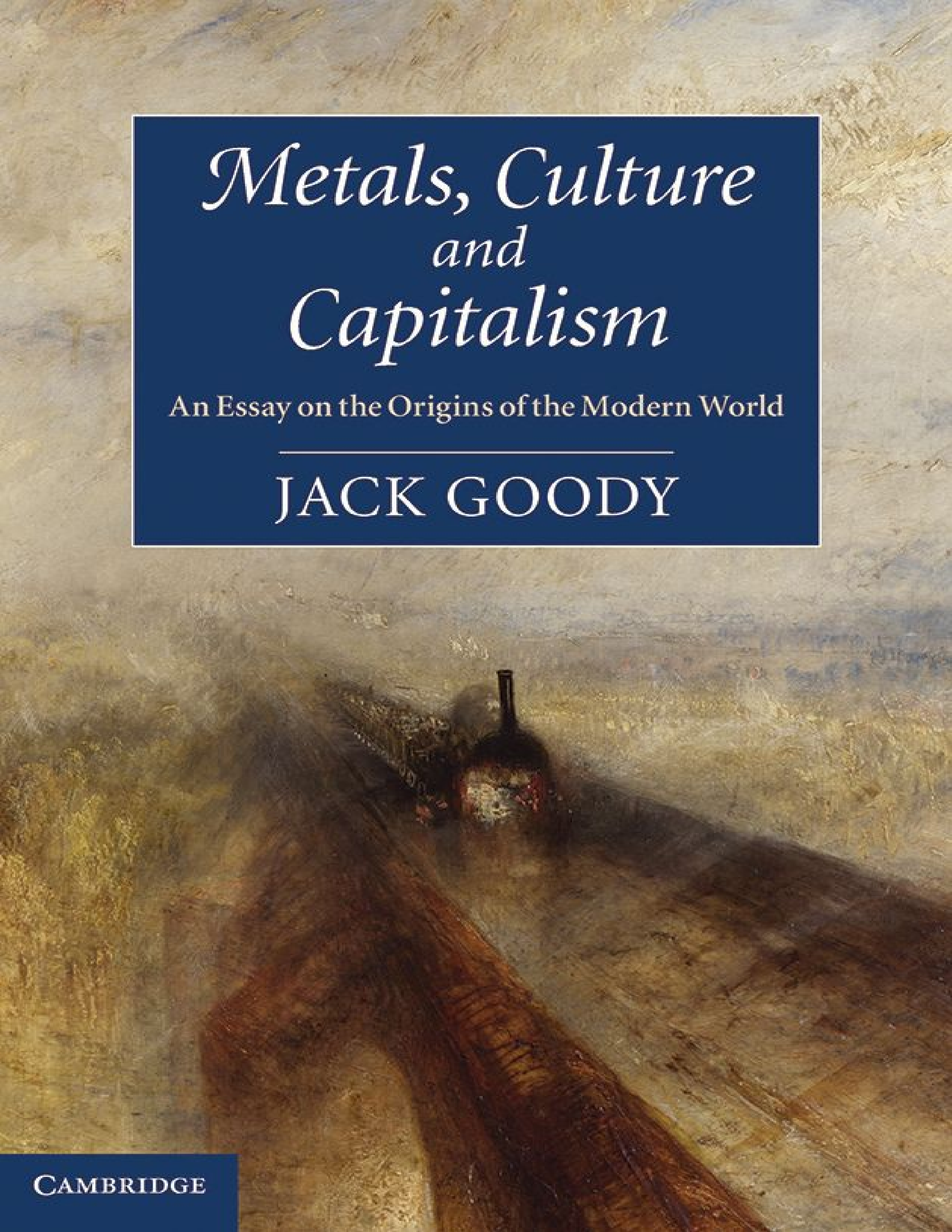

Metals, Culture and Capitalism

An Essay on the Origins of the Modern World

JACK GOODY

CAMBRIDGE

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Metals, Culture and Capitalism is an ambitious, broad-ranging account of the search for metals in Europe and the Near East from the Bronze Age to the Industrial Revolution and the relationship between this and economic activity, socio-political structures and the development of capitalism. Continuing his criticism of Eurocentric traditions, a theme explored in *The Theft of History* (2007) and *Renaissances* (2009), Jack Goody takes the Bronze Age as a starting point for a balanced account of the East and the West, seeking commonalities that recent histories overlook. Considering the role of metals in relation to early cultures, the European Renaissance and 'modernity' in general, Goody explores how the search for metals entailed other forms of knowledge, as well as the arts, leading to changes that have defined Europe and the contemporary world. This landmark text, spanning centuries, cultures and continents, promises to inspire scholars and students across the social sciences.

JACK GOODY is Emeritus Professor of Social Anthropology in the University of Cambridge and a Fellow of St John's College. Recently knighted by Her Majesty The Queen for services to anthropology, Professor Goody has researched and taught all over the world, is a Fellow of the British Academy and in 1980 was made a Foreign Honorary Member of the American Academy of Arts and Sciences. In 2004 he was elected to the National Academy of Sciences and he was elected Commandeur des Arts et Lettres in 2006.

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CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9781107029620

First published 2012

Printed in the United Kingdom by the MPG Books Group

A catalogue record for this publication is available from the British Library
Library of Congress Cataloguing in Publication data
Goody, Jack.
Metals, culture and capitalism : an essay on the origins of the modern world / Jack Goody.
pages cm
Includes bibliographical references and index.
ISBN 978-1-107-02962-0 (Hardback) – ISBN 978-1-107-61447-5 (Paperback)
1. Metallurgy–History. 2. Metallurgy–Social aspects–History. 3. Metallurgy–Economic aspects–History. 4. Metals–History. 5. Metals–Social aspects–History. 6. Metals–Economic aspects–History. 7. Civilization–History. 8. Civilization, Modern–History. 9. Capitalism–History. 10. Commerce–History. I. Title.
TN615.G66 2012
669.09–dc23
2012015669

ISBN 978-1-107-02962-0 Hardback
ISBN 978-1-107-61447-5 Paperback

This book is dedicated to the Master and Fellows of St John’s College on their five hundredth anniversary (2011) for the help so many of them have given me, now and since I came up.

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Preface

Mining is a highly dangerous occupation, involving its workers spending many hours underground in 'inhumane' conditions, subject to falls of tunnels and to the invasion of gas or of water. It is work that free men rarely wanted to do and so the Pharaohs found slaves and convicts to go there. In later times, men were forced to do this, either for money or also because they had no land, no other job. Mining has virtually disappeared in Britain (and Europe) during my lifetime and the search for metals has been largely transferred to 'developing' countries, just as in the early days Europe was the continent to be plundered, and 'developed' in the process. This book, which is an account of that search, is humbly dedicated to these miners, who formed their own community, as the work of Clancy Segal and of Slaughter and Henriques has brought out.[1] While my own trajectory led me to a different, and more comfortable, existence, my life has been much influenced by the Hunger Marches of the miners of my youth, by my serving in a regiment of Nottinghamshire miners in the war, by friends as 'Bevin Boys' on my return, by the work of the Tavistock Institute in the coalfields after the war, of the political activity of workers in the Fife coalfields, and by the attempts of Arthur Scargill and others to fight to keep the industry in this country.

This work was written because various scholars from abroad (including those at the Muslim College) had asked me to contribute a lecture for them and for CRASSH, the Centre for Arts and Humanities at Cambridge, so they could link their European studies with their homes in the east; but in the end I gave something different and got down to writing the book.

So it is about the development of society in Europe and the Near East from the Bronze Age on, when the urban civilisations had little or no metal and therefore had to search among other peoples and in other places. And so the situation remained in the Near East. But the fact that the book is largely about metals should not make us forget the other aspects of urban civilisation, the spread of literacy and of written religions. All these are linked together and it is a mistake completely to separate off the two spheres, as so many do, both scientists and humanists. Given the frequent use in the humanities of the dichotomy between sciences (and technology) and the arts (and communication), I must stress that I am not seeking to exclude one or the other (nor yet the religious or the secular) but to trace the connections in a rounded (anthropological) view.

I have not given as much attention to China and the east, nor yet to the Americas, as I should have done, but my reason is that I began with the question of Europe and the Near East – and that remains very much the focus. The former did develop an Age of Metals, possibly stimulated by the Near East but with a different history until recently. In Meso-America similarities existed at the level of urbanisation but metallurgy as distinct from metal-working (in gold) was little advanced before the coming of Europeans.

I am aware that arguments have gone on about the 'diffusionist' approach; in an essay Wengrow writes of 'the collapse of diffusionism' and offers an 'interactionist' approach instead.[2] Rather than drawing a line between 'civilised' (Bronze Age) and 'barbarian', he himself prefers 'interactionism' and would rather make a distinction between 'archival' and 'sacrificial' economies, the first associated with a complex administration, the second not. I can see some tendencies to different uses that can be so described but nothing like a dualism. One does not exclude the other. In looking at metals, we have almost certainly to take a modified 'diffusionist' approach, which is not the answer to every question and certainly does not exclude local invention. In the Early Bronze Age cultures, we find 'sacrificial' hearths although the use of metals was present in warfare and in peace; there is nothing contradictory here.

I have concentrated upon iron as it seemed to have the most immediate consequences for the history of long-term development. But this has meant a certain neglect of the precious metals which have been so significant for the exchange and booty economies, and which were often mined together with others – not so much with iron which was usually plentiful on or near the surface, but with copper and lead. And the search, in which I am especially interested, often took place more for them than for those of the less valuable, more utilitarian kind.

I have consistently used the themes 'civilised' and 'barbarian', in a technical archaeological way. I do not wish to indicate a permanent, mental difference. That my work on writing would immediately discount. When he came to London, my colleague, Kum Gandah, who helped collect and translate the later versions of the long Bagre myth of the LoDagaa, became a computer expert and statistician as the result of his schooling. The transition was quite comprehensible and the situation entirely contextual; he (and to some extent I) could operate in both modes. The terms refer to ways of living.

So, stimulated by students from Asia, this book began as an attempt to bring closer together their work and interest in Europe and the Near East and the other countries they came from. The Bronze Age had always fascinated me as a focus for a balanced account of the east and the west, a common origin rather than the divisive versions of many recent historians. Comparative advantage was to be found in both at different times. But in exploring the early lead of China in metallurgy, paper, printing and other fields, one also wanted to account for the later achievement of Europe, both economically and intellectually (for they do intersect). This could be best done by concentrating on the fact that the Bronze Age civilisations had few indigenous metals and that those had to be searched for among the ‘barbarians’ at the ‘periphery’, a process that eventually led to their own advancement. Europe was one of those latter areas, inhabiting the ‘Eurasian metallogenic zone’ formed by the clashing of tectonic plates. It continued to be a source of metals for the Near East, although most trade disappeared after the decline of the Roman Empire. That was especially so when Venice took up the role of intermediary between the Levant on the one hand and the Germans and others to the north, who had specialised in iron-working since the Hallstatt period – and in copper before that. This renewal of the exchange of metals for Asian ‘luxuries’ led to the spectacular achievements made in Europe during the modern Iron Age, particularly in later medieval and subsequent times, eventually leading to what we know as the Industrial Revolution. That change included the achievements in the realm of knowledge, in the arts, which were now able to expand in a secular direction as the result of their release from Abrahamistic hegemony, as well as in the use of metals. Many of the prerequisites of those developments, of gunpowder and cast iron, as well as of porcelain, the compass, of silk textiles, first took place in China – as did much early science. A considerable contribution was also made by other written civilisations. But my question here is different. How did Europe itself take off after the Renaissance to produce what has been called ‘capitalism’?

What especially interests me here is the role of metals not only in relation to early cultures but to the European Renaissance and to ‘modernity’ in general. The search for those materials entailed one for other forms of knowledge (including those about the underworld and even the other world) as well as the arts, leading up to the changes that have occurred in Europe and the contemporary world.

I start with the Bronze Age area that was so central to the beginning of civilisation in the sense of the culture of cities. It also saw the invention both of writing and of the plough. But the river valleys where it occurred had no copper to make the bronze nor did they have other metals. These had to be sought from the dwellers in the hill country, the ‘barbarians’ who, in the course of this search for and supply of metals, changed their way of life.

Literacy was all-important in this exchange that developed, inside between the urban centres and the plough farmers, outside with the ‘barbarian’ hill tribes, in the first place as a record-keeping device. Subsequently it became a tool for more complex language use and spread in all directions as the search for metals extended further into the Mediterranean, the Eurasian plateau and into Europe, not only to the centre but also to Spain, and to the west, as well as to Greece and subsequently Rome. But that expansion was in the Iron Age, when the production of the metal largely centred on southern Germany and Austria. The collapse of the Empire in the west saw the decline of trade to the Near East, even though local iron-working continued, especially for swords and protective armour. However exchange with the east, for its spices, textiles and other ‘luxuries’ was virtually discontinued, not to be restarted in a major way until Islam, Byzantium and others took it up again in the new millennium. For in the Near East, exchange with Asia had never ceased and led to the development of a bourgeois culture that has been compared with later Italy. But the Near East was always short of metals at a time of increasing usage. Their metals came from various parts but mainly from Central Europe and the exchange of goods with the north was essential to the development of trade in Venice and other Italian towns. It was this activity that involved the birth of Renaissance culture and then to its extension to the north. The Germans had been experts in metals from the Hallstatt period and developed and transmitted that expertise. It was they who were called to Britain to modernise the mines and the whole production of metals so needed by Elizabeth in her struggle with the Spanish, who were themselves bringing precious metals across the Atlantic. The English industry, with its plentiful and available supplies of iron and coal (for coke) then took off with the help of German mining engineers and metallurgists as well as of local contributors. These resources the valleys of the Near East hardly ever had and

Europe took over the industries they had developed and brought them into the modern iron age.

In this discussion, I am pursuing the theme of the alternation, which was at the same time a spiralling, in the movement of the east and west towards 'modernisation', which constituted another view of Eurasian history, especially to those notions expressed in works written following the Industrial Revolution, the period of hegemonic European dominance. This was a sphere in which 'progress' was clear, unlike others, and it is the transfer of the notion to other fields that has so often blighted the consideration of the past. This and the failure to appreciate the common roots of the economies and cultures of Eurasia and their continuing interaction, as well as the to and fro movement in European as well as Eurasian societies, means that we need to discount much 'essentialist' history that assumes that 'modernisation' and 'capitalism' were inventions of Englishmen, or even Europeans, flattering to our egos as that idea has been.

In this piece I have covered a long period of time and will undoubtedly have got some things wrong, although I hope my references will usually bear me out. On few, perhaps none, of the subjects am I expert, but the expert does not always see the wood for the trees. One reason for my taking a long time-span is that historians have taken a much too restricted view of their subject and this has prevented them from going back to the commonalities which join us both to the Near and the Far East of what is essentially one continent. For this reason I would question the history cultivated in part of that region, in Europe since the eighteenth, but especially the nineteenth and twentieth centuries when the west led the way in many things. They emphasised the development of 'capitalism' as a new mode of production in Europe (an idea not limited to Marxism) and have therefore overlooked the commonalities of which I have spoken. Undoubtedly something happened in the west in the 'modern' period but this development should be seen within the context of 'alternation' and of the occurrence of similar activities in other parts of the world. If I have moved around chronologically, it is partly to emphasise the process of development over the long term, of the similarities in many respects of accountancy, trading and exchange, as with early eastern colonies in the western Mediterranean, of Europeans in the east, and of the foundation of the Turks in Vienna. These were structural similarities which over-ride considerations of time or place.

I have tried to take the analysis up nearly to the present day in the belief that anthropologists (and prehistorians) do not explicitly consider the relationship of what they do to the contemporary world and that historians (and sociologists) rarely look far enough back or beyond their own shores. So it is an attempt to counter those approaches from the angle of the social (and broadly human) sciences.

The general approach has some political implications in the context of contemporary life. It means that ‘capitalist’ or ‘socialist’ no longer define alternative political systems. Most economies are ‘capitalist’ in that they involve exchange, accumulation and all that that implies. All such systems are also influenced by some social considerations, although this occurs in varying degrees. So all political programmes are composite in this sense, with varying emphases in one tendency or another, in particular on equality or differentiation, both aspects of all systems.

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[1] See Segal 1960 and Slaughter and Henriques 1956.

[2] Wengrow 2009.

Acknowledgements

In writing this book I realise how much I have come to depend on others, especially owing to my age. For the manuscript, I have had enormous help from Melanie Hale and Mark Offord who have to decipher my handwriting, then there is support from Susan Mansfield in the College Office of St John's and Peter Hutton in the Library, Dora Kemp in the McDonald Institute (for the maps), together with the porters and staff of the College, and that of the mairie of Bouzigues as well as A. Mertens of Micro 34. There are a considerable number of colleagues at Cambridge and elsewhere, especially the late John Alexander, Mauro Ambrosoli, Graeme Barker, Hélène Bras, Christian Bromberger, Pat Boyd, Peter Burke, Jim Charles, Peter Garnsey, Ariane Gastambide, Richard Goody, Chris Hann and his students, Charles Higham, Deborah Howard, Stephen Hugh-Jones, Gilbert Lewis, Peter Linehan, Jo MacDermott, David McMullen, Vanessa Maher, Preston Miracle and his students, Basim Musallam, Mark Nichols, Jean-Marie Privat, Xavier Ribes, Colin Renfrew, Jacques Roman, Ulinka Rublack, Richard Tapper and Tony Wrigley. Their help has been especially important in the many fields in which I am certainly no 'expert'. I am also grateful to Peter Goddard and the members of the Institute of Advanced Study at Princeton for giving me such a pleasant place to complete the manuscript in early 2011. Then there is the debt owed to my former students, Cesare Poppi of the Veneto and Paul Sant Cassia of the University of Malta. But especially thanks go to Juliet Mitchell, who started me off and wanted me to turn what began as an essay into a book. So here it is. She lived for better (and worse) with it from start to finish, reading every word. Meanwhile there were other family to keep me going and encouraging me in various ways, Jeremy, Joanna, Jane, Mary, Rachel and Polly.

I am also grateful to libraries for help with the project, to Mark Nichols of St John's, to John Reynolds, Lizz Edwards-Waller and the University Library, to Aidan Baker at the Haddon Library, to Kirstie Venanzi, and others at the Institute at Princeton, who have all helped me get at their treasures despite my limited mobility. And thanks to all those involved in publishing, distributing, yes and in reading the manuscript. I have been helped with references by many colleagues at St John’s and elsewhere, and I am sure there are others. I have received help from Richard Fisher and his colleagues, especially Lucy Rhymer, at Cambridge University Press as well as the readers and editors supplied by them who have made many helpful suggestions.

In this enquiry I have not only been dependent on many friends and relatives but also especially upon several central books, on Gordon Childe’s *What Happened in History* and subsequent works, on David Clarke’s account of trade in prehistoric Europe, on Ashtor on the economy of the Near East, on Agricola for activities on mining, on Lane and Braudel for contacts of Venice with the North and East, Klingender on the Industrial Revolution,[1] on Tylecote and Aitchison on metallurgy in general, on Chernykh for Eurasia, on Needham, Wagner and Barnard for China and on the various other references that I have used in earlier books.

But above all I remember the earlier help of my mother, Lilian Rankine Goody of Turriff (she always retained her maiden name) and of my father, Harold Ernest Goody of Fulham, both of whom left school at sixteen but developed their own interests in work and education and were so pleased when their two sons obtained sizarships and later PhDs (without loans) at St John’s College, Cambridge, later becoming Fellows of the college, as they also would have been when they both subsequently became members of the National Academy of the USA. It was they who introduced us to the College, to which I offer this book in its five hundreth year. It has not only educated me but has given me a room to work in as well as helping me in many ways to produce my work. I also thank my family past and present for their varied support and of those people, mainly women, who have enabled me to continue my work.

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[1] Who has an excellent description of the development of industry in Britain.

Chronology

c. 6000–4000 BCE	Chalcolithic period using copper
c. 3300–1200 BCE	Bronze Age in the Near East
c. 3000–1000 BCE	Bronze Age in India
c. 2300–600 BCE	Bronze Age in Europe
c. 2000–700 BCE	Bronze Age in China
c. 1500 BCE	Replacement of chariot by warhorse
c. 1500 BCE	High-fired stoneware in China
c. 1300–300 BCE	Spread of use of iron in the Near East
c. 800–600 BCE	China develops wrought iron
700–600 BCE	Hallstatt culture (first Iron Age in Europe)
500–100 BCE	La Tène culture (second Iron Age in Europe)
fifth century BCE	Heavy use of iron by Greece and Rome
c. 300–200 BCE	China develops cast iron
91 BCE	Earliest recorded blast furnace in China
55–54 BCE	First Roman invasion of Britannia by Julius Caesar
43–84 CE	Second Roman invasion and conquest of Britannia
c. 410	Withdrawal of Roman Empire from provinces begins, leading to reduction in the use of iron
c. 780	Revival of metallurgy in Europe
793–1012	Viking and Norse raids and invasions of Britain
ninth–seventeenth centuries	Prominence of Venice as a centre of international trade, importing metal from the north and exporting to the east
c. 1000	Large-scale mining of metals in Europe resumes
c. 1150–1350	Possible making of cast iron by blast furnaces in Sweden
thirteenth–sixteenth centuries	Germany continues at the forefront of metallurgy and mining

1326	First cannon in Europe, using Chinese powder
1340	First blast furnace in Europe at Namur
thirteenth–fifteenth centuries	First water-powered bloomeries in Europe
c. 1454	The gun comes into general use in Europe
fifteenth century	Development of *Stückofen* blast furnace in Germany
1556	Publication of *de re metallica* by Georgius Agricola
1698	Thomas Savery in France invents the atmospheric steam engine
seventeenth century	Development of the indirect process of making wrought iron in Europe
1709	Abraham Darby smelts iron using coke
1722	Newcomen steam pump first used in mining
eighteenth century	Cast iron becomes widely deployed in England
1779	Building of the first cast iron bridge at Coalbrookdale
1784	Puddling process of iron production invented in England
1855	Bessemer process for making steel patented in England

PART I

Explorers

1
The Age of Metals in the Ancient Near East

Although the early stages of mankind are defined by the materials from which tools and other objects are made (stone, copper and its alloy, bronze, and iron), all derived from the earth's surface, we do not always think sufficiently about the effects that these materials have had on human life, especially metals in their distribution and in the technology of their production, let alone in their uses.[1] We speak of the Bronze Age which arose fully around 3000 BCE without giving sufficient thought to where that material came from – there was little enough metal on the riverain sites of the Near East where the 'age' originated. Nor do we think that, in speaking of the Iron Age, it was not the discovery of iron, which was known long before, but its widespread use by the Hittites and urban societies of Crete, Greece and Rome that marked the beginning of its effective influence. And even then there was all the difference between the simple iron-making found earlier on and which diffused throughout Africa, and that which developed in Eurasia, especially in India, in China and later on in modern Europe.[2]

The Bronze Age in most cases was preceded by the Chalcolithic, the Copper Age, which used the same metal but mostly in its 'raw' state, often without any casting, but worked by hammering. The question of the origins of metallurgy in the Old World (see Appendix 1) has been much discussed and a recent study concludes that this began around the eleventh to ninth millennium BCE in South West Asia due to 'a desire to adorn the human body . . . using colourful ores and naturally-occurring metals'.[3] That may well be the case; experimentation with coloured stones was certainly important. But what is more important for human history is the deliberate use, the casting or manufacturing of metal tools and weapons, which had so many implications for the creation of complex cultures. That aspect seems more closely linked to the use of kilns for pottery and eventually to the control of fire. Not that beads were without such implications but if they could be said to have 'developed' at all, it was not in the same way or with such important results for the human race.

However, this was a very significant period in human history, as a prehistorian notes: 'During the thousand odd years of the Chalcolithic', he declares, people made 'many discoveries pregnant with revolutionary consequences – the metallurgy of copper and bronze, the harnessing of animal motor power, wheeled vehicles, the potters' wheel, bricks, the seal.'[4] These achievements were not technical alone but also intellectual and cognitive. Even before 3000 BCE they were spreading from the Near East not only to the Aegean but to India: 'In a thousand years they would reach China and Britain.' In this chapter I want to look at the great extension of metal-working from its beginning in the Near East and the search for metals in Europe, as well as with some of the many consequences, one of the major transformations in the history of humanity.

The first food producing societies were to be found earlier in the Near East but they lacked the control of heat for pottery, being known as the pre-pottery Neolithic. In East Asia, pottery long preceded settled agriculture and in the west permanent human settlement had begun even before food production. Sedentarism was seen at Ohalo in Israel about 20,000 years ago but the first permanent settlement was in sites like Jarmo in Kurdistan, an agricultural village where the change to the new way of living took place around 8500–6500 BCE. The production in place of the collection of food by humans also meant the gathering together of animals that lived on their detritus or under their protection, that is, not only domestic animals like cats and dogs that were deliberately fed by them but also rats and in parts foxes and rabbits that consumed the droppings, as well as birds like gulls and sparrows that profited from what they cultivated or collected. The production of food also produced a surplus for gleaners and crop thieves.

Only in the later period did some pottery, including painted ware, appear in that area. A Neolithic pre-pottery stage existed at Jericho up to 5000 BCE. Grain was cultivated using stone sickles and stored in granaries, located in a town-like settlement. Pots were then produced with the clay dried in the sun or baked over an open fire. However painted pottery responds better to being fired in a closed container or kiln, and this pyrotechnology would later be a key for metallurgy.[5] Kilns were widely found in ancient Persia, one of the main areas that developed in the early Neolithic.

Some use of metals had already occurred in the Stone Age with the employment of natural gold for its 'glitter' and even copper as a form of malleable stone, largely for decorative purposes. Their further use began in the Near East around 8000 BCE. What then changed things was the employment of heat to work the metal by annealing in order to prevent cracking. It is the melting and smelting of copper from ore that marks the beginning of the Bronze Age,[6] and for this a forced draught was necessary to raise the temperature to 1084.5 degrees Celsius. ‘The melting and smelting of copper’, it has been rightly said, ‘was probably a result of the development of kilns for firing pottery’.[7] This controlled the fire for intensive heating.

However, fire was certainly not first used for pottery but for light (in caves), for heat, for defence and for cooking. Its importance in early human life has been emphasised by many commentators.[8] It was already used in the Palaeolithic for cooking the meat of wild animals and in the Neolithic for preparing that of domestic ones as well as for bread and other grain-based products, and subsequently in kilns for pottery; the ovens for smelting metal were a subsequent development.

This use was not discovered in the highly fertile valleys where the Bronze Age flourished but by the dwellers in the hills nearby. In the Chalcolithic period, say from about 6000 to 4000 BCE, the lowlanders exchanged their surplus Neolithic grain from the richer valleys with the products of highland metal-workers. During this long period they learnt to work ‘stone’ by hammering free copper. Shallow mining for coloured ores (and paints) occurred in Hungary and Poland as early as about 35000 BCE, and for flints in Palaeolithic France and later in Belgium and Poland.[9] Copper could have been found this way and smelted as the result of heating colourful stones. As Charles,[10] the historian of metallurgy, spells out, arsenic could have been added to make a stronger material, leading eventually to its replacement by tin, perhaps because of the poisonous nature of the former, perhaps because of the gold colour of the latter. Finally there was the slow shift to iron in the Near East. However, in South East Asia, there was no shift from bronze to iron, for they were worked and used jointly, and the Iron Age saw a huge growth in the employment of bronze for ornaments. Save for two localised centres of bronze-working in Mexico and Peru, there was no equivalent development in the New World, Oceania nor, in most cases, Africa south of the Sahara until historic times, although simple iron-working spread widely from the Mediterranean.

The Chalcolithic, then, saw the development of smelting which was dependent on the furnace or kiln used for the pottery of the upper Neolithic.

The smelting of copper took place in double-tiered kilns which could raise the temperature for reducing blue malachite to red copper – and was also employed to make the glazes that required a greater heat than that needed for making plain earthenware. The process of smelting seems to have been first carried out in Susa in Persia south of the Caspian Sea where, then situated on the drier plateau above the Mesopotamian valley, farming had earlier been developed. At an early period farming cultures stretched from the Balkans to southern Afghanistan using similar forms of plastic art and the decoration of prestige pottery.[11] Before 3500 BCE most of the early metal objects themselves made from local supplies of copper were exported from there into the lowlands. From these drier areas metallurgy was transmitted not only to Sumer in Mesopotamia but to Harappa in the Indus Valley.

Both in Mesopotamia and in India recent research suggests that the classical Bronze Age cultures were preceded by a period of developing urbanisation – in Uruk in the Susiana plains of Khazakhstan[12] and in the pre-Harappan phase of the Indus Valley.[13] This work has emphasised the role of long-distance trade routes in this early period, linking up the alluvial valleys with the surrounding resource-rich areas, the Zagros–Luristan highlands in the first case, and those of Baluchistan, Afghanistan and Pakistan in the second. Exchange was nothing new, but with metals the increase was immense, and hence the communication between groups.

In Late Chalcolithic times we find a series of Uruk sites developed from southern Mesopotamia scattered along the trade routes in the northern Syrian–Mesopotamian plains that indicate exchanges between those sites and the local societies.[14] The position of some of their outposts, especially in the Zagros hills, ‘strongly suggests that highland resources were being exploited for the alluvial market’.[15] These resources comprised metals, especially copper in the Taurus highlands of Anatolia where the traces of smelting have been uncovered at this time,[16] near to the Ergani copper mines which possibly predated the Uruk enclaves in the north. The area south of the Taurus was very rich in copper and still is. That around Diyārbakir may have been ‘the home of metallurgy’; it is on the banks of the Tigris that the earliest copper objects, hammered out of natural metal, have been discovered coming from the late ninth or early eighth millennium.[17] But copper was also obtained from elsewhere; in the Iranian plateau, for example, where Uruk pottery has been found near an important metallurgical centre dating from the fifth millennium. Significant copper sources long existed at Sialk before the Uruk contacts. But while Uruk enclaves later controlled the flow of goods to the lowlands, the actual sources of the materials and the nearby access routes were held by 'indigenous communities that were willing to trade'.[18] Indeed the exploitation of copper took place 'well before the Uruk period',[19] although in a less complex context. In the valleys, copper was later imported to be transformed into bronze and used for weapons, for tools and for the plough; these were all products of an asymmetrical exchange with the metal producing areas which showed the advantage of the 'literate expansion' over the local Al Ubaid populations of 'barbarians'. But this was not only a one-way transmission. It is also important to emphasise that one of the difficulties with discussions of 'exchange' is that they often neglect this reverse process but even the content of the transaction in favour of an abstraction privileging a notional symmetry, as suggested by Marcel Mauss.[20] An exchange is not simply equal. The trade in pottery, so esteemed by archaeologists because of its preservation, has very different implications from the exchange of metals, which in the case of early iron may leave little trace. Nevertheless the implications are quite different. With iron one can conquer, with pottery one cannot. The importation of most metals, like the contemporary importation of oil, operated in a different way; these materials had little 'value' unless used in a more complex economy when they were highly dependent upon the technological developments of the latter which in fact created their original 'value' in the first place. The exchange is automatically asymmetrical but produces the wherewithal of growth.

Before the Chalcolithic the farming culture of the Neolithic had already spread westwards from the Near East to the Mediterranean, and from the Lebanon and Palestine north to Greece, the Balkans and the Pontic region, and south to the Nile delta (as well of course as going eastwards to India and to China). Some migrated to mainland Europe from Greece and the Black Sea, or travelled along the North African coast and eventually crossed into Iberia. Those that remained in that delta later developed the Chalcolithic culture of the Badarians, which was followed by that of the Amratians and then in about 3500 BCE of the Gerzeans. The latter smelted copper, built kilns for painted pottery and voyaged in the Mediterranean by sea, all practices that seem to have come from Mesopotamia. The following pre-dynastic period of 3250 to 3000 BCE used copper more extensively for both weapons and tools, and led directly to the dynastic Egyptians and to their construction of the

Pyramids.

The use of copper for tools and ornaments instead of stone (and sometimes of clay) involved the discovery of, first, its malleability, second, its fusibility, then, third, the possibility of its reduction from ore, and later, fourth, of its combination with alloys.[21] Copper itself may have first appeared as a superior sort of stone which could be sharpened to cut like flint but could also be bent, shaped by hammering or beaten out into sheets, as it was in early Mesopotamia, in Egypt and in recent times by the Columbian Indians of North America. When heated, it becomes as plastic as clay, even becoming liquid, so that it could be cast into a mould whose shape it took on when cooled; with working it then becomes as hard as stone, giving a good cutting edge. You did not simply 'sculpt' copper, as you did with some of the early metals, but like clay you could join pieces together, or more usually mould in a clay container, itself perhaps built around wax which the molten copper replaces, as in the process known as *cire perdue* or 'lost wax'. That method can produce objects in an unlimited number of intricate shapes, but so too could the ordinary moulding in China.

In the Old World copper was rarely found as a raw metal, but it can be readily produced by heating the ores called oxides, carbonates, silicates and sulphides, usually by means of charcoal made by burning wood in an insufficiency of air as in the covered heap of the *carbonier* or charcoal-maker. These ores do not look like copper but are brightly coloured and so would attract man's attention; and their preparation by heat would eventually lead to the reduction of other metals, silver, lead and tin. A further development was the combination of copper with another material to make it harder or more pleasing to the eye; the advantages of an alloy such as bronze were well understood. The Mesopotamian smiths were clearly experimenting with this and with a number of combinations.

The metallurgist, Charles, sees copper being formed 'by the weathering and breakdown of originally sulfitic materials'[22] which were oxidized in an arid climate such as existed in the Pontic and Zagros areas, thereby producing conditions 'conducive to the formation of [metallic, "native"] copper'. Neolithic humans started to work this ductile material around 8000 BCE and the copper could then be given a work-hardening by cold hammering to make the edges sharper, and even shaped more readily by annealing in a mild heat. A greater heat could be obtained by using the kilns for making pottery or for the baking of stones for flaking. With those higher heats, the ore could not simply be annealed but smelted, thus adding to the supply of natural copper. This reduction of copper ore was facilitated by the use of a flux, such as an iron oxide, to help separate the liquid copper from the earthy gangue that produced a slag. Such a procedure may indeed have been the origin of the production of metallic iron, which was easier to obtain and therefore cheaper.[23] For, as the Bronze Age developed, ‘the effort to obtain better copper smelting led to improved furnace operations. More efficient use of fluxes and greater control of combustion and heat consumption meant there was an increased incidence of metallic iron occurring in the spent charge material’,[24] which may have led to an upsurge of interest in iron for its own sake.

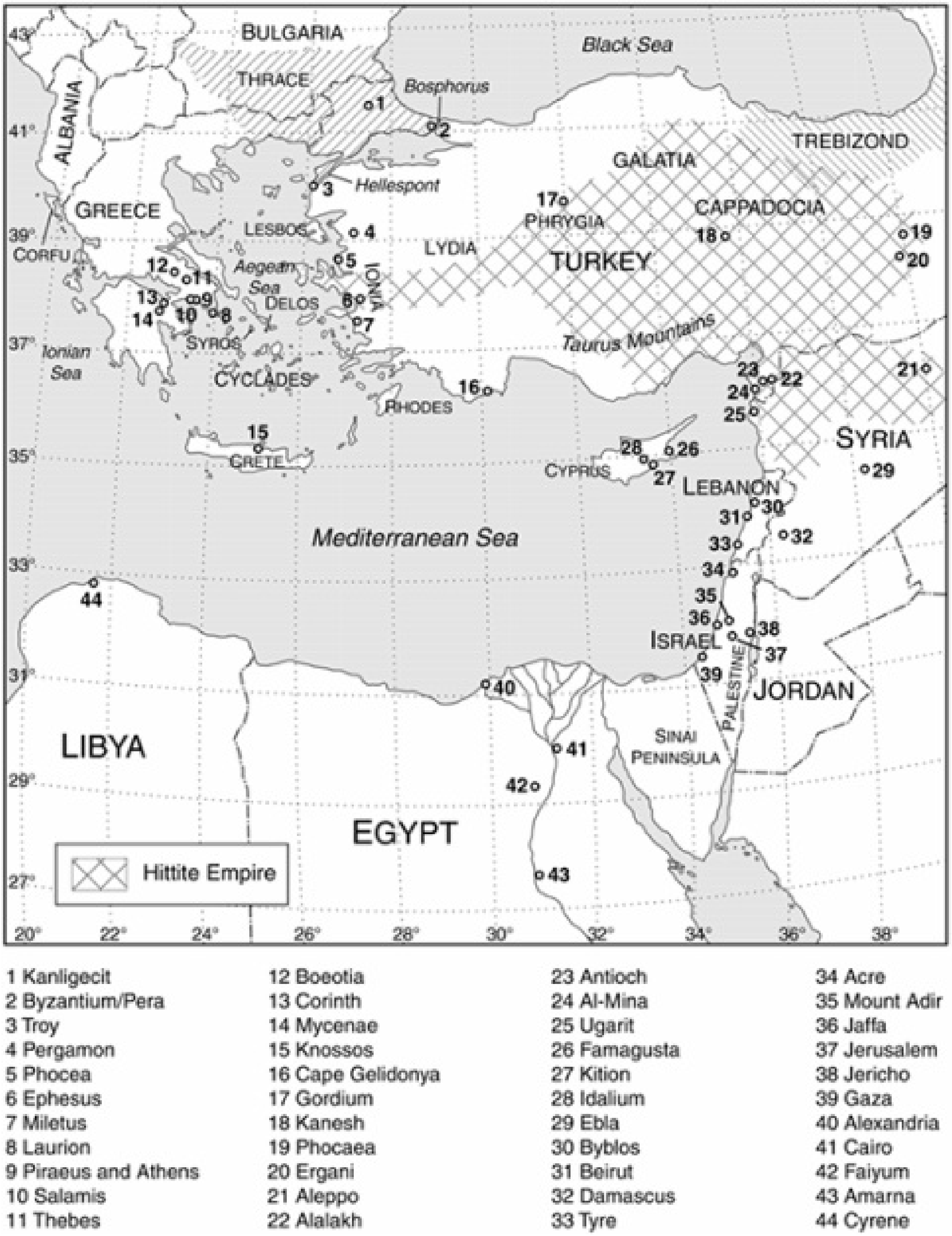
Copper appeared early in Anatolia, at Çatal Hüyük even before the first ceramics, but there was a very slow development until the mid fourth millennium; its use was low from archaeological finds.[25] There was an explosion in the Middle Bronze Age and in the Late Bronze Age there was a heavy use by the Hittite Empire, possibly as a result of the coming of iron.

In the Near East bronze began to replace copper to obtain hardened instruments between 3300 and 3000 BCE, in India soon after, but in Italy not until 1800 BCE. Different metals including silver, lead and tin could by then be cast in moulds of various shapes rather than simply treated by cold-working. Alloys could be made, especially of copper and arsenic or tin, and these non-ferrous ores were found in the volcanic rocks in some highland areas. A metal tool made of bronze is more durable than one of stone or bone because, when it is worn or broken, it can be repaired and even recast to produce a new one. It is stronger too than copper. To make it required the use of a furnace to heat the metal, where one could enhance the draught by means of a chimney; the use of a pair of bellows would later do the same but more intensively. The process also required a container for the liquid metal known as a crucible, as well as a mould to produce the desired shape.

In the Near East copper was at first alloyed with arsenic, apparently deliberately,[26] in order to make a bronze, and only later combined with tin. Copper–arsenic alloys have many advantages over pure copper both in terms of casting and in the resultant properties,[27] and these would have led to their conscious selection. The arsenic was eventually replaced by tin which was normally traded as cassiterite. However tin was rare in the early Mediterranean and often had to be brought from some distance.[28] It is possible that tin as metal or as cassiterite was imported from Central Europe to the northern Black Sea region during the Late Bronze Age. There were very important tin deposits in the Bohemian Erzgebirge as well as some in Yugoslavia. It has been suggested that the adoption of tin–bronze as an alloy may not have been for metallurgical reasons, since arsenic or nickel–bronze was nearly as effective, and in some cases occurred naturally, but rather for aesthetic ones as it was golden in colour and often first used for jewellery. Moreover as a metal, tin was prestigious, being rare and coming from afar. Chernykh[29] writes of a 1,000 km tin trade route extending westward from the Altai in the Late Bronze Age of Central Asia. The latter had been strongly influenced by the transfer of eastern European skills, possibly by migration, to Kazakhstan and the Altai, which became the main mining culture for the province because of their easily accessible copper and tin deposits. That development led to the westward advance of the significant Seima–Turbino people with the predominance of tin–bronze (and some jade and thin-bladed tools) rather than the arsenic variety, coming from the Altai and Tien Shan. These horsed nomads spread very rapidly to Eastern Europe in the sixteenth century BCE through the forest-steppe zone.

The distant origin also applied to other metals. Indeed one of the features of their coming to the Aegean, for instance, was the 'marked increase in trade and in contact', providing 'an international spirit'[30] to the Early Bronze Age which distinguishes it from previous periods. Metal-working had arrived in the Aegean from the Troad or from elsewhere in Anatolia. The archaeologist, Renfrew, writes that the 'idea of metallurgy *may* have been brought to the Aegean from outside',[31] indicating doubt. He emphasises, quite rightly, 'the essential autonomy' of the new culture it produced; nevertheless metal-working itself apparently did arrive from abroad. But that is not to deny the role of invention in this or in other activities, for instance, in the decoration of pots, though not in the introduction of pottery itself; one has to distinguish different elements and not be too enmeshed in a holistic 'anthropological' view. A recognition of this potential distinction is necessary if we are to understand the role of 'culture' as well as the fact that, contrary to the view of many historians, sociologists and indeed anthropologists, each human society, even early ones, is not static but inventive and independent – in some respects but certainly not in all.

The Bronze Age heralded what has been called the Urban Revolution. The Sumerian city-states were established around 3500 BCE and made much use of the copper from the highlands to the north and east. The local inhabitants of those areas were encouraged to provide such metals in exchange for the products they lacked. In this way, trade expanded rapidly. The use of metal however spread independently of the urbanisation and of the writing, both of which characterised this phase in the riverain societies, as they later did in Anatolia, in Greece and Italy and then in parts of Europe (Map 1). It spread to the many 'tribal' societies in whose lands the metal ores were to be found. Metals are unevenly distributed in the world, much more so than the stone suitable for tool manufacture, such as flint, chert and obsidian, so that they had to be sought out and fetched from these other societies. Even with stone there had been some movement in search of materials, as we see from the traffic to the flint mines of Grime's Graves in East Anglia or that for obsidian in the eastern Mediterranean.[32] Grime's Graves were part of a widespread attempt at early mining during the Neolithic that became more complicated than the simple pits of gatherer–hunter–fishers.[33] At the same time they acquired Cornish greenstone for tough mining tools and conducted operations that were 'semi-specialist', periodically employing local labour. It also involved long-distance exchange, frequently extending for 200–300 miles, which included a range of other commodities in an elaborate network of trade or gift.



Map 1 Eastern Mediterranean

Stone and bone had been the dominant materials for tools and weapons throughout the long millennia of the lithic ages, but this was now the Age of Metals. There are many things one can do with stone tools but there can be no doubt that metals increased the productivity of the farmer, of the artisan, of the hunter and of the warrior, facilitating work in the fields and forests, improving the cutting edges of sharp instruments, including for the heads of arrows. But with the use of metals, the search for the basic materials had to extend more widely. This was by no means the origin of long-distance trade, which occurred with Baltic amber for example, but now exchange became more intensive, more essential for the work of every day, even involving the courts of centralised kingdoms as well as using specialist merchants and artisans to seek out and process the ores required. Moreover, the exploration and acquisition of raw metals coincided, not altogether by chance, with the invention of writing, which permitted the more precise communication at a distance between the parties involved in these ventures, as we see from the early use of writing in Mesopotamia, and before that of inscribed tokens. As well of course as leading eventually to the development of book-learning, of the culture of the book, of libraries and of the creation of 'literature' and literacy in all its forms.

So the use of metals had many internal concomitants. 'Copper and tin are localised in nature, providing opportunities to restrict access to them', according to an archaeologist.[34] 'The conversion of both into artefacts is demanding, but in the case of simple trinkets or ornaments, does not require a long apprenticeship or full-time involvement. If, however, the elite seek to restrict access to bronze and have it converted into intricate, large and demanding status objects, then it will be necessary to engage and control full-time specialists.' The author then goes on to say that it is necessary to specify the range of such uses in each particular case and to realise that other objects, in stone for example, can also be 'symbols of wealth'.[35] But metals, at least bronze, can be employed more generally for weapons and tools, not simply as 'symbolic' objects. Moreover, in most places in the Near East, the Bronze Age was accompanied by a dramatic series of other changes, such as the introduction of the plough, the use of animal labour for transport, for farming and for war, providing a source of non-human energy, and as we have noted, the invention of writing, all of which altered the modes of production and of communication, as well as introducing a significant level of economic differentiation, of stratification, even of classes.

The search for metals itself transformed the Near East. The Fertile Crescent was swarming with wagons, full of valuable goods and hauled by oxen.[36] For example, the town of Ebla in north Syria was critical not only for such communication with Mesopotamia but with Ugarit and the Phoenician coast, down south to Egypt as well as up north to Troy, to the Dardanelles, to the Black Sea, to Greece and to Europe. The route south led to Egypt that was short of materials as in Mesopotamia, and depended upon importing wood from Lebanon. The importance of Lebanese cedar-wood for that country was already established even before its unification under Menes. That trade had important cultural consequences. It led the biblical Giblites to become merchants, importing many articles from Egypt in exchange for wood, including hieroglyphic writing itself. The achievements of the Bronze Age were thus spread around the eastern Mediterranean when the riverain societies went in their search of the materials in short supply in the river valleys. It was a quest that took the Mesopotamians eastwards to the mountains of Iran, north to Anatolia and to Syria as well as south to the Gulf, just as it sent the Egyptians to the Phoenician coast for the cedars of Lebanon. For this latter material Byblos was the best port, as well as producing the olive oil that the Egyptians needed both for food and for light. In that town their traders built a large stone temple, sending inscribed verses to its shrine that even specified the names of donors; this list showed that Egyptians of all sorts, both officials and merchants, visited the temple and some even settled at the port. As a result, local men were trained in Egyptian writing, doubtless for trading purposes, but that was just part of the Egyptian culture they acquired. They received both manufactured goods and natural products such as corn from the valley, all of which was exchanged for the wood. From Mesopotamia, too, the influence of urban civilisations was extended by trade; shortly after 2000 BCE or even before, establishments of Semitic Assyrian merchants existed at Kanesh (the ancient Kültepe) in Anatolia. Their revealing letters give a picture of regular caravans crossing the Syrian steppes and the Taurus mountains (‘the mountains of silver’) on their way back and forth to their homeland.

For it was not only the state that traded. As one historian notes, ‘Assyrian commerce was in the hands of powerful and wealthy families who managed their financial affairs without government intervention’.[37] Exchange in the Near East was increasingly left to ‘professional merchants under armed escort, with regular caravans of pack-donkeys with two-wheeled ox-carts’.[38] All commercial traffic with Anatolia went through these Assyrian merchants. At Kanesh they had established an important trading centre, over 600 miles from Ashur, with caravans taking zinc and returning with silver and gold. Rulers themselves made arrangements with private traders and the whole economy was regulated ‘by very specific laws’. The Kanesh documents show

Assyrians practising barter but there was also ‘big business based on profit’, which could be more readily calculated in the new, written, mode.

The Levantine coast was especially important in this traffic, lying halfway between Egypt and Mesopotamia, and giving access to Europe. As maritime traders navigating the Mediterranean and yet farther afield, conducting commerce on a large scale, particularly in the metals needed by the major powers, the Assyrians dominated in the second millennium BCE, as the Phoenicians did later in the first. But much local exchange already existed in the eastern Mediterranean. ‘There is no doubt that the peoples of Byblos in the third millennium, and in Ugarit in the second millennium, were vigorously trading with Egypt, Crete, Greece and Sicily.’ And this activity of the Levant widened out and continued down until the Middle Ages, when Syrian merchants still formed ‘a large and prosperous settlement’ in France.

Lying nearby this coast was the important trading city of Ebla. Eblaites, a Syrian people carrying out sophisticated trade, were said to be ‘the first advocates of the profit theory’.[39] This notion seems slightly dubious, but it nonetheless bears witness to the great extent of commerce in the area, especially that in metals. Though this exchange was often ‘unequal’, it was carried out by individuals who needed to make some kind of a bargain. Sometimes that could be a more equal affair, sometimes less. A document in the Ebla royal library dating from the middle of the third millennium BCE records a treaty between that city-state and Ashur some 400 miles away, giving its Assyrian merchants a level of diplomatic immunity. ‘The treaty guaranteed merchants freedom of movement, security, and insurance coverage for any risks connected with their business activities.’[40] They could use the Eblaite trade centres and at the same time Ebla could create one in Ashur. This was just one of the centres the Assyrians maintained throughout the Fertile Crescent, from Egypt to the Persian Gulf, and the agreement indicates the existence of a commercial law.

There was indeed an extensive network of trading establishments throughout western Anatolia and the Aegean giving rise to some of the first large settlements in that area. During the Early Bronze Age ‘barbarian’ Anatolia had been a centre for the development of metallurgy and for the emergence of new production techniques for tin–bronze. The silver mines of the Taurus were discovered and a miners’ village has been excavated which may have produced the tin.[41] North-western Iran was probably also a source of the metal during the second millennium BCE when it attracted the attention of Assyrian merchants. Tin was then exported to Cappadocia when local supplies appear to have been getting low.[42] This metal was taken through Kanesh and the Eblaite trading caravans, bringing it from Asia, would then have it re-exported westwards to the coastal cities from where traders would ship it to the Mycenaean states.[43] Early on Armenian metal production also became of considerable importance and provides evidence for the working of tin–bronze that was initially exported into Sumeria and then on to Anatolia.[44] But not all of the acquisition of goods was peaceful. Much of the later military activity of Akkadian kings was to defend their economic gains, especially in trade, in order to maintain 'Mesopotamian commercial leadership'. Conditions for this became increasingly adverse with competition becoming more intense and leading to the outbreak of armed struggles.

Ebla was part of this larger Anatolian trade network that produced a number of early chiefdoms, probably established with 'the contribution of rich traders'[45] who exploited the resources of the Taurus mountains in both silver and tin. This network spread to Syria, to Mesopotamia in the south, as well as over to Troy and to the Aegean in the north and west. It was at the request of traders involved in this network that the Akkadian king, Sargon, made a foray into Anatolia where some of his tradesmen claimed to have been maltreated by the local rulers. To the north, the link to Troy, situated where the land and sea routes met, was especially important. Troy as well as the surrounding area controlling the Dardanelles, lying at the entrance to the Black Sea and at the crossing to Europe, was strongly associated with metallurgy.[46] This link was important both for the Danube route running north to Transylvania with its gold and copper, and leading to central Europe, as well as for expansion to the eastern Mediterranean. With regard to the first, there is evidence of its significance both for weaponry and for jewellery from the beginning of the European Bronze Age about 2300 BCE. Regarding the second, in Cyprus discoveries of jewellery also show a connection from the early third millennium with both Anatolia and with the Levant, as well as with the whole Aegean.[47]

In both Anatolia and the Levant, the trading activities of Mesopotamia had led to the foundation of a series of small states as they searched for strategic materials, as well as leading to the creation of the 'barbarian' kingdom of the Hittites whose tentacles extended as far as Europe.[48] What was remarkable was the scale of these trading activities compared to earlier transactions. Caravans of 300 donkeys travelling 500 miles were a regular occurrence, carrying enough metal to equip a small state.

These activities led to the spread of metal-using but some writers have placed more emphasis on the contribution of local societies. An early metal-using horizon has been reported in the central Mediterranean with the techniques coming from Dalmatia and involving a south-west spread across the central Alps in the later fifth millennium.[49] It was certainly in the communities of Neolithic farmers that copper technology appeared in Balkan village centres around 5000 BCE (or even before) though the metal was rare and expensive until the Alpine, Saxon and Bohemian lodes opened up about 2500 BCE, at the same time as the ard, or scratch plough, spread through the area, replacing the hoe in the next 500 years. In the following period this and accompanying techniques transformed Europe.

It is possible that in Sardinia too there was also a relatively widespread development of the use of metal at this time. Natural copper was smelted both on Lipari and in Sardinia in the late fifth and early fourth millennia. The second half of that period saw the production of large artefacts by casting, and in some cases arsenic may have been added. Extensive networks of exchange developed, but these diminished in the second half of the millennium. We also find the manufacture of axes, daggers and halberds, which although not very effective as weapons may yet have had a symbolic as well as a functional use. The fabrication of these larger 'weapons' meant that by the beginning of the third millennium metal artefacts encouraged 'powerful social actors in their own right'.

The Bronze Age chiefdoms of the Danube and Middle Europe of the Tumulus culture were stimulated from the Aegean, especially with regard to metals.[50] Their use was largely elitist and the accumulation of bronze increased stratification and widened the gap between the elite and the commoner, as well as boosting the acquisition and inheritance of property. As has been remarked 'all the traditional elements of "heroic societies" were now emerging'.[51] This was not only a matter of the trade in metals themselves but around 1800 BCE Central European cultures widely adopted Balkan–Anatolian ceramic and artefact styles, especially in weaponry, giving rise to hoards of copper ingots on the routes radiating out from the mining centres.

Ancient Egypt was similar to Mesopotamia in having its Bronze Age, which was preceded by a copper one, built around a very fertile valley, the Nile. That produced an impressive surplus of food, but neither metals nor wood, which had to be exchanged. But in general, according to Childe, there was less scope for merchants than in Mesopotamia. Childe held a very centralised view of the Egyptian state ('totalitarian' he called it, in the terminology of the day) that he saw as conducting all these operations of exchange. The river was obviously useful for the centralised control of traffic as well as for the transport of large stones and timber for building purposes and also for the supply of the water for agriculture and for fishing, but that would also have been true in Mesopotamia. The establishment of the monarchy meant the country as a whole was relatively peaceful and the mass of people did reasonably well despite the vast inequalities. But metals were not widely used and for some time the farmers seem to have continued to employ stone tools, and initially there was not even a wheel for ceramic work.

But to get most of these materials to the valley meant trading at a distance. After 2600 BCE, Egyptian texts describe voyaging to the Levant, as well as to Punt in the south and to Sinai in the north, for the import of timber and metals. Not only Egyptians were involved but others from the eastern Mediterranean such as the later Phoenicians who were more expert traders and sea-farers and had made the sea their own. Later still, from the seventh century BCE, the Mediterranean Greeks were also employed on shipping ventures down the Nile. Around the same time, the Egyptian Pharaoh, Necho II, used Phoenicians to circumnavigate the African continent; they also built some warships for him in the Mediterranean, and he constructed a canal for access between the Nile and the Red Sea.

Despite all this trading and exploration, metals were still difficult to obtain and too costly for many. In Egypt throughout the third millennium not only cultivators but quarrymen too had to be content with stone tools. It was the same in the Indus Valley in India where chert knives were common enough to suggest a shortage of metal tools. In both cases the use of metals was elitist. To acquire this new equipment meant employing the specialist labour necessary for the search and recovery of metals. It was largely the upper strata that could afford this, and the wider population consequently became in some ways more dependent on the elite, on the metal owners for whom it was critical for warfare. Nevertheless it was increasingly used both for agricultural work and for transport (for ship-building and then for canals and carts) as well as for artisanship and for the arts.[52] The two first are obvious, the last less so. The emergence of the art of sculpture took place long before the use of metals. Stone tools can be used to produce this, especially in wood, hence the prevalence in Neolithic societies of work both in this material and in clay. But to transform harder materials that can withstand the ravages of time and the elements, whether for building, for inscriptions or for carving stone, metal tools, particularly of iron, were more than useful, both for free-standing objects and for the work on specialist constructions. The classic capitals on temples were carved with these instruments that were also used for the sculptures that decorated them. Only through this use were they likely to produce the representative mask or the realistic (even if somewhat idealised) figure. All these were effectively the fruits of the Age of Metals.

However, as we have seen, neither in Mesopotamia nor in the Nile valley was metal or even wood readily available; indeed in the swamps that terminate the Tigris and the Euphrates even stone is rare and has to be imported. The acquisition of all these materials there was largely centralised. After 2500 BCE the trade in metals, crucial for the armaments industries, was in theory a royal monopoly. The ruler's household was the principal market for metal and for similar commodities, which it necessarily dominated, although the existence of a multiplicity of city-states as well as of religious authorities and of private traders limited those centralising tendencies. The cuneiform script records expeditions for all the materials needed for developments in the rich valleys, expeditors travelling to Oman and to other foreign countries. So that even the manufacturing population was dependent for its supplies upon a central source, the *ishakku* (the high priest) or else the war-chief or the city governor. Copper later came chiefly from Magan (that is, Oman) and probably from the eastern mountains as well. And the search itself was conducted not only by palace complexes but by private merchants. In Oman and south-eastern Arabia there are the copper mines of the Al Hajjar Mountains, where production began around 3000 BCE. The metal was exported not only to Mesopotamia but to the Indus Valley and Central Asia.[53] In the Early Bronze Age at Tell Abraq we find the use of tin–bronze together with that of both pure copper and arsenical bronze;[54] though the source of the tin is unidentified, it may have been obtained from Drangiana in eastern Iran, from Syria, from Asia Minor and later even from Europe. For silver and lead the Taurus mountains were a source. Timber came from the north-east and perhaps from the hills of Syria, the best stone from Oman. Trade also involved an extensive trade in luxuries, with lapis lazuli coming from Afghanistan, mother-of-pearl from the Persian Gulf, sank shells from peninsular India, as well as items from the Indus valley itself. This was work in which individuals took part, sometimes collectively. Colonies of merchants were established in some locations, such as on the plateau of Asia Minor at Kanesh, partly to ensure the regular transhipment of goods. By and large, mountain regions produced fewer artefacts than lowland ones, even outside the river valleys.[55] But the trade was two-way. At the beginning of the second millennium, and probably well before,[56] merchants were engaged in the import of metals in return for the woollen and other products of Mesopotamia. That trade was interrupted in Hammurabi's time, leading to an opening up of the Mediterranean, especially to Cyprus.

The early significance of the maritime trade throughout Eurasia has been emphasised by Ray,[57] especially that resulting from the unequal distribution of mineral resources. She does not see the system as 'controlled by the state nor based solely on prestige or luxury items. Instead, it was driven by the entrepreneur and sustained by a regular demand for commodities such as coarse cloth, timber' and similar items.[58] In contrast to Ratnagar, she argues that 'there is little to support the hypothesis that "bronze technology required central organisation . . . which iron production did not"'.[59] 'Required' is perhaps too strong, but 'encouraged' is surely correct. The prominent role of the chief in receiving traders and other visitors is certainly confirmed by my experience of market activity among the Gonja of West Africa, though the individual entrepreneur was also essential to this activity; centralised and individual participation were certainly not alternatives that excluded one another. The two often worked together, but the state frequently took part, in Mesopotamia, in Egypt and later on in Venice.

Ray repeats and reinforces the claim that trade has often been seen as an important factor in the emergence of early Mesopotamian civilisation, where the external commerce became so significant in the middle of the Uruk period (3600–3100 BCE), especially that to the south when Meluhha in south Pakistan, Dilmun on the Arabian Gulf, and Mangan on both sides of that sea were often mentioned. As Sargon of Akkad boasted,

> The ships from Meluhha
> the ships from Mangan
> the ships from Dilmun

he made tie-up alongside
the quay of Akkad.

Precious stones, wood and copper from Mangan were especially important and were some of the commodities traded in exchange for the locally produced wool, silver-ware and other products. Sargon's son, Manishtushu, 'took possession as far as the Silver Mines, and from the Mountains of the Lower Sea he carried off their stones.'[60] But while trade encouraged peaceful exchange, it sometimes led to the conquest of the sources. Traders went not only to the south but also westwards into Anatolia and later to the Mediterranean as well as eastwards too. From Mesopotamia they went north-east to Afghanistan and east, to the Harappan port of Lothal in Gujarat, taking the route from the Persian Gulf around to the present-day Pakistan. Harappan seals have been found in Mesopotamia and Mesopotamian ones in India,[61] indicating the considerable extent of the traffic. Semitic merchants from the Near East were certainly involved from early times and much later on they followed the Romans to south India, leaving Jewish colonies at Bombay and Cochin on the west coast.

After 3800 BCE the Bronze Age civilisation of Mesopotamia was changed by the emigration of other Semitic-speakers from Arabia, possibly as the result of the increasing desiccation of that area.[62] Ecological factors may have had a long-standing effect. According to one Orientalist, C. H. Becker, the later Arab conquests of the Near East were not so much the result of the spread of Muslim ideas as of problems, causing the shortage of food and of grazing land. One reason he gives is that Arab tribes on the border of Mesopotamia had already begun their invasion of the area well before the Muslim period, though the religion undoubtedly supplied an added driving force to push them along. As a result of an earlier thrust in 2500 BCE the first Arab dynasty, that of Hammurabi, was established in Babylonia; that was followed by the migration of the Arameans and the Chaldeans, giving rise to the rule of Nebuchadnezzar.

So important was metal to all these societies that it formed the most prominent deposit in all early graves. Its introduction had changed the social system including the basic rights to land, that is, the very relationships of humanity to the earth. This now included a legal distinction (or a jural one, in the absence of a written code) between the soil and the sub-soil. That distinction seems to have begun in the valleys of Mesopotamia, but it was soon found in Egypt, arriving perhaps by stimulus diffusion. Mineral rights in the sub-soil were usually those of landlords or chiefs, rights of 'sovereignty'. And on a more general level, landlords had also arisen as the result of the animal-drawn plough that radically changed the nature not only of landholding but of agriculture, as we shall see.

In the course of all the trade that was involved, the Mesopotamians themselves went westwards to the Mediterranean to find resources and the Egyptians travelled northwards to Sinai and the Lebanon. The minerals in the Levant itself, as distinct from the wood, are few compared with those further north in Cyprus, in Anatolia or on the European mainland. Moreover the stately trees became over-exploited. Despite this happening the trade in wood between Egypt and Byblos developed in the Early Bronze Age as did the Levantine towns of Ebla and Mari, with their access to metals. These two towns near the coast were open to influences from both Egypt and Mesopotamia, each of which colonised the region at different times and exploited it for raw materials, including metals, which were later largely brought by sea. In the Middle Bronze Age there were a number of independent city-states in the region, some being dominated by the larger powers. The trade of these towns seems to have been accompanied by the development of writing systems and extensive archives. In the Early Bronze Age, Mesopotamia invented cuneiform, a logographic script; in the Levant writing was sometimes on fragile Egyptian papyrus, easily damaged by humidity, rather than on indestructible clay tablets as in Mesopotamia, but the use of both shows the influence of each of these civilisations. In one of the nearby coastal cities, at Ugarit (Al-Ubaid) in Phoenicia, writing took the form of the consonantal alphabet, the ancestor of the Greek, of which, it has been said the main result was to facilitate the recording of economic data. Data of this kind had predominated in the writing systems of the Near East but the recording of information was particularly useful for a trading city which had an island port and ties all around, to Egypt in the south, to Ebla and Mari in the east, by sea to Cyprus and to Crete in the west, and in the north to the Hittites and to Anatolia.[63] From these coastal towns trade and cultural influences spread widely in all these directions, going both in and out. So Phoenician art was affected both by Egyptian and by the Mycenaean; at the same time the work of Levantine artists has been found in the Nile delta. Phoenicia now played a very important part in this trade in the eastern Mediterranean, as we see from the imports there of Cypriot and Mycenaean ceramics. Later, at the end of the fourteenth century, exports from Tyre included silver, copper, woven fabrics, dried fish and ceramics, and trade then extended as far as the western Mediterranean, mostly in metals.

Not all such 'exchange' was peaceful. Metal gave the urbanising people of the Bronze Age a considerable advantage in fighting the rural populations for the supplies they needed. The Egyptians used metal weaponry to control the nomads in the vicinity of the Sinai mines, which were exploited by imported labour and slaves, and protected by the army; the sign-making of these people was one manifestation and possible source of the early alphabetic system. They also conquered the gold mines of Nubia, taking the metal obtained there as booty. Such mines were always a magnet for raiders, as they remain today. In Mesopotamia too the aim of the city-states was to obtain and control the supply of raw materials, metals, stone and timber, and to this end they engaged in wars of conquest. In a few cases they were successful, but by and large the inhabitants of the hills and mountains (and even of the deserts) who controlled these materials, maintained their independence, partly because they had been stimulated by the neighbouring cultures into becoming metal-users themselves, and were more able to organise their own defence. However it was the inhabitants of the plains who, in the Late Bronze Age, had the chariots, while the hills, where they could not go, were the domain of guerrilla infantry.[64] This dominance changed with the transformation that took place with the coming of the Sea Peoples and the collapse of the palaces.

Sometimes warfare was directed not at the 'barbarian' suppliers of metals but at other kingdoms for booty. In about 2250 BCE the acquisitions of Sargon of Akkad were of this kind. He and his son extended their domain from the Persian Gulf to the Mediterranean, creating in the process a vast military empire. The successful campaigns of the dynasty meant they carried off large quantities of booty, which benefited not only the regime and its immediate dependents but also the military who had acquired the loot in the first place and the merchants who disposed of it. Captives taken in battle also swelled the numbers of the dependent workers ('slaves'). In equipping the military for this aggressive activity, the trade in metals was an imperial monopoly that maintained the power of the ruler. As an outcome of this whole process that ruler was sometimes installed as a god, though in Sargon's case his deification did not prevent the collapse of the dynasty a century later. Even with regime change, urban life continued to grow and new cities such as Nineveh developed their own independent existence.

As with the Egyptian armies, the military success of these Akkadians was due mainly to their superior weapons, including the armour of bronze against which the flint instruments of the enemy were largely ineffective. The urban civilisations could only be resisted by their enemies copying their equipment. The production of similar armaments, however, was supported, not by a complex Bronze Age economy, but by the seizure of booty. Consequently warfare was widespread. However, other elements of the dominant culture were spread not only through war but through trade and other forms of peaceful communication. In these various ways, 'civilisation' was extended and the 'barbarians' produced new metal equipment, including items such as the heavy plough.

It spread to the islands of the Mediterranean that also made their own contribution. In the east the Cycladic Islands, adjacent to Anatolia, became the centre of a lively culture dating from the Early Bronze Age about 3000 BCE, possibly founding a 'colony' in Crete, but which also had contacts to the 'emerging town' of Troy and with its hinterland of Anatolia.[65] It was mainly the demand for bronze that linked Troy to the Aegean. Copper was found on the island of Kythnos and on the Greek mainland. Merchants travelled throughout the area, leading to an enrichment of Cycladic culture and to the development of a distinctive art. In this network of exchange, Troy and its counterparts, the towns of Poliochni on Lemnos and Thermi on Lesbos, were 'staging-posts' linking the Aegean with Anatolia and further north with the Black Sea. The settlement of Troy itself was established at the beginning of the Bronze Age around 3000 BCE, and it was a manufacturing as well as a trading centre with a rich elite that acquired the famous treasure dug up by Schliemann in the first half of the nineteenth century.

The proliferation of writing enabled more complex transactions to take place, especially, as we have seen, between Kanesh and Assyria. For instance, a sophisticated distribution system using record-keeping devices was found at Değirmentepe in Turkey.[66] In the port of Mersin seals were made with tin bronze in the Halaf period.[67] Merchants from Assyria settled temporarily in the lower towns (hence the *karum* system) to sell textiles, perfumes and zinc and to buy gold, silver and *amatum* (metal); they sold on credit, paid a commission to agents and made formal agreements which were then sealed.[68] 'Commercial law' was already in place. Western Anatolia became less important than the east, to which tin, becoming rarer in Anatolia, was imported from Afghanistan, arriving through the Assyrian trade that now reached even Turkey, bringing back gold and silver.[69] Nevertheless the second half of this period saw a significant decline in the quality of social life through general disturbances both in Anatolia and in the Aegean.

Metals came not only from the east but from the north. In the Early Bronze Age the Urals had already become a source for the surrounding area,[70] as well as having important connections with Mongolia and China which in exchange sent their own cultural contributions westwards. ‘These networks across Eurasia are astonishing’,[71] particularly with wheeled vehicles pulled by horses travelling in both directions. Horse rearing and metal work developed in the west, especially in northern Hungary and the Carpathians, with horses possibly going down to northern Italy where their harness bore the compass decoration associated with Troy and Mycenae. The horse was used to harness the chariot by about 1500 BCE, especially by the local Cimmerians, Thracians and Phrygians of the Carpathian fringe. It was the Phrygian horsemen that also invaded the Hittite kingdom from across the Bosphorus and in eastern Europe we find the rise of horse-mounted pastoral societies at the time of the emergence of a fully developed Bronze Age with the first evidence of iron metallurgy. The adoption of this technology, which was more widely dispersed by the collapse of the Hittite Empire, indeed perhaps before, led to the conquest of the forests using the iron axe.[72]

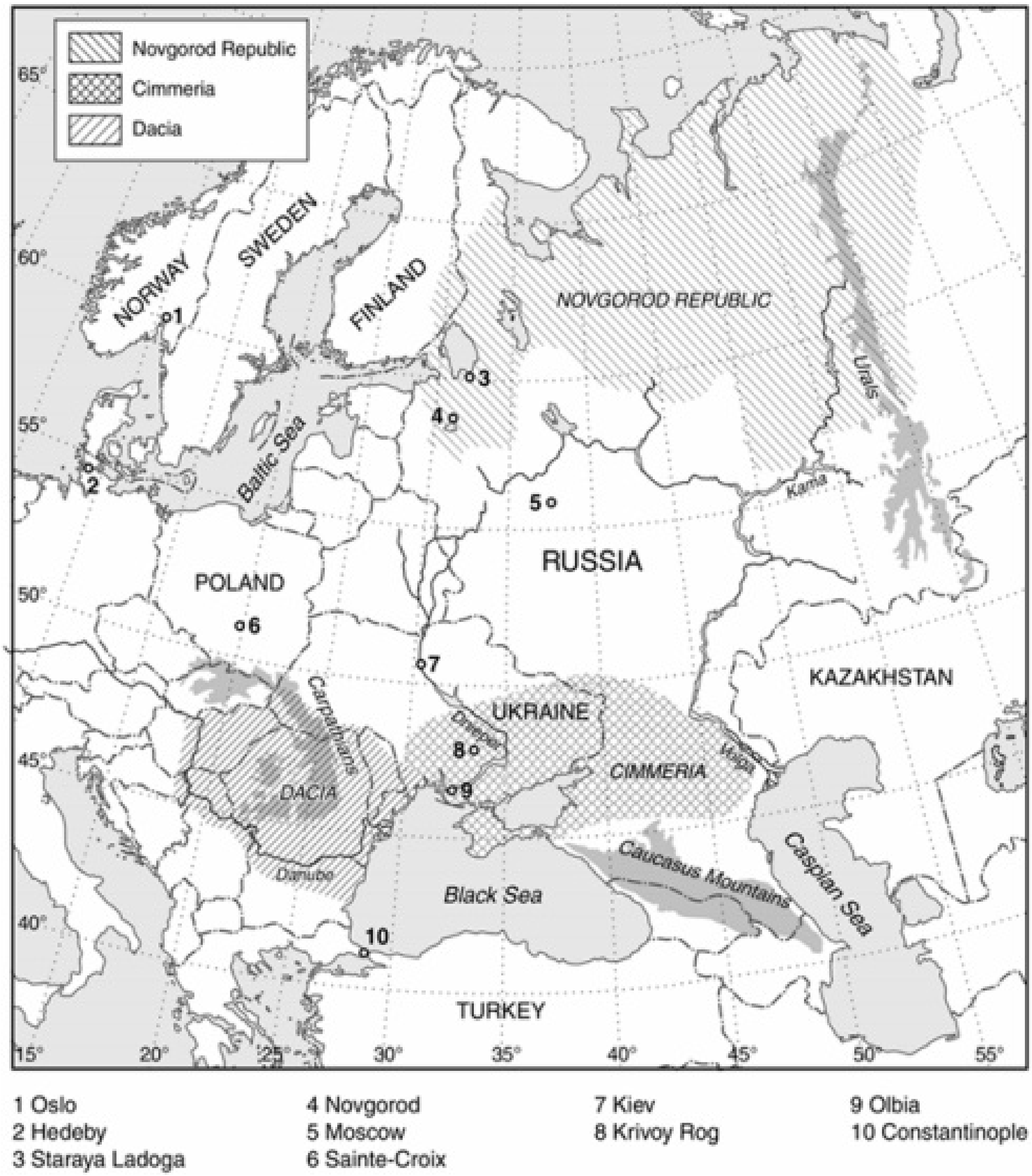
While I will be concentrating on the utilitarian metals in this book, the precious ones were always of immense importance, especially in the early days when they were objects of looting and plunder as much as of exchange. The precious metals were also especially important as a standard of value. Barley had often been employed to pay wages to specialist workers since that was necessary to maintain life. But metals too came to be used, including silver and copper for small amounts, and these could be exchanged for other items, including food. These materials acted in this way as a generalised medium of exchange. At first the metal was not made into coins, though the units themselves were often guaranteed by the state, but they had to be weighed out for each transaction. For this purpose balances appear quite early to measure the right quantities.[73] However, metals were not essential to create that exchange economy, although many now tend to make that assumption. Before that barter was not the only alternative to metal coinage, despite the belief of many scholars about money.[74] In Tibet and north China blocks of tea were used as an intermediary. In rural Africa, even today, transactions take place using shell money, cowries brought in from the Maldive Islands in the Indian Ocean.[75] Cowries were also a unit of currency in China and some early metal coins were cast in the form of these shells. They themselves were unalterable whereas metal (and tea) could be tampered with and had continually to be inspected and weighed when any suspicion arose, as it did in medieval Europe; even today's banks weigh large quantities of coin rather than count them individually.

The use of metals became increasingly widespread. In the Roman period the precious ones were essential in balancing the books with the east for the importation of its treasures. The significance of the Roman trade with India, especially South India, has been well discussed by the historian, Romila Thapar.[76] At this time the trade deficit of Europe was often blamed on women and on their desires. But the need for gold was not only for the luxury trade but for paying the huge standing army that came into existence under the Empire as well as for the cost of 'barbarian' mercenaries. With an army of this size, the process of provisioning was enormous, both for everyday rations and for military equipment in the widest sense.[77] So the necessary holdings of precious metals had to be acquired, by exchange, by mining, or by booty. In the case of the former, the northward transmission of West African gold, already coming in Carthaginian times, may have augmented Roman supplies as early as the fourth to the sixth centuries CE.[78] In the second case, some 800 Roman gold mines are known to have existed in north-west Spain, many worked by hydraulic means.[79] Booty was also considerable; the sacking of Jerusalem in 270 CE put so much gold into circulation that the price in Syria is said to have halved.[80] Constantine's dissolution of the 'pagan' temples also had a substantial impact on the economy;[81] the acquisition of booty always remained one aspect of the change in religious dispensation, and even of its secularisation. Tomb robbery too sometimes played a significant part in circulating the hitherto untouchable.

In Egypt, the sequence of development in the Age of Metals was much as in Mesopotamia. The Neolithic villagers of the Badarian culture lived in the swamps of the river Nile by hunting and fishing but the inhabitants also grew food grains and bred stock. They were acquainted with the use of gold and copper, bringing the metals from Sinai, gold from Nubia, wood from the Lebanon, together of course with other commodities, such as spices from

Arabia. In the following Gerzean stage they made implements and weapons out of cast copper, while decorative materials such as lapis lazuli reached the area from Afghanistan. Some of this consequent trade in metals, stone and other materials required movement by ship, some of these built from papyrus but in the coastal areas there were boats with sails, which provided evidence of contact both with Mesopotamia and with the Mediterranean world. In Egypt the Pharaoh himself sent out expeditions, supported by the royal army, to mine copper in Sinai,[82] and the state also equipped ships to sail to the Lebanon for wood. This material, absent in the Nile Valley, was used for construction as well as for luxury purposes for a growing difference is observed between the goods of the rich ('luxuries') and those of the poor ('necessities'). This difference was also noticeable in Mesopotamia where transactions involved the exchange of wool in return for the metals, largely copper coming from Oman and tin from Anatolia and Afghanistan; metals formed much of the foundation of this elaborate exchange in which specialist, literate merchants were engaged, taking part in a complex calculation of the profit and the loss.[83]

The notion of metal-working being diffused possibly to Egypt and later to India and China but also to Europe from the Near East has been challenged in the work of Colin Renfrew, who argues for its 'independent' invention in other parts. With heat technology already being applied to pottery in the Neolithic period, it was always possible to take the further step in transforming other raw materials. However the evidence for such activity is sometimes slight. In Iberia, which has been claimed as 'independent',[84] this consists of an isolated find dating from the first half of the fifth millennium BCE. Renfrew has also reviewed the Bronze Age in eastern Europe which seems to develop over a long period from about 4000 BCE (Map 2). There are some indications of influences from Aegean and Anatolian metallurgy[85] but he nevertheless thinks its roots were local and ascribes the changes involved to 'cultural progress' rather than to an 'influx' of humanity from another area.[86] In so arguing he qualifies the notion of a Balkanic–Bnatolian 'complex' but on the other hand rejects the 'migrationist diffusionist view' in favour of independent invention. The diffusionist view he rejects is one that depends largely on the migration of people, whereas I would place much more emphasis on the diffusion (or 'contagion') of ideas. The features of such 'contagion' that are adopted by any society would obviously entail an adjustment of the elements as the result of such a change, but, despite much recent anthropological theory, the idea of internal development of a major kind in technical matters needs to be treated with some reserve and in this case is somewhat Eurocentric. For it sees the rich Bronze Age as being ‘a uniquely European phenomenon’, ‘a kind of culture distinctively its own’.[87] Of course, every culture, whatever that entity may be, is unique, so is every individual; but that does not mean that they or we are completely dissimilar or that we have not acquired some features from another society or from another individual.



Map 2 Eastern Europe

Renfrew's thesis receives some support from Chernykh's analysis of the material from south-eastern Europe, then in the Soviet zone. In his foreword to the translation of this book, Kohl writes that the author suggests two 'important developments in the manufacture of metal weapons and tools, such as the emergence and refinement of shaft-hole axes, occurred first in the metalliferous areas north of the alluvial plains, upon which the earliest literate civilizations developed, and diffused from there south into Mesopotamia and south Asia. In other words, the innovative areas, metallurgically speaking, were frequently occupied by less developed "barbarian" societies, which combined very early in the Bronze Age their mastery of metallurgy with the domestication of the horse to perfect a form of mounted pastoral nomadism that would continue to threaten militarily more "civilized" societies to the south and later to the west almost to the beginnings of modern times. From a military perspective, more mobile societies in the so-called peripheral areas were often superior to the more sedentary, agrarian-based cultures in the cores'.[88] I have no quarrel with this statement that mirrors my own criticisms of the core–periphery model. Certainly there was a remarkable early efflorescence of copper metallurgy in south-east Europe but Chernykh suggests that the original stimulus for metal-working came from Anatolia.[89] However it was massively developed in the Balkans. Production fluctuated and there was a downturn in the Early Bronze Age of the mid fourth millennium BCE. It was the Caucasian cultures that dominated this scene and became 'some of the most important in Eurasia'.[90] In the Karelian culture of the forest and forest-steppe zone we find 'the first definite instance in the whole of northern Eurasia of the independent development of metallurgy in the absence of any stimulus from more developed centres'.[91] Shortly before that the author has said that '[a] level of basic metallurgy, linked only to the widespread use of an unambiguously native copper has, in practice, never been identified among Old World cultures'. There is not enough evidence of a general development of the technique. That is, he sees the 'explosion' of copper metallurgy in south-eastern Europe in Carpatho-Balkan cultures as possibly having been set off by events in Asia Minor, and by the movement of Carpathians from their restrictive, normative system at the end of the fifth and start of the fourth millennia. The problem of the origins of the metal age (copper) is complicated when he speaks of 'the sudden emergence and spectacular florescence of the Carpatho-Balkan Metallurgical Province . . . in Chalcolithic times'.[92] But the southern Balkans are included in his concept of the eastern Mediterranean. Nevertheless he sees the finds of the Cucuteni–Tripolye culture in Bulgaria and Romania, displaying a mixed farming economy, as showing a 'phenomenally high level of development' and the discovery of ancient mines there as having 'completely overturned previous conceptions about the nature of ancient mining' in that area.[93] The dates of the earliest metal production in Europe have been 'significantly pushed back' revealing an 'autonomous' culture.

However, he suggests[94] that the initial stimulus for the mining and metallurgy in south-east Europe came from Asia Minor.[95] But at the end of the fifth millennium BCE metallurgy in Asia 'stagnated' whereas in Europe it flourished. It had probably needed a new environment in which to develop, as later iron did in the Mediterranean or again with Tudor metallurgy. At this earlier time Balkan societies spread the copper technology throughout south-eastern Europe, but there was no urban civilisation.

The Carpatho-Balkan Copper Age (Eneolithic) suffered a serious collapse and was followed in the period 3500–2500 BCE, according to Chernykh, by the more 'barbarian' Early Bronze Age of the Circumpontic Metallurgical Province which stretched across the Eurasian plain to the limits of China itself and south to the upper reaches of the Tigris and Euphrates. Seeds of flax were found from Kuro-Araks sites, together with evidence of sickles (including those of metal), animal traction and simple ploughs; stock rearing consisted of sheep, goats and horses. These are among the first metal agricultural tools, dating from the end of the Early Bronze Age, though there were similar ones from Ur and Susa from the middle of the third millennium BCE.[96] Indeed contacts extended to the Palestine region. The metal was deliberately alloyed arsenical–bronze but overall there are comparatively few finds.

To the north of the region we find the Maikop culture of the modern Caucasus, the remains of which are mainly in kurgan burials, some magnificent ones of royal type. The livestock kept was as in Transcaucasia but pigs were common. Pottery was made on a wheel, as in Mesopotamia and the gold ornaments and bronze tools 'lead us' to the same 'civilisation'.[97] The similarities in the artefacts within various sites in that area suggest dates in the late fourth millennium BCE. However, some of the graves have a four-wheeled cart buried in them. It was early in the Middle Bronze Age (2700–2500 BCE) that tin–bronze emerged there, replacing the arsenical bronze with a high nickel content (silvery but fragile), presumed to have come from the Anatolian–Iranian mining centres. There are links not only with Anatolia but with the Corded Ware culture of western Europe.[98] But the Kurgan culture in the north mostly imported copper from the metal-rich south and Chernykh notes that the international division of labour only became possible with the discovery of metal.[99] 'The beginning of the Metal Age in the eastern part of Europe is connected with [the] steppe and forest-steppe peoples',[100] those of the Khvalynsk–Sredny Stog cultures of the area surrounding the Sea of Azov, where there is a marked predominance of ornament. The copper itself apparently came from a Carpatho-Balkan source, for example, in the Ai Bunar in southern Bulgaria. Linguistically the European steppe belt consisted of two groups, the Indo-Iranian in the north with the Seima–Turbino population in the south.

