The Evolution of the Book

Frederick G. Kilgour

New York Oxford Oxford University Press 1998

Oxford University Press

Oxford New York
Athens Auckland Bangkok Bogota Bombay
Buenos Aires Calcutta Cape Town Dar es Salaam
Delhi Florence Hong Kong Istanbul Karachi
Kuala Lumpur Madras Madrid Melbourne
Mexico City Nairobi Paris Singapore
Taipei Tokyo Toronto Warsaw

and associated companies in
Berlin Ibadan

Published by Oxford University Press, Inc.,
198 Madison Avenue, New York, New York 10016

Oxford is a registered trademark of Oxford University Press

Library of Congress Cataloging-in-Publication Data
Kilgour, Frederick G.
The evolution of the book /
by Frederick G. Kligour.
p. cm.
Includes bibliographical
references and index.
ISBN 0-19-511859-6
1. Books—History. I. Title.
Z4.K54 1998
002'.09—DC21 97-14430

1 2 3 4 5 6 7 8 9

Printed in the United States of America
on acid-free paper

1 Dynamics of the Book

IN THE LAST THIRD of the twentieth century, the book in the shape of a long-familiar object composed of inked sheets folded, cut, and bound began to metamorphose into the book as a screen display on an electronic machine; the transformation, in materials, shape, and structure, of the device for carrying written and graphic information was more extreme than any since the original creations on clay and papyrus in the third millennium B.C. Through historical analysis of the societal needs that have invoked the transformations of the book, and the technologies that have shaped them, *The Evolution of the Book* aims to shed light on the present emergence of the electronic book.

This work treats a "book" as a storehouse of human knowledge intended for dissemination in the form of an artifact that is portable—or at least transportable—and that contains arrangements of signs that convey information. The information may comprise stories, myths, songs, and reality; the signs may be representations of human speech or graphic presentations of such things as maps, musical notes, or pictures. With respect to portability, a volume of the elephant folio of Audubon's *Birds of America* and a copy of the Comprehensive Edition of *The Times Atlas of the World* might be looked upon as transportable, and a volume of the Gutenberg Bible as portable, even if a bit difficult to lug about. The electronic-book system, when fully developed, will need to be accessible by a device that will serve as a comfortable vade mecum for an individual user.

Over the last five thousand years there have been four transformations of the "book" in which each manifestation has differed from its predecessors in shape and structure. The successive, sometimes overlapping, forms were the clay tablet inscribed with a stylus (2500 B.C.–A.D. 100), the papyrus roll written on with brush or pen (2000 B.C.–A.D. 700), the codex, originally inscribed with pen (A.D. 100), and the electronic book, currently in the process of innovation. There have also been three major transformations in method and power application in reproducing the codex: machine printing from cast type, powered by human muscle (1455–1814); nonhuman power driving both presses and typecasting machines (1814–1970); and computer-driven photocomposition combined with offset printing (1970–). Extremely long periods of stability characterize the first three shapes of the book; clay tablets and papyrus-roll books existed for twenty-five hundred years, and the codex for nearly two thousand years. An Egyptian of the twentieth century B.C. would immediately have recognized, could he have seen it, a Greek or Roman papyrus-roll book of the time of Christ; similarly, a Greek or Roman living in the second century A.D. who had become familiar with the then new handwritten codex would have no trouble recognizing our machine-printed book of the twentieth century.

The historical pattern of the book, in which long periods of stability in format alternate with periods of radical change, resembles the pattern observed in organic evolution by Niles Eldredge and Stephen Jay Gould in 1972.[1] To paraphrase Eldredge, punctuated equilibria at its simplest entails the recognition of lack of change and the realization that patterns of change in the fossil record, when they do occur, are best explained by extinction and change in geographically isolated species. In short, the theory postulates long-term stability of species (with, at most, minor modifications) in paleontologic time, and punctuating bursts of time in which many species were extinguished. It has been estimated that as many as four and a half million species, or 90 percent of the whole, became extinct at the end of the Paleozoic era; new species evolved from parental species that escaped extinction by virtue of their geographic isolation.[2]

A similar pattern of punctuated equilibria prevails in the evolution of the book. The Sumerians invented writing toward the end of the fourth millennium B.C. and from their ubiquitous clay developed the tablet on which to inscribe it. The Egyptians soon afterward learned of writing from the Mesopotamians and used the papyrus plant, which existed only in Egypt, to develop the papyrus roll on which to write. Although neither the clay tablet nor the papyrus roll changed in form during the next three thousand years, a significant modification related to both book forms did take place in that the numbers of writing symbols were reduced during that period from a couple of thousand pictographs to a dozen or so alphabetic characters, resulting in great increases in the speed of writing. Form aside, the major change throughout the entire history of the book has been in the continuous increase in speed of production: from the days required to handwrite a single copy, to the minutes to machine-print thousands of copies, to the seconds to compose and display text on an electronic screen.

