different in form and configuration, for example, the warp beam of the back-strap loom used by the Benglong Ethnic Group in Yunnan is hung high in the upper part of the wooden house, the warp beam of the back-strap loom by Uygur Ethnic Group in Xinjiang is fixed on two ground piles; the back-strap loom used by the Miao Ethinc Groups in Wenshan, Yunnan has a special wooden rack for fastening the warp beam. The warp beams for this type of hanging-shaft back-strap looms are usually equipped with "shenghua" or "goat horns", i.e., ratchet wheels at both ends of the warp beam, for controlling the getting out of release of organzine in weaving process. Patterns of Shenghua had appeared in large numbers in painted pottery and spinning wheel artifacts of the Neolithic Era. This could perhaps indicate that hanging-shaft back-strap looms also appeared quite early.

2.3.2 Treadle Loom

The Treadle loom appeared in about the Warring States period, and was hailed by Dr. Joseph Needham as a major contribution of China to the world textile technology. "*Liezi · Tangwen*" recorded of a story of "Ji Chang Learned Archery", describing Ji Chang as, "lying face up under the loom operated by his wife, with eyes fixed on the Qianting (literally the pulling mechanism)". Here, Qianting is probably the treadle. The earliest image of treadle looms appeared in the stone

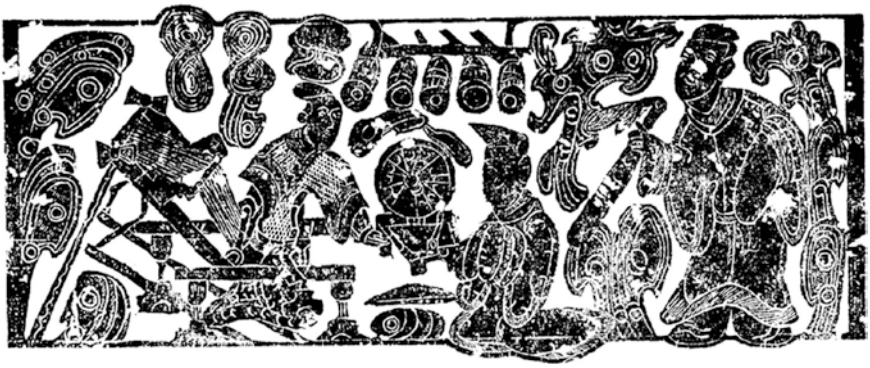


Fig. 31 Scene of weaving in stone relief of the Han Dynasty

reliefs of the Eastern Han Dynasty, for example, stone reliefs were unearthed in Hongdaoyuan and Longyangdian of Tengxian County, Wu Liang Shrine in Jiaxiang County, Guo Ju Temple in Xiaotanshan to the northwest of Fei Cheng, Ciyun Temple in Jinyangshan in Ji Ning, Shandong Province; Liuhuangcheng Township in Peixian County, Honglou in Tongshan County, and Caozhuang in Sihong County in Jiangsu Province; Zengjiabao in Chengdu, Sichuan province, etc.

The connection between the heddles and treadles of looms on stone reliefs unearthed in Wu Liang Shrine, Honglou, Caozhuang and other places is special: below the warp surface in the upper middle of the loom, there are two mutually perpendicular short rods extending out, with each short rod connected to a treadle by flexible rope or rigid wood (as shown in Fig. 31). Seen from subsequent vertical treadle looms, we can speculate that such oblique looms should have adopted the central axis device, on which there is a pair of mutually perpendicular short rods connected via cranks or ropes to the two treadles, constituting two linkage mechanisms. It seems that this can be better corroborated by the glazed pottery loom model of the Eastern Han Dynasty now kept in the Guimet Museum in France. Thus, we have recovered a Han-Dynasty inclined treadle loom (as shown in Fig. 32) according to this loom model and the loom image in Han-Dynasty Stone reliefs. Seen from its principle, this loom can be called axle oblique treadle loom.

The oblique treadle looms later became gradually uncommon, but its traces can still be seen in the "*Time-Honored Institutions of Carpenters*" of the Yuan Dynasty. Its rack is basically vertical, and it was called vertical loom. The image of the earliest vertical loom appear in "*Avatamsaka* Sutra" on the northern wall of K98 dating back to the Five Dynasties and found in Mogao Grottoes in Dunhuang, Gansu. However, in late-Tang Dunhuang documents, cotton fabrics were mentioned with the name of "Li Ji"(meaning "manufactured with vertical loom"). Since then, pictures of vertical looms were found in Northern Song Dynasty murals in Kaihua Temple in Gaoping, Shanxi Province, and the Ming Dynasty "*Picture of Silkworm Palace*" now kept in the National Museum. However, the most detailed record is none other than the vertical loom recorded in

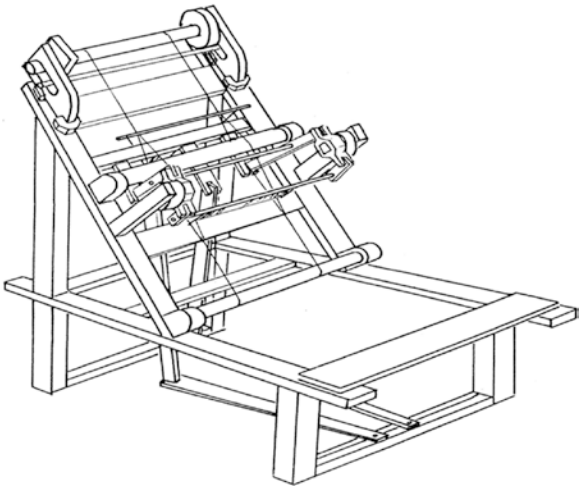


Fig. 32 Restored Han-Dynasty axle oblique treadle loom

"*Time-Honored Institutions of Carpenters*" by Xue Jingshi in the Yuan Dynasty. It can be restored according to the size and graphics recorded in the book.

Treadle looms have many different types. One of them is the one whose tension is controlled by the weaver physically. And this can be called treadle Izanbata Loom. The earliest graphic description of treadle Izanbata Loom is found in the Eastern Han stone reliefs in Zengjiabao, Chengdu, Sichuan province, while the clearest record is found in "*Time-Honored Institutions of Carpenters*" by Xue Jingshi of the Yuan Dynasty. Such looms are still in civilian use, for example the grass cloth of Liuyang, Hunan; cotton cloth of Fufeng, Shaanxi are woven with them. The basic characteristics of such looms are tilted body, the single heddle and single treadle, and use of the waist to control the tension. Specifically, treadle Izanbata looms can be divided into direct patterning horizontal loom without tension compensation and pressurized patterning horizontal loom with tension compensation. Looms used in the area of Yao Ethnic Group in Hunan belong to the first category, i.e., direct patterning horizontal loom. It has a rack consisting of two prostrate frames and two socles, and the major opening component beyond the rack is a heddle-lifting lever mounted on the straight frame, in the middle here is a pivot, behind which there is a short rod connected through rope to the foot. Before the pivot, there are two short rods, for lifting a heddle. The simplest pressurized Itanzaba is the pattern-making loom used by Tujia Ethnic Group in Xiangxi, Hunan province. It also has a tilted horizontal frame harboring the straight frame, on which there is a pair of crow wood, with one end attached to the treadle lever and the other to the heddle opening. The fundamental difference in the opening setup is the adoption of a tension compensation device, that is, there is a warp-compression rod between the treadle rod which is connected to the rear end of the crow wood (as shown in Fig. 33).

Seen from successive collection of paintings, dual-heddle model was adopted mostly in treadle loom from the Tang and Song Dynasties, that is, two treadles were used to control the two heddles respectively, and the two heddles were used to open

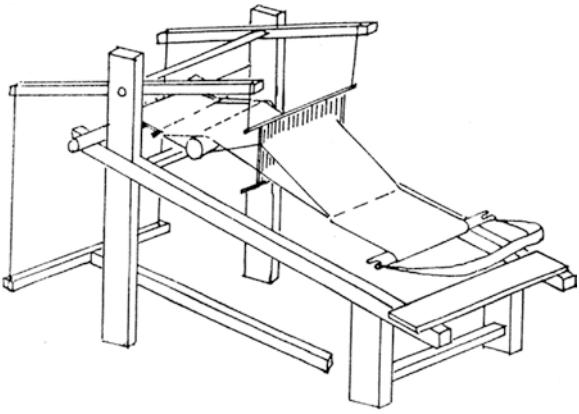


Fig. 33 Restored treadle Itanzana loom

two shuttle sheds for weaving plain fabrics. The warp surface is generally horizontal. Dual-heddle treadle loom was depicted in the "*Silkworm and Weaving*" claimed to be the work of Liang Kai in the Southern Song Dynasty and "*Farming and Weaving*" by Cheng Qi in the Yuan Dynasty. In the two pictures, the looms had basically the same model, each having two treadles, one long and the other short. The longer treadle was connected to a longer crow wood for controlling a heddle. The shorter treadle was connected to two shorter crow wood for controlling the other heddle. Two groups of crow wood were mounted on the rack in the middle of the loom. And the rack was equivalent to the original "horse head", but it was far bigger in size. The warp surface was no longer inclined as in the oblique looms of the Han Dynasty. At the point of weaving, the warp surface was basically horizontal, but the position of the warp beam was slightly higher. In the center, a warp compression wood was used to press the warp threads down, playing the role of a tension compensation apparatus. The loom depicted in "*Collection of Pictures for the Convenience of the People*" of the Ming Dynasty is the same as this one. This type of dual-heddle loom used crow wood for lifting the heddle upward and thus opening it via the treadle. While being opened, the two heddles had no direct relationship to each other, since they were lifted with independent transmission from the treadle. Therefore, we call this double-heddle treadle loom single-motion double-heddle loom.

The single-motion double-heddle loom is still in use. The existing silk tapestry loom is a case in point. However, its crow wood is installed transversely. On top of the rack, there is an axis in the same direction as the warp. Two pieces of crow wood are mounted on the axis, in the same direction as the weft thread. Below the loom, there are two treadle rods in the same direction as the crow wood. The rods are connected via rope to the crow wood beside the loom. This device is quite similar to the Fanzi mounted on the Ming and Qing jacquard machines.

In about the turn of Yuan-Ming Dynasty, interactive double-treadle double-heddle looms appeared. The characteristic of such a loom is the use of pressed down heddle openings. Two treadles are connected respectively to the lower parts of the two heddles, while on the top of the loom there is a lever with both ends respectively connected to the upper portions of the two heddles. In this way, when the weaver

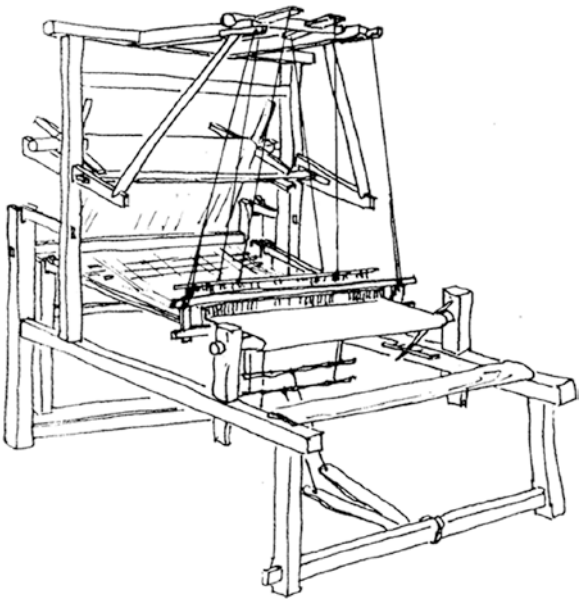


Fig. 34 Interactive dual-heddle dual-treadle loom

stamps down one treadle, a heddle presses a set of warp down. At the same time, the upper part of this heedle pulls the lever on top of the loom, lifting the other heddle to form a clearer opening. To open another shed, the other treadle is stamped down. The opening mechanism is very concise (as shown in Fig. 34), and was very popular in the twelfth and thirteenth centuries in Europe. The evolution of China's prime loom from the single-motion to interaction may have benefited from the flourishing of cultural interchange in the thirteenth century. The double-treadle double-heddle looms seen now among the common people are basically of this model.

2.3.3 Patterning Looms and Patterning Technology

The patterning loom is the most complex among looms, and patterning technology is the most complex among all textile technologies. The so-called patterning technology is a complex information storage technology. To produce patterned silk products, complex patterning information must be stored via a variety of patterning apparatuses installed on the loom, so as to ensure repeated use of the stored information about the opening of the heddle. This is like the computer program today. After being programmed, all the operations can be repeated, without starting from scratch every time. Seen from the Warring States brocade unearthed in Chu Tombs in Mashan, Jiangling, Hubei province, China has had mature patterning looms and technologies in the Spring and Autumn Period at the latest.

However, patterning technology is not perfected at one go. It has experienced a process from cross-stitching to jacquard. All the aforementioned looms can use a cross-stitch lever to weaving patterns, especially the original back-strap loom, oblique loom and level looms. In history, they were used for weaving cross-stitching

fabrics. There are two cross-stitching methods. One is cross-stitching one weft and weaving one weft. This method requires a well-thought-out plan on the part of the weaver. The other is cross-stitching one loop and weaving one loop. This method had seen wider application. But no matter what, this second approach still did not improve work efficiency, because the cross-stitch information cannot be stored for a long period of time or used repeatedly. To solve this problem, the ancient people explored two ways, thus ushering in patterning technology. One way was to "soften" the cross-stitch lever, that is, replace the cross-stitch lever with the heddle, leading to the evolution into multi-heddle patterning looms; the other way is to keep the regularity formed on the cross-stitch lever unchanged, and to seek a certain kind of relationship for passing the regularity repeatedly to the warp thread. Therefore, patterning looms with pattern board appeared.

2.3.4 Multi-heddle Patterning Looms

It is generally believed that multi-heddle patterning looms appeared in the Han Dynasty. Reliable evidence comes from a note in the "*Records of the Three Kingdoms · Biographies of Fangshi's and Artisans*": "50 treadles for 50 heddles, and 60 treadles for 60 heddles." The old damask loom mentioned in the three Kingdoms period is apparently a loom of the Han Dynasty. Such a loom with one treadle controlling one heddle and equality in number of treadles and that of heddles must have been multi-heddle treadle patterning looms, and be called in nowadays multi-heddle multi-treadle looms. Of course, before this, there should have been hand-lifting multi-heddle patterning looms.

The multi-heddle treadle loom can still be found in Shuangliu County, Sichuan, called Dingqiao loom. In fact, this is a bar loom, distributed throughout the country. It is characterized by control of one heddle with one treadle, a large number of heddles, but the magnitude is relatively narrow and it can only be used to weave belts. There are two types of heddles used in Dingqiao looms. One is lifting heddle, also known as Fanzi, with upward openings, and lifted via the crow wood by the treadle. The other is crouching heddle, also known as Zhanzi, with downward openings. The treadle directly pulls the lower border of Zhanzi to press down the heddle, compressing the warp threads in the meanwhile. Zhanzi is restored to the original position using the stretch of the arc on the top of the loom. Of course the Dingqiao loom is not equal to the Han-Dynasty multi-heddle treadle loom. We know that crouching heddle did not appear in the Han Dynasty, and the width of Han-Dyansty fabrics was far greater than that produced using Dingqiao loom. However, the main principle is the same (as shown in Fig. 35).

2.3.5 Low Pattern-Board Patterning Looms

Low pattern-board patterning looms can take many forms, and bamboo-barrel looms are a typical example. The bamboo-barrel loom usually has a cross-stitch

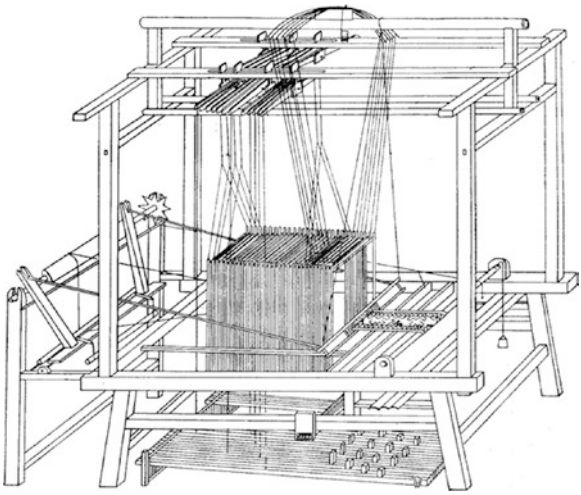


Fig. 35 Multi-heddle treadle loom

lever made of bamboo; therefore, patterning looms with pattern boards evolved from the cross-stitching initially adopted bamboo pattern boards, which appeared approximately in the Han dynasty. However, prototypes of looms with such boards can still be found nowadays, especially in Guangxi, Hunan and Guizhou. Locally they are generally called bamboo-barrel looms or pig-pen looms. This type of loom features a large bamboo cage hanging on it, and on the cages about 100 patterning bamboo sticks are arranged, integrating with the crane rope to form a pattern board. To open the shed, the following steps must be followed: the warp threads need to be lifted are wired to the heddles in front of the bamboo sticks, and those do not need to be lifted are placed behind the bamboo sticks. Thus the two sets of heddles are separated. Then, lift the bamboo cage so that the warps form an opening, and then use the warp compression board and open bamboo pipe and other tools to make the opening clearer. The bamboo sticks serving as the pattern board are moved to the other side of the bamboo cage, in the last row, for the next cycle. This principle is very scientific (as shown in Fig. 36).

Prototypes of bamboo-barrel looms are found in modern times, but their traces can also be found in ancient historical data. patterning looms described in "*Ode to the Weaving Woman*" by Wang Yi in the Eastern Han Dynasty should be a loom with bamboo pattern board. The ode reads as follows: "The threads take turns and twists to present various images. Major changes are made with simple moves, and a slight compression makes the textile flat as the vast plain. Making use of the light from the sun and the moon, the weavers operate the looms methodically. Three beams are clearly arranged, and on them threads flit. The two horses stand neck and neck, as if marching to war. Square and circular lines intersect to produce the most spectacular patterns. Insects, birds and beasts all have their places on the textiles. Rabbits sit with ears pricked up, as if in leisure or agitation. Fierce dogs come in pairs, leaping into the air and hiding their feet. The tall towers stand opposing each other, with a clear pond at their feet. The shuttle darts back and forth like

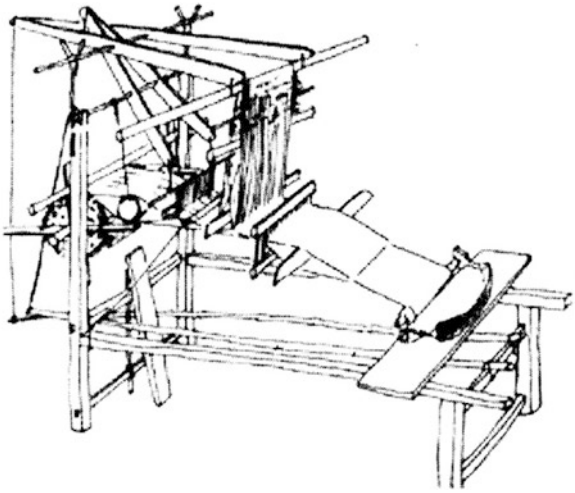


Fig. 36 Bamboo-barrel loom with pattern board

fish scrambling for food, breaking the peace of the pond surface. The lulu's (literally deer antlers) rise simultaneously, and threads relax. Threads bend, extend, and move freely like the stars on the star chart, coming and going without feeling fatigue." In the text, tall towers and lulu's should both refer to the apparatus lifting the bamboo pattern board. The star chart is the bamboo pattern board. Bamboo-pattern-board looms were still in use in the Tang Dynasty. Therefore, in the Tang Dynasty, Shi Jianwu had the following verses in his poem "*Damask Weaving in Regions to the South of Changjiang River*": "when my confidantes come to view the new pattern, the mandarin ducks are just about to take a new branch."

2.3.6 Draw Looms

The draw loom is a patterning looms featuring thread-based pattern board. On the one hand, it is a direct transformation of the bamboo pattern-board loom; on the other hand, it is the product of integrating the 1-N suspension system of Central Asian weft brocade loom and the traditional Chinese pattern board.