It is of course possible that metallurgy developed independently in more than one area. Such a process seems to have happened in the Americas but in general it seems that in Eurasia the diffusion of metallurgical knowledge (and perhaps of people too) played a significant role in this as in many other of the features of its social life. Independent invention is clearly a possibility, particularly in metallurgy that developed on the basis of the pyrotechnology used for pottery. But we need also to consider two facts, firstly, the tendencies of many authorities to assume independent invention in their own 'culture' for reasons of prestige and, secondly, the timing of these particular developments in world historical terms. In his discussion of the Aegean, the author also emphasises the sudden expansion that marked the second phase of the Bronze Age. There was extensive commercial activity stimulated by the new technology that spread with great rapidity. The period now shows 'a very marked increase in trade and in contact', undoubtedly in part the result of its impact that had such a profound influence on 'crafts', on agriculture and on warfare. The coming of metals resulted not only in extensive trade but also in the exchange of other information of all kinds as well as more immediately in the building of ships to transport the ore and other bulk objects, evidence of which is found in the excavations of the Cape Gelindonya wreck, dating from the second millennium, referred to below. That spread was certainly 'diffused', not only for copper but also for lead, which was easily smelted and used early on for rivets to mend pottery. There was undoubtedly some Anatolian influence[101] but also a degree of local invention (or adaptation). Both processes occurred simultaneously.

Much exploration took place in other societies; metals had to be searched for and found. There was some local tin in the west although early bronze there was mostly alloyed with arsenic. In the Near East that local supply was soon exhausted so later on, when tin–bronze is found, the tin probably came from Afghanistan, Italy or Spain. For there was nothing left in the eastern Mediterranean, although earlier there may have been an alluvial deposit in the Troad. Not only metals but metallurgy itself seems to have come early to the Aegean region, having arrived from Mesopotamia or from southern Anatolia.

In this first chapter I have tried to sketch out the story of the Bronze Age in the Ancient Near East about 3000 BCE. This period of invention is important for me historically, because it was from there that 'civilisation', the culture of cities, spread to the Nile Valley in Egypt, to the Indus Valley in India and to the Yellow River Valley in China, thus emphasising the early cultural unity of the Eurasian continent which later scholars have tended to divide, with a progressive west (Europe) and a more backwards east (Asia). The culture of cities was built upon the economic development of agriculture by means of the plough, the coming of the Age of Metals and the search for those and other materials which was found among the 'barbarians', a trade that was facilitated by the invention of writing as an 'accountant's script'. Eventually these changes spread to India and China in the east and reached Greece and Rome expanding through the eastern then the western Mediterranean.

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1 See Thomsen 1848.

2 Fagan 1965.

3 Roberts *et al*. 2009: 1012.

4 Childe 1942: 83.

5 Aitchison 1960: 69.

6 Greene 1986: 143.

7 Renfrew 1969: 36.

8 Lévi-Strauss 1970; Goudsblom 1992. On the role of cooked food in an evolutionary perspective, see Wrangham 2009.

9 Clarke 1979: 285.

10 Charles 1994.

11 Chernykh 1992: 29.

12 Algaze 2005.

13 Allchin and Allchin 1997.

14 Algaze 2005: 53.

15 Algaze 2005: 63.

16 Algaze 2005: 69.

17 Fehérvári 1977: 14.

18 Algaze 2005: 71.

19 Algaze 2005: 75.

20 Mauss 1954.

21 Childe 1942.

22 Charles 1980: 159.

23 Charles 1980: 116–25.

24 Charles 1980: 169.

25 Chernykh 1992: 168.

26 According to Renfrew 1967: 14 and Charles 1974.

27 Charles 1980: 168.

28 Renfrew 1967: 13.

29 Chernykh 1992: 194.

30 Renfrew 1967: 15.

31 Renfrew 1967: 15, my italics.

32 Renfrew *et al*. 1982.

33 Clarke 1979: 286.

34 Higham 1996.

35 Higham 1996: 14.

36 Sherratt 1993.

37 Pettinato 1991: 168.

38 Clarke 1979: 291.

39 Pettinato 1991: 169.

40 Pettinato 1991: 5.

41 Şahoğlu 2005: 341.

42 The work of Yener *et al*. at Göltepe in Turkey has altered views on tin mines in Anatolia. But the production of tin had ended by about 2200 BCE, mainly through exhaustion (Yener *et al*. 2003: 195).

43 Clarke 1979: 202.

44 Burney 1977: 6.

45 Şahoğlu 2005: 344.

46 On the connection of Troy with Europe, see Sherratt 1993: 22–6.

47 Webb *et al*. 2006: 283.

48 Clarke 1979: 291.

49 Skeates 1993: 34.

50 Clarke 1979: 292.

51 Clarke 1979: 293.

52 The weaponry of the Bronze Age in Europe is discussed by Harding 2000: 273.

53 Weeks 2003: 1.

54 Weeks 2003: 3.

55 Chernykh 1992: 159.

56 Daniel 1968: 69.

57 Ray 2003.

58 Ray 2003: 82.

59 Ray 2003: 83.

60 Childe 1942: 150–1.

61 For information on the connections between the Indus and Mesopotamian Valleys, see Lamberg-Karlovsky 1981: 389, especially for the discussion of the Akkadian cylinder seal showing a Meluhhan (i.e. from what is thought to be the Indus Valley) interpreter sitting in the lap of the king Ibbi-Sin who has just been given a red dog (for ceremonial purposes?).

62 Ashtor 1976: 10.

63 Gubel 1999: 50.

64 Drews 1993.

65 Abulafia 2011: 17.

66 Yener 2000: 126–7.

67 Yener 2000: 65.

68 Karaduman 2008.

69 Larsen 1976: 86.

70 Sherratt 1993: 25, Chernykh 1992.

71 Sherratt 1993: 26.

72 Clarke 1979: 315.

73 Ward-Perkins 2005: 116.

74 Ward-Perkins 2005: 116.

75 The Sumerians also used these shells (Daniel 1968: 120).

76 Thapar 1997, in the introduction to a volume of Italian–French essays on the subject.

77 See Tchernia 2002; Remesal 2002; Le Roux 1995; Whittaker 1997; Nonnis and Ricci 2007.

78 Grand in Wilson 2007: 122.

79 Wilson 2007: 113.

80 Wilson 2007: 109.

81 Wilson 2007: 121.

82 Childe 1942: 125.

83 Goody 1986: 74–6.

84 Ruíz-Taboada and Montero-Ruíz 1999; Renfrew 1969.

85 Sherratt 1993.

86 Renfrew 1969: 15.

87 Renfrew 1969: 39.

88 Kohl 1992: xvi.

89 Chernykh 1992: 51.

90 Chernykh 1992: 55.

91 Chernykh 1992: 189.

92 Kohl 1992: xvii.

93 Chernykh 1992: 37–8.

94 Chernykh 1992: Chapter 2.

95 Chernykh 1992: 298.

96 Chernykh 1992: 64.

97 Chernykh 1992: 72.

98 Chernykh 1992: 107.

99 Chernykh 1992: 159.

100 Chernykh 1992: 46.

101 Renfrew 1967: 12. On eastern Mediterranean influences in the European Bronze Age, see Harding 2000: 228.

2
A Bronze Age without bronze

The Near East was the kernel of the Age of Metals but itself had few of these and other materials such as wood and sometimes even stone for building. For these it had to search and exchange among 'barbarians', thus changing the nature of these societies. I have looked at the eastwards search and the transmission or creation of the Bronze Age in the Indus and Yellow River valleys. But of immense significance was the search eastwards to the Lebanon for wood and to Cyprus and eventually Europe itself for copper.

So, in the Bronze Age, it was not simply a matter of collecting the precious ones, gold and silver, as 'decorative' or monetary items, but of locating deposits of working metals and of bringing them back in mass. As with the Egyptian imports of the cedars of Lebanon or the Mesopotamian acquisition of teak from India, this usually required shipment by sea in boats that could take the heavy weights, which meant the construction of larger and more solid craft, and acted as a spur to invention. In the eastern Mediterranean the development of sea-faring occurred in many communities and the transport and exchange of commodities resulted in the establishment of trading posts and even colonies, such as the Indian one on the island of Socotra, or the settlements of the Carthaginians throughout the Mediterranean. Much later, after the Middle Ages, we have the *fondaco* of the Turks at Venice, that of the Venetians in Constantinople, or of the northern Europeans on the west coast of Africa. These were essentially establishments where large quantities of goods were brought down to ports of trade from which bulk transport was readily available, and where the exchange was not simply the 'silent trade of the Moors' but required some degree of local organisation. Carrying-trade of this kind involved transporting large cargoes of metals (or indeed other large-scale items such as slaves from West Africa, cowries from the Maldives and cloth from India) led to the founding of 'factories' by local 'agreement', although in many cases these factories were followed by the creation of colonies by military intervention, as at Carthage or in West Africa.

In the course of this trade in Mesopotamia and the Near East, whether for metals or for other commodities, the tentacles of the ‘civilised’ powers spread far and wide, not only in the search for raw materials but also in that for luxury and even for staple items. The raw materials included wood from India, copper from Oman, and other materials from far afield, later some from the various corners of the Mediterranean.

Ever since the introduction of metals, the area was ripe for a more intensive exploration by the inhabitants that lived on its eastern shore for the profit both of themselves and for the wider Near East, not only for metals of the precious kind but as well of course for luxury goods, and for the other materials needed both for tools and for weapons. The first metals did not come from the Mediterranean but from the east and the south. Only later did they have to use the resources of the inland sea.

The island of Cyprus, the island of copper, was one of the areas most affected by the search for metals. It possessed large quantities of copper which the locals learnt to turn into tools and weapons for their owners’ use. But it did not create an urban society nor did it export copper goods, just the raw metal. However the nearby island of Crete attracted refugees from the Nile delta as well as colonists from Syria who brought with them a number of crafts including metallurgy. The interaction of these various cultures resulted in intense activity in a number of fields. ‘The cultivation of vines and olives, and the exploitation of the island’s natural resources in timber, copper, and murex shell (used for dyes), could now profitably yield an exportable surplus.’[1] Crete subsequently developed its own urban civilisation that then spread through the eastern Mediterranean. Crops and crafts dispersed throughout the islands of the Aegean which in return contributed their own resources. There was often little attraction for farmers in some of these islands but they possessed various materials – copper, emery, obsidian and marble – which could be exchanged for foodstuffs. The islands became populated mostly by workers in metal and by carvers of marble, producing items that could be exchanged with Egypt and the other countries who came there to trade; their graves contained many metal weapons which they probably exchanged to make a living. The same occurred in the Taurus mountains of Asia Minor from which Mesopotamia got many of its metals and in return for which they sent the abundant products of the valleys. The producers of metals not only imported those products but also adopted cuneiform writing and cylinder seals; and in the course of this process the ‘barbarians’ became more ‘civilised’ but without taking on all the features of the Urban Revolution.

In this way the use of metals in the west also spread throughout the Mediterranean, as well as along a northern route to Europe exploiting the presence of these resources in Transylvania and in the central part of the region. To the south-east, copper metallurgy came around 5000 BCE or before.[2] In Spain in the west Rio Tinto was rich in copper and later on colonies of people may have come from the eastern littoral and helped develop Bronze Age production at El Argar from 1700 BCE. In mainland Europe, copper mining had already taken off in a comprehensive way in the Carpatho-Balkan developments. After a period of decline there was a massive increase in bronze production in the Carpathians in 1800–1600 BCE, using Transylvanian copper as well as Bohemian tin. Trade took this bronze to Scandinavia, with textiles also going there in return for amber.[3] Along the route itself many fortified sites grew up. Around 1900–1800 BCE there is some evidence in Italy of trade over the Brenner pass,[4] but copper was not of great importance south of the River Po,[5] whereas in the Austrian Alps it had been used since about 1200 BCE. Tin for later bronze was more difficult to come by but there were mines in Coruna in north-west Spain as well as in Portugal, and of course in Cornwall. Though in the west tin–bronze is relatively late, it seems highly probable that its widespread use in the Near East coincided with the ability to trade in bulk over considerable distances, at least through intermediaries.

The trade went from the Near East to Europe, importantly through Troy. One prehistorian speaks of donkey caravans that may have trekked annually from Troy, situated at the crossroads of the Fertile Crescent, to Bulgaria for copper, gold, wool and other commodities.[6] These resources came by land and sea, being brought in from considerable distances and in considerable loads, 12 ½ tons of tin in one caravan, and in the case of timber, 40 shiploads of cedar logs from Byblos at one time as early as 2650 BCE. Metals were brought from much further afield. In this pursuit merchants from Ebla travelled through the city-states where they would engage in business transactions amounting to millions of dollars in today’s ‘values’. Their caravans went to Kanesh in Anatolia, to Ur, to Nineveh, to Sinai, and to the Lebanon from where ships crossed to Cyprus. But the Eblaites themselves preferred the caravan trade that brought in metals from Anatolia and lapis lazuli from Afghanistan by way of Iran, leaving the sea trade to others. It was the maritime citizens of Ugarit, Byblos and Tyre, as well as Ionia, who organised the route by sea to Cyprus, Crete and elsewhere.[7] But the demand came largely from royalty. 'The dynasts of Egypt and Mesopotamia' organised networks 'to supply the raw materials necessary for the maintenance of the state against its rivals.'[8] These 'strategic raw materials' included 'big timber for chariots, carts, ships and buildings as well as the metals for the tools of production and the weapons of military power'.[9] The Akkadian ruler, Naram-Sin sent his own expeditions to collect the prized cedars from the Lebanon, as did many subsequent Mesopotamian rulers.

Further up this coast, Troy was critical for Europe and traders could readily make the short journey to Thrace where 'Anatolian' settlements were to be found at Kanligeçit. This establishment of expatriate posts to facilitate trade took place as early as the third millennium, but had even occurred at Uruk a millennium earlier; this recurrent phenomenon eventually led to many 'colonies' being set up in the western Mediterranean. In the east however the Anatolian network was largely by land and centred on metals from the Taurus including silver and tin, reaching its zenith at the beginning of Early Bronze Age III when it seems to have been accompanied by accelerated social differentiation.[10] Within this network one of the main pottery forms had to do with drinking vessels, testifying to the contemporary importance of wine as an elite beverage; it was also traded to the 'barbarians' who themselves only brewed beer.[11] Eventually the vine itself was cultivated throughout the Mediterranean region.

As the result of disturbances in the later part of the Early Bronze Age the colonies that had been established in Thrace and Syros were abandoned, but the extensive trade networks were revived at the beginning of the second millennium BCE, supplying a different set of goods. Trade routes shifted, and the region picked up in the Middle Bronze Age, resulting in Mediterranean contacts between the Hittite and the Minoan civilisations. In this way the area of 'civilised' life in the Near East expanded by the mid second millennium, stretching to the Adriatic and the Black Sea. It was during this period that Babylonian mathematics was constructed, that glass was made in the New Kingdom of Egypt, that the alphabet was created in Phoenicia and that iron began to be worked in Armenia. In metal-working the end of that millennium saw improved methods of both mining and smelting, including the exploitation of the deep ores in the Austrian Alps and perhaps elsewhere, together with better ways of casting and hammering. The use of scrap improved the supply of bronze, the market for which widened, in Europe first to the central area, then to Britain and the west of the continent. Specialised metal tools became available for carpentry as well as weapons for war, being used for helmets, shields and swords.

Anatolian immigrants probably founded the first city 'civilisation' in Europe, producing the Minoan culture of Crete that eventually resulted from this activity of exchange. The population had a strong artistic bent, and were firmly attached to the sea; they have even been associated with King Minos and the creation of a naval empire. The great Cretan palace of Knossos was built around 1950 BCE at a time when the country was at a crossroads and there was ample evidence of connections with Egypt, the Levant and with the Cyclades. From 1900 onwards the Minoan society saw the appearance of seals, followed by a writing system, which was mainly for accounts. Eventually this 'pictographic' script was abandoned in favour of the syllabic Linear A, apparently written in Luvian that was possibly the language of Troy and related to the Indo-European Hittite. The flourishing civilisation communicated with all the surrounding countries but around 1525 BCE it suffered the great earthquake of Thera as well as various economic and political changes, including the invasion by the Mycenaeans from mainland Greece.

These invaders adopted the writing system in Linear B to record their Greek dialect and continued to trade with Rhodes and Troy, extending their range as far as Italy and Sicily. The Greek mainland at this period saw the extension of urbanisation to Mycenae as well as in Asia to the Hittite heartland in central Anatolia. Mycenae was also a warrior society, employing chariots and a large amount of bronze weaponry. To produce these they developed links with Cyprus for its copper resources as well as trading with Miletus and the Anatolian coast. The search for metals also brought them westwards to Ischia, Tuscany and Sardinia, places to which they travelled in larger vessels with higher bulwarks using sail as well as oars. These traders penetrated the central Mediterranean, possibly settled there at the obsidian island of Lipari, at Thapsos in eastern Sicily, as well as near Taranto and at Cyprus in the east. Taranto provided access to the copper of South Italy.[12]

But even more significant was the trade eastwards to the Levant where Mycenaean pots have been found at Ugarit and Byblos as well as in Canaan. Although regional trade was well advanced, it was often interrupted by warfare and by invasions, such as those of the Hyksos dynasty from the north, who had introduced chariots and wore bronze armour, and by the conquests by the Hittites of Troy and elsewhere. Decline set in during the Late Bronze Age when the disruption also affected Mycenae.

Metal now permitted the carpentry for the construction of 'effective plank boats'[13] that could travel further with larger loads. Mycenaean trading stations appeared on Lipari, the island in the Tyrrhenian Sea. On land, a route along the Danube was established in the early second millennium with the trading of metals as 'the major element'. That route brought along the Scandinavian amber, some of which also reached the Mediterranean by crossing the Alps to Italy and Greece and provided the means by which a new Tumulus network linked up with Mycenaean activity. The Hungarian plain was already one way in which this happened, for Neolithic farming had come here from the Near East, preceded by people (or ideas) travelling to Europe along the coastal regions and exploiting the rich resources of the Mediterranean. Most of the exchange that the existence of these routes now encouraged was indirect through chains of traders and it was probably not until the first millennium that one saw the direct conjunction of Mediterranean maritime routes with trans-European ones.

In the Mediterranean itself Mycenaean commercial and political activity had first developed in the Cyclades, then in central Crete, in Rhodes as well as in Cyprus. Merchants' quarters were set up in Miletus and at al-Mina on the coast of Asia Minor and both Levantine, that is, Phoenician, and Mycenaean shipping seems to have been equally important in this network, especially on the tin and ivory trail. The extent of this sea-borne trade is amply illustrated in the elaborate contents of the Cape Gelidonya shipwreck. This activity was accompanied by the rise of the Mycenaean state which participated in and then took over the Cretan network in the Levant, to the Nile and to Cyprus, beginning around 1600 BCE, with the conquest of Knossos coming some 150 years later. This period saw the conversion of the script to Linear B, and merchant activity extended to the whole of the eastern Mediterranean from the Tyrrhenian to the Black Sea, at the same time as exploring Europe itself for cheaper metals. The search spread as far as 'metal-rich' Italy and the Danube delta. In Europe the 'fully developed bronze technologies' of the Alps, Bohemia and the Carpathians were already based on deep gallery mining, producing sufficient metal for its wide use. At some Tyrolean sites the enterprises may have involved as many as 180 workers in all. Bronze now replaced stone for many tools, the peak occurring under the Urnfield culture about 1200–900 BCE.

The rise of the Mycenaeans led to the commercial penetration by the Greeks of the Asiatic coast. The states based upon urban revenue spread from the Near East to the European mainland, linking that continent with the world of the two great contemporary empires, the Egyptian and the Hittite. So a centralised literate bureaucracy took over from the 'barbarian' tribes. The coming of the horse-mounted pastoralists, especially the Phrygians from the Pontic region, led to the collapse of the Hittite Empire and to the dissemination of early iron technology through the extended trade networks. However that collapse also saw other changes in the area, as well as the coming of the mounted nomads, for there was the disintegration of the Mycenaean states, the withdrawal of Egypt from the Levant, and the activities of what have been called the 'Mycenaeanised sea peoples'. As a consequence around 1300 BCE the Near East experienced a recession. When the exploitation of metals picked up again, it was Cyprus that profited, as did the silver-rich island of Sardinia. The Adriatic opened up too and in Europe there was a general increase in the volume of metal produced by the Urnfield cultures. The appearance in the west–central part of more fortified centres served to guard the textile and metal manufacturing sites. Many aspects of this Urnfield complex involved the transfer to that part of Europe of the economic pattern that had existed in east–central Europe for 500 years.[14] This included a degree of agricultural intensification that produced fields able to accommodate more sheep; these sheep provided the wool needed for exchange with the expansion of metal-working. The tools for smiths also developed, as did their products that included not only weapons, but musical instruments and drinking vessels,[15] all requirements of the elite. As we have seen, the collapse of the Ancient Near East with its 'command economies' meant a dispersal of technologies, involving the shift from bronze to iron. Europe itself did not experience this transformation for a further half a millennium; that continent increasingly came into the picture with the extension of urban networks first to Anatolia and then to Greece and Italy, offering a more direct link to central Europe by way of the Alps, always an important source of metal.

The renewed momentum of the Near East in the Mediterranean led to the Phoenician penetration of the western area through Sardinia and the Tyrrhenian Sea, together with the Arameans and the Greeks. This movement also resulted in the transformation of Etruria, which already had links with Sardinia, with the rich Alpine region and with the Greek coastal colonies. Italy became a major point of contact between the maritime and the overland routes, a position that she continued to retain in Mediterranean commerce and later on in contacts between east and west. The Greeks obtained iron from Elba in Etruria where a large-scale industry developed. However iron was resisted by some of the European elites who depended on their monopolistic control of bronze. But after 750 BCE bronze was finally replaced by iron, beginning in the central area; the elites consequently lost control of their monopoly in metals and turned to other goods for status and for use, possibly to the horses brought in from the steppes.

Metals had followed a broadly similar route as the Neolithic food producers had earlier done (or at least their mode of production) when they or it travelled from the Caspian to the shores of the Mediterranean, going south to Phoenicia, Palestine and Egypt and north to Troy, the Dardanelles and the Black Sea. Food production came to Europe not only through Egypt, North Africa and Spain but by way of the Aegean, which was already being much visited. But in the Metal Age vessels from the Nile appeared in that area before the end of the fourth millennium, visiting Cyprus (where smelting itself was practised from 2500 BCE), probably Crete as well, although this island received more influence from its connections with Asia Minor, especially with the region around Troy, and the traditions of Sumer are reflected in its metallurgy.[16] With the short sea-voyage, Troy was a key not only to Europe and the Dardanelles but to the metals located around the Black Sea; exchange and war made it a substantial citadel on the Asian coast.

This change was not confined to the west. As the result of commerce and of intercourse more generally extending through Central Asia, even some oases entered the Metal Age. The alluvial civilisations of the south also spread their influence north to Anatolia, to Iran, even to the hill country and yet further north; new cities arose in Syria and Asia Minor. On the route leading through the Eurasian corridor, the Bactrian oasis in the foothill zone of southern Turkmenistan was occupied by 2200 BCE.[17] Influences came from Iran and the Indus valley and a complex urban culture grew up, using *bullae*, cylinder seals and imported stone and metal. There is even evidence of a state-type society in southern Turkmenistan dating from the mid to late third millennium; Margiana was later occupied and practised irrigation agriculture producing a type of ‘feudal’ manor (*gala*), possibly the dwelling of a regional khan who controlled the canals. Bactria was on the way to China where in the late third millennium BCE the first use of bronze was seen in Gansu in the west of the country.

Further to the west there were the Bronze Age cultures of the Circumpontic region of the USSR (Southern Soviet Central Asia), especially the culture of Namazga IV that dates from the Early Bronze Age. This culture made pottery with the wheel. But it is in the Middle Bronze Age that an efflorescence took place in the whole southern area with cities being built at the end of the third millennium. This efflorescence included a very large number of ornaments, which resemble those from Iranian sites with parallels in Harappa, including seals. The centre of Altyn-Depe was occupied by a priestly elite with the craftsmen found in the 'poorest section',[18] together with two-tiered pottery kilns. In addition there were quarters for its 'prosperous' citizens – the bourgeoisie had arrived,[19] especially with developed craft production made possible by irrigated agriculture.

Bronze was adopted by the Longshan cultures of the Central Plains from about 2000 BCE, and at Erlitou its widespread use occurred in the period 1600–1400 BCE. A full Bronze Age was established, and both literacy and towns developed. At that time the oases did not develop in quite the same way but their style of life did change subsequently. With the increase in long-distance trade, power became concentrated in the hands of merchants, and much later during the Parthian period about the first century CE Near East city structures were introduced. The source of wealth had shifted from the rural khans, and trade expanded to southern and northern Iran as well as to South Asia 'in quest of resources'.[20] It is now that the re-establishment of settlements in Margiana took place with the first major period of caravan trade from China to the Parthian and Roman worlds. Everywhere the middle classes increased, trade and transport improved, here and elsewhere. On land too the use of the light horse-drawn chariot from the Caucasus and Central Asia shortened travelling time for the few, but its use was mainly for war and display. In the Mediterranean the Egyptians could build ships 204 feet long so they were able to sail to Byblos in four days. Commerce spread and with it urban society and the use of imported metals.

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[1] Childe 1942: 153.

[2] Chernykh 1992: 13.

[3] Sherratt 1993: 29.

[4] Tylecote 1992: 23.

[5] Harding 1983: 30.

[6] Zeuner 1965; Clarke 1979: 292.

[7] Pettinato 1986: 162.

[8] Clarke 1979: 290.

[9] Clarke 1979: 290.

[10] Şahoğlu 2005: 354.

[11] Goody 1982.

[12] Abulafia 2011: 35.

[13] Clarke 1979: 295.

[14] Sherratt 1993: 43.

[15] Sherratt 1993: 36.

[16] Aitchison 1960: 51.

[17] Hiebert 1994: 174.

[18] Chernykh 1992: 174.

[19] Chernykh 1992: 174.

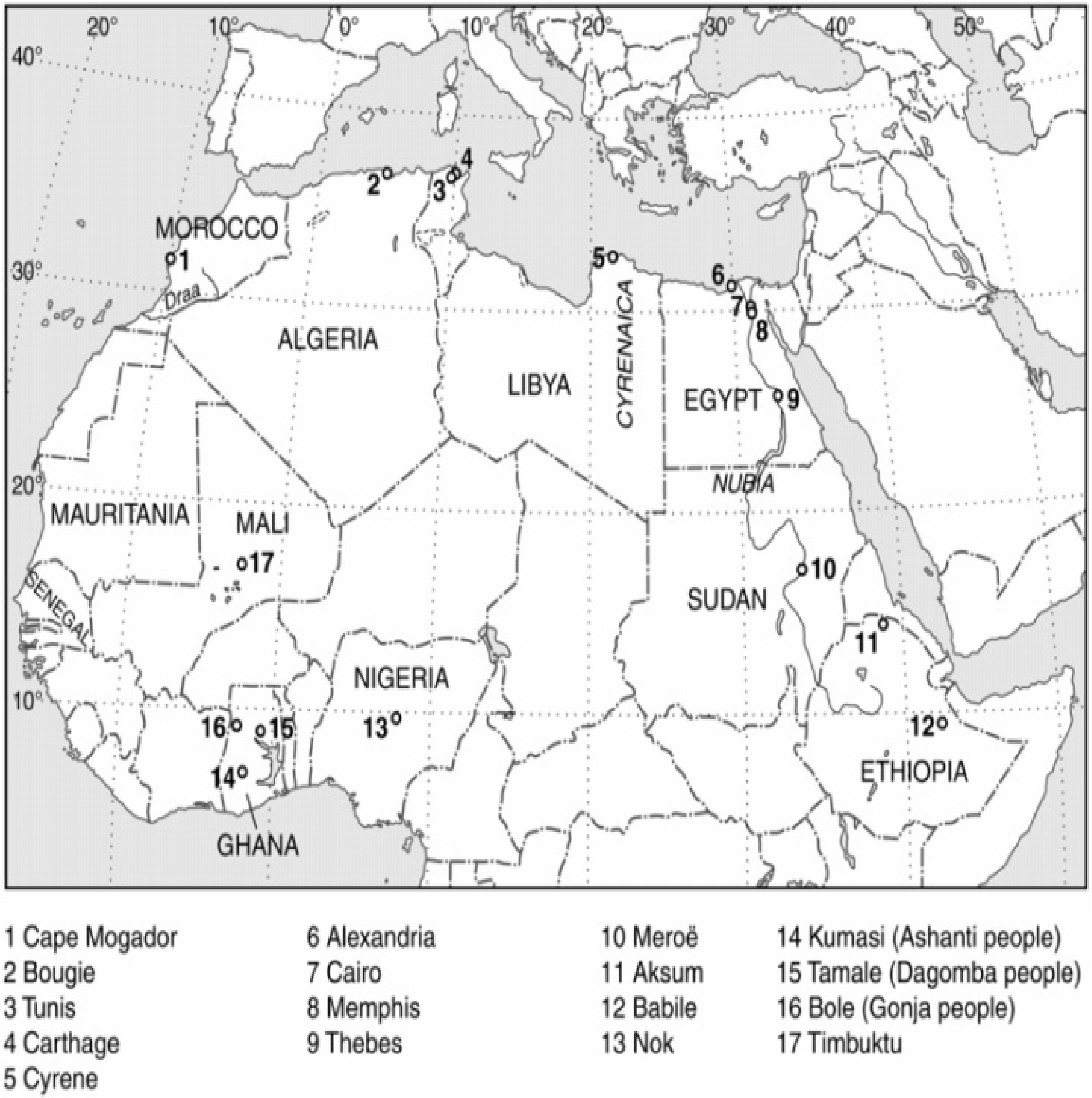
[20] Hiebert 1994: 178.

3
Metals and society

Concerning all this earlier activity relating to the search for and the processing of metals, Childe makes an important point about the inventiveness of humanity and the uniqueness of their discovery:

> The sciences applied in metallurgy are more abstruse than those employed in agriculture or even pot-making. The chemical change effected by smelting is much more unexpected than that which transforms clay into pottery. The conversion of crystalline or powdery green or blue ores into tough red copper is a veritable transubstantiation. The change from the solid to the liquid state and back again, controlled in casting, is hardly less startling. The actual manipulations themselves are more intricate and exacting even than those involved in pot-making, spinning or boat-building.[1]

Childe suggests that the processing of copper, initiating the Age of Metals, led to the emergence of specialists that were withdrawn from the process of primary production itself. ‘Metallurgy’, he wrote, ‘is a full-time job’.[2] There is certainly a considerable specialisation involved in metal-working and Childe was right about the role of metallurgy, but not altogether correct in saying this was necessarily full-time. Recently in Africa, I knew a number of iron-workers, smiths, among the LoDagaa of Northern Ghana, but none were full-time. Low-grade iron ore, in the form of laterite, was available everywhere. They worked at iron and ran smithies, though as we will see in Chapter 9 the critical smelting had by then been replaced by the importation of cheap metal, mass-produced by casting in European factories like the ones at Middlesbrough in northern England, a technique which came late to Europe. Africa had simple forges, but no smelting now since the cast iron was purchased ready-made (Map 3). The smiths, like my friend Bonyiri among the LoDagaa, were part-time, farming as anyone else the rest of the day. The money people made from the forge they dedicated to its shrine, although using the money for daily living.



Map 3 Africa

There were in fact no full-time specialists among the LoDagaa. Men who ran ferries, women who brewed beer, did this along with their other tasks. This was also true of the neighbouring Gonja, a simple centralised state where smiths were basic to the political organisation, making iron bullets for the chiefs to arm the *mbongwura* (lit. 'Asante chiefs'), the gunners of the kingdom whose imported arms they formerly repaired. They still mended European muskets known as 'Dane guns' – a reference to earlier North German and Scandinavian production – and those used for hunting, for show and sometimes for violent action. But like most other smiths in the area they also had a peacekeeping function, and were involved as silent intermediaries in many quarrels, since it was they who could ‘make hot things cold’ by throwing ashes (LoDagaa, *tampello*) from the fire on to the trouble. In Gonja they also formed an occupational group (*boiepo*), a kind of guild or caste, who passed on their craft to other members whereas among the LoDagaa anyone could get trained by a smith on the payment of a fee. In Gonja, the group was endogamous and the trade secrets were kept to the ‘couple’ (though they could marry into some other specialist groups). However in neither case did the specialism mean that they were full-time; each smith also had to hoe the land, although in earlier times in Gonja he may have been more fully supported by the chief or by the community.

The smiths were craftsmen in iron, with their forges and earlier their smelters; copper and gold, both scarce, were worked by part-timers, although among the Ligbi of north-west Asante there were specialist merchants in gold – as vividly shown in a drawing in Binger’s account.[3] I earlier had a delicate ring mounted with a ground-nut created by a craftsman in copper, a part-time copper smith, and there were also those who worked in stone to make arm bangles and in wood to carve hoe-handles and other objects; none of them worked full-time at the craft. These activities were very much an addition to farming; indeed at an important funeral I have seen a cow being killed to celebrate (and ‘sanctify’) each of these extra activities in which money (shell-money, cowries) had been made, even including farming itself which, although this was carried out largely to supply the household, could sometimes produce a small surplus in the granary for sale at the end of the year, possibly to turn into beer.

The question of full-time work is however something of a red-herring in such an economy. Clearly these trades could in theory become full-time if there was enough demand and enough surplus to maintain the specialist, since one could always purchase grains and some meat and beer in the local market (and formerly obtain it through booty). It was the same with any other activity, such as drumming in Gonja, xylophone-playing among the LoDagaa, textile making, again in Gonja, religious teaching, all these formed specialisms but they were part-time; the only possible exceptions to this were the schoolmaster at the Quranic school (in Bole, Gonja) or the ones in the new Government establishments throughout the region, the first receiving gifts from the parents of pupils, the second a salary from the administration (and paid for through taxes). Even so, each teacher had their own farm, often getting help from their pupils to hoe it. The focus on full-time specialists derives from the industrial economy in which we live, where many people are totally withdrawn from food production and engage full-time in quite a different type of work situation.[4]

In early metal-producing societies deep mining was a partial exception, giving rise to specialist communities who did little or nothing else, and in some centralised communities, even to the employment of slaves and criminal labour which forced them to work underground in terrible conditions. This was the case in the deep mines in Ancient Egypt. But in northern Asante the gold seams are now being excavated by local farmers (with the chief taking his cut) digging shallow tunnels of the kind built to excavate coal that were found until recently among the peasants of St Perdoux in the Lot and described by Tayrac.[5] That form of near-surface mining in ‘fox-holes’ could be carried on part-time, but not the deep variety.[6]

Specialist occupations were therefore important for social development, but not quite in the way Childe described. For most activities in early Neolithic or Chalcolithic societies were not concentrated outside the household but took place inside. Nor, as he proclaims, were people in those societies normally ‘withdrawn from direct food production’, though the possibility is always there, given an exchange economy. If a person takes this step to specialise, he can certainly migrate more freely than a farmer who has to establish some kind of rights to land, though in a simple hoe economy this problem is not as difficult as it becomes under plough agriculture, since land is usually available. Sometimes full-time specialists of this kind were fixed in one place and sometimes itinerant; both types were found in the Ancient Near East and both did different kinds of work. In some cases the client came to the specialist, in others the specialist to the client. These activities did not necessarily involve movement from place to place. Ideas might move rather than people and in this way local farmers might add to their part-time activities. Certainly in rural Africa in recent times boat-building, potting and weaving were often carried out by farmers who continued with their everyday job in growing or in preparing food. This kind of part-time specialism was much more common than is often thought even in early modern society. Before factory production, many tasks were carried out in the home, mending machinery, cracking nuts, dehusking corn, weaving, breeding silkworms and so on, that later on were allocated to specialists.

However, the smiths were perhaps ‘the practical bearers of the scientific tradition under barbarism’, as Childe maintains, for they advanced the study of ‘chemistry’, leading eventually to the equivocal experimental–theoretical work of the Alchemists and to the kind of practical mining activity described by Agricola.[7] But one should not neglect the technological–scientific aspects of other spheres even in the Neolithic, in the manufacture of stone tools, in weaving and especially in pottery with the kiln and the control of heat, but also in agriculture, fishing, hunting, house-building and food preparation. And all this was often involved with magical activity, as he stresses;[8] indeed much technology, and science as well, has been linked to transcendental and similar beliefs, which some would now see as external to their operation. These activities, science–technology and magic–religion, are not to be viewed as exclusive, though nowadays there are many reasons why the two should be kept in separate boxes.

In contemporary workshops and factories specialist production means something different, not merely specialist work but the division of that work into partial tasks involving the equivalent of factory, or at least organised, labour of the kind envisaged by Adam Smith. Such a division needed investment in equipment and in machinery that required the accumulation of capital by entrepreneurs, or by those who were willing to provide funds and to receive ‘share certificates’ in return. These certificates could then be bought and sold in an exchange, a stage in the progression to modern ‘capitalism’ that was already to be found in the Ancient Near East.[9]

Specialised activities were often ‘secret’, being passed down either in return for a fee, as among the LoDagaa, or else being the property of a group which claims the unique capacity to practise the craft, as among the Gonja or in an Indian caste system where out-marriage outside might compromise the ‘mystery’. But the formation of relatively closed groups emerges even under conditions of joint work when the very activity itself brings people together in an exclusive manner but there is no real attempt at the retention of any specialist knowledge, rather an effort to encourage the solidarity of common participation. This situation is found in many factories and work-places today. Closed groups may also arise as the result of families wanting to preserve their privileged employment or their societal status, as was recently the case in Britain with doctors and with dockers. Nor is this situation necessarily unproductive, for the value of the familial transmission of expertise must be recognised. Indeed, although we may view education as ‘broadening the mind’ and leading to a choice of (or uncertainty about) subsequent career, in the past many educational systems have encouraged a child to follow in the footsteps of the father (or other relative) rather than trying to teach him or her an alternative, often concentrating instead upon instruction in religion. Early schools in the Abrahamistic traditions tended to do precisely this as the priests were in charge; it was they who taught religion, and one’s profession one learnt at home, which privileged continuity rather than mobility. There was no question of a ‘calling’.

The system was obviously conservative, both for religion and for work, but not entirely so; the literacy that these religions taught in order to read the Book occasionally led to other opportunities. Education might result not only in religious acquiescence but in secular achievement. Even the practical activities of metal-workers could lead to a search beyond the everyday, a search not only for technical improvement in the technique of working them but for the metals themselves, which is a major theme of this book. The search for new solutions, which accompanied this conservative focus of traditional training, has been a constant feature of human life and one that is emphasised in many of the myths even of ‘primitive’ society, though the seeking may often apply to new knowledge of a transcendental kind rather than to secular achievement. However the search marked other aspects of social life as well. From our standpoint, changes in these areas may seem agonisingly slow, almost static, but that is because with literacy today the speed of ‘discovery’ has grown so rapid. In Europe, this speed has occurred mainly but not simply following the Italian Renaissance (which was by no means unique, as I have suggested elsewhere[10]) and the shift of emphasis to secular learning, with the invention of the printing press (and earlier of printing and paper) and indeed since the very development of writing (at the same time as that of bronze) and today of the computer.

Childe himself has documented these changes in his book, *Man Makes Himself*, especially those in the Neolithic. He shows how the Age of Metals was built on the basis of the achievements of the Neolithic but in the Near East that only followed rather slowly. The long development of this period involved the whole shift from food gathering to food production, the domestication of both plants and animals. The control of animals meant they were available not only for food but for transportation in the form of riding and also for carrying and traction, for non-human energy as well as for the production of materials such as wool or leather. Traction required a harness and a yoke to give the ox, with its broad shoulders, the possibility of pulling a cart or a plough. The cart itself represented a development from a sledge and the use of rotary motion in the shape of a wheel, which Africa never had before invasion by Europeans; the plough involved the change from human digging with the hoe to the use of animal traction to pull it. It begins to be reported from the Near East by 3000 BCE and for India soon after, although in China only shortly after 1400 BCE. Both of these developments, the cart and the plough, involved the use of metal.

Of the plough Childe writes that it changed farming from plot cultivation to agriculture (the tillage of fields), and indissolubly welded cultivation and stock-breeding. It relieved women of the most exacting drudgery in the fields, but deprived them of their monopoly over the cereal crops and the social status that this conferred. Whereas women normally hoe plots among ‘barbarians’, he claims, it is men who plough fields. In even the oldest Sumerian and Egyptian documents the ploughmen are males. To support their heavy work plough-oxen need better fodder than can be got by grazing on the steppe; so they are generally kept in stalls and fed on specially grown hay, or even barley. As a result stall dung became available to fertilise the fields. But the most decisive innovation was that brought about by harnessing the ox; then humans began to control a motive power other than that furnished by muscular energy. The ox was the first step towards the steam engine and petrol motor.[11]

Childe’s statement disregards the control of fire, pottery and the kiln, as well as the loom, as among those first steps. On the subject of women ‘normally’ hoeing the plots, he was not altogether correct. In Africa there are a few societies where they do, but generally it is a male occupation. However the importance of the plough is if anything under-estimated. Plough farming changes the very nature of land tenure since in farming with the aid of animal traction a man could plough much more land than anyone could hoe. Land immediately became a scarce commodity instead of a comparatively ‘free’ good, as before it often was for producing food, even with hoe agriculture but not the land one was actually using; the coming of the plough meant that it was possible for a person to produce a plentiful surplus over his needs (if he had the land) and so pay for the work of others. The land became ‘private property’, as Engels would say, but in a somewhat different way than that which was envisaged under the hoe alternative, where the remainder served as a common ‘reserve’. But now economic stratification became an intrinsic part of society, whereas in the Neolithic, humans were relatively equal from that point of view; the amount one could cultivate with the hoe or digging stick was strictly limited by a person's available strength and energy during the farming season. Even employing someone as tenant or as slave did not produce much more than he or she consumed. With the plough it was very different. When a friend of mine in northern Ghana acquired this instrument, he set his horses (in this instance) to plough a much larger area of land than it would have been possible for him otherwise to farm, and to create a field rather than a plot in Childe's terms. He could do this because the group to which he belonged, his clan or lineage, owned a large area that was normally kept as a reserve for shifting, hoe farming. People would move there when the yield of the current farm dropped significantly. This was the area on which he encroached with his plough, making up for the loss of fertility involved in the permanent use of land by his use of the dung from the animals, which he needed for ploughing, to manure the land. That was before the coming of the tractor. The LoDagaa had previously known only the benefits of fallow and of wood-ash to maintain the fertility of the soil, which was otherwise restored by shifting one's plot and using the reserve. In doing all this he took for his private use land that had earlier been 'communal', and so differentiated himself economically from his fellow beings.

Plough farming was not the beginning of economic stratification. Chiefs existed with hoe cultivation (and even before), and they were supported by their community. Their superior position was sometimes derived from conquest and military supremacy but also because they had become better off through owning a shrine or playing a judicial role in dispute cases. But with the plough there is permanent economic stratification, resulting in inequality at the more basic level of farming, in producing the food one eats, and that difference affected the whole of a person's way of life. The plough was a novel means of production. It never reached Africa, America or Oceania before the coming of the Eurasians, and when it did, it led to a more complex form of social stratification, although the developments of intensive cultivation in South and Meso-America were in some ways comparable.

The effect (of the 'cow farming, not man', as my LoDagaa friend, Bonyiri, said) was dramatic. Early accounts of Lagash in Mesopotamia show that most holdings fall in the range of 0.8 to 2.5 acres, but one temple official held 35.5 acres, a huge difference in land tenure. That difference was especially significant because of the fertility of the valley soil so the use of the plough meant that extra land was a great asset. Depending on the size of their holding, households were differentiated into the rich and the poor to a much greater extent than would occur in a purely Neolithic economy, with all its varied restrictions. For the previous hoe culture was basically egalitarian in that a man could only cultivate so much land in the absence of animal or mechanical traction, and it was therefore hardly worthwhile to employ others. Land that was not cultivated by one individual tended to go back into a pool and to be jointly 'owned' as a resource. All that changed with the coming of the plough and the use of the power of animals and metal tools since one man could then farm much more than another.

In Eurasia, the use of animals was not only for the plough but for transport in peace and above all in war, both of which activities needed metals. The horse, an import from Central Asia, was far swifter than the ox or the ass and therefore more adapted to warfare. Later the horses of the Spanish conquerors of the New World terrified the Mexicans, who had no such animals, as they did those in the rural communities of northern Ghana such as the LoDagaa where local men and women were chased down for human booty as slaves and for the plunder of grain by the horsemen of the centralised states of Gonja, Dagomba and the Mamprusi, who had metal both for their harness and for their imported guns.[12] And the acquisition of horses already represented the presence of considerable stratification because it was the chiefs who acquired them through the exchange of booty; the commoners were the foot soldiers and fought very differently with bows and arrows, except for a number of the chief's personal followers, the *mbongwura*, who had been equipped with guns acquired from the European invaders, Protestants who were always willing to ignore the Papal ban in the course of commerce. In Eurasia the chiefs had earlier fought from carts, that is, from the chariots which became one of the main prestige features of the royal graves; this form of transport probably arrived in China from the Caucasus and which, like the horses that pulled them, characterised upper groups in various parts of the continent.[13] Then as now horses meant aristocracy and investment. The cart as a chariot also developed an important peacetime use for competitive sport as well as having a role in transporting heavy goods, including farm produce; in West Africa, before the advent of the barrow, the cycle, the car, the truck and the train from Europe, it was always apparent how much the absence of wheeled transport affected the whole rural situation, making humans (usually women, and still today) beasts of burden in transporting smaller loads and limiting longer journeys, for instance, for the relief of hunger or famine.

These additional forms of transport all involved the wheel. In earlier times simple rotary motion, which was in effect absent from Africa (as it was from America, except for some children's toys), was employed in many contexts but the development of the wheel came only much later; in western Iran, Sialk III saw the making of pottery on a fast-spinning wheel as well as the appearance of the casting of copper. Pottery benefited not only from the increased speed of production this provided but also from the greater regularity of the resulting product and from the application of high heat. The wheel and rotary motion obviously had other uses besides pottery and transport; it was important for the quern as well as in wells to raise water; later on it was used in milling grain and for most types of machine, especially in mining and metallurgy where it was employed for lowering miners down the pit, for raising and transporting the ore, and for evacuating water. The first wheels that appear in Sumerian sculptures consisted of three pieces of solid wood, mortised together and bound with leather tyres attached by copper nails. They developed into one-piece affairs with an axle to which they were bound with leather thongs, and were known to be employed in India from about 2000 BCE and in Crete at about the same time.

Animal power had been made possible by the use of the East African ass that was found in Egypt by 3000 BCE. Asiatic asses and horses were domesticated in the Neolithic and harnessed to pull the light wheeled chariots, thereby increasing the speed of travel. Over desert greater use was made of the camel. Travel by water also saw a number of developments in boats, with the oar, the square sail, the lateen version, and eventually the use of iron, coal and steam, all of which augmented foreign trade. But up to the nineteenth century little change took place on land following the Roman roads, bridges and carriages (except possibly with the addition of metal springs). Production by means of the potters' wheel and the weavers' loom already involved the use of simple machines that worked with human effort. However the application of non-human energy transformed the process of transportation, as it did for ploughing and later for mining and for machines generally. All subsequent developments with non-human energy employed the use of metals, principally the cheaper iron of later times but also of copper and bronze in the harness, the axle and the wheel in earlier ones.

Apart from these fundamental material changes, were there any other general features that marked the coming of the Age of Metals? In thinking of the Bronze Age civilisation, metallurgy is only one element and the transformation that took place cannot be reduced to its consequences alone. There was the presence of towns, of many crafts and above all the invention of writing and the plough, both of which created new forms of differentiation, of haves and have-nots, of class, which meant a differentiation of the richer and the poorer whatever the type of productive system. The fact that in the Bronze Age any elements, such as the smelting of metals and the practice of literacy, could spread (or arise) separately, did not of course turn all recipient societies into Bronze Age cultures in the full sense, but it did broaden the range of those affected, especially at first the metal-users. Those various features may indeed have been invented independently, although they now cluster around a certain period in a societal framework. And it is that clustering that is of major social significance. But that does not negate the value of looking at individual items, such as the search for metals and its importance, as long as it is done within a wider context. And this is what I want to accomplish in the chapters that follow.

To return to Childe, he also wrote as if Neolithic societies were all matrilineal, later changing to patrilineal. This was certainly not the case. In Africa farming societies were predominantly patrilineal, though there was a swathe of matrilineal ones in the Congo, on whose social organisation Audrey Richards has written.[14] In the forest area cattle-keeping, essentially a male occupation, was impossible for ecological reasons; the prevalent tsetse fly was mortal for larger livestock. As Aberle has maintained,[15] the cow is the enemy of matriliny. In early Neolithic society there was some carry-over from the division of labour found in hunting and gathering cultures, where the men are hunters (concerned with wild animals) and the women are gatherers (concerned with wild plants). In some cases that division continued with the domestication of plants and animals, women tending to the former, and men to the latter. Nevertheless the added strength of most men as the result of sexual dimorphism was often required for clearing trees and plots of ground, even where women did the rest of the farming, so that men were usually heavily involved in agriculture.

It is true that the forest appears to be the environment in which women's 'vegetable' work is most valued, but in the Congo with the tsetse fly as an enemy there are no cattle to occupy men as in other mixed agricultural societies. So they could perhaps be presumed to spend more time on the farm, in fact they do much more hunting in the wild. In West Africa even today, there are cattle in plenty that could theoretically occupy them, but agriculture is mostly an adult activity (except at the harvest time). It was boys, and sometimes 'slaves', who looked after the cattle, while men usually farmed (and hunted very occasionally). The factors that predisposed a society to be patrilineal or matrilineal were certainly not only the physical division of labour; as with many other things, Childe was in error here.

However there is nothing wrong to my mind with his explanation in terms of social evolution, as long as this is not always unilinear, especially if we are dealing with physical objects. But the evolution of 'patriarchy' or of 'war-chiefs' is less straightforward, more complex. The general shift Childe posits from shrine to temples, and from seals to writing, is more acceptable. With other aspects of social life, the correlations are not as clear cut as earlier writers have often suggested, neither in terms of 'lineality' nor the development of specialist work.

Returning to the latter question, the Age of Metals did eventually produce specialist, full-time, workers who became particularly important with the changes in agriculture. With the use of the plough they could now produce a considerable surplus. Miners, metal-workers and traders could all be supported on a full-time basis and permanently located within urban settlements, away from the farm which others worked. The growth of towns and improved food production meant exchange between the two and the development of markets even for food, so that non-producers could survive and proliferate in numerous fields. This they did, in religion, in teaching, in learning, as well as in many crafts – in food preparation such as baking and in the production of 'luxury' items, fruit, flowers, as well as food and clothes. The largely urban population of non-food producers grew and pursued many occupations in specialist institutions, in workshops, schools and factories, stimulating exchange, both external and internal.

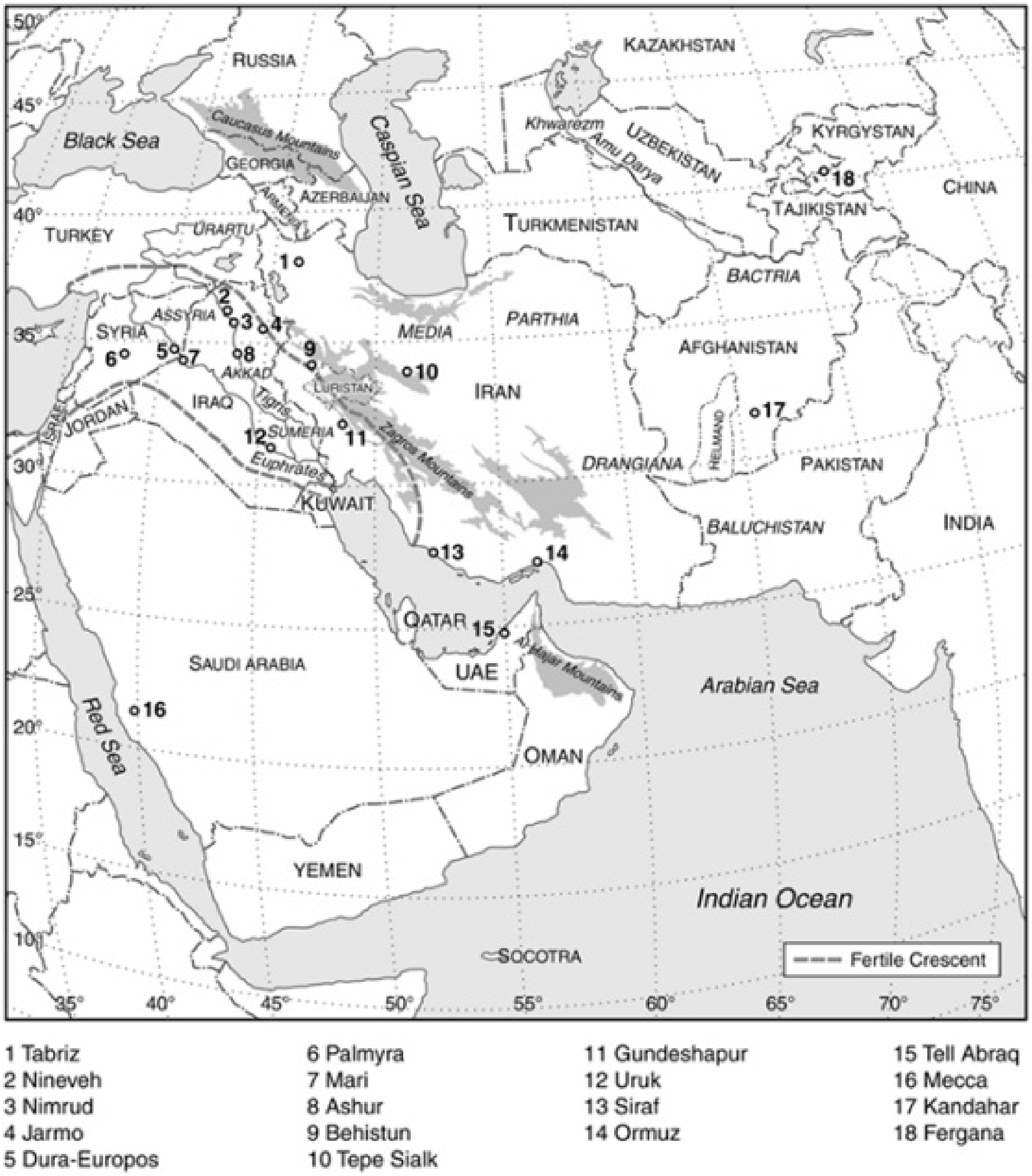
With urbanisation, the proximity of the inhabitants and their exchangist occupations developed intercourse, especially with the coming of the written word which, though it permitted communication at a distance, flourished in towns with their schools and libraries, courts, concerts, theatres and museums. All of these now required their own specialists, such as the teachers of the written word that were so often linked to the religious sphere. The new context also speeded up the rhythm of social change, for example in helping to increase innovations including those centring on metals –

machinery for making further goods, for agriculture, for transport, for domestic equipment and for processes concerned with food or with heat, as well as that involved in the wider search for knowledge.

Childe also raises the problem of democracy but this is one I will discuss later after considering the coming of iron, as it is to that event it has often been linked; iron was found everywhere, unlike other metals which were rarer and could be more easily accumulated by elites. The coming of metals and of the Urban Revolution themselves are probably happenings of too broad a character on which to pin any other overall developments of this kind, but the control of bronze facilitated the centralisation in a type of royal rule. With the accumulation of copper, authority necessarily became more concentrated, although chiefship had already existed earlier on. As we have seen, a greater degree of economic stratification and privileged ownership of land certainly occurred with the coming of plough agriculture and that drastically altered the rural scene and all that depended upon it, leading to the appearance of landlords, both residential and absentee. But that change also produced enough extra food to allow many to pursue alternative ways of making a living.

Metals of course were developed not only in the Ancient Near East, where they were first produced. India and South East Asia were of great importance in the subsequent process, so especially was China. But the rest of the world made little use of metals before the ‘expansion of Europe’. Africa did in fact acquire iron-making of a simple kind early on from Egypt and North Africa, while South America produced precious metals, but not bronze (except in isolated areas) or iron. These various developments will be briefly discussed in the rest of this chapter.

The earliest agriculture found in India, at least to date, comes from north-west of the continent, on the borders of the Iranian plateau where it first took place. At Mehrgarh there is a pre-ceramic Neolithic lasting perhaps from 6000 to 5000 BCE. However trade links with the Arabian Sea and Central Asia were already established. Mudbricks, architecture, cereals and livestock appeared. Pottery came at the third stage of Mehrgarh and copper tools at the end of this period.[16] It was during the second half of the fourth millennium BCE that new elements became evident. This was the local build-up of the Neolithic into the Chalcolithic, with its distant trade already in process, which led to the Harappan phase of the Indus valley. This turned into a fully fledged Bronze Age society about 2550 BCE,[17] with populous cities, highly skilled industries, far-flung commerce, together with a writing system, not so far deciphered (Map 4). But again the valley had little timber for building, nor did it have either good stone or metals. In the Mature Indus Civilisation there is greater evidence of copper and of tin–bronze,[18] so there must have been a supply of both. In fact they all had to be brought in along the major rivers that flowed down the valley. Copper came from Rajputana, tin, gold and lapis lazuli from further afield. For trade was not confined to this region alone and some products were even imported from Mesopotamia, as well as fish from the Arabian Sea. Indeed there was a 'strong and prosperous merchant community'.[19]



Map 4 West and Central Asia

The beginning of the later Iron Age is controversial but it apparently commenced about 1000 BCE, although iron-working itself appeared in several areas in the second half of the second millennium. This is coincidental with the secondary spread of the Indo-Aryans and may have been brought in by their horse-riding bands who possibly reached the extreme south of the sub-continent in the opening centuries of the first millennium. Both iron-working and the linguistic spread coincided roughly with the appearance in India of new burial customs which recall those of the Caucasus and of northern Iran and contributed to the development of the megalithic grave complex.[20] This was also the beginning of the 'Aryanisation' of the south.

Later, the south also became the focus of much trading activity. The *Periplus*, a sailor's account of the first century CE, refers to the import of copper in the Indian Ocean trade, although the metal (as well as tin) was widely available in India. On the other hand the Geniza documents of the end of the first millennium CE speak of the trade from India in these same metals, together with the export of steel and bronze vessels.[21] Metal was available there, often in considerable quantities, though not always within any particular cultural or political unit. Earlier, in the Harappan culture of the Indus valley, the metals for high-tin–bronze were much used, even for mirrors. A large amount of copper was available to smiths and was later employed extensively for statuary and for the plates that recorded the donations to temples. Deposits of the metal are known in Karnataka and in Tamil Nadu, but base metals are in general fewer in the south than in the more mountainous north.

After the decline of the Harappan cultures, maritime networks expanded in the third and second millennium not only to the Persian Gulf but to the west coast of India and even further afield. How did this development affect South East Asia? There was no uniformity in the introduction of metals to those parts. On the mainland the arrival of a clearly demarcated Bronze Age was later followed by the introduction of iron. Evidence of the smelting and alloying of copper and tin is found towards the end of the second millennium BCE. Higham suggests that copper-based artefacts were first locally cast by the eleventh century BCE when their repertoire included axes, chisels, awls, fish hooks and projectile points, copied from Neolithic prototypes.[22] By contrast, in island South East Asia bronze and iron appeared together only around 500 BCE.[23]

In the Roman period, gold coins from the Empire abound, revealing the strength of commerce with the south-west and the south-east of the sub-continent. Rome had for long traded overland with India, and the route from Antioch was followed by Isidore of Charax in the reign of Augustus.[24] He gave details of the supply stations maintained by the Parthian Government who collected tribute from the traders. Nearby the Sako Scythians had been driven westwards from Chinese territory by the Yue-chi who had established a powerful realm in the former Greek Kingdom of Bactria under the Kushan dynasty. The same group had migrated ahead of the Yue-chi and in the first century CE battled in the Helmand area of Afghanistan. They maintained the trade route that carried Chinese silks that eventually went to Petra in the Near East and then to Europe. However, in the first two centuries CE the policy of the Roman Empire was to encourage the alternative sea-route to India in order to cut out Parthian intermediaries.[25] A Chinese annal, written about 91 CE, told of an embassy to Parthia returning with ostrich eggs from Petra. A further chronicle of the fifth century CE speaks of an envoy being sent to Syria on the western sea (the Mediterranean), with its wealth, its cloth (made from the produce of wild silkworms) and its juices. But the Parthians inhibited trade by land, so the many merchants travelled by sea.

China itself had had its own Age of Metals by the end of the third millennium BCE. Some aspects were ultimately derived from the Near East but more proximally from the bronze-casting societies of Central Asia. Its adoption would have been facilitated by the development of high-heat ceramics in the preceding Neolithic. That we will discuss later partly because of the remarkable achievements in the smelting of iron. South America on the other hand had no Age of Bronze (except in a few pockets) but nevertheless it had its own Urban Revolution.[26] 'In the absence of bronze weaponry no apparent basis for technological superiority in warfare existed.'[27] So Aztec expansion was related to the numbers and the skill of their soldiers. By contrast, the smelting of metal on which 'the development of the Mesopotamian phalanx may have depended provided the Ancient World with an important source of superiority'. But in America there was no such material superiority. Developing their civilisation ('synoecism' it has been called[28]) about 500 BCE, the Aztecs of Mexico of course had precious metals, the gold in plenty that attracted the Spanish and changed the face of Europe, as well as having writing (late), maize, but no irrigation and with largely stone tools; there was only the use of raw copper, rarely either smelting or casting, and then mainly for bells (Map 5a and Map 5b).

Map 5 Central and South America

Of the other advanced cultures of America, the Mayan of south-east Mexico, probably another offshoot of the Olmec as was the Aztec, flourished around the same time and was likewise centred on maize. Weapons and tools were of wood and stone, occasionally of copper. The Peruvians (later the Incas) did develop metallurgy, including 'casting, alloying, annealing, soldering in bronze, copper and gold, gilding and the manufacture of copper weapons and helmets'.[29] In addition they wove textiles but had no writing and no wheeled transport; as a beast of burden, the llama left a lot to be desired. Nevertheless a search for precious metals did take place in the continent as well as for other goods and long-distance trade took place in cotton, cacao and salt. The search was clearly important but it did not occur on the same scale as in the Old World. Nor did it have the implications for the base metals and consequently neither for the science nor the practical activity that they generated elsewhere. Before the coming of the Europeans to America with their swords and other iron weaponry, their guns as well as their horses, the search for metals was in general confined to the precious. Europeans expanded the hunt, and money-men like the Fugger were early participants in the colonial project which did so much harm to the native population and at the same time stimulated the trade, industry and general activity of Western Europe, including its artistic and intellectual life. But until the time of their coming there was nothing in the region quite like the search for metals and the trade that took place westwards in the Levant and the Mediterranean as well as eastwards through Iran.

For bronze the Near East had been dependent on the Anatolian, Persian and Arabian highlands, and later on the Mediterranean and Europe for copper, and on long-distance trade for a supply of tin. Situated to the west of the Anatolian highlands, the coastal town of Troy that was occupied about 3000 BCE was central to the trade. Tin–bronzes did not in fact appear until about 2200 to 1900 BCE, before which bronze was an alloy of arsenic and copper. The working of bronze spread from Mesopotamia to Syria and Palestine around that time and it was probably from Syria that diffusion took place to the Aegean where there is evidence not only of trade but of the similarity of objects produced. In the same period, bronze was found in Lesbos and in other places in the region. But as the nearby supplies ran out, merchants had to explore further and further afield, which meant travelling to mainland Europe and the western Mediterranean. Europe became more central to 'civilised' life (Map 6).

Map 6 Central Mediterranean

The movement into Central Europe for metals led over to Transylvania and into Austria. In the Mediterranean there were also the voyages of the Phoenicians and others to Carthage, Spain, Sicily and even to Cornwall, where at Carloggas tin was already being smelted in 1600 BCE. In that period there is evidence in the Mediterranean of trade in metals in a wrecked Syrian ship which was taking copper from Cyprus over to Crete, part of the push that later involved the expansion of the Greeks, the conquests of the Romans and the associated movement of Judaism and Christianity. The inland sea opened up not only to the search for metals but to the extension of urban civilisation. From the Near East that search had also led eastwards, up to Iran and the Caucasus to the Iranian plateau and over to the nomadic zone, eventually leading to China. The expansion in their use also led southwards to Egypt and on to Africa on the one hand, and to India on the other, though this was also reached from the Iranian plateau.

But the search did not involve metals alone. The power of the bureaucratic state followed the same course from the Near East, and including writing and 'civilisation' itself, monotheism too, later including Islam, by conquest as well as by conversion. These Abrahamistic religions expanded in both directions, to the east as well as to the west, and it was an expansion connected with the trade and commerce that grew out of the Urban Revolution and the literate communication that this involved. However it is with its effects in Europe and the Mediterranean that I am now primarily concerned, with the trade that criss-crossed the inland sea, that was so essential to its economy, and that declined so radically after the collapse of the Roman Empire in the west, with the coming of the 'barbarians' from the north and with the later conflicts between Islam and Christianity. Afterwards there was the gradual recovery of exchange with the Italian cities, especially in Byzantine Venice, that played such a prominent role in the achievements of the subsequent Renaissance in Europe, in marketing the metals of German mines in the Levant and in bringing back valued eastern products in return. That revival encouraged trade to the Near East, which in itself had never ceased and had experienced its own renaissance of classical scientific knowledge, as well as its own 'sprouts of capitalism', both of which fed into the general take-off of Europe.

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1 Childe 1942: 85.

2 Childe 1942: 85.

3 Binger 1892.

4 Childe 1942: 86.

5 Tayrac and Bouyssié 1996.

[6] This was so in recent years but before the suppression of slavery it was carried on by ‘captives’. On the exploitation of ‘peasant’ mines in Africa said to be ‘very dangerous’ and ‘reserved for captives’, see Terray 1974: 327–8. Terray sees the exploitation by chiefs not as due to ownership of the sub-soil but to possession of slaves. But slaves were bought and sold in the marketplace, though it was true that chiefs usually held more than others. But they could also ‘command’ part of the wealth of their territories, of animals killed, of ‘wild’ production (e.g. palm wine) and of a proportion of the labour of the inhabitants.

[7] Agricola 1950.

[8] Childe 1942: 86.

[9] Weeks 2003: 16.

[10] Goody 2009a.

[11] Childe 1942: 89.

[12] Goody 1971.

[13] Piggot 1974, 1975.

[14] Richards 1950.

[15] Aberle 1961.

[16] Allchin and Allchin 1997: 127.

[17] Allchin and Allchin 1997: 21.

[18] Allchin and Allchin 1997: 193.

[19] Childe 1942: 135.

[20] Allchin and Allchin 1997: 356.

[21] Ray 2003: 233.

[22] Higham 1996: 5.

[23] On the dating of bronze in South East Asia, see Higham and Higham 2009.

[24] Schoff 1914: 3.

[25] Schoff 1914: 19.

[26] Adams 1966.

[27] Adams 1966: 166.

[28] Daniel 1968.

[29] Daniel 1968: 152.

4
Trade and religion in the Mediterranean

In the earlier days of the Bronze Age one of the main reasons for interchange in trade or war was the search for metals. For while the river valleys of the Near East provided a perfect environment for intensive agriculture, and saw the first development of urban civilisation, it was not at all well endowed with the metals it needed, nor even with wood and stone. It was a Bronze Age without bronze. The essential copper and its alloy had to be sought elsewhere, in Oman, in Kandahar, in Pakistan, in Sinai, in Cyprus, in Spain and in Britain. The metals were to be found outside the confines of these valley societies, mainly in more hilly surroundings. In this way aspects of wider Bronze Age culture, 'the culture of cities', were spread throughout the region and elsewhere, as was also later the case in the Iron Age that originated in the hills of Anatolia.

Thus the search for metals did not occur so much within the Bronze Age communities themselves but meant travelling into the territory of 'barbarian' societies. To do that meant not simply locating the metals but often having to process them on the spot, or even to delve underground to dig them out. Some of this involved fox-holes, in other cases something more profound. Deep mining entailed the introduction of special methods, even the development of pumps, the use of the wheel, the installation of hauling equipment. Part of this technology of early civilisations was transferred to the Neolithic population who produced the ore; in particular this population learnt how to utilise the metals in warfare but also in peace, so that they were able to defend themselves against the power of the states and even to take the offensive by equipping themselves with the metal weaponry as well as by using their own innovations to achieve higher production. This process of the use and production of metals was occurring continuously on the boundaries of settled urban communities, leading not only to a spread of aspects of that 'civilisation' but subsequently to the very defeat of some of the centralised states by the 'barbarians' using their own weapons against them.

At first as we have seen, the Bronze Age states exploited the resources of countries nearby. But these soon became over-utilised, not only for the metals but also for the charcoal to smelt them, so that they had to move further away, westwards through the Mediterranean and to Central Europe and eastwards to the Eurasian plateau. Or it meant exploiting ores that were less pure, and contained for example more sulphur. This material required more complex techniques of extraction and could produce a change of methods, a development of technology.[1]

Trade in these areas was assisted by other developments. Transport improved throughout the Mediterranean, ships became bigger, lighthouses were constructed, as at Alexandria; exchange in many commodities widened, as witness the distribution of Rhodian jars from Greece for delivering olive oil and wine to Mesopotamia, the Black Sea, Carthage and to Italy. Other industries and other agricultural produce were exchanged, increasing the volume of trade, including of commodities like parchment from Pergamon. Nor was it only by sea. After 300 BCE Cornish tin was regularly sent by land to Marseilles. And of course the trade went in all directions; it was reciprocal. Every year after 114 BCE a dozen caravans crossed the deserts from China to the Near East loaded with silks and then went on to Rome. Roman glasswork in return found its way to China. With this trade, there was also considerable movement of personnel, with Levantines being ubiquitous in the east but Indians too residing in or near Egypt and later Chinese living in Baghdad. Besides the activities of merchants and the needs of colonists, the considerable armed forces, as for example of the Romans in Britain or in India, created a demand for goods from home and changed the local ways of life, especially for household goods which had often been former luxuries[2]. However Near Eastern techniques, above all in metals, had already moved both westwards and eastwards.

It was not only metals but other aspects of culture that spread. Most people think of the Abrahamistic religions as having been brought to Europe from the Near East by 'civilising' missionaries and adopted there because of their 'truth value'. That is clearly the picture proposed by the apologists for those creeds, and is seen to apply to the one to which they belong, although obviously not to the others. I do not want to substitute a gross explanation of this spread in terms of trade or the search for metals; certainly aspects of belief were relevant, just as they are with the spread of Islam or of Christianity in sub-Saharan Africa today. It would be quite wrong to see trade as being the only factor in the expansion of these faiths, but it was undoubtedly one element, and an important one. Trade not only spread religion but also many other ideas and inventions as well as many goods. Neither of the two religions I have mentioned would have made so much progress in Africa today had they not arrived with a trading or colonial background behind them. However this may be, we need to look at the spread of their forebears in the Mediterranean and the European world within the wider context of what was happening economically, politically and conceptually at the time, in a way that anthropology, with its sometimes dubious 'holism', suggests.

Tradition has it that the first Christian martyr in Britain, later St Alban, was a Roman soldier, Albano. Who else but a soldier, or perhaps a trader, would have spread the religion at that time? The interpretation of New Testament accounts as 'missions' being sent to diffuse the word seem somewhat anachronistic. Following the persecution of 303–311 CE by Diocletian, Christianity, which had by then separated itself from Judaism, did spread throughout the Mediterranean. Initially it was diffused in the Roman Empire either by soldiers such as Albano or else by traders. The very extent of that empire, H. and L. Hoover maintain in their edition of *Agricola*, the Renaissance writer on metals, mirrored the search for those materials, or at least was strongly influenced by it. Judaism was in any case spread through the inland sea primarily by trade and later probably by absorbing the Semitic Carthaginians from Tyre; it also went to the Pontic regions where Hebrew inscriptions have been found.

The Jewish diaspora is interpreted mainly in religious terms since Jewish and early Christian history is taught in the context of Religious Studies. But the Jews and Samaritans on the Isle of Delos seem to have come there through trade and there can be little doubt of its importance, nor of the role of Semitic merchants in Babylonia and, later, in the Nabatean world. The establishment of the Delian synagogue would have followed, not preceded, commerce, as elsewhere in the Mediterranean, for example, in Ostia, in Stobi, in Macedonia, in Saris in Lychi and Dura in Syria. The oldest surviving synagogue in Europe was discovered at Ostia, the port of Rome, described as 'the major synagogue of a prosperous community of hundreds of Jews, the earliest port dating from the first century CE'.[3] In the area there was also a temple to Serapis, an inscription to Isis and shrines to Mithras. We have also to consider the spread of other 'Oriental cults', such as Mazdaism, part of the wider Zoroastrian faith, as well as of the Egyptian Isis, throughout the Roman world.[4] Evidence of these cults has been found even as far west as Britain.[5] These various beliefs were carried along the trade routes, a trade in which metals were very important. In the western Mediterranean Jews were heavily involved in precious metals, especially the gold trade in the Sahara and their traders even had representatives in Timbuktu.[6] They also had a large colony in Tagort but later suffered persecution.

Evidence of the extent of the Jewish diaspora from the Lebanon–Palestine region can be seen in the excavations done in the Pontic area around the Ukranian town of Sevastopol, specifically in Chersonesia.[7] This port was originally settled in the fifth century BCE and had a Jewish presence by the late third century CE, perhaps earlier, and a Christian one by the fifth. Jewish relics have also been found at Panticapaeum, Phanageria, and Gorgippa, now located in Russian territory. Historical interest in these settlements is more concerned with synagogues than with trade but in the context of the wider picture, of Jewish populations in Cairo for instance, particularly those connected with Indian commerce, this emphasis seems to weigh the problem too much in a supernatural rather than in a natural direction. That is not unusual with communities defined by their religion. The widespread impression that the destruction of the Temple in 73 CE marked a watershed in the diaspora of Jews in the Mediterranean is 'fundamentally erroneous'. As has been remarked, the dispersal of the Jews had begun long before the Temple fell and their native land came under Roman control.[8] Above all they were engaged in trade.

That trade led east as well as west. The routes from the Levant to the east went through northern Persia on the one hand, and south-east through Petra and Palmyra to the Gulf areas on the other, but started from the Mediterranean coast between the boundaries of present-day Turkey and Egypt. The one from Petra led to Gaza from where they shipped the myrrh they found in Socatra and in Southern Arabia[9] as well as goods from India.[10] Petra has produced evidence of Indian pottery. For all of these voyages the Nabateans acted as escorts. Other great trading centres were situated at Palmyra and at Dura-Europa, and at all three there is evidence of Jewish or Semitic activity. Indeed trading in both the east and west was an important factor in dispersion, there and in Syria, Persia and of course in India where Semitic Aramaean traders brought the consonantal alphabet. In the west too they spread throughout the Roman Empire that gave them a special dispensation to continue their worship as well as their trade. To take into account this aspect of the scattering of the community brings its experience more into line with that of other inhabitants of the Levant, such as the citizens of Tyre or Aleppo, of Phoenicia and Syria, as well as of the history of other Jewish communities in subsequent times. But it is an aspect that is not brought out in most accounts of the 'diaspora' which are more concerned with the religious than with the commercial aspects of the dispersal, more interested in the archaeology of synagogues than in the acquisition of traders' accounts, which unlike the multitudinous records of merchants in Mesopotamia, many of them Semitic, and written on permanent clay tablets, were on perishable papyrus.[11]

Islam on the other hand was spread mainly through conquest and conversion, both in the Near East and in North Africa, with Ben Nafi and his army already making the passage from Morocco to Spain in 715. However the Abbasids in Baghdad, as well as the merchants in Cairo, Damascus and the Yemen, were heavily involved in trade both to the east and to the west, and it was through trading communities (or *zongo*), so hospitable to Islam, that the religion spread throughout West Africa in the twentieth century. Kum Gandah, my collaborator in recording the Second Bagre 'myth' of the LoDagaa, had 'become' a Muslim when he was a trader, very unusually among his people who had resisted all Abrahamistic religions; occasionally someone like Benima, my collaborator in writing down the First Bagre, was converted. He had been a soldier in Burma where he had been greatly impressed by their mosques; on his return that interest led him to trade in 'patent medicines' along with other Muslims while he was living in the Zongo at the market town of Babile.

The problem of 'myth', which much concerned me at the time as the result of my fieldwork in Africa, needed to be considered in the context of the supposed divide between rational and non-rational man. It was customary to place myth in the 'primitive', 'non-rational' societies, though there was an occasional extension into the modern. But by and large it was to be found among the non-rational, the 'absurd' according to Lévi-Strauss. However the Abrahamistic stories may also appear equally absurd to others. Nevertheless the distinction between myth ('primitive') and religion ('modern') was quite general. I myself found such a division unacceptable; and if I wrote of 'myth', it was only because it was 'oral', not 'written', for the appelation 'irrational' applied to both.

The situation of ‘barbarians’ appropriating the methods of the ‘civilised’ arose constantly in the Ancient Near East, and elsewhere too as with the Celts or Germans in the later Roman era, as with the much later diffusion of the musket and of gunpowder in West Africa despite the Papal ban on trading with the ‘heathen’. A leakage to the ‘enemy’ was impossible to prevent, given the pressure on some independent trader (Protestant in the African case) or wayward artisan to pass on his knowledge to the other side, the transfer to the less well-endowed by a person looking for an income, indeed for a profit or simply for prestige. The consequences of such transmission could be immense and even shattering. Rome fell to the invading ‘barbarians’, the empire of Sargon of Akkad fell to those from Gutium, and in the same way the lands of Mesopotamia were successively overrun by Elamites, Amorites, Haldites, Kanites, Medes, Persians and Macedonians. It was similar in the Nile Valley where punitive expeditions and new additions to frontier defences could not permanently protect the Old and Middle Kingdoms from invasion. The New Empire, however, tried to do just that by advancing its frontiers, but that did not prevent invasion by the Libyans, by the Philistines ‘and other barbarians who had been trained in “civilized warfare” as mercenaries in the imperial armies’,[12] as was later the case with Nubians, Assyrians, and more.

That search for metals and the transactions of trade led to communication with the east as well as with the west, and subsequently to the spread eastwards, to India and beyond, of the Biblical Aramaic as well as its merchants, its alphabet and sometimes its religion; the westwards move too resulted in the spread of the Greek alphabet (a modification of the Semitic Phoenician which was already in use in Spain and North Africa), and of written culture more generally. Whether or not the alphabet was invented by them, certainly these trading communities encouraged its use. In both directions the move was led by people speaking Semitic languages who were often traders, and that was one of their specialities.

Central to the search for wood and metals for the river valleys was the Levantine coast, with its supplies of cedar-wood and its opening to European sources of the latter. This coast was the home of the Phoenicians who later expanded into Carthage in North Africa from the port of Tyre. Tyre was one of the important Phoenician cities. It seems to have been occupied from the middle of the third millennium BCE.[13] Its fate went up and down, but it provided a link with Damascus; cursed by Ezekiel, besieged by

Nebuchadnezzar, the ruler who seized the Jews, it was obviously a trading town of first importance, located midway between Egypt and Mesopotamia. Towards the beginning of the third millennium, Bronze Age cities had been established in the coastal strip, trading by land and by sea, especially with Mesopotamia and Egypt. The Pharaoh of the latter country even had ships built of cedar-wood at nearby Byblos for carrying his goods to various ports.

While the inhabitants of the Levant made systematic voyages across the Mediterranean as early as the beginning of the second millennium BCE, the Tyrian and Sidonian commercial expansion began seriously only in the mid eleventh century. Before then Ugarit and Alalakh had contributed most to the trade with the Aegean during the second millennium, though many of the inhabitants of the first had come from the south. The disappearance of those cities may have been connected with the coming of the 'Sea Peoples' during the twelfth century, after which Tyre became a considerable commercial centre, using the vast coniferous forests of the Lebanon to build its ships.[14] Meanwhile, after conquering Babylon, under Tiglath-Pileser I of Assyria (c. 1114–1076 BCE), it pushed toward the Mediterranean coast and became the dominant power, replacing the Egyptian hegemony. That kingdom itself suffered from attacks of Urartian 'barbarians' on the northern frontier where they controlled the trade routes including the metals of Asia Minor as well as the supply of horses.[15] The Hittite region was destroyed by these northerners, Phrygian horsemen from across the Bosphorus, who conquered the coastal areas as well as confronting the Assyrians. Some raiders apparently went even further south. In 1227 BCE '[N]ortherners from many lands' attacked the Nile, armed in the latest Anatolian-Aegean garb with crested helmets, plate armour, Aegean rapiers and the round cavalry and infantry shields.[16] This raid was followed by another in 1196 BCE when a large fleet was accompanied by a land army with chariots and bullock carts; at this time some settled in Palestine, where they were known as the Philistines.

During all this disturbance, Tyre appears to have kept largely independent of the advance of the Assyrians from the interior but its fleet remained of interest to the invaders, protected in the island city both to transport men and materials and to fight the Greek 'pirates'. The Assyrian forces even conquered their colony at Kition in Cyprus; however despite the conquest, inhabitants there still managed to produce metals which were listed by the Assyrians as part of their booty. In addition to this, the booty included elephant hides, tusks and ivory work, plus purple robes, as well as gold, silver, tin, copper and bronze bars. However it was not only Cyprus and the Aegean but the whole Mediterranean that had become a Phoenician trading area in which they established an efficient network of ports including ones in Malta, Sicily and Sardinia, as well as in the Balearics. They had relations with the Etruscans in Italy as well as coming into conflict with the Greeks and the Romans.

On the coast of the Levant the Phoenicians were oriented mainly towards the Mediterranean (as were the Sea Peoples), marketing their own manufactures and materials (wood) but also looking for metals to bring back from abroad. Metals were the foundation of Phoenician trade, their first identifiable base being at Kition, near Larnaka, in Cyprus, where Tyre founded a colony. For these materials they had to search throughout the inland sea; in so doing they spread their written culture, which may indeed have produced the 'first' recorded philosopher, Thales, as well as inventing the abacus, an aid so important for merchants. All this was related to the search for materials that were absent in the valleys. Of the Phoenician voyages it has been written, '[t]hese long, ambitious routes found their rationale in the search for metals'[17]. According to one writer 'the geopolitics of the later second millennium . . . hardly makes sense without considering how surrounding empires competed for access to Cypriot copper and Levantine timber'.[18] Subsequently the search went wider. 'The Ptolemies of Egypt needed to find the sources of gold, silver, tin and iron, the last of which had been strangely neglected in Egypt'[19] when other peoples made weapons of the metal. However, the Phoenicians explored and exploited the Mediterranean; because the difficulties back home with Assyrian assaults in the Lebanon led to increased settlement overseas. In this Cyprus was of central importance, so too was Egypt, both being points of contact between east (or the Near East) and west, which was later on crystallized in the person of Cleopatra and her bearing the child of Caesar whom she hoped would be the legitimate heir both to Egypt and to Rome.[20] But the links spread yet more widely. We have pottery, as well as other objects, indicating the importance of relationships between Mesopotamia and the Indus area – and later on between the Gulf and China.