The extinction of clay tablets was ensured by the difficulty of inscribing curvi-

linear alphabet-like symbols on clay. Papyrus, however, being admirably suited to cursive writing with brush or pen, persisted until the sixth century A.D., together with the writing tablet (made of two or more pieces of wood embedded with wax and held together with threads or thongs), which had been in existence at least since the fourteenth century B.C. The need to find information more rapidly than is possible in a papyrus-roll-form book initiated the development of the Greco-Roman codex in the second century A.D. Although the codex is still with us, the one major change in it having been the replacement of manual writing by machine printing, the introduction of computer-driven photocomposition and the emergence of the electronic book in the last third of the twentieth century provide the next two punctuation points in the book's history of alternating equilibrium and change. Figure 1.1 displays these seven punctuations of equilibria.

For each of the major innovations in the form of the book, five concurrent elements were necessary: (1) societal need for information; (2) technological knowledge and experience; (3) organizational experience and capability; (4) the capability

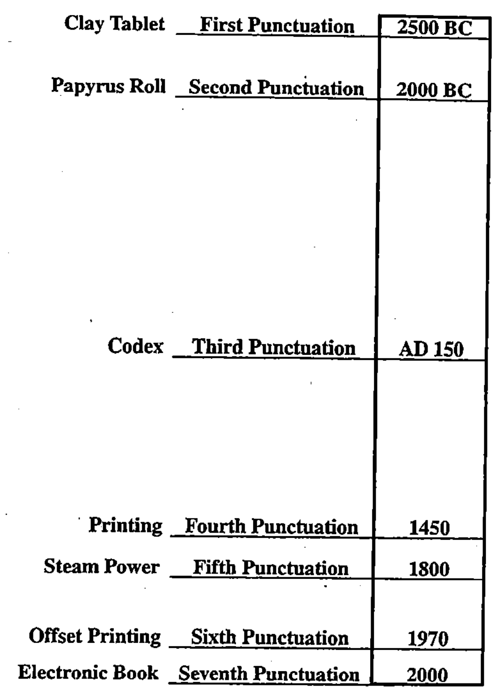

Figure 1.1. Seven punctuations of equilibria of the book over forty-five hundred years.

of integrating a new form into existing information systems; and (5) economic viability. The Sumerians, who lived in southern Mesopotamia (now roughly the lower half of Iraq), were the first to create word writing, in 3100 B.C., and the first to produce "textbooks," in 2900 B.C. Their need to record accounts motivated them, about 3500 B.C., to invent an elementary protowriting for marking on spherical or oblong hollow clay balls that contained tokens. During the next four centuries they developed their protowriting system through pictograph and logogram to the full cuneiform system of writing on clay tablets. Production of books in cuneiform script on clay tablets that were either sun dried or kiln baked persisted until the first century A.D.

Pictographic writing was almost certainly introduced into Egypt from Mesopotamia, and the Egyptians first inscribed pictographs—later known as hieroglyphs—on stone about 3100 B.C. A century later, and a century after the Sumerians, Egyptians had converted their picture writing to word writing, and from that time forward hieroglyphs were used only on monuments. For writing on papyrus, mostly done with a rush brush, there evolved a cursive script known as hieratic.

The need both for administrative records, as in Sumer, and for records to support Egyptian religious life shaped the development of the papyrus-roll book. The earliest known papyri date from about 2500 B.C., in the middle period of the Old Kingdom. Their contents encompass descriptions of priestly duties and ceremonies, and temple documents such as income and expenditure accounts. Subsequently the Egyptians produced books containing myths, tales, and magic, and such celebrated works as the Ramesseum Dramatic Papyrus, the earliest illustrated book (c. 1980 B.C.); the Rhind Mathematical Papyrus (c. 1700 B.C.); the Ebers Papyrus, a medical work, and the Edwin Smith Surgical Papyrus (both c. 1600 B.C.); and the Harris Papyrus (c. 1250 B.C.).

The Greeks adopted the papyrus roll for books sometime before the fourth century B.C., the date of the earliest surviving fragments of Greek books. By about the eleventh century B.C. the Greeks had taken over from the Phoenicians an alphabet-like consonantal system of writing, from which they constructed the first complete alphabet by converting four Phoenician consonants to vowels and adding a fifth vowel, thereby writing each sound individually. Although the Greeks continued to employ the papyrus roll for books after the invention of the codex-form book, by the fourth century A.D. only a quarter of Greek literary and scientific texts were on rolls.