Draw loom appeared in the Tang Dynasty. In Turpan, Xinjiang a piece of brocade with the character 吉 and pattern of paired sheep and light and trees was unearthed. The tapestry features a pattern symmetrical within a width and repeated from the top to the bottom, and may have been an instance evidencing the emergence of draw looms. However, the brocade with grouped flowers sprang up in the Early Tang Dynasty are evidently produced using draw looms equipped with 1-N suspension device [1]. Yuan Zhen's "*Poem of Weaving Women*" depiction of the households weaving tribute damasks in Jingzhou "changing stitches, lifting up the heddles, suffering from the ordeals of weaving" also refers to this type of loom. However, its physical image did not appear until the Southern Song Dynasty. The damask loom in "*Silkworm and Weaving*" currently kept in Heilongjiang Provincial Museum and the

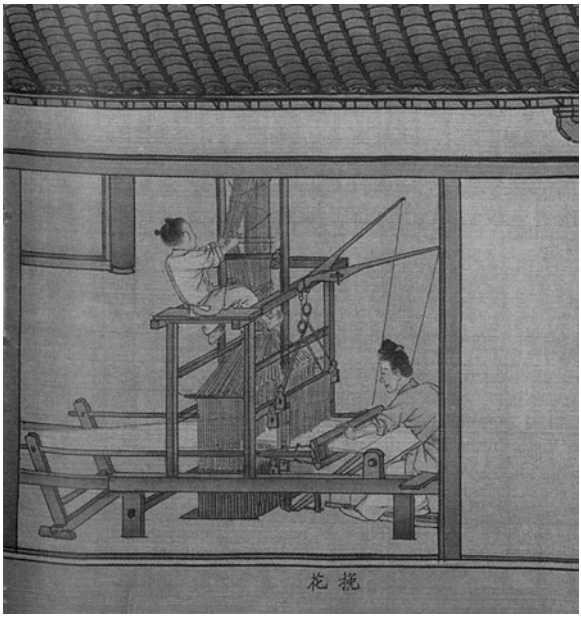


Fig. 37 Draw loom in "*silkworm and weaving*" annotated by Empress Wu

silk loom in "*Farming and Weaving*" kept in National Museum of China are cases in point (as shown in Fig. 37). This type of draw loom has a straight body, with pattern tower bulging in the middle. On the pattern tower there hangs the pattern board. A patterning servant is pulling with effort the pattern board to one side. The lower section of the pattern board is connected to lifting wires, which goes through a wheel to support it. Under the wheel, there are weights to keep it suspended over a pit. Before the pattern tower there are two ground heddles, which can be pulled up via crow wood by stepping on the treadle. The loom uses reeds which are connected to stacked wood to facilitate weft knitting.

This type of patterning looms with wired pattern board and straight frame is called the horizontal draw loom with minor pattern tower. It is mainly suitable for weaving thin fabrics like damasks, tulle, gauze and etc. and looms used in regions to the south of Changjiang River are of this type. The reason for use of horizontal frame is to reduce the reed strength of the stacked wood, just as Song Yingxing's words "due to the fineness of the silk, it is necessary to avoid the reed strength". Hua Loom contained in "*Time-Honored Institutions of Carpenters*" by Xue Jingshi in the Yuan Dynasty is also a horizontal draw loom, with the frame dimensions and components described in great detail.

Patterning looms described in the "*The Exploitation of the Works of Nature*" belongs to oblique draw loom with minor pattern tower: "The entire loom measures 1 zhang and 6 chi's. The loom has a bulging pattern tower, a wheel in the center and dangling weights under the wheel. In places with high humidity, a shed of two chi's is set up instead. The patterning worker sits on the pattern tower rack. On the lever installed at the rear of the loom for rolling up the silk, there are two

Fig. 38 Draw loom with major pattern source

pieces of stacked wood about 4 chi's in length. And their ends are plugged into the ends of the reed…. The frame is connected in two directions, one to ground peace, and the other to the white pattern tower, about one chi lower than the oblique support. In this way, the facilitating strength of the stacked wood is great." Obviously, the purpose of adopting oblique frame is to increase the weft-knitting momentum. The development of draw looms in the Qing Dynasty has a notable feature, that is, the increase in frame inclination.

Patterning looms with major pattern boards mark the peak of draw looms, and Nanjing pattern-copying satin loom and decorative pattern loom are typical examples. The characteristic of this type of loom is with large and annular pattern board. It can also be seen as a result of further separation of pattern board from lifting wires. The pattern cycle can be very large, for weaving like robe-use materials and the like, with cycles exceeding ten meters. In patterning, the worker sits on the middle of the loom and pulls the pattern board backward. The frame is usually oblique. The number of heddles used varies according to fabrics, ranging from two, five or eight. Two kinds of heddles, i.e., lifting heddle and prostrate heddle, are used, according to different varieties of textiles (as shown in Fig. 38).

2.3.7 Pattern Board—Patterning Program

Program used in patterning looms is known as the pattern board. Song Yingxing in "*The Exploitation of the Works of Nature*" offered a very classic explanation for pattern board:

Craftsmen designing pattern boards are most ingenious in scheming. At first, the painter draws the pattern on paper. The pattern board maker measures the

dimensions of the pattern with silk thread, calculates the time by seconds and quickly weaves the board. Then the board is hung on the pattern tower. Even if the weaver has no idea of the pattern, she can still knit the warps and wefts, and lift the weights according to dimensions and degrees. After throwing rounds of the shuttle, she will find the pattern woven on the fabric.

This thread-made pattern board later developed into the grain board used on the Jacquard loom. Here perforated cardboard and steel needles are used to control patterning. Difference in perforating location means difference in patterns woven. Then, the perforated cardboard inspired the signal transmission principle in telegraph, and resulted in the prototype of the early computer. It can be seen that patterning looms invented in ancient China has had enormous impact on the history of modern science and technology in the world.

2.4 Dyeing

2.4.1 Stone Dying and Grass Dyeing

In ancient times, use of binder or extremely fine particles of mineral pigment to print mineral pigment on fabrics is called stone dyeing. Commonly used pigments came in red, yellow, green, blue, black, white and other colors. Among them, red iron ore, also known as ocher hematite (Fe_2O_3), was the earliest pigment used for coloring fabrics, but it was soon replaced on a large scale by cinnabar (HgS). On satin fabrics of Yangshao Culture in Qingtai Village, Xingyang, Henan Province, traces of cinnabar can be seen. Cinnabar became more common in the Yin and Zhou period; it was widely welcomed for its pure, concentrated and bright color. In the Han-Dynasty Tombs in Mawangdui entire sheets of fabrics dyed with cinnabar were unearthed. Fabrics dyed this way gradually became uncommon in subsequent eras. The yellow raw mineral materials mainly included sulfur, which can be further divided into orpiment (As_2S_3) and realgar (AsS). It was used in painting and dyeing back in the Western Zhou Dynasty. Yellow with a red hue, it has a plump and pure color. Later, yellow mineral pigment in fabric dyeing was replaced by golden color. Most of the green pigments were minerals containing copper ions, including Mallache ($CuSO_4$), malachite green ($CuCO_3 \cdot Cu\ (OH)_2$), azurite ($2CuCO_3 \cdot Cu\ (OH)_2$), wherein malachite is emerald.

White powders came in a rich variety. One was called chalky soil, also known as Baishantu, and was used as a fabric whitener, and a white pigment. Later, lead powder ($PbCO_3 \cdot Pb\ (OH)_2$) was used. Also known as Hu powder, it was turned into paste for use; another was litharge, prepared by mixing ceruse with perilla oil. In printed fabrics unearthed in Mawangdui, Changsha, there were cases of using sericite $KAl_2\ (Si_3A_1)\ O_{10}\ (OH\ F)_2$ powder as white pigment and galena (the main component being PbS) as the silver-gray pigment. Ink was the primary black raw mineral material; in the early stages, natural black minerals might have been used. Later smoke paint and loose coal were burned to produce ink, and various glutinous materials or spices were added, improving the color and luster of the ink.

In textile dyeing in ancient, China plant dyes were mostly used. "*Rites of Zhou · Offices of Earth*" had a post of "managing dyeing plants": "managing collection of dyeing plants in spring and autumn, keeping the right amount of storage, for distribution at appropriate times". Dyeing plants are vegetation-based dyes, now known as vegetable dyes. "*Six Codes of the Tang Dynasty*" records: "usually dyes are made of plants, sometimes their flowers and leaves, sometimes their stems and fruits and sometimes their roots and barks. All have to be gathered from appropriate places in appropriate times." The most important red dyes include madder, Safflowers, and hematoxylin; yellow dyes include pagodatree flower buds, Gardenia, amur corktree, rehmannia and etc.; indigo was the primary blue dye, and indigo plants, true indigo plants, woads and other plants could used to make indigo. Purple dye came from Lithospermum alone and green dye had only a frozen green. Black and brown dyes had a greater variety; virtually the barks and stems of all plants contain tannin, and can be dyed dark brown via a mordant dying process .

2.4.2 Safflower and Red Dyeing

Safflower contains two pigments: carthamin that is soluble in alkali but insoluble in acid or water, and yellow pigment that is in acid and water but not in alkali. Safflower dye preparation, extraction and a series of technology for dyeing with it are based on this principle.

Preparation of safflower dye was generally conducted in two approaches. One can be called dry safflower, the other saffron cake. The method for making dry safflower is called "flower-killing Method" in *Essential Techniques for the Peasantry* after picking, pestle [the flower] into pulp, spread the pulp out in water, pour the mixture into a cloth bag and twist to remove the yellow juice; pestle again, add millet starch and vinegar, and remove the juice with the cloth bag. Collect the red dye left in the bag, store it in a urn, seal the urn with cloth. When cock crows, pestle the red dye again to make it uniform. Spread it out on a mat to dry." The safflower cakes were prepared in a similar manner, and the difference lied in the last step: the red dye was modeled into thin cakes and dried in the shade for storage.

In the early stages of using safflowers, the finest carthamin was used for the preparation of rouge, and the inferior dye containing yellow pigment was used in silk dyeing. Since about the Tang Dynasty, technology for separating carthamin and yellow pigment witnessed further improvement, and people were able to dye fabrics with pure carthamin called true red. In the Ming Dynasty, Fang Yizhi said in his "*Essentials of Physics*": "immerse safflowers with river water, collect them the next day, and wash away the yellow juice. Then wash them with warm lukewarm water, add beanstalk ash and mix, wash with water, and sprinkle ebony soup (pestle ebony with equal amount of dry safflower). The silk can thus be dyed to different hues of red by adding a yellow pigment." At first, neutral or acidic river water is used to immerse the safflowers aims at further removing yellow pigment in the safflower cake. Then alkaline beanstalk ash is used to extract the carthamin and the acid agent ebony water is added to turn it acidic, so as to make it suitable

for dyeing. Change the concentration of carthamin dye, and we can get different dye colors, such as lotus red, pink, silver red, bright pink, etc.

2.4.3 Indigo and Blue Dyeing

The leaves and stems of blue grasses all contain indoxyl which can be turned into indigo by condensation reaction. However, its presence in the cells of different plants is different. In woads, it is in the form of isatin B, which releases indolol in hydrolysis when it encounters alkali and thus oxidized to produce indigo. In other blue grasses such as indigo plants, strobilanthes cusia it is in the form of indigo glycosides, which must go through a long period of fermentation to release indole hydroxyalkyl via hydrolysis under the influence of the enzymes and acids, before being oxidized to produce indigo. This principle determines the course for development of indigo dyeing technology in China.

The early blue dyeing process involves alkali-based indigo production which was only applicable to woads. Initially plant ash was used together with blue dye, and the alkaline agent hydrolyzes the woad glycosides which becomes oxidized and accumulated on the surface of the fabric. In the Wei and Jin Dynasties, lime was used to ferment and hydrolyze woad to produce indigo, before restoring it for dyeing. The method for making indigo was recorded in *Essential Techniques for the Peasantry*: "in mid-July, dig a pit capable of holding about 100 bundles of woads. Coat the walls and bottom with five cun's of wheat stalk mud, cover the walls with thatch. Cut the woads and stand them upside down in the pit. Add water, press the woads down with wood and stone for one night. In colder days, immense them in water for one more night. Wash away the residual plant and put the juice in urns. For each ten dan [Chinese unit of dry measure, 10 sheng = 1 dou, 10 dou = 1 dan,] urns, add 1 dou and 5 sheng of lime. Pestle with hands quickly for about one meal. Wait for the mixture to clear up, discharge the water. Prepare a separate pit for storing the blue condensation. Wait until the condensation becomes thick porridge, put it back into the urns, and indigo is made." The indigo-making method recorded in "*The Exploitation of the Works of Nature*" is similar. But it mentions immersion in water for seven days, increasing the fermentation time, rendering it possible to directly make indigo out of plants which originally required enzymes and acids for hydrolysis to release hydroxyl. Therefore, the latter method can be referred to as fermentation indigo-making. Making indigo from indigo plants might have appeared in about Tang and Song Dynasties. Prior to this, the indigo plants could only be used to dye green, and was unacceptable as a indigo dye.

The resultant indigo itself is not soluble in acid or alkali solution. Before being used in dyeing, it must be reduced into the leucoindigo, which can be dissolved in an alkaline solution for deying. "*The Exploitation of the Works of Nature*" said: "After put into the urn, the indigo must be mixed with straw ash water and churned with bamboo sticks each day, for countless times." The purpose of adding straw ash water is to increase the alkalinity of the solution, to cancel the acid generated during fermentation, so as to speed up the reaction process. Churning is intended

to accelerate fermentation and restoration of indigo into leucoindigo for dissolution in the dye solution, ensure dyeing of the fibers and oxidation of the dye in air to form indigo so that it can adhere to the fibers. The process is repeated several times so that darker and more secure blue cyan can be obtained.

2.4.4 Mordanting

In addition to safflower which is a acid dye, the indigo which is a reduction dye, and a small number of direct dyes including gardenia, curcuma root, turmeric and so on, most of the dyes contain mordant genes, and can be used in dyeing by using mordant technology.

Dyeing process of mordant dyes firstly involves mordant. Most of the ancient mordant can be divided into two types: iron and aluminum mordant. The iron mordant comes mainly from green vitriol, and the basic ingredient is $FeSO_4$ black. Because it can be used in dyeing black, it is also known as copperas. In the Tang Dynasty, Chen Cangqi recorded an artificial iron pulp for use as iron mordant in "*Supplement to Materia Medica*": "immerse iron under water in a contain. After a long time, the blue foam would be released from the iron, and that foam could be used for dyeing blue." The principle is to let the iron get oxidized in the water and form ferric oxide, which is converted into ferric hydroxide for precipitation. A very small amount of iron ions can play the role of mordant. Aluminum ion mordant is commonly alum-based, mainly composed of $KAl\ (SO_4)_2$. However, its application started late. In the Central Plains, plant ash was used as the earlier mordant. According to the historical records of the Wei and Tang Period, plants burnt back then for making mordant included quinoa, eurya, symplocos, artemisia and etc. According to tests by modern scientific methods, those plants are rich in aluminum elements. Therefore, the main role of plant ash is aluminum mordant.

The origin of the mordant process can be attributed to a variety of different factors. But the types of the process have always remained four, i.e., the same mordant method, pre-mordant method, post-mordant method and multi-mordant method.

2.4.5 The Five Elements and Five Colors

Many of the above dyes can be used through a variety of processes like single dyeing and multiple dyeing, etc., and formulations to dye numerous colors. The rich variety of color names in ancient times bespeaks the developed dyeing technology.

We found in the analysis and research of brocade with Chinese-style clouds and beasts pattern unearthed in Xinjiang and other places that most of the clouds and beasts patterns had used a total of five colors exactly. Within some tapestry, the warp threads of only three colors could be used in the same area, the weavers adopted change of colors in different regions so as to increase the number of colors. In some areas only four colors can be used within the same region, and the weaver added another color. The brocade of "Five Stars Rising in the East to Benefit China" unearthed in Niya had five colors in all the regions, and it no

longer separated regions. This phenomenon is not accidental. It should have been relevant to the theory of yin and yang and five elements.

Examination of Works in "*Rites of Zhou · Office of Winter*" records: "in painting the five colors should be properly arranged. The east belongs to green, south to red, west to white and north to black. The sky belongs to dark, and earth to yellow. Green and white succeed each other, so do red and black, yellow and dark. Match green with red, and we get patterns. Match red with white, and we get grains. Match white with black, and we get Fu, a solemn design. Match black with green and we get Fu, a pattern used on official robes. Fabrics complete with the five colors are called embroidery." The record indicates that the standard five colors are red, yellow, green, white and black. Generally, they are associated with the five elements or five directions in traditional Chinese culture. Metal, water, wood, fire and earth in the five elements or Venus, Jupiter, Mercury, Mars and Saturn in the five planets correspond to white, black, blue, red and yellow. East, West, South and North in the five directions respectively correspond to blue, red, white and black; the dark sky and yellow earth are located in the center, and correspond to yellow. The five colors in Han Dynasty brocade with clouds and beasts pattern are apparently related to this theory. This is especially true for "five stars rising in the east to benefit China", which obviously associated the five stars with the five colors on the fabric. However, back then, the five colors used in brocade were generally blue, red, yellow, green and white. Replacement of black and blue with blue and green respectively is probably because brocade treasured beautiful outlook, so weavers preferred more beautiful colors or because non-governmental use of five colors was not very strict.

In the Han Dynasty, record of color names became increasingly richer, but also quite dispersed. Literature recording color names in a more concentrated manner include "*Explaining and Analyzing Characters*" of the Han Dynasty, "*Scattered Gold Pieces*" and "*Records of Discontinuing Farming in Nan Village*" of the Yuan Dynasty, "*Humble Undertakings*", "*The Exploitation of the Works of Nature*", and "*Records of Heavenly Waters and Ice-capped Mountains*" of the Ming Dynasty, "*Painted Boats in Yangzhou*" and "*Classic on Cloths*" of the Qing Dynasty, and "*Principles and Stitchings of Chinese Embroidery*" of the modern times. In addition, the archives of the Ming and Qing Dynasties contained abundant records on colors of tribute satins and silks. For example, the color red includes over 20 sub-categories: scarlet, pink, rouge red, flesh red, Boluo red, deciduous red, purplish red, black red, ever-young red, ebony red, crimson, slight red, lotus red, silver red, bright pink, wooden red, verging red, recessive red, Huai'an red, Beijing red, Begonia red, double red, bright red, blood red, deep red, paralleling red and etc. yellow includes almost 30 sub-categories: ocher yellow, apricot yellow, gardenia yellow, persimmon yellow, light yellow, turmeric, willow yellow, golden yellow, tender yellow, river yellow, reddish yellow, incense, ivory, Zhongming, Yuanyan, honey yellow, bright yellow, bronze, fence yellow, pine flower, seedling color, lotus, sand, beige, pink yellow, Garcinia yellow, old light yellow, dark light yellow, silver light yellow, honey color, water-honey, clay golden; the color blue includes blue green, egg blue, turquoise blue, sky blue, convergent blue, shrimp blue, Mianyang blue, black blue, exemplary blue, small urn blue, tide blue, the Sui blue, sea blue, cattail green, azurite, Beijing green, Buddha blue, ink blue, true blue, green palpable, dovetail blue, glue blue, cattail blue,

red blue, Beijing blue, navy, sapphire blue, lake blue, moon blue, soft blue, double blue, royal blue, dark greyish green, gray-green, peach green. Almost each color has over 20 sub-categories, indicating superb dyeing technology in ancient China.

2.5 Grade Silk

2.5.1 Cloths and Silks: Plain Fabrics

Plain weave as the simplest weave system in textiles is commonly described as a system of staggered up and down threads. Although it produces only a small variety of fabrics, it is the most basic weave system, applied in more than 99 % of all fabrics. For example, linen and cotton produced on massive scales adopt plain weave, and are often called cloths. When used in silk, this system has different names according to the silk thickness, weft density, additional twist, or involvement of scouring.

The earliest name for plain weave silk fabrics is Bo (silk), and the other general name is Zeng. In the Han Dynasty, "Zeng Bo" were used simultaneously. Xu Shen said in "*Explaining and Analyzing Characters*": "Zeng, also known as silk" and "silk, also known as Zeng." In about the turn between Wei and Tang Dynasties, Juan became a generic term for plain weave fabrics. "*Explaining and Analyzing Characters*" described Juan as plain weave fabric with straw color, which probably refers to the color of yellow resultant from time instead of dyeing. In the commentaries of various schools in Wei and Tang period, Juan was listed as a major category name for silks. In taxation, it became the general name for silk, indicating that Juan had become the generic term for silks with ordinary plain weave.

However, Juan itself is subject to a lot of sub-categories. Gao (Onyx silk), Wan (white silk), Su (plain silk), Xiao (raw silk) are ordinary ungummed plain fabric. Lian is the alias for gummed but undyed silk. The names of the color silks late became very simple: just add a color name before Juan. However, in the early days, they were very complex, with a specific Chinese character for each color. For example, 璹 refers to pure red, 纁 to light crimson, 絺 to madder-dyed red, and 绀green with red. "*Explaining and Analyzing Characters*" collects over 30 such characters, but the majority of them were abandoned.