In the late seventh century, trade in the Mediterranean further expanded, a century after the creation of Magna Græcia in southern Italy with its fine temples at Paestum. Greek enterprise accompanied that of the Etruscans; they exploited the iron in Elba as well as trading to Spain. Their migration was led by Phocaea on the Ionian coast, whose riches had laid it and its neighbours open to Persian aggression. That pressure encouraged looking abroad, as it did for other inhabitants of the littoral. Like the Phoenicians, the Israelites and the Arameans also settled in these other parts; some of the dispersion, to Babylon, for example, was by force. But these people were all engaged in trade and in exploring and establishing factories, bringing along their beliefs, going especially to the western Mediterranean. Metals, writing and written religions were all part of this movement.

There is already ample evidence for a thriving trade between the Levant and the Aegean world as early as the second millennium BCE.[21] Indeed some accounts tell a story of one Cadmus coming with other Phoenicians to Boeotia and even bringing the alphabet with them. The idea was derided by a number of classical scholars who went 'so far as to erase totally every trace of a Phoenician presence in Greece in ancient times'.[22] But in recent times this Eurocentric thesis, espoused by Julius Beloch who did not accept the Semitic penetration, has been challenged. But communication was considerable. Trade flowed from the Aegean not only to the coastal cities but even to Mesopotamia. And travellers went both ways; for instance, it is said that Cadmus was sent from the Levant to find his sister Europa, settled in Greece and was the founder of the famous House of Oedipus.

Immediately north of Tyre to which it was often linked, the port of Sidon was prominent 'in the exploration of the Mediterranean undertaken by Phoenician cities from the end of the second millennium'.[23] The inhabitants also went to every corner of the inland sea but concentrated on the Aegean where they founded several trading posts. Meanwhile under King David Israel extended its borders northward to Tyre, which sent cedars for the building of the Temple at Jerusalem. A generation later its ruler, Hiram I, reinforced the ties with Israel, sending craftsmen and organizing a joint voyage for gold to Ophir (whose location is disputed). Tyre also founded a colony at Auza in Libya as well as trading and sending its script to Assyria. In the Bible the prophet, Isaiah, himself praised the city 'whose merchants are princes, whose traffickers are the honourable of the earth'.[24] Both the Levantines and the Egyptians needed bigger boats for this trade, in order to transport the heavy wood and metals, and this gave a fillip to the development of larger and steadier marine craft.

Tyre and Sidon were part of the Phoenician coast whose sailors travelled widely. Some classical writers date the foundation of the Phoenician colonies as early as the twelfth century BCE, at Cadiz in Spain, which was a suitable port for exporting metal from nearby Tarshish, at Utica in Tunisia and at Lixos in Morocco, places that may also have been visited for metals.[25] However archaeology suggests a later date, the end of the ninth century BCE when the founding of these colonies was the result not of invasion of the homeland so much as of the intensification of their earlier trading expeditions.[26] It was nevertheless the pressure from Assyria under Sargon of Akkad and his successors that increasingly forced Phoenicia ‘to look to the Aegean and the western Mediterranean for new markets’; the founding of Carthage by Tyrian refugees, traditionally in 814 BCE, has to be seen in this context. In the Levant the Phoenicians had to pay the Assyrians a tribute in British tin ‘from early times’.[27] But there is also evidence of substantial commercial interaction, especially with the countries bordering on the Aegean and with Egypt, so their colonisation in the west was only partly due to the Assyrian threat, being mainly the result of trade and the search for metals.[28] At that time the Aegean was largely Egyptian territory, so the Phoenicians had to explore other islands and other sea-routes, ‘profiting from the decline of the Mycenaean sea power’ in the west. In Egypt itself, the Phoenician presence was recorded at Memphis around 900 BCE and was probably to be found at Thebes. Their ship owners also maintained regular branch offices along the sea-routes. The communities they established seem to have been related to the rapid expansion of the trade in metals, as in the case of the iron industry under the Libyan Pharaoh (950–750 BCE). The Phoenicians already had a ‘market economy’, and a money one, although not necessarily using coinage.[29]

The Phoenician merchants and searchers travelled to Carthage on the North African shore where they established an important colony and exploited the metals of the western Mediterranean, especially those in the south of Spain where Carthagena or the New Carthage was built; silver was being excavated at Monte Romero in Huelva in the seventh century BCE.[30] But they also sought the riches of Africa, from where they bought gold.[31] Carthage was a literate society, establishing a large library, and in many ways constituting the rival of Greece and Rome, and contributed to written history through the Tyrian archives[32]; it was also a society that organised itself in a distinctly ‘democratic’ way with frequent elections among its citizens.

In the western Mediterranean, Carthage was only one destination for these searchers (Map 7). There were explorations on the coast of Spain, to Malaga, as well as to Sardinia, Sicily, Crete, Cyprus, and voyages to Cornwall for tin, which has been mined there both before and up to the nineteenth century. The extent of Carthage's influence is discussed by Whittaker[33] on whom the influence of Polanyi was strong in his characterization of 'ports of trade', in the emphasis on political over economic relations and in the rejection of the relevance of 'formal caravans' in 'administered trade' which 'guaranteed prices' and therefore involved political price-fixing rather than the 'capitalist' market; trade prices were fixed by a 'non-commercial mechanism'.[34] But this influence he modifies by admitting the role of price though it was still less important than goodwill and he even queries the use of the term 'commerce'.

Carthage itself had a fine harbour but was dependent not only on its trade and its wealth in silver, gold and base metals from Africa, Spain and the Mediterranean, but also upon its developed agriculture, exporting wheat, oil and dried fruit. Most of the metals fed back into the Near East, especially to the states with their courts and their temples, their archives and their libraries. The alphabetic script the Phoenicians created was used not only for trading activities but for many of the very considerable intellectual and other achievements made at this time. Despite these the role of Carthage has been largely 'deleted' from the history of the Mediterranean, leaving its resurrection to the archaeologist and the antiquarian. All the activity that marked Carthage also took place in the Levant as well as among their neighbours and fellow Semitic-speakers in Ancient Israel. Those neighbours had of course a very similar language and a common boundary with Tyre, the 'mother-town' of Carthage, situated in the south of what is today the Lebanon, near the Israeli border.

1 Marseilles
2 Agde
3 Barcelona
4 Toledo
5 Lisbon
6 Huelva
7 Tarshish
8 Cadiz
9 Gibraltar
10 Málaga
11 Granada
12 El Argar
13 Cartagena

Map 7 Western Mediterranean

The Phoenicians settled in many parts outside their home territory, some nearby in Israel, some in Egypt, others in Assyria as well as in the north of the Mediterranean as far as Marseilles and Agde where together with the Etruscans and Greeks they traded in Near Eastern produce, as well as the fermented juice of the grape, originally a fruit from that area, in addition to the utensils used for its semi-ritual consumption.[35] There was plenty of trading going on from that part of the Lebanese coast. Even before the arrival of the Israelites the section between Gaza and Jaffa was occupied by the Philistines, who gave their name to Palestine, called so after the Peleseti, the dominant group among these Sea Peoples coming down from the Aegean, possibly Crete, in the twelfth century BCE. These people had ravaged the coasts down from Anatolia, where they acquired iron and smithying that they readily adopted. Iron weapons enabled them to push inland and conquer some of the Israelite tribes. Of their original language there is no record but eventually they came to speak Aramaic, a Semitic tongue. One clue to their origins lies in the fact that in the thirteenth century they produced pottery akin to that of Mycenae. Even away from the coast, Israel had a thriving commercial sector; before their slavery in Egypt, they probably came from the Semitic peoples of Mesopotamia, who were heavily involved in trading. That commercial success enabled them to build some impressive buildings, including the Temple itself, and in the course of its restoration the Laws of the book of Deuteronomy was rediscovered.

Herodotus describes how in the late sixth century some sailed down the Red Sea at the bidding of the Pharaoh, Necho, to circumnavigate the whole of Africa. Hanno on the other hand went down the west coast of that continent from the Carthaginian colonies in Morocco but no account of that voyage has been preserved in Greek. His journey is recorded in a Roman manuscript and it can be followed down south as far as the mouth of the Senegal River and to the island of ‘Cerne’. This was eminently possible because the Carthaginians had already established a permanent settlement at Lixos on the Atlantic coast of Morocco and there is even evidence of some Phoenician pottery as far as Cape Mogador further down.

The early dispersion of Phoenicians in the search for metals led to the founding of a large colony in Spain where mining, later accompanied by metal-working, was already widespread. They also seem to have visited the Atlantic islands including Britain to acquire the tin later needed to melt with copper to make bronze. Their voyages to these islands are described in the account of Himilco’s journey, which is only known because details were incorporated in the *Ora Maritima* of Avienus, a Roman geographical textbook of the fourth century CE. His journey was ‘doubtless intended to open up the western tin route, perhaps at a time the Spanish mines were not yielding enough’.[36] The British source of tin was probably known to

Mediterranean traders using the overland route through Gaul, but there is no direct archaeological evidence to support these contacts, only later Iron Age finds (fourth–first centuries BCE) that indicate Iberian links.

By this time, the Iron Age was already well developed, although Phoenician trade seems to have been largely in copper, silver and gold. But the comparative rarity of deposits of iron in the Mediterranean and the plentiful rich ores in northern Europe created a disparity between the two regions which became a central feature of Europe's trade with the east. The 'barbarian' territories had a distinct advantage in this respect. Iron gave more durable and sharper tools and weapons than bronze, and it was cheaper; their availability enabled humans to exploit the heavy lime and clay soils deriving from the glacial periods. It was also, as Childe had remarked, a more 'democratic' material,[37] with kingdoms often having to make way for the participation of warriors and even for the appearance of 'free men'.

In Europe knowledge of iron had reached the eastern Danube by the close of the Middle Bronze Age about 1300 BCE, at first imported, and by sea to the Italian mainland at about the same time; local production began between 1100 and 800 BCE. In the west the Phoenician trading posts introduced the metal into south Iberia about 900–800 BCE but the abundance of local supplies of bronze kept that going longer.

In all the eastern Mediterranean, trade was very active. The sea-borne relations between Greece, Ionia and Troy (nearby to important gold mines) are well known, but the whole of the Aegean was criss-crossed by maritime routes. Indeed the early Minoan Bronze Age in Crete 'may have been inaugurated by people from some part of the eastern Mediterranean . . . Crete was perhaps the New World of this time',[38] with everyone anxious to go there to seek their fortune. Some of these searchers possibly came from the Syrian area, bringing with them not only seals but the idea of writing itself. For a long time the eastern Mediterranean had been a great centre of trade – the Egyptians with Syria and Palestine, the Syrians and the Cretans to Egypt. The movement of goods took place in both directions; an inscribed alabaster jar from Egypt has been found at the harbour town of Knossos, the capital of Minoan Crete.

The Minoan civilisation had become rich by acquiring wealth from trade and 'by mining and working metals'; Egypt had done the same.[39] A mass of Cretan pottery has been found, in Fayum and at Tell el-Amarna, the ephemeral capital of Akhenaten (1372–1354 BCE), the deviant Pharaoh.

Egyptian pottery turns up in Cyprus too with its eponymous copper as well as in Anatolia.[40] But while Crete also exported pottery, most of its essentials in wood and metals were of local origin (except for tin) and its imports were therefore mainly 'luxuries'. However, luxury items were not only brought in by palaces but also by private merchants, which was common practice in Egypt and among other neighbours; for the culture of the upper bourgeoisie very much followed royal precedent and they purchased similar consumer products. The evidence for this is largely pottery.

'By 1200 the eastern Mediterranean was being plagued by fluid and unstable alliances of pirates and mercenaries'[41] whose attacks resulted in the fall of Troy at the period known as VIIa; they were probably both the Sea Peoples and their victims, whose activities led to the weakening of Mycenaean authority, except at Athens. The Sea Peoples, who seem to have come from the north, attacked Egypt and some, the Philistines, settled in Palestine, where they became neighbours of the inland Israelites. Difficulties appeared throughout the western Mediterranean, with the loss of writing in the Aegean except among the Greek refugees in Cyprus, that is, the disappearance of evidence of the script and the reversion to non-literacy. By the end of the eighth century new trade networks had been established, not by states but by 'communities of merchants',[42] Greeks following the Mycenaean trail, Etruscan traders and above all Canaanite Phoenicians, who were the source not only of merchant activity but of the transformation of the arts of Greece and Rome. In this they were building on the earlier trade of the region with Egypt and the Aegean.

The search for metals and their use in the Mediterranean continued in the Iron Age, which was the time of the main Phoenician voyages, of the Assyrian expansion, but also that of Greece and Rome, both important iron-using cultures. As has been pointed out,[43] in Greece itself the role of metals has been given insufficient importance. But they were of central significance both in war and in peace. The search for these was significant not only for its own sake but in the diffusion of other knowledge and of urbanised life in general from the Near East to Greece, as well as from Greece and Rome, to Europe more generally and later back again. Following the Mycenaean lead, the Greeks explored the Black Sea and established a chain of early colonies around 700 to 600 BCE which was strategically placed at river mouths to give access to the interior, for example at Olbia on the mouth of the Dnieper opening the way to Kiev and the Baltic trade. Greek wine, oil, pottery, jewellery and metalware went upstream and in return amber, furs, hides, pitch, gold, slaves, wheat and horses came to the coast. The same was true of the Danube trade, but that included iron ingots.[44]

The search went on elsewhere too, both for precious and for base metals, for gold in Africa, for silver in Athens, for various metals in Spain and in northern Europe, including copper; iron now gradually extended its use, in peace and in war, without altogether eliminating the need for bronze. The Iron Age proper is the subject of the next chapter, but as it includes the critical classical period that saw the transfer of the urban civilisations to Europe, I will briefly introduce it here. As we have seen in their search the Phoenicians, who later struggled with Rome, had earlier settled in some numbers in Cyprus. There Kition, a town with a Semitic name, was the site of a small settlement between c.1000–750 BCE, succeeded by a much larger one, possibly paying homage to Sargon II of Assyria who ruled between 722 and 705 BCE, but always maintaining close ties with Tyre. This site was the main Phoenician base in Cyprus, the settlement of Salamis being Hellenic. In Rhodes the Phoenicians were the successors to the Mycenaeans, and the early geometric style there was more akin to the Phoenician tradition.[45] They also traded in Crete and in the whole Aegean area and Homer mentions their metal work as producing objects of luxury. They had many settlements in Sicily although they had to withdraw from some before the invading Greeks. However they do not seem to have colonised the Italian mainland, that was left to the Etruscans and the Greeks. As we have seen, the Phoenicians founded Gades (Cadiz) in Spain possibly in the twelfth century, settled in Sardinia by the ninth (where they left the Nora stone), as well as in Malta in the eighth and in the Balearics. The north of Sardinia however continued to be controlled by the Etruscans, while the Greeks colonised nearby Marseilles as well as occupying much of Sicily and south Italy, and also Cyrene in Libya. The Phoenicians brought back large quantities of metals to the eastern Mediterranean, including tin from Spain. They also travelled north to Asia Minor, to Lydia for example, which was the home of Croesus.[46]

The nature of the trade appears in the excavation of a wreck in Huelva in 700 BCE packed with bronze tools, mainly of Iberian origin. A similar wreck comes from Béziers in south-west France. In the eastern Mediterranean the great bulk of the trade was in Levantine hands. Indeed with the collapse of the Mycenaean states around 1100 BCE, it was the Phoenicians who took over the routes, leading to their early voyages in the western Mediterranean in

1100–1000 BCE and to establishments on the northern littoral.[47] But this was not the beginning of their maritime activity; there is evidence of a close connection with the Etruscans, who were influenced by Phoenician art and from whom they purchased the products of their rich mines. Indirectly the Etruscan kingdom was the offspring of ‘colonial expansion’, especially for metals. That whole effort was epitomised by the history of the Phoenicians, with their introduction of a full iron technology, and bringing the economies of littoral Europe, that is, of Spain, France and Italy, into contact with a literate civilisation.

Trade in many commodities continued to expand. Cyprus and Crete sent wine to Egypt, the Cyclades sent stone tools. However metals grew ever more prominent and became ‘a leading motive for commercial venturing’.[48] Before the Carthaginians the Mycenaeans of mainland Greece, taking over from the Minoans, voyaged round the Mediterranean shores as far as Spain where they developed the export of copper around 2500 BCE which sent metal objects as far as Asia. At the same time metal technology from Troy went north to the Danube where it reached as far as modern Vienna and the Erzgebirge in Bohemia. Troy is of course closely connected to the Greeks who as successors to the mainland Mycenaeans were great Mediterranean traders. And before the rise of Athens, Corinth too brought back metals and foodstuffs in return for fine vases. Their journeys to Italy and elsewhere were highly significant: ‘[t]o write the history of Greek civilisation . . . . without much reference to the waters of the central and western Mediterranean is like writing the history of the Italian Renaissance as if it all happened in Florence and Venice’.[49] Tin from Britain was sent by the Greeks across France to Marseilles and to the east. For after local supplies diminished, the search for tin had taken the Sumerian traders to Bohemia and Saxony where they left their mark and contributed to the spread of bronze.[50]

There are two general views about the whole spread of metal technology in Europe. There is Childe’s hypothesis of its development in south-west Asia and its diffusion across Europe in a north-westerly direction and there is Renfrew’s argument that there were two centres of independent invention in Iberia and the Balkans. But in both cases the smelting of metals followed the existence of a heat technology that produced earthenware, or even high-heat stoneware in the Chinese case. Thus, as Aitchison supposes, metal might have first appeared with the smelting of the appropriate stones (ore) in a double-tier pottery-kiln.[51]

In recent work '[a] full-blown copper metallurgy in central Italy' has recently been pushed back to the early or mid fourth millennium BCE, with both arsenic and antimony being present.[52] It is suggested that after a formative period in the Late Neolithic, a local tradition of metal-working emerged in central Italy in the Early Copper Age (mid fourth millennium BCE), possibly 'following a short but momentous intensification period in the Final Neolithic', with the 'contemporary inception of copper mining and smelting in Tuscany and neighbouring Liguria'.[53] The transition to tin–bronze thus occurred about 2200–2000 BCE. The region of Tuscany was rich in the necessary metals but the technology for exploiting them probably came from the eastern Alps.[54] This origin would suggest the advent of metallurgy to Europe through the Danube area, later one of the main routes for iron, and coming from Anatolia by way of the Black Sea area. But as with iron, this northern route did not exclude its transmission through the Mediterranean as well and this activity undoubtedly comprised a local contribution. The search for metals for the Near East went on through both channels, the northern and the southern.

Traditionally the Neolithic entered Europe around 3000 BCE, on the one hand by way of Gibraltar into Spain and on the other by the Black Sea along the Danube. The southern route remained important later on but the latter was also significant for copper and then for iron-working. There was a further path north of the Black Sea, which also branched eastwards to China. All these routes were relevant in the spread of metals. From Spain the Neolithic from North Africa had already spread to France and in about 2300 BCE to Britain. But metal production did not appear there until 400 years later and there was no copper age and no Urban Revolution until the classical period. Development in Iberia antedated Central Europe, giving birth to what has been called the 'proto-Chalcolithic', extending to about 2200 BCE when the red copper age began. In Central Europe the metal was mined in the Carpathians, with the techniques possibly derived from the Caucasus, and the products themselves were influenced by models from Troy. Gold had preceded copper in the region and its sale may well have funded the later trade in copper artefacts. After 2200 BCE Central Europe, especially Hungary, began supplying copper for both tools and weapons.

In France the Iron Age itself began in the eighth century BCE, perhaps later. Groups of horsemen armed with long swords arrived from the Danubian area going south to the Mediterranean. In that area the local people of the Iron Age in the south may have already been Celts, that is, Celtic speakers, from Central Europe but the first certain dates are dependent upon the appearance of Greek or Roman imports, beginning in 600 to 550 BCE.[55] This period is well into the Age of Iron.

The Greeks shared this great interest in mines and metal. The silver mines of Mount Laurion, first exploited by the Mycenaeans in the second millennium BCE,[56] formed the economic mainstay of Athens and, beginning in about 500 BCE, its revenues were used to build up the navy.[57] In later times the mines became exhausted, but there can be no doubt 'that the dominance of Athens and its position as a sea-power were directly due to the revenue from its mines'.[58] These furnished funds to build the fleet which defeated the Persians at Salamis. The mines were owned by the state, as so often in Antiquity, and it was the state that benefited from the profit they made, and suffered when they declined. However at the end of the fourth century the domination of the Macedonians 'flooded Greece with the money from the mines of Thrace' that had been discovered by the Phoenicians and later reputedly managed by Thucydides, and this flow from the north took over from the production of the mine in Athens. Philip of Macedonia himself accumulated great wealth from the Thracian gold and silver mines and from all the riches of the Balkans.[59]

It was however the Romans who followed and were 'the most intensive miners', as well as being enthusiastic searchers after the metallic wealth already mined. The latter was the objective of most of its conquests, for prominent countries at this time necessarily possessed, or had access to, their own mines for military and financial purposes and that made them a ready target. Thus a map showing the extensions of the Empire coincides in a fascinating manner with the metal distribution in Europe, Asia, and North Africa. Furthermore, 'the great indentations into the periphery of the imperial map, though many were rich from an agricultural point of view, had no lure for the Roman because they had no mineral wealth'.[60] The very boundaries of the Roman Empire, then, were the result of the distribution of metals. Even the Roman invasion of Britain was no doubt 'mainly designed to tap the island's mineral wealth'[61]. The Romans took over all mining (especially for gold) as well as related enterprises, exploiting many current property disputes. They were heavily involved in metals and they organised the sources systematically but are not regarded as metallurgical innovators. The industry there used local labour and existing technology, so for iron it was largely making use of surface ores.

In Spain the Romans also used some of the same mineral sources as had their rivals, the Carthaginians. The shafts of the silver mines are said to have been begun by Hannibal (247–187 BCE) – but in fact they were opened long before. Pliny claims the finest silver came from there and one of these mines furnished Hannibal with three hundred pounds weight of silver every day. His workings are said to have been at Castulo, near Linares, where he married his rich wife, Himili; north of Linares the ancient silver mines are still known as Los Pozus de Annibil.[62] The Carthaginians and the Romans used this silver to pay their mercenaries.[63] In classical times Spanish ores became 'an important factor in rural politics'. And not only rural; Tiberias had Marius, the richest man in Spain, executed in order to be able to confiscate his gold-mines.[64]

Some of these natural resources, especially in precious metals, became relatively exhausted before the end of the Roman Empire. This was partly a reflection of their wide usage, for European Antiquity belonged firmly to and developed the iron-using cultures, which required gold for many purposes, especially to use in trade with the east, in paying labourers and particularly in employing 'tribal' soldiers. Gold was already becoming scarce in classical times but some came to Greece from Central Europe. The Romans also exploited deposits in the Basque area of Spain, as well as getting the metal from Britain, Ireland and from Saharan Africa. But the situation in the Mediterranean, and trading with Europe as a whole, collapsed with the fall of the Roman Empire. So the whole trade in the Mediterranean was strongly affected by its decline and I need briefly to sketch the consequences in order to round off the theme of trade in that area. The reasons for this have been disputed. According to the well-known thesis of the historian, Pirenne, it was the Arab invasions that interrupted the sea trade in a way that produced a sharp decline in the exchange economy. The thesis has been much criticised. The archaeologists, Hodges and Whitehouse, have shown that some trade continued with the Muslim east by way of the Russian rivers to Baghdad[65] but this was never of the same dimensions as under the Roman economy. Others like Childe have followed the historian, Rostovtzeff, who saw the decline of Rome as one involving the replacement of the villa economy linked to the town by a precursor of the more or less self-sufficient medieval manor, with dependent tenants paying rent and making most of the goods they needed on the estate. That led to the dramatic decline in the level of urban activity.[66] This argument suggests that the Dark Ages had already begun one hundred and fifty years before the descent of the 'barbarians' and long before the coming of the Muslims. The result was that the diminished urban bourgeoisie could no longer support the huge demands of the army at the frontiers, now a permanent force employing many 'barbarian' mercenaries, all having to be paid in precious metals, and equipped through the use of iron.

In the early Middle Ages, supplies of silver had subsequently to come largely from inner Asia, which went mainly to the Near East although some went to the Baltic Sea through the Russian route. Certainly a little trade continued after the Romans withdrew but the Arab documents[67] seem to agree that there was a sharp decline when that happened. The Muslim conflict with Byzantium and its conquest of the North African and the Spanish coasts, as well as the occupation of the large islands in the centre, Cyprus, Sicily and Malta, had major consequences for the economic life of the whole surrounding region. It was not only the economic life of Europe that was cut off but the intellectual achievements of the east were not easily communicated and its new religion greatly limited its access to its pagan past, even the classical past whose heritage had been destroyed by the earlier migration of the Celtic and Germanic peoples. Their conquest of the Western Roman Empire had played a great part in destroying the urban centres that carried on both trade and learning. The destruction of city life was highly significant for east–west relations, but the collapse never included the eastern Empire, Byzantium and the territory it controlled. From there, exchange with the east continued, despite the absence of exchange with western Europe.

The eruption of Muslims reduced the size of the eastern Empire and turned the great lake into a scene of naval warfare and piracy rather than one of largely peaceful exchange. Ashtor notes '[t]rade disappeared almost altogether in the Mediterranean in the course of the eighth century' and 'the picture of conditions . . . which emerges from the accounts of the Arabic writers is of a situation which rendered impossible the continuation of regular and wholesale trade' between the Muslim ports of the Near East on the one hand and the Byzantine and occidental countries on the other. The Byzantines launched many attacks on Muslim ports, as the Muslims did on Christian ones. A group of Spanish Muslims occupied Alexandria as a basis for their piratical activities, and the Muslim rulers of Tunisia attacked the island of Sicily, capturing Palermo and conquering Brindisi and Bari on the Italian mainland, giving them a base in the south which also became important in the re-emergence in Europe of medicine, science and even some arts. The Byzantines counter-attacked in Syria as well as in Cyprus but they were defeated by the opposing forces. And so the conflicts proceeded.

In fact there was almost continuous war in the eastern and southern Mediterranean between Christian and Muslim, leading to the ruin of many towns, especially those along the coast. Their decline was partly related to the religious struggle and partly to the general collapse of the economy. One can see the results of that struggle, which involved the taking of prisoners and booty, in the retreat of the villagers from the coast to more easily defended sites in the hills. This happened in the hilltops in Southern France between Saint-Tropez and Cavalière and in the move of Montpellier from the coast at Maguelone where the ruins of the earlier Cathedral still stand. It was the same with areas in the Muslim Near East that were in danger from the Byzantine navy. The Christian forces had some advantage in military capacity, for example with its use of Greek fire, until the Muslims made up this technological gap, borrowing the lateen sail from the Copts. This sail was triangular, the upper eye being held by a long yard and rigged aslant towards the stern, making for greater manoeuvrability with control from the deck being much easier than with the square one.

The conflicts continued. A contemporary Arab geographer reports that Muslim and Byzantine sailors attacked each other on land, sacking the towns and taking much booty, including gold and prisoners, both for slavery and for ransom.[68] For the victims this was no different from the piracy that had haunted the Mediterranean through the ages.[69] But it was carried out by states, indeed religious groups, and was therefore more general and to some more 'legitimate'. Despite some exceptions, the hiatus in trade seems to have lasted as long as 250 years. It was only when Venice and Genoa had established regular commercial voyages to the area accompanied by armed galleys that such raiding became exceptional.

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[1] Bromehead 1956.

[2] Wickham 2005.

3 Abulafia 2011: 212.

4 Cumont 1911.

5 Toynbee 1985.

6 Bovill 1933.

7 Geldern and Maclennan forthcoming; Minns 1913.

8 Gruen 2002: vi.

9 Taylor 2001.

10 Butcher 2003: 96.

11 In reading through works specifically on the diaspora, I have been surprised at the lack of attention to trade and commerce, which are often less prestigious than religion. And this view may play its part in these works.

12 Childe 1981: 81.

13 Jidejian 1996.

14 Jidejian 1996: 58.

15 Jidejian 1996: 84.

16 Clarke 1979: 310.

17 Abulafia 2011: 90.

18 Monroe 2005: 166.

19 Abulafia 2011: 156.

20 Connelly 2009.

21 Jidejian 1996: 66.

22 E.g. Bernal 1987.

23 Gubel 1999: 58.

24 Isaiah 23:8.

25 Others have claimed (Davies 1935: 67) that Tarshish is probably not to be identified with Tartessus in Spain but with Turša in Tuscany.

26 Harden 1962: 63.

27 Davies 1935: 144.

28 There is evidence of copper being exported from Huelva harbour in the Late Bronze Age but exploitation went on much earlier and there is a suggestion of its appearing from the Chalcolithic period in the Algarve and in Spain (Davies 1935: 118).

29 Abulafia 2011: 70.

30 Kassianidou 1993.

31 Whittaker 1976: 87.

32 Jidejian 1996: 59, referring to Dius and Menander of Ephesus.

33 Whittaker 1976.

[34] Whittaker 1976: 85.

[35] Dietler 1990.

[36] Harden 1962: 173.

[37] Clarke 1979: 318.

[38] Hood 1972: 49.

[39] Aitchison 1960: 147.

[40] Hood 1972: 124.

[41] Abulafia 2011: 52.

[42] Abulafia 2011: 63.

[43] Snodgrass 1971: 280.

[44] Clarke 1979: 402.

[45] Harden 1962: 61.

[46] Aitchison 1960: 144.

[47] Clarke 1979: 316.

[48] Aitchison 1960: 55.

[49] Abulafia 2011: 89.

[50] Aitchison 1960: 63.

[51] Aitchison 1960: 40, discussing the experiments of Coghlan.

[52] Dolfini 2010: 718.

[53] Dolfini 2010: 718.

[54] Dolfini 2010: 719.

[55] Gallet de Santerre 2000: 48.

[56] Bromehead 1956: 1.

[57] Hoover and Hoover 1950: 27.

[58] Hoover and Hoover 1950: 27.

[59] Davies 1935: 235.

[60] Hoover and Hoover 1950: 83.

[61] Bromehead 1956: 9.

[62] Hoover and Hoover 1950: 42. See Davies 1935: 98 and Pliny's *Natural History*.

[63] Davies 1935: 108.

[64] Davies 1935: 114.

[65] Hodges and Whitehouse 1983.

[66] Childe 1942: 284.

[67] Examined by Ashtor 1986: 102.

[68] Ashtor 1986: 103. Attacks in the Mediterranean meant the withdrawal of the coastal population, even at a much later date in Spain, see Colley 2006: 56.

69 On the general security of the Mediterranean which made the galleys so necessary, even at a much later date, see Colley 2006.

5
The coming of the Iron Age and classical civilisation

At a certain point in Antiquity the eastern Mediterranean suffered a series of disturbances that accompanied the diminishing use of bronze, perhaps because of difficulties in importing tin. That resulted in the greater prominence of iron as an alternative, for this was locally available. It is generally thought that iron was known as a workable metal during most of the Bronze Age. In its natural state it was widely available on the earth's surface, of which its ores make up 5 per cent of the total, and as its acquisition seldom involved deep mining it could be easily recovered. Nevertheless it required labour-intensive methods to process and to begin with it was therefore costly. Iron is somewhat different from the other metals. Although it is widespread, in the west the 'bloom' could only be worked by smithying to give wrought iron, while in China, which had wrought iron about 800–600 BCE, the history was different and higher heats were possible so iron ore could eventually be made liquid and cast, leaving its slag free.[1] Pure iron has a melting point of 1540 degrees Centigrade (higher than copper at 1083 degrees) and in Europe this temperature could only be obtained in the Middle Ages or even on a large scale in the eighteenth or nineteenth centuries.[2] So early iron in the west had to be produced by partial reduction at about 1200 degrees with the aid of charcoal. At this heat iron ore yields not a puddle but a spongy mass (a 'bloom') mixed with slag.[3] This is what the blacksmith has to work with, making iron articles by heating and hammering the product to get rid of the unwanted impurities. The result was a 'poor substitute' for bronze, especially as it was brittle in its normal state.[4] What changed the situation and led to a greatly increased use was the creation of a carburised form, in which bloom iron was treated to make it harder, not only by carburisation but by quenching and tempering. All of these processes seem to have been discovered on the spot by blacksmiths working with the actual metal. It was only in the carburised form of steel made with added charcoal that the metal had distinct advantages over copper. Carburisation lowered the melting point of pure iron but it needed the addition of lime to clear the slag.

If the ratio of fuel to ore is large and the bellows sufficiently powerful, the iron can absorb enough carbon to make an alloy, that is, cast iron, which melted at 1150 degrees Celsius. The resulting lumps can then be reheated in a crucible to be cast like bronze. While in the west this result was achieved only occasionally, China did it regularly. But in the west even when it was possible to make cast iron, the wrought variety was still often required for most purposes and it could be made either indirectly by conversion in the smithy fire or directly, as in Europe, with a lower fuel–ore ratio. Otherwise, in Europe and in the Near East, production was of wrought iron and until well into the fifteenth century cast iron was made only with difficulty. When the gun then came into general use in about 1454, there is evidence of the use of alloyed cast iron for cannon balls, made with a lower melting point.[5] Although the casting of iron was not widely deployed, at least in England, until the eighteenth century or later, it became critical to the Industrial Revolution for the mass use of iron, and before that for weaponry. Casting needed higher temperatures through a blast furnace. This may have already appeared in Sweden between 1150 and 1350, possibly coming from China via Persia and the Mongols,[6] possibly a local development. Even though cast iron could then be made, most of the production was still turned into wrought, which was more malleable. Nevertheless it was used early on for making cannon, for which bronze was even better but was expensive. That realisation led to the development of furnaces for the casting of iron guns, much cheaper to manufacture than bronze ones. Hence the English domination in naval warfare, through their ability to produce cheaper guns.

Iron had been used as early as Mycenaean times, seemingly imported from the Levant[7] where it was produced during the thirteenth century BCE or even before, south of the Black Sea. ‘Some groups of people living in Asia Minor and Anatolia under the mighty rule of the Hittite Empire appear to have already acquired a metallurgical knowledge in iron-making, and this coincides with the fact that smelted iron emerges in the Mycenaean world.’[8] During the twelfth century the Hittite Empire collapsed and the technology spread. Iron tools and weapons start to appear throughout the Eastern Mediterranean including Greece where until then we find it used only for jewels.

Carburisation to make steel had been done deliberately by the tenth century BCE; even an eleventh-century knife has been found at Idalion in Cyprus and an iron pick on Mount Adir in Palestine, the site of early iron-making at Gerar. After 900 BCE the production of iron implements increased rapidly. Large hoards of them have been discovered at Hasanlu in northern Iran, and again at Gordion, the capital of ancient Phrygia; at Nimrud in Iraq Mallowan came across another major assemblage. In fact neo-Babylonian writings show a different technological world in respect of iron, with axes, hoes, picks, saws, arrow heads, scissors, fetters, furniture and lamps being made of the metal. It became much used for all of these tools as well as to give a cutting edge for knives and daggers. By the beginning of the seventh century, forging acquired yet another additional process, that is, quenching or rapid cooling. This suppresses the development of pearlite, creating martensite that is significantly harder but more brittle. By the fourth century BCE, to this ‘doctoring’ had been added the additional one of tempering which involved carefully reheating the metal and thus precipitating and diffusing the iron carbide to reduce the brittleness induced by quenching. All this precious knowledge of metallurgy was gained by an empirical approach, as was also the case with the techniques and machinery required for mining, so well described in the Italian Renaissance by the writer Agricola. This earlier, largely unwritten, metallurgical activity was one of the initiators of science, even of ‘modern’ science in a technical sense.

Iron was not scarce like the copper, and especially the tin of the Later Bronze Age. It was readily found throughout the world but in varying strengths and qualities. For example, throughout Africa there were plenty of laterite soils containing a percentage of iron, but it was laborious to turn them into metal, especially in the low-heat kilns. So iron was not originally the cheap metal that became in Europe much later with the development of larger blast furnaces. In China smaller ones were already in use in the third century BCE to make the cheaper cast iron. In Europe, as we have seen, that seems first to have happened in Sweden where iron-smelting and exporting developed substantially when the furnaces and cast iron occurred, together with signs of possible contacts with the east. On the other hand in Africa the process of producing iron was long and relatively expensive; there were many small forges, and formerly many little ‘foundries’, and iron objects were not easy to come by as the process remained technologically ‘simple’, with low productivity, as the furnaces could not raise high enough temperatures to melt the ore, just to make a bloom. Simple iron-working had come to Africa from the Mediterranean, both from Egypt via Meroë in the present-day Sudan, and also across the Sahara from the north.[9] In the early Mediterranean it also involved much work and in the Mycenaean period it was said that 'iron was as costly as gold'[10] – it became more common by the ninth century.

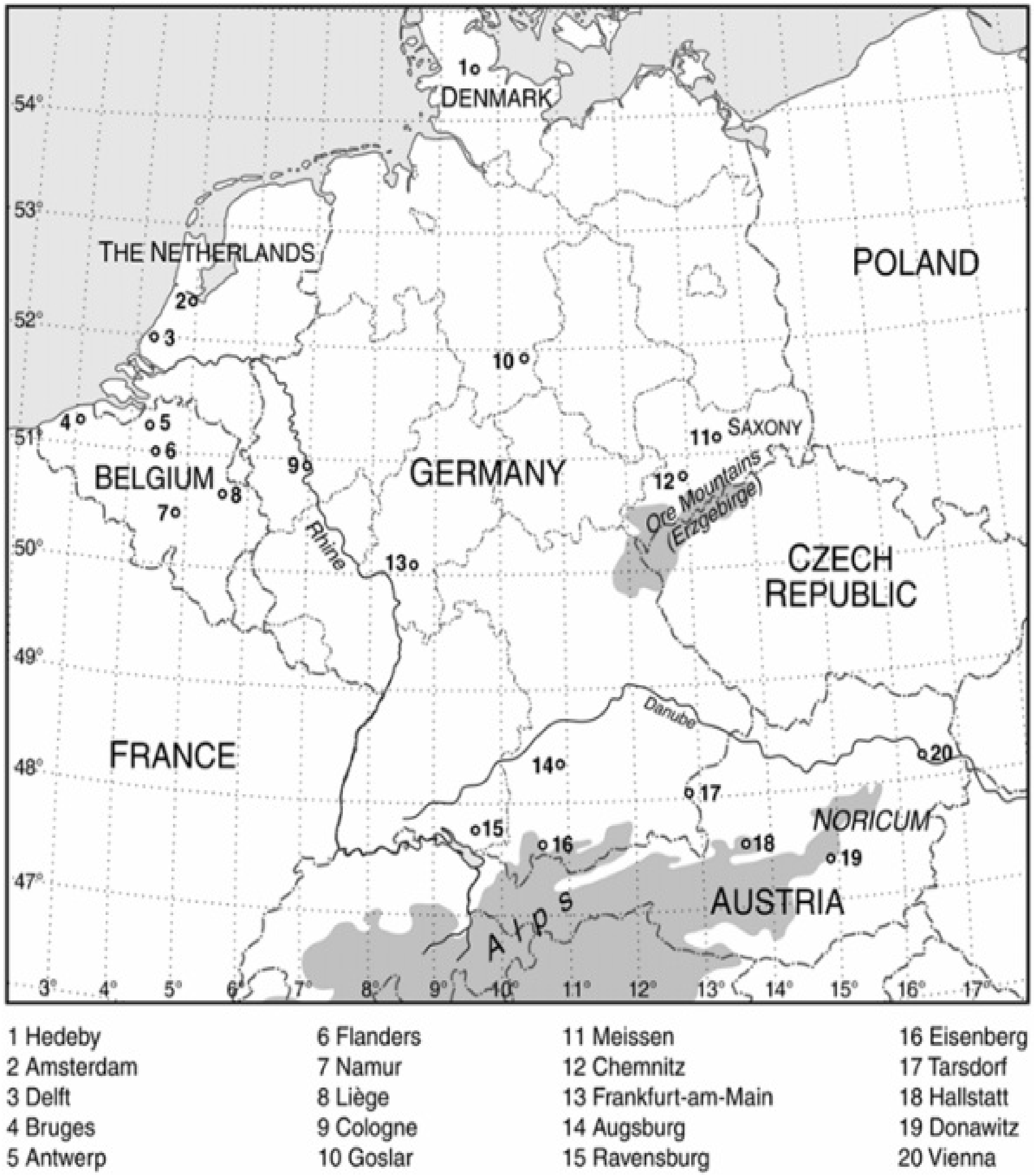
So with these difficulties in production early iron often appears as a 'valuable' as in the elaborate hoes and axes for ceremonial use that were found in some royal houses in Central Africa. There are also the reports from the south-west of the continent of small European craft being deliberately shipwrecked in order that locals could extract the metals in the nails. Of course all this changed in the nineteenth century with the importation of cheap iron from European sources that could now produce cast iron on a massive scale.

The Iron Age was not therefore a single transformation. The early use of the metal, including meteoric, is reported from many parts. It is the process of smelting the ore that was significant and even that can vary with the region. This shift to iron is not a point on an absolute time scale, but the manufactured metal gradually came to be the dominant form from the classical world onwards. Iron was not altogether absent before, as we have noted, but now it began to be employed more extensively both in peace and for war. In peace it was used for a variety of tools, especially for the plough and for horse harnesses, no doubt first in warfare (for wheeled carts, chariots) but not confined to that activity. In China the artisans of the Bronze Age by and large worked for courts; in the Iron Age we find independent artisans as well.[11] In war iron was used for fine blades for swords, for the tips of pikes and for armour for defensive purposes, not simply to equip the elites as was usually the case with bronze, but for the soldiery itself. For this period saw fundamental changes in warfare.[12] It had been chariots that dominated Bronze Age fighting but in the Iron Age warfare was synonymous with infantry concentration. Chariot troops were ancillary. A 'revolution in swordsmanship' now developed in the Aegean, in Egypt and Ugarit around 1200 BCE, a demand for 'long slashing swords' especially from northern Italy, the Balkans and the eastern kingdom. Drews sees the Trojan War as one of Greek Iron Age infantry against Bronze Age Trojan charioteers, the same being true of the upland Israelite infantry (with Jehovah's help) conquering the plains of Canaan defended by chariots.

Achaeans (northern Greek warriors coming from the area beyond the Minoan civilisation) sacked Thebes in Bactria as well as Troy VI. They were resisted by the Libyan chieftain, Merye, who fought against the Egyptian chariots of Merneptah, as well as mercenaries from Sardinia, Sicily, Italy and Lycia, places that were in contact not only with the civilised kingdoms but also with the 'barbarians' of Marsa Matruh.[13] The role and extent of chariots in the eastern Mediterranean had been remarkable. These chariots were manned by two bowmen armed with composite bows that increased their range. However the activities of the soldiery of the Sea Peoples led to the development of weaponry for hand-to-hand fighting, especially in Greece where the swords used were of the slashing variety from north Italy and the Balkans. Warfare was now based upon mass armies, citizen militias, the elements of which were to be found at Mycenae, with close-order formations using the thrusting spear and wearing defensive armour, a system of warfare that was especially characteristic of frontier societies and brought about a 'military revolution' that was a prerequisite of the changes taking place with the coming of the Iron Age. According to Drews, it was not so much the coming of iron that caused the Catastrophe (leading to the Dark Ages) throughout the eastern Mediterranean (with the attacks of the Sea Peoples and the destruction of palaces) as the previous change to mass infantry tactics to defeat the chariots which had until then dominated warfare. Drews does not see the Catastrophe as being caused by the switch to iron, for although a small amount was then in use in the eastern Mediterranean (3 per cent according to Waldbaum), the shift away from royal chariot fighting and use of mass infantry (employing long swords and javelins) had already occurred. The long sword was an efficient bronze one, the Naue Type II that may have come from northern Italy.[14]

Iron-working became widespread in the Anatolia–Iranian region between 1500 and 1000 BCE when it was primarily used for swords and daggers. The Iron Age proper began there about 1200 BCE and 200 years later its use spread rapidly. Soon it travelled to Palestine to be taken up by the Philistines and the Phoenicians, then to Carthage, and on down to Nigeria and to Nok by 400 to 300 BCE. In this way the smithying and the forging of iron, with its employment both for tools and for weapons, came from Western Asia to Europe and Africa. Earlier it went from Anatolia to the Aegean islands and to Greece where it was extensively employed for weapons. By 800 BCE its use was even more widespread. Greek influences were felt in Italy by way of the

Etruscans, while the Phoenicians also left their mark in Spain. By that time there is also the Celtic Hallstatt culture in Central Europe, the first Iron Age reaching Britain about three hundred years later; iron-working remained especially important in Austria and Southern Germany (as copper had earlier been), as well as spreading to the west and north. The Frisians, like the Celts and the Romans, were iron-users from the continent, who pushed westwards in their search for new territories and for new sources (Map 8).



Map 8 Central and Northern Europe

In the eighth century, the Celts had already spread the use of the horse and chariot in war, a practice that had been developed around the Caucasus and flourished among the Cimmerians, who though defeated by the Scyths spread the new techniques over Central Europe. One other thing was needed, 'the craft of working iron' which the archaeologist, Hawkes, sees as coming from

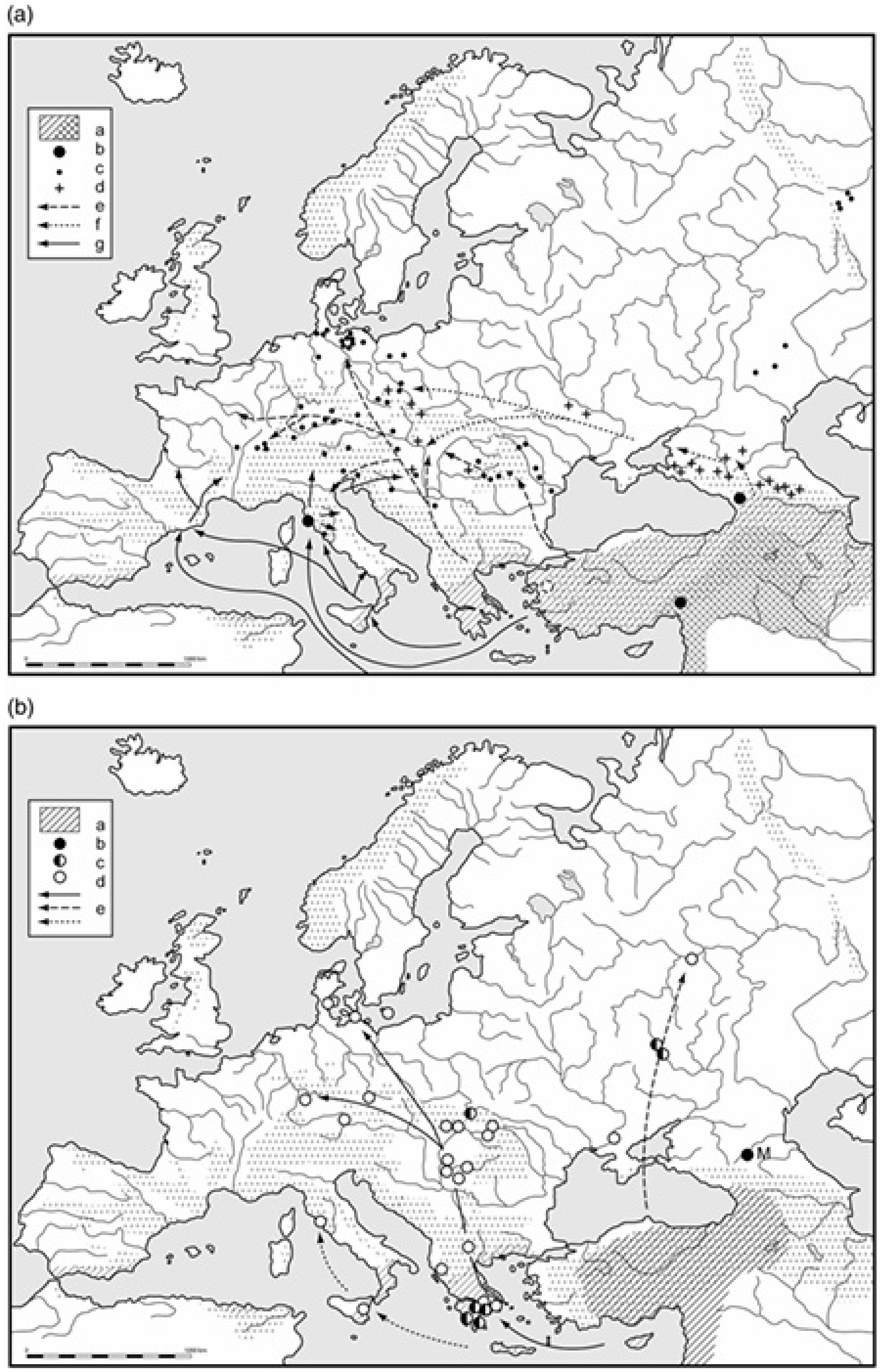
Italy.[15] Iron-working spread from Anatolia to the Etruscans, as well as through Transylvania to the Alps at Noricum. Together with the mining of iron and copper one also found that of salt, the use of which enabled the conservation of meat killed with the iron weapons. This Hallstatt culture went with Celtic warriors down the Rhône and then into Southern France and Spain. The Mediterranean merchants meanwhile came to France by the southern route and traded their goods up the Rhône valley in exchange for raw materials, especially the metals, of the north.

This was not the first time that the Greeks had visited the coast. From their colonies and trading stations at the mouths of rivers, they expanded their interests in Europe, taking with them coins that had first been struck in Lydia, as well as goods. Expansion followed in what have been called the 'Greek Middle Ages', a dark age following the efflorescence of creation in the Cretan and Mycenaean cultures. From the eighth century BCE, the Greeks made further contact in the west, founding the first colonies in the south of Italy and Sicily, where they were in competition with both the Etruscans and the Carthaginians. Herodotus wrote of a certain Greek who landed in the south of Spain in the middle of the seventh century; indeed some modern scholars think that, following the path of the Phoenicians, the Greeks first went to Spain and only after that founded Marseilles. In any case they knew of references to the voyages of Hercules who searched for the golden apple of the Hesperides in the west; 'more prosaically they tried to open outlets for their commerce and, doubtless, to approach the sources of tin'.[16] Before the Phocean, that is, Greek, colonisation of Marseilles, merchants from Rhodes visited the southern coast of France and Spain where they founded various 'comptoires' (or trading establishments). In the seventh century BCE there is evidence of Rhodian commerce in the lower Rhône valley as well as in Catalonia but there is no proof that they proceeded to Marseilles or to Agde. It seems to have been the Etruscans who first exploited the market in Languedoc in the south west of France; archaeology has revealed traces of their presence along the coast especially at the mouth of the Hérault, both at Pézenas and at the port of Lattes (Lattera). It is possible that Phoenicians and Carthaginians also traded here before the Greeks but the evidence is again unclear. The Phoenicians trading off the coast had a 'significant' role in catalysing a more complex form of social organisation in Europe. That included movements by sea. They probably brought the sail and the keeled galley to Atlantic shipping. Until the exploratory voyages of Himilco, the

Carthaginian, in 450 BCE and the Massiliote, Pytheas, in 310 BCE, most sea voyages were of short duration; now they could be longer.

In Egypt the craft of iron-working arrived by 700 through Greek or Carian traders,[17] although it did not become common there until after 650 BCE. It then spread much more widely, and between 500 and 200 BCE developed in Aksum in Ethiopia in the fourth century BCE, in Meroë, connected with Egypt, and in Algeria where it developed under Carthaginian influence. North of the Sahara iron was produced in the Atlas Mountains before the third century BCE. Then it went down to East Africa, or possibly through Mesopotamia and South Arabia. In Africa the pattern of acceptance was similar to other places with mixed farming and pastoral populations. Knowledge was passed on to the pastoralists and from them to farmers in East Africa in the later first millennium BCE when it has been linked to the spread of agriculture,[18] not along established trade routes from urban 'civilisations' but over local networks between Neolithic communities.[19] Before that, copper-making in Mauritania and Senegal had been passed on with long-distance trade. The iron technology transmitted in this way was of the 'simple' kind; there was no steel (by cementation) or pattern-welding as found in Europe. Iron-making also went eastwards to Iran, reaching to India and possibly China in about 600 BCE. It was in the latter that a tradition of cast iron was started; unlike bronze, iron does not melt until heated to a temperature of 1535 degrees Celsius, which in the west was not regularly obtained until much later.[20] Iron ore can be made to absorb carbon so that it forms a liquid alloy, cast iron, which melts at 1150 degrees Celsius; however only the Chinese did this routinely since they already had the high-heat technology with stoneware pottery. This temperature was possible in a blast furnace when the cast iron collects at the base of the furnace and is withdrawn as a liquid rather than as a lump.

The reception of a society to iron-working depended upon the link to other features, upon its usefulness in different economies as well as upon social and religious considerations. In the Black Sea coastlands and in the plains north of the Caucasus, it spread only slowly, not to settled farmers, as in Europe but to pastoralists, to Scythians, not reaching east–central Europe before the ninth century BCE. To the north-west of Europe it was widely used by 600 BCE while further north, in Russia and Scandinavia, it was not common until well into the first millennium CE.[21] This whole movement of iron-working westwards through the Mediterranean and Europe is shown in two maps that I reproduce as Map 9a and Map 9b.[22]



Map 9 Iron into Europe
Source: H. Haefner and R. Pleiner, *Frühes Eisen in Europa*

The spread of iron, as of metals, the knowledge of metallurgy, the growth of trade as well as the military usage, both of which had long existed in the Mediterranean, entailed much movement of peoples to and fro, especially with the running down of supplies of precious ones in the Near East. The Iron Age saw the colonising activities of the Etruscans, the Greeks and the Phoenicians, following the paths of Minoan and Mycenaean traders along the Mediterranean littoral, which even preceded their mining in Spain. These people carried with them the knowledge of writing, sometimes of alphabetic writing; other forms of script were already known in Mycenaean Greece, in Crete and in Cyprus. The composition of monumental inscriptions in stone, such as the famous ones at Bisutun made by Darius of Persia, had probably to be done with iron tools; copper was hardly strong or sharp enough. It was the same with the delicate Greek sculpture in stone, virtually impossible before the use of iron. Of course plenty of stone figures, the more rounded forms, emerged from the Neolithic in Eurasia, Africa, Oceania and South America, especially those of the Olmec; these societies did not have iron but on the other hand their sculptures were not of the precise, 'realistic', quality of the Greeks. With the alphabet, its use in trade and its instruction in schools, writing became more 'democratic', less 'scribal', less 'monumental' and public, more personal, and expanded westwards through Greece and Rome, as well as into Carthage, creating a Mediterranean Antiquity which can be seen as an Iron Age prolongation of the culture of the Ancient Near East, modified and augmented by local contributions. This movement spread alphabetic writing not only to the west but also to the east through Aramaic-speaking tribes, especially with the proselytising power of written religions. In the west there was first the Carthaginian Baal and other 'oriental cults', and then from the same area Judaism, Christianity and later Islam, all which travelled in both directions. Judaism, as Bernal has argued, seems to have been adopted by the Phoenicians, that is, by the defeated Carthaginians, as those Semitic speakers had so much in common, culturally and religiously.[23] That adoption added to the spread of Judaism in the Empire when the Romans 'deleted' the town and dispersed its libraries. The Carthaginians had had their major mines in Spain, which became a target of the Romans when Carthage was now the enemy. They were certainly powerful rivals for these mineral resources. The country had already been defeated in the first Punic War in Sicily, when Rome invented the iron grapple enabling its infantry to attack at sea. Later Carthage was conquered in North Africa itself.

Mention of Carthage, Africa and Rome raises the whole question of the role of metals in these various struggles, not simply as a general resource but in warfare, both offensively and defensively, especially with the widespread development of metallic body armour that was so prominent a part of the equipment of these states. Humans have always wanted to protect their own bodies. In fighting, they have done so not only with shields, as in the Pacific, but with padded clothing in the Far East, or in West Africa where chiefs and elders wore Islamic-inspired 'magical' smocks covered with small pockets containing verses from the Holy Book to give supernatural, and actual, protection in warding off arrows or javelins. This textile or leather covering led to the manufacture of armour, that is, of metals to shield the body, and that in turn resulted in a much greater demand for iron.

To protect the head, helmets of bronze were found to be not strong enough against the heavy swords of the northern tribesmen and the Romans adopted iron ones, polished so as to deflect the sword-blades. The Etruscans had started to procure the metal from Elba and in Tuscany about 900 BCE, providing a powerful tool for their expansion, and subsequently the sources proved to be a target for the Romans. At first the latter's weapons had been made largely of wood as the Etruscans denied them iron, except for farming.[24] The Romans reacted with violence and took over their territory. There they developed the copper mines of the area and exported the metal to Malabar and Broach in India, although that country had its own supplies. Brass, an alloy of copper and zinc which resembled gold in colour, became very popular in classical times and was traded to Africa and the east where it was said to have been more expensive than silver. It was used subsequently in English churches, although much of the material originated in the metal-working industries of Germany, France and the region of the River Meuse. The English developed their own style of working it but this was not popular abroad where the Flemish manner was preferred.

But the mass use of metals was first not for decoration but mainly for weapons of war. For this activity copper and bronze had always been prominent, both in offence and in defence. In offence they were already used as edges and points, in the axe, the spear and the javelin, and the appearance of iron only added the sword. Swords of bronze were indeed found in Greek graves, for example. But their length exceeded the structural capabilities of the material and it was only with iron forging from about 1200 BCE that they became a serious military weapon. In the defensive range, protective armour is reported for the Seima–Turbino culture of the Altai of the Late Bronze

Age,[25] and we already find helmets of bronze being made by the Sumerians from 2500 BCE. The Greeks wore the same type, as did the legionnaires of the early Roman Republic but, as we have seen, in the Empire of the first century BCE they were made of iron instead. Body armour with overlapping scales of bronze is represented in art from 1500 BCE but was confined to a small elite. By classical times bronze breastplates were more common, and this metal was used well into the Iron Age. But bronze mail, which provided flexibility, was not practicable because of the weakness of the alloy. The first iron body armour appeared in Hellenistic times; it was mail and became widespread in the Imperial period of Rome. For Roman soldiers mail (*lorica hamata*) dates from the third century BCE and may indeed be Celtic in origin; the 'barbarian' Celts from Central Europe were certainly great smelters and users of iron, both in war and in peace. The Germans who had been using iron in the earlier Celtic Hallstatt culture employed the heavy plough before 75 BCE, but about 400 BCE the centre of the industry had moved from Noricum in Austria to the Celtic lands in the south-west of Europe, including Spain[26] which was obviously one of the attractions. The Celts used metal for weapons as well as for the plough, but even in the later La Tène culture they forged iron locally in farms and hamlets, including for military purposes, not in the hill forts they built, as it was always made individually rather than industrially.[27] Armour of plate-iron as distinct from mail was known as *lorica segmentata*, and was later produced on a large scale for the Roman army. All such iron protection was at first confined to the elite and its use only become generalised in the later Roman Empire, together with the long sword that was adopted from the 'barbarians'. To produce this iron, coal was sometimes used, but not in any regular manner as in contemporary China.

The Etruscans, who were great users of iron, had also developed a navy, a system of writing (or inscription), and used technology to increase both their luxury and their armaments industries, as well as to support public engineering projects, especially in irrigation and in drainage tunnels. They initiated change not only in large-scale water control but in public works generally. They had borrowed much of their knowledge from the Greeks with whom 'they maintained close trading contacts', seeking iron from the Greek colony on Elba.[28] The Romans in turn acquired much from the Etruscans, particularly in military matters. 'It is important to realize', writes one commentator, 'that the wealth of the Etruscans was due mainly to their skill as metallurgists and workers on iron and bronze. Their military equipment would have been of excellent quality.' And again, '[t]he trade in base metals was the real foundation of Etruscan prosperity'.[29] Their equipment consisted of stout bronze helmets, body armour of bronze plates, shields and short swords. The forging of longer sword-blades was always a highly specialist activity, as in Germany and the Far East, involving complex processes of laminating sharp steel and solid wrought iron in which the 'barbarians' were acknowledged experts.

Like Greece, the Mediterranean societies could all make use of cheap maritime transport, which was so expensive by land. So they established coastal colonies, including at the Black Sea, and their sales and their imports meant they were able to specialise in their activities. That meant that Athens could become dependent upon supplies of grain provided by North Africa and the Black Sea region so that it could concentrate on the provision of manufactured goods such as painted pottery, or on olive oil or the products of the silver mines at Laurion. That this way trade developed. In the fifth century the father of Demosthenes owned a workshop for bedsteads as well as an arms factory. This specialisation involving the import of grain from abroad became the rule and was continued in Rome, in Venice and of course today, so that whole countries would become more artisanal or even more industrial, leaving the production of cereals and various vegetable products to others. However, the exchange was never totally equal, involving a stratification of an economic and valuational kind between the two parties.

The Greeks made much use of iron and steel. The Early Geometric period of the ninth century BCE was already iron-using for trade and other purposes. In their warfare against the Persians and others they were heavy users, above all in the equipment of the conqueror, Alexander, the Macedonian. The role of warfare in Greek society is emphasised in an account by a classical scholar[30] who agrees that 'war was a normal part of life' but following the anthropologist, Clifford Geertz, wants to call attention to it as 'a symbolic expression', as a 'ritual' like sacrifice. There were undoubtedly aspects that were ritualised, formalised and 'codified' but to speak of it in these terms ('The campaign . . . becomes a closed system')[31] neglects more pragmatic aspects. The system, Connor argues, derives its power 'in large part from its ability to provide a coherent way of looking at the world, of seeing and interpreting experience'.[32] In a later postscript to his essay, Connor seems to move away from this emphasis on ritualisation, without rejecting it as one element among others. For while there were certainly changes in warfare over time, as he suggests, there was also a continuity that encompassed Greek mercenaries, Alexander's conquests and led to the conquest of colonies and to the great enterprises of Roman warfare.

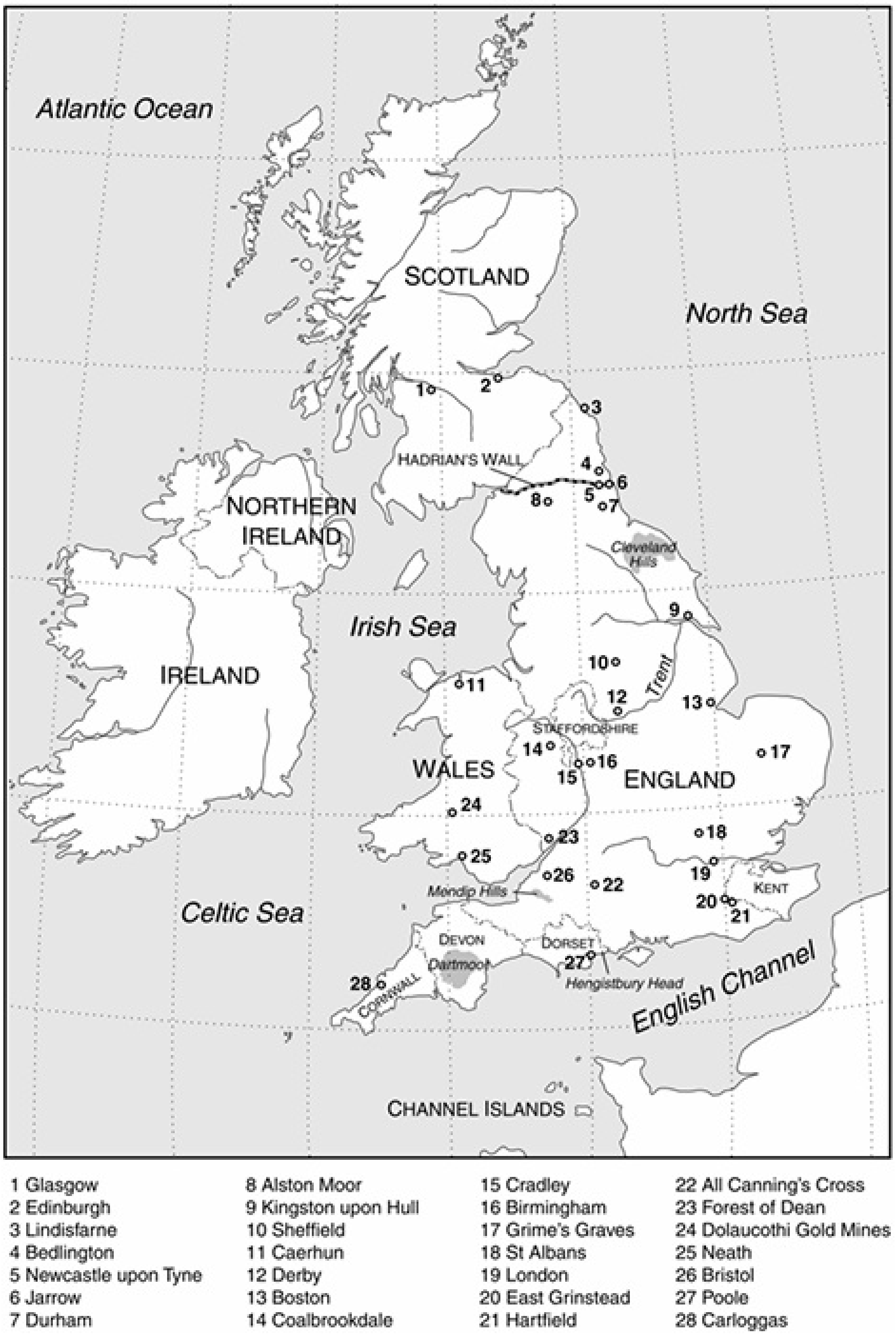
From Greece, iron-using reached the rest of Europe, spreading with the development of commerce in the seventh to the sixth century. To the north, however, Hungary probably acquired it from the Cimmerians in Eastern Europe. These were 'barbarians' who brought a knowledge of iron-working from beyond the Carpathians, coming there by way of the Black Sea and Anatolia, but in Europe their influence did not extend much south of the Danube.[33] In the Balkans, iron-working, which only began later, seems to have come from Italy where it had developed through the Etruscans, the Greeks and the Carthaginians.

In Italy, Rome took over from the Etruscans and the making of iron was much increased. With the extension of their control over Central Italy, the Romans secured access to its mineral wealth that was of crucial importance to their activities, as were the Balkan mines. It was this wealth in Elba that had been mainly responsible for the success of the Etruscans and which now fell into Roman hands, supplying them with the materials needed for war. Eventually they became the rulers of the whole of Italy, for when they defeated Pyrrhus, they sealed the fate of the Greek colonies in Campania in the south. Their troops had been rapidly deployed along the main lines of communication, which had been so well developed, built with an engineering skill 'inherited from the Etruscans'.[34] Along the straight Roman roads, with frequent halting places, iron-clad soldiers, carts and carriages could move more rapidly from one place to another. Road-building and conquest were carried out throughout northern Europe, in Gaul, in Britain and in Spain. Despite ritual prohibitions on the use of iron, their mines later supplied the arms for Scipio's invasion of Africa in 204 BCE.[35]

The fighting forces of the Romans changed from using the Greek *phalanx*, which involved a solid mass of armoured hoplites used so successfully by Alexander, to one in favour of the legions, more adapted to warfare against fast-moving 'barbarians'. However, without developing all the features of the Bronze Age, these 'barbarian' societies could themselves exploit some of the advantages of the urban cultures, such as metal-working and coined money, which in the long run told against the urbanised settlements. In the meanwhile Rome employed the legion, both in attack and defence. This formation consisted of three lines, the first comprising lightly armed youths together with a fully equipped group of soldiers, with oblong shields of alloy instead of the earlier round ones, and who were also protected with body armour. In the second rank, too, they were fully armed, but not those in the rear echelon. The hoplites, and the obligation of citizens to belong to a ‘regiment’, were essential to participatory ‘democracy’, as in other conscript armies, and that situation changed when a permanent professional force was established, who of course had to be paid. For all this equipment that an extensive army required, whether conscript or professional, Rome used a great amount of basic metals, as well as the precious ones for jewellery and bullion. Bronze was still widely employed for coinage, for fittings for vehicles and for arrows, as well as for casting statues and for a number of domestic utensils like cauldrons; lead and tin too were common, partly for alloys, the first also for water-pipes for drinking water or baths. Iron however was employed for weapons and for tools that required a sharper edge, in agriculture, in crafts, as well as for inscriptions. The metal of course was very important not only to the Greeks for their *xiphos* sword and the Romans for their *gladius*, which became larger in the later Empire (the *spatha*) but was also used in the Persian and Sassanid Empires. These instruments were worked by smiths from wrought iron and in Italy guilds of blacksmiths (*fabri*) had a special quarter, particularly in Milan and Brescia, where they worked iron and steel from Noricum; this was much prized though not as much as the Parthian steel from Persia and the Indian from Hyderabad.[36] Of this metal, the military required large amounts. A whole legion consisting of 5,000–6,000 men would be equipped with helmets, chain-mail and other protective gear as well as with fighting weapons – swords, daggers and spears – all made from iron. The extent of these requirements can be gained from the example of Britain itself which was garrisoned by four legions, plus auxiliary troops; the demand would have been great, especially when compared with that needed for earlier forces. Nor was it only weaponry. The timber forts built by the army needed thousands of iron nails plus tons of lead for the water supply and for various stone buildings, so the impact of the Roman conquest on the use and production of all these materials was very considerable. Most of this use ended with the withdrawal of the troops from the western Empire, which meant a huge decline in mining.[37]

Roman mining was especially important in Spain, described as the ‘principal attraction’ for Rome,[38] where Pliny the Elder saw it in action in 72–74 CE when he held an official post there. In his day, Como was also famous for its iron industry and the Romans extended mining there, and throughout Europe, especially at Noricum. The analysis of Arctic ice caves shows that in 79 BCE lead pollution in Rome was high and the same levels were not seen again until metal was exploited in the Harz mountains in the early Middle Ages.[39] Activity was great and the Spanish mines were the most important metal deposits in Europe. Speaking of the silver–lead mines, Pliny wrote: 'The mountain has been excavated for a distance of 1,500 paces, and along this distance there are water-carriers standing by torch-light night and day steadily baling the water (thus) making quite a river.' Water was a major problem in European mines, and gave rise to many early technological inventions. In the first century BCE Diodorus Siculus refers to the Spanish mines, saying in Book V: 'Sometimes at great depths they meet great rivers underground, but by art give check to the violence of the streams, for by cutting trenches they divert the current, and being sure to gain what they aim at when they have begun, they never leave off till they have finished it. And they admirably pump out the water with those instruments called Egyptian pumps, invented by Archimedes, the Syracusan, when he was in Egypt. By these, with constant pumping by turns they throw up the water to the mouth of the pit and thus drain the mine; for this engine is so ingeniously contrived that a vast quantity of water is strangely and with little labour cast out.'[40] The Romans carried out both depth and surface mining. The latter was practised in soft rocks in the auriferous region of north-west Spain where the techniques involved the control of river water. By contrast the deposits, mainly copper, of southern Spain were in hard rock which meant tunnelling – and there water presented a problem of a different kind, both to empty and to lift.[41]

The main Roman mines in Spain had been taken by force from the Carthaginians who, as we have seen, were part of the earlier dispersal in the Mediterranean, and these mines may have been exploited even earlier by the Mycenaeans. The larger ones were found at Rio Tinto in the Huelva region of south-western Spain. Tin was also found there, but in the third century Spanish mines gave way to the British in the Roman market (Map 10).[42] Silver constituted the main attraction, but copper continued to be produced. In time this important centre became virtually a 'school of mines'[43] and its engineers were appointed in many parts, including being sent to the 'barbarians'. At one level it was state-owned by the imperial government but that did not necessarily mean it was exploited directly by that body. In fact they were usually exploited by companies (*societates*) or by individuals, who sold and exported the metals, paying a royalty to the state. The Spanish mines supplied the metallic needs of much of the north of Europe, but the direction of the movement of metals later changed into one coming largely down from Britain. In either direction the metal trade was massive and could ‘carry’ other commodities. It has been suggested that the exports of metal from the Massif Central were a supporting factor in the distribution of *terra sigillata* pottery from La Graufesenque near Millau, a process that also happened in the reverse direction with pottery placed among African shipments of grain. It was the scale of this mining exploitation that distinguished Roman metallurgy from earlier and indeed later periods, not its technology. The Romans did not invent new methods so much as intensify the use of existing ones. In fact in the whole sphere of metallurgy little change was made in Europe until a limited use of cast iron appeared in the fourteenth century, the large-scale use not being adopted until the eighteenth, otherwise mining remained much the same in terms of its methods up until the Renaissance, although there were of course some minor changes; the activity never stood completely still.



Map 10 Britain

Under Rome, once the metals had been smelted, they were usually taken to the workshops of particular industries, most cities receiving what they needed directly from the smelter. Certain places saw the development of some large-scale concerns, as in the production of vessels of copper alloy at Capua, situated near to Pozzuoli, then the greatest port in Italy and useful for export and distribution. But production on a large scale took place elsewhere too. For example, the mines at Noricum in Austria later on sent iron to Aquileia at the head of the Adriatic where silver ware and glass were also produced; the steel from Noricum was second in quality only to the special product from India which was imported at great expense. In Roman times metal work was indeed among the most widely traded of manufactured products. Silver plate was used extensively by the middle classes and produced in a factory system with a complex division of labour. It is thought that the extent of this use of plate was unparalleled until the eighteenth century when the distribution of wealth was not dissimilar to that in the Roman Empire;[44] it is only in the later period that dinner services again appear on the tables of ordinary farmers. All this activity, it is argued, makes it difficult to sustain the 'minimalist' view of the Roman economy, which certainly had its large-scale components.[45]

However it was not domestic uses but above all the military ones that required major quantities of metal, in this case of iron, to equip the soldiers with body armour, helmets and swords. And the army itself was huge in order to defend all those long frontiers the metal-seeking Empire had established. Despite this widespread employment of metal, archaeology displays some gaps in our knowledge. The only mention of anything like a repair shop in Webster's account of the Roman army in Britain is at the frontier fort of Caerhun in Wales where a small annexe 'appears to be associated with metal-working'.[46] But of metal use, mining and manufacture there is ample evidence. The mining itself was usually carried out by slave labour, though it should be added that most workers were allowed to earn money for themselves and some lived quite well; slaves might in fact rise to positions of considerable responsibility. But slavery was nevertheless opposed by some, even then, and it has also been claimed that it may have made labour too cheap to provide an incentive to change the way things were, to create labour-saving devices. In any case, during this period inventions seem to have been few but certainly not altogether absent.

One of these was the use of mills for making flour that began in Rome after 330 BCE; sometime after 100 BCE these rotary wheels were driven by non-human labour, by donkeys. Much later during the late thirteenth century it was these mills that enabled forging to take place mechanically. A *moulin à fer* existed in France as early as 1249 when water-power was being used. And in 1408 the bishop of Durham established the first documented water-powered bloomery in Britain.[47] Iron machinery was incorporated into these mills that represented an important prelude to industrial activity. Nor was the mill alone among the Iron Age inventions or adaptations, many of which were related to mining. ‘The block and pulley, the windlass, the use of water-wheels, the transmission of power through shafts and gear-wheels, chain-pumps, piston-pumps with valves, were all known to the Greeks and Romans, and possibly before.’[48] Some were certainly found even earlier, in the mines of Carthage for example, and they belonged to the unwritten ‘technological’ tradition rather than to the written ‘scientific’ one; consequently they remained largely undocumented but there were many of them, the evidence for which is mainly archaeological.

At the site of an important Roman gold mine at Dolaucothi in south-west Wales, water channels and reservoirs have been found in the hills above the workings; these were used to collect the water, then to let it rush down suddenly to remove the overlaying soil and the loose rock. Precious metals like gold were sought for payment, for exchange and for decoration. Spain contained the richest deposits in Europe and ‘metallurgy had become the hand-maiden of imperial luxury’.[49] But Wales too was important and in the mine the Romans installed a water-wheel, operating in the reverse manner to that for flour mills and raising water from the deep shafts and tunnels. The water was used not only to wash away the top-soil and to refresh the site but also to clean the precious ores once they had been extracted from the mine. One problem with the abundance of water in Europe, so important for agriculture in the eyes of many earlier commentators – as well as for power, was that an excess led to problems of flooding, making the metals difficult to work. The invention and use of hydraulic machinery mitigated the difficulty, which was eventually solved by the coming of the steam engine in the eighteenth century, so important in the development of the whole industry.

As we have seen, many inventions in the mines had already been made by the Roman period. There was the famous screw of Archimedes that enabled water to be evacuated. This instrument gave a lift of 6–12 ft and was specially made for irrigation, the first reference being in an Egyptian papyrus of the second century BCE. In the mine, water could also be brought up from the depths by the use of buckets attached to an endless chain wound round a drum, making use of rotary motion. Then there was the pumping equipment invented by Ktesibios that was equipped with valves, cylinders and pistons. This machine worked like a hand pump but there is no record of its actual use to raise water; however, it could also be employed for circulating air that was equally important in deep mines. Nor is there any record of use in the case of the other interesting pneumatic and hydraulic machines described by Hero of Alexandria. Metals played an important part not only in this machinery but in automata. They had been known from the days of Philo of Byzantium and Hero of Alexandria, both of whom wrote on the subject. In the early medieval period the 'technology was better preserved in the Byzantine and Muslim worlds' than in Western Europe.[50] Westerners saw these products when travelling to the east and in the tenth century we have Liudprand's description of a visit to the imperial court of Constantinople where he sees the throne of Solomon displayed. There was a tree 'made of bronze gilded work, whose branches were filled with birds',[51] reminding one of Yeats' poem, 'Sailing to Byzantium'. The technology became widely known in the west by the thirteenth century, being found in some great palaces. And 'major advances were occurring in mechanics and engineering in and around the thirteenth century. This was the age that saw the birth of windmills, the rebirth of stone bridges'; at the same time, Roger Bacon was specialising in other developments, though many identified these with 'speculation'.[52]

One of these inventions was the water-clock with metal gear-wheels, also employed to work the complex grinding mills driven by water-power. This time-piece was the starting point for subsequent clockwork machines which included watches and clocks of all types.[53] But the Romans had also used metal even when they were building in stone, though not like the Chinese for pagodas or chain bridges in cast iron. We see this from the holes for metal rivets in the walls of buildings at Palmyra in Syria when the metal was removed during the Islamic period, showing its value in the Near East before the era of cheap imports from Europe began much later with the industrial manufacture of cast iron.

But it was not only states that could equip themselves with metal weapons and tools, now even 'barbarians' and some individuals could do so too, operating on an almost personal basis and giving rise to more 'democratic' or even 'republican' forms of government. Nevertheless body armour was still expensive, booty was not for everybody and its acquisition could produce its own form of military tyrant. Warfare led to the taking, or at least to the sale, of slaves who were employed for despised or difficult work, for instance, in the Laurion silver mines on which Athens was so dependent. The Roman conquests themselves produced many captives, in Britain and elsewhere, and doubtless slave-dealers as well. However cheaper iron tools were also employed for much activity of a peaceful kind among the rural population, many of whom adopted the plough and greatly increased their agricultural productivity.

Iron was not confined to the classical civilisations of Greece and Rome but spread throughout the ‘barbaric’ lands. The working of iron was much more widely distributed than that of other metals, and that changed the situation for many outside the urban ‘civilisations’ since it became available to the many, not only to the few. But certain places were especially known for its production. Concentrated workings of iron took place at Roman Noricum in Austria, for instance, the district situated around Hallstatt, the type-site from which iron-working diffused to Britain and to western Europe in the fifth century BCE. The basic material was available everywhere, though the volume of the deposits, their quality and their accessibility varied greatly. Its manufacture had spread inevitably from Anatolia to other ‘barbarian’ cultures, as in the case of bronze, but the materials for that alloy were rarer. Iron-making became extensive throughout Europe. In the south of Poland, in the area of Sainte-Croix, there are traces of iron-working extending over 800 km with thousands of ovens dating from the second century CE.[54] At Les Martys in the French province of Aude and in the Montagne Noire in Languedoc, there is extensive evidence of such activity from the beginning of the Christian era, and again one must envisage a largely military use under the Romans. In southern Norway one finds remnants of iron-working from the fourth century CE with an increase in production that is later linked to the Viking conquests of the ninth century which depended so heavily on the metal.[55] These very extensive finds provide evidence not only of local activity but also of a substantial trade in the metal as well as for its use in war.

The south of France produced much evidence of its use and had earlier been strongly influenced by the Bronze Age settlers of the Tumulus period as well as by Iron Age Greek (and other) traders coming along the littoral of the Mediterranean. The coastal trade may have existed as early as the eighth century BCE when there was a route from Greece to Catalonia and also to south Italy. The presence of Magna Græcia there certainly led to Greek colonists coming to Marseilles, and from the sixth century there were also the Etruscans.[56] By that time the iron-using Celts had come down to the Mediterranean, invading Spain where they met the Iberian people; these Celts were later followed by the German-speaking Vandals and Visigoths as well as others, also coming as invaders with their iron weapons to metal-rich Spain. While the uses of iron, like other base metals, were multiple, there is little doubt that the early importance was for war and the production not only of superior cutting edges but also for the less expensive protection of the head and body.

The archaeology of the Iron Age in southern Gaul and in Spain has shown ample evidence of a warrior society, especially in the Second Iron Age where the type-site of La Tène in Switzerland has produced a significant cache of weapons. Elsewhere we find not only weapons, especially swords, scabbards, helmets and lances, but also examples of horse harness, for these warriors, fierce according to Caesar, were armed riders with a 'heroic' culture. This culture included elaborate helmets like that of Montlauces but also the remnants of many skulls, apparently decapitated as battle trophies or promoted as ancestral figures and nailed through with shafts of iron. The Iron Age was certainly not the first to experience warfare between groups, but after the Bronze Age these weapons helped to 'democratise' war and to spread these activities among various peoples where the rulers established their *oppida* as fortified structures, which persisted down the centuries in the shape of 'feudal' castles and similar strong points that could hold the enemy warriors at bay, at least temporarily. The impact of the Near East on Europe is epitomised in the advent of metal technology and later of literacy, which in the Mediterranean was first brought by the Greeks to Marseilles, and then by the Etruscans to Lattes. It was the Etruscans who appear to have developed urbanisation there and their creation of ports attracted local populations of Gauls, who were also engaged in the construction of nearby *oppida*.[57] One element of this complex reality is not superstructural in opposition to the infrastructural; the metal and the literacy emerge together and support one another.

The interpretation of sculptures in the northern part of Spain, and of Celtic Gaul, shows the inhabitants to be interested in war, hunting and in solemn processions.[58] Especially significant are the nailed skulls, which bear witness to the nature of this warrior and 'heroic' society. However, the sites become increasingly urbanised and were in some cases guarded by sculptures of lions. Another animal, the horse, was also important by the fifth century and is represented above all on stelae which were put up to mark the limits of a property and to display for funerary or commemorative purposes. Apart from this aristocratic cult, later on in the fourth century, we find evidence of temples influenced by the Greeks and the Phoenicians especially in the south, evidence of growing urbanisation.

Already, the whole of Southern France and Spain seem to have been radically changed by the Iron Age. Gaulish and Iberian soldiery came down with iron weapons and horses that have left their mark archaeologically.[59] The horses enabled them to conquer foot soldiers, the iron weapons to kill and decapitate their opponents. In their forts human skulls and jaws are well represented, some of the skulls being hung on iron nails as visible trophies. It was iron too that subsequently enabled the urbanised Greeks and Romans to establish themselves on these coasts, the former as colonists, the latter as invaders.

The metallurgical weapons of the incomers combined with the organisation associated with their urban culture usually enabled them to dominate the ‘barbarian’ metal-users. But the latter displayed considerable skills that were found among Celts generally, as in the case of the Iceni of East Anglia who made not only magnificent gold torques but also the formidable war chariots and other weapons of Boudica in her revolt against the conquering Romans. The Iceni undoubtedly suffered at the hands of those who brought ‘civilisation’, urban life, written culture and a complex military organisation to the ‘barbarians’ of this country, but the Celts also acted in an aggressive Iron Age manner like other ‘tribal’ peoples.

But before the arrival of the German-speakers, the first Roman colony outside Italy had been created in 121 BCE at the port of Narbonne in present-day Languedoc. It was the main city in the area, which had earlier been under the Celtic Volques Arécomiques. Lying at the mouth of the River Aude, it was well placed to communicate by land and by sea. From the quais of La Nautique have been recovered the debris of vases from La Graufesenque (near Millau) which were brought over by cart and exported through the town. As the result of its activity, Narbonne itself was very cosmopolitan, with its own Jewish cemetery and its many connections with the east, only thirty days sailing to Alexandria, fewer to Africa; it was populated by many traders from the Mediterranean, a connection that was evident in its dyeing of purple cloth with *murex* from the Lebanon. The oriental influence was especially apparent in the old Roman town of Nîmes nearby with its dealers in papyrus and its cults of Isis, Serapis and Anubis. Links with the eastern Mediterranean continued in the Visigoth period when these were reinforced by the Arian religion common to both. In this exchange the town of Toulouse was also important, since this was situated roughly halfway between the Atlantic and the Mediterranean; it was a great agricultural centre as well as being a university town, a ‘city of Minerva’ as the poet, Martial, wrote.

The produce of the region consisted of wine from Béziers that soon came to replace imports from Italy as well as the mined minerals from Lodève in the hills over which came the pottery-laden carts from La Graufesenque. In the Roman period of the south-west, the rural economy was organised around luxurious villas, such as the one at Loupian in the Hérault, which employed as many as 400 workers and ran as a more or less self-sufficient unit; there were some 1,500 of these villas in Languedoc, constructed on land which the Romans had seized from the peasantry and which often served as the basis in later medieval times of manorial domains.

Along the coastal plain itself there was considerable traffic but also much went overseas, especially from Narbonne and Agde, which has produced the wrecks of ships in the bed of the Hérault holding cargos of bars of copper and lead together with heavy mill-stones of basalt and amphorae of all kinds.[60] The Gallo-Romans exploited iron and precious metals throughout the area but especially in the Montagne Noire above Carcassonne in the Tarn, as well as copper in the upper valley of the Orbs together with lead and silver in the north of the Hérault, giving rise to an active metal industry of some importance. The mining of metals was accompanied by that of stone and of clay, for in places the making of pottery had reached an industrial level as at La Graufesenque.[61] The produce of this industry together with that of agriculture were partly for export through Narbonne, a town which also boasted of having a meeting place (*schola*) for its merchants, mostly freed men, in the Italian port of Ostia, who travelled from there in the Mediterranean as far as Sicily and Spain.

The Montagne Noire produced a variety of metals, which were exported through Narbonne, together with *sigillata* ware, local wine from Gaillac and Béziers, as well as oil and salt. After the Roman period the exploitation of metal was continued in a minor way by the local seigneurie, as at Cabaret which controlled the passage to the mineral riches of the hill country. There they developed water-mills using the abundant streams flowing down from the hills, which later helped to produce the textile sheets exported to the Near East and subsequently to manufacture paper, both of which activities used large quantities of water to provide the power and to wash the product.

Of iron mines the most important in the area in the Gallo-Roman period,[62] especially at Les Martys, were found in conjunction with copper and arsenic. The ore containing these two metals had been much used before tin alloy was common, it being recognised by its smell.[63] This was transported near to the wooded area because of the need for charcoal, and an intense activity, which may have given the place its name, began in the second century BCE and continued until the first CE, with an important production in 'les bas fourneaux' and leaving a huge mass of clinker. Production continued in the grotto-mine of Calel in the north of the Montagne Noire where there is more evidence of the mining of iron later from the eleventh century. Meanwhile at the copper mine in Durfort nearby, the waters of the Sor were diverted to drive mills for bellows that heated the ore.[64] In 1283 there is a reference to a hydraulic forge for working iron, an ancestor of the Catalan type of furnace and the earliest mention of a mill in the Midi. All this required wood from the hill country to make charcoal for fuel. In the nearby village of Escousens the main activity remained charcoal-making, which in the middle of the nineteenth century still occupied 40 per cent of the population, though on the land cleared to make the fuel they were also farmers. However there is no record of an iron mine in the neighbourhood and copper alone seems to have been worked there in the twentieth century which was probably a medieval exploitation for there is a traditional link with Durfort.[65] The mills in the area were associated with textiles (for sheets as well as for fulling) and later in the century with paper and of course with grain; until very recently water-power was all-important. These mines were later opened up again by a German company, so some metal remained.

There was a variety of metals on the Montagne Noire, both precious and 'base'. Today, things are very different. As in most of Europe the precious have long since disappeared. Copper, now imported, is still worked at Durfort but essentially for *objets d'art*. Although there is evidence of earlier forges, as at Arfons, iron is no longer mined anywhere in the region; its production has virtually vanished from western Europe for it is cheaper to buy overseas. But the region bears signs of Roman workshops, and metals were certainly dispatched abroad by way of Narbonne and Agde, as well as being worked locally. Plenty of water-power was available for this purpose, which was later used by the textile and paper industries, but I know of no evidence of its early use in local mines, though water-wheels have been found in Roman ones both in Spain and in Wales.

In the Cévennes, the hill country north of Montpellier and Avignon, there were more metals, but fuel was a major problem as the trees were mostly chestnut, which provided the basic subsistence, even for bread (*le pain des bois* it was called). This flour was also exported to Italy and to the towns of Languedoc. However, the peasants also engaged in mining. Gold was found there, but for other metals there was a need for more fuel and following the partial deforestation at an early period the exploitation of coal on peasant lines became increasingly frequent. Around Alès holes appeared almost everywhere, for near some villages there was also iron to be found. Mills, fed by the mountain waters, were used 'à batre fer'.[66] In the fifteenth century these mills were omnipresent, for oil, for cereals, for sheets, for paper and for iron. The hills of the Cévennes were populated as heavily as the plain below and were also the first area in France to practise sericulture as early as 1234 when the cultivation of the silkworm probably came from Italy. After a period of depression at the closing of the Middle Ages, the 'industry revived at the end of the fifteenth century with the spread of the white mulberry'. From 1540 the 'folie de soie' was stimulated by the acquisition of American silver, 'porteur de luxe'.[67] However the development of the European silk meant that it became much less of a luxury, being used not only by courtiers but by the growing middle class, now breaking the barriers of the sumptuary legislation: in the Roman period under the Emperor Aurelian (270–275 CE) silk from China sold at the price of gold, so could only be afforded by the very few.

Leaving aside the production of metals in the south of France, in England, with its plentiful supply of copper and tin, the coming of iron was somewhat delayed. But when it came even the local farmer could clear his fields more easily with metal tools at his disposal and thus extend the zone of cultivation. On hilltops the makers of iron fortified the summits with ditches and with ramparts, some of their chiefs acquiring war chariots. It was well before the coming of the Romans to Britain that iron-using began and it existed largely on the basis of imported artefacts, which were mostly made of bronze but also included iron weapons as well as trinkets. The earliest traces of iron-working in Britain come from Wiltshire in the south of the country in the seventh to sixth centuries BCE, suggesting a north German connection from Hallstatt. This was followed by the second Iron Age, called La Tène, which began about 450 BCE.

This coming of iron produced important changes. In France, the First Iron Age ('Hallstattien') 'was the great period of agricultural development in our region [Languedoc] . . . axes and metal ploughs by themselves permitted the clearing and breaking up of the land of someone of importance'.[68] The subsequent La Tène culture (named after a Swiss site) was marked by increased influences from the Mediterranean and it also changed the artistic style in the development of ornament. At the same time the aristocracy discarded the four-wheeled for the two-wheeled chariot, and the Etruscan model was improved by the adoption of iron tyres that provided a solid grip when galloping over rough ground. In addition the 'beloved sword was developed from the Hallstatt dirk', presumably by using a wholly new technique.[69] This period was when the 'barbarian' warriors sacked Rome, invaded Greece and established the Celtic-speaking kingdom of Galatia in Asia Minor. The swords of the Celts were praised by Caesar, but in battle those now made in Noricum were even better; the Germans were already fine smiths.

The Hallstatt cemetery where the earlier iron was found dates from the eighth century BCE and iron-making had probably come there from Asia Minor by way of the Danube, as bronze and farming had done earlier. Some of the evidence of early iron has disappeared because of corrosion but it is clear that the use of bronze-edged tools now tended to diminish, presumably due to steel taking over the 'edge role'. However it was not until the first century BCE that iron tools became widely available. Differences in the levels of usage were then visible, with a 'low-prestige' industry based on local production and a 'high-prestige' one built up on superior ores or upon better skills in steeling. The products of the latter were widely traded, especially the swords and the horse-harnesses, and these may even have been subject to some kind of royal control.[70] This control applied to the products, not to their manufacture, which took place locally. Iron-smelting was already present before the coming of the Romans, for example in All Cannings Cross in southern Britain.[71] These ores were initially worked over a wide area for 'low-prestige' objects, for there were numerous small-scale deposits. In the south-west a knowledge of iron is most likely to have been obtained 'as an incidental benefit to the trade in copper and tin with Brittany and beyond', possibly in the sixth century.[72]

With the advent of the Roman armies in southern Gaul the intensification of trade developed with Iron Age Britain. Metal was one of the main attractions for making the crossing. It has been said[73] that the Roman invasion ‘was no doubt mainly designed to tap the island’s mineral wealth’, though it may also have been to stop refugees from Gaul from having harbourage there as well as of course as enhancing the prestige of the Emperor.[74] Roman iron-working began soon after the landing. On the Dorset coast at Poole Harbour and Hengistbury there was a link with the Channel Islands to Brittany and thus by the mouth of the Garonne over to the Mediterranean: ‘The Romans demand for raw materials such as metal and hides, corn and slaves, created an entirely new situation in Britain. These products were suddenly endowed with a greatly increased value and could be used to procure luxury items such as Italian wine, coloured glass trinkets and no doubt a good deal more besides . . . Metals extracted in various parts of western Britain were now transported in bulk to the Dorset ports for refinement and transshipment – lead/silver from the Mendips, copper/silver from the Dartmoor fringes and tin from Cornwall.’[75] However, with the invasion of Julius Caesar, the importance of the Dorset area declined in favour of Kent and Essex, where he landed.

After the coming of the Romans the production of iron took off. The Germans and Scandinavians often contented themselves with bog-iron until the Middle Ages but here ore was required. In an interesting experiment, the archaeologist, Cleere, and his team attempted to reconstruct a Roman furnace in Kent. This was a large-scale operation that ran from the first to the third centuries CE, ‘perhaps second only to that of Noricum (modern Steiermark, Austria)’.[76] It appears to have been organised partly as a state enterprise, in the hands of the British Fleet (*Classis Britannica*) whose responsibility it was to supply the garrison. This production made use of local ore and much locally made charcoal in the ‘direct process’ of reducing iron straight from the ore. It required only a relatively low temperature to operate, leaving a sponge (the bloom) at the bottom of the furnace in which the stony part of the ore (the gangue) was separated from the reduced metal by the formation of an associated slag with a relatively low melting point.

This was a low-heat operation, for in the west the earliest type of furnace was simply a hollow in the ground lined with clay, a ‘bowl-furnace’ that could be stimulated with bellows and gave a metal which was worked up into the bloom. These furnaces might even have to be opened up every time they were used, so they often proliferated in early iron districts; there were some 30,000–50,000 of these around Tarxdorf.[77] Iron was thus widely exploited, usually in small deposits. The ore had to be relatively easy to smelt and was dug in open-cast pits with the charcoal coming from local hardwoods, especially from birch and oak. The ‘bowl-furnace’ developed into the ‘shaft-furnace’ that was found until recently in sub-Saharan Africa with an aperture for removing the slag. Shaft-furnaces permitted a more continuous process[78] and could lead to the ‘*Stückofen*’ (or Catalan) furnace and these eventually to the blast furnace, which produced a more highly carbonised bloom in a higher temperature but not always high enough to form liquid cast iron as in the east, except occasionally by chance. The Stückofen nevertheless could produce pig-iron but could give wrought by the ‘indirect process’. There were no bellows driven by water-mills until the thirteenth century at which point a more steady draft became possible.[79] The simple method of making bloom had existed before the coming of the Romans and is referred to by Caesar in his *Gallic Wars*. More intensive production began immediately after the invasion in 43 CE, so that the local resources of wood were soon depleted and the industry moved to the High Weald near East Grinstead until the mid third century. Then charcoal again experienced over-exploitation and iron-making passed to the Forest of Dean. For the most part the working of iron ore was carried out by private enterprise, as we see from inscriptions at Lyons, but in Britain the Fleet was heavily involved. Its metal industry would have supplied not only the garrison with arms but also the civilian population for their own many purposes.

In Noricum the ore was an iron carbonate containing manganese, which made the manufacturing of steel easier. For that product (‘hard iron’) more charcoal was added. There ‘the possibility of producing steel by the direct process was due to this use of the shaft-furnace’. In addition the Romans imported ‘seric iron’, believed to be from China, hence the name, but in fact from India. This was a crucible steel and in later Islamic times that came from Damascus; after prolonged forging and quenching, the blades became etched with a characteristic watered design. The Indians had sent this steel to Axum in Ethiopia as well as to Persia, where it was eventually made by a similar process.

To heat the furnaces, either for a preliminary roasting or for subsequent smelting, charcoal had to be employed, and it was also needed to mix with the ore in order to make steel, that is, carburised iron. The roasting benefited the carbonate modules, helping them to drive off water. In this process charcoal was used at a ratio of 1:1, or in some cases of 2:1. According to Cleere his most successful trial, the second, produced 20 lb of iron from 201 lb of ore and 265.5 lb of charcoal.[80] A large amount of local wood, of birch or oak, had to be burnt for this quantity of iron. It is no wonder that by the mid second century CE the fuel and ore resources of the original area were so depleted that the centre of the industry had to move, and then once again in the mid third century. The exhaustion of fuel took place in many other areas in Europe until eventually in much later times the utilisation of deep-mined coal solved the problem, although this had already been used by the Romans and the Chinese.

Since the bulk of the usage of iron and other metal was for weaponry, and some for building, production in Britain decreased greatly with the end of the western Empire. In the north of Italy there had been factories (*fabricae*) for shields at Cremona and Verona, for body armour at Mantua, for bows at Pavia and for arrows at Concordia.[81] All of these diminished in size with the dissolution of the army. But in the post-Roman west, the bulk of consumer goods also disappeared. In Britain most pottery became very basic and only vessels made without the use of the wheel were available;[82] the widely diffused products of Roman times became luxury items. It was the same with the building trade. 'There is no evidence whatsoever of the continued quarrying of building stone, nor of the preparation of mortar, nor of the manufacture and use of bricks and tiles.'[83] Britain returned to an almost aceramic state,[84] but the withdrawal did not mean a change in population, though in England Anglo-Saxons became supreme, because the same field systems continued; the sociologist, Homans, however, has argued for the influence of the largely gradual movement of the Frisians from the present-day German–Dutch border.[85] Certainly '[S]omething dramatic happened to the basic fabric of all socio-economic activity in Britain . . . after the withdrawal of Roman imperial power from the provinces in c. 410.' The situation was 'totally different' in the east.[86]

The disappearance of the Roman state led to a radical change in the whole metal industry in the west which had been run centrally, 'nationalised' in fact. But that did not at all mean the decline of activity in the eastern Empire, in Byzantium centred upon Constantinople, and many Syrian merchants even continued to operate in Gaul together with Greeks and Jews. The galleys of Alexandria still sailed with grain for Iberia and the Hellespont. Oriental goods still came to Byzantium and, globally, 'the fall of Rome was an event of relatively localised importance'.[87]

The argument about the reasons for the fall of Rome has recently been polarised between writers like the ancient historian, Ward-Perkins, who has expressed a modified view of the traditional destruction of the Roman state and economy by the German tribes from the north, and the 'transformative' view of the 'Later Antiquity' scholars who see a gradual incorporation of the 'barbarians'; at the same time this alternative approach also involved a shift from examining the economy and similar topics to one that concentrated on the acquisition by the 'barbarians' of a monotheistic religion, not so much the formalism of sects as contemplative and ascetic practices such as those of St Cuthbert of Lindisfarne who spent solitary nights standing in the cold waters of the North Sea and praising God as he did so. To support his view Ward-Perkins puts forward evidence of a rapid decline in the quality and distribution of pottery and other Roman products that were not simply 'luxuries' but had been adapted to the needs of the middle and farming classes, of the disappearance of building in stone and mortar in many parts, and of the drop in literacy, even possibly a reversion to non-literacy. In the west the decline in the economy, which had been based to a considerable extent on state activity, was remarkable. This decline was accompanied by the growth of Christianity that, without necessarily going as far as Gibbon thought, had some devastating cultural consequences for the Empire. It took money away from the Roman state and from local municipalities by encouraging bequests to the church rather than donations to citizens.[88] But the concentration on the Christian story also meant the virtual disappearance of Roman secular culture (except for the language) in later schools, and even of much popular literacy, together with the attempt to replace that earlier learning by Christian dogma. Not that this attempt was limited to Christianity; it was a feature of all the Abrahamistic religions where the triumph of monotheism came at the expense not only of the plurality of secular knowledge but also of the restriction of the arts, especially of the non-religious kind – indeed in the case of Judaism, Islam and early (and above all Calvinistic) Christianity, of all representation, including in drama and sculpture, which had been numbered among the great achievements of the classical civilisations.

Both Ward-Perkins and Gibbon are correct; literate culture suffered a severe blow not only from the 'barbarians' who developed their own form of restricted literacy but above all from Christianity and other similar religions that substituted sacred for secular knowledge, monotheism for diversity, belief for ‘rationality’. The collapse of western Rome did not affect the eastern empire to the same extent; that did not fall, even under ‘barbarian’ invasions, and it remained part of a wider, exchangist, Eurasian economy which remained vigorous.

To the contrary Liebeschuetz[89] insists on the importance of Christian values, including the ideal of charity. He writes approvingly of the professional ‘undogmatic’, ‘unsentimental’, ‘scientific history’ of the ancient historian, A. H. M. Jones,[90] although he himself is clearly strongly influenced by Christianity. The notion of charity changed with the adoption of a monotheistic creed and its establishment of definite and exclusive boundaries but the ideal surely cannot be said to be ‘new’; certainly the notion was not confined to Christianity and existed prominently in Islam, in Judaism, in Buddhism and among the Pharisees as well as in many polytheistic religions. For, in general terms, the societies of the Bronze Age that created greater stratification had also to look after the poor they created, as is the case today; specialisation had brought about unemployment, wealth implied poverty, development under-development. Nor is the existence of consensus (or its consequences) confined to Christianity, although the notion of charity offered primarily to believers certainly helped to create such a view. But it was divisive in other ways too. We must also remember the divisions between Christian communities as well as the solidarity within them, for they are aspects one of another, leading to the wars between Asian Visigoths and the Goths in Constantinople on the one hand, and Roman Christians on the other, as well as much later marking the conflict between Protestants and Catholics as illustrated in graves of martyrs of both kinds in Romeland, St Albans, as well as in many other places. As for Christian asceticism, a measure of rejection of some aspects of worldly life exists in most religions, especially in stratified societies. The view that these are ‘Christian’ virtues in any exclusive sense is hardly sustainable if one takes a wider, less ‘Eurocentric’, attitude to religion. This is not to say that its influence on Europe and the world was not of primary significance, but never in an exclusive way. That assumption is too theological in a very limited sense.

What Liebeschuetz has done is to go back to the essayist, Montesquieu,[91] and ‘concentrate on the military system’.[92] I want to concentrate not so much on the military system of the Romans which he sees as decaying within the Empire, as on recognising the many strengths of the ‘barbarians’, specifically in iron-using, in a manner that fits with ‘transformative’ views. They were recruited by the Empire because of their strength, but that partial incorporation created obvious problems. It was recognised that '[f]ederates constituted a great danger to the imperial government', especially as they achieved high rank.[93] In the west the commander of the army later became the *de facto* ruler of the Empire. Not so in the east. Montesquieu speaks of the absence of a strenuous training programme with the carrying of full equipment on long exercises in the west so the Roman soldier was no longer able to wear the heavy helmet and armour against the 'unarmoured northern barbarians'.[94] In the west, Rome had gone over to a professional army, which was expensive and meant paying and equipping 'barbarian' mercenaries, as well as eventually leading to the rule of generals. In the east they enjoyed a measure of demobilisation, resulting in civil control of the military.

But the process did not only affect the nature of solidarity. From Rome and the Near East, metal-working spread rapidly to those outside the urban cultures, that is, to Europe, to Africa and to the east. While iron had been first developed in Anatolia by the Hittites, it soon spread elsewhere. It was never possible to keep the secrets of metal-working within one community because the settled 'civilisations' had to engage in the search for metals in other parts; in China this was not true to the same extent for one searched within the same 'culture area'. In the west looking outside meant that the 'barbarians' were always being influenced by the more developed urban cultures. So that even societies that had not gone through the Urban Revolution could enter straight to the Iron Age. The transition to metal-working took place in some of the 'tribal' societies of Central Europe who armed themselves with iron weapons against the powers of the settled states and indeed developed not only armaments but some of its more peaceful instruments. The methods of iron-working were diffused along the amber route to northern Europe, coming up through Italy as well as north by way of the Danube. But diffusion also entailed local additions, sometimes transformations. The metal was commonly used in the same way by 'barbarian' tribes elsewhere. In historic times in Central Asia the Mongols were widely known for their metallurgical skills; in Europe it was the Germans and Celts who used iron weaponry in attacks on Rome and earlier in their movement into Britain. They employed iron not only for weaponry but also for axes to clear the ground and for ploughs to till it, tools which they themselves helped develop, just as Central Asia did the chariot. This use of metal did not necessarily lead to urbanisation nor to urban arts and crafts in Childe's sense, but it made for a more complex culture.

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1 See Young *et al*. 1999. Iron in China began to be made by at least 600 BC and proliferated greatly during the period of Warring States.

2 Tylecote 1992: 48. It may be that early mining could produce the high temperatures, but that at this stage the west did not know what to do with them.

3 See Glossary for the puddling process.

4 Maddin *et al*. 1937.

5 Tylecote 1992: 81.

6 Tylecote 1992: 76.

7 Varoufakis 1981: 31.

8 Varoufakis 1981: 31.

9 Fagan 1965. Although in the North Cameroons there seems to have been something of a breakthrough, which occasionally happened through experiment.

10 Forbes 1956: 58.

11 Barbieri-Low 2007: 41.

12 Drews 1993: 229.

13 Drews 1993: 216.

14 Drews 1993: 205.

15 Hawkes 1965: 63.

16 Gallet de Santerre 2000: 49.

17 Tylecote 1992: 47.

18 Alexander 1980.

19 Alexander 1980.

20 Tylecote 1992: 48.

21 Alexander 1980.

22 From Haefner and Pleiner 1982.

23 M. Bernal, personal communication.

24 Webster 1969: 24.

25 Chernykh 1992: 226.

26 Forbes 1958: 55.

27 Childe 1942: 231.

28 Webster 1969: 2.

29 Abulafia 2011: 109.

30 Connor 2004: 13.

31 Connor 2004: 30.

32 Connor 2004: 31.

33 Alexander 1962: 129–30.

34 Webster 1969: 28.

35 Forbes 1958: 59.

36 Forbes 1958: 57.

37 Forbes 1958: 61.

38 Hawkes 1965: 64.

39 Wilson 2007: 119.

40 Hoover and Hoover 1950: 149n.

41 Woods 1987.

42 Davies 1935: 84.

43 Davies 1935: 10.

44 Greene 1986: 167.

45 Goody and Whittaker 2001.

46 Webster 1969: 218.

47 Charles 1997: 419.

48 Hoover and Hoover 1950: 149.

49 Aitchison 1960: 150.

50 Kieckhefer 1989: 100.

51 Liudprand of Cremona, *Antapodosis* 6.5 (trans. F. A. Wright in *The Works of Liudprand of Cremona*, London, 1930: 207). Quoted in Kieckhefer 1989: 101.

52 Kieckhefer 1989: 101.

53 Childe 1942: 261.

54 Braunstein 2003: 129.

55 Braunstein 2003: 172.

56 Sanders 1957: 359.

57 Py 2010: 36.

58 Roure and Pernet 2011: 51.

59 Roure and Pernet 2011.

60 Gallet de Santerre 2000: 89.

61 Gallet de Santerre 2000: 96.

62 Anon 2007a: 12.

63 J. Charles, personal communication.

64 Anon 2007a.

65 Davies 1935: 31.

66 Ladurie 1969: 77.

67 Ladurie 1969: 80.

68 Louis *et. al* 1955: 10.

69 Hawkes 1965: 68.

70 Alexander 1982: 64.

71 Excavated by Cunliffe.

72 Alexander 1982: 98.

73 Bromehead 1956: 9.

74 See Davies 1935: 150. Agricola speaks of the gold and silver (and other metals). This opinion is also shared by Aitchison who writes that before Caesar's invasion Britain was known as a source of metals, though the copper probably came from Ireland. So 'one powerful motive for the Roman visit was to obtain a share in Britain's export trade and, generally, to acquire metals' (Aitchison 1960: 133).

75 Cunliffe 1991: 600.

76 Cleere 1971: 204.

77 Davies 1935: 49.

78 Davies 1935: 49.

79 Davies 1935: 37.

80 Cleere 1971: 213.

81 Ward-Perkins 2005: 103.

82 Ward-Perkins 2005: 104.

83 Ward-Perkins 2005: 108.

84 Wickham 2005: 308.

85 Homans 1957.

86 Ward-Perkins 2005: 107.

87 Aitchison 1960: 222.

88 Goody 1983.

89 Liebeschuetz 1990.

90 Liebeschuetz 1990: 239.

91 Montesquieu 1900.

92 Liebeschuetz 1990: 245.

93 Liebeschuetz 1990: 248.

94 Liebeschuetz 1990: 236.

6
After the Romans

The departure of the Roman state in the west brought 'desolation to metallurgy as well as to most of the cultural activities of our continent'.[1] 'With the final departure of the Romans in the fourth century evidence of most forms of economic and social activity ceased'. The 'barbarians' had taken over much of the Empire and the Goths now ruled over Noricum, 'the nursery of the iron industries of the continent'.[2] But these barbarians were metallurgically 'inept and jejune' claims Aitchison in his comprehensive history on the subject in the west.[3] While large-scale mining suffered for some centuries, iron obviously continued to be produced locally and fine metal work was even made, especially in Kent. However, the author tends to play down the contribution that these 'barbarians' made to the use of metals. The mines in Spain were certainly closed under the Visigoths and the Roman state that ran them disappeared from view. The inhabitants now had no metal to send eastwards to exchange for oriental luxuries. But despite the hiatus we should not discount all 'barbarian' activity. It was not just the 'decline' in the Roman army that brought about their prevalence, but the strength of these enemies who were, independently, workers in iron and steel, and had an efficient weaponry, concentrating more on offence than defence. It was the Romans who were 'static' in terms of frontier defences, as in Britain, a system that employed permanent forces stationed in one place and at great expense.

Agriculturally the 'barbarians' promoted the iron plough and militarily the long sword. Iron production may have been on a local back-yard scale for 200 years after the fall of the Empire, and the Cornish tin-working and local mining in Derbyshire may have radically declined. But some trade with Europe had continued, as we see from the magnificent ship-burial at Sutton Hoo, dating about the early seventh century CE, in which was found many Frankish coins as well as silver-ware from the Mediterranean including a Coptic bronze bowl from Egypt, a shield and helmet from Sweden and a silver dish from Byzantium. The difference with earlier Rome was that these were luxuries for chieftains whereas the region in the past had mass-produced goods for at least part of its populace.[4] In western Europe the revival of metallurgy began about 780 CE and it came through Arab inspiration from the east.[5] There were of course few metals in their lands and these they acquired by conquest or by trade. When they conquered Spain they opened up several of the workings that had been neglected since the fall of the Empire, especially ones providing precious metals. It was the reign of Charlemagne, about 760 CE, which did the same for mines in Czechoslovakia, in Germany and in east Europe generally. Nearly 200 years later, in about 965, a huge silver-bearing vein associated with iron ore was discovered at Goslar in the Harz mountains, a find destined to become 'the greatest in Europe'.[6] The mining of precious metals had begun in earnest.

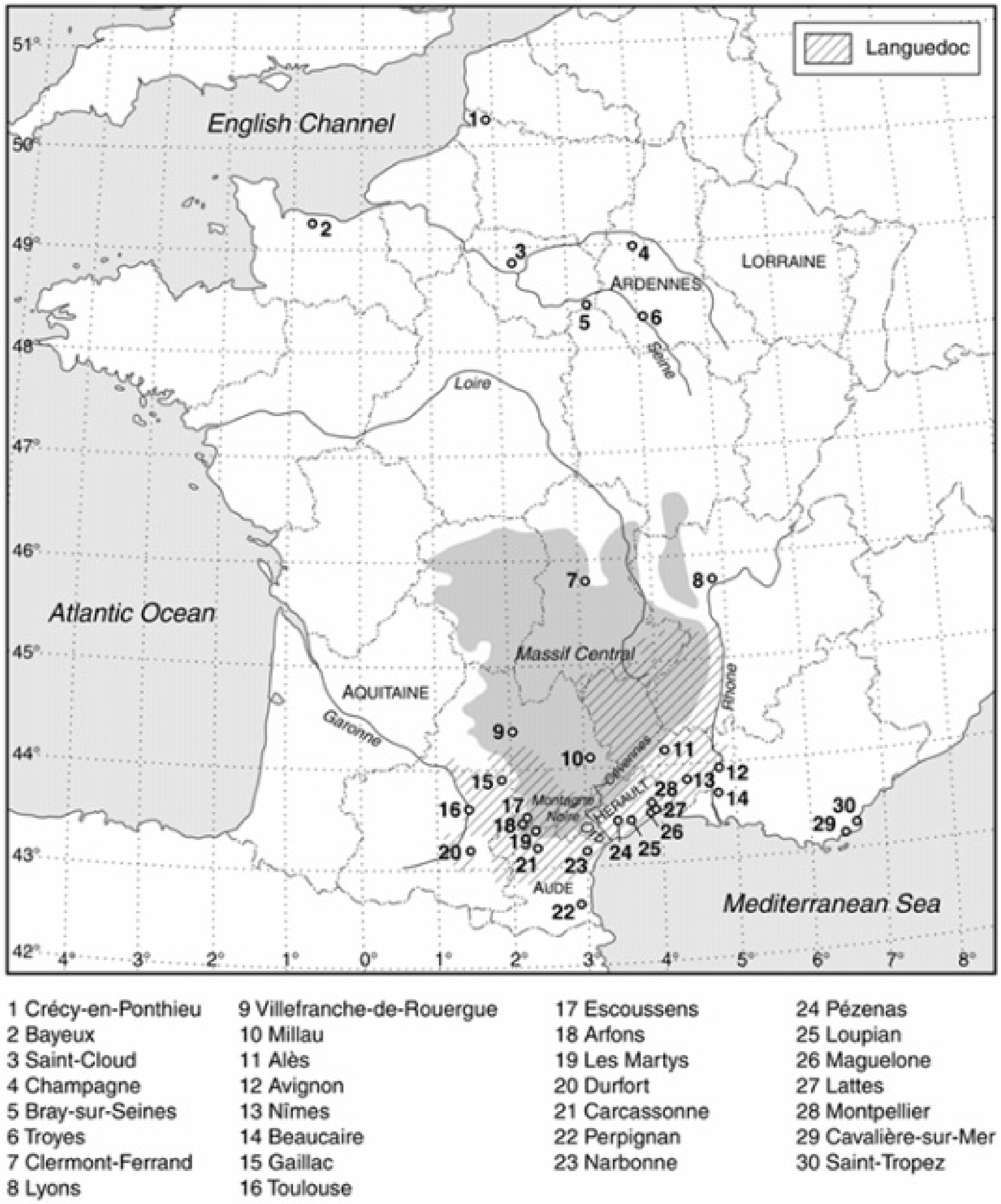
Among these metal-using 'barbarians' were the German-speaking Visigoths. As we saw, even those at the fringes of urban centres were influenced by the metal-using cultures since it was outside the valleys that these materials were to be found, especially with bronze but also with iron. Like bronze-casting before it, the making of iron spread to Europe through the Mediterranean by way of the classical world but also through the Pontic or Romanian area to central Europe where they exploited the rich store of metals in the mountainous areas. The latter route was the one followed by both the Celtic and Germanic peoples, some of whom, the Goths for example, had been influenced by the Greeks who had settled in the Crimean region. But the development of the Iron Age among the northern 'barbarians' did not always come by way of the classical civilisations, as was often the case in the south, but it grew through 'barbarian' contacts. In any case, in the exploitation of iron there was not so much difference between the capacity of the city civilisations and that of the 'barbarians'; the latter not only had the iron plough (which they developed) but the iron weaponry, both offensive and defensive, which they took and improved, as with the sword.

As a result, the Celts and the Germans were not much worse equipped than the Roman armies they faced, though they clearly lacked their organisation. And some elements were incorporated into Roman culture as mercenaries or as federates and others were drawn south independently by the attractions of the Mediterranean. It was easy for them to be part of the 'civilised' forces, and in the fifth century they could attain high rank, being residents in the Empire at the same time as defining its boundaries. Most of their contributions depended on military strength on the basis of which they were first recruited, but it was as a group, not as individuals. As a result of their increasing employment in this way, they gradually took over control, a process which eventually led to the very dissolution of the Empire they were called in to protect. And in other areas, as with the Celts of Iberia and the Visigoths of Aquitaine, these people established their own kingdoms.

One of the groups, the Visigoths, were driven westwards by the army of the Huns in the Pontic region but in their subsequent invasion of Europe there was a clear 'technical superiority on the part of the invaders [the Goths] in metal-working'.[7] It may be significant that under their leader, Alaric, they 'advanced from Epirus to Noricum' before he made his move into Italy.[8] Noricum was the centre of the Roman iron industry in Austria as of the earlier Hallstatt culture and metal-working remained one of 'the most widely developed activities of that period'.[9] Still today in the area the connection with iron is strong. There is a story that the local inhabitants captured a waterman who offered them a choice between gold for ten years, silver for a hundred or iron for ever; they chose the latter, hence the name Erzberg, near Leoben, Donawitz and Eisenberg. When children of this region go to school, they greet each other with the miners' greeting, *Glück auf*. And they are taught about Roman miners looking for silver and iron there. Moreover, even today the professors at the Montana University wear miners' clothes when they take up their post.

The Visigoths originally came from the Caucasus, moved to the Danube area and first fought the Romans in 238 CE. The Emperor, Caracalla (r. 198–217), is said to have paid as much to barbarian mercenaries as he did to Roman soldiers. There is a dedication to him in the Cserno region of Dacia where we find Roman iron mines, probably leased to contractors.[10] There is ample evidence of early mining in the Balkan region where the Celts had already exploited the iron mines at Mount Trgovi, an area that became so important to the Romans at Segestica (Siscia), connecting Pannonia and Dalmatia. The mining took place in the Una–Japra–Sana valley in present-day Bosnia; there were more than thirty *ferrariae* in the area of Mount Majdan. The ore was transported to Siscia and also to Sirmium, Singidunum, Viminacium and Mursa where there were workshops.[11] Davies speaks of skilled Dacian miners being taken to Bohemia by the Marcomanni where they became the Saxon experts of the Middle Ages. Saxon miners from Chemnitz were later called to the Balkans in the thirteenth century and in the fourteenth may have introduced water-bellowing, for they were noted for their knowledge of advanced techniques in metals. Vladimir I of Bulgaria invited them to come from Transylvania in the thirteenth century and they were also mining in Hungary and Austria.

The Visigoths had become Christians of the Arian creed, which at the time dominated the east. In this 'heresy', attributed to Arius in the fourth century, Christ was seen as 'created' and emphasis was placed upon the uniqueness of the High God. The belief was declared a 'heresy' by the Council of Nicaea in 325 but it continued to be current among the Visigoths in the west. They themselves wandered about the frontier of the Roman Empire, a journey which culminated in 410 in their sacking Rome under Alaric, ostensibly to help the Emperor. They followed the Vandals into Gaul, and later established themselves independently at Toulouse, a town which had earlier been invaded by the Volsques Tectosages, 'd'origine grecque', and then by the Romans too (Map 11).[12]



Map 11 France

In Toulouse the Visigoths suffered famine because the Emperor denied them the shipment of wheat from North Africa he had promised (as plunderers they were dependent on others) and they were compelled to leave to seek refuge in Spain. In the south of that peninsular they were repelled by the Vandals and returned to the north under their king Athaulf, established a kingdom in Spain, although some went back to France under Wallia, and successfully set themselves up again in Toulouse. This Roman city remained an important cultural and trading centre. There the merchants included Syrians from Antioch, an indication of the long-standing relationships existing through the Mediterranean, as witnessed by the Greek and Jewish doctors working there.[13] These 'ancient nomads'[14] had their centre in the old Roman town that had all the necessary civic buildings together with a university that taught Greek and Latin as well as the law. In 418 CE the Visigoths made a further alliance with the Romans, becoming a 'barbarian' state within the Empire. Indeed they remained closely integrated with them and at a meeting at Beaucaire in 455 they even proposed Avitus, the father-in-law of Sidonius Apollinaris of Clermont-Ferrand, as the Emperor of Rome. This arrangement within the Empire gave the Visigoths access to the fertile lands of the south-west as well as to the pastures of the hills, both to the fields of wheat and to the vineyards established earlier by the Romans as well as to 'the mines of iron, of lead or of silver of the Cévennes, to the gold one found on searching the beds of the many water-courses coming down from the Pyrenées'.[15]

Languedoc itself was therefore spared the full weight of the 'barbarian' invasion of Gaul, which mostly affected the north-east. The Alamans came south in the middle of the third century, followed by other groups of 'barbarians'. In 406 the Vandals passed through on their way to Spain and then it was the turn of the Visigoths, who had already been converted to Arian Christianity in the east. All these people were equipped with iron weapons that enabled them to conquer new territories and the existing peasantries. Like others the Visigoths were constantly concerned both with metals and with war. A historian writes of 'their passion for metal-work'[16] and an illustration of Mozarab origin dating from 1109 shows a soldier with helmet, a coat of mail, a shield, sword and lance, very well equipped for Iron Age warfare.[17] Like many 'barbarians', they were not attached to any specific place or piece of land but were prepared to use their arms to support a more itinerant, and in this sense a freer, way of life. The Romans however tried to settle them around Toulouse and to keep them from occupying any port on the Mediterranean, which they saw as their own *mare nostrum*. But that did not stop all their ties with the east and at one time after 466 King Euric entered into negotiation with Constantinople and the Roman Empire of the east, for there continued to be many relationships with those parts, especially religious ones.

The links of the Visigoths with the east had been long-standing. For many years Constantinople was a town devoted to Arian Christianity. When the Goths under Gainas, ostensibly defending the Western Empire, were massacred in a church which had been assigned to them (for official Orthodox worship) by the bishop, Chrysostom, the Roman creed began to triumph. The church had been allocated to the Goths although not for Arian services, and they had taken refuge there in an uprising.[18] Burning down a church in Constantinople full of Arian Christians was hardly an example of tolerance among the Orthodox. And that was but one of many examples. We can argue that monotheism introduced (or greatly extended) the notion of intolerance, since it proclaimed the verity of only one system of belief, whereas polytheism was obviously plural in its approaches, hence not intolerant of agnosticism or even non-belief, secularity.

The bishop was a noted preacher whose sermons had been recorded; he worked for the poor and favoured the simple life, but he was also against any role of the female sex, who gave the church so much support, and called for the concentration on Christian, and therefore not ‘pagan’, knowledge. Constantinople and Alexandria were thus the homes of divergent Christian beliefs. Soon after Arianism was rooted out of the New Rome by Chrysostom, Nestorius became archbishop in the fourth century; his own heresy rejected Arianism but was also against the divinity of Christ and condemned by the Council of Ephesus in 431 even though it continued in Persia and the east, in some areas down to the present day.

Why did the barbarians make for Spain in the south, which was in a sense a ‘dead end’? The climate was undoubtedly a factor but so too was its fabled riches in metals. These were not only precious ones, although always attractive to people on the move, but also iron for the weapons on which they depended to maintain their way of life. Some of the Spanish miners had in fact joined the Gothic ranks in order to escape the harsh conditions of the state’s gold mines.[19] After the Romans had left a decline in mining had taken place but it was revived by the Moors in the eighth century. In Central Europe production in earnest began again later, around 1000 CE and in Sweden later still in the fourteenth century. However it was the Germans who were ‘the leading metal-miners of the world’[20] from 1200 down to the modern period and they spread their expertise around. As early as 1314 they were producing iron in the south-west of England and Henry VI employed immigrants both from Hungary and Bohemia. Such activity was much encouraged by the international financiers of the period.

At this time the Romans themselves took part in defence and in its organisation. Throughout the Empire these duties were increasingly taken over by bishops, who often came from an elitist civilian background like Synesius in Cyrenaica.[21] He was a rich aristocrat and a reluctant bishop who engaged in local affairs, particularly in the defence of the community. Though there was some recruitment of Huns and similar fighters, Imperial forces were no longer available to the same extent; defences such as town walls had to be built, militias organised, in a rather feudal manner, he himself had a 'fortified residence' and his weapons were 'made locally'.[22] The church organised the country and accumulated local powers as well as the wealth it needed, often from widows and other women of the aristocracy; and this was a process which created some tension within that class,[23] and changed the rules of the domestic game.[24]

When the Roman Empire fell, it did so very differently in Britain and northern France, where it disappeared almost completely, than below the Loire and in Italy, where aspects of the life continued, especially on the landed estates.[25] Where it did fall, it was largely because 'barbarians', pushed on by the Huns, had taken over some of the outlying parts of the state and established separate jurisdictions. Warfare brought it down, just as it had created it. This caused the Empire to collapse economically through increasing military expenditure.[26] The coming of the Huns had pushed the Visigoths, who ravaged the countryside, into the Danube and Balkan areas, with their huge reserves of metal.[27] The Huns were nomads with an Asiatic background. Their connections with the Hsiung-nu, sometimes even called Huns, who were known to the Chinese, and to the Hephthalites, Central Asian nomads who moved into India in the fifth to the sixth centuries CE, are uncertain, but the very possibility shows the importance of the peoples of the Eurasiatic steppe, particularly in the context of metal-working.

The maintenance of frontiers, especially in the east, had been hugely expensive; the soldiers were professionals, well paid and they constituted some 400,000 at the time of Diocletian in the third century, a colossal outlay which led to financial reform, increased taxes and monetary devaluation.[28] On the frontier itself there was much interaction between the garrisons and the local 'barbarians', with whom they had to trade for everyday consumables. The latter were thus enriched as well as armed; ‘more Roman weapons have been found in deposits in Danish peat bogs than anywhere else in Europe’.[29] This Roman weaponry was critical both in establishing a frontier and in destroying it. The later Roman army has been stigmatised as ‘barbarianised’ and it is the case that many were recruited. But despite the claim that officers had become more like traders and slave-dealers, the armies retained their political role and were still the ‘arbiters of the imperial power’, at least in the west.[30]

The Roman frontiers were the Rhine, the Danube and, on the eastern front, Persia. The former faced the German ‘barbarians’, for towards the end the Celts lived largely within the frontier. But the east saw the rise of Persian power under the father of Shapur and of the Sasanian dynasty. Although they suffered defeats at the hands of the Germans, especially in 9 CE with the slaughter of the legions commanded by Varus, in the fifth century the new threat was from the state of Persia on the Asiatic frontier when even Roman emperors were captured and humiliated. The Persians were not ‘barbarians’ in the archaeological sense, but inhabitants of a city civilisation, which derived from that of Mesopotamia. It possessed not only an old written tradition and a culture of metals, but had developed its own high culture with a culture of flowers that I have seen as characteristic of the major Eurasian civilisation.[31] So developed was it that one wonders what would have happened had it defeated the Greeks or Romans who characterised it quite unjustly in Orientalist terms.

For the Romans the Persians were at once enemies of the state and governed by ‘non-rationality’. Their leaders were liable to be treated inhumanely as when in a different context the future Christian Emperor, Constantine, had the captured Frankish kings in 306 fed to wild beasts in the arena at Trier. True, the enemy did the same, but they were ‘barbarians’ and not ‘civilised’ town dwellers.

Another such ‘barbarian’ culture that was highly dependent on metals was that of the Vikings. Scandinavia had large sources of metal, especially bog-iron – of which they made great use – and of charcoal, as well as important relations with the east. Their armaments consisted of helmet, mail coat, sword, javelin, shield, cutlass and later the axe. The blades of the swords were often pattern-welded, and came from central Europe[32] to which they were linked by the amber route. Their name may even come from Viken, near Oslo, which was a source of iron. They were closely linked to the Anglo-

Saxons, originally from the Danish border, whose national epic, *Beowulf*, is full of references not simply to Scandinavia but also to the weapons they used, that is, to mail, helmets and to swords, the latter often specifically named like humans and richly endowed with powerful magic. In their ships, hung with their iron shields, the Vikings sailed the Atlantic to Iceland, Greenland and even to America, and in the east they went down the Russian rivers to Staraja Lagoda, near Novgorod. From there they either went on to Kiev, the Black Sea and Constantinople, where they were recruited to the Varangian Guard of the Patriarch of the Eastern Church who later fought the crusading Norsemen coming from their kingdom in Sicily, or else down the Volga to the Caspian Sea with its silver mines, and on to Islamic Baghdad, as witnessed by the number of Arabic coins found in northern Europe.

The Rus, as the Swedes were known in Russia, went down the Varangian route by way of the Dnieper and at one point their leader, Rurik, conquered Novgorod and founded the state of Russia, whose capital was later the Christianised Kiev. There they threw back the attacking Germans but were eventually defeated by the 'infidel' Mongols coming from the Polovstian steppes in 1240.

The Norsemen from the same area also reached the eastern Mediterranean by travelling down the west coast of France from the base they had established in Normandy, past Muslim Spain and on through the Mediterranean to Alexandria and the Levant. At the Arsenal in Venice there is a lion, the emblem of the patron, St Mark (whose relics were originally taken from the Egyptian port), which was found by the Venetians in the Greek harbour of Piraeus and bears a runic inscription testifying to the presence of Vikings in the area.[33] Despite all this activity in foreign lands, the Vikings were probably inferior in weaponry to the Franks; though they had their frightening axes, defensively they at first often lacked a 'byrnie' or mail-shirt. But with their ships they were more mobile than the enemy and were always armed with iron weapons. There is a passage in a Norse Saga which has Canute sending from England to Norway for three dozen axes, 'and let them be good axes', he adds. Shipwrecks attest to the fact that there was an active trade in weapons going on in the region. Their production and export was stimulated not only by frequent raids but also because of the trade for furs; this meant that Viking objects in the mountains of Finland are found right up north and the fur provided the basis of a commerce that brought in a flood of Arab and Byzantine, as well as German coins. It was a material that everybody wanted, as they later did from Canada, partly for decoration and display. Meanwhile all this raiding employed weapons of iron, a material that was so plentiful in Scandinavia, together with the charcoal needed to heat both kiln and forge. Armed with these weapons they forced many into submission, raiding the monasteries and churches in Christian countries in search of valuable booty, in part almost putting an end to organised religious life itself, so devastating were their raids.

The Vikings' activity depended heavily upon their ships and weapons. The ships transported goods and people for trade, for conquest and for colonisation. The axe was to become their typical weapon but the sword too was very popular. The blade often seems to have been imported from the Rhine area in Germany, the home of much early iron-working in Europe, which produced blades of laminated steel specially created for performance in northern climes. These blades were in fact pattern-welded, not a true damascene which was made from high carbon steel or *wootz* from India or Iran (see Appendix 2).[34]

It was not until about the tenth century that properly quench-hardened and tempered steel became more common and we find blades such as the Frankish 'Ulfberht' blades which were used in Viking raids against the Franks, despite Charles the Bald's attempt to forbid their export. Damascus steel, originally from India, also became very popular. Damascus blades came from the seventh century with the Arab conquest, although oriental or Indian steel had already entered Europe. Strips are hammered out as in earlier Roman pattern-welding using low-carbon iron at low temperatures; Anglo-Saxon swords were often edged with steel and quench-hardened.[35] Both damascening and pattern-welding were attempts to solve the problem of high-carbon steel which either broke or bent. In Japan the low-carbon iron core of the blade was brought in contact with pieces of high-carbon steel and hammered together, giving maximum hardness on the cutting edge, and low enough in carbon at the core to provide toughness. Medieval swords, such as the heavier ones of the Viking period, were made of layers of much higher carbon content with lower-carbon material at the core.

Viking weaponry, which was employed by the Normans in their conquest of England, is well illustrated in the Bayeux Tapestry. However, the pointed shields and long mail-shirts were not typical of the early Vikings who had round shields and later sometimes a short byrnie with a pointed helmet, although this was not worn by every warrior. The boats they used for both trading and for conquest were made with the help of an ‘abundance of iron tools and the plentiful supply of wood’ that made plank-work easy[36] and were clinched with iron nails. The occupants were especially well armed with iron weapons and protected with their shields; with this weaponry, they conquered a vast array of territories.

Arab writers have suggested that both the Rus and the Franks in Germany knew how to make strong swords of a kind that were greatly prized and entered into trade;[37] ‘Muslim buyers were short of iron and glad to purchase swords from the north’.[38] For the Vikings were also traders, and especially those going from the North Sea to the Baltic across the Jutland peninsula. They also spread west to Britain and the Atlantic, as well as going down south to the Mediterranean. The Swedes among them had particularly strong contacts with the east down the Russian rivers, and some Arabs such as Al-Tartushi even visited the market of Hedeby in Jutland, an important trading centre that he found ‘dirty and poor’. From there goods were exported into European Russia including amber, weapons (especially swords), tin and lead ingots, glass and wine. The exports of amber and swords were ‘quite substantial’, as an Islamic source notes that the Volga Bulghars supplied large quantities to Kwarazm in Central Asia. In return they were sent dirhams, quantities of which have been found in the Swedish hoards; bullion was going westwards, rather than to the east, as was usually the case.[39]

Northern Europe remained largely ‘barbarian’, despite the influence of the Romans, then of the Christian church with their considerable use of iron. During the Middle Ages there was initially little development of iron technology; one observer writes: ‘[f]or seven centuries after the break-up of the Roman Empire in the west there are few signs of technical change in the European iron industry, and the methods used differ little from those of the Roman period’.[40] Indeed there was even something of a relapse and not only in metals. Building in stone virtually vanished with the Romans and Bede relates how some monks crossed over to Gaul in order to bring back masons and glaziers who knew the technology to build a church. In the seventh century Benedict Biscop had to seek help from across the Channel for his small building at Jarrow. Saxon construction was mostly in wood and grit; only with the Normans was limestone used once again and that needed to be worked with iron and cut with a hammer, chisel and saw.

Like the use of all other metals, iron-working declined with the fall of

Rome; on the continent it was only revived by the tenth century. Around 1000 CE some former metal production sites started working again although the mining of the metals had taken place earlier. An archaeologist speaks of Roman mines in Aquitaine being reopened in the tenth century, 'perhaps by Germans', the centre of exploitation being at Villefranche-de-Rouergue.[41] In northern France, Lorraine experienced an early revival and central Europe too picked up; England followed in the eleventh century in a more general revival of trade, of knowledge and of contact with the east. Then too, iron-working revived in the Forest of Dean.

By the late eleventh century the use of iron tools increased throughout western Europe, including the large plough that was needed for the heavy northern soils. Mining had continued for a variety of metals, especially in Germany. In the tenth century Frankish miners worked various Saxon deposits including the silver and copper ores. In 1115 some workers from the Harz mountains went down to Tuscany to mine the copper once again. In 1299 the silver mines of Devon were leased to the Florentine firm of Frescobaldi by Edward II and in 1359 lead ore in Alston Moor was leased to Tillmann of Cologne.

The Romans had employed water-power both in mines and flour mills but these suffered at the hands of the 'barbarians' and mills did not re-appear very quickly.[42] But by the time of the Domesday Book there were some 5,600 mills in England south of the Trent, to be followed later by windmills. For some processes like fulling cloth, this mechanisation started only in the twelfth century when a hammer to beat the cloth was driven by water-power. This process seems first to have occurred around Prato in Italy in 1108, and it was later found in France and in England. By the end of the fourteenth century water was used to drive the bellows needed to heat kilns, as had long been the case in China. In France water was also employed for grinding machines. The importance of power-tools meanwhile was aided by the development of gearing, derived from the machinery for clocks. Through this gearing, which was made out of wood rather than of metal, the amount of power generated by mills could be greatly increased.

In Europe the later development of cast iron was connected with the use of blast furnaces which, as we have noted, were probably found in Sweden in the period between 1150 and 1350 when they may have been influenced by China by way of the Mongols.[43] The first documented case of the furnace in Europe is at Ferriere, Italy, in 1313, the idea once again probably having come from the east. But most of the cast iron was nevertheless still converted into wrought although some was used for gun-making, as bronze was so expensive. But the production of enough cast iron for a bombard was ‘fraught with difficulties until well into the fifteenth century’.[44]

The Black Death of the fourteenth century meant restrictions on labour for metallurgy and many other activities. When the labour situation improved, German workers were imported for those purposes both to France and to England. By this time the old mines were often becoming exhausted and deeper mining and new techniques were required. Deeper mines brought more water that required capital to control; larger furnaces had to be built, which was done with the aid of investment by the money-men, resulting in early western ‘capitalism’. The new boom lasted from 1460 to 1530 when it was disrupted by the flood of metals from the New World and the ensuing crisis in credit.[45]

Iron became increasingly important throughout the continent and its production ever more specialised. In the north, iron for swords was often imported from Spain. These required expert welding to keep the core strong with wrought iron and the blade sharp with steel. As a result of this specialisation, the trade in iron increased even if the metal itself was widely present. Iberian swords (*falcata*) were known from the fifth century BCE, being used by Hannibal in attacking Rome, but later the Spanish produced Muslim scimitars, as well as the swords of El Cid and the rapiers of d’Artagnan and the Musketeers, possibly influencing those of Japan. They were made by mixing hard steel (with high carbon content) and soft at a temperature of 1454 degrees Celsius for a specified period of time, calculated by the recital of psalms and prayers. Afterwards, the metal was cooled by quenching with water – or sometimes oil. This is said to have been ‘Damascus’ but was local European. Swords from Toledo were imported throughout the continent both for display and for combat, and the use of metal continued to be developed. Spain kept up her interest and expertise in metallurgy in later times, as witness not only the sword-making in Toledo but Catalan iron-making more generally. The latter activity was already known in the first century BCE and is mentioned by Grattius ‘Faliscus’ in *Cynegetica*. The town of Toledo, known in Roman times, had long been involved in the industry and became an important centre of Jewish–Arab, and later Christian–Arab, culture, as well as being noted in the thirteenth century for its school of translators under Alfonso X. It produced a steel which was cooled in special, local water, accompanied by prayers, and decorated with a design called ‘damask’; it appears to have been known for its metal from Roman times, and it later became an important Judeo-Arab centre for crafts. It was this long metallurgical tradition that lay behind the work of Alonso Barba and others when they came to South America, an activity that attracted the interest of European bankers like the Fugger of South Germany. The Incas of Peru had already worked with bronze and other non-ferrous metals when the Spaniards came. After their arrival the silver mines of Potosí in Bolivia were extensively exploited. These mines are described by Barba who, about 1600, brought the ‘patio process’ from Spain in which the ores were spread out on a stone floor and trampled under foot.[46]

The specialised sword and its use by heavy armed horsemen, by the knights in their shining armour, was very prominent in the medieval period. The history of these horsemen goes back to the defeat of the Roman Emperor, Valens, by Gothic cavalry at the Battle of Adrianople in 378 CE, after which the mounted arm assumed an ascendancy in warfare. This supremacy of the knight depended upon a number of technical changes, including the harnessing of the horse for agricultural transport and the improvement of yield-returns for corn in order to feed them; they required a lot of grain to maintain, especially the heavy horse needed to carry a knight with all his armour. Much medieval equipment of this kind was made in Germany, Italy and the Low Countries, and foreign armourers worked in England, although the local guilds were also involved, for many local adaptations were needed. Wearing all that equipment the knight required a stirrup to help him mount. Its iron version was common by the seventh century, the war saddle by the sixth (with double girth by the twelfth), the curb bit, so important for controlling the horse, by about the same time, the iron horseshoe from the ninth and the spur from the eleventh. There was also the matter of cross-breeding the heavy European horse with the speedier and lighter Arabian variety. Before the emergence of the war horse, a lighter one had been employed to draw the chariot but its use in war stopped in the middle of the second millennium BCE, probably related to the spread of iron weaponry.[47] The heavy horse or destrier that was needed to carry the weight of a knight required time and skill for its breeding and its training. All these various developments were stimulated by the demands of the warrior. Armour became more and more elaborate and therefore more costly and only for the few; it has been estimated that the comparative cost of equipping a knight was the equivalent to that of making a Centurion tank in the Second World War.

The mounted elites employing these horses and the armour they wore were a central element of feudalism, the warriors needing a castle as a base. They were always elites and the soldiers more generally never made use of iron in the same massive way as the Romans did. After Antiquity, the military employment of protective clothing made from iron was by no means eliminated but it became more elitist. The development of the face-concealing helmet became more widespread and probably gave an impetus to heraldry and to the identification of knights by other means.[48] In Archaic Greece, too, the use of the face-covering helmets of the Corinthian type produced an anonymity that was 'partly relieved by the use of individual devices on the shield'.[49] Many Norman soldiers, originally from Scandinavia, had a knee-length mail-shirt for defence, the hauberk, which was a later version of the Saxon byrnie. Face protection existed but plate armour, the earliest of which only appears after 1200, was definitely for the few. It soon began to replace mail but full suits do not appear until the beginning of the fifteenth century. The new equipment gave excellent protection to the knight's body but it impeded his mobility to a considerable extent. In the end the thickness needed to stop a missile, firstly the arrows from the cross-bow, then the balls from the arquebus or musket, made it quite impractical for actual warfare, though not of course for display at ceremonies or in castles.

The cross-bow had increased the penetration of arrows. This was not a purely European invention for it has been found in Chinese graves from the fifth century BCE.[50] The Romans too knew of the principle, but it was only later that the west developed the weapon. Then the arrows could penetrate armour of increasing thicknesses. It had the advantage not only of penetration but of portability; the weapon was more powerful over shorter distances than the longbow and could readily kill an armoured horseman, a knight, which heralded the increasing dominance of the infantry. The foot soldier could now challenge the mounted elite and hence threaten the very existence of the 'feudal' order. In 1139 the Lateran Council, fearing that eventuality, banned the cross-bow as being 'hateful to God and unfit for Christians'.[51] However it proved so useful in the Crusaders' struggle against the 'heathens' that its use became widely accepted. But the cross-bow was about to be replaced following the adoption of a Chinese invention important in war and in mining – that is, gunpowder. The earliest unequivocal European evidence for the existence of a weapon projecting a missile by the force of exploding gunpowder is in a Florentine ordinance of 1326 and in the well-known illustration of a vase-shaped cannon in a treatise on kingship of 1326–7 by Walter de Milemete now in Christ Church, Oxford. Hand firearms were then introduced by the 1370s but at first they seem to have been of little tactical importance.[52]

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1 Aitchison 1960: 222.

2 Aitchison 1960: 222.

3 Aitchison 1960: 223.

4 Ward-Perkins 2005: Chapters 5 and 6.

5 Aitchison 1960: 241.

6 Aitchison 1960: 241.

7 Marrou 1977: 142; quoted in Heather 1999: 410.

8 Heather 1999: 51n.

9 Heather 1999: 410.

10 Davies 1935: 208.

11 I owe this information to M.Sardelic.

12 Schmidt 1997: 14.

13 Schmidt 1997: 35.

14 Schmidt 1997: 35.

15 Schmidt 1997: 33.

16 Schmidt 1997: 32.

17 Schmidt 1997.

18 Liebeschuetz 1990: 191.

19 Ward-Perkins 2005: 50.

20 Aitchison 1960: 321.

21 Liebeschuetz 1990: 228ff.

22 Liebeschuetz 1990: 231.

23 Liebeschuetz 1990: 227.

24 Goody 1983.

25 Heather 2005: 437.

26 Heather 2005: Chapter 10.

27 Heather 2005; Dušanič 2003.

28 Heather 2005: 364.

29 Heather 2005: 418.

30 Lee 1998: Chapter 7.

31 Goody 1993.

32 Roesdahl *et al*. 1992: 195.

33 Arbman 1961: 203.

34 Aitchison 1960: 351.

35 Tylecote 1992: 78.

36 Kendrick 1968: 24.

37 Arbman 1961: 21.

38 Abulafia 2011: 248.

39 Noonan 1997: 153.

40 Crossley 1981: 29.

41 Davies 1935: 81.

42 Aitchison 1960: 307.

43 Tylecote 1962: 76.

44 Tylecote 1962: 77. In the sixteenth century Biringuccio discussed the production of cannon and cast iron cannon-balls.

45 Forbes 1958: 78.

46 Tylecote 1992: 118.

47 Guilmartin 1997: 535.

48 Blair 1987: 169.

49 Snodgrass 1980: 106.

50 Regarding the Chinese version of the cross-bow and the arcuballista, see Needham and Yates 1994: 120, the first of which came into use before 500 BCE in the period of chariot warfare. The ruling class were ‘relatively unprotected by armour’, very different from the situation in Europe (Needham and Yates 1994: 185).

51 Guilmartin 1997: 539.

52 Blair 1987: 170.

PART II

Merchants

7
‘Capitalism’, exchange and the Near East

By the twelfth century the supply of silver in Asia was largely exhausted, and the metal was then exploited once again in the north of Europe, in England, France and in Germany, much being shipped to the Near East through the port of Venice which, as we have seen, was so heavily involved in this trade. This independent republic had maintained and developed ties with both the Muslim and Christian worlds to the east. The main flow of metals, as of wood and of wool, was from west to east, to pay for the spices, silks and valuables once again coming from India and the Arab lands.[1] Between 1170 and 1220 the situation changed somewhat and in Europe precious metals were mined further west, and closer to the Venetian republic that exported them. A rich lode of silver was discovered at Freiburg in Saxony and started ‘a frenetic search for new mines’; with their expertise in metals, transmitted since before the Hallstatt period, Saxon miners went through Bohemia and Hungary to the Carpathians and yet further east. For Venice in their eastern trade, metals from Central Europe were as important as western woollens. For her ‘rise to commercial prominence in the thirteenth century was based not only on the growth of its trade in goods created by the Venetians but also on the growth of metal production in Europe, an achievement not of Venetians but of German miners and merchants’.[2] Germany and its sphere of influence was of the greatest importance. Despite all their activity, little technological progress seemed to have been made, but some have said the same for the Romans. Some change certainly took place in the medieval period; especially in Central Europe where the concepts of ‘Saxon’ and ‘miner’ became almost equivalent. These men began mining in Hungary in Transylvania (where they are known as *Szászok*, or *Saşi* in Romanian), at Schemnitz as early as 745, and in the Harz by 970; much later, in 1551, 200 miners were sent to Spain to reopen the mines in Seville, and in 1624 in Konigsberg the Norwegian king put out a call for miners from Germany. In the Tudor period, and before, the English crown did the same. The Germans were the recognised specialists in metallurgy throughout Europe.

Despite all this activity, mining and metals did not have it all their own way. The sixteenth-century German writer, Agricola, quotes a number of classical authors who wrote of the harmful influences of gold and silver, for bribery, for corruption, for theft and for pillage. In this context bank tellers were especially at risk. Their problems were seen as resulting from metals and mining but the same difficulties would arise for intermediaries with any media of exchange, such as cowries or other forms of shell-money. So the condemnation was not limited to the precious metals, the stones of exchange value. Some authors considered that even iron should remain in the ground where it was, hidden, as among humans it causes death and injury. In the sixteenth century Agricola expressed this worry about metals. Well before that, Herodotus had had a similar complaint. So too had the elder Pliny; the latter writes of a Senate decree even forbidding mining in Italy.[3] The Quran puts the problem in stronger language – 'dire evil resideth in it as well as an advantage to mankind'.[4] Were these the reasons that Rome closed its mines from time to time, as in Macedonia?[5] There was clearly much ambivalence connected with their presence. Agricola does not deny the harm metals have done, but he also insists upon the good to which they give rise, upon the many tools that one needs even for the harvest.

In spite of the post-Roman collapse of Mediterranean commerce in the west, the production of metals resumed its importance in Europe, partly because of the need of the Near East. More generally, trade from the Near to the Far East, to India and beyond, had continued vigorously throughout the earlier period. With the rule of Islam under the Abbasids, exchange and manufacture developed and the flow of precious metals increased, partly through the confiscation of gold from churches and convents as well as from the palaces of Persian kings and nobles, and even from the tombs of Egyptian Pharaohs. In addition some recently won gold flowed from the mines in Libya but the main source was always the western Sudan. The excellent quality of the dinar over time was due not only to that steady supply of gold but also to the technology and achievement of Muslim minters who had a thorough knowledge of cupellation for the removal of lead, the separation of gold from silver by means of nitric acid, and of the extraction of gold and silver through amalgamation with mercury.

With a solid currency, trade with the east prospered and banking flourished, for there was a low rate of interest of 4 per cent to 10 per cent on the average, and many people could borrow to conduct their trading or manufacturing operations. The Near East was also well known for trading and banking. In the manufacture of textiles there were the linens of Egypt, as well as the different woollen fabrics. Syria and Iran were known for their silks, as was Palestine. Baghdad too had its cottons, a material originally coming from India, and there were important weaving centres in northern Mesopotamia. These centres had long existed, partly in royal factories or workshops that were called *tiraz* in Arabia and partly also as private industries, even at the village level. The advance of trading and manufacturing activity, including in glass, metal-work and in book production, was closely related to the spread of Islam – the Prophet himself was a trader – and to the fact that the expansion of the religion created one huge economic zone stretching from the shores of the Atlantic to the Chinese border. Its extent also affected the supply of raw materials, for wool could now come from many parts and dyes like saffron from different areas. There was, in effect, a vast common market created by religion.

To take one example, the glass industry produced many items for this trade, which were widely circulated. The industry had existed from the fourth millennium BCE and there are instructions in cuneiform texts saying how silica was employed. Glass of all kinds was produced in Syria, Palestine and in Egypt where the process probably originated. But it shifted westwards partly because of the problem of heat, being taken up in the cooler Rome and Venice, and partly because of a general shift of industrial production to that different area. The same happened with paper-making. Rag paper was a Muslim development, though paper itself was brought to Samarkand in 751 by Chinese prisoners; these pounded fibrous materials in mortars, added chemical ingredients and then applied the technique of sizing with a starch glue. At the end of that century paper-mills were constructed on the river in Baghdad. From there the industry spread to Arabia, to the Yemen, to Syria and then to Egypt, and finally to Spain, Italy and Europe generally. For that too shifted westward mainly because of power, the water to supply the mills. This paper was used not only in commerce, for bank and other records, as well as for correspondence as the Geniza manuscripts show, but also for extensive book production and for intellectual work more generally. With paper materials, Islam and China were able to establish large libraries, much larger than in the west where apart from imported papyrus chosen for some documents, all writing was on skins, laboriously copied, or on wax tablets; the advent of Gutenberg with his iron-made printer, press and metal type, dramatically changed the situation, by using printed paper for the communication of ideas, for the presentation of old ones and for the arts.

But the trade was not only in base metals but in precious ones too. Already in Phoenician times some trade from Egypt and the Near East went in a southern direction, down the Nile valley to the Sudan and to sub-Saharan East Africa. In the pharaonic period there are accounts of expeditions marked not so much by trade as by colonial plunder, though Egyptian techniques such as iron-making were also transmitted southwards. Much later, in the Muslim period, gold was obtained from a number of parts of Africa, especially as we have seen from the mines of the Senegal area from which the metal had already been sent across the Sahara in Phoenician and Roman times, as well as from those nearby in Nubia. In the kingdom of Asante in present-day Ghana there was both alluvial gold, also found in the Lobi area to the north, and gold which was 'mined' in simple galleries dug into the earth; these tunnels in the ground were found in the shallow coal mines of the peasants of St Perdoux in the Lot and of Alès in the Cevennes.[6] They were not at all well supported and always likely to 'cave in', burying the miners under the earth.[7] Simple as this mining was, it produced a considerable amount of gold; in the Asante case some was exported along the 'Gold Coast', some was sold by Ligby traders at Begho, and then traded across the Sahara (while some of it was used locally for regalia), to be exchanged for what were trinkets, that is, for Venetian glass beads from Murano (originally from the Near East) and for their Egyptian equivalents, salt and soap. For the north this trade was very profitable, exchanging cheap products for precious metals. For the south the incoming products included the valuable salt from the Saharan mines at Aoudaghost, as well as cowries, the small white shells imported from the Maldives in the Indian Ocean that served as units of exchange in the markets but especially as bridewealth in marriages. There were also some metal goods made of copper, bronze or even iron; trays made of brass came from Morocco and Egypt while a pewter ewer bearing the personal arms of Richard II, now in the medieval collection of the British Museum, was found in Kumasi incorporated in a war shrine, and probably came down along the Saharan route.[8] That earlier caravan trade had also brought down copper and the technology of copper-working used to create the Benin Bronzes, and later introduced the practice of iron-working. Porcelain and enamel plates from the north were also part of the incoming trade and decorated the doorways of the richer houses, together with cotton cloth, silk thread, later the guns and even some Arabic books.

Gold was taken across the Sahara by merchants from markets in Timbuktu and Gao. Some caravans went directly to North Africa, where much was eventually traded to Rome and Venice; it entered the mints and formed part of the bullion sent to the Near East in return for the spices and silks supplied to Europe that made the latter port so central to the continent's economy. The inhabitants of that town became rich on exchange and they promoted not only the printing press and publishing such as the Aldus imprint, but also became patrons of the flourishing artistic scene that was so important a part of the life of the Republic, even influencing the iconophobic Near East. Of this, we are reminded by Gentile Bellini's stay in Istanbul where he was despatched to paint the portrait of the Turkish ruler now in the National Gallery.[9] A large part of the gold from Senegal also went to Egypt, either by a route north of Lake Chad or else by way of the Muslim centre of Kairouan in Tunisia and the North African littoral. It was the latter route that was famously taken by the medieval ruler of Ghana, Mansa Musa, whose journey was described by Ibn Battutah. When the monarch made the pilgrimage to Mecca he brought so much gold to Cairo in the thirteenth century that it affected the very price in the city's exchanges. From Cairo he continued on to Mecca and on his return brought back with him a learned Muslim who started the 'University' of Timbuktu, emphasising once again the connection between money, metal, religion and scholarship, which also marked the history of the towns of Venice and Padua, and indeed of the whole of Italy at this time.

All this activity stimulated the economy both of Europe and the Near East. In his analysis of the latter, especially in relation to Europe, Ashtor raises the problem of why, with all the exchange and manufacturing, a 'true capitalism' did not develop there, given its strength and the continued contacts with the east. For it had a large class of merchants, which he calls a bourgeoisie, who carried on activities 'by methods of rational capital accounting'; there was a 'relatively free market'[10] and they had their own 'culture'. As an answer, he refers to Max Weber and claims that this mercantile activity, though strong, never dominated the whole economic sphere in the way it did in the west. The shadow of the Protestant ethic overlays the discussion. There were some relatively 'big industries producing for export'; however they were managed by the state, not by traders, as in Florence. We do not find, he claims, the 'crushing predominance of the big industry'.[11] But while the same dominance may not have been present as later on with metal-based civilisations in the west, the trade was by no means always small-scale. Participating in a world-wide activity were a group of Jewish merchants, the Radhanites, whose ties enabled them to travel between the east and the west, even when the two were at war. They moved between the kingdom of the Franks and the Far East both by sea and by land. With them they took eunuchs, slaves and furs, bringing back musk, aloe wood, camphor and cinnamon in exchange. As we have seen, metals too were involved with iron, swords and currency going eastwards, and steel and manufactures occasionally coming back. The merchants of the Cairo Geniza received goods from Europe, and travelled back and forth to India. Before the Industrial Revolution there was little difference in the trade or occupations of one set of merchants rather than another.

The trade continued to India, even when it declined with Europe, and in the Fatimid period many Cairo merchants were involved, sending copper coins, lead and textiles there in order to acquire their spices and other products. This trade was undertaken by a lively bourgeoisie ‘exactly as in the Italian republic’. Indeed in Syria it was ‘the golden age of the bourgeoisie’. Their importance is illustrated by the publication of the *Merchants’ Guide* at the beginning of the eleventh century, which demonstrates both their power and their achievements. Industry flourished throughout the country, new methods were introduced, and there was much free enterprise as well as the activities of the royal factories. Fabrics came to Egypt from other parts of the Near East, and the trade was vigorous. The sugar industry there improved its methods, setting up large factories in the expectation of profit. According to Ashtor that industry, which also made alkalis to purify the product, definitely had ‘a capitalist character’.[12] His statement recalls Mintz’s characterisation of the Caribbean sugar industry as ‘capitalism before capitalism’, indicating that the emergence of this type of production, together with the use of proletarian labour, had been a long-developing process and, as Braudel suggested, was not confined to post-Renaissance Europe. But production eventually shifted to the west, where it acquired cheaper metals, the energy and the heat for a mass product that would then be traded to the east as well as to the whole world.

Trade, manufacture, banking and administration made the bourgeoisie of the Near East increasingly important. In the later eleventh century those in Syria and in Upper Mesopotamia aspired to a degree of political independence, attempting to found independent urban republics, for they always thought themselves exploited for tax by the Fatimid and other rulers. Their revolts were at times successful and they temporarily took over the government, even employing princes as ‘condottieri’. Indeed in making this specific comparison of their roles, Ashtor draws attention to the ‘long party strife, which reminds us so strongly of the politics of an Italian city in the Trecento’.[13] The comparison is appropriate. The Near East had a rich and growing middle class which sometimes allied itself with the princes, sometimes with the lesser merchants, sometimes with the proletariat and occasionally even with the mob. But the urban population strongly influenced public policy, as in North Italy and in other parts of the world.

The period of bourgeois revolts and their central role ended with the coming of the ‘pagan’ Mongols whose armies were so much stronger, using Chinese artillery, superior iron weaponry and innovatory tactics. The conquering Ilkans or Mongol rulers of Persia moved their capital to Tabriz and changed the system of government. But at the same time the economy declined and the population of Iraq sank drastically.[14] However, trade did not stop. In 1294 the Ilkhans tried to introduce paper money into Persia, modelled on the Chinese. But the public were not ready to accept it, even when the notes themselves were covered with the titles of the Ilkhans, with Muslim professions of faith and with Chinese characters, proving that it was the latter who ‘had introduced block-printing’. After this failure, not only paper money but block-printing as a whole was discontinued. The recrudescence of the Semitic rejection of figurative representation, and in this case of printing itself, meant the loss of important new forms of communication, and this resulted in an impoverishment of the culture in comparison with the post-Gutenburg west.

This extensive commerce continued despite the problems caused by the religious prohibition on lending money on interest; the same prohibition based on biblical injunctions existed in Italy and in the whole of Christian Europe generally as well as in the Jewish and Muslim markets. But, as many discovered, it was not a formidable problem to overcome, nor were the other difficulties raised by Ashtor. According to him, capitalism was inhibited because the laws of inheritance ‘probably impeded the concentration of capital’, although with several children, the splitting of the inheritance was always a problem no matter where one was, except for landed estates in upper-class England. The commercial activities of the Muslim government, he also claims, ‘hampered the development of a capitalistic economy’, for example in the grain trade; but the Venetians too needed to ensure the supply of materials such as timber and iron, in order to exchange for grain in the *annona*, and this trade was organised by the state, with the help of private merchants. There as elsewhere the arsenal itself, like the army, was a largely Government institution. State participation in manufacture and commerce was widespread in early societies and was by no means confined to the Near East. Ashtor also claims that there was ‘the fear of security’, with merchants liable to have their wealth confiscated by the state. But we easily forget that dangers existed throughout Europe with the highwaymen on the roads, and with the pirates at sea; these often required protected convoys and caravans, as at Venice. Moreover the requisition (or acquisition) of wealth by the state was universal, including in Europe with kings and governments collecting money especially to pay for wars, sometimes through irregular long-term loans as with the Venetian’s *estima* but also by taxes, such as the *decima*; the former was not a regular imposition but a forced loan in the event of war, the latter a steady yearly imposition. All in all, there seems little in the Near East that inhibited the emergence of ‘true capitalism’; and we would rather see this activity as a phase in the development of a growing exchangist and industrial economy which in the end lacked the cheap power and materials that widespread development needed.

For there can be little doubt that a type of market economy existed, even way back in the Ancient Near East. This was so not only in the Near East but in China as well. Regarding the latter, Barbieri-Low rejects the application of Polanyi’s approach (and that of Finley, though they did not consider the east) in favour of a modified ‘modernism’. In particular he rejects the categorical, stage divisions of the former.[15] Trade had long been known, for the region was in the forefront of economic development, partly because of the fertility of the well-watered valleys which Neolithic agriculture was developing with the use of animal traction and the plough, and partly because of the possibility of using the surplus production to elaborate an urban civilisation with its temples, workshops and palaces, but also to exchange some of the surplus produced with the inhabitants of the hill country for the basic metals it lacked – that is, for copper and its alloys, as well as for precious metals, jewels and other valuables both to treasure and to exchange. These developments also produced the first attempts at recording such transactions with a simple token system, with the use of cylinder seals (which existed well before the tablets) and finally with proto-literate inscriptions of the latter, giving the contents of the exchange in the form of *bullae*. Some 5,000 tablets have been found in Uruk's temple complex devoted to the god Innana, the overwhelming majority of which were concerned with the central administrative control of economic activity.[16] These tablets seem to prove 'that writing developed as a direct consequence of an expanding economy'. Its further development recording 'spoken' language happened about the middle of the third millennium; but in its opening phase Mesopotamian writing had to do with counting or recording rather than with spoken language. Moreover numbers often formed a separate code, as they do in Europe today, having a distinct iconic form rather than a phonological one and therefore being the same in many languages, giving great communicative power. As a result the full potential of writing did not emerge until much later, almost at the time that iron began to replace copper. Nevertheless this early period saw the development of mathematics out of the recording of numbers, leading to the emergence of a sexagisimal system, of an abstract, context-independent range of numeral signs, as well as the beginning of multiplication and of division.[17] The development of mathematics shifted from the Near East with the disappearance of the ancient civilisations and the accounting procedures found there, but the influence of Babylonian mathematics persisted not only in Greece but later in the Islamic Renaissance and in the accounting procedures of Venice and the Italian Renaissance.

Many have seen the development of writing in the Near East as having to do with merchant exchange, and the earlier tokens involved in such activities were the forerunners of more extensive forms of the transcription of speech. That exchange was a matter not simply of counting and recording the items but of detailing the nature of the commodities transacted, which required writing down of the names of goods, a transcription of language. However this may be, that eventually developed into a full writing system of the logographic type, the cuneiform of Mesopotamia, which was similar in form to the hieroglyphics of Egypt and the characters of China (perhaps with different origins). In the Near East, exchange gave rise to the Assyrian merchant activity at Kanesh, recorded in letters from the trading colony in Anatolia where metal was obtained back to the other part of the family, who were sending wool and textiles from the south. These records included statements of the profit and the loss made by the expeditions, including not only the price paid and received for the goods themselves, but also a calculation of the costs of the journey such as the time and the 'gifts' spent crossing rivers. These various aspects of the trading voyages were given a value, stated in 'abstract' terms, which reduced time and goods to a standard reckoning (a 'money') and providing the basis for the merchant to work out of the 'value' of his visit. Some rough reckoning must always have accompanied human activity of this kind, in order to see whether it was 'worthwhile'. But writing gave this a precise form that enabled one to calculate whether the voyage should be repeated.

In fact the accounting of receipts and outgoings, for storage as well as for exchange, is present in the very first written form of the 'accountants' script' of the Uruk period.[18] The tablets are pre-cuneiform and are numeric, giving way much later to language-functional writing; even with an alphabet, numeric systems but now form a distinct icon-based code pointed the way to the further development of logographic writing. The written calculations referred not only to actual transactions but to expectations, to planning, and to the balance between them, which meant calculating a debit and a credit.

Therefore the idea that the Ancient Economy, here or later on, was somehow of a totally different kind from later economies seems to me to need qualifying and Polanyi's analysis of such systems is not altogether supported by the evidence. True, early on there was some reciprocity, just as there were ports of trade, but these modes of 'exchange' also existed in later times and did not constitute alternative 'stages' of development, although they became more important at some times than at others. While they were important, they did not exclude the forms of trade and monetary exchange that has so dominated later periods, especially after the coming of the Age of Metals. But Polanyi's approach seems to exclude the co-existence of a plurality of modes of transacting goods, whereas it appears that 'the seeds of capitalism' were in fact sown early on. The role of the trader as entrepreneur increased over time, and that of the ruling elite in this was more or less significant, as in Venice or in Florence, but the activity continued throughout and individuals as well as governments were involved, both in exchange and in manufacture.

The Roman economy, as described by Ward-Perkins,[19] displays many of these 'seeds of capitalism'. While the state played a huge role, not only in conquering profitable territory which provided their various metals as well as providing an extensive market through the standing army and the local elite, merchants and entrepreneurs were often involved in running the mines as well as in large-scale production in the case of *sigillata* ware.[20] As a result of their activity goods circulated in large quantities, the pottery reached all the way to the south of India and the north of Britain. Iron was obtained widely, supervised by the state, and manufactured by individuals for the purposes both of war and of peace.

From one point of view 'capitalism' might be said to have pursued the same trajectory as that of metals; trading in these and general exchange activity grew gradually, sometimes declining for a period, as in the post-Roman Mediterranean, but in the long run there was a forward movement to greater complexity. The trade in precious metals produced coinage and a more abstract calculus developed within finance, banking and exchange, so well discussed by de Roover for Venice. But these institutions were pan-Mediterranean and certainly affected the east, including the Far East, as well as the west. This Italian development was largely a rebirth or elaboration of earlier aspects of the world of exchange, building on all the complexity of the Roman economy, with its *commenda*, its banking, and its varied manufacture of metal work and of pottery for export, as well as for other household, agricultural and military purposes.[21] And before that, in Mesopotamia, with its search for metals in exchange for wool and other local manufactures, of its parallel development of accounting techniques. Not that this was the beginning of exchange, as we have seen. That had already occurred in the Neolithic period before the Age of Metals. Any subsequent specialisms, of which as Childe noted the Bronze Age produced many, implied exchange for other commodities, and that process continued to develop during the following millennia.

After the Crusade there was a change in the character of trade with the Near East. Then it had involved iron, pitch and arms but in the fifteenth century it brought mainly olive oil, cheap and dried fruits, copper (for small coins) and cheap cloth.[22] No longer did Europe supply the raw materials and arms but new manufactures and foodstuffs.