In addition, plain weave fabric of fine silk and low density gives a light and thin sensation and may be referred to as 纱 (gauze), or more specifically, plain weave gauze. In ancient times, 纱 is also written as 沙. "*Book of Rites*" said "The queen and ladies of Zhou Dynasty wear white fine silk gauze for undergarment, and call it 素沙 (plain gauze)." Here the phrase 素沙 means that the gauze has holes capable of letting sand through. In the Han Dynasty, there were plain gauze, square-pored gauze and other varieties of gauze. Plain gauze is an ordinary gauze, but it is also quite thin. There was another kind of holed gauze, which was also known as meshed gauze, used in the Han Dynasty often as Qishi (black gauze), a material for making hats or pads. However, plain fabric with coarse thread and high density might be called 绨 (heavy silk). "*Explaining and Analyzing Characters*" recorded: "Ti is a kind of thick Zeng". In historical documents, there is a fabric called 缣 (fine silk), which might

be a fabric woven with double structure. Such weave system appeared very early. In the Tomb of Fu Hao in Yin Ruins in Anyang, Henan, traces of many fabrics with this weave system was found on the prints of bronze utensils. There were double warp, double weft and basket weaves, featuring two threads up and two threads down. Later, similar artifacts were found in the tomb of Huang Junmeng and his wife in Chunqiu, Xinyang, Henan province. A greater discovery was made in Han Tombs in Mancheng, Hebei. By the use of twisted silk, plain weave fabrics were produced, and degummed to make creping. This plain silk fabric with light texture, thin strands and crepe surface was called fine silk gauze in ancient times, and later as the crepe.

2.5.2 From Damask to Thin Satin

The name of 绮 (damask) appeared earlier. In "*Songs of Chu · Evocation*", there was the sentence "纂组绮绣" (exquisite silk brocades). "*Explaining and Analyzing Characters*" said: "Damask is patterned Zeng." Patterned Zeng is plain fabric with patterns. Compare Zeng with the artifacts of Warring States Period, Qin and Han Dynasties unearthed, and we can see that patterned Zeng means fabric with plain background and shadow floral patterns at that time, which was known as 绮 in the Han Dynasty (as shown in Fig. 39).

However, in the Wei, Jin and Southern and Northern Dynasties, the name 绮 rarely appeared in real life, in addition to occasional appearance in poetry. Similar fabrics with shadow floral patterns were called 绫 (thin satin), a name

Fig. 39 Northern-dynasty Damask with pattern of city wall

very frequently seen in the Tang and Song dynasties. Generally, fabrics with plain and twill backgrounds and shadow floral patterns were called 绫. The official uniforms for officers and officials in the Tang Dynasty were made with satin: "Princes, third-rank officials, and descendants of the two kings wear satin with large cluster floral pattern, officials of the fifth rank and above satin with small cluster floral pattern, and officials of the sixth rank and above wear double strand satin…" In the Tang Dynasty, satin took up a large proportion of tribute silk fabrics, and the richness of variety was truly amazing. Dingzhou of Hebei, Caizhou of Henan, and Jiangsu and Zhejiang Provinces after the mid-Tang Dynasty were primary satin producing areas. Satin production was also huge. "*Six Codes of the Tang Dynasty*" recorded that in the official Weaving and Dyeing Department there was a specialized satin workshop responsible for selecting craftsmen with sophisticated weaving skills. In the period of Wuhou (Empress of China), satin and brocade workshop alone had 365 "craftsmen"; internal engineering office hired 83 satin workers; Concubine Palace hired 150 satin workers. Aside from official operation, private manufacture of satin also flourished. For example, He Mingyuan of Dingzhou "boasts five hundred satin looms under his name." Workshop of this size was unknown in the previous generations. To the Song, Yuan, Ming and Qing Dynasties, the emergence of the name 绫 increased, and varieties also became more abundant. However, they were mostly single-layer floral fabrics on the background with oblique pattern (as shown in Fig. 40).

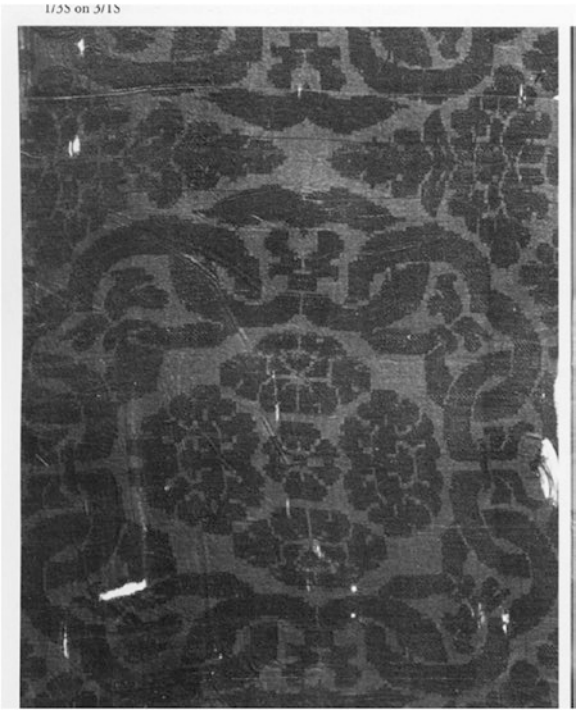


Fig. 40 Liao-dynasty thin satin with cluster floral pattern

An objective and apt description of the weave system for satin can be found in *Exquisite Satin*, a poem, written by Bai Juyi, a Tang Dynasty poet:

> What is Liaoling the exquisite satin like? It is different from raw silk and fine damask;
> It should be like the forty-five-Chi (15 m) waterfall spring, in front of the bright moon in Tiantaishan mountain.
> It has ingeniously woven patterns, like white mist shrouded ground and snow capped flowers.
> Who are the weavers? And who will wear it. The women in Yuexi and imperial ladies in the palace respectively.
> Last year, the imperial envoy announced the edict, requiring heavenly sampling for weaving in this world.
> Patterns like the autumn wild geese migrating south in clouds are woven, and the color of spring water in south China is dyed.
> Wider pieces are made into shirts and longer ones into skirts, crepes are ironed and patterns cut.
> Splendid color and exquisite pattern set each other off; as you turn sideways to take a look, the patterns seem to vary.

Here are a few particularly interesting verses helpful for the understanding of the satin varieties in the Tang Dynasty. For example, "What is Liaoling the exquisite satin like? It is different from raw silk and fine damask". Satin, gauze and damask are all fabrics with shadow floral patterns, but there are still differences. Bai Juyi described the subtle difference here. "It should be like the forty-five-chi waterfall spring, in front of the bright moon in Tiantaishan mountain." Back then, the weight standard for a 45 Chi (15 m) fabric equal that for a 4 Zhang, i.e., 40 Chi fabric. However, in the Tang Dynasty, weight is usually the prevailing standard in inspection. Therefore, weavers back then preferred to weave more strands to guarantee weight. "It has ingeniously woven patterns, like white mist shrouded ground and snow capped flowers." Here the ground and flowers refer to the background and flowers in the pattern woven. However, what's even more amazing is Bai Juyi's aptness in using "mist" and "snow". Both mist and snow are white. Back then, satin produced in eastern Zhejiang mainly features plain weave background with patterns. This apparent effect of this satin is exactly darker background, as if shrouded in white mist, and brighter floral pattern, as if capped with snow. "Who are the weavers? And who will wear it. The women in Yuexi and imperial ladies in the palace respectively. Last year, the imperial envoy announced the edict, requiring heavenly sampling for weaving in this world." These verses indicate that satin production was commissioned by the palace, and satin pattern was also designed in the palace. However, the production, i.e., weaving, was conducted in Yuezhou in East Zhejiang, i.e., today's Shaoxing, Zhejiang. "Patterns like the autumn wild geese migrating south in clouds are woven, and the color of spring water in south China is dyed." Here the procedure of weaving before dyeing is clearly pointed out. "Autumn wild geese migrating south in clouds" was a very common pattern on damask used in official uniforms in the Tang Dynasty. The official history has records of wild goose holding official ribbon. The records and the verse can corroborate each other. "color of spring water in south China" is an

extraordinary color. And this description accords with the definition of fabrics with shadow floral patterns. “Splendid color and exquisite pattern set each other off; as you turn sideways to take a look, the patterns seem to vary.” The “splendid color” refers to one extraordinary color, instead of a color set. “Set off” is the situation of patterns on shadow flower fabrics “partly hidden partly visible”. Seen under the sun from different angles, the pattern varies from weak to strong according to the illumination angle, and even disappears sometimes. This is the reason for “as you turn sideways to take a look, the patterns seem to vary.”.

2.5.3 Duan (Satin): The Most Popular Fabric in the Ming and Qing Dynasties

Satin is fabric woven with satin pattern weave system. In the Song and Yuan Dynasties, satin is generally referred to as “Zhu Si” (color silk fabric), and the name of 缎 did not appear frequently until in the Ming and Qing literatures. In some cases, the satins were named after their origins, for example, 川缎 (Sichuan Satin), 广缎 (Guangzhou Satin), 京缎 (Beijing Satin), 潞缎 (Lu’an Satin). In others they were named according to their purposes, for example, 袍缎 (robe satin), 裙缎 (skirt satin), 通袖缎 (through sleeve satin). In still other cases, they were named after the patterns, for example, cloud satin, dragon satin, python satin. In the fourth cases, they were named after the size of weave system cycles, for example, five-strand satin, eight-strand satin, six-strand satin and seven-strand satin. In addition, there were cases of naming satins according to processing features, for example, plain weave satin, shadow flower satin, decorated satin. The earliest artifact of shadow flower satin ever seen was the Wumei Satin unearthed in Tomb of Qian Yu (1320) in Wuxi, Jiangsu (as shown in Fig. 41). Since then, shadow flower satin became very common, for example, it was found in the Tomb of Li Yu’an (1350) [2] in Zoucheng and Cao’s Tomb (1367) in Suzhou, Jiangsu.

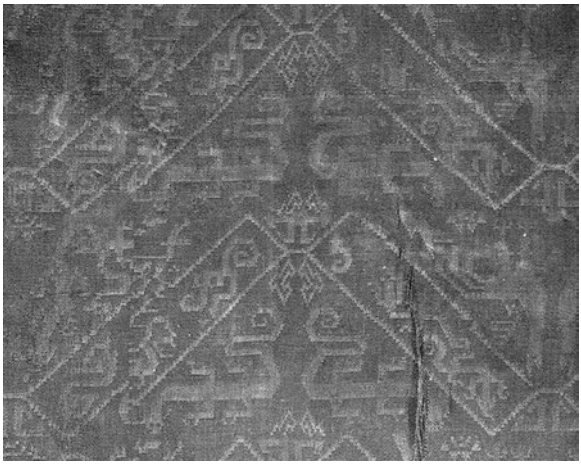


Fig. 41 Shadow flower satin fabric of the Ming dynasty

Satin fabrics are usually woven with silk, and can be divided into many varieties. The shadow flower satin refers to single jacquard fabric with surface taking normal and reverse satin patterns as the pattern and ground weave alternatively. The ground weave and pattern have the same organizational unit but different light surfaces. Therefore, the satin can display patterns. Today it is known as Two-side Satin. Sometimes, satin with warp surface for ground and weft surface for pattern is called shadow flower satin, while that with weft surface for ground and warp surface for pattern is called patterned satin. Generally, 彭缎 (Peng satin), 贡缎 (tribute satin), 库缎 (satin brocade), 头号 (quality satin), 摹本 (facsimile copy), 花累 (stacked flowers) seen in the historical data of the Ming and Qing Dynasties all refer to shadow flower satin. Plain satin refers to satin fabrics without patterning. Generally only warp-surface satin has the gloss effect of satins. The main difference between the various plain satins lies in the size of the weave cycle.

There are also dyed satin fabrics. That is to say, there are satin fabrics of more than two colors, the most common of which is the shinning satin. This is a single patterned satin whose weft and warp threads are different in color (often of two contrasting colors). Ordinary weave system takes the warp surface as the ground, weft surface or weft oblique pattern as the pattern. Thus, in warp surface dominated by the warp thread color, there is often the weft thread color flickering. Therefore, it is called shining satin or shining color. "*Annals of Lin'an in the Reigin of Xianchun*" recorded that among Zhu Silks there is a variety "shinning brown", which is perhaps the predecessor shining satin. Unfortunately there is no physical evidence. In the Ming Dynasty, satin names more specifically pointed dark green against shining scarlet, or scarlet against shining official green and other colors for the warp and weft silk, indicating that the usage of shining was indeed just right.

2.5.4 Sha (Gauze) and Luo (Thin Silk): Hank Warp Fabrics

In Weaving, the warp threads of gauze and Luo are hank to form sparse holes, hence the name Shaluo (literally sand net). Sha originally meant "with holes for draining sand". Therefore, some of the loose plain weaves may also be referred to as Sha. However, in Hank warp fabrics, there is a variety in which two warp yarns intertwine and each weft twists for once also has particularly evident square holes, which are less prone to slip, thus making the fabric more solid, hence the name Sha. The 1:1 twisted sash for plain weave is called square-hole gauze, also known as single-thread gauze. This type of gauze appeared in about the late Tang Dynasty. Wang Jian's verse "in the palace people still wear single-thread gauze" in his "*The Tapestry Song*" refers to this kind of gauze. In about the early Song Dynasty, the shadow flower pattern gauze appeared. The shadow flower pattern gauze is in fact jacquard fabrics with hank silk system and plain weave or other ordinary system as the ground and pattern alternatively. It mainly includes bright-ground gauze, solid-ground gauze, floating flower gaize. spring gauze and other varieties (as shown in Fig. 42).

Luo is also hank warp fabric, but its holes are not square. Therefore, people usually say: square-holed fabric is gauze, pepper-holed is Luo. The early gauze fabric

Fig. 42 Qing-dynasty gauze with geometric patterns

is often called chain gauze, and its main feature is without clear hank groups despite the strict proportionality between the ground warp and hank warp. The earliest type of this gauze appeared in the Shang Dynasty. On the Yan (a cooking utensil) and square bronze Yi (a wine container) unearthed in the Tomb of Fuhao in the Yin Ruins, there are remnant traces of gauze fabrics. Those are a case in point. Chain gauze reached its peak at the turn of Han and Tang Dynasties, and prevailed through to the late Ming Dynasty. However, production technology for gauze of such weave organization has now been lost. In fact, Hangzhou Gauze, usually called a traditional product of Hangzhou, is a warp gauze weave, that is, a hank strand fabric with missing strands along the warp or weft direction (as shown in Fig. 43).

2.5.5 Origin and Development of Chinese Silk Tapestry

Chinese silk tapestry is woven using the so-called "passing warp thread and cutting weft thread". In weaving, plain silk is used as the warp and color silk as weft, and colored wefts are woven with a small shuttle like weaving a plain weave, according to the drawings. The feature of Chinese silk tapestry is that the weft does not spread through the entire width, unlike in ordinary fabrics. Instead, it's woven into places where the appropriate color is needed. A concise description of silk tapestry weaving and its characteristics were given in the Song Dynasty by Zhuang Zhuo in his "*Little Chicken Bones*": in Dingzhou, large looms are not used in silk tapestry weaving. Colored silk is woven with the shuttle into any desired pattern of flowers and beasts. In wefting with the small shuttle, spaces are left first,

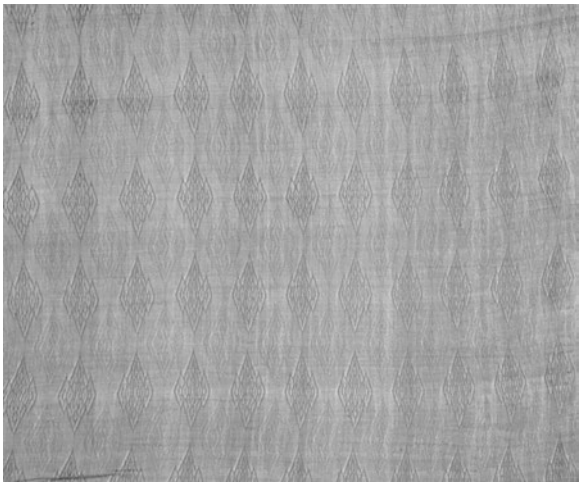


Fig. 43 Han-dynasty cup pattern gauze

and variegated threads are superimposed on the warp and weft threads for decorations, creating patterns, as if disconnected. Seen from above, it looks like chasing, hence the name Kesi (literally silk carving) One piece of clothing for women takes one year to weave. Although various patterns are woven, it is possible to make them different. This is because the weft threads are not woven in continuous lines. Here 刻丝 is silk tapestry, and sometimes written as 剋丝 or 克丝.

In China, the tapestry was first discovered to have been used in woolen fabric, known as woolen tapestry. In the Tang Dynasty, it developed into silk tapestry. Tang-Dynasty silk tapestries were unearthed in Turpan of Xinjiang, Dunhuang of Gansu, Dulan of Qinghai and other places. Song Dynasty marked the heyday of tapestry development. Thanks to the good graces of the Emperor and rapid development of academy painting accelerated the process of tapestry embroidery transforming into pure art. Silk tapestry works often take paintings as the blueprint, and contains a lot of appreciation artworks. For example, the floral tapestry album made by Zhu Kerou, a few pieces of tapestry with flowers and birds made by Shen Zifan, are typical examples. Zhu's silk tapestry works include pomegranate blossom and double birds, tea peony, duckling in the lotus pond and etc., and his style is quite similar to the academy painting of the Song Dynasty (as shown in Fig. 44). Meanwhile, the Song Dynasty also produced the large amount of tapestry daily necessities. Hong Hao recorded Uighurs weaving robes out of silk tapestry in "The Sketches in Jin Dynasty" and unearthed artifacts mostly are tapestry caps, tapestry boots covers.

To the Yuan Dynasty, silk tapestry technology witnessed further development, leading to the use of tapestry to weave works with portraits of the emperor, known as imperial portrait weaving. Imperial portrait weaving is a method of producing imperial images unique to the Mongolian Yuan Dynasty, reflecting the zest of Mongolians in silks. *Record of Sculpture Painting* in the Yuan Dynasty documented the historical data of weaving imperial portrait back then.

Fig. 44 *Peony on Chinese Silk Tapestry* by Zhu Kerou of Song dynasty

In the Mongolian Yuan Dynasty, painted portrait was taken as the manuscript. The Nepalese Araniko is the first person known to weave imperial portraits. However, the authentic tapestry imperial portraits handed down only include Emperor Wenzhong and Emperor and Empress Mingzong of the Yuan Dynasty on the tapestry Mandala now kept in the Metropolitan Museum. Although this is not exactly the same as imperial portrait weaving in record, we can still see the technique and proficiency of weaving.

2.5.6 Brocade: The Most Luxuriant Silk Fabric

The character 锦 (brocade) is a combination of 金 (gold) and 帛 (silk), indicating original understanding and interpretation of brocade: "brocade, like gold, requires painstaking effort labor for production. It is expensive as gold, and only the most venerable are worthy." The reason for involvement of great effort is indeed attributable to the complexity of the process and superb skills required. Brocade is a gloss silk fabric, and a color fabric. Through changes in texture, it can display different patterns of a variety of colors. Back then, this type of fabric was called brocade. And later a pattern was slowly formed: patterned [fabrics] woven with colored silks are called brocade. Analyze the fabric at that time, we know that patterned [fabrics] woven with colored silks are mostly heavy fabrics. However, in the Song and Yuan dynasties, a large number of gloss silk fabrics or heavy fabrics emerged, and the name of brocade became less frequently used. Most of them were specifically called satin, damask, etc. The benefit of such a phenomenon is

that the range of brocade was limited mainly to fabrics with supplementary weave and multiple layers.

In literature, the character "锦" first appeared in the "*Book of Songs · Minor Odes · Xiang Bo*": "萋兮斐兮,成是贝锦" (Elegant lines may be made out to shell brocade.) However, in authentic artifacts, the earliest brocade identified is the warp brocade that started appearing in the Western Zhou Dynasty. It is called warp brocade because it was woven with double weave featuring patterns formed by warp threads. In the tombs of Eastern Zhou Dynasty in the Warring States Period, warp brocade had become the dominant brocade. One of the most famous is the warp brocade with dancing figures and beasts unearthed in Chu Tombs in Mashan, Jiangling, Hubei province. For warp threads, it used deep red, dark yellow and brown, changing color by the zone. The weft threads are brown. In the pattern, there were opposing dancing figures, paired dragons, paired phoenixes, and paired unicorns, as well as other geometric pattern themes, in a weft-direction layout. The brocade measures 5.5 cm warp-wise and 49.1 cm weft-wise, indicating that multi-heddle draw looms had been used in weaving warp brocade (as shown in Fig. 45). The Han Dynasties are also an era of extreme popularity for brocade. Among brocade unearthed in Mawangdui, Changsha, Hunan Province, there are velvet circle brocade and embossed brocade. Those types of brocade were produced by weaving yet another layer of embossed pattern on the basis of the pattern on the warp brocade. Therefore, the patterns on fabrics increased, enriching the patterns on fabrics, adding to their beauty. This variety is likely the "weaving picturesque brocade" recorded in the Han Dynasty literature.