In all this, the Near East was not very different from either China or India, who also formed parts of the exchangist economy. According to informed observers, the former displayed 'sprouts of capitalism'. The extent of the Chinese achievement in science has been well chronicled by Needham. It was the same with production; at the end of the eighteenth century China was still the major exporting power, especially with its manufacture of high-heat porcelain. It also made paper as well as gunpowder and produced block-printing. In India, according to Nehru, first prime minister, its independent move to capitalism was interrupted by colonial conquest and exploitation. India did well with colourful textiles as well as with pepper and other tropical produce, and is now doing well in industrial production. It was a ‘periphery’ country to Europe’s ‘core’ only for a limited period.

However, this distinction between ‘core’ and ‘periphery’ has always seemed in need of ‘processional’ treatment. India may have been a ‘dependent’ country in those terms during the railway age of the nineteenth century when the industrialism of the west temporarily led the way to development, to ‘capitalism’. But dependency at this time did not make it ‘peripheral’ over the longer term. It had exported *wootz* steel to the west, as well as jewels, perfume and cloth until that was factory-made in Europe, during a period of domination that was reversed within fifty years of the country acquiring the necessary machinery. Cloth went to China, too, by way of Lahore, as did sugar; Marco Polo met an Indian merchant selling sweet meats in a local bazaar. Buddhism and Sanskritic knowledge, which brought many scholars to its universities, travelled the same way, and also possibly crucible steel. Zinc, porcelain and paper came the other way, going both by land and by sea. The eastern seas were a hive of activity, and saw the great voyages to Africa through Malaysia. The port of Malacca already had its Chinese quarter when the Portuguese arrived, also using their ships and guns (but more manoeuvrable). As in Europe’s case, in the longer term dependency was reversed; core became periphery, periphery became core. Alternation was the name of the game.

Conquest – or at least dominance, as in the case of China, was an important factor. The ships that ensured Venetian trade to the Near East, were always accompanied by armed galleys with superior armament that frightened off both Turk and pirate. Ashtor sees the dominance of the European fleet in the Mediterranean as being an example of the technological decline of the Near East. At the same time the Venetians were superior in the manufacture of gunpowder as well as of guns. It has been maintained that Muslim technology in firearms was constrained by the nomads’ preference for fighting with cavalry, but he suggests it was also part of a general decline in the Near Eastern technology in later medieval times. However, the cannon on Venetian ships were also of bronze like those of other powers, not of iron. In the fourteenth century its artillery, mounted on the galleys that took the trade to the Near East, was superior to that of the Muslims and most other nations. And they used steel projectiles, made in Brescia.[23] But it was a question not only of technology but also of the supplies of metal, wood and water that inhibited 'industry' and development in this area.

Ashtor's conclusion about why the Near East never achieved 'true capitalism', despite all this activity, commercial, industrial, financial, in relation to manufacture, trade and exchange with the east and later with the west, strongly resembles Braudel's as to why financial capitalism was developed only in Europe, and America. The question is wrongly phrased. It is true that the Near East did not produce the European developments of the nineteenth century. But this is a different question from the advent of 'capitalism', as Wrigley makes clear.[24] In my opinion, and in Braudel's too, this form of economy began to develop early on in world history and while it took on special shape in the nineteenth century with the advent of the steam engine, the blast furnace, the railway and perhaps even 'financial' capitalism, these events were not discontinuous with what went on before. The earlier forms did not represent a 'false' capitalism (as distinct from a 'true' one) nor even an incomplete one, but a point in the development of an exchange economy that subsequently involved large-scale 'finance' and manufacture. In the nineteenth century leadership of the economy certainly swung to western Europe and to America but that was for a particular period of time, not a permanent state of affairs. And that advantage is changing again today, with the emergence of China and India as world powers. Whatever this situation, the sprouts of 'capitalism', not simply 'petty capitalism', were present in the Near East long before the Italian Renaissance. The contemporary achievement of the eastern powers is nothing new, nor a wholesale introduction from the west, but a building up of an earlier pre-eminence.

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[1] Lane and Mueller 1985: 135.

[2] Lane and Mueller 1985: 138.

[3] *Natural History* 23.4.78.

[4] Aitchison 1960: 1.

[5] Davies 1935: 228.

[6] Tayrac and Pernelle 2002.

[7] Ferguson 1974.

[8] See Goody 1971; Bovill 1933; Ashtor 1986: 101.

[9] Goody 2009a: 253; see also Brotton and Jardine 2000.

[10] Ashtor 1986: 112.

[11] Ashtor 1986: 113.

[12] Ashtor 1976: 199.

[13] Ashtor 1976: 231.

[14] Adams 1965.

[15] Barbieri-Low 2007. On the operation of the market in the Chinese case, see Chapter 4.

[16] Nissen *et al*. 1993: 116.

[17] Goody 1986.

[18] Nissen *et al*. 1993: Chapter 16.

[19] Ward-Perkins 2005.

[20] Goody and Whittaker 2001.

[21] On (minor) differences in the commenda, see Ashtor 1986: 553ff.

[22] Ashtor 1986: 586.

[23] Ashtor 1986: 146.

[24] Wrigley 2004.

8
China and the Eurasian corridor

The search for metals and other products went on of course not only in the Mediterranean to the west but also to the east, to the hill country of the Zagros mountains and of the Persian plateau along the route that led to India and to China. Despite the collapse of the Roman Empire in the west, in the latter countries iron-working flourished. Like the 'barbarians' in the west, the inhabitants, especially the Persians, proved to be the conquerors and to some extent the successors of the Mesopotamian civilisation of the valleys.

The development of those regimes, where bronze metallurgy had begun, is instructive. The Iron Age 'started' in the east about 1300 BCE marked by major disturbances in the region and the appearance of the Medes in the Zagros mountains on the Iranian plateau. These were people who had also acquired the techniques of metal-working from the settled urban communities but were largely dependent upon a pastoral economy and consequently could raise a mobile military force. Indeed these Indo-European-speaking horsemen became dominant in the politics of the region. The Zagros mountains were of course a place where early domestication had taken place. The whole area became one that challenged Mesopotamian hegemony, and would both attack others and defend itself. It was there that various groups emerged, not only the Medes and the Scythians but also the Achaemenians, that is, the dynasty founded by Cyrus in about 550 BCE and that in 331 BCE was conquered by Alexander of Macedon, another great Iron Age general. He in turn founded his own dynasty, the Seleucids, which was followed by the Parthians and then by the Sasanians (c. 224–651 CE), both of whom controlled the western Silk Road, just as Alexander had fought his way to Bactria in Central Eurasia, which communicated with China, and from there entered the north of India, attempting to return via Baluchistan.

It was during the period of Disunion (220–589 CE), that, despite the constant warfare, international trade flourished; the Silk Road became the main route for Eurasian trade, an activity in which aristocrats were heavily involved. The spread of Buddhism from India and the establishment of steppe empires stimulated exchange of all kinds, with raw silk as the main export, until sericulture developed in the eastern Mediterranean from the sixth century. In return China imported mainly luxury items. Silk was used to pay off the Turkish and other nomads much as gold was used by Rome to keep western ‘barbarians’ quiet. Dozens of merchants came together in one caravan, just as they did in galleys from Venice in the west – there was some safety in numbers. By the end of the fourth century the trade was dominated by Sogdian merchants from the borders of Persia, who were found in many towns in northern China. It was a trade in which Buddhist monasteries, growing in importance in the fifth and sixth centuries, played a critical role in developing of credit facilities; the religion was later proscribed in 845 when its statues were melted for coin.[1]

This exchange was less problematic after the split in the Turkish empire at the end of the sixth century and Yongdi, son of Wendi, developed the capital at Luoyang, built the Grand Canal, and attempted to regain the empire. The construction of this canal eased the transport between north and south and stimulated overland trade to the west. Market activity grew rapidly under the Tang, despite the increase in regulation. But trade with India grew and when that declined in the seventh century, exchange with Persia and the Islamic Empire increased, despite the spread of silk technology to the Near East. But communication along the Eurasian corridor had existed long before that took place.

The Persians had moved from Central Asia to the Zagros mountains at the beginning of the first millennium BCE, and it was then inhabited both by agriculturalists and by pastoralists. They were augmented by a Turkic-speaking population at the end of that millennium; not for the last time the Persians were much affected by the infiltration of Turkic nomads from the east, with their mobility and bringing with them a plurality of religious practices. The mix of peoples, languages and religions was continent-wide; just as Indo-European speakers settled near the China Sea,[2] so Ural–Altaic ones came to northern Scandinavia. This criss-crossing in the movement of peoples and goods was obviously of fundamental importance in the story of Eurasian cultures. In the shape of the Achaemenians who held power about 550 to 331 BCE, these Persians were in many ways heirs to the ‘civilisations’ of the Ancient Near East which, spreading both east and west, passed on that heritage to their successors and conquerors, the Semitic-speaking Arabs, who followed earlier members of the wider language group. The Persians represented its extension of urban culture in a north-easterly direction, towards the mountains of metal-rich Afghanistan, which had long communicated with China and Tibet by a variety of routes. They thus became intermediaries in an exchange that at times included direct contact and may have resulted in the spread of metallurgy, which was usually associated with the hills as well as earlier of farming and of Neolithic society that preferred the lower lands. Later on the religions of the Near East reached China by the same routes, Zoroastrianism, Judaism, Nestorian Christianity and of course Islam, just as elements of Chinese culture came the other way, including the transmission of painting to Persia, of printing, porcelain, paper and powder, as well as many other aspects of science and technology, such as advances in the furnaces used for iron-working. Given the movement of peoples and ideas, the exchange is not surprising except to entrenched Europeanists and their eastern equivalents who see the movement as one way from a unique point, as the recent history of political ideas itself demonstrates. Later on the Central Asian peoples, who were an essential part of this process of communication and who furnished their neighbours not only with metals but also with the mercenaries (*mamluks*) to support their regimes, went on a wave of conquest in both directions. The Mongols, the Turks, the Celts, the Goths and the Huns were all ‘barbarians’ of the Iron Age, much influenced by the production of metals in peace as in war. The search for these commodities by the settled peoples of the cities had resulted in the transmission of their metallurgical techniques to the inhabitants of the area, those who commanded the steppe regions which then descended into the urban societies of China, the Near East and of Europe using the very weapons and technology that the more ‘advanced’ societies had put into their hands.

Communication with Central Asia and hence Europe was made easier by the pan-Asian empire under Genghis and his Mongol successors who reinstated the overland trade network, especially with their use of Uighur caravaners. But over time it was the Ortoq merchants (Muslim foreigners) who most benefited, acting as agents for the Mongol leaders, and may have shipped quantities of silver to the Islamic world.[3] But conflict among the leaders meant there was little stability on land and hence a reversion to the maritime trade by way of India and the Persian Gulf. This was the time when Ibn Battuta visited the sub-continent in 1341 and reported Chinese ships to be dominating the routes between that country and China, especially carrying blue and white porcelain, known to the Chinese as Mohamedan Blue, the colouring of which was dependent on the imports of cobalt from Persia. The bulk transport of pottery was much easier by sea. European traders too purchased objects of Chinese porcelain as well as silks together with silver from South America, for the Spanish founded a silvery in Manila in 1571 and the Ming allowed the Portuguese to establish trade with Macao in 1557.

The foundation of this achievement was the fine loess (or yellow earth) rock dust that covered the plains of north China. This dust consisted mainly of quartz with a high melting point. But it also had a low clay content, meaning it did not shrink. Ceramics and metals were developed together. In the west metal objects were made with a hammer in the smithying tradition. In China the earliest metal came from the potter's piece-moulds which impelled them to an efficient kiln technology: 'In ancient Mesopotamia, potters modelled their kilns on smelting furnaces, in which the smithy strives to keep the metal and fuel in close contact with each other: thus, they built kilns of brick from the ground up, with large fireboxes directly beneath the pots, producing a uniform but modest temperature (of about 1,000 degrees Celsius). The potter, however, achieves the best results by separating pots from the source of heat in the kiln. In the loess soil of China, all that artisans had to do was excavate a chamber in rising ground, tamp the walls and create a vent to the surface; the sandy soil provided excellent insulation, and an effective chimney gave a good draft and a strong flame' according to Finaly.[4] In this way the 10-ft-long 'dragon kilns' of the Han could use natural draughts to produce a higher temperature than European kilns could obtain before the nineteenth century. This had already been achieved by the Zhou dynasty (1027–221 BCE), who fired their better kilns at about 1250 degrees Celsius, making pots hard and resonant. The Zhou produced high-fired ware but not until the Yuan dynasty (1271–1368 CE) at Jingdezhen in the south do we get 'true porcelain' in the thirteenth century.

The subsequent development of 'true porcelain' at Jingdezhen led to the vigorous growth of the export trade, encouraged by the improvement of Chinese shipping and exchange through principally Muslim connections with the Near East. Later cobalt blue was brought there from the Persian area to create the famous blue and white ware. Especially with the use of local cobalt, which meant its colours did not run, 'plain' porcelain could now be painted and exported to the Near East that had long had a tradition of such colourful decoration. The growth of the industry was enormous. By the sixteenth century according to Finlay it had become 'the largest industrial operation in the world',[5] with over 1,000 kilns, 70,000 workers and 'a production process that anticipated modern methods of assembly-line manufacture'[6] which depended on employing a sophisticated division of labour. At first the blue and white was for export, but the court ordered large quantities and eventually the values of sculpture in earlier Chinese pottery were rejected in favour of painted surfaces. Porcelain became a world-wide export and a valued acquisition in 'upper' homes in Europe and elsewhere. Cabinets, and indeed palaces, were specially built to contain the finest examples – except in India where religious prohibitions meant that clay-based terracotta, being absorbent and therefore possibly polluting, could not be used. In the Near East it was the use of painted decoration on tin-glazed earthenware that influenced the Chinese towards the development of blue and white ware. In the west, it had enabled potters to cover the brown earthenware, virtually the only pottery made there since the fall of the Roman Empire, with colourful designs on majolica, faïence and Delftware. Tin-glazed earthenware became very popular but it could not hold its own with the massive import of porcelain that came about a century after de Gama's voyage. The tableware then came in mainly Dutch ships, with the start of the Ming dynasty that overthrew the Mongols and restored a predilection for sea transport. The Portuguese could only establish a base at Macao some time later, by which time the Dutch were taking over the Asian trade. By then the European craze for porcelain had begun in earnest.

Europe now offered an expanding market. Until the sixteenth century most people had used trenchers of wood and bread. Only late in that century did earthenware vessels replace leather in England. In Italy majolica came into fashion among the growing middle class. That was the golden age of Dutch imports and they represented a change not only in tableware but also diet. Spices came in large quantities from the east but also hot drinks and sugar from elsewhere. At the same time the notion of individual servings became more common and communal eating less so, so that individual tableware flourished.

Porcelain was imported to Europe in large quantities, especially through Portugal and Holland, and monarchs even employed alchemists to attempt to reproduce it. This was eventually achieved in 1708 by Johann Böttger, who had fled Prussia and been seized by Augustus of Saxony and forced to work in the dungeons of Dresden. The creation of the famous factory at Meissen followed in 1710, but the procedures were soon pirated throughout the continent once the problems of building high-firing kilns and obtaining sources of kaolin (China Clay) had been solved. For the manufacture of porcelain depended not only on high-heat but on the materials used, that is, china-stone and China-Clay (kaolin). The two components fused when heated to above 1,300 degrees Celsius, producing vitrification (Finlay 1998: 145).

Like others in the region, the Mongol army that raided into China in one direction and as far away as the Baltic in the other consisted primarily of armed horsemen, with a special, 'Mongolian', bow, each cavalry man having four or five horses. It also made use of iron weapons and even the Chinese siege technology employing gunpowder.[7] To maintain such an army, estimated as many as 800,000 men, the Mongols had to have access to a huge amount of booty since there was no settled community for its support. Under Quibilai part of that army conquered South China and part proceeded westwards under Hulegu. The latter invaded Persia and destroyed the Assassins, putting an end to the Abbasid Caliphate with the sacking of Baghdad in 1258. The army then went on to Palestine where it was halted by the new Mamluk dynasty of Egypt under Saladin, itself led by soldiers of Turkish slave origin, also from the steppes.

Typical of these steppe peoples were the Parthians who, as rulers of Persia followed the Seleucids of Alexander and the Achaemenians of Cyrus. They ruled for some 500 years from 247 BCE to 224 CE and possessed a formidable fighting force that defeated the Roman general, Crassus in 53 BCE. This force consisted of light cavalry equipped with a powerful bow that could pierce armour, as well as having heavy cavalry bearing lances and wearing armour of plate or mail. But the Parthians were also intermediaries in more peaceful activities. By the last quarter of the second century exchange with China and the east flourished, especially in the valued silk trade, a material that is mentioned in Greek sources as early as the fourth century BCE, so that the commerce would undoubtedly have begun well before this time. With the classical period it grew in importance. In the early first century BCE the exchange brought Chinese ambassadors to the head of the Persian Gulf although for luxury goods including silk, camel caravans were preferred as safer than water transport. But whether by land or sea, there was always an imbalance in favour of the east, which meant that silver had to be sent to China where hoards of Parthian coins have been unearthed.[8] Meanwhile gold went to India.

Under the Sasanians who succeeded the Parthians and again controlled both the land routes to China and the sea routes to India, trade expanded even more, especially in luxury goods such as incense, spices and silk fabrics and thread. Silk thread was brought back and woven in the Near East where the industry developed, while textiles, cobalt, silver, vessels, glass and horses went to China in exchange.[9] The Sasanian ruler, Shapur (239/40–272 CE), the son of Ardashir, founder of the dynasty who had overthrown the Parthian ruler in 224, built the city of Gundeshapur in Khuzistan, near the Indian 'border'. The town became famous as a centre of learning, especially in medicine, as well as for the production of silk; scientific texts were translated there, establishing a tradition that was taken over by the Muslim Abbasids. A number of scholars from Antioch settled in the town, including its Christian bishop at a time when Nestorian Christianity was being persecuted in the Levant by the Orthodox. Learned men from India as well as Jews from Baghdad worked there, for the regime permitted every faith and even defended the prophet, Mani (c. 216–277 CE), who attempted a synthesis of all of them. But when Shapur died, the Zoroastrian priesthood took over control once again and began to persecute other faiths in a distinctly monotheistic manner, 'mono' meaning only the one had the truth and the salvation. In that religion fire rituals played a very prominent part and these may have been associated with smithying and the furnace. The tribes inhabiting the area between Persia and China were all greatly influenced by the coming of the Iron Age and made use of that metal both offensively and defensively. But learning also flourished. Under Khusrau (531–579 CE), one of the last of the Sasanian kings, Persia not only extended its dominance to the north and west by allying itself with the Turks, but also to the east and south down to Arabia and the Red Sea, and at the same time it was also a regime that encouraged scholarship. When Justinian closed the Academy of Athens in 539, Khusrau welcomed its scholars to Iran. In this way Persia profited from the intolerance of early Christianity, especially towards so-called 'pagan' aspects of classical culture, and that learning influenced the Renaissance of their Muslim successors, the Abbasids.

From the north of Persia and the Caspian and Black Seas in the west a huge steppe and desert belt stretches to the upper Yellow River valley in China to the east. In historical times this has provided a valuable corridor for the transmission of techniques and ideas. So scholars have inevitably speculated about the earlier cultural migration of agriculture and of urban civilisation itself; but there was little archaeological evidence on this topic.[10]

In his account of Chinese archaeology, Chang draws attention to the importance of that steppe area for cultural transmission between the Iran–Iraq area on the one hand and the Yellow River region on the other, with the influence of these urban societies spreading through many scattered settlements.[11] In the millennium before Christ, a single cultural area existed in this broader region. The steppe tribes including the Scythians became expert in metal-working and archaeologists have reported evidence of large-scale iron-smelting and forging as well as weapon manufacturing and general smithying in a variety of metals. Iron was obtained from the very same deposits that are used in the modern works in the area of Krivoy Rog.[12] The land between the Fertile Crescent and China had seen considerable commercial relations well before the steppes were conquered by the Arabs.[13]

However with the later unification of those lands under Islam, trade in the resultant common market certainly increased, leading to a prosperous economic life for many of the inhabitants. Whereas the earlier trade had been mainly in luxuries, under the Abbasids considerable quantities of goods for mass consumption were exchanged between the distant provinces of their vast empire.[14] In his work on the economy of the area Ashtor lists some of the many transactions that were taking place, concluding '[t]here can be no doubt that the increase in the volume of trade ushered in a flowering period for many towns', the very opposite of what was happening in the Europe of this period. Trade between the east and west of Asia developed and for a short time the earlier Persian and Chinese civilisations came into contact in Bactria and elsewhere. This prosperity resulted in the flow of precious metals to the towns of the Near East.[15] The whole of the extensive world of Islam flourished economically, and with that the field of science, with the Abbasids reviving the achievements of Classical Antiquity, and despite the bias against figurative representation, even of some of the arts as well as a result of the contact with China and the acquisition of paper-making techniques.

The east of Eurasia, however, had a different history of iron from the west. Beginning with India, the earliest farmers had settled in the peninsular by the third millennium BCE (Map 12). The Iron Age came from the north about 800 BCE, probably through Sialk in Iran. The influence would have come from the Eurasian corridor running between east and west. Iron-using communities emerged in the upland regions of the south of the continent in the latter part of the second millennium BCE. Then they expanded down to the river valleys into the area that traded directly with Rome. The building of megalithic structures in the south was associated not only with the manufacture of iron but also with potsherds, some inscribed with graffiti dating from 300 BCE and written in the Brahmi script, a derivative of that used for the Semitic Aramaic and which was employed for trading purposes as well as subsequently for local rituals. These megalithic sites have yielded a profusion of iron agricultural instruments; in the middle to the end of the first millennium BCE, the inhabitants used a wide range of these tools such as axes, ploughshares, hoes, sickles and spades. These instruments also entered into commerce, which thus contributed something to the revenues of the area, and the income was used in turn for the construction of wells and tanks, as is noted in various religious inscriptions. The developed agriculture in the south was often irrigated and a kind of water-lifting device is referred to, as well as the plantation of trees both for timber and for fruit. These special forms of cultivation were associated with trading networks whose members made donations to the Buddhist community. To the south of India, Sri Lanka seems to have been part of the same Iron Age network and the coming of iron occurred there in about 900 BCE with no preceding Copper or Bronze Age. In this whole area, iron ore was widely found and seldom required mining, but nevertheless the extraction was always labour-intensive, involving the employment of many workers with different skills.

Map 12 India

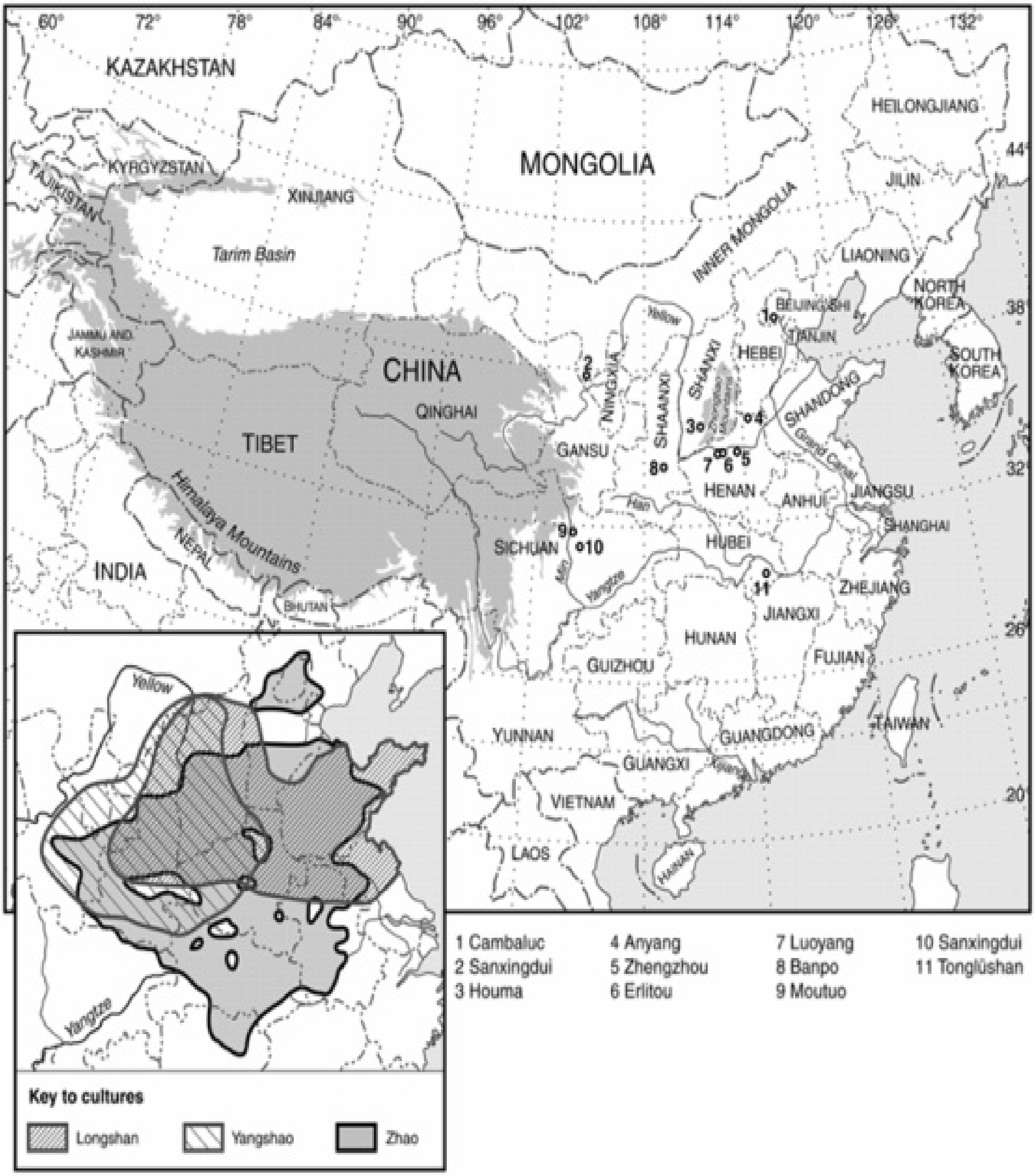
In India more generally the manufacture not only of iron but of iron in the form of steel became very important. *Wootz* or crucible steel was a metal of unusual hardness and high-tensile strength, especially associated with Hyderabad, and by the mid first millennium CE it had become a major trade item in the western Indian Ocean being exported to Rome where it was greatly prized. It was made in crucibles using iron produced on a small-scale, but employing very large bellows.[16] This product resembled Damascene steel as found in later medieval times and the technique may have been imported there by the Arabs.

At first the network of southern trade was largely confined to the western Indian Ocean. It was especially active with the Romans when traders visited the country by sea following the monsoon winds, both to Muziris on the east and to Arikamedu on the west, as described in a sailor's account from the second century CE. The trade went in both directions, as we learn from the Mesopotamian material discussed by Ghosh.[17] That commercial activity continued after the Romans, especially with the Sasanian port at Siraf on the Persian Gulf. In the fifth century the port of Banbhore was given as a dowry to the Sasanian king, who obviously participated in the trading network. By the middle of the first millennium CE its scope had expanded in both directions to Indonesia and to East Africa. Hinduism itself was exported to South East Asia, taken there largely by traders. There is much evidence for Indian trade in South East Asia from at least the fourth century BCE; their specialists settled in coastal Thai towns and established manufacturing facilities for glass and hard stone beads. They also searched for gold, calling the area Suwannabhumi, the land of gold, but doubtless tin was also in their sights. It is very likely that this Indian trade may have introduced iron to South East Asia, though there was also later on a market for the cast iron agricultural instruments (and weapons) of Chinese origin.[18]

The voyages of these traders were often intertwined with pilgrimages, conveying those who took part in commerce too, as was also the case with the Christians and Muslims going to Jerusalem and Mecca respectively; pilgrims used the same ships and caravans as did merchants, and did a little commerce on the side. In Europe this occurred in Venice when they were offered transport to the east in the galleys. Subsequently trade between India and the Near East continued under the Muslim Abbasids and in many parts of the east Islam became the great cosmopolitan trading religion. It was Muslims indeed who led the great Chinese expeditions to East Africa for they were the important travellers and geographers; they also did much of the trading in India, not having the taboos on ocean travel that confined some Hindus. But the coming of Islam, although the Prophet was a trader, did not altogether displace the commercial activity of the Hindus, Buddhists or even of the Jains; all three religions flourished among merchants along with oriental Judaism and Thomasian Christianity, especially in the south of India, despite taboos on travel, exchange and money-dealing.

The lands farther east were also radically affected – Bali, Java and mainland Malaysia, where Islam built many mosques such as the one at Banbhore with its Kufic inscriptions dating from 727 – and south at Mantai where much Chinese export pottery has been found, as it has in the Persian Gulf. In the south of India an extensive network of trade was organised by the Ayyavole, a group associated with the Brahmins, for that part of the country had resisted Islam and remained Hindu, which strongly affected South East Asia and the islands. This group became especially important in the eighth or ninth century and had links with families both in Tamil Nadu and in Kannada. It also provided semi-military units, which were originally hired to protect caravans. And in the course of this activity they became traders themselves, merchants who often acted under royal protection, collecting taxes for the king.

China had quite a different history (Map 13). From the very beginning, the 'Pekin man' of Palaeolithic times had a blade industry as opposed to the hand axe cultures of Europe and Africa, and moreover he knew how to control fire, helpful for splitting stones for blades, essential for pottery kilns and a thousand years later for metal-working. At first fires were used for cooking, heating and defence; but later in the Neolithic for baking clay into pottery for which the kiln was developed. Agriculture in China was to some extent a local development involving millet in the Yellow River valley and rice in the Yangtze. The transition from hunting and gathering to settled farming in the region dates to the sixth or seventh millennium BCE. In the Yangtze rice was being experimented with from about the same period but only became an important part of the economy in the fourth millennium. A bronze metallurgy was acquired from the Near East by way of many intermediaries, and it was becoming established in the late third millennium BCE in Gansu and Xinjiang: 'The sudden appearance of early bronzes in the Central Plains was a result of influence from Northwest China.'[19] Recently in rural Africa pottery was fired not in a kiln but in an open hearth with branches laid over the pots, a process that produced ordinary earthenware, but in China we have the early report of six kilns for the site of Banpo on a tributary of the West River.[20] Heating technology was clearly well developed in the late Neolithic, leading on to the high-heat methods required for stoneware and later for cast iron.



Map 13 China

The attainment of high heat was an important technique which was to move westwards only very much later. The world's first glazed stonewares, 'primitive porcelain', were made by this means in southern China 'sometime in the middle Shang dynasty',[21] but they of course changed greatly under the

Han. Some help in their manufacture came from using clays that were lower in iron oxides. The south was on a geologically distinct plate and differed from the north, which gave clays suitable for stoneware utilising the abundance of relatively refractory material. Nevertheless potters took a long time, some 7,000 years, to develop their kiln technology that was only able to produce true high-fired stoneware in about 1500 BCE. That high-fired pottery was originally confined to the south for a variety of reasons, including the nature of the clay which could produce stoneware and porcelain, hard vitrified wares which had to be fired above 1200 degrees Celsius, and porcelain itself at a yet higher temperature. From the time of the Shang, white clay (kaolin or 'China clay') was used, though porcelain proper only appeared in the Tang. Significantly in some settlements bronze-casting took place in the same areas as ceramic manufacture, so there was interaction between the two activities.[22] In China, the moulding of metals was often done by using piece-moulds that came from the decoration of pottery.[23] Although China arrived late on the metallurgical scene, its forges exploited many techniques and developed with high-heat pottery. Cast iron, which required this heat, seems to have developed in the south, with wrought iron coming in the north.[24]

The Longshan Neolithic cultures situated in Shandong had already produced the black, high-fired, wheel-made, eggshell pottery. Chang writes of the new type of Neolithic culture in Shandong that exhibited several remarkable characteristics which included pottery that was 'thin, hard, lustrous and black', dramatically different from the painted sherds in Yangshao; the Black Pottery culture, which had connections with and developed into the Shang, the first historical dynasty, included the oracle bones that were so important for signs of early Chinese writing. This Neolithic society dates from a period (around 3000 BCE) when there is already evidence of an elaborate agriculture with sacrifice, rice, peanuts (American), and the breeding of water buffalo, pig, dog and sheep.

The earlier Shang were already metal-users on a considerable scale and had a written tradition dating from the mid sixteenth to the eleventh century. Writing was preceded by pottery marks as well as those on small bronze plates.[25] Shang culture also featured what are presumably royal tombs full of elaborate bronze vessels, as well as war chariots of what appear to be a Caucasian type.[26] These vehicles are found in royal graves from the period around 1250 BCE together with many bronze vessels, as at Anyang. However there were forerunners in metal-working. Significantly, in the very north of China, there is evidence of bronze-casting dating from 2150–1750 BCE.

The third and second millennia saw increasing warfare, the creation of complex urban settlements, and then the casting of bronze. This may have been preceded by a Chalcolithic Age, but a number of sites have yielded primitive tools of both copper and bronze that suggests otherwise. Although the smelting of metals was influenced by western developments, it was soon adapted to the high-heat ceramic technology of earlier times. Chinese bronze-casting represents the reconstruction of forms based on Neolithic crafts. According to Barnard ‘foundry practise in China was a direct offspring of a pottery culture . . . Not only does there exist a strong identity between pottery-culture kilns and the furnaces of the bronze age, but one may see the carrying-over of many techniques.’[27] It became of course a much more complex process, involving a large-scale, labour-intensive chain of production, with ore-miners, fuel gatherers, ceramicists and foundry workers. Bronze was also expensive and under the Shang used mainly by the court for ritual purposes, with some examples of great size.[28] That situation was to change with iron, which was used more widely. High-heat stoneware or porcelain production demanded the kind of temperature that would melt iron as well as copper, so that cast iron was made soon after the metal was introduced, although originally it was wrought iron that first came from the west. This development meant that the peaceful use of iron was more widespread, especially for agriculture, implements being made more cheaply by the casting process.

So that even in the Bronze Age China’s technological history was markedly different both from India and the west. While bronze began to be made in North India around 3000 BCE, it only started in the far west of China in the late third millennium under strong influence from steppe cultures such as the Seima–Turbino.[29] The ‘steppe bridge’ had opened up about 2000 BCE when people of the region became relatively unified with the adoption of similar livelihoods, similar ceramics and similar weapons in an area that Chernykh (1992) calls the Eurasian Metallurgical Province with developments of the Srubnaya and Andronovo cultures.[30] These developments involved weapons, chariots, bronze, weapon types and fabrics, and arose because the Neolithic cultures of Iran, dating from 5500 BCE, probably introduced domesticated sheep which used the otherwise valueless steppe grass to produce a number of valuable products. The hordes of sheep that developed there in the mid third millennium could be more effectively herded by riders on horses. The first evidence of domesticated horses comes from the important Dereivka settlement about 4000 BCE where the skeletons of the animals show evidence of bit wear preceding the invention of the wheel, but later they assisted not only herding but in providing the means of bulk transport by carts needed to fully open up the steppes, and so freeing mankind from the river valleys.[31] The earliest wheeled vehicles appeared west of the Caspian in about 2900 BCE in the Yamnaya (Pit Grave) culture on the lower Dnieper with its iron objects and extensive bronze. Wagons and two-wheeled carts are found around 3300 to 2100 BCE in Mesopotamia, Hungary and Poland as well as in the steppes. These vehicles obviously facilitated long-distance migration, which seems to show up in the distribution of the Indo-European languages that we have mentioned.

There seems little doubt that metal-working itself came to China from the Anatolian/Iranian area by the Northern or, possibly and, by the Central Asiatic roads.[32] The transmission from Iran to India was earlier. Chernykh's groundbreaking text on early metallurgy in the USSR[33] is especially important as well as the discovery of the metal-using and mining sites east of the Urals; when they are seen from a Russian perspective they change the relation between Europe and Asia. The importance of this corridor was noted by Chang[34] in relation to the influence upon the Neolithic in Mongolia. Such reports emphasise the contacts between the cultures of the eastern Eurasian steppe and those of China, providing evidence of the beginning of metallurgy in this part of the world. Those contacts serve to take the focus away from the Central Plain of China and point to links in Eurasia which is joined together not only by the absence of barriers but by the presence of similar types of artefact. The appearance of wheeled transport, metallurgy and the use and breeding of horses[35] demonstrated that a movement of ideas and of significant social change had taken place across the whole area. This transmission took place from the early to middle second millennium BCE, the period posited for the move of *centum* Indo-European speakers (Tocharian) into the Tarim Basin, part of the eastward spread of those languages.[36] The bronze culture of the Tarim Basin was already linked to that of the west.[37] In addition the physical remains of its people resemble Mediterranean rather than Mongolian types. Here the movement of peoples does seem to be connected to changes in culture.[38]

Bronze was very rarely found in the Longshan walled settlements of the Central Plains, and only came into its own at Xia sites like Erlitou in the third period of occupation when the first piece-mould wine flasks were cast.[39] China developed a metal technology there early in the second millennium as the result of these contacts, but rather than a one-sided matter, this cultural transmission was a process of interaction together with local creation. The movement in the other direction, westwards, mostly occurred much later. Needham speculates about its later influence on the technological advances of Europe in the late thirteenth and fourteenth centuries CE, such as for gunpowder, the blast furnace, block-printing, a form of bridge-building and even the mechanised clock, which first appeared in Europe during the second half of the thirteenth century although the European version depended on utilising the energy in a coiled spring, the gradual release of which gave the characteristic tick-tock sound. All this later interaction coincided with the Pax Tartarica, established by the Mongol empire, when 'merchants could range unhindered from Carcassonne to Cambaluc'[40] and when the Eurasian corridor became very open.

Bronze was also used at Sanxingdui in Sichuan (c. 1600–1000 BCE) where the artefact types are very different from those discovered at Anyang, a late Shang royal centre, in the Zhongyuan regime of the Central Plains of the Yellow River Valley (the Hwang Ho). There they were associated with royalty, often for ritual, and were largely found in burials, whereas in Sichuan they appear in sacrificial pits. But the technique of bronze-casting followed that of Anyang, especially in the use of the section-moulds, common in pottery, and first found at Erlitou dating from about 1500 BCE. There are Shang sites which even seem to have antedated the Anyang period, occurring before 1400 BCE; and there are bronze-casting sites and fine bronzes which have been found at Zhengzhou. These two main centres are far apart, but the trade in metals extended widely, both for considerable distances along the Yangtze River and also reaching from the far north to the south, some of the metal in Sanxingdui even coming from Yunnan.[41] But later, with the enlargement of the sphere of Shang influence, trade increased and copper and tin became available from an even wider area. However, influences on production came perhaps from even further afield. Indeed the finds at nearby Moutuo on the upper Min River made in 1992 show that Sichuan was in touch with distant cultures, that is, with the world of the steppes. The Shang bronzes display some similarities with Central Asian metal works but it is only in the Anyang phase of the fifteenth century BCE that we find a symbiosis between these forms and an indigenous Chinese development, reflecting relations between the settler population and the northern nomads. Indeed the former have always found it difficult to acknowledge the contribution of ‘barbarians’.[42]

As in the Near East and India, there was little metal in the river valleys where the city civilisations began. Bronze had to be shipped into the Yellow River valley. There is still a copper mine at Tonglüshan in Hubei and a bronze foundry at Houma in Shanxi, sources that may have been used at that time. The most powerful states of the period were blessed with rich copper deposits within relatively easy reach,[43] in the Zhongtiao Mountains for Jin and along the Huai and Han Rivers for Zhou. But until iron took over, the peasantry were little affected by the use of the metal; in Western China agricultural implements remained basically of wood and stone, and it was mainly some weapons and prestige objects that were cast in bronze. However, bronze was used for casting axle bushings for carts and for some high-status agricultural tools.[44]

Recent excavations have shown that iron-smelting first came to China from the north. Iron seems to have been brought to Siberia by the Scythians, perhaps as early as the eighth century BCE. Wrought iron came over what is now the border of Xinjiang and Mongolia and dates from the later fifth century BCE. This iron technology may have come from them as early as the eighth or seventh century BCE. It has been found in Xinjiang that had at that time little contact with the Central Plain. In the north this was first used in conjunction with bronze for luxury products. The south of China had imported bronze-casting from the north and used it to manufacture not simply ritual but agricultural tools, especially under the Wu regime. But bronze was expensive and hard to come by so they developed iron implements for the latter, which was made much easier by the use of casting. Wagner[45] has suggested that in Wu the employment of larger copper-type furnaces led directly to working in iron. In these furnaces a flux helped reduce the melting point of the silicon gangue in the copper core. In this process the iron from the flux was normally in a way that could lead to the production of metallic iron and hence to the development of the blast furnace. Bloomery iron on the other hand had been introduced from the north and the first casting involved the carbonisation and smelting of the metal in a cupola-type furnace, used for making bronze. It was this model that was present.

Before the fifth century all the smelted iron is thought to have been made by the solid-state bloomery process.[46] In the first century BCE under the Han an indirect form of wrought iron began to be made from cast iron. The spread of smelting techniques for iron had reached India by the end of the second millennium and possibly China by the beginning of the first.

This probably emerged as a major industry for tool-making as early as the sixth century BCE, though the material was not widely used until the fifth.[47] By then both cast iron (pig-iron) and wrought iron had appeared. Bronze was still used for some weapons although in the north very little for agriculture. In the south some metal tools were then made of bronze but cast iron soon took over. The illustrations of these implements that appear in Chang[48] and in Bernard[49] show a considerable development, a whole array that only appeared in Europe in such quantities at a much later date. Iron was also employed for cauldrons and in the fifth century for weapons too, even some of wrought iron. From then on, there were substantial developments. A blast furnace is recorded for 91 BCE and steel was made in crucibles, as in India. There is the possibility that the Turks or some other Central Asian people developed combined steel and iron sword-blades and that this technique then diffused both east to China and especially to Japan and also west to northern Europe, to the Vikings and the Franks.[50] The swords that appear in the late Zhou resemble the Hallstatt types in Europe and may indicate some measure of diffusion.[51] The Chinese also developed the sabre or broadsword (the *dao*), which was single-edged but hardly curved. The curved sword was introduced to India in the thirteenth century by invading Muslims.

Iron-smelting in a blast furnace produced liquid metal (cast iron); for wrought iron an indirect process using a finery may have been employed. The blast furnace seems to have come to Europe from the Near East, for the co-fusion methods of steel-making which uses cast and wrought iron was found in Iran from the tenth century, the cast iron presumably coming from such furnaces. High-carbon steel was being produced in the eastern Iranian region from the tenth century CE. In China what they called *bin* iron was imported from the sixth and seventh centuries, the subsequent gap to the tenth century being possibly due to the eruption of Islam. But by then steel was produced at Merv by co-fusion, a Chinese invention. For steel had been imported, probably from India for it seems to have been the same as *wootz*, which was produced by the cementation of wrought iron in small crucibles at very high temperatures.[52] That seems to be connected with the 'watered steel' blades of Persia, known as Damascus or damascened steel. This is a subject, as Wagner maintains, of great complexity for 'watered steel' is not the same as 'pattern-moulded' that was formed by forge-welding irons of different compositions.

Though metal-working itself, and even iron, came from the Near East over the Eurasian plateau, China had nevertheless a very different history of metals. Two major western-language studies have appeared on metals in ancient China, Barnard on bronze[53] and Needham on iron[54] (together with that of Wagner[55]). Barnard summarises their common conclusion as:

'(1) The presence in certain regions of iron ores high in phosphorus, or minerals containing it which could be added to the charge.
(2) The availability (and discovery) of good refractory clays, whether for blast-furnace or crucible processes.
(3) The use of coal, at least from the +4th century onwards, perhaps long before, which permitted attainment of high temperatures in the large piles surrounding crucibles. At the same time these would exclude sulphur.
(4) The invention of the double-acting piston-bellows (perhaps in the –4th century, more probably by the +3rd), enabling a strong continuous blast to be employed.
(5) The application of water-power to metallurgical bellows as early as the +lst century, greatly strengthening the blast and saving labour.'[56]

The use of water-power is interesting because the oldest mills in China, possibly invented by 31 CE, were not for grinding cereals but for operating blowing-engines in iron-works.[57] Wagner puts these earlier and writes of large-scale water-mills that began to appear in the third to fourth centuries, but for grain, testifying to the shift from millet (for porridge) to wheat (for flour, for noodles etc.). As a result of the An Lushan rebellion against the Tang, led by a general of Sogdian descent, there was a shift of population from the northern millet- to the southern rice-growing region. Commerce boomed again, especially along the Yangtzi River and at Yangzhou, which developed as a market, above all in metals and salt. There was also an advantage obtained through the phosphorous ores that existed in some parts,[58] as well as the refractory clays for the furnace, the early use of coal (which happened first for metallurgy during the Han),[59] and the employment of the bellows as well as of water-power. The double-acting, single-cylinder, piston bellows is characteristically Chinese, but the double-cylinder variety itself is found all over South East Asia;[60] this gave a powerful and continuous blast to furnaces, so that iron could be readily melted. Coal was only used for smelting there (as distinct from baking-moulds) by the later first millennium BCE. From this time massive castings could be made, as for the suspension bridge across the Yellow River in 720 CE.[61]

On the basis of present evidence it seems that iron-making first appeared in northern China, coming from non-Chinese nomads living beyond the Zhou Empire. If so, it came with the bloomery process, in which a small-scale hearth or shaft-furnace produces wrought iron in the solid state at temperatures around 1200–1300 degrees Celsius. But the operator does not have perfect control of the process so that it is quite possible to produce steel or even cast iron in this way. Cast iron is however useless to a smith, whose existence is based on the hammering of solid, wrought iron.[62] In China wrought iron was already known by the eighth century BCE and was thought to have come through Scythian peoples; however the earliest date for Scythian iron east of the Urals is the seventh century. But the use of the metal may have come to Xinyang from the Chust culture of the Ferghana valley in modern Uzbekistan where we find iron from the beginning of the first millennium BCE.

The Scythians may indeed have transmitted early iron directly to Korea at about the same time. For there is a link to early bloomeries in Japan, ancestors of the *tatara* furnace. Chinese bronze artisans however did not use smithying techniques according to Barnard, but Wagner is dubious on this topic;[63] moreover hot forging would have been useless in shaping bronze which it makes brittle but is essential for making sharp edges from iron, especially of the meteoric variety.

The earliest artefacts of smelted iron from China are from the royal tombs of Guo, a minor state, in Henan in the ninth–eighth centuries BCE (the period of Western Zhou). Bloomery iron-making seems to have come from Iran in the north and the first iron-casting involved the carburisation and smelting of iron blooms in a cupola furnace of the sort used for melting bronze. This is described in a German manuscript of 1454, and ‘it is possible that iron-casting began in Europe in this way’.[64] Along with the blast furnace, cast iron seems first to have been employed in the south of China, possibly in the ancient state of Chu where the widespread use of iron developed in the early fourth century. The bronze-casting techniques of the north were taken over by the 'barbarian' Wu and applied to new uses 'in particular the production of agricultural implements'.[65] Bronze was costly for this purpose, being rare in that region, so a new metal was found, though this development may have occurred in Chu rather than in Wu.

The blast furnace that emerged in China, together with fining, produces cast iron with c. 4 per cent carbon and this can be used in a foundry. But if it is to be converted into wrought iron for smithying having about 0.1 per cent carbon, this has to be done by fining or by puddling, as for steel with a lower per cent carbon. The puddling process, developed in Britain in 1784, led to the Bessemer convertor of 1835 and then more efficient devices. This whole 'indirect' process provides large economies of scale which has had important consequences, being one of the factors behind the rise of metal-using in the west[66] and possibly the rise of the Qin in China in the third century BCE.[67]

Cast iron was brittle but cheaper than bronze, little use for weapons but useful for tools. In the west there was no important use before the cannon. In the east there was the development of the finery to decarbonise the iron to make wrought, so the bloomery became uncompetitive because production through the blast furnace was much more efficient. The brittleness was overcome by the invention of malleable cast iron. Cast iron can be made more 'malleable' by heat treatment (annealing), a process that in Europe was patented by Prince Rupert in 1670. But it was already known in China in the third century BCE.[68] Under the Qin the expansion of agriculture was certainly related to the use of cast iron; some have also maintained that the rise of the Qin itself was also linked to the superiority of its iron, both in agriculture and in weaponry.

In the third century BCE the production of iron in large-scale iron works led to the rise of what Needham has called 'primitive capitalists' or industrialists, anyhow of money-men who established enterprises requiring a significant amount of capital. The state was always wary of such men but appreciated their ability to create goods and work, especially by employing free labour. These iron-works were very like the 'iron plantations' of eighteenth-century America or the *jörnbruk* of southern Sweden;[69] they formed largely self-sufficient communities at the centre of large tracts of forest. Under the Qin, industrialists were even moved into such areas to establish ironworks and employ labour. By the third century BCE iron was mass-produced on a very large scale, so that many peasants were using instruments of cast iron.

The archaeologist, K. C. Chang, gives the reasons for this situation and explains that the 'Chinese artisans of the seventh century BC possessed great skill in the casting of intricate bronze objects and were able to fire pottery at high temperatures . . . The initial production of cast iron was reinforced by the invention of double-cylinder bellows with reciprocating motion (fourth century BC), the double-acting (push–pull) cylinder bellows (second century BC), and the application of water-power to these bellows in the first century AD. A reinforcing result . . . is the fact that the rendering of cast iron from ore allows for the mass-production of the full range of alloys at a highly efficient rate. Thus iron became the metal of the Chinese peasantry and found its early and large-scale use in the fashioning of agricultural implements.'[70] This peasant use was a 'highly significant event in Chinese economic history'.[71] The implements produced included axes, adzes, chisels, spades, sickles and hoes, but the plough was 'relatively rare' and did not replace the spade and hoe.[72] We find ploughs from the Warring States period but they would probably have been incapable of turning over the soil to any depth. Deep ploughing with cattle came only in the middle of the Western Han. This was an important development and Guo Moruo (Kuo Mo-Jo), who long studied the problem, thought that 'the gradual introduction of deeper ploughing with iron ploughshares was one of the most important factors which led to the decline of slave-owning society and the transition to feudalism, a turning-point being the land reforms of Shang Yang in –350'.[73] At that time, irrigation techniques and intensive farming became increasingly elaborate, especially during the Eastern Zhou, but that mode of cultivation often did not involve the use of the plough.

All this production raised the question of fuel; wood and charcoal were often in short supply. Coal came to be widely used in Hebei in the eleventh century for both iron and for ceramics. This was a frontier area and the Chinese government was keen to keep iron production under control because of its primary use for weaponry and hence to avoid it being smuggled to the Liao Empire to the north. Of course, peasants also had 'a wide range of iron tools . . . including ploughshares, hoes, spades, barrows, knives, nails and pots'[74] but even here the distribution was controlled. The use of coal rather than charcoal for large-scale production raised certain difficulties that for some time hindered its industrial use. Wood produces a reductive atmosphere that gives porcelain a hint of greenish colour, and only a little ash that would otherwise stain the white. Coal produces shorter flames at lower temperature but creates more ash; the oxidised atmosphere tends to make for yellowish porcelain, with sulphur staining the surface and lowering the quality of the iron products.[75] The shift from firewood to coal also required a variety of technical innovations in the structure of kilns, in the process of firing and in the management of the products, as well as considerable capital for new tools and kilns.

Presumably because of its military role but also to raise taxes, the iron industry was subject to heavy state intervention but it reached a high level of sophistication by the late Warring States period when cast iron was produced in blast furnaces. An iron monopoly was established in c. 119 BCE by the centralised Han dynasty. There were no small bloomery furnaces as in the west but foundries existed in which 'raw iron was either cast into tools and weapons in a cupola furnace or converted into wrought iron in a fining hearth', a process that gave stronger products.[76] While cast iron could not be used for all purposes, it could make cheap tools and in Hebei peasants used 'a wide range', especially ploughshares, hoes, spades, barrows, knives, nails and pots.[77] But military uses were kept more tightly under control.

It is possible that the small cupola furnaces found in Guangzhou were similar to that used by itinerant iron-workers ('Gypsies') in eighteenth-century Rome and may possibly have been brought to Europe at that time.[78] Superficially this resembled a small blast furnace; fuel and iron are charged into the top, a blast of air is blown in down one or more tuyères near the bottom and molten iron is tapped through a hole.

Further to the east, iron took on a more specialised role. The Japanese sword-smiths, making the samurai weapons, were highly prized in the country, although the techniques that they developed came from China. The low-carbon iron core of the blade was brought in contact with pieces of high-carbon steel and hammered together, giving maximum hardness to the cutting edge and low enough carbon in the core to provide toughness. Medieval swords in Europe, like the heavier ones of the Viking period, were also made with layers of much higher-carbon content in the blade and lower-carbon material at the core. Sabres with curved blades were made from crucible steel from India, at once ductile and malleable. A recent study of the Japanese version begins, '[t]he Japanese sword is probably the deadliest cutting weapon developed by man. Razor-sharp and almost unbreakable, it can literally cut a man in half'.[79] In Shinto and in Buddhist thought they also had a strong religious meaning. '*Kendō*' (the Way of The Sword) was the spiritual study of sword-fighting which aimed beyond victory in combat towards the ultimate understanding of Zen Buddhism. Swords were of special interest to many Taoist alchemists.[80] The sword is thus considered an implement of enlightenment and, as such, it sometimes has Buddhist inscriptions or deities carved onto the blade; 'Some swords were even venerated in shrines as the very manifestation of the Shinto deity.' In addition the swords were prized both for the beauty of their shape and for the metal itself which was very carefully polished by specialists. The blade was formed by heating and folding a steel billet to form a laminate, the grain of which was brought out by the polishing. The hues and patterns were described by terms such as 'drifting sand', which referred to the role played by the nature deities, the Shinto *kami*, in the furnace. The curved sword of the samurai was perfected during the Heian period (794–1185 CE) and continued to be important until the mainly peaceful reign of the Tokugawa dynasty led to its becoming more a sign of authority.

Chinese developments included the fan- or piston-blowing furnace that was used early on to create higher heat, together with forms of mass-production, demanding certain organisational techniques such as we only find in Europe at the end of the eighteenth century in the context of military equipment. The development of blast furnaces produced the molten metal that was needed for the mass-production of cast iron implements. With all the farming instruments, and the rarity of animals for traction, at least in the more fertile south, China did not make great use of the plough at this time. That in any case was less important for the form of intensive agriculture in the tropical part of the country. Although blast furnaces and the production of cast iron existed in China over a long period, the technological development of iron-working seems to stop with the Ming (1368–1644), whereas in Europe the furnaces gradually got larger especially with mass-production for military uses. That continent recovered from its backward position and went on to conquer the world following a series of inventions in the field.

The different history of Chinese metallurgy is related to the earlier use of heat for ceramics. The critical aspect of metal work there was that it was 'a direct offspring of pottery culture'.[81] The Chinese had succeeded long before others in high-firing pottery to make stoneware and porcelain, 'China' as it was called in English. Stoneware was made in Germany in the fourteenth century according to Finlay[82] but had little circulation. Porcelain, so-called after Marco Polo's description, was a translucent, vitrified form first made during the Tang (618–907 CE) and fired at a high temperature. It was a variety of the stoneware made as early as 1400 BCE during the Shang dynasty, and was usually opaque. Porcelain itself was a major export to the rest of the world, which had had its own earthenware pottery since the Neolithic but it was of a relatively simple kind. Fragments of this more developed export pottery have been found at Basra dating from the tenth century,[83] sherds litter the beaches of East Africa, and in America they are scattered round Jefferson's house in Virginia. In time the high value of these exports led after many experiments to imitations in Europe and the Near East. There were also other developments. The Near East saw the rediscovery of tin-glaze that the Assyrians had already known about. In using this ware they were going against Islamic sumptuary prohibitions. Nevertheless Chinese pottery greatly influenced the area, especially the south, which in turn influenced Europe. A revival of tin-glaze (including Tustse-ware) took place in Andalucia and led to the creation of majolica, which the Italians thought came from the Balearic island of Majorca, hence its name; in fact it came from Islamic Spain in the thirteenth century and was taken up in Delft in Holland. Other European countries too were affected by this pottery. But porcelain proper was only made there in 1708 in Saxony with the assistance of an alchemist; that was followed by Sèvres in 1745 and later in England where bone ash was used in 1800.

China had already had an important influence on the Near East, for in 800 CE Harun al-Rashid had been presented with Tang pottery incorporating figurative designs; such designs became permissible, especially in Persia, except for mosques. It was in the Tang that true porcelain was made at a temperature of 1454 degrees Celsius. In between 750 and 1000 CE, profound changes took place in the structure of society and there was 'the emergence of an identifiable urban class with its own culture'.[84] This has been described by a Japanese scholar as an Oriental Renaissance; printing, gunpowder and the compass were important in the renaissances both in the east and in the west, and it was the Song that developed the use of mineral fuel, of water-power and methods of steel-making. The demand for better guns did not come until the Yuan; for this purpose bronze was preferred, but economic factors pushed towards the improvement of cast iron to use for this purpose. The achievement of the earliest Chinese artillery is represented by a gun in

Woolwich Rotunda Museum dated 1338.[85]

Islam discovered how to produce soft porcelain by the twelfth century and stoneware was made in Germany by the sixteenth (and in England by the eighteenth), no doubt due to improvement in the kilns. But porcelain proper, made with the aid of special 'China clay', had to wait until the end of the seventeenth century when it was produced in St Cloud near Paris. In England its eventual manufacture has been seen as leading the 'revolution' in modern consumer culture, even adopting the Chinese willow pattern for household use. But the point about consumption could have already been argued for Roman *sigillata* tableware, which was widely used and exported. However, the import of porcelain had been a key part of the 'chinoiserie' that swept Britain in the eighteenth century. The significance of the process was much greater than that term suggests, both from the standpoint of the Chinese export industry and for the developing consumerism of the west. In addition to this everyday pottery, there was also a flourishing 'art market' in China, with the production of precious objects, of delicately shaped and finely glazed vases not just for the Imperial court but also for wealthy collectors. Their conscious aestheticism took a written form and ran parallel to that of the west in the post-classical period. This explicit appreciation of ceramics 'began' in the eighth century CE, with the rise of tea culture with all its specialised utensils.[86] On the other hand large quantities of everyday household ware were produced by methods that the art historian, Ledderose, defines as quasi-industrial in that their manufacture involved the precise division of tasks that Adam Smith describes for modern 'capitalist' production.[87] His thesis covers the production of large-scale products such as dressed stone tablets for inscribing the vast repertory of Buddhist scriptures at Yunju Monastery in Hebei, a remarkable project that spanned several centuries. That China went in for a type of mass-production can also be seen from the extent of the export trade, not of course for the 'art market', as witness the number of pieces which have been salvaged from sunken ships in the China seas, transporting these goods for sale in Europe and in the Near East. This porcelain was a unique product that diffused widely around the world and supported the Chinese economy. The application of heat to metals did the same for the export trade, both of bronze vessels and of money ('cash') to South East Asia but elsewhere this trade never attained the same level. While cast iron utensils dominated the internal market, they were never a central factor in exports, as they became so much later in the west, except for the neighbouring countries. This was perhaps because the internal market in China alone was already so large, since it had become a huge and relatively centralised country under the Chin (221–207 BCE), a single unit with many spoken languages but one script, one written culture and one bureaucracy.

The question of metals raises the interesting one of the similarities and differences with the Near East. This problem was not discussed in Childe's book. It is true that he is mainly concerned with Mesopotamia, and only residually with India, but he calls his account a general history and yet gives little consideration either to China or, in a different perspective, to Middle and South America. He was still caught up in the nineteenth-century concentration upon Europe's, even upon England's, own position, especially in the production of metal goods. At this time, it was this continent, indeed this country, that was in the ascendant and looked back to the Near East in a 'Eurocentric' way. This view was especially associated with Marx and Weber who saw 'capitalism' as originating in the west and in this they were by no means alone. It was this same approach that led Childe to play down developments in the east, and in doing so he overlooked the very crucial differences in the use of metals that marked the histories of China and the west, including India and the Near East. Often mistakenly thought of in terms of 'oriental despotism', China must have been very different from that if Childe's view of the 'democratic' implications of iron technology are at all correct, particularly about its access by the peasantry. The production of the metal was certainly more prevalent in those parts, as iron could be melted and cast. The development of a wide range of iron tools for agricultural use, including of course the wheelbarrow, shows not only the inventiveness of the east, but also the high level of farming it produced.

So the differences with the Near East were important. Firstly, the alluvial valley where the urban civilisation first appeared in China, the valley of the Yellow River, was less separated from supplies of metal and wood than those in the Near East, Egypt or India. Copper was to be found in many parts of the country, unified under the Chin and the Han – and frequently thereafter – while the loess surroundings of the valley were by no means a desert as was the case elsewhere. So the metals did not require quite the same long search by land and sea in the west; China was in fact a large, multi-ethnic 'culture', partly held together by the common logographic script which meant that this writing, unlike an alphabet, could be read by the different language-users without the necessity of translation. The extent of the ensuing 'cultural' network provided the opportunity to find materials within the area of 'civilisation' instead of having to look outside. It also offered a large internal 'market' for mass-produced goods.

Later on cast iron was even used as a construction material in the building of pagodas, long before it was employed for skyscrapers in the west. The oldest pagoda still standing today dates from 1061 CE and has thirteen stories. There were reportedly iron-chain suspension bridges in the Tibetan area from the sixth century, whereas in Europe similar bridges were used only 1,000 years later. Cast iron was also employed for making statues for religious purposes as well as for large bells in Buddhist monasteries. A big iron structure such as the Celestial Axis of 695 CE used some 1,325 tons. But since the third century BCE it was mainly small iron-works scattered throughout the region that produced ploughshares and agricultural tools. Iron was also needed for other domestic products, such as wire and machinery (mills), as well as in the important ship-building industry, for transport as well as for military use.

So metal technology was well advanced in China in the early years of our era, partly because of the previous development of the high-heat firing of pottery to create stoneware and later for making the highly complicated bronze objects that have been found in the royal tombs of the Shang. These products were created not through the lost wax procedure used in the west but rather by employing sectional-moulds as in pottery, which could in principle be reused. High-fired pottery in the form of porcelain was not made in Europe (except 'accidentally') until it was produced in Meissen in Germany, by Spode and Wedgwood in Staffordshire,[88] in Sèvres in France and in Delft in Holland. Like cast iron it was not made in mass in Europe until the Industrial Revolution when it was associated with large-scale production. In the east the earlier growth of such an industry had meant the expansion both of consumers and of manufacturers. In the third century BCE the production of steel already involved a group of 'primitive capitalists or industrialists who succeeded in amassing great wealth by the pursuit of production almost on a factory scale';[89] the distribution of their products was widespread. So there was nothing small-scale or 'petty' about this 'capitalism'. Several of these men arose to positions of great importance in national life through their control of iron. Production involved individual industrialists but at other times iron was 'nationalised' and produced under government auspices.[90] As the metal was used so widely it was impossible to control. Moreover, there was always some conflict between trading and national interests. In about 130 BCE their production techniques were spread by deserters to Ferghana and to Parthia. From the mid Ming, the industrial town of Foshan, near Guangzhou, received pig-iron from large blast furnaces in the hills, its products to be sent far and wide, some as wrought iron, to South East Asia, although the latter was a prohibited export under the early Qing.[91] The local metal industry in China, as everywhere, declined with the import of cheaper iron from nineteenth-century Europe, when the process was opened up; wrought iron was also traded from there to Japan, again leading to the loss of mining jobs.[92]

The material presented here and earlier leads us to ask whether there are any general characteristics associated with early Iron Age societies. At the very beginning I touched upon the question of specialist work. But Childe also notes that cheap iron tools reduced the dependence of the small producer on great households; these tools were cheaper and more widespread in the east than in the west. He describes the role of iron in the west in the following words: 'Cheap iron democratized agriculture and industry and warfare too. Any peasant could afford an iron axe to clear fresh land for himself and iron ploughshares wherewith to break up stony ground. The common artisan could own a kit of metal tools that made him independent of the households of kings, gods, or nobles.'[93] But there wrought iron was still rather expensive, and that independence came at a price. If he could afford it, the small farmer gained increased independence in breaking new ground, in cutting down trees and in digging drainage channels. For the greater rainfall of the north, so useful in agriculture, for water-power for mills and in the production of metals, also meant that paths and fields sometimes became lakes; at certain times of the year mud and water were problems for transport, for agriculture and in the mines. That situation pushed some to develop appropriate instruments or machines for controlling the water, as we see in Hellenistic times, in the Renaissance and in the lead-up to the Industrial Revolution. Development of these solutions was slow, slower in earlier times, but problem-solving was a characteristic of all hominids, especially with language use.

Regarding other social implications, Childe sees the Iron Age as associated both with democracy and with monotheism. However these features were at least pre-figured in earlier societies. Despite Europe's claim to uniqueness in this respect, democracy, the consultation of the people, existed in many a small-scale Neolithic and hunting-and-gathering community, as recently in Africa and Australia. The idea that time has seen a growth in 'democracy', beginning with the Greeks, seems to me to be misleading, except in terms of representative democracies with writing and the vote. Not only did many tribal societies have extensive consultation, but in more complex ones, more complex than a city-state, the development of 'representation' was called for, since a growth in size requires some such mechanism. Nevertheless the people have often been consulted at varying intervals, and in varying ways, though the growth of monarchy has also seen the development of authoritarianism, even of tyranny. A single authority of this kind can become out of control but it may be deemed necessary in certain circumstances, especially war.

Democracy had become more difficult with the concentration of wealth, especially of metals, in the royal arsenals of the Bronze Age.[94] But the Iron Age revived the possibility. It encouraged more 'democratic' tendencies than bronze, since the metal was found everywhere and was not therefore precious in most circumstances; it even often gave some individuals access both to weapons and to tools. Aristotle understood this wider participation in military affairs as being connected with democracy[95] and the Greek vote certainly had a link with service in the militia. So iron helped to make the Metal Age more 'democratic'. Other metals were rare, pricey, hard to find; they had to be searched for, often in strange lands, and they were hoarded by rulers, lay and priestly. Iron was not like that; obviously it had to be paid for, and in certain situations was a rare good. In Africa, for example, it was precious when extracted, although the ore was commonplace. However in earlier Bronze Age times at a local level consultation of the people was not excluded, even in some highly centralised regions.[96] Moreover, in the hills marginality often meant internal consultation. In Europe, before the Plague and the 'Black Death' of around 1350, there was a continual expansion of population clearing new territories; in the Cévennes, for example, areas were established as 'asiles de libertés', with democratic institutions attracting new settlement.[97] The result of this expansion was deforestation of the hills to obtain charcoal, leading to the development of the first coal mines in France, 'les trous de renard', appearing at Alès in 1240, which escaped the exactions of the feudal hierarchy that existed down in the plain.

Consultation was never perfect. The democracy of Iron Age Athens, for example, was confined to male citizens (the military), excluding women, metics and slaves. Indeed women tended to be less prominent than in the earlier Bronze Age,[98] especially with the coming of iron weaponry, plough agriculture and the 'world religions'. None of these favoured their participation. In a traditional Israeli synagogue I saw women confined to the gallery upstairs, as they were until recently at some College feasts in Cambridge, and in both cases the common factor was the Abrahamistic religion in which males assumed a special place in conducting the service to a male God, whether in Judaism, Christianity or in Islam, setting on one side the local cults often with more feminine characteristics, like the earth divinity itself. These Near Eastern religions were not the only ones to do this; in India written Hinduism with its Brahman priests stood out against the unwritten, local *matas*, often female, but these Judaic monotheisms, organised by male priests, were unique, hegemonic credos that fought to eliminate all other gods, intolerantly. Polytheism did not. It would be crass to link this phenomena with warrior rule in the mass-warfare of the Iron Age, but nevertheless both co-existed side-by-side, male supremacy in both religion and in war.

Monotheism, the worship of one God, necessarily comprised the idea of one creator, the High God. This latter notion is however common even in polytheistic religions in Africa and elsewhere, despite Abrahamistic views to the contrary. The acknowledgement of a creator god did not exclude the efficacy of others in their own spheres. That idea of the High God who created the world merged into monotheism for the deviant Egyptian Pharaoh, Akhenaten, but it was a feature of much Semitic belief.

While China was polytheistic, having a number of gods and spirits apart from what Buddhism produced, Confucianism itself was non-theistic. But it was to Confucianism that the tradition looked back, a written resource on which to draw as well as providing the basis for the examinations which were used for recruitment to the governing bureaucracy and to the literati. Confucian writings were 'hegemonic' in the sense that they existed as a written model but they were not of the transcendental variety that virtually excluded research into earthly matters. In other words it did not hold back enquiry in the way that the Abrahamic creeds did, at least for most of the time. In those God had provided the answers and was not to be queried; in China enquiry was more open.

There was certainly religious change in the Near East in the Iron Age.

Childe writes more generally of ‘the social ferment’ of this period ‘which began to dissolve the established ideologies’.[99] Indeed he sees the ‘ferment’ as part of the contribution that Greece made to intellectual advance in Antiquity, the stirring up of received ideas. I would understand this ferment as more specifically linked to changes in the means of communication – that is, in writing and its extension into other, non-bureaucratic, non-religious, fields, as well as to the increased search for metals and other goods in foreign lands and other cultures, and yet more generally to the greater speed of cultural change that literacy brings. But the economic aspects of the coming of metals, especially for war, were undoubtedly very important. Childe talks of ‘[c]heap iron tools and weapons’ although in the west it is not clear that iron was at first particularly cheap. The ore was more readily available but not the processed metal. The latter was always important in warfare even though the ore was no longer always much of a valuable. Power was acquired by the many, even including ‘barbarians’ like the Celts and Germans or those of Central Asia, the Scythians, the Huns, the Turks and the Mongols, who all became experienced iron-workers. But it was also critical to states like those of Greece and Rome with their large empires (or spheres of influence) established with the help of iron weapons, body armour and massive armies. They also profited from the more peaceful uses of metal for the plough, farm implements and for ships and carts, as well as in the mines and even in the building of temples where the stones were held together with iron rivets and decorated with carvings made with iron tools.

The production of iron was highly significant not only then but right down to the present day, being essential to most industrial work. Earlier the metal had contributed indirectly to some of the great achievements of the Greeks but more specifically to those of the Romans, as well as of the Indians and most strikingly of the Chinese. Some also see metal as being connected with the introduction of money, especially of the small change that facilitated local transactions. In making this claim they tend to over-emphasise the value of metal. For Africa and the Near East managed such exchanges perfectly well using shell-money, later using cowries imported from the Maldives, as others had long done with other valuables.

Looking at the Iron Age as a whole, the use of the metal soon spread to the ‘barbarians’, whether in Europe, Asia or even in Africa. It was not a rare commodity. Such ‘barbarians’ developed their weaponry, at least in Eurasia, and equipped forces that attacked the urban civilisations, the written cultures of the earlier Bronze Age. They attacked but they also developed, with the heavy plough, the heavy sword, and in metal work more generally, both in Germany and on the Asian steppe. Their ability to do this was always significant, for the great civilisations had little of their own by way of metals, deposits of which were usually found in the hills, and so had to be acquired from others, either by war or by trade. The trade in metals, precious as well as base, between Europe and the Near East (and hence with the rest of the 'civilised' world) got cut off, or greatly diminished, after the decline and fall of the western Roman Empire, partly due to the descent of those 'barbarian' forces, as well as to the advent of Islam and its conflicts with eastern Christianity. But commerce was subsequently renewed in the Middle Ages by the Italian States, a revival and development in which Venice played an especially prominent role. It is that slow process occurring in parts of Europe, and in particular the role metal played, leading to the Industrial Revolution, that concerns us in the rest of this book.

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1 Von Glahn ms: 37.

2 Mair 1998.

3 Von Glahn ms: 71.

4 Finlay 1988: 147.

5 Finlay 1988: 156.

6 Finlay 1988: 156.

7 Garthwaite 2005: 138.

8 Garthwaite 2005: 76.

9 Garthwaite 2005: 99.

10 Chang 1977: 193.

11 Chang 1977.

12 Beckwith 2010: 9.

13 See Anthony 1998.

14 Ashtor 1986: 78.

15 Ashtor 1986: 86.

16 Ray 2003: 120.

17 Ghosh 1992.

18 In Higham's excavations at Ban Non Wat, we find that the initial Iron Age burials contained glass,

carnelian, agate and of course, iron offerings (Higham, personal communication).

19 Zhimin 1998: 59.

20 Chang 1977: 100–1.

21 Kerr and Wood 2004: 134.

22 Kerr and Wood 2004: 9.

23 Tylecote 1992: 41. This method was also employed in Europe for *terra sigillata*.

24 Wagner 1999.

25 Chang 1977: 229.

26 Piggott 1974 and 1975.

27 Barnard 1961: 59.

28 The largest *ding* cooking vessel that has been found is 1.33m high and weighs 833kg. According to the three words cast into the body, it was made for king Zu Geng in order to offer sacrifices to his mother, emphasising the importance of the ancestors.

29 See Chernykh 1992: 190.

30 Anthony 1998: 94.

31 Chernykh 1992: 143.

32 Linduff and Mei 2009; Chernykh 1992.

33 Chernykh 1992.

34 Chang 1977: 193.

35 The early role of the horse, except for culinary purposes, has been treated in a valuable overview by Renfrew (1998).

36 Boltz 1999: 84.

37 Shui 1998: 115.

38 On the route of the Silk Road, running from the Tarim basin to Kashgar and Ferghana, then branching north to Samarkand, the Oxus, Merv, Iran and the Near East, see Kuzmina 1998: 63. He stresses the fundamental importance of the Eurasian steppeland as a zone of cultural communication from very early times.

39 Linduff and Mei 2009.

40 Needham 1964: 39.

41 Xu 2001: 33.

42 Chernykh 1992: 269.

43 Hsu 1999: 578.

44 Barbieri-Low 2007: 150.

45 Wagner 1993.

46 Craddock 1994: 888.

47 Chang 1977: 352.

48 Chang 1977: 354.

49 Barnard 1961.

[50] Needham 1964: 44.

[51] Tylecote 1992: 44.

[52] Wagner 2008: 270.

[53] Barnard 1961.

[54] Needham 1964.

[55] Wagner 1993.

[56] Barnard 1961: ix.

[57] Needham 1964: 18.

[58] But according to Wagner (2008: 307) this was a disadvantage in Europe until the introduction of the indirect process, from the east.

[59] Wagner 2008: 262.

[60] Needham 1964: 18.

[61] Craddock 1994: 889.

[62] Wagner 2008: 89.

[63] Wagner 2008: 90.

[64] Wagner 2008: 112.

[65] Wagner 2008: 107.

[66] Wagner 2008: 6.

[67] Wagner 2008: 6.

[68] Wagner 2008: 167.

[69] Wagner 2008: 145.

[70] Merwe 1969, quoted in Chang 1977: 355.

[71] Chang 1977: 355.

[72] Chang 1977: 355.

[73] Needham 1964: 2.

[74] Zhang 2008: 183.

[75] Zhang 2008: 188.

[76] Von Glahn ms: 12.

[77] Zhang 2008: 183.

[78] Wagner 2008: 11.

[79] Harris 2004: 24.

[80] Wagner 2008: 254–5.

[81] Barnard 1961: 59.

[82] Finlay 1988: 146.

[83] Whitehouse 1979.

[84] Twitchett 1968: 63, quoted in Wagner 2008: 278.

85 Wagner 2008: 292.

86 Needham 2004: 28–9.

87 Ledderose 2000.

88 McKenderick *et al*. 1982.

89 Needham 1964: 7.

90 Eberhard 1967.

91 Wagner 2008: 58.

92 Wagner 2008: 77.

93 Childe 1942: 191.

94 Childe 1942: 213.

95 Snodgrass 1980: 107.

96 Oppenheim 1964.

97 Ladurie 1969: 16–17.

98 Childe 1942: 216.

99 Childe 1942: 218.

9
Renewal in the west

The development of literacy in England seems to have been interrupted when the Roman army left the country, and Britain supposedly went back to an illiterate state. The movement of the written religions followed the trade routes and the conquests that had been made by the urban societies, especially that of Rome, whose rule penetrated right to the borders of Scotland, to the forests of Germany and to the Saharan fringes of North Africa, conquering the earlier 'oral' creeds and the 'barbarian' cultures that flourished there and helping to draw them into the state system. Christianity accompanied those conquests and the soldiers, like others, felt the need for supernatural support often beyond the traditional cults, and Judaism and other practices were caught up in this movement. The Romans, and to a limited extent the Greeks, had spread the knowledge of writing and of written cultures, alphabetic ones, and there was a significant level of personal as well as public literacy; from Hadrian's Wall there is considerable written evidence of the life of the soldiers stationed there, not to mention an account of the conquest of the country by Caesar as well as a mass of literature on law and other topics of 'higher knowledge'. All this came with the conquest.

However Christianity returned in the north with the Irish Columba, for religious literacy had continued there, and in Kent with the Roman Augustine, so the torch was taken up for its own purposes by the Christian Church as well as in a minor way by the Judaic religion. However it was literacy of a different kind, a 'restricted literacy'; these religions required it not to expand the secular uses, as in earlier Greece and Rome, in all their polytheistic contexts. Monotheism restricted its uses. However the more secular ones were not completely neglected; writing itself saw to that. But they played a very much lesser role than before. For the religious purposes were all-encompassing, all-consuming, while literacy provided the ability – at least to the priests, and in some cases to others – to read the words of God; the religious text, unlike most forms of secular knowledge, was unchanging, eternal. In these written monotheistic religions the emphasis was different from earlier ‘religions’ when the existence of a plurality of shrines made any one less monopolistic, less hegemonic. Of course earlier civilisations had supernatural beliefs, but theirs were not monotheistic, demanding unique adherence, like the Abrahamistic ones.[1] Monotheism meant that the aim of schools was to teach the word of God (in the yeshiva, the madrasa, or in the Cathedral), rarely to maintain or preserve the secular achievements of earlier societies, like those of Greece and Rome, as in the Academy or the Museum. Schooling was not there to open up new possibilities so much as to teach the unchanging word of God. The achievements of the Ancients were therefore not of great concern in the Middle Ages and in most contexts the religious took priority over the secular, sometimes even over the technical. Except for the very exceptional person, learning to read meant one learnt about God and the transcendental view of the universe – that is, until the Italian Renaissance and its equivalent in Islam and Judaism ‘looked back’ to the classics, reintroduced secular knowledge and went onwards to ‘modernity’.

Christianity offered just such a transcendental view of the world, often rejecting most of the secular achievements of earlier times, at least in the scientific and conceptual spheres. For Saint Augustine, curiosity was not a virtue: ‘when people study the operations of nature which lie beyond our grasp, when there is no advantage in knowing and the investigators simply desire knowledge for its own sake’.[2] There is more than a touch of his earlier Manichaeism here in the downgrading of the ‘natural’ in favour of the ‘spiritual’ universe.

But the later existence of various Judaic and Islamic communities on the periphery, in Spain, in Sicily, Greece and North Africa, threatened Christianity’s monopoly of ‘explanation’, proposing alternative creeds, albeit monotheistic ones, just as Christianity threatened theirs. Only one way could be right. Their nearby presence led to some modification of the exclusive control of learning by the Christian church, paving the way for a looking back to an alternative, more secular age in the Italian Renaissance. In relation to scientific knowledge, the Arabs had already experienced a rebirth, a Renaissance, of Greek and Roman learning, rejected at times in Byzantium, under the Abbasid dynasty of Baghdad in the eighth and ninth centuries.[3] This learning had been incorporated and extended in the Islamic world before that religion became increasingly ‘orthodox’ under the religious scholarship of the Sunnis.

The Near East itself never experienced the wholesale decline of society that followed the collapse of the western Roman Empire and its economy, the destructive advent of northern tribesmen, though it did have the religious wars. The towns did not disappear as they largely did in the west, and exchange with India and China continued. Indeed Islam built what was virtually a free-trade area stretching from Southern Spain to the borders of China, a single region not only for trade but also for information and discovery. This transmission was aided by the spread of paper from the east, and with it much information. So too the invention of gunpowder and of the compass, both essential, as Bacon pointed out, for the western Age of Discovery, and subsequently, together with the creation and exploitation of cheap metals, for the invasion of the rest of the world.

However, as we have seen, trade in the western Mediterranean did decline in the post-Roman period, for whatever reason. But with Europe it gradually revived, partly along the Russian rivers, partly surreptitiously through the Italian States not directly controlled by the Pope, especially through Venice from the eighth century. The Italians even seized the advantage of the climate and cultivated saffron from the east near San Gimignano, and this was used for dyeing cloth as well as for food. As Braudel remarked, '[f]or long periods in the past, the European world-economy appears to have rested on the slender basis of a single city-state, one with perfect or near-perfect freedom of movement, but with resources outside itself'.[4] It also grew because a part of the Near East too was interested in maintaining communication with the west; its merchants needed to dispose of its imports from further east as well as its own manufactures that, as we have seen, became considerable. Moreover the countries were always short of metals, whether precious or not, which created a demand that had to be filled from outside, from Venice.

Venice became a centre of trade long associated with the eastern Mediterranean. The town rapidly replaced Aquileia, former Roman colony and centre of trade between northern Europe and the Mediterranean before the invasion of the Huns. The Exarchate of Ravenna was lost to Byzantium in 751 when the Franks came to Italy under Charlemagne. The lagoons around the mouth of the Po were inhabited by refugees from the earlier 'barbarian' invasion from Germany, by the armies of the Lombards, and remained under loose Byzantine rule but with a Latin rite, as did parts of the Adriatic coast. In 812 a formula was agreed whereby Byzantine suzerainty remained but an annual tribute of 36 pounds of silver was paid annually to the invading Franks. That was no great burden, given the links with the metal-rich north and the trading privileges that peace brought with it. It was ‘a unique position, of which merchants took full advantage’;[5] they navigated throughout the Po delta and traded down the Adriatic to Byzantium. With Marseilles in decline, Venice was due to become ‘the main port through which contact with the eastern Mediterranean was maintained – commercial, diplomatic, ecclesiastical’. A few years after the arrangement with Pippin, son of Charlemagne, some merchants from the town stole the relics of St Mark from Alexandria and deposited them in a chapel next to the Doge’s residence. By the tenth century individual voyages to the east gave way to those of groups of merchants travelling together, especially important with the Muslim conquest of Spain and North Africa; it was a time when Jewish merchants became noticeably prominent, as we see from the documents left in the Cairo Geniza.

The destruction of Aquileia, a provincial capital where most likely Mark the Apostle had preached (and early Christians kept a strong religious connection with the east), allowed Venice to establish relationships, firstly to Christian Constantinople but also to Alexandria, with its Christian past associated with its patron, St Mark, and with the surrounding Muslim territories. Both Venice and Amalfi remained under ‘loose Byzantine suzerainty’, and hence became involved in opening up trade. Together with other Italian traders, they made a business of trading with these eastern regimes. Amalfi had even established the hospital of St John in Jerusalem to meet the needs of pilgrims and traders. In this work the Republic remained the most important and the most organised of the traders, establishing the link with both the eastern Christian and the Islamic worlds. When trade restarted between Europe and Africa, several Italian cities became involved, especially Genoa, Pisa and Northern Sicily. At that time, the Venetians even had a monopoly in the export of lead from the Barbary Coast. But the main metal was gold, guarded in transit by their armed *funduks*, for traders were frequently attacked by pirates from both shores of the Mediterranean.[6] The Europeans in exchange sent down copper, especially prized because of its colour, but glass beads, cloth and wine were also exported. Both Venice and Genoa built ships for the African market (which lacked the wood). And very much later, in 1621, Venice even established a *Fondaco dei Turchi* where traders from the east had their own mosque, their own baths, and could lead an entirely Islamic existence. In this way the town always remained largely independent of the Vatican and its interests. Its university at Padua was less dependent on the religious, more on the scientific, drawing strength from its connection with the University of Salerno and its important medical school. Its main partner, Constantinople–Istanbul, was another city that flourished on trade, especially with foreign powers, resulting in the artistic influences which this permitted, building up a magnificent collection of Chinese porcelains well as attracting painters like Bellini. With this help from the east, Venice contributed in so many ways to the florescence of European culture and to the rebirth of the classical, even if that was perhaps ‘born’ in the commercial city of Florence.

The process of renewal was in part due to the influence of Islam that had translated so much of the classical knowledge set aside by the west. Islam also spread to India, to the borders of China, to Egypt, that centre of the Mediterranean knowledge, as well as to North Africa and Southern Spain where it regenerated the lands of the Visigoths. In principle Islam was as subject to the same transcendental hegemony, with all its restrictions on natural philosophy, as Christianity or Judaism, especially when the madrasas banned ‘foreign’ (i.e. secular) sciences. But their Renaissance came before the dominance of Sunni orthodoxy. The Abbasids had inherited the Persian state that in turn greatly benefited from earlier Mesopotamian as well as from the classical culture of the Greek and Roman Empires, of which their lands were a part. They renewed the local study of Greek sciences and led a preservation (and extension) of this work through the translation movement, which had so many repercussions in the later Europe of the pre-Renaissance period. They conserved much, developed their own enquiries, and through the use of Chinese paper, circulated much of that knowledge which they preserved in large libraries usually open to scholars. But the movement did not last, although, despite the resurrection of exclusive religious doctrines by Sunni theologians, some elements of the scientific tradition continued. As has been remarked: ‘[T]he Arabs were . . . the only race which kept the light of science burning during the Dark Ages, and their words were in considerable vogue at Agricola’s time.’[7] These were often the words of the Alchemists, with whose ‘fantasy’ element Agricola strongly disagreed, but they were important as founders of modern chemistry.

And in the Middle Ages, over the long term, Islam was perhaps less hegemonic, with periods in which the religious was less dominant, as in the Abbasid regime in Baghdad or during the time of the Umayyad rulers in Southern Spain. In the latter case, the Nasrid rulers of Granada were less strict than the earlier Almohad rulers. Islam had periods in which ‘secular’ knowledge flourished, especially in astronomy and in geography which were valued by the religious for the time and direction of prayer, as well as for trade, and in medicine, too, right up to the coming of the Italian Renaissance.[8] Then it was so important for the emergence of that vital phase in European history that intervened in action as well as in thought.[9] In all this, Venice played a very prominent part, with its connections to the east and to the Muslim world, as well as its quasi-independence from Papal hegemony that accompanied those links, both Orthodox and Muslim.

The eastern trade of the Italian republics had first grown up again under the Ayyubid princes who needed the timber, iron and other materials for their wars as well as requiring a profitable outlet for their own goods and for those of others. In 1158 Romano Mairano from Venice supplied 50,000 pounds of iron to the Knights Templar; hostility in Constantinople led him to diversify and to trade from Italy, making voyages from there to Alexandria, taking wood for sale, even though this was subject to the Papal ban.[10] In return for these opportunities foreigners were granted a number of privileges that won them the right much later to have a *fondaco* (or inn) in Venice where they could store their produce, stay in comfort and conduct their business.

That renewal was interrupted not only by the advent of the Sunni but also by the appearance of the Crusaders. By then relations had restarted between Europe and the Near East; indeed the Crusaders were themselves perhaps one aspect of this renewed connection for they ostensibly came to allow pilgrims freer access to the Holy Land. In the communication between the two regions not only was Venice heavily involved but other Italian cities as well, Amalfi, Pisa and Venice’s great rival, Genoa. Like Venice the seaport of Genoa in Liguria was situated near the mountains of North Italy, in this case those bordering on Switzerland, as well as being near Milan and the manufacturing towns of Lombardy.[11] Originally it had prospered through contacts with the Etruscans and the Greeks, becoming a military establishment under the Romans. Genoa got metals both from Elba/Populonia and the Tuscan hinterland (Monte Amiata, Colline Metallifere/Massa Marittima) where mining activities had been carried out since Etruscan times. Hence too the conflicts with Pisa, which was eventually defeated. Moreover Genoa had colonies in Sardinia where Genoese is still spoken, where metal-mining, including tin, has been carried out on the west coast since Phoenician times until fairly recently (the 1970s). As with many other cities, the end of the

Empire saw its decline, but after being attacked by the Muslims, it rose again. A Fatimid fleet sacked the town in 934 (or 935) but the Genoese counter-attacked and their merchant ships were soon trading not only in the western Mediterranean but also with Palestine to the east. During the twelfth and thirteenth centuries, the city played a prominent part in the establishment of Europe’s commerce in the inland sea, importing spices and gold, exporting cloth and metals. As a result both house-building and ship-building flourished, as did the cloth industry and trade with the north.

The Genoese and Venetians founded many colonies in the western Mediterranean as well as in the east, partly through their participation in the Crusades. When these kingdoms in the Levant collapsed, the Genoese, who had a strong sea-faring tradition, entered into an alliance with Byzantium in 1261, exported to the Black Sea and occupied Pera in Constantinople and Kaffa in the Crimea, as well as various Aegean islands. They delivered victories over the Pisans in 1284 and less decisively over the Venetians in 1298, becoming the latter’s great rivals especially in the eastern trade. Their power gradually declined with the Turkish successes in the Mediterranean and they came to an understanding with Spain, moving some of their interests in a westerly direction. At the end of the thirteenth century Genoese and Mayorcan sailors penetrated through the Straits of Gibraltar to the Atlantic and had travelled down to the Canary Islands by the following century, and west to London. They brought wool directly from there and Flanders, as well as transporting alum for fixing cloth from Asian Phocaea in the opposite direction, in their ships which were patterned on the northern cogs or Locka. Indeed Genoa was the birthplace of Christopher Columbus and profited greatly from the new connection with Spain, together with the banking and commerce that that involved.

After the time of the Crusades, the Venetians and the Genoese established themselves in Constantinople and set up bases in the Black Sea. The rise of the Mongol Empire in the thirteenth century opened the route for eastern silks and the Venetians concentrated on the valuable ‘luxuries’, while the Genoese purchased slaves which they could sell to the Mamluk rulers of Egypt to supply their soldiery, of which slaves formed a part, though it was a trade displeasing to the Papal authorities.[12] The silk trade had also been active since 1257 when we learn of the colony of Italian merchants who were established at Tabriz in the Ilkhanate. We hear of a Venetian Pietro Ciliani who died there in 1264 and before Mongol ambassadors visited Genoa some five years later. Many merchants lived and worked in Tabriz in 1336.[13] Also important to Italy was the grain supply from various sources, which was required to feed the growing populations of the manufacturing towns.

Merchant activity in the east developed with the ending of the Crusades and both traders like Marco Polo (c. 1254–1324) and priests like William of Rubruck (c. 1220–c. 1293) were able to explore distant parts, establishing connections both with the Chinese and with the Mongols. Among the religious orders, it was especially the Franciscans who played a major role in opening up the Silk Route again. Political regimes also kept communications open. For example, the town of Pisa was active in relations with the east. In 1173 it made a treaty with Saladin, who had taken over in Egypt and reigned from 1169 to 1193, building up his rule on the basis of a strong army. In that treaty, Pisa agreed to export iron, timber and pitch, items for the military on which the Pope had specifically placed a religious embargo. Fibonacci, who wrote a book on Arabic numerals at the beginning of the thirteenth century, was a merchant from the town who had lived for a time in Bougie in North Africa. Venice too sent embassies to Egypt and made treaties with the sultan of Aleppo. After the Crusades an increasing number of European merchants were interested in visiting the Near East, looking for raw cotton and for spices. Trade in the latter was virtually monopolised by the Muslim Karimis of Egypt who were wealthy ship owners carrying the spices from India to the Near East; in the course of this movement of goods, they had become wholesale traders, with huge warehouses, and were protected by the Government. With these large-scale operations they put many smaller merchants out of business.

Egypt had long been a major focus of Italian trade.[14] For Venice, Alexandria was almost like Constantinople; indeed it was from there that the relics of the patron saint, St Mark, had been taken. But other traders were there too and, according to one Christian Arab writer, in 1260 as many as 996 Amalfitans worked in Cairo. Genoa too was active at this time, and later on Pisa and Sicily. They brought along cloth, furs, timber and metals such as iron, copper, lead, tin ‘which were badly needed in the Near East, and even arms, armour and slaves’.[15] The Genoese merchants and the Fatimid (Shia) rulers profited from the resurgence of trade to the Red Sea, which meant there was less emphasis on the route to India by way of the Persian Gulf and that led through the Abbasid domain.

In the Near East the recapture of Acre in 1291 saw the effective end to the

Crusades and the Pope (Nicholas IV) then attempted to cut off supplies to Egypt and to ban the trade in arms, timber and iron from Italy. Some states prohibited all trade and the ships of the Church tried to seize any forbidden merchandise. The effort to stop trade was in vain; it was too profitable to both parties and the Pope had anyhow to permit ordinary commerce. When he could Saladin bought not only armaments but European cloth for well off Egyptians. But exchange was concentrated upon the Christian territories in the east, upon Cyprus (especially the port of Famagusta) and upon Trebizond in Armenia, as well as on the Crimea, since trade to these areas was 'legitimate'.[16]

However, the harbour of Famagusta was taken by the Genoese in 1434 and the northern emporia on the land route from Central Asia, where they traded, were then controlled by the Mongols. So the traders returned to Egypt with its access to the Red Sea ports and established regular galley routes to the Levant. The Venetians then had consuls in Constantinople, Damascus, Acre, Alexandria, Beirut, Aleppo, Tabriz and at various times in other towns.[17] Other Italian republics too were involved; Florence had consuls in Alexandria and Damascus from 1422, Genoa in the same cities as well as one in Beirut. The Catalans too traded widely and Marseilles as well, while the trade of Ragusa in the Adriatic was increasing, exporting silver, lead, corals, textiles and honey. Despite the numbers taking part, the trade was still positive in favour of the Mamluks and in the fifteenth century Venice had to send 300,000 ducats in cash every year, mainly for the purchase of pepper, ginger and Syrian cotton and silk, quite apart from its exports of copper and other commodities. The Mamluks spent huge amounts on wars against the Ottomans, including the acquisition of military slaves from the countries round the Black Sea. Sultan Djakmak, who ruled between 1438 and 1453, spent 3 million dinars on wars in the first three years of his reign. Such sums ruined the nation. In fact all the emirs were lavish in their expenditure and despite the availability of Sudanese gold the state got into financial difficulties and had to raise a considerable amount in taxes.

Later, in the fifteenth century, there was a decline in the Egyptian industries. This decline was primarily the result of European competition, though these industries did not disappear altogether. But the technology of western Europe by 1500 now surpassed that of the east. Sugar and soap became less attractive as purchases from there, as did paper and glass. In particular the west had the iron to make the machines and for certain purposes the coal. They also had fast-flowing water to power those machines and to fill the canals to provide the water to drive them and used to make rag paper at Fabriano near Ancona. European textiles virtually replaced local ones. English wool, which fed the Flemish and Florentine industries, was of superior quality to that produced in the Near East. The European textiles were now manufactured using local saffron (which had migrated north to San Gimignano and Saffron Walden) and other dyes as well as the treadle loom and the automatic mill, not unknown in the east but nevertheless rare. In the Near East on the other hand technological stasis was widespread, especially in royal factories that seemed to stifle innovation. The production of fine glass vessels and in-laid work was taken over from Tyre by the Venetians with the help of Jewish craftsmen who were brought in; these products were now exported to the east, instead of being imported from there. In the fourteenth century paper too was sent and as well across the Adriatic into the Balkans and Hungary. Soap also went from southern Italy, but porcelain still came from China, some imitating local styles, though majolica was now produced in Italy. Most of these products had originally been made in the Near East. Now at the beginning of the Mamluk period early in the fourteenth century European textiles and silks were being ‘dumped’ there. In that century the value of all imports increased heavily, coming in from Languedoc, Perpignan, Flanders and from Catalonia. Venice too exported great quantities of cloth to the Levant.

In this way there was a shift of industrial activity from the Near East to the west. Lucca had become famous for its silk industry in the thirteenth century whereas formerly this had been the foremost product of Iraq or of Muslim lands in Sicily, having earlier migrated from China. Now Europeans came to the Near East seeking raw silk, not cloth, though in the Mediterranean countries they themselves had also learnt to plant mulberries and to breed worms. For silk cloth was now woven in Europe as well as in the east, and the industry expanded greatly. Despite Lucca’s attempts to restrict the movement of experts, skilled workers migrated to a number of towns.[18] Following the expansion of the northern Italian industry in the fifteenth and sixteenth century, when most Renaissance rulers tried to encourage their economies, skilled workers were offered incentives to move from Lucca and the other main towns to which the making of silk had been confined since its introduction between the ninth and eleventh centuries by Arab, Greek and Jewish artisans.[19] When Roger II of Norman Sicily had attacked Corfu, Corinth and Athens during the Second Crusade in 1147–8, he brought back dozens of Jewish silk workers from Thebes whom he put to work at his palace atelier;[20] it may have been from there that the weaving of silk spread north to Lucca. The Genoese did indeed bring cotton from Sicily to start a flourishing industry in the Middle Ages. Venice eventually did the same with silk. It had taken up the trade with the Levant, especially in Persian silks from Aleppo, after the Ottomans captured Constantinople in 1451 but it also dealt in raw silk for making thread not only from Syria and Palestine but from Greece, Albania and the Balkans as well as from Iberia and southern Italy. Some of this production was used for the local cloth industry but the larger part was re-exported as thread to countries in the north, where despite local attempts, by Jews for example, owing to the cold weather the cultivation of the silkworm never took off. But from the late fourteenth century Venice itself built up an important trade in Italian silk and wool fabrics to the Levant and it became the main clearing house, especially for velvets. Merchants came not only to Aleppo but also by land to Constantinople and through Bosnia to the harbours of the Dalmatian coast, such as Zadar (Zara) or Split (Spalato) under Venetian dominion after 1420, which was also the home of Jewish and Armenian merchants, or to Ragusa (Dubrovnik), a fully independent republic. But in the early sixteenth century the Adriatic port of Ancona in the Papal States encouraged Jewish settlement from the east and made vigorous attempts to build up the trade in cloth, partly because Florence had decided to trade to Ragusa by way of that town, the items then going further east by land; metals were also received there from England and Flanders.[21] As a result of this threatening competition Venice lowered its tariffs, making it more attractive to merchants to trade there. Some of them who came to the Old Ghetto at that time were Jews, both Iberian and Levantine; these had migrated from 'Romania' under the Turks. At this time the Venetians reversed the previous policy of their Republic towards the settlement of Jews, a move that was also encouraged by other Italian cities looking to advance their economies. These Jewish merchants could act as interpreters, especially in the importation of Greek silks (*fior di morea*) which were prized for their durability. For the expulsion of Jews had diffused technology and, for example, they taught the Turks how to make better armaments.

Silk production became very important in Italy, especially with the development at Bologna of the reeling process making use of Chinese technology, with the bobbins being driven by water-power from the canals below.[22] Workers in the silk industry also went from Lucca to Venice in 1314.[23] But it was Bologna, which exported silk to the Near East through Venice, near the mouth of the River Po, that came to dominate the European industry until merchants from Lucca also established themselves at Lyon in Southern France where they used the silk grown by Huguenot farmers in the Cévennes. There they competed strongly with the Bologna industry, as they had early knowledge of the patterns that were to be fashionable in the court of the Sun King Louis XIV at Versailles well before others did. As a result, Bologna's silk industry fell away, while in Piedmont the Dukes of Savoy sustained a policy of silk-growing on a regional scale. It was one of these mills that nevertheless provided the secrets of its mechanisation of reeling to an English worker, one John Lombe (or rather had these acquired 'surreptitiously' by him), whose family set up a mill in Derby in 1718 that undoubtedly contributed to the factory production of cotton goods, so prominent a feature of the 'Industrial Revolution' in Britain.[24] The buildings of the Lombe family on the Derwent, near Derby, were the first large manufactory in England especially built as a silk mill. Defoe recognised these as the work of 'Italian engineers' for making thrown silk.[25]

During the Renaissance the silk industry in Italy came to dominate the Levantine markets, as it did in Europe. In the sixteenth century it is said to have made up 30 per cent of French imported goods. Much later, in the late 1820s, the value of Italian exports of raw and spun silk was only 'slightly less than half that of British exports of cotton products, and the technical innovations applied to silk reeling and spinning in the nineteenth century established the foundation for the subsequent progress of mechanization'.[26] The production of textiles, so important throughout Eurasia, did not stand still.

Venice played an important part in manufacturing textiles. Nor was this the Republic's only commercial activity, for that in metals, among a number of others, continued. Even in the fifteenth century the profits from the imports of spices amounted to some £500,000 a year.[27] To offset these imports the Republic exported woollen cloth, brass, copper, tin, mercury, furs and amber (as well as silk) but the balance of trade was always negative so had to be made up with silver and gold. Since the Roman period, brass had been made in Europe by alloying copper with zinc reduced directly at the melt surface from calamine. But metal zinc was later introduced and that product seems to have come from China; here it appeared only in the sixteenth century when it came through India, which had its own supply but that was soon surpassed.[28] Bronze was of course also used in churches for monuments, and in Byzantium for the huge decorated church at Hagia Sophia. German craftsmen started to do the same in their own churches, as later did Lorenzo Ghiberti in the famous baptistery at Florence (in about 1440). The metal also came to be employed for statues, often equestrian, as well as for bell-founding and later for the first cannon which were employed at the battle of Crécy in 1346, although possibly before that. For this purpose it was being used in England by the end of the fourteenth century, though in the fifteenth century the cheaper cast iron began to take over from cast bronze.

Silk products, as we have seen, were also exported back to the Near East, as was paper and glass. The silk trade was particularly interesting. There was always the production of traditional silk cloths, *da parangon*, in Venice, which existed side-by-side with that of lighter and cheaper fabrics that were always changing according to demand. This area of production was one governed by invention rather than tradition, and from the fifteenth century was protected by patents. So too were other inventions, including a proposal for the breeding of two crops of silkworms every year instead of one. In this and other respects, the evolution of the silk cloth production in Venice contrasts sharply with the idea of industrial stagnation, which had been thought to happen in Italy. Innovators were in fact highly regarded,[29] as in metallurgy. And the changes were often dramatic. From the second half of the fifteenth century, the cultivation of mulberry trees spread rapidly not only among the estates of the aristocracy but among the merchants too; and this growth was encouraged by governments in much of central and northern Italy, spreading from the east, around Lucca, to the west, around the Terrafirma, especially in Vincenza and later Verona, all anxious to increase their industries.

So the silk trade at Venice was particularly vibrant and, contrary to many earlier assumptions, it was ‘highly flexible’. Far from being a stagnant activity that embodied the golden decline of the Italian economy, the silk industry was one of the more vital sectors that eventually came to play an important part in the industrial revolution of the peninsular.[30] Indeed at the end of the sixteenth century ‘silk was perhaps as important for the Venetian economy as pepper had been a century earlier’.[31]

Venice was always heavily involved in the processing as well as in the purchase of metals. It even sent miners abroad and in the fourteenth century they mined iron ore on Seriphas. The mints of Venice were involved in the provision of metals to the Near East and the Mamluks were regularly supplied from the mines of the Tyrol, Serbia and Bosnia, being brought there by Venetian merchants. This regular supply was possible because of the advances in European production recorded by Agricola, namely in the separation of the various metals mixed with silver and in the prevention of the mines from flooding.[32] With regard to the production of precious metals, the timing of the use of the mineral acids employed in the separation of gold and silver remains unclear. The mining of noble metals (gold) and later copper and silver in Carinthia, Styria and elsewhere in the eastern Alps from the tenth to the end of the sixteenth century provided the ground for technological development. In the 1490s quicksilver production began in the mines of Idria (today in Slovenia) that belonged to the Counts of Gorz (Gorizia). In the fifteenth century they became vassals of both Venice and of the Habsburgs, holding titles and lands in south Tyrol, and thus providing the quicksilver for the Tyrolean silver production.[33] In the *History of Inventions* Beckmann states that some Germans first used these acids at Venice to separate the gold from Spanish silver, but he disregards earlier references. The dates of the alchemist, Geber (Jābir ibn Hayyān), are disputed but he also writes of distillation to produce the *acqua regia* used in this process.

The increase in copper coins was very noticeable. In 1409 new copper mines had been discovered in Schwaz in the Tyrol and Halle in Saxony–Anhalt, and at the end of the fifteenth century the ones in Slovakia began to operate. Much of this production was sold through Venice with the Fugger as intermediaries. However, in a climate of inflation, so huge was the volume of imports, the Mamluks had difficulty maintaining the value of their copper coins and they were often sent on to India where their value was greater.[34]

At this time the Europeans exported textiles to the east, although the latter still had an industry of its own. But the technological advantages gradually accumulated in the west. The first was the treadle loom, unknown to the Arabs, which was used in Northern France by the eleventh century and by English weavers at the end of the twelfth. The second was the automatic fulling mill operated by the ample water-power and used in Italy for woollen materials at the end of the eleventh century, then spreading to Germany and to England. Water, which Europe had in plenty, was employed in other ways, giving an increase in power for mechanisation and industrialisation, as well as being valuable in agriculture.[35] Some operations needed slow streams, some fast; Europe had both. Neither of these particular inventions was taken up in the Near East that saw a decline both in private industry and in the large royal factories. There was a distinct technological stasis in the middle of the thirteenth century.

Meanwhile, the Portuguese had come on the scene in West Africa from 1445 and they began to acquire great quantities of Sudanese gold. In the fifteenth century, less went to Cairo, more to Italy. Later on they opened up the sea-route to India and so spices became rerouted, with the Venetians and others having to go to Lisbon to purchase them, for sea-transport was always cheaper than land and there were problems with the interruption of the route through Istanbul. But though the routes from India changed, some trade continued through the Near East. It was in Damascus and later Aleppo that the raw silk from Persia was handed over to Venetian merchants, together with the spices coming from Baghdad. Nor were they the only traders with the east; the Genoese too were very active in Levantine commerce as well as in the Atlantic. Nonetheless the Mamluk economy in Egypt weakened and they could not compete militarily with the Ottomans, with all their artillery and their firearms made with the help of European technicians. The Mamluks later tried to get the same type of arms from Venice in order to fight off the Portuguese in the Indian Ocean, but their ships were technically inferior to those of Europe and in combat they sank too easily. The economy of the Near East, which had earlier been so advanced, was destroyed as a result of all this military expenditure and through sticking to old methods of production.

Although trade with China and the east declined under the Ming, the Venetians made frequent visits to towns on the Silk Road, such as Trebizond and Persian cities, like Tabriz. There the Italians, both Venetians and Genoans, acquired a variety of Indian and Chinese goods, including precious stones and silks which had been transported overland, though sometimes through ports on the Persian Gulf. In the fourteenth century there had been much sea-borne trade with Ormuz; at that time the prosperous harbour was visited by Chinese ships and its rulers even sent embassies to the emperor. Trade was also attracted to the new emporia of Baghdad and Tabriz, some of which went on to the Syrian town of Aleppo (known as 'Little India'), although until the sixteenth century Damascus was more important as a point of exchange.

Venice of course had a wide range of colonies and trading ports; their merchants at Constantinople often maintained their headquarters at that city. On the Peloponnese there was also the fortress colony of Caron that had its own bishop. A difference existed between true colonies and trading posts, also called colonies but in reality groups of Europeans trading under privilege. These posts included Beirut that was visited regularly by Venetian galleys. These voyages were very important for the economy and sales of local securities took place in August with merchants trying to obtain liquidity before their departure.[36] The deep involvement of the state in commerce represented by the regular sailings of the galleys led the Venetians to interfere in the political struggles of the region. They had sent copper and arms both to Saladin and to the Turco-Persians; they also dispatched embassies and arms to the so-called ‘White Sheep’, another group of Turcoman tribes who came to power in 1467. Their prince conquered the Black Sheep, took over Baghdad and was given support by the Venetians in order to pay the dues owed to the Ottoman Turks. In 1475 the Venetians tried to send 52 mortars, 500 arquebuses and ammunition to help the Persian cause. Musketeers were dispatched to teach the army how to use the modern weapons, but all this support arrived too late and the White Sheep were beaten by the Ottomans with their superior artillery.

The imports and exports with the east as well as with the north meant the Republic of Venice had to have a very complex financial system to support this extensive exchange. These arrangements included loans from local banks to finance not only trade but also wars with the Turks and at one time even to pay the reward for attempting the assassination of enemies of the state, including King Sigismund.[37] Venice supported these activities not only with revenue from its trade which provided customs duties, from its industries in glass, beads and metal work and from its exchange in the Rialto market, but also from loans raised through banks and pawnbrokers. These loans were contributions from its citizens and occasionally from others. In 1164, the merchant Ziani who traded in the east and was a future Doge of the Republic, lent 1,150 marks of silver and received in return the revenues of the Rialto market. By 1207 however the loans of citizens had become forced contributions, and were based on an estimate of a person’s wealth; these loans earned interest, which was theoretically paid at specific intervals. But in many cases the original loan effectively became a perpetual debt even as early as 1262.[38] Eventually that system was replaced by direct taxation, known as the *decima*, which was a tax on property. Venice moved from being a regime financed by forced loans, with interest payable, to one of direct taxation with no interest, although they still received payment on Government loans. The well-known Florentine *catasto*, examined by Herlihy and Klapisch-Zuber, was constructed on the model of the Venice *estimo*, for this territory was rated to be 'the best governed of all'[39] and known for the efficiency of its financial services. In the fifteenth century the Venetians took increasing quantities of northern silver to Tunis to exchange for gold dust.[40] They continued to attract metals from the north, including iron, which were then used in exchange with the east. A well-established division of markets kept the Germans out of the long-distance trade in the east, but equally Venice's merchants were virtually forbidden to sell directly in Germany. However, there was also an important route that linked the east to western Europe from the Black Sea across Transylvania, Hungary and Bohemia to the major trading cities of Germany and Flanders. This alternative route with the Levant had been developed by the Kings of Bohemia and Hungary in connection with the German long-distance trade and it was always a cause of strife and open war with Venice.[41]

In that century German markets were buying Syrian cotton through Venice with specie being used as an exchange commodity.[42] The fact of exchanging foreign commodities in this way also meant that money had to be changed, at least when the transaction was more complicated than barter. That transaction already led to the development of money changing at the fairs of Champagne and elsewhere, and later to the emergence of deposit banks (*banchi di scritti*) which made a written record of transactions (*scritti*) on benches (*banchi*) set up at the Rialto Bridge. The location near various churches supposedly made for honesty. It was in these banks recording the customers' debts and credits that 'bank money' was invented as an internal transaction, as well as double-entry book-keeping, leading to the development of a whole branch of applied mathematics. Comparable innovations in accounting took place in other communities of literate and numerate merchants in the trading civilisations of Eurasia and were little to do with any specific religion, as has been supposed by European writers. Nevertheless the work of these money-men was not simply individual or entrepreneurial but was tied up with 'national' systems of issuing money, which meant there was some supervision, and even interference, at a governmental level, just as there is today with the private and national banks.

Of course, Venice was at the forefront not only of finance but also of ‘culture’, of painting, of architecture, of music and of literature. Gutenberg’s printing press, a product of South Germany, was introduced there in 1469 by the German, Giovanni da Spira, and by the Frenchman, Nicolas Jenson; the workshop passed to Giovanni da Colonia and then to another German. Their firm represented the beginning of ‘the greatest results in book publishing, both printing and editing’,[43] and it printed incunabula with great care as well as contributing to the wider diffusion of knowledge. The press represented another side of the contact of south Germany with Venice, particularly in the area of metal work. Many Germans were involved in the early history of Venetian printing that was often run with German capital and carried out by German labour. One of those attracted to Venice by its graphic excellence was Erhard Ratdolt of Augsburg, the home of the Fuggers. He ran a printing house in the city, started to experiment with polichrome prints on gold plates, and when he returned home to Germany took this knowledge with him. In the printing and publishing trade, relations with Germany remained close. When the accounts of Marco Polo’s travels were published in 1477, they were printed in Nuremberg.[44]

Neither the Germans nor the Venetians invented printing, but they used a local press, developed for olives, to assist in the process. The critical point about the printing that developed in Europe was the use not only of the press but of metal type, although in this case not uniquely, so that the workshop became a foundry, instead of a scriptorium, as well as a talking shop, a meeting place both for metal-workers and for intellectuals; consequently printing provided a link not only between artisans and writers but a further one between the metal industry of the north and the Renaissance of the south, with all its relationships with the Mediterranean and the east.

Printing involved the introduction of other new technologies into Venice. It was responsible not only for an enormous spread of book-knowledge, there were also changes in the large-scale manufacture of paper and of improved machines. These improvements were governed by Venice’s system of *privilegi* that was designed to protect innovations from outside the city that supplemented the local knowledge held by the guilds. Such protection was also provided for a host of innovations such as those involving the application of heat from a wood-burning furnace, those regarding the smelting of silver and the casting of bronze, as well as military ones involving the production of artillery, described by Biringuccio in 1540 in a book that was also protected by Venice's copyright. Then there were the inventions using non-human energy, especially the power of water, wind and animals, all of which were employed in mining as well as in the milling of flour and the production of textiles, the latter increasing considerably in the mid sixteenth century when the products were more and more exported eastwards. Some of these inventions, for wrought iron-working, *inter alia*, were made by the son of a citizen of Ravensburg, yet others by a Flemish inventor, yet others by a certain Hofman; all of these indicated the prominent part played by Germans and other northerners in the early inventions of the Industrial Revolution, inventions which were then developed in Venice. It was probably a German working there who had introduced the process of separating precious metals with acid, to which we have already referred.[45] The author, Biringuccio, had himself visited Germany in connection with metallurgy, and he has accounts of the making of artillery, of munitions of war and of bells,[46] which were all produced in both places.

Biringuccio had discussed the properties of the critical element in gunpowder (potassium nitrate) in 1540 and his text was widely plagiarised.[47] The mineral was at first collected from the English countryside under royal prerogative, leading to conflicts between owners and 'saltpetremen' (collectors of soil contaminated with natural waste). But the most comprehensive account came from the pen of Lazarus Ercker (1530–94), chief master of mines to Emperor Rudolf II of Bohemia. The German edition appeared in Prague in 1574 and there was no English version for a century. But in 1589 a Jewish metallurgist, Joachim Gaunz, who was arrested for denying the divinity of Christ, explained the Bohemian process using Ercker as his guide. His long manuscript was dedicated to Sir Francis Walsingham.

England was highly dependent on saltpetre for its arsenal of naval and other guns. Apart from local production, that was very divisive to collect, this came partly with importation from Morocco but especially from Germany and the Low Countries; it was produced by a centralised process for making nitre which some tried to introduce into England. As early as 1545 the German engineer, Stefan von Haschenperg, was employed by Henry VIII. In 1561 one Gerard Hoenrich entered into civil agreement with Elizabeth's Secretary, Cecil, to transfer German technology but the project did not proceed.[48] Eventually the supply problem was solved by the large-scale import of saltpetre from India, started by the East India Company around 1640, effectively replacing the highly intrusive activities of the saltpetremen working under a royal prerogative, until chemical production eventually took over in the later nineteenth century.

South Germany also saw the development of clockwork in the sense of using energy stored in a coiled, tempered-steel spring. This was a particular kind of automata that appeared in Europe in the mid fifteenth century and made way for the personal watch. But of course automata of a different kind had existed long before, in China from the third century BCE, with Hero in Alexandria and with Al-Jazari in the thirteenth century (and before). It was the control of this spring that produced the tick-tock sound, so characteristic of the Italian Renaissance time-keeping and again developed in the smithying towns of South Germany. This was certainly not the first time-keeping device; others were provided by sun, water and wax. But it was critical in the development of the precise measurement of time so important to the mechanised life of factory and work-place in the 'modern' world.

A central, important and seemingly very different part of this revival in Europe concerned metals and the associated armaments, which enabled that continent to conquer North and South America as well as Africa, India and much of the rest of the world. This conquest may also have had higher moral status, as many Europeans like to believe, but that continent undoubtedly had the means of conquering others, partly through the efforts of the metal-workers who produced the weapons, partly through the powder used to propel projectiles, a powder that was first invented in China and used in the struggle to fight off the Mongols, as well as by the Mongols themselves, who may well have transmitted the knowledge to Europe and possibly to Islam and Turkey.

Gunpowder meant that weapons of war were no longer dependent on human strength or on that of a horse but on the nature of a projectile forced by gases out of a confined space. The confined space had to be created from metals. And these weapons were developed in Europe in combination with metal technology, especially in Germany, in a manner that led on to the conquest of the east, indeed of the world. Gunpowder was a simple mixture produced without the aid of theoretical knowledge, although its production later employed it and perhaps contributed to the development of teaching the sciences since its use involved 'unseen' forces. In practice, the development advanced metallurgy. The containers or barrels it required were made of metals; at first these were of bronze, but the alloys of copper were expensive and not well adapted to withstanding gases at high pressure. In certain ways bronze cannon were better than iron and could be cast from the beginning of the fifteenth century. It was in the early sixteenth century that English smiths learnt to manufacture guns in cast bronze, but they were expensive. Wrought iron solved the problem, but prototypes still had to be reinforced with hoops to strengthen the container. Wrought iron breech loaders were the first type of gun to be produced in significant numbers.

Back in Venice those German merchants coming not only from Austria and south Germany, but also from Cologne in the west, were important as go-betweens with the Netherlands and were 'pivotal in the Mediterranean trade with the Hansa, bringing wool, sugar, spices, plus brazilwood from Venice and then in turn taking furs and craft objects from the Baltic'.[49] Northern furs were required by southerners for winter wear. But the merchants were attracted to the city not only by its commerce but also by its artistic culture and by the excellence of the book production: graphic achievement 'made printed books competitive with handwritten manuscripts, which were often decorated with splendid miniatures'.[50] This was essential for the luxury market. The great centres of exchange with Venice were Nuremberg and Augsburg, which had replaced the town of Ravensburg, and the exchange expanded from the end of the thirteenth century, taking cotton, saltpetre, wine, jewellery, spices and pottery by way of the Brenner Pass, and giving rise to a 'regular traffic of couriers'. So important was this commerce for those towns that the Venetian legal system even provided the probable model for the Constitution of Nuremberg.[51] For the art world, Dürer's visits to Venice at the end of the fifteenth and beginning of the sixteenth centuries were of great significance. So too were those of the merchants from Augsburg, especially the Welsers and the Fugger; Jörg, the brother of Jakob, had his portrait painted by Giovanni Bellini (who also did the one of the great Turkish ruler in Istanbul). The Fugger lived in Augsburg and it was to that city, and to their country estates around, that they brought back the artistic products of Venice and of the Italian Renaissance more generally, including its texts. The first building of the German Renaissance, the funerary chapel of Sankt Anna (1508–18), was erected in that city; the Fugger chapel established itself not only as a Renaissance but as a Catholic enclave within the church even when the city itself had been largely converted to Protestantism. The style however remained basically the taste of the rich elite until it gradually seeped down to the lesser, Protestant, bourgeoisie. Meanwhile, general 'culture' was increasingly imported from Italy while the products of smiths, gunsmiths and ‘technicians of German precision’ travelled in the opposite direction.

Germany was not the only northern trading partner of Venice. Contact between Italian and other northern traders had been most active in the fairs of Champagne of the twelfth and thirteenth centuries, near the town of Troyes where wool from Flanders and the north was exchanged for commodities coming from the Mediterranean and from the Levant; those were fairs at which the Italian merchants developed their banking techniques as they were the money-men in the exchanges.[52] However Troyes was right in the middle of France and the European roads leading to the town were bad; trade became increasingly unsafe and in the early fifteenth century commodities were more and more shipped by sea, especially to and from western Europe. The first Italian galleys to Bruges arrived at the end of the thirteenth century, bringing in luxury goods, but sea transport soon became in more general use, transporting wool and metal on the return journey. Venice’s interest in metals is illustrated by the Priuli *fraterna* (i.e. Society of Brothers) of London, who later in 1503 purchased tin, along with wool, and took them back to the Serenissima. From 1314 on, Venice sent round a fleet of galleys, constructed in the state arsenal, almost every year. Private traders also carried goods between the two cities, especially wool, tin and metal work, as well as collecting items to be bought by the Hanseatic merchants[53] for whom this was a major point of exchange for merchandise to and from the Mediterranean.

In about 1332–42 an Italian monk describes Cornish tin as being exported in long square slabs to Venice where it was melted, divided into little rods and stamped with the lion of St Mark before sale.[54] He goes on to note that ‘lead was mined in Devon, Somerset, Durham, Cumberland, Shropshire and Derbyshire, and the total produced has been estimated as at least the equal of central Europe’. And in the twelfth and thirteenth centuries it was exported through Boston. From Yorkshire it also went through Hull, and reached a total of fifty-two shiploads in 1305–6. Silver was produced as a by-product of lead, the richest ore being in Devon, but this was of short duration. Gold was mainly imported. Copper too was largely brought through Hull, and part was used for making pewter.

Venice was not the only Italian city to be represented in Bruges, where it concentrated on the spice trade and on finance. The Medici bank of Florence had branches there, in London, Lyons, Milan and Venice.[55] Its loggia was situated in the Beursplein, the square of which became the centre of commercial activity, giving the name of *borsa* to a financial market. But in the fifteenth century Bruges encountered difficulties and, with the uprising in Flanders against the present regent and future Hapsburg Emperor, Maximilian, the port of Antwerp became the new market and meeting place. Indeed the Emperor actually ordered the merchants to move there and this port later became the most important destination for Italian traders as well as for the Hansa, although England too became a significant point of call, especially with the opening of new routes to the east round Africa, thus bypassing the Mediterranean, and with the growth of the Atlantic trade in the west. As a result the shipping through the Mediterranean declined only in the very long run, while Antwerp developed both as a port and as a market for goods from the south, as well as dealing in metals from the south of Germany, in textiles from England, and in industrial goods from the Low Countries. The Italian trade in eastern goods gave way to the activity of German and Flemish merchants in that sphere, leaving Venice continuing to be involved in finance as well as in the introduction of new industries into the Low Countries, especially those of glass, of lace, of majolica and of fine illuminated books, although at first the Low Countries did not develop the art of printing. But in Venice that activity increased and went on to experiment in the mechanical reproduction of musical scores. Meanwhile trade in the Mediterranean was becoming increasingly open to other sea-faring countries, with merchants from Antwerp coming south after 1580, although Venice still tried to maintain its monopoly with the Levant. This exchange sustained the banking system. 'Venice was the most bullion-hungry and credit-hungry commercial market in Europe, and the rhythm of demand, tied largely to the dispatch of galleys and ships to the Levant, made the Rialto the most predictable of European banking places.'[56] Florence and western Europe carried out exchanges there, but Venice's unique importance began to grow less after the decline of the fairs in Champagne.

The conquest of Antwerp by Spanish troops in 1585 led to the beginning of the decline of that city and traders then moved to Amsterdam in Holland, with some of the Flemish going to Venice itself and founding their own *banchi di scritti*. It was during the truce in the Spanish War that Holland (or the so-called United Provinces) signed a capitulation with the Ottomans in 1612 and finally managed to move in fully on the Mediterranean and to take over the trade to the Levant.[57] Venice concentrated on 'culture' and still attracted painters and musicians from the north as well as the many students that came to its University at Padua, noted for its scientific and medical education as well as for its technology and law, partly because of the relative freedom that the Republic provided, especially in religious matters. Protestant students from the north were granted the liberty to practise their own religion; consequently it attracted many important alumni, such as Vesalius from Brussels and Harvey from England.

The exchange in which other Italian cities were involved meant that their economy also became well advanced in matters of finance, more so than London. These cities included Pisa, and especially Genoa, Florence and, outside Italy, Bruges, Barcelona and Antwerp. While Florence and Genoa were famous as the homes of international banking, Venice remained distinctive as a bullion market, importing silver and other metals from the north, transforming them in its mints, and shipping them to the east, as well as producing coins for itself and for other countries. In that city, monetary policy was controlled not by a king and his feudal lords but by the council of a republican state, albeit with the Doge as its temporary, elected Head of State and with a council consisting of nobles but many of whom were also merchants, constituting a veritable mercantile aristocracy. Under royalty, the pressures were fiscal, under the Republic primarily commercial; it was a community of merchants and manufacturers.

With renewal in the west, prosperity allowed for enquiry in the natural sciences that now became more acceptable and flourished at Padua and other centres. But of course renewal also took place in the arts, though in this case with no great help from Islam, except perhaps in Persia with its Chinese connections. For Islam was even more strongly aniconic within the overall Semitic tradition. In the art of living more generally, matters were different. Through the Crusades, influences between east and west were pronounced, above all in the area of design and metallurgy.[58] The enjoyment of luxuries was partly a result of the Crusades, silk clothing, perfumes, carpets, food or bathing, which was an important Roman tradition that Christianity had effectively modified. But in Islam baths were important not only for cleanliness but as centres of communication where individuals could discuss affairs of the day in the tepidarium and talk about politics and philosophy. In Ephesus, for example, the baths had lost their popularity after the Roman period, were completely forgotten in the Middle Ages (though not always straight away) but were popularised again with the coming of the Muslim

Seljuk and Ottoman Turks.[59] The Venetian 'colonies' in Islamic trading cities in the Near East often had a bath house. 'The bath culture', writes Erdemgil, 'which had an important place in the Roman period, had sustained its importance until the middle of [the] Byzantine period and then it was forgotten in the Mediterranean countries and Europe. It emerged more anew [*sic*] and more lively with the Turks. Numerous baths were built in Anatolia during the Seljuk and the Ottoman periods.' Indeed part of the wedding ceremonies of the Muslims took place in the baths. The bride was taken there on the last day of the wedding and 'the women enjoyed themselves by playing musical instruments and dancing while taking a bath'.[60] It is significant that the *Fondaco dei Turchi* in Venice, established only late in 1621, contained a *hamam* but that St Albans in England had no public facility from Roman times until the nineteenth century. It was Islam that gave an impetus to the luxury of baths and bathing in the late medieval west, for the practice was regarded with suspicion by many Christians, for whom it was either Jewish or 'luxurious'. Public baths were in use in some medieval European cities such as Paris and common (male and female) bathing was practised among the elite, as shown in illuminated manuscripts. However the religious movements of the thirteenth century put an end to public bathing and prepared the way for the infectious diseases of the fourteenth century.[61]

In respect of baths, as in others, the 'rebirth' of aspects of classical society came slowly, sometimes stimulated by the exchange with the east. Baths may indeed have come in earlier through the Crusades where eastern luxury, even among traders, was on display. In the sixteenth century some Genoese palaces had bathrooms, as did the Ducal palace in Urbino. In this revival, Venice played a significant role by renewing itself, and Europe more generally, through its connection with the east, for after the decline and fall of the Roman Empire it had been used to a more 'barbarian' style of life. That Empire itself has to be viewed in terms of the expansion and development of the Iron and Bronze Age cultures coming from the Near East, both through the Mediterranean and the north. For, although it was in the Bronze Age of the Near East that urban civilisation began; it was a civilisation of the river valleys without any metal, for which they had to search throughout that inland sea, and of course to the east as well. In the course of that search, they partly 'civilised' the 'barbarians', or at least educated them in the technology of metals. But after the fall of that Empire, perhaps because of the activities of the neighbouring 'barbarians' who had developed iron weapons, perhaps because of the advent of Muslims who had adopted them, there was a break in trade and communication. Nevertheless there remained a need for metals in the Near East and eventually the willingness and ability of the Europeans to supply them. This is where Venice came in, since it was near southern Germany, the source of both the metals and the techniques to exploit them. Its fleet imported spices, silks and other luxuries, and exported metals, woollens and its own manufactures; indeed it monopolised much of the eastern trade. That gave it sufficient wealth to contribute significantly to the activities of the Renaissance, to the revival of culture in Europe more generally, to a movement in which the east had significantly contributed. And it contributed not only in the matter of baths but of eating (using the fork instead of the hands), in communication, with paper and printing instead of skins and manuscript, in science and in some technology.

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1 On the difference that writing made to religion, see Goody 1986.

2 Augustine 1992: 211–2.

3 Goody 2006.

4 Braudel 1984: 89.

5 Abulafia 2011: 254.

6 Bovill 1933: 122.

7 Hoover and Hoover 1950: 608.

8 Goody 2009a.

9 Goody 2009a.

10 Abulafia 2011: 300.

11 On metals from Genoa, see Ashtor 1986: 418.

12 Abulafia 2011: 355.

13 Needham 1986: 577.

14 On textiles from Italy and elsewhere see Ashtor 1986: 18.

15 Ashtor 1976: 196.

16 On the trade with Crete and Cyprus during the ban, see Ashtor 1978: vi.

17 Howard 2000: 29–36. On the role of consuls see Howard 2000: 32.

18 See the important book by Molà (2000). See also Molà *et al*. 2000.

19 Molà 2000: 3.

20 Abulafia 2011: 319.

21 Krekic 1997.

22 Poni 2001a and 2001b. This might have come with Needham's thirteenth-century technological transmission from China, Needham 1986: 570.

23 Braudel 1984: 135.

24 Chicco 1995.

25 Quoted in Klingender 1968: 10. These silk mills at Derby, Stockport, Macclesfield and elsewhere were later converted to cotton.

26 Molà 2000: xv.

27 Aitchison 1960: 355.

28 Chakrabarti and Lahiri 1996: 30.

29 Molà 2000: 185.

30 Molà 2000: Conclusion.

31 Molà 2000: 305.

32 Ashtor 1976: 324.

33 Tremel 1954: 20, 96–8, 112–16.

34 Ashtor 1976: 325.

35 Ashtor 1976: 247.

36 Mueller 1997: 538.

37 Mueller 1997: 429.

38 Mueller 1997: 459.

39 Mueller 1997: 512.

40 Braudel 1984: 125.

41 Pach 1975 and Szelényi 2009.

42 Mueller 1997: 21.

43 Roeck 1999: 46.

44 Roeck 1999: 46.

45 Hoover and Hoover 1950: 461.

46 Hoover and Hoover 1950: 615.

47 Cressy 2011: 78.

48 Cressy 2011: 102.

49 Roeck 1999: 46.

50 Roeck 1999: 46.

51 Roeck 1999: 47.

52 Stabel 1999.

53 Stabel 1999: 34.

54 Campbell 1987: 163.

55 de Roover 1963, 2002.

56 Mueller 1997: 354.

57 See Bulut 2002.

58 Fehérvári 1977.

59 Erdemgil 1999.

60 Erdemgil 1999: 159–160.

61 Vigarello 1988.

10
Venice and the north

Speakers of Semitic languages had early on traded from the Mediterranean coast, that is from Lebanon and Israel, and had marketed their wood ('the cedars of Lebanon'), as well as their local manufactures in ceramics and in metalware. They searched for metals but they had later traded with Europe and the west, especially in the places to which the Phoenicians and Carthaginians had gone for raw metals, to Spain and to North Africa. In some cases the search for metals even led to colonial occupation, as was the case in the Roman Empire. This Empire also exploited its resources in gold that it needed to finance its trade with India as well as to keep its own soldiers and to pay off 'barbarians'. But after the fall of the Roman Empire in western Europe the metal trade declined; silver which had replaced gold from the seventh century as the metal of account was won from lead and used in local mints. The sale of wool brought silver into Britain, and some precious metal was produced locally, although much was going out through the payments of Danegeld to the Norse invaders. After the Norman Conquest when the invaders were also of Scandinavian origin, English metal exports increased by a factor of ten, with lead being exported to France, and tin to Venice. Monasteries used a lot of lead for building purposes, which the Normans encouraged; it was also important in refining for silver. Mines were opened up; in Derbyshire, lead-workers were mining in 835. By the fourteenth century lead-mining occurred all over Europe employing a great number of people; in Edward IV's time 10,000 were said to be engaged in the Mendip area alone. And in 922 the silver–copper mine was opened at Beirsdorf in Saxony.

When, in the course of the renewal of the west, Venice was keen to open up its trade through the Adriatic to the Aegean and on to Byzantium and then to the east, it exchanged its woollen goods and other manufactures, like Murano glass, a product that had earlier come from the Near East. But in its hinterlands Venice also had enormous deposits of metals in the Alps as well as in Southern Germany and in Bohemia and Moravia. These materials were one of her great exports, the trade in which made her so important in the eastern Mediterranean, which was always deficient in metals, and from which she in turn also imported so much, especially spices, perfumes, cotton and silks of this trade. As a result, the city became well off and important in the fields not only of commerce but of learning and the arts, both of which required money or leisure. This development of the material culture of the Italian Renaissance was stimulated from the east, and in Venice by a certain freedom from ecclesiastical control as well as by the coming of the printing press from nearby Germany and earlier of paper from the Mediterranean. The flourishing trade with the east led to the attraction of many, later including Jewish, merchants and money-lenders as in Shakespeare's play, but mostly it was locals involved in both manufacture and commerce. Trade in turn led to the development of banking and accountancy (including double-entry book-keeping), together with written transfers between banks. These transactions were conducted around the Rialto Bridge in the market area that in 1097 the Orio family had given to 'the signoria and the whole people of Venice'.

Trade with the east was accompanied by the construction of a great fleet in the state-controlled Arsenal (the name itself deriving from the Arabic) to protect merchants against the piracy that was prevalent in the Mediterranean of the period. Venice used its Arsenal, possibly as early as 1314, to build the *galere da mercato*, large merchant vessels that were hired out to patricians who would collect a contribution from other traders. Each Venetian trading voyage would set up a new *colleganza* or investment company to raise capital for the project. The fleet was later used for taking pilgrims to Jerusalem, a long-established practice leading to attempts by the Christian church to conquer the 'Holy Land'. It was the pilgrimage that had led up to the whole period of the Crusades from 1098 that so marked the relations between Islam and Christianity ever since; it was then the Knights Templars performed an important role transporting people and money to the east, almost creating their own banking service. These were seen by the Arabs as a religiously driven attempt to take over lands in the Near East (as indeed they were). It has led to a comparison with the state of Israel's move after 1945 to acquire those same lands and resettle in Palestine which was reinforced by Europe's ethnic discrimination over the long-term and the attempted extermination of the Jews in Germany; to Zionists, as for Christians and Muslims, Palestine is the Holy Land. The main period of the Crusades was over after the Fourth Crusade of 1204 but pilgrimages organised from Venice continued, the peak being later in the fourteenth and fifteenth centuries.

Throughout this period the supply of metal from Europe continued, with gold from the Sahara financing the eastern trade that had been in deficit from Roman times. The main flow of precious metals from east to west however was in silver from the Tyrol, Saxony and from Bosnia. Some gold also came from Hungary. Silver had earlier been mined in western Europe but was now found further east. In the twelfth century, after the flow of metals had largely stopped, Western Europe discovered new sources that were then minted for the currencies of England, France and Germany, but they were also shipped through the Mediterranean. Between 1170 and 1220, silver was found at Freiberg in Saxony as well as in Bohemia, leading to a silver ‘rush’ that also produced some copper and gold. From there German miners went to east–central Europe and yet further afield. From the twelfth century, their settlers had already built a series of towns and transported ‘the full technical apparatus of western Europe to remote valleys of Transylvania’.[1] The Saxons moved to the region from that time and founded towns in the Slovakian mountains in 1243[2] but the main migration occurred with the exploitation of the new silver mines, a movement that produced burghers, miners and craftsmen. The Carpathians became important producers of silver in the fourteenth and fifteenth centuries.[3] To evacuate the metal the Brenner Pass over the Alps was the easiest way. The *Canal del Ferro* route, going from Carinthia into Friuli and thence to Venice, always provided an important alternative, towards both northern and central Europe. Goods and people moved according to the condition of the roads and state of political events. With the development of the new mines, Venice remained probably the major port for transhipment. ‘For that republic, metals from central Europe were as important as western woollens in funding its eastern exchange, in which it enforced a monopoly. Venice’s rise to commercial prominence in the thirteenth century was based not only on the growth of its trade overseas through the efforts of Venetians but also with growth of metal production in Europe, an achievement not of Venetians but of German miners and merchants.’[4] Metals, especially iron, were also required in the Arsenal for work in connection with ship-building, as well as directly for export. In both cases, the role of metals in Venice’s activity was fundamental.

Before the end of the tenth century, Frankish miners were working copper ore in Saxony but they mined both that and silver near Goslar. Some miners seem to have gone to Sweden in about 1200 to start the mines in Falun. The trade in copper also took place at Nuremberg, the metal coming through Hungary. German miners built up an international reputation and in 1115 some from the Harz mountains were sent to take up the exploitation of the Tuscany copper ores at Massa Marittima. In the later centuries, its extraction involved long 'roasting' and was known as 'the German process'; they were at the forefront of technical change.

German traders came down to Venice with the products of their mines, financed by leading merchants in Regensburg, Augsburg, Vienna and especially Nuremberg. The economic development of Nuremberg and Augsburg also benefited from Austrian mining production, with only part of Styrian and Carinthian metal being sold directly to Venice.[5]

Indeed the richest foreigner in Venice at the time of the Fourth Crusade was Bernard the German, who marketed the silver from the eastern Alps; his counterpart in mercantile activity was the merchant Ziani who made his money in the Levant trade that in practice only Venetians entered. In the fifteenth century increasing quantities of silver were taken to Tunis to exchange for Saharan gold dust, much of which also found its way east.[6] Venice continued to attract these northern goods, metals including iron, that were then sold on by its citizens, excluding the Germans from the long-distance trade. But equally their merchants had difficulties in selling directly in Germany. They remained the essential intermediaries. The *Fondaco dei Tedeschi*, the warehouse, residence and clubhouse for the Germans located near the Rialto Bridge, became 'a conspicuous symbol of the way Venice tied the mineral-rich lands beyond the Alps to the Mediterranean'.[7] In the thirteenth century, this trade was funded by the South German cities especially Nuremberg, a town whose inhabitants were always well represented in Venice. Nevertheless the traffic in mining was not all one way, even in Italy. Agricola speaks of Italians who came to the German mountains to wash rivers for gold and garnets.[8] Moreover, the exchange was never entirely passive. As well as the metals from the north and the spices from the east, the Venetians had their own manufactures. In addition there was the pilgrimage trade to the Near East with the profitable transport of the invaders; considerable currency was brought in by the Franks to fund taking the Crusaders to the Holy Land.

All this activity continued into the early Renaissance. Printing itself involved the use of metal type and the creation of metal machines. Later the Fugger, who had a hold on the copper from Hungary and the Tyrol, traded the metal mainly through Leipzig and by 1500, Jakob had pretty well established a world monopoly. This copper from Germany was exchanged for eastern spices (as well as for gold and other goods from Africa). After 1500 it was carried less by the Venetians, more by the Portuguese and from the sixteenth century was responsible for sending on increasing amounts of brass to Nigeria where they had facilities. West Africa received copper from the north as early as the twelfth century when a caravan from Morocco abandoned a load of brass in the Western Sahara. However local supplies of copper were also available and may have been used for the well-known Benin Bronzes. After the Restoration in England in 1660 the brass industry was stimulated in the country because of the renewed demand for trinkets, which had diminished during Puritan rule.[9] Nor was Europe alone involved in the international trade in these materials. Zinc was exported from China and it turns up in India and in Iran, much going into the brass that became so popular in Africa. The Chinese production of zinc probably began in the sixteenth century. It had started in India some centuries before but China's new distillation technology enabled it to dominate the world markets.[10] Tin was also used as an alloy for pewter; the fabrication of tin-plate was probably started about 1240 in Germany.

The casting of bronze continued to exist in Europe during the medieval period, especially using clay moulds for bells. By the fourteenth century, these bells were rung together and were more musical, so that their creation required greater attention. Cast bronze was used to replace the inefficient variety of wrought iron bell, and casting in iron came later. In China of course, cast iron and blast furnaces already had a long history, but further development of the latter virtually stopped with the Ming, leaving that to the west. The earlier types of furnace were the kind that formed the 'backyard' ones reintroduced in 1950 when China was going through a difficult period and wanted to increase its production of iron. In these furnaces, coal was early on used as fuel and cast iron was being made. Some steel was even being imported from India in the fifth century as to Rome in the west, for in certain ways steel made from charcoal was superior to that made from coal, being less polluted. However, the local production of iron in China was considerable. By the eleventh century, 125,000 tons were being made from the Northern Sung mines alone, compared with an estimated 150–185,000 tonnes for the whole of Europe in 1700. Iron was found throughout the region and major workshops employed as many as 100 workers, as was the case in

Roman potteries. After 1078, coal became the primary fuel, with higher-quality anthracite being used for crucible cast iron; in Japan the Tatara process was somewhat different. The technique of making large bronze casts was used for cauldrons and for Buddhist bronzes, and the process came to Japan from China around 200 BCE. In the sixth century CE it produced the large Buddhas at the ancient capital of Nara, which were cast in sections.

Venice became primarily interested in the silver that was brought in, refined in the ghetto like copper,[11] and then shipped to the Levant and to Cyprus.[12] Metal work was the original function of the ghetto area before it was allocated to the Jewish community in 1516. Some bankers also had workshops there for dealing with metals. The ore came down from Austria and Hungary which were known as the metal producing countries, the home of the 'mercationes Austriae', that is, those trading in gold, silver, copper, tin and lead in exchange for eastern spices, and even wool for fustian, according to one report of 1573.[13] At times however the passes over the Alps were blocked and the supply of metals was 'at a dangerously low level', so the market for Levantine products would be 'glutted'.[14] In the fourteenth century copper became yet more important to Venice as it came to be used for cannon as well sometimes in the Near East for currency. Cannons were employed by the troops of the patriarch of Aquileia in the war in Friuli when besieging the city of Cividale in 1376 at the very eastern border of the Italian states. Gunpowder only appeared in Europe in about 1375 'in close association with iron-casting; this had earlier taken place in China and its culmination was the highly resistant barrel of solid metal which permitted high-nitrate compositions to exercise their propulsive properties'.[15] Needham saw this as part of what he called the '[f]ourteenth-century Cluster', that involved block-printing, first appearing in the Rhine Valley of Germany at roughly the same time.

All these acquisitions, new and old, became part of Venice's own industry, to which much attention has been drawn in recent years. The products of that industry were used to trade with Africa, the Near East and with European outlets. Metal was refined for export, so too with wool and woven silk. Workers in the latter industry came from Lucca in 1314 to assist the members of the Venetian guilds.[16] Glass beads were made in Murano and these much prized yet very cheap objects were exchanged for African gold. That gold entered the trade with the Near East but like silver much found its way yet further east, the gold to India and the silver to China, a country that later also drew on the plentiful supplies from South America by way of the Philippines. There was however a darker side to this exchange. The main commodity traded between the European and Islamic worlds was slaves.[17]

Not only precious metals but iron too was available from the north of Italy. The interest that Venice had in this trade is shown by her attempt to get a political control over the mines high up in the Italian Tyrol, that fascinating region adjoining Germany and Austria. During the 1360s Venice tried to preserve trade routes to the northeast by making treaties with the rulers of Austria, who had recently taken possession of the Tyrol. At the time of the earliest workings of the mines, between 1300 and 1400, it was the Venetians who had had general control in that area. The Republic engaged in the inconclusive war of 1487 with Duke Sigismund, as he was then, and lost the silver mines of the Valsugana valley to the Tyroleans, leading to the advent of German miners and to the investment of some capital. In the second half of the fifteenth century mining recovered, and private capital came from Venetian merchants as well as from many Germans. Primiero, the site of the mines, became a 'mineral colony' where ores of iron as well as of silver, lead and copper were mined and exported through Venice,[18] especially the silver and iron. Iron also came to Venice through Udine, where the route was known as *Canal del Ferro*, the route of iron. It came down from the Austrian–German border as iron bars to be shaped by the local smiths, at Verona, Venice and elsewhere.[19]

The productivity of these various mines was considerable. Between 1559 and 1564 the miners extracted 1,122 kg of silver and 1,886 tons of iron, about one-third of which was shipped through Venice.[20] But despite this productivity, labour relations were disturbed. One Michael Gaismair, the son of a mining company owner, led the Tyrolean peasants' revolt of 1525–6 that was joined in by local miners; and he was also a figure in the early history of Protestantism. Heavy goods, timber and metals, could be floated down the Adige from Trento, and hence to the Adriatic, a system of transport that continued until the First World War. The Venetians had valuable holdings in the mountainous area but so too did the rich merchants of southern Germany and Austria, those of Augsburg, Nuremberg, Schwaz and Innsbruck, who had important mining and financial interests. Included among these merchants were the Fugger whose firm was a partner in the Tyrolean mines.[21] Not only mining, but metal work also flourished. Up to the Renaissance Northern Italy was a main centre for the production of weapons and armour, much for export. Milanese merchants in Valencia, which benefited from the link to the Atlantic, imported armaments and ‘other metal goods’ at the end of the fifteenth century. The main industrial town however was Brescia, which belonged to Venice and there is still an important industry of light weapons, such as Beretta guns, in the area. The Venetians themselves had a major weapons industry for casting cannons at the Arsenal.

The Fugger, so prominent in the mining world of the area, were a staunchly Catholic family who with their financial acumen had organised the sale of indulgences for the Papal court and they had also established an agency within the German *Fondaco* in Venice. Their interest was primarily in metals and in money, especially in gold, silver and copper, which led them to extend their involvement to Silesia, Slovakia, as well as to Carinthia, Antwerp, Spain and eventually to New Spain. They became the owners of the mercury mines in Almaden through the confiscation of a pledge, having lent the state a substantial amount of money.[22] They were also engaged in the slave trade as well as in spices, but after the Thirty Years’ War (1618–48), they retired from business to live as nobility on their large country estates.

In early modern Europe, it was Germany that was involved in the design of more efficient furnaces.[23] They were the professionals in metallurgy: ‘The Germans were for many centuries the most skilled miners, and English mining owes much to their enterprise.’[24] Herman de Alemannia was working a mine near Dulverton in 1314 and Thomas de Alemaigne was a silver smith who re-used the refuse of mines in Devonshire; he also worked mines in Cumberland. Tilman of Cologne farmed the Alston mines in 1359. Mining then suffered a depression and it was indeed not until Elizabeth’s reign that a group of German engineers and English enterpreneurs revived the industry. In 1528 Joachim Hochstetter had become master of the mines in England and Ireland. He arranged to make a start with a thousand men under the supervision of six German experts. In 1561 Queen Elizabeth had ‘by the advice of the Council sent over for some Germans experienced in mines’[25] and presented the workings of eight counties to Daniel Hochstetter. The reason for calling in German miners was the apprehension of Spain that made England desirous of seeking self-sufficiency in metals.[26] There were substantial Catholic enemies. Contrary to the Papal ban on trading with

Muslims, Queen Elizabeth of England had supplied the independent state of Morocco with wood for ship-building, scarce in North Africa, as well as with the harquebusier to operate firearms in return for saltpetre to make her own powder. And there was always Saharan gold. El-Mansur, the ruler of Morocco, had recently beaten off a Portuguese-backed invasion; even the Turks, rulers of the neighbouring North African countries, were wary of him. It was these imports that helped the ruler mount an expedition to try and reach the sources of that gold, which England was also trying to find along the Gambia River.[27] The beginnings of the British trade in metals and in arms was involved with the hunt for gold, for exchange in Africa and from piracy on the Spanish main, and in particular with the commerce in wood for sailing ships, in harquebusiers for hand guns and, in the other direction, in saltpetre for gunpowder.

This concern with the external situation led to Elizabeth's desire to rehabilitate the mines, largely due to the need for metals for military purposes, especially for cannon for ships such as the Great Harry built earlier in Henry VIII's time. The introduction of cannon, which had been made since the fourteenth century, did away with the galleys and the use of oars, especially for the galleon, a ship with two or three decks carrying its main batteries on the broadside and lighter pieces fore and aft of the ship that had earlier been used for battering rams. That change led to the development of the sail and of sailing once again.

It was in 1543 that an English priest in royal employ developed the cast iron guns that were able to replace the bronze cannon; bronze was stronger than wrought iron ones but expensive, so that the development of a cast iron variety by the beginning of Elizabeth's reign meant that the English navy could be fitted with cheaper iron guns. This gave them a considerable advantage over other navies. Indeed already the enemy ships of the great Armada of 1588 were not only slower but had fewer short-range guns; their fleet was trained to close and board the enemy whereas the English navy could stand back and fire. The installation of cast iron guns also made the ship heavier. This is probably why the Venetians stuck to bronze cannon. Their galleys had to remain light and fast; they depended on speed and they could reach 10–11 knots under full oar. With light boats of this kind, these heavier cannon would have been impractical.

The entrepôt of Spina, an international emporium set on the navigable upper reaches of the Po River and frequented by Illyrian and 'Celtic' traders, would have traded in metals as at ‘Ferrara’ (‘the place of iron’), the centre near Spina that developed after the silting up of the Po estuary. This then represented the major market competing with nearby Ravenna for trade with the east.

The struggle against Spain was important not simply for the acquisition of precious metals from South America but for the advancement of British sea-power, leading to the expansion of trade but also to the acquisition of territory such as the North American colonies and later India. The ensuing prosperity was the basis of the greater use of metals, and for the development of smelting conveniently situated iron with nearby coal or coke. That situation led to the ‘Industrial’ (and the ‘Consumer’) Revolution of that country.

But it was not the result of greater inventiveness, given the achievements of Chinese science chronicled by Joseph Needham. Nor yet of the greater ability to explore the known world, given the Chinese voyages to Africa and their outposts in Baghdad, Malacca, South East Asia and Indonesia. Nor yet of their greater entrepreneurship, given the Chinese exports of porcelain throughout the world in the eighteenth century. It was a more temporary advantage that above all England acquired over her rivals in Europe, principally Germany and the Low Countries, and in Asia, over China and India.

The notion of self-sufficiency became crucial in times of war and war played a very important role in the development of capitalism in Europe and of east–west relations. The incoming Germans under Elizabeth looked at Britain from a somewhat colonialist point of view for they wanted the metals that they helped to mine to be sent back to their own country to be smelted. This export was however stopped by Queen Elizabeth, who had invited miners for her own purposes. She prohibited the transfer of strategic materials, being all too wary of the Spanish situation. But England was short of charcoal for metal work and although coke-smelting was beginning around 1710 to 1720, the deficiency led to the fostering of the iron industry in the American colonies. In the 1640s the works at Saugus, Massachusetts, were started by Winthrop, but well before that, in 1564, Raleigh had found ore in North Carolina. Later on restrictions would be placed on the development of the overseas industry in order to try and preserve iron-working in England. This was helped by the import of charcoal before coke took over, partly because the price was cheaper but also because to cope with this new fuel the furnaces had to be increased in size for economic reasons.

On the influence of German miners in England, there are the references in 1581 to Joachim Gaunz and the copper mines at Keswick, the efficiency of which he improved.[28] Other Germans too were involved, such as Ulrich Frosse in the tin mines of Cornwall, Christopher Schutz (who found the Calamin Stone) and Thomas Thurland. Together with some Englishmen they formed the ‘Company of Mines Royal’ and they may have introduced the method of stamping into Cornish mines as well as the jigging sieve. Stamping possibly originated at Schwaz (in the Tyrol) in 1519 for the contribution of German and Dutch mining engineers to British industry was clearly of great importance, and remained so. However the traffic was not all one-way; there is also an account, based on the Benedictine monk Matthew Paris who died in 1259, claiming that the art of tin-mining was taught to Germany by a Cornish miner who had fled there because of a murder.

German migrants went not only westwards to England but by 1560 to Ireland to assist in the mining of tin and silver, as well as, long before, eastwards to the Carpathians. The Germans also had a continuing interest in older mines and Charles V maintained his own two silver ones in Spain, while his daughter, Marie of Hungary, drew her dowry from silver from the Carpathians. But it was not only precious metals that interested them but iron as well; in fact iron it was that formed an intrinsic part of the German identity. Iron-working had been practised in Southern Germany since the Hallstatt era in the eighth century BCE and was seen as coming from that region. From there its use had passed to France and then to Britain, as well as to Scandinavia. From that period the working of iron was particularly bound up with the identity of the German people, who maintained their interest in the work and became known as metal-workers, swordsmiths and later as gunsmiths. Hirschi makes this ‘national’ identity clear in his discussion of Sebastian Münster’s work in the sixteenth century, who wrote, stressing the role of metals in their exchange with the east:

> Europe is rich in gold, silver, copper, tin, iron; especially in Germany and Norway great quantities of silver and gold are dug out of the mountains. Hungary has the best gold. Carinthia the best steel. Spices, precious stones, perfumes such as incense, etc. are not found in Europe but are brought from Asia.[29]

Hirschi comments in a more expansive manner, following his source in stressing the ‘spiritual’:

> here sexual semantics come into play. When Münster attributed a great wealth of metals to Europe, he

was endowing the continent with the same quality he had earlier attributed to his own people: ‘virile/manly/male’. The supply, refinement, and use of metals demanded male strength and skills, from mining, through the art of the smith, to war. Münster’s characteristic recognition of parallels between countries and peoples reflected in its turn the analogical thinking of ancient climatology. Conversely, spices, precious stones and perfumes represented a culture of refinement and effeminacy which in the later Middle Ages was portrayed as a threat to European morals.

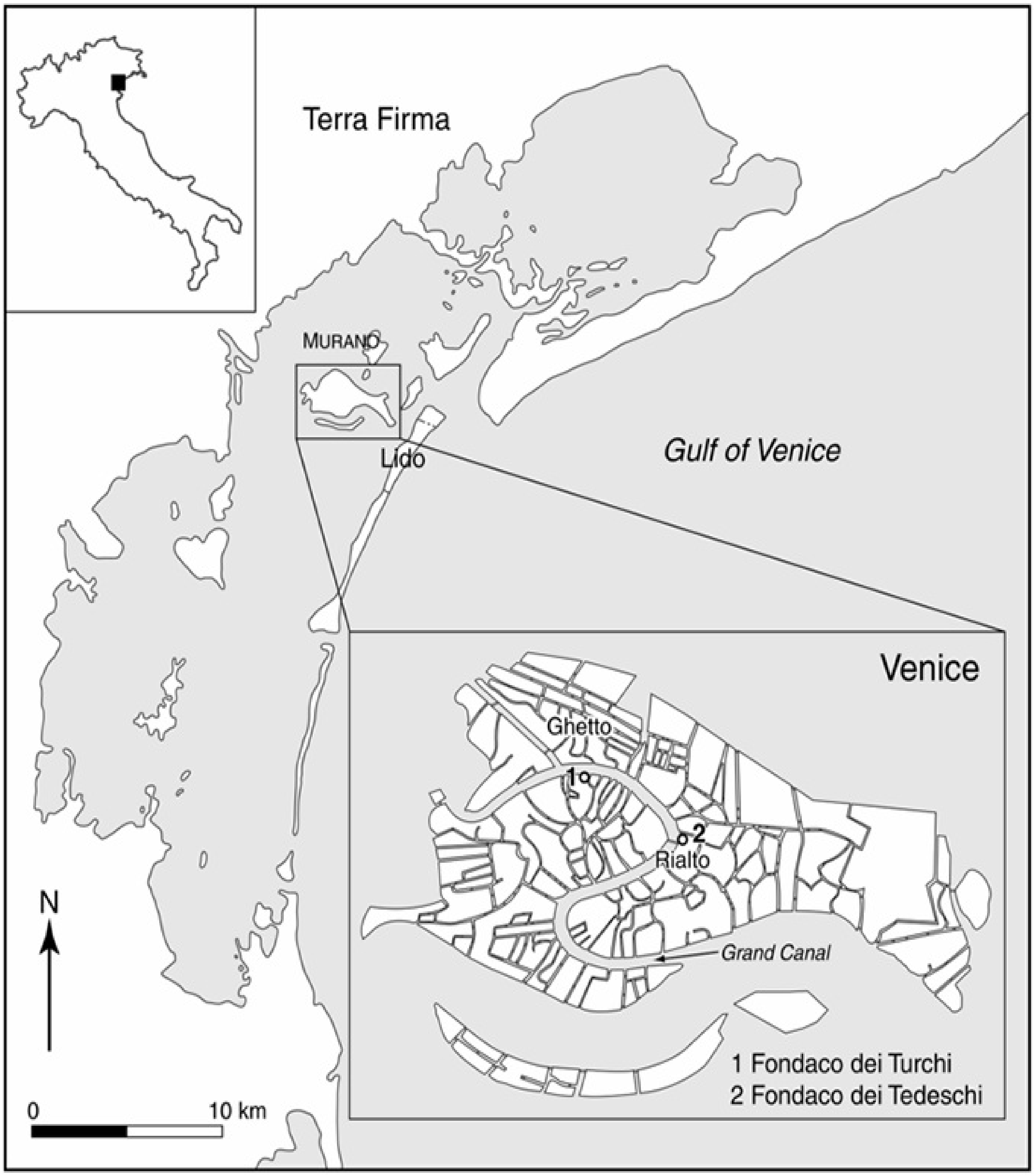
Other motifs associated with the competition for power and territory were the expansion, topography, climate and population size of Germany. Franciscus Irenicus [in 1518] conferred the seal of quality on German air, namely that it allowed the Germans to grow older than all other peoples. As for German soil, he asserted that it concealed a wealth of metals greater than that of Arabia or India; it allowed not just water but pure gold to flow down the Rhine. Nowhere else did the mountains rise so high as in Germany. Irenicus had no need to be inventive in this matter because years earlier Wimpfeling had sounded the same tune. The Alsatian had taken issue with the Italians and the French over their mutually exclusive claims to possess the temperate climactic zone.

In addition Germany is supreme by virtue of the soft winds, the amenity and utility of woods and hillsides, the abundance of broad rivers and hot springs, and the absence of cruel wild beasts. God has denied Germany nothing that is necessary for life: riches, meadows, lakes, crops, vineyards, wines of different types, wool, linen, clothing, cattle, horses, metals: gold, silver, copper, iron. Not only the mountains but the rivers Rhine and Danube ensure that Germany is not inferior to the Pactolus and the Tagus. On the other hand it lies far away from the sea, which Plato calls the teacher of dishonesty.[30]

Thus in the Renaissance the Germans, who adopted the Italian culture from Venice and North Italy, were identified, or self-identified, in humanist writings, as they had earlier been, with metal-working, with the making of guns and with other related inventions that led to the modern world, though much of the Nuremberg metal for export was small and decorative – such as for bells and bracelets rather than for tools or arms. It was this identification that sent them to the metal outcrops of western and eastern Europe, including the interior of Asiatic Russia. For there were many metals there too, especially in the Urals where, in the eighteenth century, Peter the Great established the most advanced iron industry in Europe. There had already been a number of important exploitations at Khandon in the seventeenth century, the industrial centre of the iron industry, and in the Ukraine generally, at what became Gorky. But the land behind the Urals had always been important for metals, right from their very introduction and for the transmission of metal-working to China, but especially during the early Iron Age among the many peoples that lived in the Eurasian corridor. This association continued with the Turks and the Mongols, and attracted German miners to work there.

In 1253–5, two years before the voyage of Marco Polo, the friar, William of Rubruck, made a journey to the Mongol court and reported coming across a village of ‘German slaves’.[31] This was near Talas in the Caucasus, approximately 170 miles north east of Tashkent, and belonged to Büri, a relation of Batu and Chaghtai, the Mongol leaders. In a city called Bolat the Germans were 'mining gold and manufacturing weapons'.[32] Clearly these men had become 'slaves' of the Mongols and were there for mining purposes as well as for the associated work of gunsmithery. It was these Christian miners, lacking a priest, who were the principal reason for the friar's visit, but as they were working on weapons, and had been moved to a different place, he was not permitted to see them. His visit to the Mongols was one among several at that time, made with the diplomatic intention of persuading these people to ally themselves with the Christians to defeat or at least constrict the Muslims. It was a curious situation for German metal-workers to be in but they seemed to have continued to work there as a semi-autonomous community until after the Second World War.

The strong interest in iron and other metals meant that the port of Venice provided a key service not only in the export trade to the east but also for their own industries, ship-building, printing, glass-making and metal-working (Map 14). In this exchange the old Roman town of Verona was important in providing a link with Germany along the valley of the Adige; in 1405 the citizens of Verona swore fealty to Venice but nevertheless they were granted liberties regarding trade, as was Brescia nearby.[33] Both these towns had the privilege of running fairs, of which the town of Bergamo, also involved in metal work and in the trade with the north, had the most important *kermesse* in sixteenth-century Italy. While they retained some liberties, Verona, Brescia and Bergamo remained under a strong church influence and religious orders were the major land owners. In the twentieth century several popes came from Bergamo and Brescia. But there were still many problems for Venice. In 1320 the Pope had banned Venetian trade with Alexandria, and those merchants who defied the ban were excommunicated, but not the whole city. That independence made it freer in some other ways too. From 1520 Lutheran books in Latin circulated in the town, although Rome soon made protests against their presence. Book production nevertheless remained less restricted than elsewhere.



Map 14 Venice

The opening of the trade routes to the east by the Atlantic powers had a long-term effect on Venice’s commerce, though not immediately. Trade now increased with central and eastern Europe. While the town developed its own industrial activity and new wealthy families were slowly admitted into the ruling elite, especially in time of financial and political crisis, its earlier dominance of the eastern trade effectively disappeared, though Venice did start to purchase spices in Lisbon. The Arsenal also lost its supremacy as a naval supplier. Starting in the late sixteenth century, Venetian ship owners commissioned Dutch builders whose ‘construction costs were significantly lower’, involved as they were with the increase in voyages to the Atlantic and the East.[34] Even in the Mediterranean, Atlantic shipping, based on Leghorn (Livorno), which also acquired an important Jewish population,[35] gradually imposed itself and the trade opened up to merchants from the west, especially the Dutch and the English.

As Venice’s trade routes with the east became of less importance – though as Braudel notes, never unimportant – so its relations with the west and the north increased. The Republic continued to be of significance as a major artistic centre and as a producer of luxury goods. But a new focus developed at Prague which was important not only in the silver trade from the nearby mines but also because it became the capital for the Holy Roman Emperor, Rudolph II, son of Maximilian II, in 1583, attracting both art and artists, especially from Venice.

With the exploration of America, the primary resources of Europe became of less importance. After developments in printing, and especially with the arrival of the rotary press and the daily newspaper, wood, which was needed for paper to fuel the ‘information society’, came from the forests of Canada.[36] Basic metals were supplied by North America. But after the Spanish invasion of South America it was especially the flood of precious metals that changed the situation in Europe; there was gold looted by the invaders and there was the production of the Potosí silver mine in Bolivia. With these developments across the Atlantic, the balance of Venetian affairs began to change. Although activities in the important Arsenal slowed down, recent researches point out that the management of state forests in the Alps never ceased to be an important source of business for the capital and local entrepreneurs. The silver firs (*abies alba*) of major forests (the so-called *Foreste da Rema* such as the *Cansiglio* and *Cadore* forests) still provided materials for masts and oars (though in a lesser quantity than in former centuries) as well as providing the best wood for Stradivari’s violins. In the changing economic climate forest wood became more important as timber and thousands of firs ended up in the foundations of Venetian palaces. The buildings of Venice, as well as the management of glass-making at Murano, accounted for the depletion of forests of the whole Adriatic area which was much lamented by enlightened economists.[37] In southern Europe fir forests were scarce but Venice needed a straight, strong wood. This was then taken to the river Piave and thence on to the capital where until the end of the Republic the oars were used to row the galleys to the Adriatic in waves that made the water very choppy. Meanwhile the production of non-precious metals moved elsewhere, to North America and, in Europe, to Middlesbrough, for example, where iron and coal were both plentiful and easy to recover and to process as cast iron.

In this great change the ability to cast iron was central. The Hoovers describe the making of 'bloom' and go on to detail a second process which concerns the working of iron in a furnace similar to a blast furnace but wider and higher, the German Stückofen or Catalan high-blooming furnace, to make 'masses' of wrought iron under essentially the same conditions as its predecessor, only on a larger scale.[38] With high temperatures however such a furnace could yield molten metal, and thus make the step to cast iron very easy. The making of malleable wrought iron by the treatment of the cast iron by the indirect process originated about Agricola's time. But did he understand this? For he does not discuss the sixteenth-century method of converting cast iron into wrought by roasting the pig-iron to eliminate carbon by oxidation, with subsequent melting to a 'ball' or 'mass'. In fact the puddling for this purpose did not come into general use until the end of the eighteenth century.[39] We do not know when cast iron was first made systematically, but cannons of this metal appeared at the end of the fourteenth century. That this late date for liquid iron in Europe may need to be revised is suggested in Craddock (2003). Despite this development, wrought iron was still in high demand in Europe so that the product usually had to be converted. The blast furnace, which was the next stage, required more capital and represented the end of Iron Age 'democracy' and the triumph of the money-men, at least in manufacture. The blast furnace and cast iron had been assumed to come from China but the case for independent discovery is now stronger with the discovery of the Swedish blast furnaces of the thirteenth century and its production in the Swabian Alps of central Germany as early as the twelfth century.[40]

As far as carburation was concerned, steel lay between wrought and cast iron, having higher carbon than the former and lower carbon than the latter. There were two variants of steel, 'soft' and 'hard', and in most places the material was used sparingly; it first had to be made from pure charcoal iron and was therefore particularly important in Scandinavia where these ingredients were plentiful. Swedish steel was exported to Britain, and charcoal and sheet iron from Russia. This was now made in larger kilns. But steel alone was too brittle for swords and so the cutting edges had to have an iron core; with these steel products, it was hence only in the seventeenth century that the new production techniques were introduced.[41] Cromwell could then buy swords from Solingen, which had been a medieval centre, for 7*s*. 6*d*., many being swords of fashion. In 1685 experienced German swordsmen were brought to the country to make blades at Shotley Bridge near Newcastle where they established a flourishing business; iron guns were also cast, following very much the technique of bell-making.

Copper-making continued in small furnaces and this too was a speciality of the Germans whose processes were adopted in many parts of Europe, including Britain. As we have noted, Germans were imported by Queen Elizabeth to modernise the mines. These mine-engineers organised those in the Lake District and set up a smelter at Keswick, very much according to Agricola's model, which in 1544 had six furnaces.[42] The process moved to Neath in South Wales in 1584 and was used to extract silver, but there was a problem in finding customers for all the copper.