Fig. 45 Warring-states warp brocade with dancing figures and beasts

Fig. 46 Tang-dynasty Tang brocade with pattern of bead string and pig head image

Starting from about the Wei, Jin, Southern and Northern Dynasties, weft brocade fabrics began to appear in brocade. In Turpan, Yingpan, Huahai and other places in Xinjiang, there are a lot of tombs belonging to the 5th century AD. From them various plain weft brocades were unearthed, and animal and cloud pattern accounted for the majority of the patterns, indicating that weft brocade had begun to be used in silk weaving technology. In about the Early Tang Dynasty, twill weft brocade began to appear, and then flourished. However, the weft brocades can be divided into two major types, according to some details of weaving. The so-called Western type can also be called Persian brocade, the Sogdian brocade and Zandana brocade, featuring strong Z-twist in the warp threads. The patterns carry obvious Western style, and its origin may have been the Sogdian region in the Central Asia (as shown in Fig. 46). The second type is the Tang-style weft brocade, using S-twist warp threads and featuring treasure flowers or bird and flowers as the pattern themes. It is mainly produced in the Central Plains (as shown in Fig. 47).

In the middle and late Tang Dynasty, this type of weft brocade underwent enormous changes in the basic weave system and weaving technology, and the variety of Liao-style weft brocade appeared. Because this type of brocade came into people's knowledge in the process of analyzing the silk weaving in the Liao Dynasty, and the basic characteristics of Liao-Dynasty brocade accords with the changed weave system and weaving technology, we call it Liao-style weft brocade. The fundamental difference between Liao-style weft brocade and Tang brocade lies in different roles played by the outer warp threads. In Tang brocade, the outer warp

Fig. 47 Tang-dynasty brocade with treasure flower pattern

threads only play the role of splicing and producing twill effect, while in Liao-style weft brocade, the outer warp threads appear in the surface and the reverse side of the fabric respectively only once. For the rest of the time, they are located between the upper and lower weft threads, in the position of the inner warps.

Liao-style weft brocade can be divided into two categories: twill weft brocade and satin weft brocade. Twill weft brocade can be further divided into common twill weft brocade, embossed twill weft brocade, gold-decorated twill weft brocade and rhombus twill weft brocade. Satin weft brocade refers to double weft fabric with satin as the basic solidification texture. It can be divided into ordinary Liao-style satin weft brocade, the embossed satin weft brocade, gold-decorated satin weft brocade and etc. Generally the warp threads of Liao-style weft brocade have no obvious twisting, and single outer warp thread is always used, while the inner warp threads usually take two or three threads. The weft threads are loose, and can have as many as five to seven colors. This type of texture for weft brocade is also widely used in the Song Dynasty brocade. Northern-Song Dynasty brocade with cloud and flower pattern of Ruiguang Tower in Suzhou, the Five-Dynasty brocade unearthed in the underground palace of Leifeng Pagoda in Hangzhou and the later-liang Vajracchedika Prajna-paramita Sutra now kept in Liaoning Provincial Museum have all adopted this texture, only with changes in color and twisting.

Gold can be woven into brocade to form gold-wefted brocade. Nashishi is the most famous and most characteristic gold-wefted brocade in the Yuan Dynasty, also known as Nachisi, a transliteration of Nasich, the Persian word for gold-wefted brocade (as shown in Fig. 48). Back then upscale clothing for officials was often sewn from Nasshishi, “and all of them have gold to set them off.” The government set “Dyeing, Weaving and Patterning Office” in qualified regions across the country, to gather together weavers to weave numerous Nashishi for making

Fig. 48 Yuan-dynasty gold-wefted brocade with paired lions

clothes and curtains, mattresses, and cushions for chairs and heatable brick beds used in daily life. As for the military tents, according to Marco Polo's record, were also made of gold-wefted brocade.

2.5.7 Three Famous Brocades

The three most famous brocades in legend are Song brocade, Shu brocade and cloud brocade. Song brocade, named after its era, is called Song-style brocade in the academia. Shu brocade is named after its origin, while cloud brocade is named after its pattern. However, in fact they are regionally divided.

The Song-style brocade was produced in Suzhou. In the reign of Emperor Kangxi, ten volumes of "*Model Calligraphy of Chun Hua Ge*" framed in the Song Dynasty were purchased from Ji's of Taixing, and 22 Song Brocades were taken off from the frames and sold to weavers in Suzhou for copying the pattern and production. Brocades produced used the pattern of the Song Dynasty, but the texture of the Qing Dynasty. Therefore, they can be only called Song-style brocades or imitations of Song brocades. Song brocades produced in the Ming and Qing Dynasty can be classified into Double Brocade, Fine Brocade and Box Brocade according to the level of craftsmanship, the thickness of the fabric, quality of material and application performance. Double brocade uses silk and even gold line or pieces of gold, with three-needle weft oblique pattern against the three-needle warp ground. Such brocades are heavy, delicate, with rich layers of decorative pattern colors, and are often used as huge hanging scrolls, and various bedding and

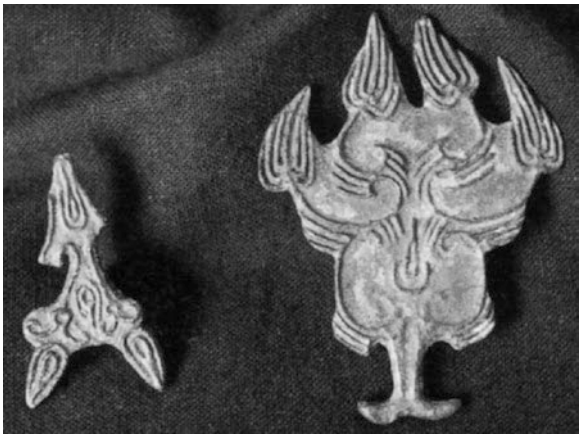


Fig. 49 Ming-dynasty song-style brocade

furnishings materials. Fine brocade has changeable textures, and are often woven with short shuttles. Often fine silk is used, and loose weave adopted to ensure medium thickness (as shown in Fig. 49). Box brocade is also known as small brocade, mostly featuring patterns of small geometric flowers or natural flowers, using elegant and simple pigments. Coarsely woven and with a soft and thin texture, it is dedicated to decorating calligraphic works, paintings and boxes.

Produced in Chengdu, Sichuan Province, the Shu brocade has been famous since ancient times. However, it was ruined in the late Ming Dynasty due to the chaos and restored in the early Qing Dynasty by people in Zhejiang. At that time, Shu Brocade was also greatly different from that between the Han and Tang Dynasties. Among the Shu Brocades of the Qing Dynasty, Huanhua Brocade, Ba Satin, Uyghur brocade are particularly famous. Most of them take the warp threads as the ground and weft threads as the pattern, i.e., a special double texture. However, there are also cases of using single interposition and double texture. The features include use of bright colors, brightness, harmonization, delicate and fine weaving, and soft and thin texture.

Cloud brocade is generally considered to be related to Nanjing, while a fairer view believed that Cloud brocade originated in the Yuan Dynasty, flourished in the Ming and Qing dynasties, and has been popular ever since. However, in fact, cloud brocade in history is just a name in praise of brocades with cloud patterns. The time for it to be used as a local special name did not come until the Republic of China. On the other hand, cloud brocade has a rich variety, most of which do not belong to the brocade range in technology, for example, the satin brocade, decorated flowers, etc. However, gold-wefted brocade and wefted brocade indeed adopted supplementary binding double structure. Gold-wefted brocade is also known as Kujin, and wefted brocade includes two-color gold-wefted silk brocade, color-pattern silk brocade, shuttle flower decoration, hibiscus-decorated brocade and other varieties.

2.5.8 Fleece Fabrics

Velvet is a kind of shell fabric with a layer of fluff on the surface resultant from weaving. In Chinese historical data, the earliest reliable record of velvet should be "timid inner lining" in "*History of Yuan · Annals of Carriage and Clothing*". Annotated by the book itself as "cut elvet", i.e., it should be velvet fabric after shearing.

There are mainly four varieties of plain velvet fabrics, including velveteen, carved velvet, double velvet, and man-shi-luflannelette. "剪绒" (shearing), "天鹅绒" (velvet), "漳绒" (Zhangzhou velvet), "建绒" (Nanjing velvet), "卫绒" (velvet) and "倭缎" (Japanese satin) are common in the Ming and Qing literatures. All of them are plain fabrics with napped structure, different only in quality and appearance. Their names may differ because of origin and customs. Some of these varieties have subcategories of "patterned and plain." Here the pattern does not result from jacquard, but from retaining part of the velvet ring without cutting it open, so as to form a carve pattern with sheared and ringed velvets. Plain velvet here mean one-sided velvet that is fully sheared and without carving, for example, Zhangzhou velvet (plain), the velvet (plain), Nanjing velvet, and etc., are generally everyone called Zhangzhou velvet (as shown in Fig. 50).

If carving is needed on Zhangzhou velvet, no shearing will be conducted during weaving. After the entire piece of fabric is completed, it will be placed on the "velvet stretch" for carving. All the carvers slightly know about painting. Before carving, it is necessary to paint with chalk the patterns on paper, divide the surface of the fabric into areas, and superimpose the paper on certain parts of the fabric to leave powder marks the pattern on it. Carving is proceeded according to the powder marks. Since no shearing is carried out on the looms in carving, weaving is fairly fast; usually one weaver can weaver 6 zhang's of fabric in one month. The carving operation is quite time-consuming, and roughly one carving worker is assigned for every four velvet looms.

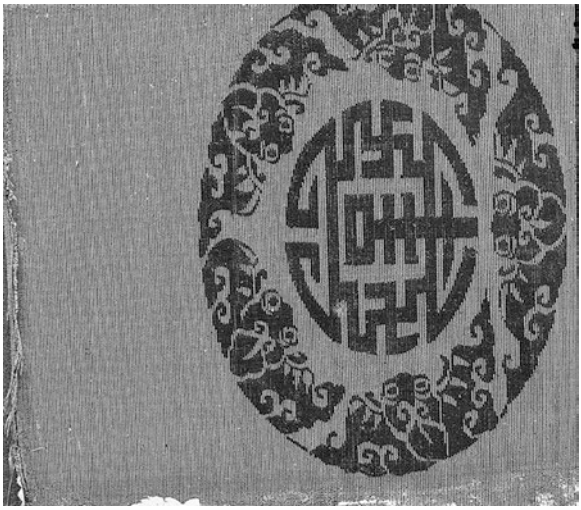


Fig. 50 Qing-dynasty Zhangzhou velvet fabric

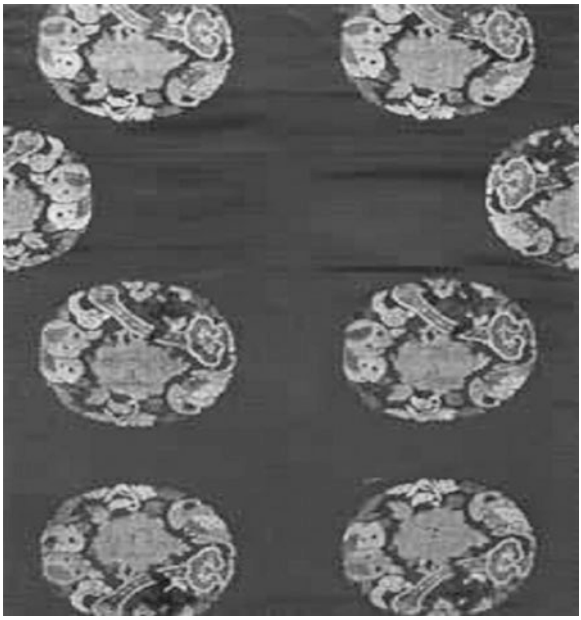


Fig. 51 Qing-dynasty Zhangzhou satin fabrics

After forming patterns with velvet rings by patterning, shearing is conducted or the velvet rings are left on the fabric. Such napped fabrics are often called Zhangzhou satin. The name of Zhangzhou satin is derived from the legend of its first origination in Zhangzhou. "*Annals of Zhangzhou Prefecture in Reign of Qianlong*" said that Zhangzhou satin is the "Produce of Zhangzhou". However, in the Ming Dynasty this type of fabric had been produced in Nanjing. Zhangzhou satin contains some very fine varieties, for example, Zhangzhou color-painted satin, gold color velvet and flower-decorated satin. They are sufficient to represent the highest level of China's ancient Silk technology (as shown in Fig. 51).

2.6 Textile Printing and Embroidery

2.6.1 The Earliest Relief Printing

The printing technology is an extension of the techniques of painting. It adds cohesive to dyes or pigments and directly print patterns with the mixture on fabrics by using embossing plates or stencils. The earliest artifact of letterpress printing was unearthed in No. 1 Han Tomb in Mawangdui, Hunan. The gold and silver printed silk unearthed from the tomb had been produced via overprint with three colors, i.e., gold, silver, and yellow. This printing method is the real source of the Chinese printing. However, the most important artifact of printing, i.e., the printing plate, was unearthed in the tomb of King Nanyue in Guangzhou. This is a

large tomb of the early Western Han Dynasty. Not only printed fabrics similar to those Mawangdui were found, but also two bronze embossed printing plates were unearthed. One was large and diamond-shaped, and its pattern is similar to the flame pattern on the gold and silver printed yarn unearthed in the Han Tomb in Mawangdui. The other is smaller, and Y shaped, and its pattern is similar to the turtle skeleton on the gold and silver printed yarn of Mawangdui. This confirms that in the early stages relief printing was adopted.

The emergence of relief printing is associated with the prevalence of seal in the Qin and Han Dynasties. In size, the printing plate is no longer than 6 cm, no wider than 4 cm wide, just slightly larger than a common seal. Seen from the contour, there is great similarity between it and a seal. On the back of the printing plate, there is a holed knob for holding it in imprinting. The method of use is also basically the same. Back then, seals mostly relied on seal mud, and the characters were inversely engraved. The printing plate was used in fabric printing, with the same method (as shown in Fig. 52). Therefore, the first appearance of embossed printing technology in China is closely related to the traditional printing manner there.

No artifact of relief printing method was found of between the Wei and Tang Dynasties. However, relief printing became very popular during the Song and Yuan Dynasties, indicating that it attained considerable development during the period. In Song and Yuan tombs around the country, especially the Tomb of Huang Sheng from the South Song Dynasty, many clothes were discovered with trimmings combining hand painting and embossed plate printing. Seen from physical analysis, this embossed plate must have been 5–50 cm in length, 1.5–5 cm in width, i.e., of a relatively long and narrow shape. Probably it had been designed for printing patterns on apparel edges. Therefore, it was applicable in color printing and gold printing. Dye paste or adhesive of appropriate thickness was coated

Fig. 52 Bronze letterpress plate of Western Han dynasty

on the pattern plate to print the background pattern. Or the plate was dipped in golden paint to print the golden outline. Then, manual painting or sketching was carried out to complete the work.

2.6.2 Tie-Dye: The Original Meaning of Resist Printing

In the ancient printing, resist printing was the most common, called Xie back then. The original meaning of Xie is Jiaoxie, equivalent to today's tie-dye. "*The Sound and Meaning of the Tripitaka*" of the Tang Dynasty said, "tie the Zeng silk up for dyeing, and untying the silk to display the pattern is called Xie", clearly explaining the original meaning of Xie as Jiaoxie. The earliest artifact of tie-dye appeared approximately in the Wei and Jin Dynasties (as shown in Fig. 53), but in the Tang Dynasty literature there were 撮晕缬 (hue-gathering tie-dye), 鱼子缬 (fish egg tie-dye), 醉眼缬 (drunken-eye tie-dye), 方胜缬 (square tie-dye)、团宫缬 (palace tie-dye), and various other names.

Artifacts of tie-dye used in apparel did not appear in large quantity until the Wei and Jin Dynasties, for example, they were unearthed in Northern Liang tombs in Buddha Temple in Dunhuang, Wei and Jin tombs in Huahai, Yumen, in Gansu Province; in Ying Pan tombs in Yuli, in Northern to Sui and Tang Dynasty Tombs in Astana, Turpan in Xinjiang. Large-scale discoveries were also made in the prime-Tang Grottoes and depositary of Buddhist sutra in Dunhuang, with some changes in the pattern. However, mostly the patterns were shaped like small dots. There were also a small number of mesh-like and flower-like patterns. Shosoin in Japan also keeps some tie-dye fabric introduced from the Tang Dynasty.

Analyze the unearthed artifacts, we find that there were three types of tie-dye methods in use back then: The first is sew and tie-dye method. Lead the thread with a needle through the fabrics, and then tighten the thread and tie them together for dyeing. This approach is called sew and tie-dyeing method. It is the most commonly used tie-dye process, as well as the most versatile one. The second is binding method, a method of binding fabrics together through stacking or non-stacking,

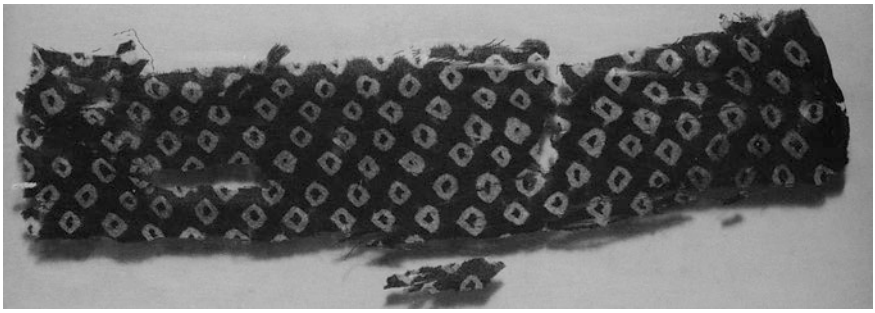


Fig. 53 Northern Liang tie-dye silk

for dyeing through tie-dye. All of the most commonly seen small-dot ring patterns in fish-egg tie-dye, drunken tie-dye and deer-background tie-dye had been created using his method. The third is the knotting method, which is one of the simplest tie-dye methods. It was so simple that needle or thread was needed. Just tie a knot, and carry out resist printing with the fabrics themselves. The resulting pattern is generally straight stripes. The "Tie-dye silk" now kept in Shosoin in Japan seems to have been the product of tie-dye via knotting method. The haloed-jade grape damask unearthed in Dulan, Qinghai is perhaps also the result of knotting method.

2.6.3 Clamp-Dye: Self-developed Resist Printing via Engraving

Jiaxie(Clamp-dye) refers to resist printing on fabrics by clamping them with two symmetrical boards. The name of Jiaxie started in the Tang Dynasty, as seen in the verse "newly clamp-dyed fabrics in Chengdu" in the poem "*Flower-chanting as a Gift to Huangpu the Supervisory Official*" by Bai Juyi of the Tang Dynasty. In the Tang Dynasty documents in Turpan, Xinjiang, a quilt named "Jiaxie" (TAMl93) was mentioned; Dunhuang manuscripts also repeatedly mentioned "Shu Xie" (S.5680) and "Jia Xie" (P.4975), both of which also refer to Jiaxie. Even "*Categorized Japanese Names*" of Japan included the phrase 夹缬. From this we can see the prevalence of Jiaxie back then.

In "*Yin Hua Lu*", a book of the Tang Dynasty, there is a record: "in the reign of emperor Xuanzong of Tang, there was a person named Liu Jieyu, who was talented and knowledge, and in the good graces of the emperor. Jieyu had an ingenious sister married to the family of Zhao. She asked a worker to engrave various flowers and printed them on silk via clamp-dye. On the occasion of Jieyu's birthday she offered a piece of clamp-dyed silk to empress Wang. The emperor saw the fabric and praised her for it. Then he ordered the palace artisans to take it as a sample for producing clamp-dye products. At first, it was strictly guarded as a secret. Later, it gradually spread out, to all over the country, and became available to even the poorest and lowest-ranking people." All of the clamp-dying artifacts unearthed date back to times after the mid-Tang Dynasty. In Turpan, Xinjiang silk with colored pattern printed on white ground and silk with red flowers and green leaves printed on azure ground were found. Multi-chrome or monochrome printed silk (as shown in Fig. 54) were found in the depositary of Buddhist sutras in Dunhuang. In addition, in the North Caucasus region of the Soviet Union, extremely exquisite clamp-dye fabrics of the Tang Dynasty were also found. In Shosoin, Japan, a large number of well-preserved Tang Dynasty clamp-dye fabrics and Japanese imitations are kept. Although occasionally seen in the historical data, the Song clamp-dye fabrics were found in the north, within the boundary of the Khitan Country. Among the silk products unearthed in Baita, Liaoqing Prefecture, Bairin Youqi, Inner Mongolia, there are a lot of the Liao-Dynasty clamp-dye fabrics. Monochromatic ones include silk with wild-geese in clouds printed on brown ground and silk with pagoda and pine trees printed on red ground. Two-colored ones include silk with Hemerocallis fulva and silk

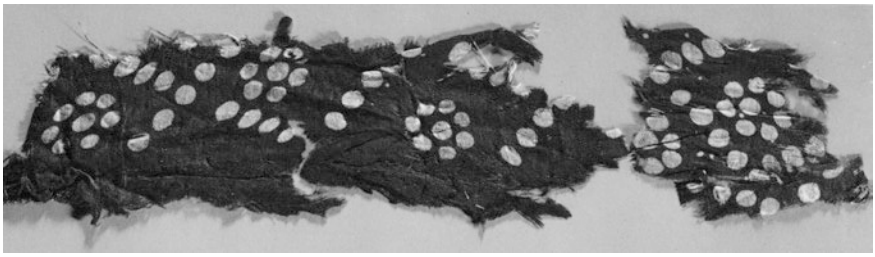


Fig. 54 Tang-dynasty clamp-dye silk

with lotus flowers. The most notable is the Namo Sakyamuni Buddha of the Liao Dynasty found in the Fogong Temple in Yingxian County, Shanxi. Measuring 65.8 cm in height and 62 cm in width, it is a very typical work of tri-color clamp-dye with color painting.

Until quite recently, practical instances of using clamp-dye method to print blue cotton quilt cover among the people in southern Zhejiang. According to our survey, the traditional clamp-dyeing has been popular in southern Zhejiang, especially in Yongjia, Ruian, Pingyang, Yueqing, Cangnan and other regions under the jurisdiction of Wenzhou. The existing clamp-dye plate measures 43.1 cm in length and 17.1 cm in width. The material selected for the pattern plate is birch-leaf pear wood, which has a fine and hard texture. Carved via waterproof penetration method, the plate has a sharp outline. The cotton cloth chosen measures 10 m in length, and 50 cm in width. Before dyeing, the cloth has to be folded into a 25-cm wide strip. Later roll the homespun into a roll with a bamboo stick as the axis, and begin folding the cloth. The quilt cover has a total of 16 figures, and 17 plates are carved. Aside from the plates for the head and tail, which are carved on one side, the rest 15 are carved both sides. Fold the cloth, and lay out the plates one by one, clamping the cloth between plates. After 16 times of folding, the cloth is ready for dyeing using a single set of indigo.

2.6.4 Batik and Blue Calico

Batik was first seen on the cotton of India or Central Asia. In 1959, an Eastern Han tomb was found in Niya, Minfeng, Xinjiang, and the earliest extant piece of batik cotton was found in it. The pattern on this piece of batik has been broken, but some of the important parts can still be speculated. What strikes the eye in the lower left corner is the image of a half-naked woman, wearing a bead ring as necklace, holding a fertile corner, and illuminated by light behind here head. There are many theories about her identity, with some claiming her to be the Goddess Ishtar, others saying she was Anahita, and still others believing her to be Hariti, while a fourth theory says she is Ardochsho. In the middle of the fabric, there is a scene of a person wrestling with a lion. The person may be the king of a country in Central

Fig. 55 Northern-dynasty batik fabrics

Fig. 56 Tang-dynasty ash-dyed silk with hunting pattern

Asia, or Heracles in Greek mythology. This theme has undoubtedly come from Greek mythology, but its appearance in a batik cotton indicates that it might have been the product of the Gandhara region in northern India. Its advent at least enables China's understanding of batik. However, in the Wei and Jin Dynasties, fabrics (as shown in Fig. 55) resultant from resist printing after dotting liquid wax on the silk using dotting-dye method in the Northwestern regions. This method of applying beeswax to fabric, casting the fabric into the dye solution, and then removing the wax is called "wax dyeing". However, in the Central Plains, wax dyeing was soon replaced by ash dye, which mainly used alkali agent, like plant ash, oyster ash in resist printing. The ash dyeing was very popular in the Tang Dynasty, and later became blue printing as widely used in cotton dyeing (as shown in Fig. 56).

2.6.5 Embroidery

Embroidery is the art of using silk thread by piercing with a needle and leading threads with it. It appeared very early in China. On bronze utensils of the Shang Dynasty, there were indeed traces of embroidery left. Mud tablets with clear impressions of embroidered coffin cover were unearthed in tombs of Western Zhou Dynasty in Hengshui, Jiangxian County, Shanxi Province.

Lock stitching is the earliest embroidery stitching in existing embroideries. The impression of embroidery unearthed in Hengshui reflected adoption of this technique, which is characterized by the front stitching hooking the stitching behind to form a curve. As a Chinese invention, this embroidering stitching reached its peak during the Warring States Period and Qin and Han Dynasties. The embroideries unearthed in No.1 Chu Tomb in Mashan, Jingzhou, and in Mawangdui, Changsha are excellent examples (as shown in Fig. 57). The prevalence of Buddhism in the Southern and Northern Dynasties widened the scope of embroidery themes. More often than not, pious believers often embroidered images of the Buddha at all costs as charitable and pious deeds. In order to improve production efficiency, the embroidery workers began to try to replace the lock stitching with split stitching, which produces basically the same apparent effects.

In the Tang and Song Dynasties, the development of embroidery art reached a new stage. The embroidery stitchings were basically complete, and all virtually stitchings had appeared. Back then, the running stitching was widely applied, featuring straight operation of the needle, and relying on the connection model between stitches for variation. It often used silk threads of a variety of colors,

Fig. 57 Longevity embroidery of the Western Han dynasty

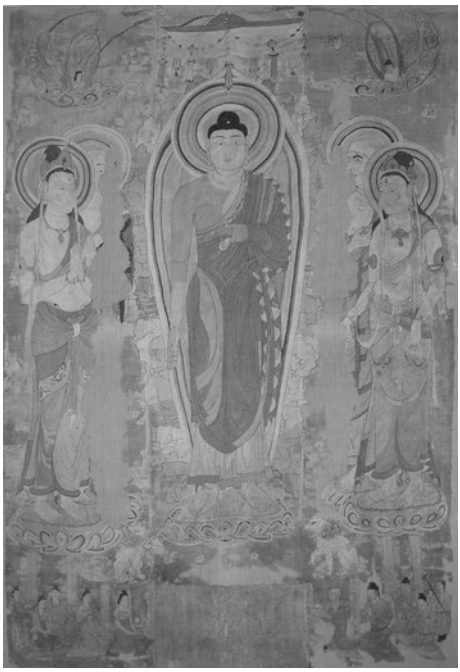


Fig. 58 Embroidered Buddha portraits of the Tang dynasty

and the resultant embroidery was colorful. Therefore, it was called "color embroidery". This has a close relationship with development of embroidery production in the Tang Dynasty, when the embroidery was used to make luxurious decorations. Historical data records that in the reign of Xuanzong of Tang Dynasty, the concubine's office boasted 700 embroiderers. The scale was enormous, and the main job of those embroiderers is to produce household decorative embroidery. Under such circumstances, extensive use of running stitching inevitably became a development trend, for improving the embroidery efficiency (as shown in Fig. 58).

At the turn of the Ming and Qing Dynasties, the embroidery became more popular. And each place around the country formed its own unique style, generating many famous brands of embroidery. Some of them were named after family names, for example, Gu's Embroidery of Luxiangyuan in Shanghai (as shown in Fig. 59). however, a large number of them were named after the places they were produced, for example, Su Embroidery, Shu Embroidery, Yue Embroidery. Etc. Aside from becoming more gorgeous and vivid in appearances, the embroidery techniques also improved.

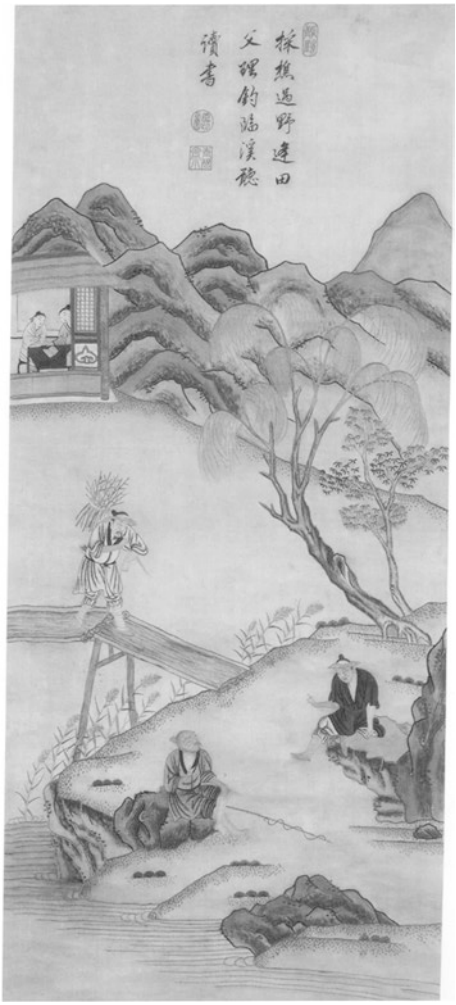


Fig. 59 Gu's Embroidery of Luxiangyuan at the turn of the Ming and Qing dynasties

3 Lecture 3 The Silk Road and Textile Culture Exchange Between East and West

The concept of Silk Road was proposed by German geographer Ferdinand von Richthofen, for describing a section of the busiest road for the East–West cultural exchanges around the Christian era. The bulk trade product for transactions on this route is silk, hence the name Silk Road. Silk Road as an important channel for

cultural exchange between the East and the West has made great contributions to the progress of human civilization. Via this route, the silk and other goods from the East were transported to the shores of the Mediterranean, while textile technology and products from Central Asia, West Asia and Europe were absorbed and integrated by the East. In the ancient Chinese science and technology, textile technology has had a huge influence on the world.

3.1 Silkworm and Silk in Western Legends

In the early years, the distant journey and inconvenient path made it impossible for foreigners to understand the real situations of the Chinese silk, and they had to resort to singular personal imaginations. They called silk-spinning worms "Can'er" or "Ser", countries with sericulture "Seres", and people keeping silkworms "Seres people". Therefore, Seres became the alias of China. In the writings of many Greek writers on the Far East, there are a variety of legends about Can'er and Seres people from the East.

In the West, the first theory on silk origin is in the story of the trees producing wool. This is perhaps related to the Westerners' understanding of the flax and wool production. Virgile (BC 70–AD 19) wrote in "*Georgics*", "the Seres people collected very fine wool from the leaves of their trees." Strabon (ca. BC 58–AD 21) wrote in the book "*Geography*": "probably for the same reason (very hot climate), wool grow in some tree branches. Niyage said, people can use this wool to weave beautiful and delicate fabrics, for example, the Macedonians use it to make cushions and saddles." By the time of Pline L'Ancien (AD 23–79), the Romans had been wearing silk clothing, but they had limited understanding of silk origins, still taking silk as wool-like fiber collected from trees. The Pline L'Ancien in his book "Natural History" offered a vivid description of the Seres people and their fabrics: the first people one encounters there are a group of Seres people, who are known far and wide for the production of wool in their forest. They spray water on the trees to scour the white fluff off the leaves, and then order their wives to complete the procedures of spinning and weaving. Thanks to such complex labor in those remote areas, noblewomen in Rome are able to wear transparent clothes and show off in the public."

Starting from about Pausanias (the Second Century AD), people already knew that silk was produced by an insect called Can'er. Therefore, Pausanias described in detail the origins of Can'er to his knowledge in "*Description of Greece*", saying: "As for the silk used by Seres for making clothes, it is not extracted from the bark, but from other sources. They have a small animal living in their country, and the Greeks called the animal "Ser", while the Seres people called it by another name. This tiny animal is two times bigger than the largest reaver, and is similar in other features to the spider spinning webs in the trees, and exactly like the spider, it has eight feet. Seres people manufactured

small cages applicable in the winter and summer for keeping these animals, which produce one kind of filament winding around their feet. In the fourth year and before, Seres people use millet as fodder to feed them but in the fifth year, they switch to green reeds, because they know those stupid worms won't live much longer. For those worms the reeds are the best of all feeds and they greedily eat these reeds, until their stomachs burst. Most of the silk is found inside their corpses."

3.2 The Routes of Silk Road

By today, the concept of Silk Road has been firmly established, and expanded. There are 3 at least generally accepted silk roads: the Steppe Silk Road, the Desert Oasis Silk Road and the Maritime Silk Road, in addition to the Southwest Silk Road, East Asia Silk Road and other theories. They have different focuses in the role played in different eras (as shown in Fig. 60).

3.2.1 The Steppe Silk Road

The Steppe Silk Road is a channel opened earlier and with a glorious history around the Fifth Century BC. This channel begins in the east from the Mongolian Plateau, crosses the natural moat Altai and the Junggar Basin to reach the Kazakh upland, or directly reaches the Black Sea lowland via the Barabbas Prairie, traversing the land from East to West. The Road passes

Fig. 60 Map of the Silk Road

boundless prairie on its way. Therefore, the people to open up this channel should be the ancient equestrian tribes. This channel was mentioned in the fifth Century BC in "*History*", the masterpiece of the Greek historian Herodotus. Back then, Scythians merchants living around the Black Sea followed this route to go to the East. Another literature mentioning the Steppe Silk Road is "*Biography of King Mu, Son of Heaven*", a Chinese book completed in the Warring States period. The book also mentioned King Mu of Zhou meeting Queen Mother of the West in his westbound journey. According to "*Biography of King Mu, Son of Heaven*", this route starts exactly from the Central Plains, crosses Xinjiang and Cong Ling Ridges and ends in prairie wilderness of Kyrgyz. This passage has also been confirmed by a large number of archaeological data. In Volga River, Siberia, Mongolia plateau, south Hetao Area, and north Xinjiang, Scythian-style artifacts like beast-head copper knives, daggers, double-ear deep-abdomen copper cauldrons, etc., could be seen. Pazyryk giant Scythian tombs located in the foothills of the Altai are particular worth mentioning. In those tombs, Chinese silk and lacquer of around the fifth century BC were found, so were the relics of the Persian Achaemenid Dynasty. These relics also show that, around the 5th century BC, Chinese silk already spread to Europe through the Steppe Silk Road.

3.2.2 The Desert Oasis Silk Road

The Desert Oasis Silk Road, also known as the Western Silk Road, is the first Silk Road proposed by Richthofen. Roughly speaking, this route starts in the east from then the capital Chang'an, and reaches Dunhuang throug Hexi Corridor. From Dunhuang onwards this silk road can be divided into two routes. The Southern route starts from Dunhuang, passes Loulan, Khotan and Yarkand, crosses Cong Ling Ridges, to reach Great Yüeh-chin (now the middle reach of Amu Darya), Parthia (i.e., Persia, now Iran), and then continues west to ndiochia (now Iraq) and Daqin (Roman Empire, now the Mediterranean coast). The Northern route starts from Dunhuang, crosses Yarkhoto, Kucha and Shule, passes Cong Ling Ridges to Dayuan (Uzbekistan, Fergana), and spreads west through Parthia to Daqin. This route mostly passes desert and Gobi along the way, and relies on oases for connection between stations. Therefore, it is known as the Desert Oasis Silk Road. During the reign of Emperor Wudi in the Han Dynasty, Zhang Qian was twice dispatched as envoy to the Western Regions, basically opening this route. And his journeys are known in history as the "Zhang Qian Opening the Way". The one thousand-odd years in the Han, Wei, Sui and Tang Dynasties marked the heyday of this route. A large number of records about Chinese silk spreading to Europe through this channel can be found in both Chinese historical classics such as "*Book of Han · Traditions of the Xiongnu*", "*Book of Han · Traditions of the Western Regions*", "*New Book of Tang · Annals on Geography*", etc., and the European books like "*Geography*". Han and Tang silks found along the way sketch even more clearly the route of this passage.

This section of the Silk Road in history has had its ups and downs. The period from Zhang Qian Opening the Way to Wei, Jin, Southern and Northern Dynasties was a turbulent period. Although exchanges on the Silk Road continued, the risk was high. This situation was greatly improved in the early Tang Dynasty, as the influence of the Tang government on Central Asia increased. Exchanges between China and Sogdian region in the Tang Dynasty witnessed unprecedented prosperity and a large number of Sogdians came to China for silk trade. However, after the eastward expansion of Islam, this situation was changed. A short period of glory didn't come along until the Mongolian army swept across Europe and Asia. After the foundation of the Ming Dynasty, this Silk Road gradually waned.

3.2.3 The Maritime Silk Road

The Maritime Silk Road was opened very early. Initially, it was the East China Sea Silk Road, leading to the Korea and Japan, and later became the South China Sea Silk Road, leading to the Southeast Asian countries. "*Book of Han · Treatise on Geography*" documented the earliest known silk trade overseas: "The Yi Zhang (director of interpreters), who is a eunuch, set off together with the businessmen to buy pearls, jade, and other exotic materials, carrying gold and all sorts of silk." This overseas trade occurred in the reign of Emperor Wudi in the Han Dynasty, the Yi Zhang surnamed Huang—belonging to the court—led a team on long voyage, reaching Kuala Dungun, Ruhmi, Zhanli, Huangzhi and Yichengbu State, and the farthest Huangzhi and Yichengbu State are located in today's India and Sri Lanka.

From the Tang Dynasty on, China's maritime silk trade develop to a new stage. At this point, the scale of the silk trade through the desert oasis gradually diminished, and An-Shi Rebellion, the Turfan occupation of Hexi Corridor and other events pushed it to the brink of termination. At the same time, the country's silk production center gradually moved south, coastal economy witnessed considerable development, ushering in an unprecedented period for the development of the Maritime Silk Road. During this period, important ports increased for foreign trade of silk, and Guangzhou, Yangzhou, Mingzhou, Quanzhou successively established Maritime Affairs Bureau. The dominating nature of maritime trade switched from tribute to commerce. According Zhao Rushi's "*Records of Foreign Peoples*" in the Song Dynasty, Wang Dayuan's "*Brief Annals of Foreign Islands*" in the Yuan Dynasty, "*Description of the Starry Raft*" and "*Research of the East and the West*" in the Ming Dynasty, and other works, China's silk had since the Tang Dynasty spread via those ports throughout Asia and to North Africa and Egypt, before being transported to Europe.

The great geographical discoveries of the fifteenth century marked a new era for the world, and brought new changes to the route of the Maritime Silk Road—the channel for direct connection between China and Europe and the Americas was opened. In the middle of the Ming Dynasty, the Spanish

and Portuguese traders reached the South China Sea from the Pacific and the Indian Oceans respectively, opening the trade routes of the Pacific and the Indian Ocean. The route lasted for over 200 years, and every year several thousand-ton or larger sailing boats crossed the Pacific, each carrying about 1,200 boxes of silk. Those ships were known as the "Silk Boat". In the seventeenth and eighteenth centuries, Netherlands and the United Kingdom successively established East India Companies in India, manipulating the silk trade with China. In the end of the eightieth century, the United States joined in the Chinese silk trade. In short, at this period of time, the Maritime Silk Road could reach anywhere in the world.

3.3 Textiles Found Along the Route of the Silk Road

Beyond China, the place along the Silk Road where the earliest textiles from China are discovered is Pazyryk, Russia. Later numerous discoveries were made in Noin Ula, Mongolia, including not only brocade and embroidery produced in China, but also a large number of embroidery and felt fabric from the West, reflecting cultural dissemination and exchange brought about by the Steppe Silk Road. Textiles kind found in places along this route in China date back to much earlier times, but here we will mainly introduce textiles from the Eastern Han, Wei, Jin dynasties to the Sui and Tang dynasties unearthed in China along the Silk Road.

3.3.1 Han and Jin Tombs in Hexi Corridor

In 1979, the Gansu Provincial Museum Archaeological Team found in the beacon sites in Majuanwan near Dunhuang a lot of fabrics of the Western Han Dynasty, the majority of which are woolen goods, but there are also some silk, including fragments of brocade with diamond pattern and cloud pattern, and silk fabrics. A greater discovery was made in Mojuzi, Wuwei, and excavations include textiles from the late Western Han Dynasty to the mid-Eastern Han Dynasty. Tomb 62 is the most important: a wide variety of silk, yarn, diamond-pattern satin, velvet-circle brocade, silk ribbons and red herringbone embossed crepes were unearthed. In recent years, a lot of silk embroidery products were unearthed in Wei and Jin tombs in Bijiatan, Huahai, Yumen, Gansu.

3.3.2 Han and Jin Tombs in Niya, Xinjiang

The Niya Relics Site is located at the end of Niya River in the desert, about 150 km to the north of Minfeng County, and it is the ancient site of the Jingjue State in the Han Dynasty. In the beginning of the twentieth century, Marc Aurel Stein entered Niya, and obtained a large number of documents and woven

Fig. 61 Han-dynasty brocade armband with the characters "五星出东方利中国" (five stars appear in the east to benefit China)

fabrics. In 1959, Xinjiang Museum Archaeological Team led by Li Yuchun found a coffin there. The coffin had two bodies, one man and one woman. The team sorted out the clothing on them and got eternal-good-luck brocade robes, white cloth embroidered trousers legs, brocade socks, gloves and chicken pillows, brocade socks with the pattern "阳", embroidered mirror sac, and embroidered powder bags. In 1995, Niya archaeologists straightened out eight tombs, of which the most important are the M3 and M8 Tombs, where a brocade quilt with the characters "王侯合昏千秋萬歲宜子孫" (A Royal Marriage Benefits Future Generations), a brocade robe with lattice pattern, a brocade pillow with the characters "安乐如意长寿无极" (Boundless happiness, contentedness, and long life), as well as the most precious brocade armband with the characters "五星出东方利中国" (five stars appear in the east to benefit China) were unearthed (as shown in Fig. 61).