In their discussion of the history of metallurgy which accompanies their edition of the Renaissance writings of Georgius Agricola, the German author of *de re metallica* (*Concerning Metals*), Herbert and Lou Hoover (the later President Herbert Hoover was himself a mining engineer), the editors of the volume, say: 'Considering the great part that metals have played in civilization, it is astonishing what a minute amount of information is available on metallurgy.'[43] There was the work of the classical authors, then a virtual blank except for the writings of the monk, Theophilus (see below), and of the Alchemists, very much part of Islamic knowledge. That gap existed largely because alternative enquiries into nature were not at all encouraged in Christian writings, or thought trivial compared to theology, the exploration not of this but the other world. About this world, all had already been said in the revealed word of God, that is, in the Creation story in the Bible (and for others in the Quran) so that enquiries had to be referred back to the Jewish 'myth'. Even in the eighteenth century William Pryce claimed that the secrets of metallurgy were probably 'not revealed to Adam' and they required the heavy toil that came with the Fall. So metals were only discovered by the smith, Cain.[44] The discussion of 'nature' was entirely dominated by religion, so there was little written on metals between

Antiquity and the Renaissance. For many, all had been said about the natural world. Augustine (354–430 CE), for example, was at first strongly influenced by Manichaeism with its dualist philosophy, rejecting the flesh (and nature) as unimportant and impure compared to the soul. Later Augustine formally abjured this doctrine as well as Neoplatonism but retained some elements in his thinking. True knowledge, he claims, was of God and of the soul, which came from looking within, not without. It was the task of Christian philosophy to seek and expand true knowledge, guided by scriptural revelation.

Early Christian schools attempted to synthesise religious and classical education but these institutions were largely swept aside by the 'barbarian' invasions after which the Church established teaching in monastic establishments with its own curriculum aimed at religious salvation not at secular knowledge. The 'grammar school' at St Albans was held in the Lady Chapel of the Abbey until the middle of the nineteenth century, emphasising its earlier role. The extreme version of this approach to the secular was represented by Manichaeism and by the Cathars of Southern France, with their other-worldly despisal of the body and of all earthly things. But such a dichotomy was not altogether absent from other forms of Christianity. What needed to be known about the world was laid out in the sacred text. Such a view of nature was not necessarily universal but it was dominant until the Renaissance and the Reformation. It led to stasis in many spheres. In his history of metals Aitchison speaks of the 'long period of intellectual torpor' and of a revival of interest in intellectual pursuits.[45] I myself would put it somewhat differently since people were still engaged in intellectual pursuits but in those associated with the other world. From my perspective there was a lull in systematic enquiries about the world outside. This preoccupation was epitomised in Caliph Omar's reported saying about the contents of the great library of Alexandria (any books that do not agree with the Book of God should be destroyed) and in Saint Augustine's rejection of secular 'philosophy'. For them everything had already been said about 'nature' in the holy texts; they had no need of 'curiosity'.

At the height of Venice's powers, she sold her services for the transport of the Crusaders. These invasions helped to stimulate the interest in metal-using in the west, as well as revealing the high standard of living of the bourgeoisie in the Byzantine and Muslim Empires. The consequence of this war was that much treasure was taken back to Europe and the products of the 'metal-working skills of the Arabs, the Persians and other eastern nations flowed westwards'.[46] The Arabs themselves introduced no new techniques for mining metals but they did influence the fabrication of metal goods, and the work of the Alchemists had considerable importance upon their treatment. But in the thirteenth century, the west gradually became more independent of the east, especially in the employment of energy for mechanical purposes. It had more easily available sources of power both in water and in wood and coal.

In Christian Europe, there was little original interest in nature, especially metals, but nevertheless a trickle of written information did appear in the medieval period. Publications on metallurgy were not altogether absent[47] but they were hardly concerned with the domestic use of metals, except for the work of Theophilus, probably a Greek monk who had settled in Germany. He gave an important description of bell-making in *de diversis artibus* (*Concerning the Various Arts*, c. 1110–40). But there is little else until we come to the fifteenth-century handbooks again from Germany, which were distributed at the end of that century by the new printing presses in regions like the Black Forest and the Harz. These were areas that contained plenty of wood, ore and water and at different times had been colonised by Flemish, German and Roman settlers.

Things were beginning to change. The Renaissance writings of Agricola represented the new order in Europe. Agricola (born Georg Bauer, 1494–1555) was a Saxon who took a medical degree in Italy and became a physician in the famous mining centre of Joachimsthal that produced coins known as *thalers* that us the *dollar*.[48] The 'district in which Agricola lived [the Harz and the Erzgebirge] was still the foremost metal-mining and metal-winning region of the world' and the centre of German activity.[49] He later found himself in the middle of the wars of religion between Catholics and Protestants; although he knew many Protestants, he remained a staunch Catholic throughout, and could not therefore be buried in the local cemetery at Halle. At the time he grew up, many students in Europe were flocking to the Italian Universities, Columbus had just 'discovered' America and a few years later Vasco da Gama rounded the Cape of Good Hope on his way to India, while Cortes entered the city of Mexico in 1520.

Agricola first attended the University of Leipzig, where he later became a lecturer; the university was one of the first to be influenced by humanism. He then visited Italy for a period of three years to carry out further work in philosophy, medicine and the natural sciences, going to Bologna, Venice and probably Padua, from which universities he would have drawn the inspiration to work in the natural sciences. He was critical of the writings of the Alchemists, who repeated theories as to the origin of metals, while he was more concerned with practical mining. But he nevertheless seems to have accepted some of their theories and one historian even writes of him as an alchemist.[50] Nor was he the only scientist to accept some of their ideas. At that time he worked with Aldus, the publisher, and also became a friend of Erasmus, who printed some of his scientific work, though he was friends not only with humanists and with proponents of the New Learning but also with many outstanding Protestants, including Melanchthon. Back home in Germany, he lived in a Saxon mining district, spent a lot of time in mines and became a shareholder in a mine appropriately called God’s Gift. His work was based not only on observation but on considerable classical learning, for as we have seen there was little else to consult: ‘Apart from the book of Genesis, the only attempts at fundamental explanation of natural phenomena were those of the Greek Philosophers and the Alchemists. Orthodox beliefs Agricola scarcely mentions; with the Alchemist he had no patience.’ Before Agricola there were therefore three views of ore deposits, that of Genesis, that of the Greek philosophers and that of the Alchemists. During the Middle Ages it was difficult to dispute the first. The second was dominated by Aristotle and the Peripatetics.[51] Regarding the third, ‘this muddled view’ made ‘harsh reading’. The work of the latter consisted not only of those in the Arab tradition going back through Geber (Jābir ibn Hayyān), for there were Egyptian and Greek varieties too. However it is the Arab activity that gave the practice its name though Agricola’s views were more influenced by Aristotle and the Peripatetics; leaving aside the Alchemists, he considered that ‘the whole thought of the learned world still flowed from the Greeks’.[52]

Agricola had visited Bologna which had only been part of the Papal States since 1506, a little before his arrival, when it was besieged and annexed, putting an end to the Libero Comune which had defeated Federico Barbarossa and captured his son who died in the city’s main tower. The Catholic Council of Trent later stopped the historical freedom of the University by introducing all sorts of checks and regulations. Paradoxically, this meant that the reaction to interference kept on the old tradition of Aristotelian ‘materialist/progressive’ thinking as against the dominant Neoplatonism of the rest of the Italian Universities – even including Padua.

However, the latter, being under Venice, that never missed a chance of asserting its independence from the Pope, enjoyed more ‘liberal’ policies and attracted more ‘modern’ thinkers from the sixteenth century, thus overtaking Bologna in fields such as medicine in which the former had for some time been the leader. This then was the context of his instruction in two universities that had early anatomy theatres where one could pursue observational knowledge of the human body.

Agricola, being well trained in the classics, has many references to Aristotle, Theophrastus, Strabo and so on. The reason for this antiquarianism is interesting. While technology had advanced slowly in the intervening period, it was not a subject for writing. During the Middle Ages, writing about nature was disapproved of by the Church except as biblical commentary. In Late Antiquity learning had been greatly influenced by the coming of Christianity that had directed attention to its own literature as distinct from the ‘pagan’ or classical variety. There was pressure to focus on the religious, which was seen as directed towards the saving of one’s soul and to the acquisition of theological knowledge, knowledge about that soul and the other world. Christian knowledge itself started from scratch, except for the Hebrew Bible; it had no other past. Jesus himself was supposedly not literate and certainly his teaching proceeded through oral channels.

In the Middle Ages, the main exception to this absence of writing about metals, as we have seen, was the German, Theophilus, who described a number of crafts, including metallurgy. His work *de diversis artibus* contains the first references in north Europe to paper and to oil painting. But in general it was only by looking back to ‘pagan’ antiquity that such scholars could think freely of nature in the way classical authors had done. In this, Agricola was very much a Renaissance man, having attended the universities in North Italy at a time they were partly independent of the Church. After that he taught classics and his writing, as we have seen, was full of antiquarian references. However, his experience in the mines meant that his scientific work was founded on ‘research and observation’. He led the battle for observation as against the inductive speculation which transcendentalism had encouraged. His work on metals represents ‘the accumulation of generations of experience and knowledge’ of a practical kind, but he was the first to give them ‘a detailed and intelligent exposition’, since earlier writers had not been interested in technological developments.

In this way Agricola combined both theoretical and practical knowledge.

He had as we have seen spent some time engaged in actual mining; he had also attended universities in Germany as well as in North Italy. His text is littered with drawings, with numerous pictures of machines and with many classical references. This combination was in itself interesting. But more importantly he succeeded in bringing the activity of miners into the framework of the written tradition. In so doing he did what literacy is able do so well; he increased systematic analysis and thereby promoted the rhythm of change, because people could now look back to a defined source and then produce the new. Literacy did not always do this; in a transcendental or theological context, the aim was to conserve the text and to eliminate the novelty and creativity that characterised parts of many 'oral' religions. A religious text was fixed in writing, whereas orality bubbled with variations. But such a stasis could happen even in a secular context, as when Confucianism became a canon. The contrast between the written and the oral represents what Childe had discussed for Ancient Egypt – that is, the separation between those practitioners with practical building and craft traditions 'which were not committed to writing'[53] and the learned development in theoretical understanding which was entrusted to a leisured class of scholars. In hegemonic religions even the advantage of writing in providing a fixed point from which to encourage the new was negated by the role of the priesthood which included the teaching and conservation of the Holy Book where the answers to 'theoretical' questions were unchangeable and already fixed in a text. Change was not permitted. Nevertheless in earlier times there was a constant division in knowledge between the practical traditions, which often remained unwritten, and the written traditions that developed 'theory', or presented 'dead' theory. This division is one that Needham refers to in distinguishing the knowledge of the clerk from that of the practitioner. The supposed reduction of the gap between the two in the Italian Renaissance had to do with his division between earlier science (as in China) and the true sciences (as later developed in Europe). He thought the Renaissance brought the two closer together.[54] However, the main result of writing in both cases was not to conserve so much as to provide a firm platform to build on what had gone before; that was done in different ways. This was not the only way to advance knowledge but it was an important result of writing. In medieval Europe, however, there appears to have been little written on technical subjects since classical times, but on the other hand there was both the written and the practical work of the Arab Alchemists, and others, which ‘gave a great standing to industrial chemistry in the discovery of the mineral acids, and described distillation apparatus of approximately modern form’.[55] Advance of knowledge there was in both areas, but this could be held up by religious or authoritarian considerations.

The crystallisation of a scientific or humanist tradition came about however only with the advent of writing which produced the divergence between ‘science’ and ‘technology’. And writing was itself a development in the emergence of specialisms, which Childe saw as linked to the coming of the Bronze Age. These were found earlier but were certainly promoted by the coming of metals. And they were clearly linked to economic and cultural complexity and to the production of a food ‘surplus’ that made possible the withdrawal of personnel from farming so they could fill other occupations and live by exchanging their products or services for food. Some of these developed as metal-workers, as record-keepers, later even ‘scientists’ working full- or part-time at the activity. It was the same with the arts and ‘entertainment’ that have played such an increasing part in peoples’ lives. These achievements were all built on the simple production first of ‘Neolithic’ and then Bronze Age societies, because in both cases there was a significant withdrawal of full-time labour from food production, and at the same time a commitment to one of the many alternative pursuits that man had developed. It was in general the new techniques of food production that enabled humans to engage fully in these other activities, which then acquired a momentum of their own, as with all such subjects, as with metallurgy or with the arts. This account depends upon a certain view of ‘development’, even of social evolution, which does not apply to all aspects of the growth of human life, but primarily to production activities, not to moral rationality. This is not being ‘materialist’, it is being ‘historical’, and in this process libraries and metals went hand in hand.

Turning back to the observational, Agricola discusses the economic exploitation of miners whose conditions have not in many cases changed a great deal since the working of the Egyptian mines. In the second century BCE the Greek geographer Agatharchides, quoted by Diodorus Siculus and by Photius, presents an account of gold-mining, which began early in the country’s history, and which gives a very different picture to the ‘progressive’ one of Agricola. The mines were manned by criminals, prisoners and the enemies of the Pharaoh, and the conditions were truly terrible:

Out of these laborious mines, those appointed overseers cause the gold to be dug up by the labour of a vast multitude of people. For the Kings of Egypt condemn to these mines notorious criminals, captives taken in war, persons sometimes falsely accused, or against whom the King is incens'd; and not only they themselves, but sometimes all their kindred and relations together with them, are sent to work here, both to punish them, and by their labour to advance the profit and gain of the Kings. There are infinite numbers upon these accounts thrust down into these mines, all bound in fetters, where they work continually, without being admitted any rest night or day, and so strictly guarded that there is no possibility or way left to make an escape. For they set over them barbarians, soldiers of various and strange languages, so that it is not possible to corrupt any of the guard by discoursing one with another, or by the gaining insinuations of familiar converse. The earth which is hardest and full of gold they soften by putting fire under it, and then work it out with their hands. The rocks thus soften'd and made more pliant and yielding, several thousands of profligate wretches break in pieces with hammers and pickaxes. There is one artist that is the overseer of the whole work, who marks out the stone, and shows the labourers the way and manner how he would have it done. Those that are the strongest amongst them that are appointed to this slavery, provided with sharp iron pickaxes, cleave the marble-shining rock by mere force and strength, and not by arts or sleight-of-hand. They undermine not the rock in a direct line, but follow the bright shining vein of the mine. They carry lamps fastened to their foreheads to give them light, being otherwise in perfect darkness in the various windings and turnings wrought in the mine; and having their bodies appearing sometimes of one colour and sometimes of another (according to the nature of the mine where they work) they throw the lumps and pieces of the stone cut out of the rock upon the floor. And thus they are employed continually without intermission, at the very nod of the overseer, who lashes them severely besides. And there are little boys who penetrate through the galleries into the cavities and with great labour and toil gather up the lumps and pieces hewed out of the rock as they are cast upon the ground, and carry them forth and lay them upon the bank. Those that are over thirty years of age take a piece of the rock of such a certain quantity, and pound it in a stone mortar with iron pestles till it be as small as a vetch; then those little stones so pounded are taken from them by women and older men, who cast them into mills that stand together there near at hand in a long row, and two or three of them being employed at one mill they grind a certain measure given to them at a time, until it is as small as fine meal. No care at all is taken of the bodies of these poor creatures, so that they have not a rag so much as to cover their nakedness, and no man that sees them can choose but commiserate their sad and deplorable condition. For though they are sick, maimed, or lame, no rest nor intermission in the least is allowed them; neither the weakness of old age, nor women's infirmities are any plea to excuse them; but all are driven to their work with blows and cudgelling, till at length, overborne with the intolerable weight of their misery, they drop down dead in the midst of their insufferable labours; so that these miserable creatures always expect the future to be more terrible than even the present, and therefore long for death as far more desirable than life.

At length the masters of the work take the stone thus ground to powder, and carry it away in order to perfect it. They spread the mineral so ground upon a broad board, somewhat sloping, and pouring water upon it, rub it and cleanse it; and so all the earthy and drossy part being separated from the rest by the water, it runs off the board, and the gold by reason of its weight remains behind. Then washing it several times again, they first rub it lightly with their hands; afterward they draw off any earthy and drossy matter with slender sponges gently applied to the powdered dust, till it be clean, pure gold. At last other workmen take it away by weight and measure, and these put it into earthen pots, and according to the quantity of the gold in every pot they mix with it some lead, grains of salt, a little tin and barley bran. Then, covering every pot close, and carefully daubing them over with clay, they put them in a furnace, where they abide five days and nights together; then after a convenient time that they have stood to cool, nothing of the other matter is to be found in the pots but only pure, refined gold, some little thing diminished in the weight. And thus gold is prepared in the borders of Egypt, and perfected and completed with so many and so great toils and vexations. And, therefore, I cannot but conclude that nature itself teaches us, that as gold is got with labour and toil, so it is kept with difficulty; it creates everywhere the greatest cares; and the use of it is mixed both with pleasure and sorrow.[56]

It was not any different in Han China, where there were ‘thousands of convict brethren, toiling and dying in the satanic iron mills’.[57]

I have paid little attention to the ‘spiritual’ side of metals. This has been discussed by a former Chief of Cabinet at the Ministry of Public Works in Paris, Paul Sébillot, who wrote extensively on the subject, recounting in considerable detail many of the earlier beliefs of miners through the world in his account of the relevant folklore.[58] More recently the student of early religions, Mircea Eliade, has written a book about the rites and beliefs associated with early metallurgy, entitled *The Forge and the Crucible*. The problem is that it proceeds from a vaguely Jungian approach, with metals being born of Mother Earth, the ores being embryos;[59] the ‘Metallurgy thus takes on the character of obstetrics’[60] with the mine as the uterus. The confirmation of these theories is drawn from here and there, everything thus being illustrative of a spiritual view of the world, an ‘archetype’ of ‘a trans-psychological’ kind; it does not seem to matter where the example comes from. In every case it represents a ritualised belief of ‘primitive societies’ that is the opposite of ‘modern’ scientific notions in which he is not interested. I would prefer to emphasise the interpenetration of what we distinguish as scientific (or technological) and spiritual ideas; both were important for earlier societies.

Underground work was particularly arduous and the difficulties are marked in the beliefs of many people. ‘Down the salt mines’ may today have become a more profitable occupation but it is always dangerous work about which there is a punitive aspect. In Christian theology, and elsewhere, the underground is the domain of the Devil. Gloomy Tartarus was contrasted with the Elysian fields. It is in the flames of the underworld that the sinful suffer and the wicked are tortured. ‘We have been with Satan’, said one of the Chilean miners rescued at San José in 2010. The ‘depths’ of the earth hide Dante’s *Inferno*, with its seven circles, just as they concealed the underworld of classical Greece, that desolate land to which Persephone had to descend for six months of every year. In many African tribes the sun, on the other hand, is identified in some general way with the Creator God. In death the good people go upwards, the bad downwards to the regions that otherwise only miners reach. God on the other hand is to be found up above in the heavens, the dwelling place of the sun. Whereas one goes upwards to the home of the gods, to Olympus in Greece and to the one God in Abrahamistic religions, one goes downwards to the Underworld, to Hell. The good go up. The notion of supernatural retribution that this involves was a feature not only of later religions but can be found among the beliefs of the LoDagaa of northern Ghana.[61]

The identification of mines with the underworld is common enough. In Europe these are the dwelling place of human-like beings, of trolls, of pixies and others, who play tricks on human kind. But they may sometimes be of help, as in the case of the 'seven dwarfs' in Snow White, who were dark in comparison with her for they come from the depths, carrying their mining tools and singing a work-song. The connection of dwarfs and miners is brought out in tales told by workers in the alpine regions of the Alto Adige, as well as appearing in their wooden sculptures.[62] These beings inhabit a gloomy place under the ground, which may sometimes be upside down, as it was for Alice when she went to Wonderland, following the rabbit down a hole. But these holes, especially in mining areas, sometimes exude pungent vapours that are harmful to men. Even today mines have a bad reputation for catastrophes that are known only too well for the frightening accounts from China, South America and even New Zealand, countries to which mining has largely migrated. It was the same in the European past when many miners were crushed, drowned or gassed underground. Those dangers undoubtedly fuelled beliefs in the supernatural and in the terrors of the mine.

The mining world was the location of numerous dangers. Arsenical-cobalt was common in Saxon mines, where the verbal origin of the name, cobalt, seems to lie in the word for the gnomes and goblins 'so universal to Saxon miners' imaginations',[63] and that in turn was related to the Greek in many parts of the west, arsenical ores were essential for the earliest copper alloy, before tin was used. The name is also employed by Agricola for an infection which 'eats away the feet of the workmen when they have become wet, and similarly their hands, and injures their lungs and eyes'.[64] He sees the word cobalt (*kobolt*) as being derived from the biblical *Cabul*.[65] When Solomon presented thirty towns in Galilee to Hiram, from whom the cedars came for the temple at Jerusalem, the Phoenician king of Tyre went to see the land of *Cabul* and then refused the gift. Mathesius claims that these places were situated near some old mines of copper and iron, and as they were mining towns, they took the name of the metal. But Hiram was skilled in metals and when he inspected the mines, he saw this earth was poor, with much cobalt. So he preferred to go elsewhere and refused Solomon's gift.

The miners not only worked in terrible conditions, they sometimes lived in the mines themselves. In Roman times, this may have been to keep unwilling workers from escaping but it happened elsewhere too and there is a report from Alcester in England of about 700 CE of smiths being buried in the earth because of their refusal to adopt Christianity.[66] The ill health of miners was already well known, and 'in the mines of the Carpathian mountains women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death'.[67] That is not a situation that time has greatly changed. It was to the miners that in 1562 Mathesius attributed the *cadmia fossilis*. This was called by Germans 'the Black Devil and the old Devil's furies, old and black *cobel*, who injure people and their cattle with their witchcraft'.[68] 'Now the Devil is a wicked, malicious spirit, who shoots his poisoned darts into the hearts of men, as sorcerers and witches shoot at the limbs of cattle and men, and work much evil and mischief with *cobalt* or *hipomane* or horses' poison . . . these are the most poisonous of the metals' that 'kill many mining people'.[69] The deep had its complement of dangers as well as the advantages of the minerals employed by humans.

Religion was earlier replete with beliefs about metal-workers, miners and smiths, the latter usually being very powerful beings. In Britain, Leach[70] speaks of a Smith God (*Goibniu* in Irish), and of a heroic smith (Govannon, son of Don) in Welsh legend but '[t]here is no evidence that he had the status Caesar attributes to the "German Vulcan"'.[71] Smithying is associated with powerful gods, like Vulcan, Odin and Mars, because of their link with weaponry as well as with the act of creation. The modern version of such an over-arching authority would no doubt be the United Nations in its attempt to control nuclear energy. But there are other examples of the links of smithying with earlier supernatural beliefs. In later Arthurian legend the 'magician' Merlin possessed the named, iron sword, Excalibur. In the Anglo-Saxon poem, *Beowulf*, swords are personalised, highly decorated, often named, and have an almost magical significance. It was not only the smithying process that evoked a vision of life and death but also that of smelting. As a Chinese writer remarked in the sixteenth century, 'when one sees the melting of metal in the great [blast] furnaces, one understands the beginning and end of

Heaven and Earth . . . This is indeed a symbol of the Tao.'[72]

Smithying had a very different image in popular belief from mining. It was concerned with the making of tools and weapons, with the welding of blades and of swords, which bring work and danger to others as well as protecting the owner. Mining, on the other hand, is a matter of digging up the metals underground in inhuman conditions. The horrific work of mining is vividly depicted in the post-war work of the sculptor Henry Moore, whose father was a miner and whose Second World War drawings for the UK Coal Board were accompanied by the statement that this is as near Hell as you can get. Moore was also commissioned to make the wartime drawings of Londoners in the Blitz, bringing out the terrors of life in the Underground to which so many resorted as an escape from the bombing of the Luftwaffe. It was the threat of the inferno coming from the Heavens that drove people to take refuge in the depths of the earth, a territory normally belonging only to the miners in their search for metals or for fuel. The sense of 'togetherness' was important and mining itself also produced strong communities that gave birth to another avant-garde artist during the First World War, the writer, D. H. Lawrence, who later regretted not acknowledging how much his miner father had taught him.

The notion of demons or of gnomes in mines was so widespread that, despite his general scepticism towards the supernatural, Agricola accepted their existence. But as we have remarked they were not all bad; some as we have seen were helpful and were known as 'little miners', being dwarfs only two feet tall. Agricola describes them in *de animantibus subterraneis*:[73]

> They are venerable looking and are clothed like miners in a filleted garment with a leather apron about their loins. This kind does not often trouble the miners, but they idle about in the shafts and tunnels and really do nothing, although they pretend to be busy in all kinds of labour, sometimes digging ore, and sometimes putting into buckets that which has been dug. Sometimes they throw pebbles at the workmen, but they rarely injure them unless the workmen first ridicule or curse them. They are not very dissimilar to Goblins, which occasionally appear to men when they go to or from their day's work, or when they attend their cattle. Because they generally appear benign to men, the Germans call them *guteli*. Those called *trulli*, which take the form of women as well as men, actually enter the service of some people, especially the *Suions*. The mining gnomes are especially active in the workings where metal has already been found, or where there are hopes of discovering it, because of which they do not discourage the miners, but on the contrary stimulate them and cause them to labour more vigorously.[74]

These were beneficial creatures, like Puck, but are not strangers to misfortune. The European beliefs discussed by Agricola are paralleled by those of the Andeans in Bolivia, Peru and Columbia who dress up in masks because they dig down – to the Devil's reaches.[75] In fact there are a great number of superstitious beliefs associated with South American mining, recent as this is.[76]

H. and L. Hoover also comment more widely:

> The German miners were not alone in such beliefs, for miners generally accepted them – even to-day the faith in 'knockers' has not entirely disappeared from Cornwall. Neither the sea nor the forest so lends itself to the substantiation of the supernatural as does the mine. The dead darkness, in which the miners' lamps serve only to distort every shape, the uncanny noises of restless rocks whose support has been undermined, the approach of danger and death without warning, the sudden vanishing or discovery of good fortune, all yield a thousand corroborations to minds long steeped in ignorance and prepared for the miraculous through religious teaching.[77]

This belief of miners turned around spirits or *Bergmännlein* in Germany who:

> made their homes underground. These spirits also appeared in woodland and around springs, but were especially prevalent in the mines. While the presence of these gnomes was a sign of the productivity of the mines, humans had to show respect for these guardians of the earth's treasure. Any harm done to the spirits could cause them to transmute noble metals into worthless dirt. This was especially true of one group, called *Kobolden*, who produced a corrosive ore, named by the miners *Koboldterz*, which corrupted valuable metal ores . . . this terminology flowed seamlessly from miners' beliefs to chemistry textbooks, and today Paracelsus is viewed in the history of chemistry as the discoverer of cobalt.[78]

The shift is seen as one from 'vernacular beliefs' to 'modern science' but the contrast conceals more than it reveals. 'Modern science' was a form of knowledge that depended upon literacy, elaboration and analysis but otherwise was grounded in the everyday usage and artisanal techniques that had dominated earlier 'vernacular' activity. That was not without its 'empirical' aspects, as many observers have stressed, testing and improving procedures; the 'beliefs' they held represented a way of coping in an oral world and all that implied.[79] Spirits were part of that world and often enough remain part of ours, the 'modern' one.

In the broader picture mining was not only concerned with religious beliefs and with gaining a living, but with the work of craftsmen who promoted aspects of practical technology and science. Not all of these were at the coal face. Mining required engineers and overseers, and there was a manager, the Bergmeister, as well as the owners of the site. These proprietors might be multiple and form a company (as in Roman mines) where each owned a particular section; they could sell the product as well as their own shares. That possibility helped to ensure a continuous search for improved techniques. For example, the methods of washing for gold (or tin) were many and varied by region. Nor were they fixed, but changed as time went on. Invention of new techniques did not begin at some quasi-mythical point in time, such as the Renaissance; it was ongoing, and Agricola, for example, presents details of new methods of washing for tin.[80] At a very basic level the search for results encouraged the use of iron tools for work on rocks because of their hardness. For all mining, as Agricola explains,[81] you needed various types of 'iron tools' and these were constantly being improved. For they needed a large amount of equipment – wedges, iron blocks, iron plates, hammers, crowbars, pikes, picks, hoes and shovels; all these iron tools were required to obtain the metal. They are used on the veins and the ore that is then put in baskets is drawn to the surface by men (if the weight is small) or by horses (if heavy). None of this is 'traditional', in the sense of static, as we see from the fundamental inventions in mining technology that heralded the 'Industrial Revolution'.

Especially mining at depth meant the invention of new techniques. H. and L. Hoover quote Agricola's *Bermannus* (c. 1530),[82] '"The depths of our shafts forced us to invent hauling machines suitable for them"'. They went so deep, up to 200 fathoms, that his interlocutor asks if they had yet reached the Kingdom of Pluto, the inferno. Mining involved not only inventions of this kind but also the development of other aspects of technical science, of surveying (to find new mines and to locate new shafts) and of assaying, which was linked both to alchemy and to chemistry. So under non-medieval conditions, the work even encouraged theoretical enquiry. In his own book, Agricola introduced a 'system' into his written analysis that according to H. and L. Hoover[83] laid the 'foundations' of the science of chemistry of which he was the first author in modern times. Literacy helped him do just that.

The machines that mining developed were of three kinds, hauling machines, ventilating machines and ladders. Agricola writes of the various types of hauling machines and many kinds of pump, some of which were used to control water from diverted streams. Others were invented so that water could be drawn from the depths or stored until brought up the shafts. These methods could be very different because shafts were not always of the same depth. Several of the ventilating machines, essential for the depths, were known to the Ancients, some using fans, others directing the air. The blowing machines made with bellows might be driven by horse-power, but this was unknown to the Ancients. Ladders underwent less development.

In this way much machinery emerged in connection with mining, firstly in

Antiquity and later in Germany, in Britain and elsewhere. That had already happened in the early mines in Spain which had to control water, as we learn from Diodorus Siculus in the first century BCE when he describes how they pumped it from 'great depths' with the help of the Egyptian pumps, called Archimedes' screws. By this means 'a vast amount of water is strangely and with little labour cast out'.[84] Strabo and Pliny both speak of the Spanish mines, where Roman water-wheels have been discovered at the workings in Rio Tinto when these were reopened in the eighteenth century. The problem of the evacuation of water lasted right through to that century when it was 'solved', giving rise to two major inventions. Firstly there was the steam engine of Newcomen in 1705 – no doubt inspired by Savery's unsuccessful attempt. This engine was installed in a colliery in Wolverhampton and further improved sixty years later by Watt, whose engine gave such power to the production of coal, iron and all the subsequent manufactures, as well as transport. Then there was another mining engineer, Stephenson who, following Trevithick, made an effort 'to further advance his calling' by inventing the locomotive, running on rails and pulling trucks (as earlier underground), and so beginning the great Railway Age. Both of which should be 'a matter of satisfaction to mining engineers'.[85] Each of these major inventions, so important for the Industrial Revolution, arose out of mining technology, employing iron for the engine and for the locomotive and track.

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[1] McNeill 1964: 10.

[2] Tylecote 1992: 88.

[3] McNeill 1964: 3.

[4] Lane and Mueller 1985: 138.

[5] Opll 1992.

[6] Braudel 1984: 125.

[7] Lane and Mueller 1985: 139.

[8] Agricola 1950: 234.

[9] Tylecote 1992: 151.

[10] Craddock 1994: 889.

[11] Mueller 1997: 151.

[12] Mueller 1997: 141.

13 Mueller 1997: 150.

14 Mueller 1997: 150–1.

15 Needham 1964: 39.

16 Braudel 1984: 135.

17 Abulafia 2011: 246.

18 Zieger 1993: 17.

19 For this information I am grateful to M. Ambrosoli of the Department of History of Udine.

20 Zieger 1993: 70.

21 Kellenbenz 1993.

22 Braudel 1982: 524.

23 Tylecote 1992: 96–7.

24 Salzman 1964: 66.

25 Hoover and Hoover 1950: 283.

26 Tylecote 1992: 95.

27 Bovill 1933: 188.

28 Hoover and Hoover 1950: 267.

29 Münster 1550: iii.

30 Praeterea ipsa Germania, benignissimo ventorum afflatus, latissimorum fluviorum & Thermarum copia, nemorum & saltuum jucunda utilitate, crudelium ferorumque animalium carentia, & magna soli fertilitate Principatum obtinet. Quicquid est, quo vita nostra carere non potest, id omne Deus Germaniae non invidit, opes, pabula, lacus, fruges, vineta, variique generis vina . . . vellera, lina, vestes juvenci, equi metalla, aurum, argentums, aes, ferrum, non solum montes, sed & flumina Rhenus, Danbiusque proferunt, ut nec Pactolo, neque Tago cedat Germania, longe a mari distans, quod Plato improbitatis magistrum appellat. Wimpfeling 1505: *Epitoma Germanicarum Rerum* 71.

31 Ruysbroeck 1990: 144.

32 Ruysbroeck 1990: 146.

33 Lanaro 2006: 27–47.

34 Aymard 2006: 372.

35 Livorno became an important centre for Sephardic Jews and also for British traders, especially in the Levant (Colley 2006: 99).

36 It was Innis’ account (Innis 1950) of this supply that partly stimulated the essay on literacy written by Watt and myself (Goody and Watt 1963).

37 Lazzarini 2006, 2009; Appuhn 2000, 2009.

38 Hoover and Hoover 1950: 420.

39 For the puddling process, see the Glossary.

40 Craddock 1994: 889.

41 Tylecote 1992: 108.

42 Tylecote 1992: 107.

43 Hoover and Hoover 1950: 353.

44 Hoover and Hoover 1950: 353.

45 Aitchison 1960: 305.

46 Aitchison 1960: 306.

47 Forbes 1958: 65.

48 Bromehead 1956: 13.

49 Aitchison 1960: 373.

50 Aitchison 1960: 293.

51 It has been suggested to me that Pliny and Aristotle gave such a comprehensive picture of the world that there was no need to write about it. But there was much opposition to such observational studies of nature, which did not continue when they might have done.

52 Hoover and Hoover 1950: xiii.

53 Childe 1942: 141.

54 Goody 2006.

55 Hoover and Hoover 1950: 353.

56 Quoted by Hoover and Hoover 1950: 279–80.

57 Barbieri-Low 2007: 258.

58 Sébillot 1894.

59 Eliade 1962: 337.

60 Eliade 1962: 8.

61 Goody 1962.

62 See L. Gottardi, Il teatra di figura nelle narratziune orde, *Annali di San Michele* 21 (2008), 231–38. Musea della Gente Trentino, especially La Miniere di Gasparo, p.234.

63 Hoover and Hoover 1950: 214.

64 Agricola 1950: 214.

65 Kobold was also a kind of German mine-spirit, like pixies, knockers, lutins, brownies, etc., discussed by Sébillot 1894: 473.

66 Davies 1935: 162.

67 Hoover and Hoover 1950: 214.

68 He also recounts many stories of *Bergmännlein* from mines in Germany, Austria, the Tyrol, Switzerland and Hungary, dwarf inhabitants of the hills who guarded their treasures.

69 Quoted in Hoover and Hoover 1950: 214.

70 Leach 1962.

71 B.G.VI.21.2 in Caesar 2008; Alexander 1982: 11.

72 Chen Jo-Shui (d. c. 1560), Needham 1964: 17.

73 Agricola in 1548.

74 Quoted in Hoover and Hoover 1950: 217.

75 Taussig 1980.

76 Pollitt 1981.

77 Hoover and Hoover 1950: 217.

78 Smith 2009: 35.

79 Goody 1986.

80 Agricola 1950: 341.

81 Agricola 1950: 150.

82 Agricola 1950: 102.

83 Hoover and Hoover 1950: 220.

84 Quoted by Hoover and Hoover 1950: 149.

85 Hoover and Hoover 1950: 149.

PART III

Accumulators

11
Iron and the Industrial Revolution

Metals were obviously crucial to the Bronze Age civilisations of the Near East, and to Eurasia generally. But these were mainly civilisations of the river valleys, where surplus food could be readily produced with the aid of the plough and where the rivers made for the easy transport of heavy goods, stone, timber and ores from other parts. To bring these, they needed ships. There was of course trade and exchange of many goods; however metals, not only precious ones but also the base variety, were essential to the development of city – and indeed of rural – life, then and ever since. But, except in China (regarding it as a unity), they had no metals themselves, and had to seek them in the other regions; for the Near East one highly important supply lay later in the Mediterranean, and then in Europe more generally.

The consequent search for metals (and wood to heat them, as well as to build) was in itself a 'civilising' process, mainly affecting populations living on the boundaries of the city cultures, especially in the Levant, where Egypt and other countries traded with 'barbarians' for copper, as well as for the cedars of Lebanon.[1] The critical players in the west were the coastal inhabitants of Tyre, Sidon, Byblos, Ugarit and elsewhere along that narrow stretch of the eastern Mediterranean, peoples who lived by the sea with little agricultural land but who developed a profound expertise in sea-faring, including trade, especially in metals. It was these men who were subsequently employed by the Egyptians to circumnavigate Africa, who established a colony in Carthage and exploited the highly productive mines in Spain, already worked by the Mycenaeans, and who built the town of New Carthage, or Carthagena, in the Iberian peninsular. In their voyages, the Phoenicians were even preceded by traders travelling around the Aegean and its various islands, from Crete and elsewhere with their many contacts both in the Near East and Greece. The Phoenicians themselves were joined in both exploration and trade by the inhabitants of neighbouring Israel (whose culture was very similar), and by the Greeks and Etruscans (and later by the Romans) whose lands bordered the inland sea and whose livelihoods were also tied up with trade (and war) along the coast.

So these communities from the eastern Mediterranean established settlements in the west: the Phoenicians in Carthage, Spain, the Balearics and Sicily; the Greeks in Sicily, southern Italy, Marseilles, Agde (in south-west France) and in Cyrene in present-day Libya; the Etruscans in Rome and Tuscany; the Jews in numerous towns round the coast. This colonisation was usually part of trading activities, but occasionally it was established by conquest, as with the Romans. But the conquests of those empire-builders were dominated by the same interest that led the Carthaginians to Spain, the search for metals, of which they required a great amount of the base variety to equip their legions in weaponry and their farmers with ploughs, the precious ones to pay for all that expansion, including mercenaries. After 400 BCE iron became especially important when it was carburised into steel, which then got rid of some of the problems of brittleness intrinsic to its earlier production. Bronze had always been a costly metal. But iron, even when made in the 'primitive' way, though often still valuable, was available to many more.

Ashton describes the process of making malleable iron in the European Middle Ages as follows: 'The ore was first crushed into fragments and mixed with a small quantity of marl and lime which served to bind it together, and the mass was then divided into lumps which were placed on a forge and surrounded with charcoal. By means of a blast produced with leathern bellows, worked either by manual labour or by water-power, the fire was maintained at a moderate temperature; and the metal was brought to a pasty, rather than a liquid form, the impurities being removed by repeated hammering.'[2]

The production of iron expanded in the classical world of Antiquity. Rome and Greece profited hugely from Iron Age technology, both for war and for peace – in ships for trade, in ploughs for agriculture, in tools and machinery, in a wider, more 'democratic' use of metals. The result was a larger domestic market, an early consumer society. But to acquire these materials involved a continuous search, especially as mines became exhausted, and wood for charcoal to smelt it ran out yet more quickly. Even the more profitable ores mines of Spain that had been so productive for the Phoenicians, for the Carthaginians, and later for the Romans, became depleted.

The exploration for metals has continued ever since, but the west is nowadays more concerned with the search for fuel to drive the machines created from them. However the need for metals of all kinds has grown with the European Renaissance, with the Spanish search for gold and silver in South America, with the exploration of the United States especially in what had been Spanish California and in formerly Russian Alaska, finding the immense deposits of coal and iron in the mid-west. Metals flourished, despite the coming of plastics in the early twentieth century that to some extent substituted for their use. The demand continued, for German industry, for Rolls-Royce engines, for all the household goods we use. Today, the Chinese have followed the trail of various colonial powers in Africa, Australia, South America and elsewhere in trying to secure the metals to supply their growing industrial activity. Russia too made its own expansion into Asia to the east, making use of German miners and mining technology to develop its industry in the Urals which ironically became so important to them in the struggle against the advancing Nazis in the Second World War. In that region there were huge reserves of coal, oil, iron and other metals, exploited earlier on but now acquired in an eastward expansion, which conquered many indigenous peoples in its path under Ivan, known as ‘The Terrible’. All this was part of Europe’s, and then Eurasia’s, thirst for resources and power.

But after the Tudor period and the foundation of the Dutch Republic, the main impetus in the further advance in the field of metals, and in the whole manufacturing economy, largely (but not entirely) shifted from the areas of Italy and even of southern Germany to that of the north, Holland and Britain, from an enclosed Mediterranean to the wider world of the Atlantic. It was Holland and Britain that expanded the use of iron, especially by solving the problem of heat and fuel, Holland making use of peat and Britain its plentiful supplies of coal (for coke) as well as the iron, found close to one another. With increased heat and ample fuel, manufacture of mass goods could eventually move for most purposes from wrought iron to cheaper cast iron and then steel.

Although there was some continuity in the use of iron and coal, there was also significant discontinuity in the Industrial Revolution in the extent and consequences of such use. Manufacture expanded notably and that had an effect of changing the ‘spirit of the age’, including its expression in art and literature.[3] That was also true of broader intellectual activity, not only of the writings of Malthus but also those of the poets and essayists who opposed him. But the reality of the early Industrial Revolution is displayed by the many people living under the kind of conditions described for mining in earlier societies. Fortunately this state of affairs was transformed with the increased production of consumer goods. Coal and iron now played an increasingly less prominent role (which lead to much industrial strife) and iron was produced predominantly in the developing world.

Typical of the reaction to the British achievements of the Industrial Revolution were Sir Matthew Digby Wyatt's remarks in the catalogue to the Great Exhibition at the Crystal Palace that opened on 1 May 1851. He argued that the construction of the exhibition 'could alone have been affected by the natives of a country in which a knowledge of the principles and practice of mechanics and machinery had been long deeply studied and widely diffused'.[4] The crux of the problem for a historian lies in the 'alone'.

Much of what we find in the material cultures of the modern world, and is yet so much more than the material base, existed in embryo with the coming of metals in the Bronze Age (and even before in that of copper). But the greatest transformation came with the advent of the mass use of iron and coal in the Industrial Revolution, as this meant that a considerable proportion of the population was now working not in farming for food on the land but in producing goods from mines and in factories. This process had begun well before but now took a quantum leap, with so many more workers not only producing the goods but transporting them (and people) across the world wherever the goods were sold. All this activity involved the expansion of knowledge and the creation of a vast system for producing it in literate form; for the Bronze Age had seen the creation of writing and libraries which were of equal importance to metals. The means of communication advanced along with the means of production, and in this way our 'modern' world took shape throughout Eurasia.

Despite the important continuity with previous metal cultures, the Industrial Revolution also experienced this quantitative leap to the factory system of production, including the new machinery, which now employed so much larger a proportion of the population. That meant that a larger and yet larger number took part in secondary rather than in primary production, having to get their food by exchange. This sector comprised not only those involved in the mining and preparation of coal and steel, but also those participating in the making and installation of the manufactured goods. The shift represented a complete change in the way of life for a large majority, involve a change in the people's relationship to the land and to work, in other words 'capitalism'.

The search for fuel as distinct from metals is well known. First wood and charcoal were used, then coal itself (later in the form of coke). Coal had not only to be brought to the surface but had first to be transported from the face to the shaft. Early on this was done by loading it into corves (or baskets) that were then pushed or pulled to the opening, often by child or female labour. In the large collieries of the north-west of England they were loaded on a sled. But there was little development of this system until about 1700 with the introduction of railed wagons in the Neath mines of Sir Humphrey Mackworth, which eventually led to the railroads of Stephenson for transporting people above ground. It was already in 1544 that Lucas van Gassel painted a mine truck on wooden rails, and this was probably not the earliest representation.[5]

In Europe coal had earlier been used not for smelting but for a preliminary 'roasting' of the ores, as well as for processing malt and in other industrial products and also domestically. It required a different, narrower, type of grate than wood, but it also made more smoke and more smell. The first was dealt with by forcing the smoke down with a baffle plate before allowing it to rise. Domestically this required a chimney. The smell (and other problems) were dealt with by turning coal into coke by methods essentially similar to those used by charcoal burners, that is, by controlled combustion, a process that was sometimes referred to as 'charking'.[6] Iron was then smelted in a reverberating furnace, in which the fuel and the ore were separated and the heat of the fire was reflected or reverberated, drawn down from the roof.

Coal had been used by the Romans for heating their forts, as well as for smithying. But in Britain the usage ceased with the withdrawal of the Empire and did not really revive until the thirteenth century, though it was used in China much earlier.[7] But for seven centuries after the withdrawal, there was scarcely a mention of coal. From the thirteenth century demand grew but it decreased with the Black Death and only revived with the growth of population beginning in the early sixteenth century. The major expansion in the use of coal came between the mid sixteenth and the later seventeenth century[8] when it became the habitual fuel of much of the nation. The growth in its use was 'spectacular' and by the beginning of the eighteenth century was many times greater than in the whole of the rest of the world. Early on, this growth was spurred by the vast increase in urban populations and by the greater cost of alternatives, since it could be delivered cheaply by sea and by canal.

The use of iron and coal, though they often were found nearby, entailed the improvement of overland transport. There was the construction of the great series of inland waterways on the model of the French *Canal du Midi* joining the Atlantic and the Mediterranean. It was James Brindley, commissioned by the Duke of Bridgewater, who built the canal from the mines themselves at Worsley to Manchester, opened in 1761. Canal building spread apace, including the Trent and Mersey canal, strongly supported by Wedgwood who wanted cheap transport to the Potteries. The same period saw the great improvements to other travel networks, with the beginning of the mail coach age, including the highway improvements under John Metcalf and John McAdam. Roads needed bridges across rivers including the great iron bridge at Coalbrookdale over the river Severn.[9] As a result of all this industrial and mining activity, intellectual life was encouraged in the provinces, especially around Glasgow and Edinburgh, as well as in the English Midlands, the first providing the focus for the Scottish Enlightenment, the second for the great achievement of the area, especially in education, that sprang up with Union in 1709. Glasgow itself had been transformed by the trade in tobacco with America and by the creation of the Carron Ironworks in 1760.

By 1700 coal had become the preferred fuel of almost all British industry, yet it was used for the generation of heat and not of power. Iron-smelting remained wedded to costly charcoal. That was to change. In 1698 Thomas Savery invented the atmospheric steam engine, in 1722 the first Newcomen steam pump was installed in a Staffordshire mine and in 1709 Abraham Darby successfully carried out the smelting of iron using coke. Coal's development was aided by the invention of the steam engine in 1750 but its use was still limited, mainly to drain mines. In the subsequent fifty years, it was adopted for all stages in the production of iron and new uses were found for it. Thus the modern coal and iron industry was born – by the end of the century 15 million tons of coal were produced every year.

The invention of the steam engine had far-reaching consequences not only for mining but for all aspects of working life, providing the power for every type of mechanisation of production; Wrigley, like many others, sees it as crucial to what he calls 'resource capitalism' and therefore to the Industrial Revolution. That was of course based on the use of coal or coke to produce the necessary energy to power the machinery. While this was an English development, it was preceded by unsuccessful experiments in France, and followed by development of the coal fields in Belgium, the north of France and the Ruhr. As with English coal districts these areas attracted industry because proximity saved money on transport, and this growth had its effect on population. But in general it was a period when England took the lead in industrial activity, a lead it later lost to the United States and then to Germany, which had done so much to stimulate the early developments in metals. But '[n]ational borders were seldom of great consequence in the early years'.[10] The Belgian industry was directly simulated by William Cockerill from England who built his textile factory at Liège in 1808 and whose son James produced the first coke-fed blast furnace in the country in 1823. The first puddling furnace followed soon after. It was consequently from Belgium that the Industrial Revolution spread to the north of France and then to the Ruhr. In this way Belgium took over the dominance in industrial production from the Netherlands where it had been based on peat, and passed this on to the Ruhr, leading to Germany's later success, also based upon the use of the steam engine and of the coke-fired blast furnace, in producing iron; this was not a development from scratch as these areas had been heavily involved in the earlier production of iron and coal by different methods.

By the twentieth century these fuels largely gave place to oil, so essential for the automobile with its invaluable mobility. The British had holdings in Burma (Burmah Oil), then in Iran (until Mosaddeq became President and nationalised the oil industry in 1951), in Alaska and now in the North Sea, in the Gulf of Mexico, in West Africa and in Russia. After the First World War, the use of oil and its discovery in the Near East, there was a distribution of those territories by the victorious allies: the French supervised Syria and the Lebanon; the British, Palestine and Iran; the United States *de facto* Saudi Arabia and the Persian Gulf, later with an outpost in Israel. The first two of these came under the newly formed League of Nations as mandated territories, expressly, it has been widely suggested, to keep an eye on the supply of oil; the third did the same but with weaponry and diplomacy rather than with occupation. Subsequently neo-colonial interests have seen the intervention in Iraq, the threats to Iran, the problems in Venezuela and the moves of the Chinese to gain access to world supplies in metal and in oil for their own industrial development. The search continues to supply the industry of the Age of Iron especially at its stage of mass-production, as well as to provide the energy required to heat the furnaces and drive the machines it has created, in particular the air conditioners, the refrigerators, the heaters and the cars that now come mainly from Japan, China, South-East and South Asia, as well as in some measure from their earlier homes in Europe and the United States.

Of course an additional source of energy was that of electricity, so important to the modern world, although its plants have been fuelled by mineral resources, coal or oil, now increasingly by nuclear or natural resources such as wind and tide. Electrical reactions of a chemical kind in the voltaic cell were developed by Humphrey Davy, a Cornishman who followed and disputed the work of Lavoisier in France and was not only knighted but was also decorated by Napoleon. Davy, who was an early employee of the Royal Institution, developed the Davy Lamp to use as a light in the mines. He also employed as an assistant Michael Faraday, who did much further work on electrochemistry and produced the dynamo to generate electricity and began the journey to today's electrical power. He also worked on metal alloys. Faraday was the son of a migrant Scottish blacksmith from Surrey who refused a knighthood and was associated all his life with a small non-Conformist sect; and although Davy was a product of the middle class, science and industry were often associated with class mobility and with Dissenters, often Quakers.

Parallel with change in fuels from wood to coal and oil were the shifting modes of warfare. The production of metals was affected not only by fuel but by the spread of gunpowder and its use both for weapons and for mining. By the sixteenth century, the cross-bow had been replaced by the musket using gunpowder to project a more dangerous metal missile. Nevertheless horsed warfare still played a part, in the shape of the light cavalry that had long dominated Central Asia. Iron had been much used for a long time before that: the Turkish archers were only lightly armoured, but they wore iron helmets and some mail. Chinese and Greek sources also claimed the Turks were skilled metallurgists in iron, as were other inhabitants of the steppes, which may explain why their myth of origin had them emerging from a cave.[11] On the other hand the Asante of West Africa also have a story of their ancestors coming from the ground, which could only be related distantly to mining. But the Turks had a long history of metal-working and these inhabitants of the central Asian area may indeed have been among the first of all iron founders.[12] They were later well known for their metal-working, especially when they reached the Balkans, an area where it had long flourished. Much later metallurgy was also practised in modern Turkey itself, which built up its own arsenal in Istanbul with the help of a cannon-founder from Frankfurt who about 1486 made cast iron in a ‘wind-pot’, or a kiln that prevented contact between metal and fuel: ‘The invention is important for it was ancestral to all the reverberatory furnaces (puddling, open hearth, etc.) of European siderurgy. This artisan had lived a long time in Turkey, where he was cannon-founder to the Sultan.’[13] The Germans had long experience of working in iron and were technologically the most up-to-date in weaponry, as in other aspects. In the Near East the manufacture of cannon as well as small arms (possibly of direct Chinese inspiration by way of Islam) changed the nature of warfare, as it did in many other parts, and laid the basis for the later Turkish Empire.

Gunpowder, closely associated with mining and with metallurgy, was a Chinese discovery that strongly influenced the world’s history, especially in the colonial conquests by Europe that were much influenced by its use. Before that happened, the Chinese not only developed gunpowder but also the metal containers needed for both cannon (or bombards) and for hand guns. The notion held by some Europeans that the Chinese only developed fire-crackers is quite wrong. In Burma in the fifteenth century the polity was greatly influenced by the coming of Ming deserters who introduced gunpowder technology and firearms to the Shan states and elsewhere. But their advantage was limited because in the same century Ayudha (Malaysia) already knew both Chinese cannon and Muslim firearms and after 1517 the Portuguese supplied the more accurate European weapons. Portuguese instructors were then employed and guns were made locally.[14] According to Needham, there may have been not one but three independent transmissions of these techniques to Europe.[15] The first was that associated with Roger Bacon (1214–92) who received a present of fire-crackers some time before 1265. This partial transmission of the discovery was soon followed by that of fire-lances, bombs and rockets to Hasan al-Rammah and Marcus Graecus by 1280 and finally there was the metal-barrel bombard and hand gun of the European military as illustrated in the famous treatise of Walter de Milamete. The first three of these inventions were known in China from the tenth century, the fourth from 1150 and the last from about 1290.

About these transmissions Bacon, who wrote of the fireworks, would have known of the travels of the Franciscan friars. In recent times they had been sent to the Mongol khan by those anxious to acquire allies in order to surround (and defeat) the Muslims. There were also Scandinavians visiting China at the time, probably by way of Novgorod who could have brought back the fire-cracker with them.

Secondly there was the transmission of early devices to Hasan al-Rammah. It seems probably that this knowledge passed through one of the Muslim experts in artillery employed by the Mongol regime in China. They used the counter-weighted trebuchet, an Arab invention, to hurl explosive bombs.[16] At the siege of Hsiangyang between 1268 and 1273 gunpowder weapons abounded and two decades later it was Chinese in the Mongol service who were the first soldiers anywhere to use metal-barrelled hand guns. Later on the Yuan failed to develop these weapons and it was their successors, the Ming, who profited from them.

The third transmission was of the metal-barrelled bombard and hand gun, known in China about 1290, which was illustrated in Walter de Milamete's manuscript in about 1300; this may have come direct through Russia and then down to the Arabs, who may possibly have received the bombard through Germany, always in the forefront of European metallurgy.

As in China the Europeans first developed a form of cannon, and only later manufactured small arms, by the middle of the fifteenth century. Until then hand cannon only differed in size from the larger variety, but portable arms were now produced having a 'slow match' to ignite the powder. Firearms of this kind were first made in Germany about 1325, initially of forged iron, and then about 1350 of cast bronze, and some time later the first cast iron cannon. Casting in sand moulds appears about 1540, its use being connected with the coming of gunpowder, and cannon balls of pig-iron (no longer of stone) were being made in England in 1497. Bronze had remained dominant until the fifteenth century when cast iron became possible and was cheaper. Early in that century casting direct from furnace to mould had been achieved in Europe, when the use of cast iron spread from Germany to the whole of Western Europe, especially for cannon balls.

The 'matchlock' mechanism with a 'slow match' that was used in the fire arms was made by German gunsmiths and this hand gun was known as the arquebus; in Britain an early form was in fact called the hackbut or in German, *Hackenbüchse* (hook gun). The same smiths also invented an S-shaped device known as the Serpentine that was later replaced by the trigger itself using a spring as well. However these guns were too heavy to fire unaided and the first musket used in Spain required a forked stick as a rest. Nevertheless they were capable of firing a bullet that pierced armour, which consequently disappeared towards the end of the sixteenth century. In the absence of armour, muskets could now be made smaller, and a less cumbrous firing method was adopted. This hand gun was the forerunner of the flintlock of the seventeenth century by way of the wheel-lock, which was again invented by German gunsmiths in order to fire the powder by means of the spark from a piece of iron pyrites fitted against the wheel. However this mechanism was too expensive except for cavalry elites and in time it was replaced by the cheaper flintlock using an adaptation of the tinder box for starting fires. The gun could now be made by using techniques of mass-production, involving blast furnaces and cast iron. In world terms these products were widely exported and hugely influential. But the hand guns were not at first universally advantageous. At the Battle of Lepanto in 1571 the Turks still relied more on archery from the Janissary ranks than did the Christian forces, who put their faith in the arquebus with its greater range. By this time European hand guns had become more efficient than either Muslim or Chinese ones. It was now Europe that developed a large-scale iron industry, both for peace and for war, and they supplied armaments and hoe blades to the Near East and to the rest of the world. For example, in Persia Uzuri Hasan (1453–78) was defeated by the superiority of the Ottoman artillery, despite acquiring arms from Vienna. Later on the Safavids used artillery against the Uzbeks, presumably with weapons purchased from the Portuguese who had taken Ormuz in 1507 and exported arms through an eastern trading company some time before the English or the Dutch did the same. Later on the English, Dutch, Germans and Scandinavians all took guns to Africa, despite the Papal ban on trading with the heathens. But they were Protestants to whom the Papal ban meant only an opportunity to trade advantageously.

The search for metals was greatly influenced by this appearance of gunpowder that saved so much individual labour in shifting rock and made it possible to exploit the deeper veins.[17] The new regime of blasting appeared in Lorraine between 1617 and 1627 causing a ‘revolution in mining’;[18] it was practised in the Harz mountains in 1633 where much progress in smelting had been made in the previous century. Mining grew in scale, becoming more profitable, and the increased activity also entailed developments in hydraulic systems as well as in transportation underground. The developments led directly to the work of Newcomen and others. Most of the increased ore was now processed in batteries of stamp-mills, being first crushed to sand and then washed to separate out the minerals. The ore was ‘roasted, smelted and refined in batteries of furnaces, each served by bellows driven by waterwheels'.[19] There was a greater need for water-power following the introduction of blasting with gunpowder, transforming the Harz into 'an enormous hydraulic engineering site'.[20] Dynamite was patented in 1867 (that later gave the Norwegian industrialist, Nobel, his enormous profits, made in peace and war and subsequently devoted to the famous Nobel prizes). From the beginning these new developments required considerable investment but gave the entrepreneur much increased profit; in this way 'capitalism' took over the industry. This growth in scale meant the decreased importance of land owners, the increasing role of well-paid experts who often became shareholders, as well as the need for investment in shared capital together with the deskilling of the miners themselves.

The industry began slowly to adopt cast iron, which could produce iron objects more cheaply and plentifully. Cast iron had been widely used in China as early as the sixth century but in the west only sporadically in the fourteenth century. It was long believed that the making of cast iron was not known in England until the fifteenth century, when it was brought there from Germany. The cannon of that period were constructed of bars of wrought iron but the inner chamber was of cast and this has suggested to some that it was not Prussia but Sussex that saw the 'early development of the art of casting', that is, before 1500.[21] There may have been a slow development from the 'Catalan hearth' to the 'Osmund furnace' to the Stückofen. But we know that in the reign of Edward III, all iron was of the bloomery variety whereas under Henry VIII most was smelted. But in any case 'the production of ordnance was undoubtedly improved by the introduction of foreign skill in Tudor times'.[22] In 1523, Charles V sent a founder of cannon shot to Britain from Spain. Henry VIII employed a number of foreigners like Peter Baude and there is evidence of immigration on 'a fairly considerable scale'.[23]

In the east the blast furnace had been developed early on, giving the greater heat that was needed to make liquid iron. These furnaces seem to be related to those in northern Persia, which may in turn have influenced the production of some cast iron in medieval Europe. In Europe we have definite evidence from the twelfth and thirteenth centuries from Sweden, northern Germany and Italy; it was there that the indirect process began to be important and 'largely economic'[24] involving what has been called the first stirrings of a kind of 'embryonic capitalism' in activities of the Hanseatic

League and Italian merchant cities. The location of these ‘stirrings’ may have been influenced by the fact that, except in certain places, the indirect process could not deal very efficiently with the phosphorus in iron ore that was widespread in Europe. Moreover, iron with low-carbon content cannot be cast except at high temperatures, so wrought iron and steel were rarely melted until recent times. With high-carbon content the melting point falls to almost the same temperature as bronze.[25] To melt wrought iron, temperatures in excess of 1550 degrees Celsius were required, which were reached in Norway in the eighteenth century.[26]

One problem with all smelting of metals was the enormous amount of fuel needed. If this was charcoal, the destruction of trees quickly led to local deforestation. To conserve stocks of wood, regulations were introduced on their cutting down, and in some cases kilns could only work for part of the year, especially as the supply of water was also a problem. The friability of charcoal meant there were limitations to the size of the furnace that it fired, especially in building up the weight of ore. During the fourteenth century, about 20 tonnes of fuel were needed for every tonne of metal (copper). With the attainment of the higher temperatures required for melting iron for casting, the demand for fuel increased. Efficiency in fuel was always a consideration, especially before coal (and then oil) came into general use.

The use of coal brought its own problems, but in any case the transport expenses involved meant moving the smelting near the supply. Instead of production being scattered in various woodlands, it was now concentrated and the furnaces much larger. In the fifteenth century the operation at Neath was carried out with the aid of German workers and the large furnaces could produce 1,200 kg in one day. But supplies were irregular and the plant eventually had to close around 1440. However despite its problems, coal helped solve the fuel question and produce the necessary heat. In a minor way, it had been used by the Romans[27] and more substantially by the Chinese; later it was employed for various early industrial processes in Europe, including the working of forges, though always rare in the Mediterranean. In time its use developed and is referred to in Liège as early as 1190–1230. Its use in metallurgy was first attempted by smiths in Central Europe, but for smelting charcoal was long preferred as the sulphur in coal ruined the iron. Its employment for domestic purposes also led to objections. It was sent by barge from Newcastle to London in 1234 as ‘sea-coal’, as distinct from charcoal (although the name may refer to its early origin rather than its route), but there were complaints from the gentry about the smoke and the smell. However it did provide heat, including the higher heat needed for smelting iron. This was partly achieved by furnace design, by the development of the blast furnace that used forced air to raise the temperature.

Coal was therefore widely used domestically and in a variety of industries but it had not taken off in smelting, partly because of its sulphur content which made the product more brittle, and partly because of its friability which like charcoal made the furnace difficult to load with extra ore. In the seventeenth century, Dudley claimed to have used the tougher and less friable coke, already employed in other industries, to smelt pig-iron, but in fact it only came to replace charcoal early in the eighteenth century with Abraham Darby at Coalbrookdale. The coke enabled the use of larger furnaces and of higher temperatures, making casting easier. Darby first produced good quality pots on a Dutch pattern but was initially unable to make satisfactory bar-iron. Coke overcame this problem but also that of the seasonal shortage of charcoal. Its use in ovens proved so successful that this was copied in France, Germany and Holland. In 1747 Darby even installed one of Newcomen’s new steam engines that dealt with the other problem of the occasional water shortages to work the mills.

The earliest blast furnace in Europe was at Namur and dates from about 1340. Another is described by Nicola Bourbon from the Ardennes, much later in 1517. In England they were used in Hartfield on the Sussex Weald between 1496 and 1520, when they came from near Bray in northern France. Those were the *Stückofen* that were developed in the Harz region of Germany. In this tall oven, higher temperatures could be reached and part of the iron contained sufficient carbon for liquefaction. The technique of further raising the carbon content to produce a satisfactory cast iron was used in the thirteenth century but not on a large scale until the fifteenth, and much later for many purposes. Furnaces of this kind were built in the neighbourhood of Brescia about 1450.[28] At that time the blast furnace was regularly employed in Europe for making cannon out of cast iron as this was less expensive than using bronze and more enduring than weapons of wrought iron. When the high shaft for smelting was developed, it produced pig-iron which could thus be turned into cast iron; it was also prized for the greater quantity of metal that could be processed, though this depended mainly on its diameter.

The Austrian *Stuckhofen*, that differed from the German *Stückofen*, is now no longer believed to be a precursor of the blast furnace.[29] In fact, it seems possible to get a high temperature even in a bloomery where the furnace master's greatest problem was to maintain the correct temperature. In Austria the most important furnace product, from very early times, was high-quality steel, which required a higher temperature and higher carbon content; some cast iron was produced incidentally, which was originally discarded with the slag. 'About the middle of the 12th century, water-power began to be used, furnaces were built larger, and more of the unwanted by-product – called *Graglach* – was produced. Fining was introduced around 1500 in order to make use of this.'[30] It is therefore not so much that Europe could not produce the heat needed for cast iron or for porcelain, but that they did not do so in bloomeries, at least before the use of water-driven bellows, giving a continuous blast, and before the construction of more efficient kilns.

In the later fourteenth century, the bellows that had previously been worked by foot now became driven by water-power. Water-powered bellows and hammers were mentioned in the eleventh and twelfth centuries and were taken up by the monastic orders, especially by the Templars; the bellows gave a more continuous blast than the hand-held variety. At first, little else changed but the Germans increased the dimensions of the furnace and the height of the chimneys.[31] The consequent increase in power meant that the ore was now more easily smelted to produce both cast and pig-iron. For most purposes the pig-iron was still turned into wrought by the indirect process. However some was now used as cast. In the Tudor period in Britain this was used for cannon and cannon balls, certainly stimulated by France. A number of French founders were employed in England but in 1543, when Henry VIII was preparing for war with France, he had to transfer the trade to English workmen.

This process was facilitated by the change in furnaces of which we have spoken. In the course of modernisation, Burchard Kranich had introduced to Elizabethan England a furnace similar to that described by Agricola, the Agricola furnace. The demand for blast furnaces and for cast iron required more capital than did the bloomery variety, but nevertheless the sixteenth century saw that spread, largely for military purposes. Cast iron was cheaper than bronze for cannon and so more blast furnaces were built to provide it in greater quantity. Later on fuel efficiency increased and in the west these furnaces became the normal way of producing iron, both cast and wrought. In the eighteenth century the furnaces became even larger and more efficient so that more ore could be processed at one time, leading to higher levels of production, as was the case with imported copper.

This search for more fuel-efficient methods paid off, prompted by the shortage and price of charcoal. European countries now sent observers to England to witness the new use of coke and coal in iron-making, especially the French and the Swedes, although these countries still had plenty of wood. But there was also a marked increase in furnace size,[32] even using charcoal but especially with coke. The capacity to cast iron was still limited until developments in gun-making led to yet bigger furnaces.

In the seventeenth century the indirect process of making wrought iron in a finery became almost universal and by 1600 there were eighty-five blast furnaces,[33] which were in the process of becoming even larger. The proportion of cast iron increased, it being used for machines to crush sugar-cane as well as in mills for water-power. Mills were employed for a variety of other purposes, including the making of tin-plate. Tin-plate had been made in Germany since about 1240 when iron sheets were hammered out by tilt-hammers and then exported, especially from Nuremberg. From England Andrew Yarranton had been expressly sent to Saxony in order to learn the secrets of its manufacture and he is credited with introducing the rolling process. But this process was only fully patented by John Hanbury in the early eighteenth century. The German monopoly itself existed until the seventeenth century and competed with the peculiarly English trade in pewter, an alloy of tin and copper. The copper had had to be imported into England, where production had largely ceased since the withdrawal of the Roman forces. Only with the reign of Elizabeth I was it revived as part of her quest for self-sufficiency. The other metallic import to England was of Swedish iron that was used at Sheffield in the making of steel for knives. Most production of this metal had moved to Sweden where there was plenty of charcoal and nearly half of its exports were of iron and copper. They supplied 50 per cent of European copper and virtually all of British. Copper also came from far and wide; Japan and the East India Company even brought it to Europe. The copper was often used for brass-making in which it was alloyed with zinc made from calamine. But in Europe, Sweden was more expert than many others in important ways and the mines used one large furnace for all stages of production, and when the Cornish industry revived at the end of the seventeenth century their experts appear to have been involved, using blast and reverberating (or cupola) furnaces, in operations that were on a larger scale than earlier.

All this production required more fuel, which was a problem not only in southern and middle Europe but elsewhere too. The opening up of the American colonies temporarily solved the problem of resource depletion, even though in Scandinavia where iron and steel had long been important, supplies remained plentiful. Britain imported some of its iron from its overseas possessions and some use of local charcoal still continued because specific products demanded it. But for most purposes coke took over around 1720, especially for iron-smelting. In the eyes of some scholars it was this shift of fuel that marked the beginning of the Industrial Revolution.

Politics, that had been so important a factor in the control of metals, largely ceased to be relevant, and from 1640 commerce and technology took over instead. With its supplies of coal and iron, its developing industry, Britain came to dominate. For 250 years from that date, 'the history of metals is predominantly a British story',[34] what we refer to as the achievement of industrial capitalism when Britain became 'the greatest iron producer in the world'.[35] Iron and coke were both found there in great quantities and their use was stimulated by developments in the making of steel. The crucible process, long used in India, was introduced in 1746, resulting in the first reliable product of this kind. The making of cheap steel was the most important development of the following century, after the invention in about 1850 of the Siemens–Martin procedure employing the regenerative principle. This pre-heated the combustion air or gas using 'chequers' (a brick-work structure), which enabled steel to be made on a large scale. Many products were now made from steel instead of iron – more attractive, harder wearing and rust-proof. Ventures in the field were now financed by merchant-bankers, often by the great capitalists of Europe, who were always especially interested in the metals trade.

Coke was just one of the factors that contributed to the growth of the industry which benefited from many other innovations. It has been said that 'Darby had ensured that plentiful pig-iron could be produced and had laid the foundations whereupon a large production of iron-castings could be built. Réaumur had published a way of making iron-castings that were tougher, stronger and "malleable". Cort had found a method of making ample quantities of the bar iron essential to the engineers for their new projects while Huntsman had discovered how to make good steel for forging into the tools required for machining . . . Patented in 1781, James Watt's new engine . . . opened the way for a huge expansion in the provision of mechanical power . . . The first Industrial Revolution of Britain, usually dated as beginning about 1760, was made possible by metallurgy. In a way it was a metallurgists' triumph.'[36] All this happened in Western Europe, not in one country alone but by the interaction of people throughout that area. Nevertheless in these particular developments Britain often stood out as a prime contributor.

Small improvements were important. It was the remelting of pig-iron from the blast furnace that was responsible 'for the high quality of British cannon of the mid-eighteenth century'.[37] Smelting had completely changed with the use of coal, and especially of coke, instead of charcoal, and of steam instead of water. By the end of the eighteenth century 'coal and the steam engine had revolutionized the making of iron in Britain'.[38] In that century the annual production of iron increased tenfold, nearly all made with coke. The work of the Darbys and the Wilkinsons had altered the casting of iron and the smelting of coke had made possible the production of a less brittle metal. All this was made possible by the resmelting of iron in a reverberating furnace, which gave a higher temperature. Until that time the piston-type bellows of China had been more efficient than the concertina-type used in the west. But the advent of the steam engine altered this technological balance in Europe's favour; now there was an increase in air pressure and a greater use of the hot blast, which made it easier to use coal as a fuel.

The 'final victory of mineral fuel in ironmaking' occurred with 'the application of steam power to the furnace, forge, and mill',[39] and had remarkable results in increasing output at the end of the eighteenth century. This development freed the British from a dependence on Swedish and Russian iron, especially after 1505. English-milled iron was considerably cheaper.

This use of coal for iron-working had been a challenge as early as the Roman period. In Britain the first patent was granted in 1611 and then to Dudley in 1622; he claimed to have used coke that was already general for both lead and copper, as well as for malt and glass. Dudley's furnace at Cradley in Worcestershire probably used low-sulphur fuel (sulphur was always a problem in burning coal), but its product would have been difficult to sell. His claim has not been substantiated; in fact it was not until Abraham Darby and his partner, who had been involved in malt-mills since 1699, that a practical method of smelting iron with coal was achieved.

In 1708, Darby who first successfully did so, founded the Bristol Iron

Company at Coalbrookdale and produced marketable iron the following year. He was able to build larger furnaces than were earlier possible and which were also more fuel-efficient. He then manufactured thin castings that could compete with brass for making pots. When Darby was setting up his coke-fed iron-smelting at Coalbrookdale, conveniently situated north of the river Severn, with coal, ironstone and limestone nearby, and a small stream providing water and the river a means of transport, he first visited Holland where the making of iron was more advanced and from where he brought back skilled workmen to Bristol. He had earlier been employed in the malt-mills in Birmingham that already used coke but this was not yet done for making iron. Already in the charcoal period, Ambrose Crowley of Greenwich had employed many workers from Liège, the town that had grown up on the iron fields stretching from northern France to the Ruhr. The first slitting mill in England for making iron was attributed to Box of Liège, though it has been claimed that one Foley, disguised as a fiddler, brought the invention back from Sweden.[40] The Foley story is similar to the one told of Lombe in north Italy for the machines used in spinning silk. Whether true or not, it indicates the strong connection of metal production, like that of textiles, throughout the whole of Europe and throws doubt upon the English account of its unique contribution to the Industrial Revolution. This attitude emerges from books like that of Ashton on medieval industry which deal with only one nation's movement to modernisation, neglecting that of the others.

With the invention of Newcomen's steam engine in 1712, a new market arose for cast iron and at his works his son cast many cylinders for these engines. They were then used to pump water in the mines from one level to another, which enabled the industry to obtain ore continuously even during periods of heavy rainfall. He extended the use of iron in other ways. In 1779 his grandson completed one of Europe's first cast iron bridges at Coalbrookdale where for Richard Trevithick he also built the first railway locomotive with a high-pressure boiler.

Trevithick was born in Cornwall in 1771 where he became a mining engineer. The costs of fuel had been so high that engineers had to concentrate on the efficiency of the steam engine which was then of the low-pressure type invented by Watt. But Trevithick used higher pressures for this same purpose and in 1797 built a working model. In 1801 he then constructed a steam carriage that he drove up a hill. Later he made an engine to power an iron-rolling mill and another to propel a barge by means of paddle wheels. In 1806 his engines powered the first steam dredger and in 1812 drove a threshing machine. With cast iron and steam, many new uses were possible. He also improved the Cornish pumping engine that was more efficient than Watt's. The Peruvian silver mines had ordered these engines and he went over there to supervise their working. But after eleven years he returned penniless to find that in his absence other engineers, particularly George Stephenson, had followed up on his inventions.

Much fine metal work depended upon the production of plate, especially of tin, made not by hammering as before but by rolling in a mill, now engine-powered. For this purpose, a mill had first been developed by John Hanbury at the end of the seventeenth century, but finer work depended upon the rolls being cast and, when lathes were built, machined. Now the mills were worked by steam. Meanwhile iron rails, replacing wooden ones, were laid at Coalbrookdale by 1767 and at the beginning of the nineteenth century they appeared in tramways. In the last decade of the eighteenth century iron boats came into use and from then on the role of the metal expanded very rapidly.

It was not only cast iron but steel, too. With the production of cheaper steel for many products, there was then a general shift to that metal. In Europe this had been made from wrought iron by a process of cementation, which meant adding more carbon by diffusion at a high temperature. In China on the other hand steel was produced by a process of co-fusion of wrought iron (low-carbon) and cast iron (high-carbon), which dated from the fourth century BCE. In the eighteenth century, however, the steel was about three times the price of bar-iron, which often had to be imported into Britain from Sweden and Russia with their large stocks of fuel and iron. The use of coal for smelting produced sulphur in the iron that was unacceptable for some purposes. For its knives Sheffield had to use Swedish iron, since production was done with charcoal that gave a 'cleaner' material.

Eventually, in these various ways Britain that had earlier been behind in the process of making iron, caught up and, with German, continental and ultimately Chinese help, surpassed others, assisted of course by the many inventions of her own and others. Britain had the advantage of possessing deposits of coal and iron nearby to one another, and eventually followed China in switching to a high-heat technology, producing porcelain, that is, 'China', after much experimentation. This achievement led to what has been characterised as the 'consumer revolution'. Again, long after China, Europe developed blast furnaces to make cast iron and that provided a cheap metal both for internal use, for railways and steam engines, as well as for export to the rest of the world: ‘The plan of *Cast Iron* Rail-Ways is said to have been introduced into England about the year 1786, as an improvement upon the Tram or *Wooden* Rail-Way.’[41] This was horse-drawn. But the use of cast iron produced an interesting rivalry between cast and wrought iron for this purpose, the latter being installed for the rails at Tindal Fell. Malleable iron was held by some to be preferable as cast iron was brittle and required the expense of repair. Malleable iron differs from cast and wrought because it has been decarbonised by oxidisation under prolonged heat and rendered capable of being malleated in a slight degree. But although there was rivalry for some time, it was the cast iron variety that won out.

Iron objects came to be one of the great exports of Europe. This mass-trade in metal goods did not begin early on, nor indeed for a certain time. For the metal could not be cast as bronze had been from the early centuries but had to be individually wrought. Some casting occurred in the thirteenth and fourteenth centuries[42] with the help of water-power. Mills then enabled bellows to be driven continuously using an advanced furnace with a hot-air system so that temperatures could be raised. However wrought iron technology had been established early on for producing individually a whole range of goods that had to be beaten out by a smith. Except for a few weapons, cast iron did not become widespread until the eighteenth century, even though it could be made earlier. Only by the middle of the nineteenth was it subjected to mass-production by industrial methods and from that time onwards the west was technologically firmly in the lead. In the past there had been large-scale use of iron, by the Romans for their military as well as for nails in the construction of buildings, by the Celts and Germans on a smaller scale for their swords and ploughs, in the Renaissance (and earlier) for many machines, especially in mining and for mills, in the early Industrial Revolution for clocks, for manufacture, for farming and for appliances of various kinds. But when the casting process was developed commercially Britain, which had the coal needed for power as well as the ore and the water, could employ the mass-export of objects of iron to the rest of the world as a politico-economic tool. She could now build the iron ships for war as well as for the large-scale transport of these objects to her many colonies and elsewhere; could construct the network of railways to carry goods and people locally; could export this invention, together with the telegraph and other machinery, not only to India but to other parts of the world; could supply hoe blades, machetes and ploughshares to increase the agricultural production of Africa and around the globe; could revolutionise land transport with the bicycle. By the 1950s in Africa the advent of the cheap cycle was the sign of the growing Chinese economy and the relative decline of the European; and then the same happened with the car, again first in Europe and America, then in the east, in Japan, China, Korea and now India.

This new trade also went to the Near East, reversing the original direction of manufactured metals. In the Middle Ages in Europe, trade with the Near East had revived, despite the attempted invasion by the Crusaders that occurred not in search for profit but of salvation. Cultural influences, like trade, continued to flow in both directions, especially through Venice giving rise to its later Turkish foundation that emphasised the link with the east, its export of metal, including coin to Egypt, its incoming trade in silks, spices and perfumes, its outgoing one in woollens, beads and ceramics as well as paper. Not only Venice but Genoa, the Amalfi coast and other Italian cities too were involved. Among other things Italy exported iron from the north that was used increasingly for agricultural tools, for machines, as well as for weaponry. Central Europe developed many such machines employed above all to extract ore for iron in addition to salt for the table. All this development led to the growth of industrial production in Europe as well as being used for weaponry.[43] And the use of metals in the process was closely linked to the identity of the Germans themselves, who had long been specialists.

Machines of course had emerged elsewhere than in the mines, especially in the loom and in reeling devices for the thread used in the widespread production of textiles in Eurasia where the cold weather made cloth so much more important a commodity than in Africa and the tropics. In Europe the production of wool, linen and imported silk and cotton encouraged the development of machinery driven both by human and by non-human energy. And there was the making of ceramics by wheel and kiln, and of food by mill and plough. In textiles it was the north of Italy that seems to have learnt from China how to mechanise the reeling of silk thread from cocoons by using water to power the machinery. In England this process was later applied so profitably to that of Indian cotton, exported as ‘Manchester cloth’ all round the world, even clothing tropical Africa. To drive this largely metal machinery needed to make cloth in mass, Europe made use of its abundant natural resources in water and coal for non-human energy. The Industrial Revolution itself was built upon these components, as well as the basic iron.

The water came from the regular rainfall of Europe, to which its agricultural achievements have been attributed. That and the hills produced the fast-flowing streams working the mills and creating the controlled power needed for processing grain, wool, silk and cotton as well as for making paper, yet another eastern product that was taken over by the west. European agriculture had shown little advantage over that of the south of China or of India, but water power did. In many a narrow valley of the European countryside one found the construction of mills where the machinery was driven by fast-flowing water. That happened in the Montagne Noire in the Tarn region of south-west France and with the Slater Mill of Pawtucket, Rhode Island, one of the first in the United States, which was built and organised on a model from the north of England where mills were constructed throughout Yorkshire. Compared with other parts of the world, water-power was especially important for this work in Europe and the northern United States. So too was coal, obviously more portable than wood and in many parts more continuously available than charcoal. And iron too was essential for most industrial production, widely available and cheap, unlike the metals that were used in the earlier Bronze Age and which, as we have seen, had to be sought out by specialist traders and accumulated centrally at courts and temples. Compared to these other metals, iron was 'of the people', the ore being available almost everywhere in some form or other. It was used not only to make the machinery needed to equip the factories of the Industrial Revolution but also for many of its specialised products such as the shoes and harnesses for horses, the nails for boats and for houses, the blades and ploughs for agricultural implements, the pipes for drainage, the plates for ships, the rails for engines and carriages as well as the engines themselves, together with the later cars and aeroplanes, the stoves for fires, the pans for cooking, the needles for sewing, the frames for windows and doors, the tools of all kinds, not to speak of the rifles, cannon and other armaments. This widespread usage of iron required not only its large-scale extraction and forging but its mass-manufacture, which was in turn related to developments in foundries, in factories and in mechanisation that employed large amounts of human and non-human labour power. It was this activity that brought about those changes in the productive processes that have so affected the modern world.

In all this expansion the iron industry was central and the mining of the metal accompanied the massive industrialisation of manufacture in England, an expansion that was carried out with German help. For example, in Middlesbrough on Teesside in the north-east of England, iron has been made for some 200 years; in fact the town came into existence for the smelting of iron and had little claim to any artistic heritage. Nevertheless, it was a centre of seething vitality. It sprang up at the turn of the nineteenth century with the 'beginning' of industrialisation but made a great leap forward in 1850 when iron was discovered in the nearby Cleveland Hills by a businessman and his German partner. They set up a foundry that became 'the epicentre of the world's steel market'.[44]

Large-scale, mass-production of cast iron or steel, using cheap materials and much non-human energy, enabled Europe and America to develop both internally and externally, that is, to 'conquer the world' with their exports, a process frequently involving territories they had invaded or threatened with their superior guns (again using iron) and their iron (and even earlier) ships. The influence over territories did not necessarily mean colonisation; sometimes it was simply a matter of domination, as happened in the Near East, especially when it produced another profitable source of non-human energy, oil, even more portable than coal. This dominance and colonisation, of which the United States itself was only the most spectacular example, both as colonised and later as mainly neo-colonialist, was the result of superior weaponry and to some extent superior transport combined with the growth of exports and a flourishing economy. These exports included the iron blades to Africa, the railways to India, the ice from Boston to Sidney, Madras and China, the weapons everywhere. Material superiority was easily seen as moral achievement. But these objects were being sent in return for the riches of the east, not necessarily more spiritual but often more beautiful, some then being shown publicly in places like the British Museum, while others were accumulated in the houses of the wealthy.