3.3.3 Loulan Ruins and the Cemetery

Loulan Ruins is located in the southern bank of Lop Nur, in Ruoqiang, Xinjiang. In 1900, Sven Hedin and his expedition team discovered the ruins of the ancient city of Loulan. In 1906, Stein came to Loulan and excavated numerous textile artifacts. In 1979, China and Japan joined hands in surveying and excavating the ancient Loulan region, and unearthed in the ruins of the ancient city of Loulan a total of 59 textiles. The two countries also carried out excavations of the platform cemetery MA and solitary desk cemetery MB in suburban Loulan, sorting out 74 pieces of fine silk products. In 2003, in the Loulan region, there was a theft in the precious royal cemetery, and Xinjiang Archaeological Personnel rushed to the scene, collecting several silk fabrics and apparel (as shown in Fig. 62).

Fig. 62 Loulan ruins

3.3.4 Yingpan Cemetry

The Yingpan is located 150 km to the southeast of the Yuli City in Xinjiang. In the decade between 1989 and 1999, archaeologists conducted three excavations in Yingpan, straightening out hundreds of tombs, and unearthing a lot of textiles. In texture, those textiles can be divided into four categories, i.e., silk, wool, cotton and linen, with the first two categories accounting for more than 1/3 of the total number of archaeological finds. In silk textiles, there are floret, damask, sash, embroidery, brocade, dyed valerian silk; in woolen goods there are felts, blankets, carpets, braided belts, woolen embroidery and woolen ropes. The woolen fabrics unearthed were more compelling: the red felt with paired human, beast and tree pattern has been the shell fabric of the robe for the owner of Tomb M15. The pattern is typical Roman style featuring naked angels and pomegranate trees (as shown in Fig. 63).

3.3.5 Sampula Cementry

The Sampula cemetery is located within in Lop County, Hotan, Xinjiang. A total of 68 tombs and two ceremonial horse burial pits were excavated, and more than a thousand pieces of archaeological finds were unearthed, including a large number of unique textiles and clothing, which brought about general concern in academic circles at home and abroad. The flared skirt decorated with a weaving wool

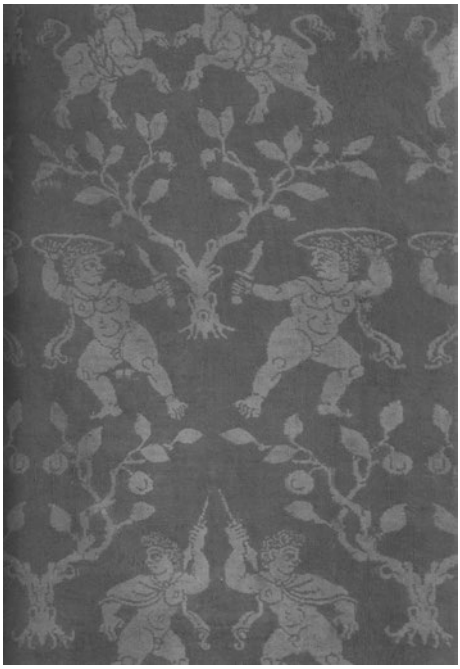


Fig. 63 Pattern of paired humans, beasts and trees on the felt

sash has been characteristic of Sampula. From wrapping up and putting on woolen blankets to keep warm and ward off cold to one-piece clothing without cutting and woven garments and pants with simple cutting, apparel unearthed in Sampula cemetery were mainly long-sleeved pullover, short-sleeved pullover, flat leg trousers, lanterns leg trousers and flared skirts.

3.3.6 Zaghunluq Cemetery

Zaghunluq Village, located in Tuogelakeleke Township, Bayingolin County, Xinjiang, has a total of hundreds of tombs. From 1985 to 1998, joint excavation was launched by the Xinjiang Museum and Bazhou Cultural Relic Management Office. The main culture of Zaghunluq No.1 Tomb consists of three phases, with the second phase equivalent to the Warring States Period and the early Western Han Dynasty, and from the tombs, brocade and embroidery from the Central Plains were unearthed. And the third phase is from Eastern Han Dynasty to Jin Dynasty, i.e., from the third to sixth Century, and from the tombs, a large number of cotton fabric and silk were unearthed. And the most important is a number of silk fabrics strengthened with tight twist threads, which were identified as the local products of Xinjiang. In addition, there is a piece of embroidery with a two-headed bird, which is also very interesting.

Fig. 64 Color silk painting unearthed in Turpan

3.3.7 Qara-Hoja and Xizhou (Tang) Fabrics Unearthed in Turpan

Archeology of the Astana and Karakhoja Tombs in Turpan, Xinjiang are the most important achievements after the foundation of the People's Republic of China in seeking for silk textiles of the Northern Dynasty to the Sui and Tang Dynasty. Since 1959, investigation and scientific excavations in Turpan region, Xinjiang were made by the archaeologists, sorting out 456 tombs in 11 batches, among which 42 belong to the Wei and Jin Dynasties, 115 to the Qara-hoja Dynasty (531–640) and 173 to the Xizhou Period of Tang Dynasty (second half of the seventh century to the second half of the eighth century). A very large number of textiles, especially silk and hemp fabrics were unearthed. From those textiles we can see the impact of silk production in the central plains on places along the Silk Road (as shown in Fig. 64).

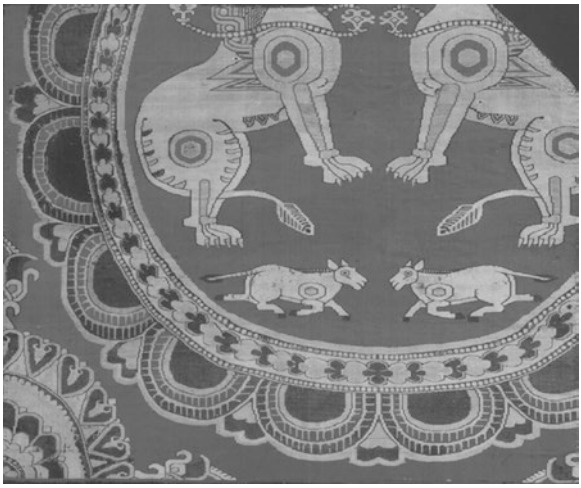


Fig. 65 Red brocade with paired lions in the nest

3.3.8 Discovery in Dulan County, Qinghai Province

From 1983 on, the Tubo Tombs in Reshui, Xiariha and other Townships in Dulan, Qinghai were discovered and excavated. According to statistics, M1 Tomb alone unearthed 300 silk pieces, with nearly 100 kinds of different patterns or structures. The majority were brocade and damask, with elaborate patterns and exquisite weaving. In era, the unearthed silk textiles dates back to as early as the early Northern Dynasty and Sui Dynasty, as well as the Tang Dynasty in its prime, while the majority belonged to the mid-Tang Dynasty, i.e., the period of Turpan occupying the Hexi Corridor. The illegal excavation in this region was also very serious, and a lot of silk textiles spread abroad. Those found in the reports are of such fine quality as to surpass the imagination of the people (as shown in Fig. 65).

3.3.9 Discovery in Famen Temple in Shaanxi

On August 23, 1981, half of the tower in the Famen Temple in Fufeng County collapsed, leading the excavations of the underground palace of Famen Temple in 1987 by Shaanxi Provincial Institute of Archaeology, bringing to light again the royal silk textiles of the Tang Dynasty buried for over 1,000 years. From the inscription in the stone tablet unearthed in Famen Temple, we can see that the most recent occasion for this underground palace to be open for welcoming and sending off Buddha's Bone occurred in the reigin of Emperor Yizong of the Tang Dynasty, and after that the underground palace was shut down. Therefore, most of the silk used for sacrifice in the underground palace were from the time of Yizong during the late Tang Dynasty. Among the silk textiles, the most beautiful is a set of five models for the Buddhist clothing made of red satin decorated with gold patterns for Statue Bodhisattva holding Sarira of the Buddha, and a brocade jacket

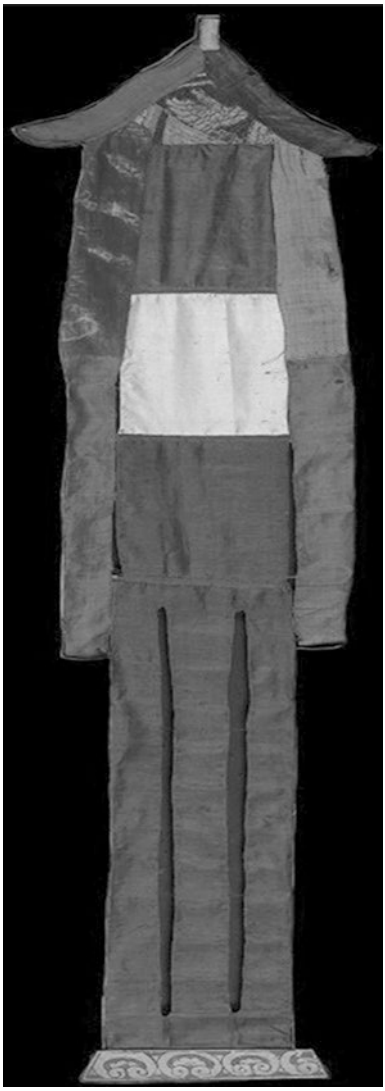


Fig. 66 Silk textiles attached to the iron flute unearthed in Famen Temple

for wrapping Buddha's fingers. Besides, in a decadent white rattan box, there was a pile of silk 23 cm in thickness, consisting of 780 layers. If unfolded and spread out, the silk would cover more than 400 square meters (as shown in Fig. 66).

3.3.10 Discovery in Dunhuang

In 1900, Wang Yuanlu opened the door to the cave holding scripture depository, and found countless manuscripts and various silk Buddha streamers and embroidered portraits. Later, Stein and Pelliot came to Dunhuang and defrauded the

Taoist Wang of about 2/3 of the relics, which were transported to Britain and France and mainly kept in British Museum in London and Musée Guimet in Paris. Those relics include many silk Buddha streamers, sutra-wrappers, embroidered portraits, and various fragments.

After the establishment of the People's Republic of China, Dunhuang Institute of Cultural Relics launched renovations on the first part of Mogao Grottoes, and discovered two batches of silk during the process. One batch were the embroidery of the Northern Wei Dynasty, and the other were from the Tang Dynasty, unearthed in 1965 from cave K130, K122, K123 in the Mogao Grottoes. Dunhuang Institute of Cultural Relics issued a report on its discovery and made a preliminary identification of the fabrics, saying they were mainly damask and florets from the Tang Dynasty, and processed via alkaline printing, clamp-resist dyeing, rubbing dyeing and other methods. In recent years, archaeological undertakings in the Northern District of Mogao Grottoes have resulted in discovery of Yuan Dynasty textiles.

3.4 The Silk Road and East-West Exchanges in Textile Technology

3.4.1 Spread of Sericulture Technology

The contribution of Chinese silk to the world lies first in spread of China's silk production technology with silk, especially the spread of sericulture technology. However, the spread of sericulture technology progressed in phases, and the first step is to spread to regions in Central Asia.

The Great Tang Records on the Western Regions written by Xuanzang in the Tang Dynasty included a story of Silk-disseminating Princess introducing silkworm to Kustana: "Formerly, this country didn't know sericulture. When it heard that the East State had sericulture, it sent an envoy to ask for it. The king of East State refused, and ordered to tighten border control, so as to prevent silkworms from getting out. The king of Kustana sent a humble letter with gifts to the East State and proposed a marriage. …ordered the envoy to exhort the bride: …traditionally we have not known sericulture, and you may take some silkworms with you, so as to make clothes for yourself. After hearing those words, the bride secretly obtained some silkworm eggs and put them in the hat wadding. …therefore, silkworm was introduced to Kustana." This story can also be seen on the painting board featuring Silk-disseminating Prince discovered by Stein in the Dandan Oilik Ruins in Hotan in Xinjiang (as shown in Fig. 67). Seen from the artifacts unearthed, this process took place in about the third century AD. Therefore, mulberries are planted in the beginning of spring, and when silkworm month comes, mulberry leaves are gathered for feeding silkworms. Regions in Central Asia began to own sericulture and silk industry.

It is said that there is also an interesting story on sericulture technology spreading to Europe from Central Asia. In the reign of Justin (483–565), the Persians

Fig. 67 Painting board featuring silk-disseminating prince discovered in Hotan

controlled the essential routes of the Silk Road, and the Oriental silk had to be resold from Persia to reach Rome. At this point, a Persian monk hid silkworm eggs in his cane and brought them to Rome. This story is documented in Theo-Phane's book (750–817). According to Theo Phane, one Persian in Byzantium once introduced the origin of silkworm. Prior to this, the Romans still knew nothing about silkworms. This Persian came from the Seres, and he collected some silkworm eggs in a small box, and brought them to the Byzantium. When spring arrived, he used mulberry leaves to feed the silkworms. After devouring these leaves, the silkworms grew wings. Justin once taught the Turks about the working-procedure the birth of silkworms and formation of cocoons, much to the surprise of the Turks, because the Turks controlled market and port of the Seres, which had all belonged to the Persians. Perhaps it is after the official introduction of silkworms that makes possible the interpretation of the secret of silk production, and classification of silkworms as moths. However, in Greek those insects should be called "Bombyx" which is the Latin name for silkworm moths today.

3.4.2 Dissemination and Exchange of Patterning Technology

In addition to the sericulture technology, reeling and silk patterning technology also had a major impact on the Western textile technology. And jacquard is an excellent example. But this view has not been widely recognized in the West. Aside from Needham, Kuhn and other scholars who study the history of Chinese science, few credit the right to the invention of the jacquard to China. This does not necessarily mean that the Westerners' Euro-centrism has played a role. Probably, this situation is caused by the East-West differences in the definition of jacquard.

The Chinese definition of jacquard: a machine whose opening is controlled by a pre-set program, so as to control the pattern woven. This program can be installed in the pattern needle or pattern card of the Modern Jacquard head, in the state-of-the-art computer, in the pattern board of the ancient jacquard, or of course in an unknown apparatus. Seen from the repeated occurrence of staggered pattern on the brocade with dancing figure and animal pattern unearthed

from a Warring-States-Period Tomb in Mashan, Jiangling, Hubei, pattern on woven brocade had used a certain method or device to control the opening of the jacquard, that is, the pattern can be repeated along the warp direction. In this way, the people developed the original cross-stitch method developed to pattern racking, thus avoiding the complexity of cross-stitch work, and duplication of memory. Even someone ignorant of patterning can sit on a jacquard and make relatively simple operations of the pedal or the heddle to produce patterns.

However, regarding the exact model of the jacquard in the Warring States period, there are still a lot of controversies. The two most important points of view are: First, it is a draw loom just like that of the subsequent generation. The patterning stands erect in the middle of the loom and stores the pattern information to control patterning. This jacquard is the same as the draw loom in the West. Second, it is a multi-heddle multi-pedal jacquard that uses drafting of the various heddles to control patterns woven. Such a jacquard can't be translated as "draw loom" in English, because it does not involving the action of drawing.

Our research of the textile products in China and along the Silk Road in the Han and Tang technically has found that there was a very clear difference between the Eastern and Western embroidered fabrics. During this period, warp-patterned brocade produced in China had patterns of meridional circulation but not zonal circulation, judged from the woven brocade unearthed in Chu Tombs in Mashan and the Han Brocade unearthed in Niya. Even if there were cup pattern gauze and geometrical pattern brocade with seemingly apparent meridional circulations, those meridional circulations are not authentic. Therefore, it is certain that the jacquard back then could only produce meridional circulation, not zonal circulation. This jacquard is not the kind of multi-crane multi-beam draw loom that produces zonal cycle and that we see later on.

It is very likely that one of the models is a multi-heddle multi-pedal machine. It is also possibly a low-pattern-card jacquard operated by one person. However, weft textiles in the West had a very strict zonal circulation, and there was no zonal cycle all along. This shows that the western loom adopted an apparatus that controls the zonal circulation, but can't control the meridional circulation. This loom is likely to be similar to the Zilu loom currently existing in Iran. Zilu loom had no patterning, but it had heddles. For each drawing, the weaver has to re-start cross-stitching, which can control the drawing of multiple warps, and form zonal pattern. When drawn up, the weaver use a jacquard weave action, thus is may be referred to as a draw loom.

It is possible to speculate that when Chinese silk products, especially brocade, spread to Central Asia, including China's northwest region, the local people began to imitate the Chinese weaving techniques. However, Western weavers turned the direction of Chinese brocade by 90°, not only changing its organization and structure, but also changed the Chinese brocade pattern cycle plan by 90°. As a result the tapestry locally produced in the Western regions had a very narrow zonal circulation, but not a fixed cycle in the meridional direction.

However, Chinese weavers were inspired later by weavers in Central Asia, and learnt the method for controlling zonal circulation. Such a loom features a

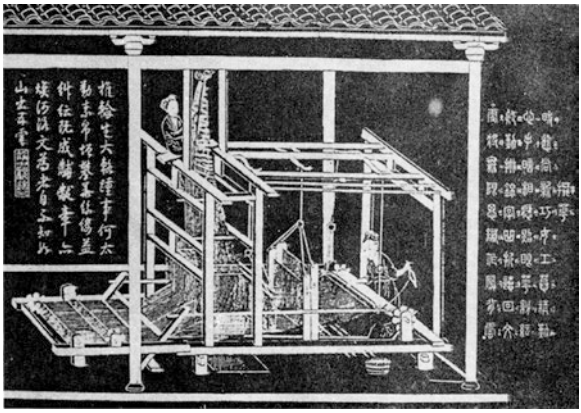


Fig. 68 Silk patterning technology in a Song-dynasty painting

thread pattern card. The brocade with pattern of lamp, trees and paired sheep unearthed in Astana, Turpan, Xinjiang is a solid evidence of zonal and meridional circulations in patterns. The small mission flower brocade flourishing in the late Sui and early Tang Dynasty is obviously produced with draw looms, indicating that jacquard is in the real sense of the word had been created back then. The jacquard should have been small jacquard looms, whose image can be clearly seen in the paintings of the Song Dynasty. The body of small jacquard loom was horizontal with the patterning source standing erectly in the middle of the loom. One operator sits beside the patterning system to push it sideways according to the requirements of the pattern to be woven. In front of the patterning source there are two floor heddles, to be controlled with feet by the weaver sitting in front of the loom—and this weaver is also responsible for driving the shuttle, knitting the weft and weaving. The core technology of this jacquard loom is the procedure to be followed in knitting patterns which is known as the "pattern source". This is regarded as an invention brought about by exchanges between Eastern and Western textile technologies, as well as a much-told story. It can be said that technological inventions are generated in the process of exchange (as shown in Fig. 68).

3.4.3 The Influence of Chinese Silk on World Technology

China's contribution to world civilization is also reflected in China's four great inventions—papermaking, printing, gunpowder, and the compass. These are scientific and technological achievements in which the Chinese people are most likely to take pride. Of the four great inventions, two are directly to silk. The word "纸" (paper) originally meant "velvet accumulated in the process of making silk floss". "*Explaining and Analyzing Characters*" said, "paper is the condensation formed on the bamboo curtain used in washing silk." "*Tongsu Wen*"

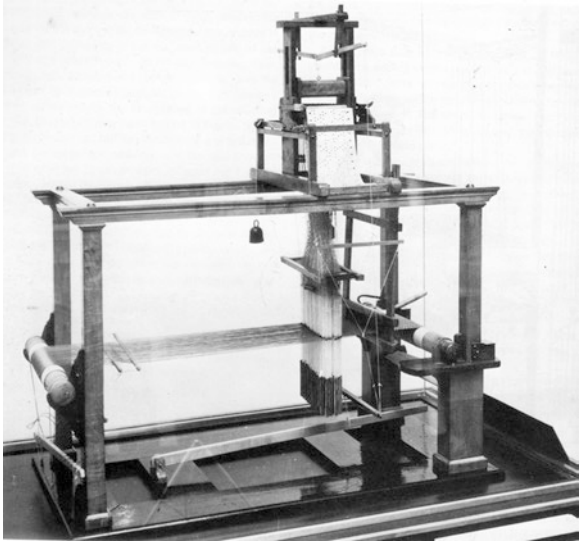


Fig. 69 Jacquard with perforated paper head invented by Jacquard

(Book of Idioms) said: "square floc is called paper." In other words, the paper is the thin layer of floc accumulated on the bamboo foil when it is used in rinsing silk in water. The invention of printing is also directly associated with letterpress printing technology used on silk. The printed silk unearthed at Mawangdui has a large area of colored overprint, which is nearly 1,000 earlier than the official appearance of woodblock prints in the Tang Dynasty. So it can be safely said that relief printing on silk is the originator of the subsequent woodblock printing. In addition, the advancement of the Maritime Silk Road also directly promoted the practical application and improvement of the compass. Therefore, it was suggested that China's four great inventions are actually three great inventions, because silk can be used to replace paper and printing. This is quite a novel point of view, but it is not unreasonable.

The loom is an extremely delicate mechanical structure, the structure for transmitting force from the pedal through the connecting rod to the heddles opening is a contribution of the Chinese people to the history of the world's machinery. The principle of silk patterning is the process of transforming patterns into the patterning procedure by cooperation between the heddle and the pedal and the rod, or by formulating and storing the pattern source. This principle contains profound mathematical thinking. After it spread to Europe, it not only had a great impact on the development of European silk technology, for example in Lyon, France Jacquard invented the Jacquard loom (as shown in Fig. 69) based on the patterning principle of Chinese looms, but also had a tremendous impact on the development of modern telegraphciples of computer.

3.5 The Silk Road and East-West Exchange in Textile Technology

3.5.1 Introduction of Western Motifs in the Han and Jin Dynasties

Back in 1959, in Niya archaeology, two blue printed cotton textiles that can be pieced together (as shown in Fig. 70) were found. They were decorated with white flower patterns, produced via a process commonly known as batik. The two pieces of cotton can be pieced into one, and in the most important and most complete area, there is one nude woman figure, which has prompted many discussions. The original report claim this picture to be Bodhisattva, but study by recent scholars has shown that there are many possibilities for this image: one is Tyche in Greek mythology, another is Hariti of Hindu mythology or Hirati in Buddhism, still another is Aldoksho, harvest goddess of the Kushan Empire. This image has been more popular in the Gandhara culture area in northwestern India, and is often presented as a female holing a horn bouquet, and considered locally as the god protecting the children.

A lot of interesting textiles were also unearthed in the Sampula Tombs in Lop County in the Hotan region. The most notable is the fabric used for the two pant legs. Woven via wool tapestry technique, one pant leg has a large portrait of a warrior, and the other shows a human-torso horse blowing Piccolo (as shown in Fig. 71). The human-torso horse is the centaur in Greek and Roman mythology. His presence further confirmed the influence of Hellenistic art on this region. The warrior portrait is very much similar to the head portrait of Hermes found on woolen fabric in Loulan by Stein, and to Greek-style portraits of painted pottery unearthed in the ruins of Khalchayan in Transoxania in Central Asian.

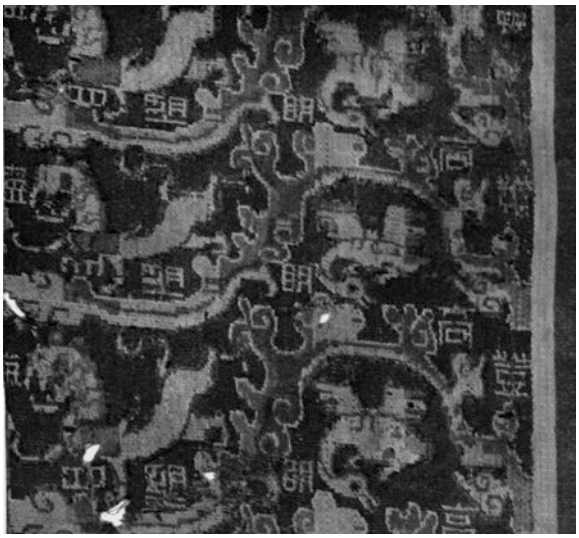


Fig. 70 Blue-white wax printed cotton cloth unearthed in Niya

And probably it is related to the Heresh Family of the early Kushan Empire. All of these no doubt results from the influence by the culture of Gandhara on Northwest China.

The wool fabric unearthed in Yingpan is more compelling, of which the most prominent are the felt with pattern of paired beasts and trees, the felt with pattern of eagle, snake and flying figures, and the felt with pattern of coiling vine, blooms and trees. The first one is used as the fabric in the robe for the owner of Tomb M15. It adopts a double-layer structure, and display the pattern and the texture with red and yellow respectively. What's more peculiar is its pattern, which is regular and symmetrical in overall design, with each zone consisting of six pairs of opposing characters and animals along the axis of a pomegranate tree (the length of each zone is 0.8 m). Each pair spans the entire width of the fabric via two-sides-continual (width over 1.18 m). Patterns in each zone are vertically symmetrical in layout. The four pairs of characters in the pattern are consistent in image: all are male, naked, with curly hair, high nose and big eyes. Each pair characters pose differently. Holding weapons and standing opposing each other, showing different postures of sparring, the characters are meticulous and vivid. The two groups of animals, i.e., one pair of sheep and one pair of cattle, are shown with fore hoofs raised in the air, bespeaking their supple and agile bodies. The animal images are very dynamic. The overall patterns on the gowns also reflect the impact of Hellenistic culture and art. The above nude male may be Eros in Greek mythology, whose hair-style is different from the hair style of Eros in Western Art that is popular in Milan or Kuqa. Adoption of the statue of Eros in the classical art or Gandhara Art shows that this robe has obviously been from Bactria or Gandhara or other Hellenistic world.

Fig. 71 Centaur warrior woolen fabric unearthed in Sampula

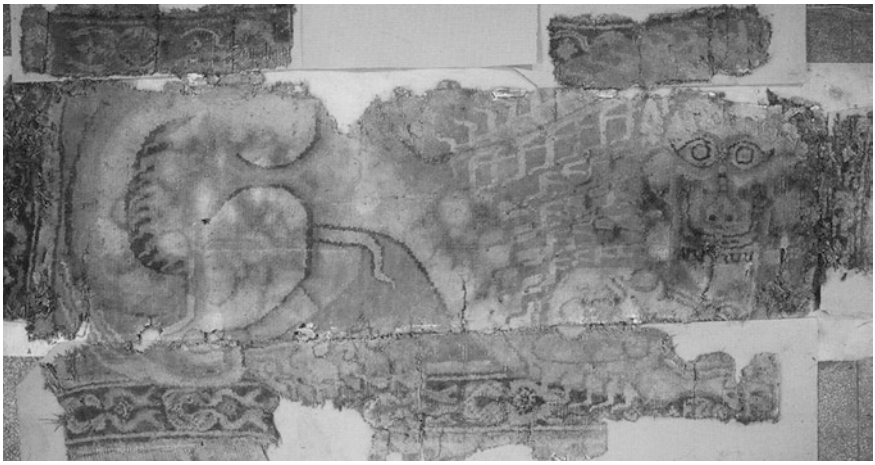


Fig. 72 Lion-pattern carpet

In excavating Niya in 1959, a complete tufted carpet was unearthed, featuring an interlocking grape leaf pattern, which is obviously also a Western motif. The 1995 Niya Tombs also yielded the same results: most of the coffin lids were covered by one layer of blankets or felt rugs. Yingpan cemetery had a very close scenario. A lot of blankets, mainly plain slub woolen blankets, were also unearthed. Less than 1 m in width and about 1.5 m in length, those blankets were used to wrap the bodies or covering wooden coffins. One of the most elaborate piece is a tufted carpet, covering the painted wooden coffin of M15 Tomb. The carpet uses the method of single warp and buckle, and fluff is 1.5–2 cm long. The main pattern is a prostrate lion, surrounded by a double border. The lion has distinctive profiling, with narrowed waist and augmented torso and hip to create big ups and downs, so as to present a strong dynamism. This image of the lion has a significantly exotic style (as shown in Fig. 72).

3.5.2 Application of Western Motifs in Chinese Brocade

In the Wei and Tang period, not only were there fabrics with Western motifs directly imported into Northwest China from the West, but also were these motifs began to be attracted to China's silk artisans who used them in silk products produced in China.

Lion: in Persian art, image of lion is often seen. Some people think that lion is the incarnation of the god Mithra, and the major attendant to the principal Persian god Ahura. On the brocade with lattice animal pattern unearthed in Turpan, Xinjiang, there were lion images. On the brocade-lined satin robe in private collection in Hong Kong, there are also patterns of cloud mountain and lions. Those can all serve as proof.

Fig. 73 Elephant pattern in the brocade with quartet cirrus clouds in pearls and paired beasts

Elephant: Elephants are also produced in the South Asian region, and are a vital transport in the subtropical jungles. In addition, the elephant back is also the stage for people to perform. The so-called "elephant dance" is dance performed on the backs of elephants. The elephant in the lattice and beast pattern on the brocade is in fact a stage with a propped canopy, a lotus throne and people mounted on elephant back. On the brocade with the pattern of quartet cirrus clouds in pearls and paired beasts kept in China National Silk Museum there is also the image of elephant dancing, with the musicians playing lute (as shown in Fig. 73) on the back of an elephant.

Sheep: In the Northern Dynasty the image of the West Asian long-horned sheep came to China, usually posed as standing or crouching. Compared to sheep modeled on Persian utensils, we can see that the sheep is actually a kind of goat, and perhaps there is an ibex, which generally boasts a robust shape and can take leaping postures. In Persian works of art, there are examples of giving such goats wings.

Deer: The situation of deer is similar to that of sheep. From the Northern Dynasty to the Tang Dynasty, the deer pattern is also quite different from the modeling of the traditional Chinese deer. This is a red deer, also known as stag. Robust in body, stags can grow to 1.8 m in length, about 1.5 m tall at the shoulder. The bucks have horns, with as many as 8 forks, and can be used as ride. The Persian deer patterns always feature female red deer, which are also a far cry from the traditional Chinese deer. Therefore, such deer patterns should have come from West Asia. The deer brocade of the early Tang Dynasty is the red deer brocade.

Horse: since the Han Dynasty, horses from Central Asia have been treasured in the East. Emperor Wu of Han launched several expeditions to Dayuan in order

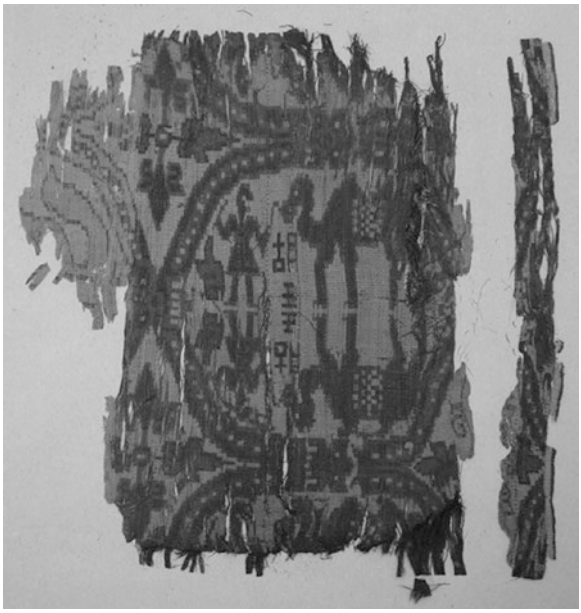


Fig. 74 Sui dynasty brocade "Hu King leading a Camel"

to look for Ferghana horses. In the Tang Dynasty, there was also silk-horse trade on the national borders. In Persia, horses were also deemed to be gods by the local, and they can grow wings to become heavenly horses. One theory says that the horse is the sun god of Egypt, another theory says that it is a Persian God Tishtrya. In the end of the Northern Dynasty the pattern of "heavenly horses travelling across the sky" came to China, and appeared frequently among the brocade patterns.

Camel: camels, the famed ships of the desert, are the main means of delivery on the Silk Road. It is not native to China. From the Northern Dynasty onwards, a large number of murals, portrait bricks, pottery, and silk products appeared with patterns depicting trade with camels. The most famous is the Sui Dynasty brocade "Hu King leading a Camel" Unearthed in Turpan and the brocade "paired wave, lion, elephant and camel" unearthed in Dulan (as shown in Fig. 74).

Pig: pigs usually appear in patterns with the heads only. With green face and ferocious fangs, they are wild boars widespread in West Asia and South Asia. They often appear in gold and silver utensils and stone art. Generally the pigs were in two situations, either as being hunted and killed, or only as showing the head. The latter is considered to be the incarnation of Verethraghna in Persian Zoroastrianism. In the Sui Dynasty, such modeling appeared on the sarcophagus in the Central Plains, and three cases have been found in the Tang Dynasty brocade.

Peacock: Native to South Asia and very beautiful, peacocks were known to the central plains in about the Han Dynasty or earlier. In the Northern Dynasty, there were records of "Satin with Spotted Peacock Pattern" and real-life instances of brocade with paired lions and paired peacocks. At this point, the peacock mostly held in

Fig. 75 Red brocade with quartet cloud in pearls and Sun God

its mouth a ribbon or a flower. This is a unique posture. This posture might be related to the image of ribbon-holding birds found in the subsequent Sogdian brocade.

Deva: "*Report Regarding Gaochang Ordinance on the Residual Ill-gotten Money*" (574) unearthed in Astana, Turpan, Xinjiang mentioned several times the name of the "deva brocade", which should brocade with "Deva" patterns produced in the hinterland. Deva is the principal god, i.e., the heavenly god in the primitive religion of the Aryans. By the Vedic era, deva remained the name of deity in India and Iran, but the positions were very different. In Iran, deva was known as Daeva, and regarded as the incarnation of the devil. In India, deva was considered the good god overcoming demons. Seen from the perspective of good gods overcoming demons in general doctrines, Deva in the "deva brocade" is not the evil god of Iran but a deity from ancient India.

Helios the Sun God: Helios was the Sun God in Greek mythology, and was different from the subsequent naked Apollo. Legend has it that he was the son of Hyperion the Titan and Theia his sister and wife. Each day, he drove a four-horse golden carriage across the sky, from east to west. He set off in the morning and receded in the evening, showering sunlight on the earth. When Helios appeared on the brocade between Northern Dynasty and the Sui Dynasty, the sources of cultural factors contained became more complex. The Red Brocade with quartet cloud in Pearls and Sun God unearthed in Reshui Tomb in Dulan, Qinghai is the most typical among all the brocades featuring the Sun God (as shown in Fig. 75) unearthed in the Northwest region. The cluster skeleton consists of cirrus cloud as the outer layer and combined pearls as the inner circle. Between circles there are patterns of beasts and flowers that serve as connection. Beyond the outer circle,

there are the cirrus cloud and the Chinese character "吉" (auspicious), and within the circle there is the sun god Helios. Helios wears a jeweled hat, beyond which there is a canopy. He sits on a lotus throne, wearing a cross collar shirt tightened about his waist, and with his hands fixed before him in the posture of Mudra, his legs crossed in front of him, and his head set off with the light of ringed pearls. The throne is placed on a wagon drawn by six horses. The wagon has six wheels centered on a platform, and the horses are all winged immortal horses, grouped into three pairs running in opposite directions. There are two halberd-wielding guards on board seeminlgy driving the wagon. There are another two who can be seen in the faces, seemingly holding the dragon-headed streamer. The whole pattern is symmetrical and balanced, and gives off a solemn and serene atmosphere. Upon careful analysis we can see that the image of Helios contains factors from Greece, India, Persia, China and other cultural circles. Although the gods and themes were Greek, their modeling is distinctively indicative of Indian Buddhism: canopy, halo, streamers, lotus throne, etc. are factors unique to Buddhism. As for the ringed pearls and other decorative designs, as well as the skeleton are of Sassanid Persian style. The origin of this brocade has been determined as the hinterland of China, thus there are more Chinese cultural factors: the presence of the Chinese characters "吉" and "昌" is the most obvious symbol, ring-holding beast and the dragon-headed streamer are also characteristic of China. In addition, the brocade adopts a structure integrating plain and loop stitch, which is also a Chinese culture factor. Seen in this light, Helios has undergone an extraordinary trip in his journey from the West to the East, from the ancient to the medieval period, and has experienced enormous changes in form. Therefore, we have encountered a lot of difficulties in determining its prototype.

Grapes: Grapes are said to have been brought back by Zhang Qian when he opened the road to the Western Regions. Grapes seemed to have emerged in silk patterns in the late Eastern Han Dynasty. The damask with bird, beast and grape pattern unearthed in Minfeng, Xinjiang, is an example. In addition, according to the record in "*Miscellany of the Western Capital*", in the Han Dynasty there were grape brocades. In the Wei and Jin Dynasties, grape pattern had wider applications, as represented by the embroidery with dragon, bird and grape pattern unearthed in Turpan, Xinjiang. The book also recorded Zhao Shihu producing grape brocade. Grape patterns became even more popular in the Tang Dynasty, and were reflected in Dunhuang frescoes, bronze mirrors, and other works of art.

Strange text: in literatures of the Tang Dynasty, there were decrees forbidding weaving strange texts, which should refer to Foreign Languages. The first foreign languages to appear on silk fabrics should be Kharosthi around the third century AD. In Han-style tapestry fragments found at Niya, Loulan, Camp and other places we have discovered some remnants of Kharosthi texts written with ink, and one of them means "brocade with Chinese characters woven". In a tapestry with beast face patterns unearthed in Yingpan we can see a line of Kharosthi, aside from the Chinese character for "王" (king). This tapestry has obviously adopted the Chinese technology, that's to say, the weaver producing this tapestry should be a Chinese, who woven Chinese characters and Kharosthi in it so that it can

be sold on the silk road teeming with Chinese and people using Kharosthi. Here, Kharosthi and Chinese characters are very similar in meaning, and both are used as adornment, rather than as the main body of the pattern.

3.5.3 Popularity and Domestication of Linked-Pearl Pattern

It is generally believed that the greatest impact of the Western culture on silk pattern is the linked-pearl pattern. The linked-pearl pattern is in fact not a thematic patterns, but a skeleton pattern, i.e., a larger geometric skeleton formed by connecting circular geometrical points of similar sizes, and used as the framework for animals, flowers, and other kinds of patterns, and sometimes interspersed in specific patterns for decoration. The first use of linked-pearl pattern as silk pattern was seen in apparel description on the murals in the Tomb of Xu Xianxiu from the Northern Qi Dynasty. In the murals, there are two silk patterns: one features a Buddha head with linked-pearl pattern, and the other is the paired deer pattern included in a linked-pearl pattern. The artifact with linked-pearl pattern was first seen in the Northern Dynasty.

After the establishment of the Tang Dynasty, this kind of pattern was gradually absorbed and digested. And in China, nest of linked pearls with Chinese characteristics appeared. The first step in absorption is imitation and simulation. In the Sui dynasty, He Chou succeeded in imitating Persian gold cotton lined brocade. In the silk works from the early to middle Tang Dynasty, a few pieces large brocade with linked-pearl nest pattern were undoubtedly woven in China. In the "Blossoming Tree and Paired Deer" brocade unearthed in Turpan, the nest of linked pearls are in the shape of a pair of big deer with the obverse and inverse Chinese characters "花树对鹿" in it. In the "Four Riders Hunting a Lion" brocade currently kept in Japan, the nest measures up to 45 cm in diameter. Within the linked-pearl nest, there are four riders hunting a lion, and horses are branded with the Chinese characters "山" and "吉". In Dulan, Qinghai, the "large linked-pearl nest with paired tiger" brocade, "large linked-pearl nest with lion hunting" brocade, "large linked-pearl nest with tiger hunting" brocade were unearthed. The manufacturing process for those tapestries are very delicate, using weft patterns, and the nest circulation is large, and the focus of imitation. There is a category of the smaller linked-pearl nest, for example, paired horses, paired sheep, paired phoenix, paired peacocks and etc., uses warp pattern, but with substantial change in style.

The digestion process is actually the process of change. For pattern, the linked-pearl pattern is still used, but with changes. Also a skillful treatment is made and the theme pattern replaced. A prominent example is the "small nest, linked pearl and small flower" brocade and "medium nest paired pearls and paired dragons" damask.

Pattern of "small nest, linked pearl and small flower" brocade was found in many places around the country, including Turpan, Dulan, Shosoin and Soviet Central Asia. However, the most amazing is the numerous "linked pearl and small flower" patterns painted in Dunhuang murals and the painted warrior figurines in

Fig. 76 Damask with nest of linked pearls and paired dragons

the Tomb of Prince Yide in Shanxi. Most of Dunhuang murals were completed in the Sui Dynasty and early Tang Dynasty, and Tomb of Prince Yide (706) belonged to the mid-Tang Dynasty. The brocade patterns adopt staggered arrangement, with small flower groups within the circle of linked pearls and ten flowers without it. However, the variations are quiet rich and color changes even more complicated. From a stylistic point of view, the linked-pearl pattern has retreated to a position that is not very noticeable, but the whole picture is more like grouped flowers. It should be noted that the kind of tapestry has clearly adopted jacquard technology exactly as used in future generations. And undoubtedly this technology is a typical Chinese technology.