With the use of cast iron metal objects became cheap, plentiful and 'of the people'. This had been made in early China and long used for the large-scale production of agricultural tools. But in the west it was deliberately produced only in the thirteenth or fourteenth centuries CE and then sporadically. In the fifteenth it was used more often, for casting cannon for which it was stronger than the wrought variety and cheaper than bronze. In America cast iron was first employed in Virginia in 1619 but in the eighteenth and nineteenth centuries it was used more widely, especially for the construction of early sky scrapers, as it had been much earlier for pagodas in China.[45] But the alloy was brittle and needed careful attention which in the twentieth century led to it being replaced by mass-produced steel which had by then become available, and, after 1945, by a more ductile version of cast iron (the spheroidal graphite variety). However it remained useful for automobile engines, for some mechanical parts, as well as for pipes, sluices and furnaces; it was cheap, strong and easy to produce for multiple uses. But to make it needed greater heat and therefore more fuel and energy.

In Europe cast iron seems to have developed in a military context for guns and firearms; cheap metal and gunpowder were crucial to the conquest of the world, partly for cannon on ships like the caravel and partly for hand guns against the 'Indians' in various parts of the world. At home the impact of the new weaponry was slow. The development of large wrought iron cannon in the fourteenth century did not really threaten the defensive castle that the heavy-armoured knight needed as a refuge. But their inviolability did cease in the fifteenth with the coming of siege-cannons. Many of these developments in heavy ordnance were made by German craftsmen, also employed in the Turkish Arsenal in Istanbul, others elsewhere in Europe. The cannon were used systematically by Frederick I, Elector of Brandenburg, between 1417 and 1425, but it was the French and the Ottomans themselves who were the first to use these heavy weapons outside their own realms; Charles VII of France employed them to reduce the English forts at the end of the Hundred Years War, and again in Italy in 1494. Sultan Mehmed II used cannon to attack Constantinople in 1453, bringing the Byzantine Empire to its end, and then driving on through Greece and the Balkans as far as Vienna where the Turkish forces were finally forced back in 1529.

The appearance of these cannon changed the design of castles (and of ships) but they continued as fortifications until the time in the mid nineteenth century when the invention of rifled artillery further transformed positional warfare. The American Civil War saw their first major use, with guns made of high-quality cast iron which had several times the effective range and accuracy of their predecessors as well as firing an explosive shell. The effects were seen in 1865 with the demolition of the supposedly impregnable confederate fortifications in Savannah, Georgia (Map 15). The industrial development of the United States, which produced these weapons, had been encouraged, then resisted by the colonial power. The Iron Act of 1750 attempted to limit that industry in the colonies, principally in the United States, and restricted the production of iron in order to protect the work in

Britain. This was a typical measure to try to limit ‘technology transfer’ such as has later been applied to China and Iran, with equally unsuccessful results.

Map 15 North America

Iron production in the American colonies was at times encouraged and at others discouraged. They were encouraged to produce cheap raw iron, having plenty of charcoal, but to take finished products from the Mother Country. But Britain found it cheaper to import iron from Sweden and Russia, at least until the inventions of Watt and Cort. Cort succeeded in making a better quality of iron more cheaply by puddling and rolling, pressing out impurities and making an iron superior to the Swedes. He brought together a number of improvements to make cheaper iron, made possible in a combination with Watt's engine.

An important development for cannon was their combination with sea-power. The mounting of cheaper cannon on ships enabled Elizabeth's navy to defeat the Spanish Armada although it was the armed caravel that proved so effective in Africa and on the Indian Ocean. These ships were smaller and in some ways less advanced than those they were up against but with cannon mounted aboard and their greater manoeuvrability, they were more or less invincible and with guns helped establish the routes to the east, along which Indian cloth and tropical spices came direct to Europe.

The new mechanism of the flintlock emerged at the start of industrialisation when the production of weapons was among the first to be subject to large-scale methods of production. Ground forces, citizen armies, became bigger, and large numbers of guns were needed to equip them. During the Napoleonic Wars, from 1804 to 1815, more than 1.6 million muskets were assembled in Birmingham alone and nearly 2.7 million 'fitted up' in London; the armaments industry was massive, as in the American Civil War and then in the two world wars that followed, when other production of metals took second place.

To produce these large numbers, standardisation clearly had to occur. Whereas earlier small arms had been produced by one smith, a gunsmith, even in the 1700s ordnance officials in the Tower of London divided the manufacture of guns into locks, barrels and so on, sub-contracting for each of the component parts. In 1722 they managed to produce a standard musket, the 'Long Land' or 'Brown Bess' of the American Revolution (1775–83); later in the Civil War rifles became widespread, as did rifled cannon. This whole development represented the triumph of military industrialisation, the large-scale production of cheap iron weapons for a mass-army by the process of casting. Mass-armaments for democratic armies, cast in iron, marked a turning point in the modern search for weaponry. In the First and Second World Wars iron went into mass-produced ships, into aircraft, into tanks, into guns, into mines and into munitions and this superseded almost all civilian uses. Existing iron was collected for recycling from all and sundry. This even led to the dismantling of the railings in St John's College, Cambridge, to use for scrap, as well as those on Midsummer Common where the rumps are still visible in their concrete base. And the same concern led to the bombing of the factories in Coventry and Düsseldorf where the iron was being processed. That was later followed by the triumphant generosity of dealers in scrap metal like Sir Humphrey Cripps who, apart from gaining a considerable profit, initiated a large number of valuable educational projects through the charitable foundation established as a result of these dealings in 'old iron'.

The railroad engineers of America, like Leland Stanford, were his peacetime counterparts, as were those who built the network of railroads in India, and in various other parts of the world during the Railway Age – men like Andrew Carnegie who also devoted his steel-made fortune to education, or even Henry Ford with his mass-produced, iron-made, automobile or, in a somewhat different mode, those men who profited from the invention and distribution of the metal tin-can, the cast iron predecessor of which had been developed for the navy and was important in the production of much industrial food.[46] Britain had taken the lead with railways, that she exported vigorously, but America soon caught up. So too did the major industrial powers in Europe, with Germany building a railway to Baghdad in its *Drang nach Osten*, and France being no less active too. All this varied activity was of course critical for contemporary life, for commuting to work in factory or in office, by train or by car, and for the consumption of tinned foods to make daily living easier, for the manufacture of multifold goods using non-human energy. But the development of metal did not follow the same path everywhere.

In pre-colonial South America the search for metals was centred not so much upon the 'base' but upon the precious ones, that is, upon gold and silver, the seizure of which fuelled Europe's trade to the east as well as providing capital for her own move towards commercialisation, mechanisation and industrialisation. In North America, the 'base' or 'utilitarian' metals were found in plenty where they were later used for armaments, as we have seen, for railroads, shipping and for the economy in general. But in the early stages of conquest it was from the south of that continent that gold and silver were taken to Europe, mainly through Panama, and it was then that its treasured objects were melted down for their crude value as bullion. From the north came cotton, tobacco, meat and agricultural products. However, in Spain and Portugal precious metals from the south went not only to meet the increased requirement of consumption and exchange, but were also used to pay for the wars of Charles V as well as to decorate the Baroque churches with their efflorescence of gold leaf, as in the memorial to Christopher Columbus in Seville's highly gilded Catholic cathedral. In the Protestant countries, on the other hand, the churches were often bare, stripped of 'distracting' ornaments. However at least some of the American gold was obtained by piracy or by exchange and devoted not to religious ends but to furthering more material pursuits, for example, in purchasing the considerable lands that the church in Britain was forced to give up under the Reformation. This process of stripping the church was good for business and good for education, that is, in the provision of a school in Norwich using an ancient ossuary, or in the founding of libraries of universities and colleges, including the valuable collections of ancient books and manuscripts confiscated from monasteries and given to Corpus Christi College, Cambridge, by the Anglican Archbishop Parker. At this period, universities were being founded throughout Europe, under Catholic regimes as well as under Protestant ones, for countries needed institutions of higher learning to train the clerks to administer the property of state and the church as well as to prepare the clergy to preach to the population. But in Protestant and free-thinking areas those institutions did not always suffer from the same kind of tight ecclesiastical control that was exercised by the Catholic Church with its 'index'. Consequently their curriculum was more open, although not always immediately, to the teaching of wider knowledge and secular fields; even poets and dramatists were found within their cloisters where more mundane spheres of scholarship were now permitted. In the course of time greater opportunity was created for the possibility of learning and research, of a Renaissance from earlier times, though the influence of the church on education, often highly conservative, still remained very powerful.

The subject of most painting likewise changed. With the development of a rich bourgeoisie, the patrons no longer wanted to see the working class, unless in a rural setting. The Reformation meant that no longer was painting limited to ecclesiastical topics; the Church did not prohibit pagan themes and there was a revival of early Greek mythology. In the longer run the Reformation encouraged the production of landscapes and genre painting representing the common man in his struggle against the authoritarianism of the Spanish Catholic Church. But this theme was not altogether to the taste of the new bourgeoisie who preferred the mythological.[47] Sweden and Belgium were also centres of the Industrial Revolution in the seventeenth and early eighteenth centuries. They exported iron in the latter part of the century, mainly to Britain, which provided a flourishing art market for the wealthy bourgeoisie.[48]

Of course there was a substantial change in people's lives with the Industrial Revolution, not only because of the technical changes themselves but because with the use of coal, and the casting of iron (and high-heat kilns more generally), goods and machines could now be provided for a much larger part of the population than hitherto. The improved standard of living was not at first noticeable, except in pockets. The system of mass-factory production led to the kind of living conditions for the working class recorded by Friedrich Engels in *The Condition of the Working Class in England* (1844), in novels such as Charles Dickens' *Hard Times* (1854), and in the paintings of John Cooke Bourne (1814–96) and others. Gradually, life improved for the majority, though there was always a great gap between the bankers and the others; the wages of the latter class (with the help of the unions) and manufactured goods became more plentiful. For most people life meant making things in the factory or workshop or in some way assisting in this process. Primary food production was increasingly concentrated on large mechanised farms, employing fewer and fewer labourers. So the majority of people lived on money wages that they could exchange for the necessities (and later the luxuries) of life. Money played an increasing part, and with it banks, bankers and financiers, all critical to the raising of capital. In fact capitalism had existed long before the development of modern 'capitalism' though obviously with more limited functions. Money-men have been around as long as money, exchange and credit. All except the simplest form of exchange involved their interventions and their prominence was already part of the growing process of stratification associated with the towns as much as it was with the country, with the activities of the urban bourgeoisie as with land owning in the country.

The precious metal from the South American mines and royal treasuries decorated the Catholic churches but was also invested to produce the wealth that led to further economic growth, especially among Protestants, and was used for a variety of purposes. In contrast to Catholicism, the Reformation produced many churches that were barren of decorative and precious metals – the image of the plain whitened walls of one in Holland stands out in my mind, as does the destruction of ‘decoration’ in East Anglia including the breaking of stained glass in order to let in the light of God so that the congregation could reach that ‘holy’, aniconic state supposed to have marked early Christianity. It was this ‘Puritanism’, reverting to the earlier Semitic practice of opposition to images, and combined with the adoption of certain of its features by a reformed Catholicism, that served as an intellectual underpinning of the many changes that were taking place. Some extreme versions of this doctrine even led to the melting down of church bells for their content of bronze, the casting of which by bell-founders had pioneered the way for the casting of cannon.

According to Braudel, ‘[w]ith mining, in Germany or rather Central Europe in the broad sense, including Poland, Hungary and the Scandinavian countries, capitalism entered upon a new and decisive stage. For here the merchant system took control of production and reorganised it’.[49] While the fifteenth century did not invent mining or capitalism, it was a turning point, Braudel argues, for both technical and working conditions. But was it? Surely Braudel is getting caught up in his own notion of ‘development’. He recognises that the trade in metals is an ancient one and writes of the artisans in Europe as early as the twelfth century, when German miners moved into eastern countries. But he then goes on to speak of deep-mining only developing at that time, opening the door to the creation of rich merchants at the end of the fifteenth century. However deep-mining was a feature of the Egyptians, Carthaginians and the Romans in Southern Spain and rich merchants were certainly involved; in this sense ‘capitalism’ began much earlier.

Moreover the mines were responsible not only for the very rich but also for the very poor. When the mines themselves were not worked by forced labour, they established a ‘working-class proletariat’ that had often given up hunting or farming. But this development did not happen only in the early modern period. Braudel overlooks the long-standing operation of the mining industry; and while he recognised some aspects of capitalism in the merchant activity of earlier times, he is also concerned to emphasise the radical changes that ‘finance capitalism’, the ‘new’ capitalism, brought about. The mining industry he sees as part of this later process but it had in fact developed long before the Early Modern period, both in its private and in its public aspects. The sub-soil has frequently been a part of a state or monarch’s ‘sovereignty’, sometimes differentiated from a farmer’s rights, occasionally not. And in the first of these dispensations, men have always worked under terrible conditions, sometimes as slaves, sometimes as paid labourers. But deep-mining certainly did not begin with industrial capitalism, and the mechanisation and invention, to evacuate water for example, did not start with the 'modern' science and technology of the post-Renaissance period. That much is clear from Agricola. In these aspects, European advantage in the nineteenth century has distorted our vision of history and the coming of the modern world.[50]

This saw the birth of what is known as 'capitalism' to many, since the 1820s. There were great changes in the modes of life accompanying the process but the use of this word obscures the nature of the transition. It neglects the earlier role of 'capital' and the accumulation of wealth. It is as misleading in this respect as Polanyi's division of economic activity into 'market' and 'non-market.' In this, the author was followed by Finley in his study of the Roman economy which denies it a market base and even rejected the very notion of economy. It is certainly necessary to distinguish Roman from later activity of this kind; but it is also essential to see it as a predecessor. The employment of categorical terms to mark off periods leads to a neglect of continuities and to a search for general characterisations of a 'spiritual' kind, as in the case of Max Weber's association of capitalism with the Protestant ethic, both of them supposedly marking Europe and nowhere else. It was their 'genius' that produced modernisation – but that is a thesis I reject.

I conclude this chapter by referring to E. A. Wrigley's account of modern developments[51] partly because in discussing 'capitalism' he distinguished two aspects, 'institutional' and 'resource' capitalism and secondly because he deals not so much directly with metals in the Industrial Revolution but with heat, and therefore with coal and coke. So the 'divergence of the English' he relates not to 'essentialist' features but to their specific achievements in this domain, which were undoubtedly helped from the outside, in Europe, and in the Near East and in Asia more widely. His own work however places emphasis on the contributions of the European continent; following Malthus and others, he would contrast England and Europe with the East. My own analysis takes me in another direction.

The general drift of my discussion of the so-called Industrial Revolution is not so very different from his own more specific analysis of 'a mineral-based energy economy'[52] except that I would see this change as part of a process going back to the beginning of the Age of Metals in which both India and China took part. Only at a late stage was it concerned with Europe itself. I do not accept the Malthusian view of the division between the practices of east and west, where his Europeanist approach was mistaken, and demonstratively so in the achievements of the contemporary east. For much the same reason, I am also worried by the dichotomy between an organic and a capitalist economy as I see the shift between the two as being ‘a cumulative progressive unitary phenomenon’,[53] with important peaks, but not as representing an absolute binary division.

What Wrigley’s important works on economic development and demographic growth[54] do is to differentiate between ‘institutional capitalism’ and ‘resource capitalism’. The former corresponds to most recent conceptions, which like Braudel I would see as going back to much earlier times and as being an aspect of a complex exchange economy. Resource capitalism on the other hand is mineral-based, drawing its energy from coal, coke and other fossilised fuels, the usage of which releases the economy from some of the restraints on resources intrinsic to the organic variety as analysed by the classical economists. That economy was a high-heat one, needed for the smelting of metals, and for the baking of clay to make ‘China’.

There are two other general problems to be touched upon. The first has to do with property rights, but it also extends to the way economists of the classical variety tend to treat earlier or simpler societies. Many analysts have been concerned with property rights and usually refer to these in relation to their assumed absence in eastern countries. However, every culture has some defined rights in property, if only to enable primary production to proceed: ‘These are my crops, not yours.’ And there is also some mechanism, not necessarily a court, to sanction a breach of those rights. Of course they differ in their specifications from society to society, but only within certain limits. What westerners mean by no rights is no rights the same as theirs, so that entrepreneurs could operate in areas other than their own. Changes in property rights certainly occurred over time with the development of exchange, becoming more explicit and more complex (as with the copyright developed in Venice). Obviously the changes reflect changing circumstances. Nevertheless for the actors these changes are not completely discontinuous (or completely binary) as the economist’s distinction would imply, since human beings themselves had to live through such periods and had to work out their own relations with both the past and the present in mind, as many in

Africa do at this moment.

Following Adam Smith, Wrigley places much emphasis on the part played by specialist production in increasing output. Specialisms involve exchange; nobody now does everything. This is a subject we have discussed earlier in relation to Childe's view of the Urban Revolution. Once again economists sometimes think of capitalism as inventing the division of labour, but it was of course widespread in earlier industry, as Ledderose notes for China.[55] Another problem concerns the notion of the European or English divergence on the road to 'capitalism'. Some have seen this as an in-born propensity, a question of 'cultural genes'. Others have attributed it to more proximate factors. But we have to take into account the long-standing history of the Bronze Age, which produced libraries as well as metals, and at the same time to consider the specific developments of the post-Renaissance period. This problem lies at the heart of my enquiry. In looking at the divergence of England, Wrigley is quite specific that this was not built in but occurred at a particular time, beginning in Tudor England. It ceased when the United States and Germany adopted a similar system. Earlier, it had been Germany that had been ahead in metallurgy and they certainly contributed to the modernisation of English mines in the Tudor period – indeed both before and after – in a way that led to its great advances in the use of iron, coal and coke. That development was not specifically English but rather an international one, continuing what had gone on before only in an intensified way.

In fact, well before England Wrigley sees the Dutch Republic as having all the features of 'modernisation', of 'capitalism' in the first sense. But it had no industrial revolution, for that development was based upon a 'mineral-based energy economy' that the Netherlands never had. In other words, it had no coal and steel; the 'Industrial Revolution' first came into being in England with its vast resources of both and the world-changing inventions involved in their exploitation.[56] This development meant 'a different sort of capitalism' which could now overcome the problems inherent in all organic (Malthusian) economies. For example it provided the cheap heat that was necessary for the production of plentiful glass. In the eighteenth century the agriculturalist, Arthur Young, was struck by the fact that he could not see a single pane of glass in the windows of a large village in the Garonne valley in France, in contrast to what he would find in England.[57]

I would myself wish to modify the division into organic economies and others and to see the shift to mineral-based systems as developing right from the beginning of the Age of Metals (and even earlier with the use of heat in the pottery Neolithic). The problem with that division is that this Neolithic economy was already partly mineral-based, as in the manufacture of pottery, so the division is perhaps no more satisfactory than that between market-based and subsistence economies (for all had some exchange), nor with the common sociological split between traditional ('static') and modern ('rational') economies (for some human invention is always present). We need a form of conceptualism that reckons with continuity as well as with change, and that is difficult to accomplish with such dichotomous concepts.

The early development in Holland has been analysed by Dutch writers who, like Adam Smith, recognise the non-sustainable basis of earlier 'capitalist' economies. The growth of industry was stimulated by the use of low-cost energy in the shape of peat and water-power.[58] The peat was limited. In England however the problem was solved because the shift from an organic to a mineral base was one involving the move to coal (and iron). As Wrigley sees it, the move away from an exclusively organic economy was a *sine qua non* of achieving a capacity for exponential growth,[59] which was supposed to make poverty redundant. Exponential growth certainly took place but was was also subject to alternation, as development had been in the past. Economic leadership was taken over, firstly by the United States and Germany, and now (in many ways) by China and India. The shift itself throws some doubt on the definition of capitalism in terms of continuous growth, unless we can see 'continuous growth', not in one country, or even under one regime, but in the world economy as a whole.

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1 For a discussion of the use of the terms 'civilised' and 'barbarian', see Daniel 1968, Chapter 1.

2 Ashton 1993: 2.

3 Klingender 1968: 91ff.

4 Quoted in Klingender 1968: 142–3.

5 Klingender 1968: 51.

6 Hatcher 1993: 456.

7 And in Britain possibly in the middle of the twelfth (Salzman 1964: 1).

8 Hatcher 1993: 5.

9 See Klingender 1968: 13.

[10] Wrigley 1962: 16.

[11] Beckwith 2010: 114.

[12] Needham 1964: 23.

[13] Needham 1964: 22.

[14] Liebermann 2003: 253.

[15] Needham 1986: 568 ff.

[16] Needham 1986: 574.

[17] Bartels 2009: 52.

[18] Bartels 2009: 82.

[19] Bartels 2009: 83.

[20] Bartels 2009: 83.

[21] Ashton 1993: 4.

[22] Ashton 1993: 4.

[23] Ashton 1963: 4.

[24] Wagner 2008:349.

[25] Wagner 2008: 161.

[26] Wagner 2008: 261.

[27] Coal was then used for smelting in certain parts (Davies 1935: 153 n.) but owing to its impurities was thought inferior to charcoal until the invention of coke in the seventeenth century.

[28] Forbes 1958: 74–75.

[29] On the difference between the Austrian Stuckhofen and the German Stückofen, see Wagner 2008: 352.

[30] Wagner 2008: 352.

[31] Aitchison 1960: 340.

[32] Tylecote 1992: 130.

[33] Aitchison 1960: 435.

[34] Aitchison 1960: 420.

[35] Charles 1997: 419.

[36] Aitchison 1960: 465.

[37] Tylecote 1992: 139.

[38] Tylecote 1992: 124.

[39] Ashton 1963: 97.

[40] Ashton 1963: 20.

[41] Longridge 1827: 5.

[42] Singer *et al*. 1954.

[43] Agricola 1950.

44 Quotations from Ruth Sunderland, ‘My home town is fighting decline’, *Observer* 7 March 2010.

45 Needham 1964: 21.

46 Goody 1982.

47 Klingender 1968: 51.

48 Klingender 1968: 55.

49 Braudel 1982: 321.

50 Goody 2006.

51 Wrigley 1962, 1988, 2004.

52 Wrigley 1988: 81.

53 Wrigley 1988: 3.

54 Wrigley 1962, 1988, 2004.

55 Ledderose 2000.

56 Wrigley 1988: 104.

57 Wrigley 1988: 125.

58 De Vries and van der Woude 1997: 338–9. On the use of peat for the Netherlands, of its gradual disappearance and the advantages of cheap and plentiful coal in England for domestic heating and for industry (but not at first for iron) see Hatcher 1993: 550.

59 Wrigley 2004: 66.

12
Metals, ‘capitalism’ and the renaissances

Although the proximate impetus for this book came from students from the east, some wearing their veils, I have always wanted to pursue the story of the Bronze Age in more recent times, perhaps ever since I was in the ‘Middle East’ during the Second World War and ‘discovered’ civilisations in Asia that existed much earlier than my own. The Bronze Age meant the development of urban life, not only of the metal plough and the spear, the sword and the axe but of writing, with a complete shift in the mode of communication.[1] If this was not the beginning of scientific and cultural life, at least it gave those activities a great spur and eventually pointed the way to the modern world; if it was not the beginning of artistic activity, it represented the birthplace of many of those forms that we value today. In talking of the role of metals in this Bronze Age, I have never wanted to exclude the more ‘spiritual’ aspects of culture, so important for an anthropologist. But on the other hand I have never accepted a complete gap between the two. Libraries proceeded from writing; in Mesopotamia writing was at first developed for accounting. Our division between the material and the spiritual has always seemed to me a crude and primitive distinction related to that between the soul and the body which I had considered at some length when writing on LoDagaa funerary practices.[2] There appeared to be little firm basis for this widespread dichotomy. The Bronze Age that was the effective beginning of the Age of Metals also produced the golden treasures of Ur.

At a similar level of abstraction, magic and science (or technology) have always been intertwined for me as with the Oceanic fishermen discussed by Malinowski, as with the Alchemists of the Islamic, European and indeed Chinese ‘Middle Ages’, as with Newton himself and perhaps even with Joseph Needham. It is true that with the later separation of these aspects, the advance of knowledge of the world proceeded more rapidly, but in the minds of most they are still intertwined. Nevertheless the long-term development of mankind did involve a certain separation, as it did with the arts and sciences.

But earlier, among the LoDagaa, there was little discrimination between these activities, between powder for a gun and ‘medicine’ from a shrine.

The search for metals fuelled developments in the largely unreconstructed (‘barbarian’) west even when Europe served as a supplier not only of precious metals but of base ones too, metals such as copper, tin and later iron. The local production of iron was especially important to the Greeks and Romans because of the nature of their weaponry, defensive as well as offensive, and for their agriculture, their ships, their buildings and their tools. All this required the metal in large quantities. And that material came mainly from outside the confines of urban ‘civilisation’, provided by tribesmen such as the hillfolk of Anatolia and of the Iranian plateau, the Celts and Germans from northern Europe as well as the Turks and Mongols of central and northern Asia. In producing the iron, they also copied the weapons of the ‘civilised’, and used them against the town societies, in the course of which process they created their own Hallstatt and La Tène cultures in Europe developing iron-working, for ploughing as well as for fighting. And this practice of searching for metals among the ‘barbarians’ to supply the ‘civilised’ lived on in Germany, in particular. But after the post-Roman collapse that continent more generally revived the earlier provision of metals of all kinds to the Near East, mainly by export through Venice. Together with Florence and other Italian cities, much of the inspiration and the supporting commerce for the Italian Renaissance came from these centres, linking peripheral Europe to the Near East and thence to the cultures of both India and China. At the same time trade spread the achievements of the Renaissance to the societies of the north, renewing those of the classical world as well as encouraging the new, not only to the southern Germans of Augsburg but to the citizens at Prague and Vienna, as well as to the French, to the Dutch, to the Hanseatic towns, and then to London.

The relation between the urban ‘civilisations’ of the Bronze Age (and later) and the ‘barbarian’ areas is somewhat akin to that envisaged by sociologists between the core and the periphery. The problem of this discussion, which in some respects fits the initial Age of Metals well enough, is that the metaphor of the core seems to solidify relations in a defined way by making these situations permanent, or semi-permanent. Not only were they relative and variable over time, as with Europe and the Near East, but the societies could also be internally differentiated in various ways. India is often seen as being peripheral to Europe’s core, but before the Industrial Revolution it exported its cotton cloth as well as selling *wootz* steel to Rome and spices to the world. It was ‘dependent’ only for a relatively short period, and now the boot is almost on the other foot. We have to see this relation as multiplex and dynamic, changeable too and not as highly structured in sociological terms.

The concept of core and periphery is particularly troubling because of the limitations placed on it by the original formulation. In 1974 Wallerstein specified a world system as essentially a world economy that he saw as being developed in a northern European core, accumulating resources from a vast periphery. Cores exported manufacture, the periphery exported agricultural goods and other raw materials in an asymmetrical exchange. One problem is that Wallerstein saw only modern European imperialism as producing such a system; in other words the concepts were tied to what people have tended to call capitalism and this happened only in Europe. Here he follows his master, Braudel, though the latter modifies the dichotomy, and indeed most nineteenth- and twentieth-century thinkers,[3] in separating the institutions of the west too radically from those of the earlier and other world, indeed in a thoroughly ethnocentric manner. The nature of this dichotomy has already been queried in considering the Ancient Near East where the author claims that Wallerstein ‘does not recognize the process of asymmetrical exchange and cross-cultural interdependence in earlier societies because of “his rigid conceptualization of both trade and ancient empires”’.[4] For he sees trade in earlier times as based on ‘preciosities’ not on bulk staples, but this dichotomy Algaze characterises as ‘false and modernist’, ancient trade consisting of copper and wood essential for the ‘resource-impoverished alluvial environment of southern Iraq’.[5] Even textiles were mass-produced. ‘Each major city-state had a palace organised weaving establishment where thousands of dependent workers (and, on occasion, their children) laboured to process wool into finished fabricated garments’.[6] But Wallerstein was mistaken not only economically but also politically. He viewed the modern economy ‘as quite different from earlier empires’. They were ‘essentially homeostatic institutions’ with a simple political system,[7] the state economies being co-terminous with the politics. Again Wallerstein is making the problematic divisions that many earlier writers made between pre- and post-Renaissance (that is Italian), without adapting the concept of the economy to apply to other societies. This approaches the distinction of Polanyi between market and non-market societies, hiving off the Ancient Economy into another category altogether. Once again, modern is seen as one deriving from Western Europe's situation in the nineteenth century. But that uniqueness is also seen as beginning much earlier with a claim to the singular significance of the Greek alphabet. My questioning did not seek to deny that something important happened in the west both in the eighteenth and nineteenth centuries and of course in the Ancient World, as with the alphabet. However this 'uniqueness' has to be seen in more precise and substantial terms than that of the advent of 'Antiquity' and 'capitalism' to Europe alone. The events have to be understood in the context of a true world system, that is, in the light of the intensification of exchange and of specialist activity in the increasing search for, and the use of, metals as well as of the knowledge of the world more generally in a now literate situation. In metallurgy that use involved the application of high-heat technology and of mass-production together with the expertise in iron that developed in Europe later (and elsewhere too), first with Germany leading the way, then partly as the result of efforts of the Tudors in seeking supremacy in North America and over the repatriation of the wealth of the south of that continent. That took place based in a land where coal and iron were plentiful and conveniently located, and where local ingenuity led to an advance in the processing of these minerals, notably with the development of the steam engine by Newcomen and Watt and of the railway by Trevithick and Stephenson.

Taking this into account avoids the problems involved in drawing a classificatory boundary around 'civilisation', a process which too often gets bogged down in static categories,[8] like traditional and modern, civilisation and hinterland or centre and periphery. We have to see the relationship as changing over time, as alternating or spiralling, with metal-suppliers becoming metal-users and developing the use of cheaper materials (iron and then cast iron) that then dominated the world. This process had already been adumbrated by Childe;[9] like many others, Lévi-Strauss emphasised the role of the steam engine in what he called 'hot' societies; so too have T. S. Eliot and other poets with respect to literature. But once again the temperature must be subject to change, not treated as a 'primordial' feature.[10]

To recapitulate, the mining of European metals, which had long sustained east–west relationships in the Mediterranean and in Central Europe, declined after Rome and again after the mid sixteenth century and the invasion of the Americas.[11] Whether this was the reason for the shift of investment is unclear, but American mines, especially in South America where the labour force was much more ‘docile’, were more profitable, and the Fugger, the epitome of ‘capitalism’, were soon busy making gains in that part of the world. In Europe the supplies of many ores were now dwindling in relation to increasing demand, as were those of the wood to fuel the furnaces, but this was the case neither with coal nor with iron. At the same time wages were going up, partly to purchase the goods being made with these materials. For western Europe it was more profitable for money-men to mine elsewhere, even in Scandinavia or in Russia in the north with their wood and ore, as well as further afield in America, and then in Siam and the Far East. But this flexibility of venue was not always possible. Mercury was needed in the silver mines of South America for the amalgam process, and this had to come from Almaden in Spain that until 1645 was under the control of the Fugger. The other source of mercury was a mine at Idria owned by the Austrian state. Both ownerships were understandable because in many cases the scale of the equipment excluded the small-scale miner and opened the way for large enterprises, as with this one organised by the state or others set up by large private capitalists or their companies. Complex machinery and organisation encouraged such operations. But in a few spheres it was extraordinary what could be done by a large number of small entrepreneurs, in mining or in shipping. Capitalism did not always have to be on such a grand scale, although finance capitalism largely was, but also often supported by individual ‘shares’. Both iron and coal were then extracted by relatively small enterprises before they became more ‘professional’ industries, as was the case with coal in the French Lot or with silver at today’s Potosí in Bolivia, mainly part-time.

Aside from such miners, it was in Central Europe that the ‘highest concentrations’ of peasant workers, that is, farmers who were also ‘labouring’ in factories, were to be found;[12] sometimes these were home-workers associated with a larger enterprise, as in the putting-out system. The woollen manufactory of this kind in Linz, acquired in 1754 by Maria Theresa, employed 15,600 workers, two-thirds being spinners or weavers working at home. The mix of factory and home-workers was not unusual, with the labour of the former sometimes being recruited from among criminals or orphans in a slave-like way, as had been often the case in mines.

This whole development of industrial production in the use of metals and textiles led to what is often called ‘capitalism’, not some essentially European phenomenon delivered by religion as Weber had suggested, nor yet some underlying quality of people as a 'race', as Sombart seemed to propose in writing of the Semitic contribution. As we have seen, the activities of Germans, of Jews and many others have more concrete explanations. Nor was it the case of an inevitable development out of the contradictions of a unique or at least dominant European 'feudalism'. In its extreme form the western thesis held that it was only Europeans who knew how to invent, a notion linked to the belief that earlier societies were necessarily static and even non-rational.[13] The idea that Europeans invented a new form of rationality or even social change itself was a product of their temporary superiority in the nineteenth century and the attempt to explain why until then others had not achieved what they had done. However invention is not something that is alien to any human mind nor yet is rationality; they appear throughout human existence in different forms, at different tempos and in different mixes. From the very beginning, humans have invented solutions to their problems; and they have explored the world around them, often ending with transcendental visions. The idea of an earlier, static, 'primitive', non-rational, society, has been maintained by many sociologists and historians, including Marx and Weber, but it is quite foreign to the experience of most of those who have engaged in 'participant observation' among such peoples. As has been said of the coal industry, the methods of coal-making 'benefited from continuous improvement, but the advances were normally the result of multitudes of small steps taken with the aid of the pragmatic ingenuity of generations of working miners rather than giant leaps facilitated by scientific breakthrough'.[14] The same was true of agriculture. Life has not changed in this respect. Man is a 'rational' animal, whatever that may imply, and rationality is not simply an attribute of modern man, though with writing and computers he may have become more 'rational' in terms of an array of more limited and obvious criteria.[15] The change that has occurred over history is a much more concrete matter than is often suggested, associated with the development of human communication (especially writing), of human thought (speech) and human activity (social intelligence).

From the beginning of the Age of Metals what we see is part of this long-term development of cultural features, in Eurasia involving a movement of objects, techniques and ideas, first mainly from west to east, then from east to west. The direction of this movement continued in that way until the Renaissance and was later largely reversed, as it may well be doing again. 'Religions' were part of this movement, so too were other cults and much information of a technical or scientific kind. Christianity and Judaism spread from the Near East in both directions, and so from the eighth century did Islam, extending over three continents, as did the others in a minor way, giving Muslims a privileged access to knowledge, goods and techniques, including paper and gunpowder, both essential to 'modernity'; and these it passed to the west together with the other Chinese invention of printing (though not the press). Looking at 'la longue durée', this alternation between east and west in the level of 'civilised' life is clear, and at no time did either hold the sole secret of development. For the same was true elsewhere. 'The genius of medieval Arabs', writes Lyons, 'lay in their extraordinary receptiveness to new ideas, their ability to identify and adopt what they needed from foreign cultures – first Persia and Hindu, then Greek – and to modify and enhance these notions to fit the practical, intellectual, and especially religious demands of their own times'.[16] He continues, 'Arab scholars effectively enjoyed a global monopoly of the far reaches of the world that remained unrivalled until Europe's age of Discovery'.[17] 'Innovations of all kinds' flowed from that direction, though in time that flow would be less of 'a one-way street'. How different that suggestion is from the 'essentialist' approach of some Europeanists who considered theirs as the home of inventions and trace their superiority back to an Antiquity that had itself grown out of the Ancient Near East. The social history of metals and the Near East generally make us rethink and re-orient our world.

Inventions, then, took place throughout Eurasia. Needham has written of the early achievements of Chinese science and technology, especially in the realm of metal-working. From the Song period they led the world in most of the sciences and also in some of the arts right up to the Italian Renaissance. The country remained the leading exporter not only of ideas but of goods until the beginning of the nineteenth century. There is also much evidence of the success of India, not like China with porcelain but with the production of steel, in calculation and in mathematics too, as well as in the export of cloth to South East Asia and then to Europe, together with many other commodities – valuables such as spices, jewels and perfumes and even metal went to the Roman world, cotton to Egypt and sugar to the Mediterranean, all three also going to the east.

The differences in the course of world development since the Renaissance have been partly a matter of the increasing speed of communication that followed the transmission of techniques and knowledge. At earlier periods what happened in one part of the Eurasian continent influenced another over the longer term. The wheel would slowly migrate from the Near East both to China and to Europe; it was apparently not invented twice. With intellectual notions it was often different, but ideas were also passed on in a similar way. Certain methods of 'logic' may possibly have travelled from Greece to China and Japan, just as paper, printing and powder flowed in the opposite direction. In this process, the contact of people and the exchange of goods and materials were critical. With the increase in the kind and volume of goods, those contacts intensified the exchange of ideas, which boosted the development of culture and technology.

What were the factors that permitted this intensification? Clearly the improvement in communications was one, prosperity another. But in this process of exchange there was no undisputed leader, no quasi-permanent superior, no victorious culture, at least on a permanent basis. There was a swing that varied in different contexts. In communications, the Chinese invented paper while the Europeans were writing on skins or wax tablets. They invented block-printing when Europeans were writing by hand, often copying at great length. But it was Europe that used the press, derived from that employed for crushing olives and grapes, both Mediterranean products that Greece had exported in a processed form. And the Europeans later developed the rotary press and made other advances based on Chinese discoveries, especially with metal weaponry and machinery. No one region or people had the monopoly on inventions nor upon creativity in all its various shapes. The Jesuits brought some aspects of the science of the Italian Renaissance to the Chinese; the Mongols may have transmitted gunpowder to the west, with such earth-shaking consequences. Later on it was the Americans and the British who developed the atomic bomb, helped by émigré scientists, the Germans and Russians who built the space programme, and now the pendulum seems to be swinging eastwards again. This situation is associated not only with the search for metals but for the many developments in science and the arts as well as for the solution to other problems, often in health, that has driven so much of human life.

In this discussion of metals and development, I do not wish to imply that all Eurasian civilisations, by which I simply refer to those urban societies that had writing, were always proceeding in a neck-and-neck race to develop life in towns. There were many relapses, many alternations. But the general direction is clear. The Bronze Age was first developed in the Ancient Near

East and only later in India, China and in Europe; the speculation about the Early Bronze Age in South East Asia seems to have evaporated. But in the Iron Age, India produced high-quality steel that was even imported to Rome, while cast iron was manufactured in China in the third century BCE, and not deliberately in Britain until much later. There was a swing between the two, which I have called an alternation[18] but which one of my French reviewers refers to more felicitously as 'l'histoire penduleuse',[19] although it is a spiral rather than a pendular movement. Later on the technical advantage swings towards the European, not only in the Italian Renaissance but especially with the German metal-workers and later with the British. This was one among many such swings, not only between continents but between countries, a most important part of which was in communications, in paper and in printing.

Such a swing occurred with the working of the metals themselves, for their techniques were transmitted to the 'barbarians' who controlled both the raw materials and the power to process them, that is, the wood for the charcoal to heat the furnaces, the water to drive the mills, later the fossil fuel – especially the coal – to replace wood and do a possibly less devastating a job, and later still the deposits of oil, a more flexible fuel but in many ways yet more harmful to human life. The use of metals reached a peak with the development of machines, not only for the manufacturing of goods which initially were often substitutes for imports from the east, porcelain from China, cotton from India, silk and paper from the Near East, though ultimately from China too. Successful substitution (or copying) became a central goal of the Industrial Revolution but one that also developed the mass-produced iron for the use of agriculture and transport, for ships, cars, railroads and for the steam engines to drive the trains, both the latter being inventions of mining engineers, as well as the large-scale production of iron for building and for a variety of domestic purposes – for gutters and girders, for grates and stoves which respectively transformed the drainage of roads, for the strength of buildings, as well as establishing the British tradition of stews and over-cooked vegetables. In other words, it was central to the 'consumer revolution'. But apart from these peaceful uses there was also the very important place of armaments in equipping first the legionnaire and then the knight decked out in armour, which was followed by the age of gunpowder involving the work of smiths (that is, gunsmiths) using the metal, powder and projectiles. These military innovations originated in the east but were developed in Germany as well as among the ‘barbarians’ of the steppes who may indeed have transmitted not only the chariot and the horse to the Far East but metal-working itself. The role of the gunsmith began with the need of metal containers to hold the explosion of powder, both for cannon and for firearms. The emphasis on the military use of metal occurred right from the beginning of the Bronze Age. Childe wrote that ‘Oriental monarchies were created by war, maintained by continual war, and eventually destroyed by war’.[20] War involved the accumulation of valuable metals and that was so not only of the Orient. The cost of metal used in the equipment for war, seen as needed to defend the ruler or the nation, has often succeeded in ruining what it sought to preserve.

This situation with regard to the Industrial Revolution was not simply the achievement of Anglo-Americans, though they did tend to dominate its origins from the beginning of the nineteenth century. But it also lay in the earlier period, that of German metal-workers, of Italian traders and producers, of Spanish miners, of Roman manufacture, of Greek knowhow, not to speak of the later French industry which had been a main producer of early motor cars along with the German Daimler, of the supersonic Concorde and the highly successful Airbus as well as being a nuclear power in its own ‘right’, despite enemy occupation and plunder during the Second World War. Nor was the industrial development consequent on that ‘revolution’ confined to Europe, although that continent had both the metals and the power. On a smaller scale mechanical and industrial advance took place in Asia. In the Near East, firearms were developed in the Turkish Arsenal, and it was its towns, its industries and its manufactures that helped to keep Europe in business during the years leading up to the Italian Renaissance. Further to the east other important metal-using cultures were also so much more, India with its bronze and iron, China with its early pyrotechnology and casting of both, nowadays clearly major competitors in the productive, educational and artistic processes in which alternation between these various written cultures is the order of the day.

In this volume, I have tried to outline the relationship between the Ancient Near East and Europe from very early days in the context of the search for metals. In the Age of Bronze it was essential to search for and import these materials because there was little in the fertile valleys where the surplus-producing agriculture was developed, largely through ploughing with animal traction in favourable environmental circumstances and giving sufficient both to feed specialists in the towns and to exchange with ‘barbarians’ for metals. Thus the early city cultures, the first ‘civilisations’, were forced to look outside themselves to the societies beyond their boundaries from whom they sought these goods, especially metals. Those outside were influenced by this exchange and themselves soon became metal-users, both in war and in peace. And this interaction was especially important in the Iron Age as the metal was no longer scarce, so its use was widespread and that encouraged expansion.

Although the ore was found almost everywhere, its quality varied and it continued to be imported, especially in the processed form of iron and steel. Metals, precious and everyday, were always required by the Near East and even after the fall of Rome and the collapse of the western economy, the eastern Empire, and later Byzantium and the Arabs, continued to exchange these and other goods with India and China. But in the west, trade diminished and items that had become widely used under the Romans now reverted to the status of ‘luxuries’, as trade in the Mediterranean declined radically, especially with the struggle between Christian Byzantium and a conquering Islam. However, in the Near East itself the economy flourished, continuing the intercourse with the Orient that resulted in a flourishing economy and produced many manufactured goods. At the same time it developed systems of information employing eastern inventions such as paper and even some wood-block-printing. This revolution in the means of communication was accompanied by a significant growth of information, by larger libraries, more interpersonal writing as well as by a renaissance of classical scientific knowledge, all this leading to a period of economic and manufacturing development that has been compared to early modern Italy.

This wider perspective provides an alternative view of the world. Not one where the east was backward (it had cast iron, paper and wood-block-printing long before the west), not centralised (although China had one script, it had much local diversity), not despotic (for consultation of the people took many forms), not without law (by which people mean without European law), not feckless in population growth (having a lower marital fertility). And, except under Islam and some pockets, it had few of the monotheistic restrictions on information and on the arts that marked the post-classical west. The Near East itself developed its trade eastwards, importing spices and cloth, as well as organising its own manufactures and finances in a ‘capitalist’ way, according to Ashtor and others. In the new millennium the European economy emerged from its stasis once again and it wanted to import more of the rare ‘luxuries’ of the east that had continued to trickle in along the Russian rivers, as well as wishing to renew the export of its own wool, metals and other products in exchange. Trade started up again, especially through Venice and the other Italian towns that drew their metals and much of their markets for oriental goods from the north where they also sent their own cultural products. Ever since the coming of metals, Germany and Austria had been not only a source of ore but also of expertise in all the related specialisms. Their miners, especially the Saxons, spread to Italy, to France, to Britain in the west, to Hungary, to the Balkans, to Eastern Europe in general and even to Russia in the east. These countries developed their own expertise in metallurgy as well as eventually learning from the high-heat technologies further east. The expertise was transmitted to Britain developing its own tradition of working metals, though all that diminished after the Roman period. With German help, it grew up again, especially in the Tudor period when metals were needed to combat the Spaniards, their rich rivals in the Atlantic trade. That help was particularly evident in matters of weaponry, in both muskets and cannon, which in Germany involved the creation of metal containers for the Chinese gunpowder. The seafaring nations of the Atlantic coast, especially Britain and Holland, rendered these weapons more mobile by installing them on ships. Along with other Atlantic powers, this permitted them to conquer much of the world. Britain was well placed in this new Iron Age. It had a wealth of conveniently sited metals together with the coal (later turned into coke) that was needed to smelt the iron and to replace the increasingly scarce charcoal. This was known as sea-coal and was transported cheaply by water. So it was able to produce the heat for the inexpensive iron needed to manufacture the weapons, the steel-clad ships (the ‘Ironclads’), as well as the hoe-blades, ploughs, railways, steam engines, cotton mills and other machinery, ending today with the cars, aeroplanes, rockets, together with the radios and televisions, the typewriters and the computers themselves. The conquest of the world was not effected only by force. Together with Germany and other nations, the country developed a tradition of study and research in materials and their origins which was in many ways the foundation of much ‘scientific’ knowledge (and alchemy), often linked to ‘technology’ both here and in China. My discussion of developments leading to the Industrial Revolution seems closest to that of Goldstone.[21] I would also place emphasis on British achievements in this field while at the same time seeing these in a European, indeed a Eurasian context, as well as being wary of binary distinctions between modern and earlier science, unless these concepts are given a more specific formulation.[22]

Academic study always had a tendency to drift away from its more practical cousin, technology, pulled aside by the existence of literacy and of a scholarly elite; in this way 'science' became concerned with the more abstract topics and with more general subjects like the order of this world, which had previously been the domain of religions. That at least happened with the dominance of the monotheistic creeds from whose constraints the various Renaissances have had to break loose, or at least undo some of their confining strings and allocate a specific sphere to the supernatural.

However, we have to think about the Age of Metals not only in terms of technology but of art, as at Ur in the Ancient Near East. That problem continues. What is the connection between the Industrial Revolution with its use of coal, coke and steel, and the European Renaissance with its flowering of the arts and of other forms of knowledge?[23] In Europe that expansion was clearly an aspect of the limited secularisation of society that I have mentioned. In earlier Europe all 'high' art had been religious and financed through the Church. Some was admirable, some pedestrian, but it was strictly limited in terms of topic; indeed earlier Semitic traditions had even rejected all such representations, as still today in much of Islam. Religious art, like religious drama and literature as a whole, was originally a daring breach in the complete rejection of figurative icons. The limits of this art were gradually widened to include nature, at first seen as a background or through a window, then whole landscapes, finally in the hands of Poussin inhabited by human or supernatural figures. And in Flemish art, the permitted topics were extended to everyday life. There had already been a secularising aspect of the Italian Renaissance in portraying noble and mythical occasions, and 'popular' art did not always have the same restrictions as the 'high'. But in general art was extended at the same time as science was reinstated, as also happened in other Renaissances. Both of these activities had become more specialist, especially with the change in the mode of communications, the growth of literacy with the word now duplicated in print and with the development of distinct consumers both of the written and of the aesthetic. All this activity required economic success, in the very first place in the agricultural production of the fertile river valleys, later in the realm of production and exchange. It was no accident that Venice and the Italian cities played such a prominent part in trade with the east (especially in metals), in the development of accounting and in the revolution in the arts as well as in printing (together with south Germany) that marked the European Renaissance.

This is the story of this book but it has somewhat metamorphosed as I was writing. As I have said, it began with an attempt to draw attention to the long-standing connections between the Near East and Europe. That entailed going back to the Bronze Age in Mesopotamia, which for me represents the junction point in Eurasia between the history of the east and the west, a multiplex unity to which historians rarely look back in their effort to establish the uniqueness of the west. It was also characterised by a Bronze Age without bronze, which involved the search for metal among hill peoples, both west to the ‘barbarian’ Mediterranean and Europe, and east through the Eurasian corridor to India and China. In the European case the transfer of metals was later interrupted by the post-Roman decline in trade through the inland sea. This decline was eventually reversed by the revival of internal and external exchange, one involving the Italian cities especially Venice whose galleys were travelling to the east, and depended very much on German metals being brought down in return for the ‘luxury’ products of the east.

That led me to approach another much-debated topic, the rise of Europe. I had always had problems with friends and scholars like Ernest Gellner and Alan Macfarlane who did not altogether approve of my attempt to query the uniqueness of the west and to stress the contribution to contemporary society made by the east. They considered this endeavour did not fully appreciate the central role that Europe, and particularly England, had played in the formation of ‘capitalism’, industrialisation and modernity, which they attributed to deep-seated causes of an ‘essentialist’ kind. It was not enough to talk as I had of alternation, of the connection between the east and the west, between one metal-using and literate region and another. One had to consider the specific reasons for western pre-eminence in the recent past. However, for this, Weber and Marx, Malthus and other western historians, writing at Europe’s zenith, were in my opinion insufficient. They were mesmerised by the British triumph in the Industrial Revolution. In this, they were not altogether wrong but they foreshortened and localised what was a much wider movement. Many looked for ‘spiritual’ explanations, others for natural, specifically European, ones. I myself considered that these accounts did not allow enough space for alternation between the east and the west but on the other hand implied or indeed claimed the long-term superiority of the latter. But I was also drawn to the fact that, in considering development ever since the search for copper among the European ‘barbarians’, there had been a similar alternation. Germany had first played a prominent part. The Iron Age had come to Britain from Hallstatt in Austria, Saxon miners had dominated production in Eastern Europe. German pre-eminence in this sphere, and in the whole scientific and technical enterprise connected to it, was summed up in the work of Agricola, author of *de re metallica*. Queen Elizabeth had called in the help of their mining ‘engineers’ when she feared the Spanish navy that her cannon (and the elements) helped drive away. Then their domination in mining and in iron-working was taken over by the British equivalents, among whom were those who assisted at the birth of the Railway Age and much of the Industrial Revolution, exploiting Britain’s wealth in huge and conveniently placed supplies of coal (for coke) and iron. It was this combination that gave the country such an advantage (temporary, of course) in the development of the modern age which had so impressed earlier, and even later, historians and sociologists. That development represented not only a shift of achievement from the east, particularly in gunpowder and high-heat technology, but also one within Europe itself between Italy and France, Germany and Holland, not to speak of Spain or Portugal. The balance in these achievements went back and forth, as they continue to do today. Europe and Eurasia are much more the context of ‘modernisation’ than Anglo-Saxon historiography allows. The current prominence of Germany and China is nothing new but part of this alternation between roughly equivalent societies. Neither Protestantism nor Catholicism, Islam nor Buddhism had a permanent advantage; all participated in some measure.

The theme of this book has been central to my thinking. Not only has it tried to link up east and west but also to associate ‘culture’ and industry which have been hopelessly divided. In Europe the theme has led to emphasising the contribution of other countries to modernisation that the nineteenth century has seen as uniquely English (even Protestant). It also brings together in my mind the ancient and the modern without creating an unsustainable gap between the two, as well as bringing the Near East (ancient and modern), its populations and its ‘civilisation’, and later its religions and its industry, into the frame with developments in Europe (including the Renaissance). Sweden and the Low Countries made a contribution as well as France, Italy and Spain but especially Germany. It has long struck me as ironic that Germans helped Peter the Great build up Russian industry in the Urals, an industry that did so much, with only limited help from elsewhere, to defeat the Nazi tanks and infantry at Stalingrad. Germany possessed a long-term expertise in metal-work, ever since the first iron age in Hallstatt, but their later activity was important because the Urals were so significant in the transmission of iron (and before that of copper) to Asia. However the Eurasian corridor to China, along which we later received so much, especially high-heat technology enabled the west to work both in pottery (for the manufacture of porcelain, for 'China') and in iron (for casting that material).

This then is the outline of the development of the modern world. The Eurasian economy was built on the Age of Metals but exchanged information as well as materials with the east (when not specifically prevented), a process in which the west had no permanent advantage. So that the various civilisations of Eurasia and the various units that make them up pursued an alternating rather than a predetermined course of development, 'une histoire pendulaire', at the same time as spiralling upwards, at least in certain respects.

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1 Goody 1986.

2 Goody 1962.

3 Goody 2006.

4 Algaze 2005: 7.

5 Algaze 2005: 8.

6 Algaze 2005: 4.

7 Wallerstein 1974: 84–5.

8 That question preoccupied Eric Wolf, who preferred the phrase 'social sets' as supplying a dynamic aspect to their relationship, concerned as it was with a historical reality. See Wolf 1967.

9 Childe 1942: 71–2; Wolf 1967: 458.

10 In Charbonnier 1961: 38–9.

11 Braudel 1982: 325.

12 Braudel 1982: 330.

13 Landes 1998.

14 Hatcher 1993: 112.

15 Man has always been involved in a search, as the Bagre myth of the LoDagaa (Goody 1972) brings

out; that included metals as well as transcendental values, but the latter expanded in various ways following the invention of writing.

16 Lyons 2009: 144.

17 Lyons 2009: 145.

18 Goody 2009b.

19 Verdrager 2010.

20 Childe 1981: 81.

21 Goldstone 2002.

22 See Lieberman 2009: 573; Goldstone 2002.

23 See Klingender 1968.

1. Shang Dynasty Bronze Mask, c.1766-1028 BC © Asian Art & Archaeology, Inc./Corbis.

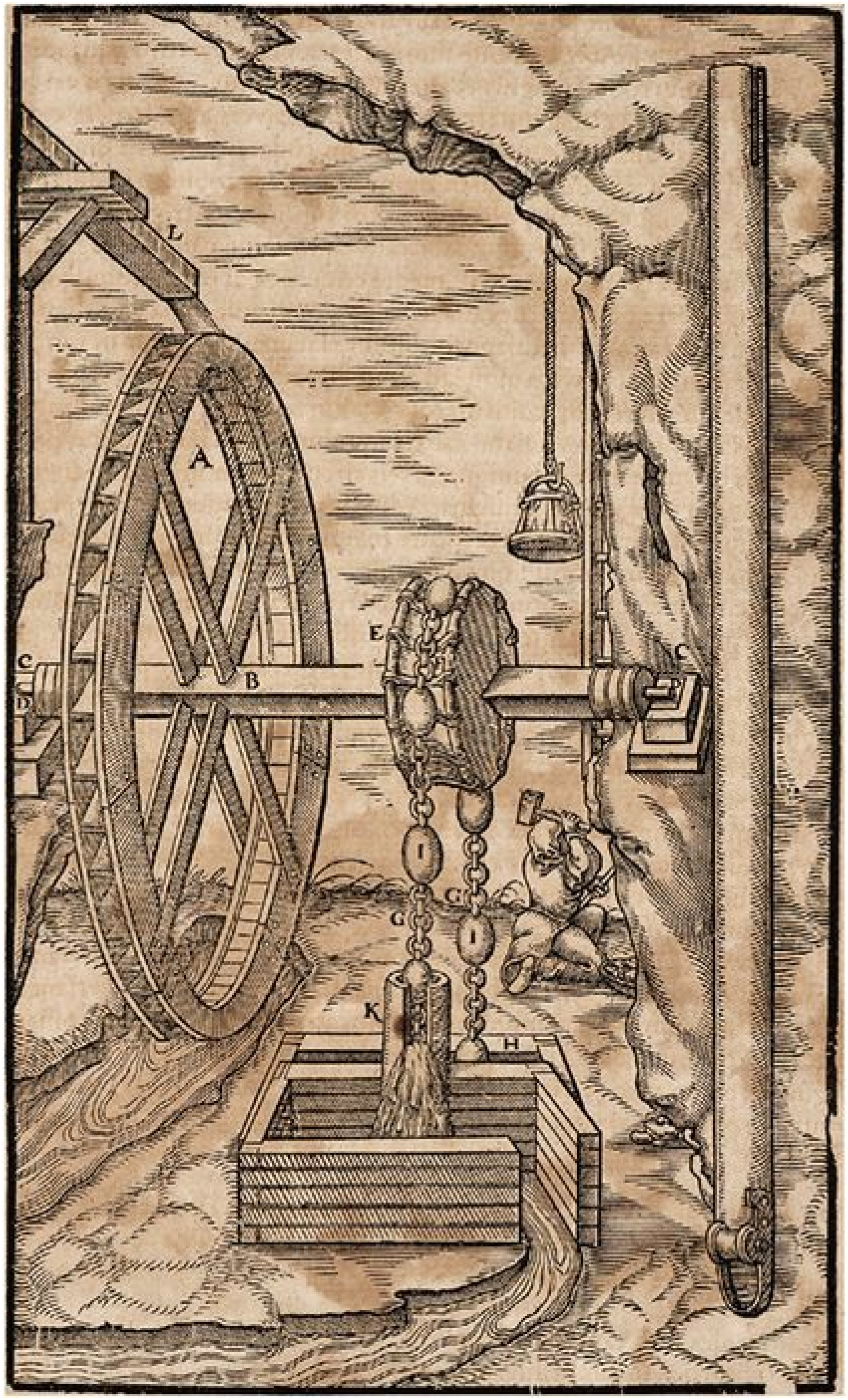
2. Bronze Statuette of a legionary. Roman, second century AD © The Trustees of the British Museum.

3. Magnificent view of Iron Pagoda [c. 1049], Iron Pagoda Park, Kaifeng, Henan Province, China © TAO Images Limited.

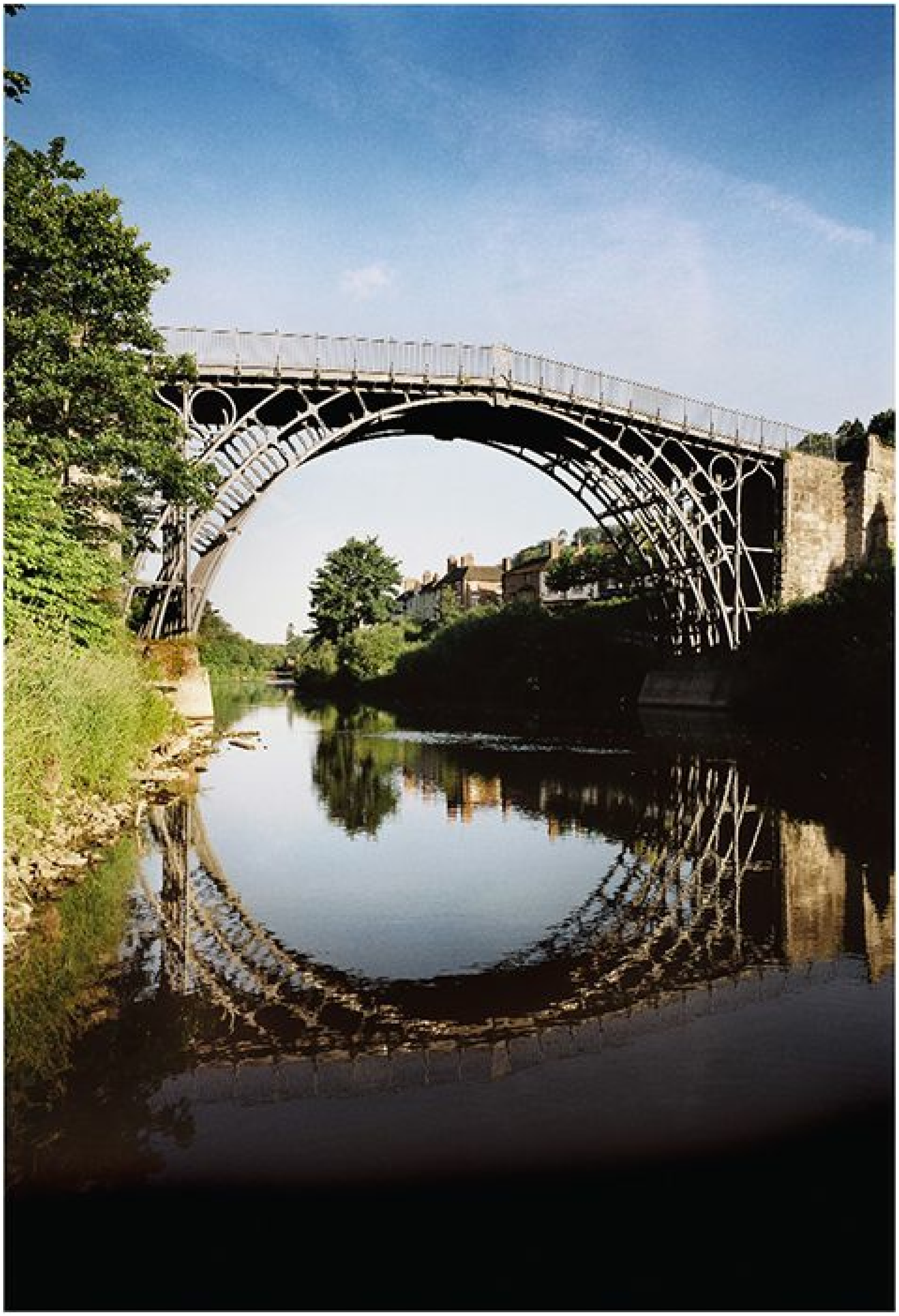
4. Visigothic footsoldier with helmet, coat of mail and spear. Mozarabic book illumination, 1109. Illustration to the Apocalypse Commentary of Beato de Liebana © akg-images/British Library.

5. Japanese Officer’s Shingunto, c.1350 © Photo: akg-images/Interfoto

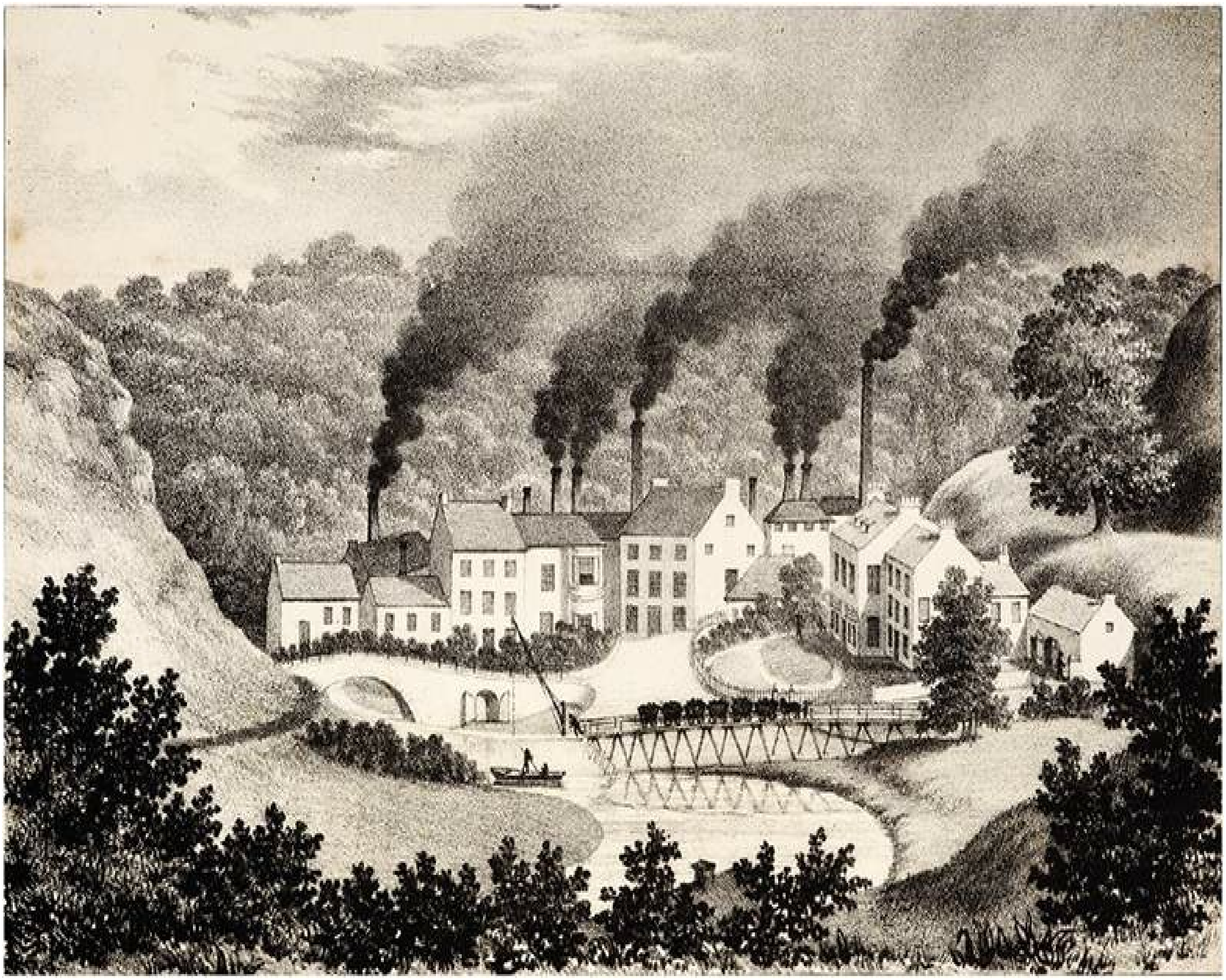
6. Asante Ewer. Medieval English, about 1390–1400. Found in the Asante kingdom (modern Ghana), West Africa, in 1896 © The Trustees of the British Museum.



7. Illustration of mining machinery. Agricola, *De Re Metallica,* book VII (Basel, 1657). Reproduced by kind permission of the Syndics of Cambridge University Library.



8. Iron Bridge, built 1779 © James Davies/Arcaid/Corbis.



9. Bedlington Iron Works, near Morpeth. Drawn by W. A. Thompson N.C., 1827. M. Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways* (Newcastle, 1827). Reproduced by kind permission of the Syndics of Cambridge University Library.

10. Ligbi weighing gold in Salaga market. L.G. Binger, *Du Niger au Golfe de Guinée par le pays de Kong et le Mossi*, vol. II (Paris, 1892). Reproduced by kind permission of the Syndics of Cambridge University Library.

11. Dane gun, made of metal and wood © The Trustees of the British Museum.

12. A statue of Queen Boadicea of the Iceni standing on her chariot (Photo by Hulton Archive/Getty Images) © Getty Images

Appendix 1: The metallurgy of iron

J. A. CHARLES

There are two main products in iron, wrought and cast. The former requires a lower temperature, the latter a higher one to make liquid iron, from which the slag floats off, and which can be cast to the required shape. Wrought iron has to be hammered into shape by a smith.

In a blast furnace, if the phosphorus content of the iron is low, as from 'siliceous' iron oxides (e.g. Cumbrian haematite), treatment of the iron produced can be in a reverberatory hearth or converter vessel with a siliceous lining and slag produced, progressively lowering the carbon content to the required level, with silicon and manganese being removed to an acid slag. Using a 'basic' (calcareous) vessel lining or hearth, a 'basic' slag high in lime can be produced and this can remove phosphorus.

Cast iron can be grey or white, depending on the form of the carbon that has been rejected from solution during solidification. In grey cast iron the carbon is present as graphite flakes, nodules or spheroids. Only in relatively recent years has control of graphite form by melt inoculation been possible to give the tougher form where graphite spheroids or nodules are produced rather than the flakes, to give a much tougher product, 'SG' iron.

If the cooling rate to solidification is high, and the composition of the iron is suitable, white cast iron is produced where the carbon is present as iron carbide (Fe_3C). Heat treatment of the white iron can cause the formation of nodular graphite from the iron carbide, with toughness in the final product. This malleabilising process is often attributed to Rupert of the Rhine and is the technique by which very delicate cast iron jewellery can be produced, usually known as 'Berlin jewellery' and associated with the Franco-Prussian wars.

Cast iron can be turned into wrought by the puddling process. In this a high-carbon iron, which has a melting point achievable in an early reverberatory furnace, is subjected to oxidising conditions from air access and iron oxide on the hearth, so that carbon and phosphorus are progressively lowered and the melting point is raised. The iron then becomes 'pasty' and is made into a ball on the end of a bar, extracted from the furnace and hammered or squeezed to remove slag. At the puddling temperatures iron phosphate is stable and phosphorus as well as carbon is removed from the iron. The product is wrought iron.

To produce heat and the reducing conditions to turn oxides into metal, charcoal was used first of all. The use of coal in iron-making was never very successful until coked coal was introduced. Hence ‘Salvation by coke’, when it was first used in blast furnaces. In a blast furnace the iron produced absorbs sulphur from coal and its presence in iron gives brittleness. Also most coals are friable and any increase in shaft height can lead to a breakdown of the charge structure and blockage to ascending gases, reducing output. If coal is previously coked, volatiles have already been driven off and a much stronger carbon form produced, maintaining an open texture to the charge, enabling higher shafts, higher temperatures and greater output.

Appendix 2: Damascene steel and blades

In an article of 1981, Christian Bromberger explains that western metallurgists only discovered the nature of 'oriental steel' at the beginning of the nineteenth century, although they had known and used it since Roman times. This steel was known as 'Damascene', possibly so called after the town with a flourishing manufacture of armaments; however the steel may in fact have been named after the patterning of damask cloth. In Arabic it was known as *al-hindi*, as the recipe originally came to the Near East from India, around Hyderabad, and from Transoxiana in Persia. The steel was made in India, even before the Christian era. Some iron for this purpose was imported from Sofala, in south-east Africa and the finished product was sent not only to the Near East but also it is claimed to China[1] (though the process was also carried out there, from whence it may possibly have come). In fact it appears that in East Africa the Haya did invent a type of high-heat blast furnace which allowed them to forge carbon steel at 1,802° C nearly 2000 years ago.[2] Such partial results were always possible in the experimentation of smiths. Moreover, the reach of metallurgy extended well beyond that of a particular 'society' or 'culture'. Even Rome had imported Indian steel. In the east, the disks were often made up into blades, later into curved ones, for the sabre which was made to cut whereas the western sword was largely a weapon of penetration. These different weapons were associated not only with different steels and modes of manufacture but with different ways of fighting. The sabre was, for example, used in cavalry warfare, the sword mainly on foot.

The blades made of this material were characterised by both hardness and elasticity, and despite many attempts could not be reproduced by western workers until very much later. It was made by the crucible firing of a combination of pearlite providing ductility and cementite (6.7 per cent), giving hardness. A high percentage of carbon was obtained through mixing the two and heating them together for many hours, along with charcoal or carboniferous plants. Then there was a slow cooling giving a primary crystallisation of large dendritic crystals with low-carbon content surrounded by a secondary crystallisation of cementite. The metal however could not be forged in this condition. That involved a further heating to render it more malleable, by increasing its ductility. It was then beaten into disks ('petits pains') to be sent to the smiths. Then care had to be taken not to reheat the product too much but instead to do so several times at a low temperature, a complicated process which the westerners never mastered, even important metallurgists like Réaumur in France. Indeed it was only possible for the west to discover this process with the aid of the microscope and modern technical knowledge, and even this knowledge was not complete and the problem puzzled Faraday himself. However, the methods varied; the Indian was one and somewhat different from the Persian.[3] Bromberger also speaks of the steel being exported to China where the crucible process existed, so some local specialists must have wanted this particular variety. Karlsson writes of the 'international arms trade' running 'from China to the Iberian peninsula, passing either over Basra and the Gulf or through Egypt and the Red Sea',[4] while Needham also refers to the presence of Indian *wootz* in China.[5]

Chinese iron itself was also exported to the west where it had a high reputation and was probably used in Damascus, for crucible iron was produced at many small kilns in Shanxi, in contrast to the larger blast furnaces in other parts of the country.[6] Although iron was found almost everywhere, it varied in quality and the finished article was exchanged very widely for different purposes.

The opposition between the western pointed sword, a piercing instrument of rigid metal, and the more flexible sabre, a single-edged cutting weapon of crucible steel, has also been discussed by A. Mazahéri, the Iranian scholar, in an article in *Annales* where he reviews their critical roles.[7] The crucible steel called Damascus was connected with Persian steel (*poulad*) and already recognised in the European Middle Ages for its superior qualities. The differences between Frankish blades and those made of Indian steel is discussed by Ibn Hudhayl in the fourteenth century.[8] The material was widely used. Although the steel was known in Arabic as Indian, it was also manufactured in the early Islamic world and exchanged through long-distance trade even before that time.[9] Manufacture also took place in Seville in late twelfth-century Spain, and Ceuta in North Africa was another important centre.

The Yemenis too imported Indian steel in Antiquity and later made their own. It is said the Arabs even carried this knowledge to Toledo (as well as

Damascus[10]) but clearly sword-making had been practised there long before, though later developed by the Arabs. Toledo steel is more likely to have come from Europe, for the process of pattern-welding was known to the Anglo-Saxons and even before. According to Rāġib,[11] this 'damas d'assemblage (corroyage)' (welded steel) was a copy of the real damask from the east, made by the Romans and the Celts. The cheaper 'false damask' was even made in Sind in India as well as in Russia and elswhere in the west.

The crucible steel came not only from Syria and India; the other great centres were Malaysia and Sri Lanka.[12] But the process varied; for the *wootz* itself, the crucibles were sealed which was not the case elsewhere where the cover was often open. Although the west overtook the east in the production of steel in the nineteenth century, in its time the damascene sword was the best in the world.[13] Indeed it was not only porcelain that was exported. Up to about 1700 China had the world's largest and most efficient iron industry, but about that time the British iron industry began the extraordinary sequence of technical improvements that brought down the price of iron dramatically and was an early factor in the Industrial Revolution. As with textiles and pottery, iron tools and weaponry were taken over by the west from a flourishing eastern production.[14]

The westerners also tried to reproduce the Islamic weapons but they could copy only their design rather than produce them in cast iron. According to Mazahéri, the techniques of crucible steel first arose not in India but were imported there from China by the Indo-Scythians in the time of Kanishka, 78–103 CE.[15] The steel was transformed into the sabre which was made of crucible iron, then cooled in the air and polished for a long time.[16] While the sword was characteristic of the west, eastern sabres also were most prized there. Possibly, he claims, 'the marvellous swords' of Roland and Olivier in *Le Chanson de Roland* were of this kind. So too may have been that of Mahomet, inherited by his cousin, Ali, which could have been a gift from the Sassanids who were already equipped with the sabre in Roman times. This weapon was celebrated in both Sassanian and Parthian traditions. As distinct from the Persians, the latter had a military tradition in the time of Herodotus, like most of Central Asia, leading to the spread of cavalry down to India and displacing the charioteer with his archers by the gentlemen on horseback. The Scythians and their neighbours may even have got the crucible steel from China which by then had made various forms of cast iron. Certainly Central

Asia was an area that had long specialised in metal production. That continued to be the case. Excavations have shown that in the 8th–12th centuries CE Merv in Turkmenistan and Akhsiket in Uzbekistan were important centres for the production of crucible steel, though in India and Sri Lanka, with their superior ore, the evidence dates from 300 BCE.[17]

At first the east produced straight ‘sabres’ (with one cutting edge), for the curved weapon did not make its appearance until the fifth century CE. Or even later, for Rāġib claims that the curved sabres were not found in Iran until the twelfth century.[18] But the sabre itself was used well before, possibly helping to establish the unification of China – later it was notably employed by the founder of the Han dynasty. It is also said that the Silk Road itself was made possible by the contribution of the sabre to warfare against the sword of the existing inhabitants, coming out of the superior knowledge of metallurgy (which later was transmitted to the Persians by Chinese deserters). It was this knowledge of metals and weaponry that enabled them to conquer Greek Bactria and for the Parthians to defeat the Romans under Crassus. The eastern sabre won out against the western sword.

However, as Al-Biruni suggested, pattern-welded blades were better in northern climes than ones made from crucible steel (*wootz*) which were more brittle in a cold climate.[19] It should be added that in the west too there was a one-sided blade, the seaxes or scramasaxes of the Anglo-Saxon period.[20] After the Romans departed, the development of swords still progressed but otherwise metallurgy as a whole regressed in Western Europe.

Damascene steel was a variety of crucible steel that was widely important in the east. It was not made in Europe where iron was the result of the solid-state bloomery process and was occasionally transformed to steel by solid-state cementation with charcoal. Recent research[21] has tended to find liquid iron and steel being made over a much wider area, but cast iron had its difficulties when made into white cast iron and its manufacture did not really take off in Europe until the eighteenth century. With grey cast iron, and especially the malleable variety, much more could be done through white-heart cast iron, for which white cast iron is a better starting point. Huntsman appears to have rediscovered the process in England in the mid-eighteenth century, especially for making clock springs at Sheffield, though this did no more than melt steel already made by cementation.

Crucibles, as distinct from furnaces, were common in the Ancient World, especially in India, in the Middle East and in Central Asia.[22] In Sri Lanka, crucible steel was supplemented by that made in wind-furnaces (west-facing furnaces) that were built into the top of hills and produced high-quality steel in the Islamic period. In the Bronze Age those furnaces were also found in Jordan, Palestine and Egypt and the Aegean.[23]

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1 Bromberger 1981: 349.

2 Schmidt and Avery 1978.

3 Bromberger 1981: 348.

4 Karlsson 2000: 247.

5 Needham 1974: 224.

6 Zaky 1955–6: 290; Wagner 2008: 38.

7 Mazahéri 1958.

8 Karlsson 2000: 241.

9 Karlsson 2000: 248.

10 Zaky 1955–6: 295.

11 Rāġib 1997: 32.

12 Rāġib 1997: 38.

13 Rāġib 1997: 60.

14 Wagner 2008: 74.

15 Mazahéri 1958: 672.

16 Mazahéri 1958: 674.

17 Srinivasan and Ranganathan 2004: 126.

18 Rāġib 1997: 38.

19 Tylecote and Gilmour 1986: 250 ff.

20 Tylecote and Gilmour 1986: 123.

21 Craddock 2003.

22 Craddock 2003: 24.

23 Weisgerber 2003: 83.

Glossary (with the aid of J. A. Charles)

Adit	an almost horizontal shaft, for access or drainage.
Alluvial	soil deposited by running water.
Alluvium	matter transported by suspension and deposited by rivers or floods.
Amatum	ingot from iron.
Anneal	to subject (glass or metal) to process of heating and slow cooling in order to toughen and reduce brittleness.
Ard	a light scratch plough.
Assaying	testing the composition of a metal.
***Bin* iron**	probably high-carbon steel imported by China in the sixth and seventh centuries CE.
Blast furnace	a shaft into which air is blown at the base to burn fuel in the chamber.
Blende	zinc sulphide ore, often associated with galena (*q.v.*).
Bloom	roughly rectangular mass of metal.
Bloomery	simple furnace for producing blooms.
Brass	alloy of copper and zinc.
Calamine	zinc carbonate.
Carburisation	process of combining an element with carbon.
Cassiterite	stannic dioxide, the most common ore of tin.
Cast iron	iron–carbon alloy distinguished from steel by its lower melting point and containing substantial amounts of carbon as cementite (*q.v.*) or graphite on solidification.
Cementation	process of impregnating the surface of one substance with another by surrounding it with powder and heating.
Cementite	hard and brittle compound of iron and carbon.
Cementum	Latin form of cement.

Charking	means of burning charcoal.
Cinnabar	brownish-red mercuric sulphide, the main source of mercury.
Cochlea	Archimedes screw, anything spiral-like.
Co-fusion	low-carbon production of steel from wrought iron (*q.v.*).
Coked coal (coke)	coal heated to drive off volatile constituents.
Convertor vessel	barrel for converting pig-iron (*q.v.*) to steel in Bessemer process.
Cupellation	process of recovering precious metals from lead by melting the alloy, gradually oxidising the lead and absorbing the lead oxide into a hearth of bone ash.
Dendritic crystal	crystal that forms a tree-like or fractal pattern, sometimes produced in the solidification of metals.
Fining	operation of converting cast iron (*q.v.*) into malleable iron in a hearth, urged by a blast of fresh air, with charcoal as the fuel.
Flux	addition used to increase the fluidity of slags and to refine the metal by reacting with chemical impurities.
Fulling	process of cleansing and thickening cloth by beating and washing.
Gad	short chisel-like instrument for breaking rock.
Galena	lead sulphide, the chief source of lead.
Gangue	valueless material in an ore.
Gossan	decomposed rock of a reddish colour, resulting from oxidised pyrites (iron sulphide).
Grey cast iron	having a microstructure containing graphite that gives a grey appearance to a fracture.
Hushing	breaking down of softer beds of metal ores with a strong current of water.
Jigging sieve	sieve for jigging (separating) ore by applying water.
Laminate	binding together of thin metal layers or sheets.
Laterite	variety of ferruginous, reddish soil.

Litharge	lead monoxide.
Lode	vein, a clearly defined mass of ore.
Loess	deposit of fine yellow sand, clay and silt loam.
Madjan	water-driven bellows.
Malachite	carbonate of copper bearing a beautiful green colour.
Malleabilising process	process to toughen cast iron (*q.v.*) by converting cementite (*q.v.*) in the microstructure into nodular carbon by heat treatment.
Marl	fine-grained sedimentary rock.
Martensite	crystal strucure of hardened steel.
Matte	crude mixture of sulphides, formed by smelting sulphide ores of metals.
Melt	to liquefy a solid.
Milled hammer	one with a ridged face.
Minium	red lead.
Mispickel	arsenopyrite.
Muller	flat heavy stone or iron pulverising tool.
Oligist	a variety of haematite.
Pattern-welded	technique used by Anglo-Saxon smiths for forging blades.
Pearlite	layered combination of ferrite and cementite (*q.v.*) found in steel and cast iron (*q.v.*).
Pewter	alloy of tin, lead, etc.
Pig	mass of metal cast in a simple shape for remelting.
Pig-iron	iron in pigs or rough bars.
Placer	surface sediment containing particles of valuable metal or mineral.
Puddling process	to convert molten pig-iron (*q.v.*) to wrought iron (*q.v.*) by heating with ferric oxide to oxidise the carbon.
Quenching	cooling metal in water to harden it.
Quern	stone mill for grinding, worked by hand.

Reduction	heating in absence of air and presence of reducing gases.
Refractory	ability to withstand high temperatures without fusion or decomposition.
Reverberatory (furnace)	heat is reflected from the roof of a metallurgical furnace.
Saltpetre	potassium nitrate.
Schist	any crystalline foliated metamorphic rock.
Seric iron	crucible iron supposedly from China (actually, India).
'SG' iron	Spheroidal Graphite cast iron (*q.v.*), which has high ductility.
Shaft furnace	furnace of upright form that is charged at the top and tapped at the bottom.
Slag	cinder, the fused material formed during the smelting or refining of metals.
Slitting mill	a water-mill that slit iron bars into rods.
Smelt	to extract a metal from ore by heating to produce a molten product.
Speiss	mass of arsenides and commonly antinomy products – a first result of smelting some ores.
Steel	alloy of iron containing carbon.
Stope	step-like excavation in a mine.
Tap (the slag or metal)	to let out of a furnace.
Tempering	softening by heating.
Tilt-hammer	heavy forge hammer titled by a pivoted lever.
Tuyère	pipe or nozzle through which an air blast is delivered.
White iron	cast iron (*q.v.*) with lower silicon content and which precipitates cementites (*q.v.*) rather than graphites.
Wootz	Species of steel developed in India around 300 BCE and characterised by a pattern of bands or sheets of micro carbides within a tempered martensite (*q.v.*) or pearlite (*q.v.*) matrix.
Wrought iron	Low-carbon form of iron.

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