Now let's take a look at the Damask with Nest of Linked Pearls and Paired Dragons (as shown in Fig. 76) popular in the Tang Dynasty. This type of damask was popular far and wide. Samples were unearthed in Dulan and Turpan and Shosoin also handed down many pieces. The most famous one, unearthed in Turpan, had an annotation of the first year of Jingyun, and the annotation indicates its origin as Shuangliu County, Jiannan (now Shuangliu, Sichuan). This annotation confirmed that this type of damasks had been popular in the mid-Tang Dynasty. We do not have to discuss the dragon theme or the significance of its combination with linked-pearl design. We have only to take a look at the changes in the nest ring, which includes linked pearls, double linked pearls, linked petals, curly grass and etc. to learn the ingenuity of weavers in re-creation and reprocessing during imitation.

Further localization of linked-pearl pattern is LingYanggong Patterns. Whenever they talk about the silk pattern of the Tang Dynasty, people will always relish in "LingYanggong Patterns": "Dou Shilun, styled Xiyan, Nayan, is the son of Dou Kang, Duke of Chen. He was originally consultant of Prince Qin (later Emperor Taizong of the Tang Dynasty), military consultant of the premier. He was an ingenious man. When he first started create silk patterns, he had the honor

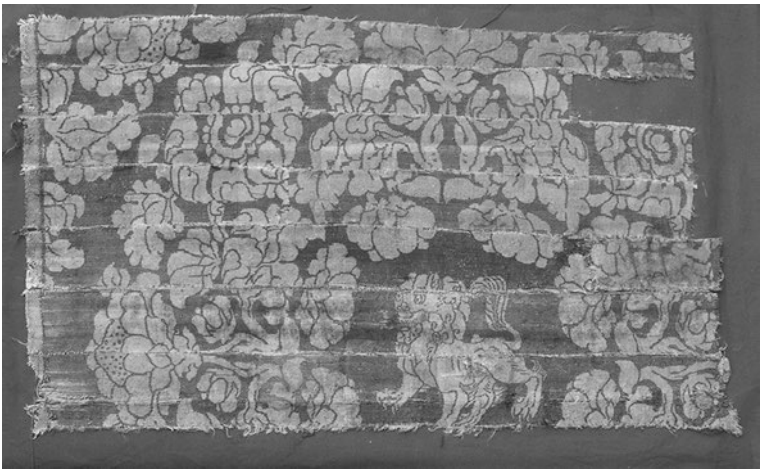


Fig. 77 The brocade with patter of nest, precious flowers and standing lions

of accompanying the imperial carriage, and was thus made official of Yizhou, in charge of manufacturing affairs. The auspicious damask patterns created by him were elaborate and splendid, and were called Lingyanggong Patterns by the people of Sichuan today. In the time of Emperor Gaozu and Emperor Taizong of the Tang Dynasty, the paired pheasants, fighting goats, flying phoenixes and roaming deer on the brocade made by the internal office were created by Dou Shilun, and were handed down as of today." This text tells us that: Dou Shilun once designed the patterns for brocade and damask submitted as imperial tribute in the early Tang Dynasty, and formed a certain style called "LingYanggong Patterns". This kind of patterns could still be seen when Zhang Yanyuan (ca. early Dazhong years, 847) wrote "*Notes on Famous Paintings of the Past Dynasties*". According to our research, the combination of garland nest with animal patterns is probably the model of LingYanggong Patterns.

The nest garland used in Lingyanggong Patterns can be divided into three types. The first is the combination ring, for example, the above-mentioned damask with pattern of nest, dual pearls and paired dragons also counts as a combination of two different linked pearls. Subsequently, petals plus linked pearls, curly grass plus linked pearls, curly grass plus flowers (flower plus beads) and other variations came along. It is the kind of LingYanggong Pattern closer to the linked pearl nest pattern. The second is curly grass garland. The pattern described in the Tang Dynasty verse "pomegranate in full blossom, like the skillfully arranged patterns in the brocade". There are many actual instances. Although the "nest, grape, standing phoenix" brocade found in the cave holding scripture depository in Mogao Grottoes in Dunhuang had been broken (as shown in Fig. 77), the garland can still be recovered, and the standing phoenix also could be seen roughly. The third adopts bud-shaped precious flower pattern in making the garland, which has three categories, that is, with the bud visible, hidden, and half visible. The theme pattern

has rich variations, and involves, from the physical point of view, phoenix, mandarin ducks, dragons, lions, birds, deer, peacocks and etc., mostly images familiar and favored in the Chinese tradition.

3.5.4 Lion and Eagle Design on Gold Brocade

In the Mongolian Yuan Dynasty, the exchanges between Europe and Asia reached an unprecedented peak, and results in exchanges between Islamic art and Chinese art were very conspicuous. Fabrics unearthed in this period included not only textiles with the style of the Central Plains, but also many products of Western-style produced in the Central Plains. Most of these products featured eagles, lions, Griffin, auspicious beasts and other large beasts or birds. "*The Catalog of Sichuan Silk Brocade*" included quartet golden eagles, lion pack, sitting elephant and other Western-style patterns. Many cases of eagle patterns are found on the Silk Road, witnessing the existence of cultural exchanges between the East and the West.

Eagle patterns had emerged in the Tang Dynasty, and most of them were in the form of ribbon-holding birds, with Central Asian style. In the Mongolian Yuan Dynasty, eagle pattern basically inherited the style of the Tang Dynasty, and often featured paired eagles. Brocade with such patterns were found in Inner Mongolia. Museum of Arts and Crafts of Berlin, Germany, and Krefeld Textile Museum now keeps the famous "gold brocade with black-texture and paired parrot" (as shown in Fig. 78). In the wings of parrots, Persian texts were woven. This is the more common symmetrical form. The double-headed bird patterns were originally common in Western fabrics, and a large number of instances could be found especially in tapestry collections of the tenth to thirteenth century in Europe. In the gold brocade of the Mongolian Yuan Dynasty, there were a large number of similar patterns. Cleveland Museum now keeps two large pieces of Gold brocade from the Yuan Dynasty, and the central themes are the double-headed bird. One of them is red-backgrounded gold brocade, featuring a double-headed bird on cirrus clouds. The other is originally red backgrounded, but has now become black backgrounded, brocade with pattern of petal nest and paired beasts, beyond which there is the pattern of a double-headed bird. The double-headed birds on the two pieces of fabric have one thing in common, that is, with one claw grasping a dragon head. This is very important and typical model of double-headed eagle in Central Asia.

There is yet another eagle pattern featuring eagles arranged in a symmetrical array or single queue, marching toward one direction. Take for example the famous gold brocade Buddha Garment kept in Beijing Palace Museum. Although the majority of the garment bespeaks that it is a product of the Ming Dynasty, the section of eagle pattern brocade on the ornament indicates that it can be a product of the Yuan Dynasty. Of the eagle patterns on the garment, one row marches left and the other row marches right. The layout is significantly different from the other eagle pattern. Another example is the brocade hood with paired eagle pattern unearthed in Mingshui Tombs in Damaoqi, Inner Mongolia. This hood has also adopted eagle patterns in symmetrical rows, and opposing eagles in pairs. This style is quite different from the pattern of eagles standing back-to-back and turning around to face each other.

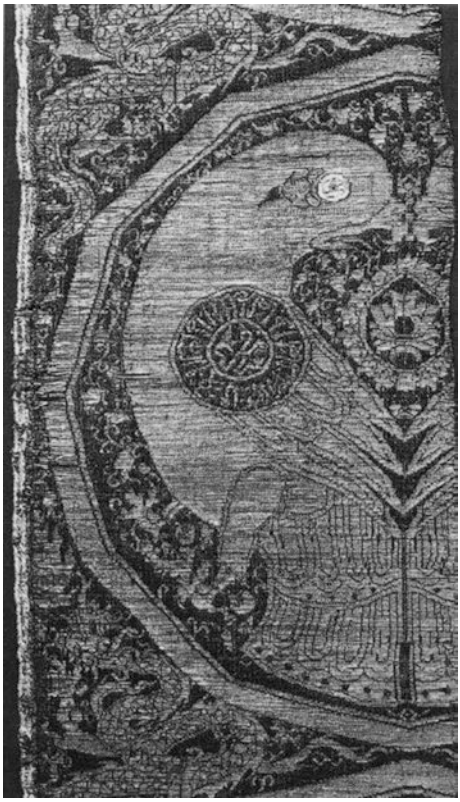


Fig. 78 Gold brocade with paired parrot pattern of Yuan-dynasty

In addition to eagle, paired beasts are also popular in the pattern of gold brocade, especially Sphinx with human face and lion body and Griffin with an eagle beak and beast body. A sphinx pattern (as shown in Fig. 79) unearthed in Mingshui Tombs in Damaoqi, Inner Mongolia is also a typical Western theme. A similar model is also frequently seen on Iranian pottery and bronze mirrors of the Mongolia era in Central Asia. A more typical lion pattern can be found on the black-back-grounded gold brocade with pattern of nest, paired lions and paired Griffins. The brocade is now kept in the Cleveland Museum. In the nest, the paired lions are doing back-leaps, presenting a very supple and robust image. This style of posing back-to-back and turning around to face each other is roughly the same as that of the above mentioned paired birds. On gold brocade of the same period, paired Griffins and other themes can be seen. Paired leopard pattern is seen in the above-mentioned black-back-grounded gold brocade with petal nest and paired beasts that is kept in Cleveland Museum. On the tail of each leopard, there is a dragon head, as typical of the Central Asian style. Paired Griffin patterns can not only be seen beyond the nest circle on the aforementioned "black-texture, paired nests, paired lions and paired Griffins" gold brocade, but also be found on gold brocade unearthed in Yanhu Ancient Tombs in Xinjiang as well as a large number of gold brocade of that period. (colored picture: "red group nest, paired Griffins" gold brocade, Yuan Dynasty, kept in Mongol-Yuan Culture Museum). In addition, on the

Fig. 79 Gold brocade with lion-body human-face pattern

color brocade, there are numerous patterns of Griffin, for example, the brocade quilt unearthed in the ruins of ancient city of Jininglu in Inner Mongolia, has adopted the Griffin theme which was once very popular in Central Asia (as shown in Fig. 80).

3.5.5 Chinese Style and Foreign-Flower Pattern

In the seventeenth and eighteenth centuries, with the overseas trade along Eastern route becoming increasingly busier, a lot of luxury goods in China were shipped to European countries, with tea, silk and porcelain as the bulk commodities. The exotic silk and porcelain patterns brought about the visualized fantasy of the Chinese Empire. Coupled with the information disclosed in the letters of the missionaries preaching in China, and the rendering of Western businessmen doing business in China, the fantasy materialized into a surge of zeal in Chinese luxury good sweeping across Europe. This is the "Chinese style" in the decorative arts.

"Chinese style" is called "Chinoiserie" in French. As an art deco style, it first appeared in the seventeenth century. In the mid-eighteenth century, it witnessed prominent development under the advocate of the French court of Louis XV, spreading rapidly to the rest of Europe. It is worth noting that "Chinese style" is different from the decorative style of goods made in China. It is not a direct imitation of Chinese decorative style, but a elegant, gorgeous and exotic decorative style, produced by taking the distant and mysterious Chinese kingdom as the

Fig. 80 Gold brocade with lion-body human-face pattern

source of inspiration, selecting certain Chinese elements (characters, backgrounds or items) as materials, processing them via the rich association of the Europeans, and combining them with their traditional composition methods. Many decorative historians believe that the Rococo decorative style, which was popular in the French court and the rest of Europe, has a manifestation of the "Chinese style".

The "Chinese style" in the European silk is mainly reflected in the eighteenth century in France, and Lyon, Doyle, Paris and other cities are the production centers of such silk fabric. Back then, the Rococo style rose, and Art Deco designers combined the delicate gorgeous Rococo Art with the Chinese style in the imagination of Europeans. Therefore, Chinese characters wearing robes, richly ornamented towers and pavilions, beautiful rural scenery, wind, flower, snow, and moons in the four seasons, and other Chinese themes appeared in large numbers in the French silk products.

The first manifest of "Chinese style" in the textile sector was in tapestry, including wall blanket and embroidered tapestry. London's Soho tapestry and embroidered tapestry in the late seventieth century early eightieth century reflected the Chinese style, later the two French tapestry factories Gobelins and Beauvais produced after the 1720s a series of large tapestries featuring Chinese themes, exerting a significant impact on contemporary silk patterns. French silk fabrics first demonstrated oriental influence in "exotic pattern", but the influence was not obvious. The so-called exotic pattern was a singular pattern with abstract themes and was quite popular between 1795 and 1815. By about 1840, in France there appeared in a concentrated manner a batch of silk fabrics with "Chinese style". Among them, those produced in Lyon were especially exquisite, and became typical of "Chinese style" in the era of Louis XV in France.

The glory of Chinese-style silk fabrics in Lyon can be attributed to the famous French pattern designer Jean Revel. Jean Revel was also a painter, good at depicting flowers, but known for design of dyeing and weaving patterns. His major contribution is the invention of color shades gradient seepage weaving method, which makes possible natural blooming effect, and silk flowers vivid as those in paintings. He also invented the "coordinate paper design method", that is, marking weaving points one by one in coordinate paper, so as to warp or weft patterning. This method is of great significance in the history of fabric design. The invention of this technology makes it possible for silk patterns to manifest lifelike images, and for the pursuit of painting-like effect. In response to the fashion of the society, dyeing designers in Lyon sought inspirations from the works of artists famous for displaying the Chinese themes, including Boucher and Jean Pillement. Jean Pillement is especially worth mentioning in that he directly designed patterns for Lyon silk, resulting in a large number of outstanding Chinese-style silk patterns. The patterns featured the life of the Chinese people, who are depicted as wearing Chinese robes, taking a walk, or enjoying tea, or chatting, or angling, all in a leisurely manner. The characters and scenes were often placed in the beautiful gardens of China, with towers and pavilions, exquisite pagodas, grotesque rockery caves and palm trees arousing fantasies coupled with umbrellas, shells, Chinese appliances and a variety of strange birds and animals symbolic of the Chinese, producing strong exotic feelings. The composition follows the tradition of the West, with combination of flowers supported by diamond-shaped skeletons and Chinese elements, and unique water surface plus floating islands.

Among "Chinese-style" works produced in Europe, there is a variety in direct imitation of the Chinese traditional patterns. The subject matters of such patterns include dragons in the cloud, flowers, birds, bamboo growing among rocks, etc. With expression techniques are close to those in Chinese silk products, they were sometimes taken for the authentic Chinese products. In the Palace Museum, there is a piece of "acid blue rib background with bamboo leaves" silk, identified and kept as a Chinese product. Seen from the point of fabric patterns (bamboo twigs and bamboo leaves), color (light acid blue), organization (plain background with warp-floated pattern) and structure, it may be regarded as a work of the late Qing Dynasty. However, upon close observation, we can see on the back of the cloth a light purple mark (in which Stamp Pad, instead of Chinese inkpad, is used). Surrounding the duck trade mark, there is the text of "Registered Trade Mark, L Permezel and Cie, Lyon, Yards86". This shows that the fabric has been a product of Lyon, France. I do not know how did it enter the court and replace "the imperial appliance". The difference between the patterns of Chinese-style, the first category, and the Chinese patterns is that the former is relatively rough and perfunctory. Exquisite brush flower-and-bird pattern was sometimes expressed as sketch-style single-outline flat-color.

In addition to localized production, from the seventeenth to the eighteenth century, European countries ordered from China a large number of customized Chinese-style silk fabrics, jacquard patterns, printed patterns, and manual paintings, via the mode of sample processing. Then, according to the fashion of Europe, European designers were commissioned to design the patterns, and Chinese craftsmen to

process and produce the final product. Kept in the Palace Museum there is a color woven satin with large flower pattern, which can be seen in the British theatrical costumes of eighteenth century, and the colors are also very close to the British original. Similar fabrics are also kept in Switzerland, the United States and other countries. However, it is inappropriate to consider them Chinese products, which are vastly different from European products mainly in weaving techniques and the width of the fabric. Thus they are considered as woven fabrics exported to Europe.

Among export Silks, there are hand-painted works. These fabrics, mostly from Suzhou, Hangzhou and other places, were shipped to Guangzhou for painting patterns popular in Europe via hand-painting in workshops there, and exported to Europe. Most of silk fabrics had light-colored or natural colored background, and mostly had chiffon and satin, plain weave fabric as the shell fabric. Most of the patterns are flowering plants. Some took the soft floral branches for skeletons, to be filled with bunches of flowers or images of Western ladies. Others took the curly ribbons for skeletons, which were embellished with Chinese artifacts that the Westerners were keen on (as shown in Fig. 81). Still others adopted overall single-flower pattern, using Chinese-style themes like rockery, flower beds and flowering plants.

Undoubtedly, during the Kangxi and Qianlong periods, there were large imports of European silk, particularly from France and Italy. Probably European silk had been brought to China by missionaries. In the objects kept in the Palace Museum,

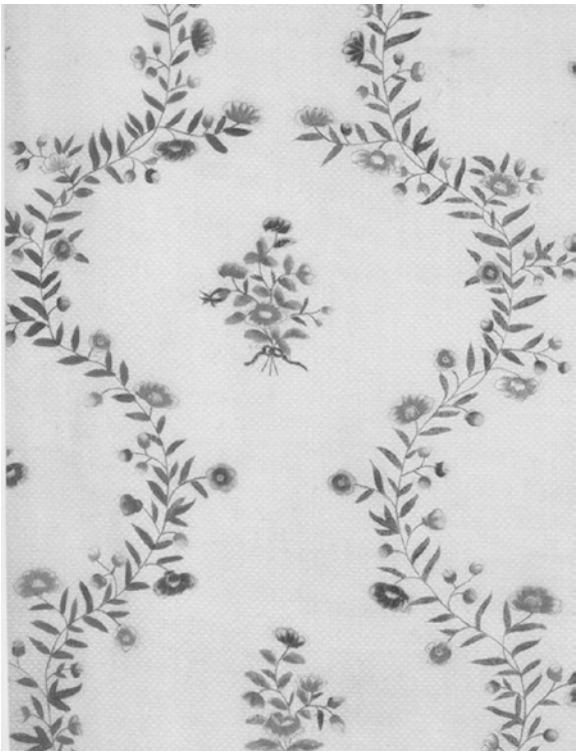


Fig. 81 Chinese-style painted fabrics with hand-painting in Europe

Fig. 82 Foreign-flower fabrics of the Qing dynasty

there are a lot of Qianlong-period fabrics with extremely strong Western flavor. For example, some feature roses. Upon comparison with similar designs made in France, we have found that those roses had been very typical of Western design, and the gold, silver line materials used, their organizational structure, and the design of light and shade effect had been unknown to Chinese silk fabrics. Therefore, they are undoubtedly products imported from the West. It should be especially pointed out that, some of the objects, are incorrectly considered to be gold-background fabrics, or regarded as Nanjing Cloud-pattern Brocade. The fact may have been just the opposite. It was the introduction from Europe a large number of silk products using gold that had inspired Chinese weavers, and that prompted the appearance of gold-background fabrics among Cloud-pattern Brocade. It was the influence of modern European art that caused China to slowly introduce three-dimensional effect in silk designs. Interestingly, a fabric kept in the Palace Museum is exactly the same as the saddle cushion of Emperor Qianlong in painting.

From the Yuan Dynasty onwards, foreign-flower patterns appeared on Chinese silk. They usually feature curly grass and large flowers: the flowers are large and color scheme special. In the Ming and Qing dynasties, such fabrics increased. After the mid-Qing Dynasty, foreign-flower patterns were increasingly used, featuring roses, morning-glories, China rose, peonies, lotuses and other large flowers, and transformations were made, for example, peonies were given pointed petals, and lotuses circular petals. They were different from Chinese tradition and were thus known as foreign flowers (as shown in Fig. 82).

References

1. Zhao F (2004) Jin, taquete and samite silks: the evolution of textiles along the silk road, China: dawn of a Golden Age (200–750 AD). The Metropolitan Museum of Art and Yale University Press, pp 67–77
2. Cultural Relics Administrative Office of Zouxian County, Shandong Province (1977) Briefing on clearing the Yuan dynasty tomb of Li Yu'an in Zouxian County. Cultural Relics 1977(7)

Author Biography

Feng Zhao born in Zhuji, Zhejiang in 1961 and was admitted to Zhejiang Institute of Silk Textile Technology in Spring 1978. In 1984, he received the Master Degree of Engineering from Zhejiang Institute of Silk Textile Technology and obtained his doctorate degree from China Textile University in 1997. He conducted visiting research in Metropolitan Museum of Art of New York during 1997–1998, in Royal Ontario Museum of Toronto in 1999, and in the British Museum in 2006. At present he holds the posts of deputy director and professor of Chinese Silk Museum, professor and doctoral supervisor of Shanghai Donghua University (the former China Textile University), member of National Commission for Cultural Relics Identification, director of International Center for the Study of Ancient Textiles (CIETA), Deputy to the 11th National People's Congress.

Works: The General History of Chinese Silk, A History of Chinese Silk Art, Textiles From Dunhuang etc.