The codex-form book of the second century was structurally the same as our present-day book in being composed of leaves bound together between two covers. Its form derived from the wooden writing tablets that had been used for fifteen hundred years to record impermanent commercial and administrative records, notes, school exercises, and the dictated first drafts of books. Codex texts were transferred, at least at first, from papyrus rolls. In 1970 Kurt Weitzmann accurately characterized this introduction: "The most fundamental change in the whole history of the book was that from roll to codex."[3] A quarter century later Weitzmann's evaluation is still accurate, but a quarter century hence it may not be.

Early Christians, like their modern counterparts, were a disputatious lot, given to written and oral debates supported by extensive quotations from texts that were difficult to search on papyrus rolls. For readier access they used the technique of sewing together gatherings of folded sheets of papyrus or parchment and sewing the outermost gatherings to wood, papyrus, or leather covers. In addition to making parts of text more readily available, the codex was more compact and less costly to produce and store than the papyrus roll. The success of the new form is revealed by the fact that 158 of 172 known biblical manuscripts written before A.D. 400 are codices, and only 14 are rolls; of the 118 Christian nonbiblical texts of the same period 83 are codices, and only 35 are rolls.

From 400 to 1300, Byzantium, Islam, and to a lesser extent the Christian West preserved and transmitted to Europe the corpus of Greek writings that fired the Renaissance. Byzantium added new knowledge and literature. Islam led the advance of the book by making innumerable contributions, including the importation of the Chinese method of making paper, until the twelfth century, at which time there began two centuries of decline in Islam and two centuries of advance in the West. By the fourteenth century the West was far in the lead of book production.

From the fifth century until the twelfth the Christian church dominated culture in the West, particularly in its monasteries. Saint Benedict, promulgating his Rule in the first half of the sixth century, prescribed four hours of daily reading, all of which was done orally by selected readers to the rest of the monks. This edict not only impelled copying and preservation of books in monastic libraries but also generated scriptoria in which books were copied. The Carolingian revival of culture in the last half of the eighth century renewed the scholarly activity of interpreting biblical texts and the texts written by the church fathers, generating a consequent increase in copying.

The acceleration, still continuing, of the Western demand for information began in the eleventh century with the appearance of universities, notably a medical school at Salerno and a law school at Bologna. To satisfy the rising number of faculty and student users of books, stationers associated with universities developed a primitive multiple-copy publishing system by lending to clients, for a fee, an exemplar (a university-approved copy) for producing personal copies. Tables of contents and indexes, which began to be added to books of that time, greatly improved retrieval of information from within texts, another boon to scholars. Two other events fueled the increasing demand for books—the invention of eyeglasses, at the end of the thirteenth century, and the development of silent reading, particularly among the elite of the fourteenth century. For four thousand years, "reading" had meant reading aloud and one book could be shared with many listeners, whereas silent readers needed a copy apiece.

In the early fifteenth century, wood-block prints depicting saints, and scenes from the Bible and from legends, began to be produced in Germany and the Netherlands and enjoyed great popularity with the illiterate masses. Later in the fifteenth century captions were added to these prints, and by the 1420s there were book-form sequences composed of block prints, carrying elaborated captions, that outlined the biblical stories and legends. These block books were also extremely popular.

The technologies that Gutenberg successfully brought together to invent printing from cast metal type included metallurgy and the techniques for providing molds, presses, inks, and paper. Gutenberg's typecasting mold, a success in itself, is still used in some shops today. The wooden screw press had been in use in producing papyrus and paper for thousands of years before Gutenberg modified it in the fifteenth century to make it a printing press. Paper technology was well-known by Gutenberg's time, but for printing from type there needed to be developed oil-based inks that would adhere to metal, as the water-based inks previously used by scribes would not.

Gutenberg was an inventive genius, but he did not possess the entrepreneurial skill to crown his immeasurably important creation with commercial success; that was accomplished by Johann Fust, who converted Gutenberg's invention into a business enterprise that could exist on the revenue it brought in. Fust, having financed the development of the process of printing from cast type by lending Gutenberg huge sums of money, none of which was left after Gutenberg finished printing his famous Bible, brought a successful suit for foreclosure, thereby acquiring Gutenberg's shop, equipment, tools, inventory, and supplies. He successfully transformed the moribund printshop into the first major publishing business. The publishing of literally millions of copies of books printed from cast type in the last third of the fifteenth century attests to the volume of society's pent-up demand for book information and the success of the printing press in supplying it.

A century and a half after Gutenberg the need for timely information became sufficiently intense to bring newspapers into being. The oldest known newspaper sheets were printed in the Netherlands in 1605, the first British newspaper appeared in 1621, and the first Paris weekly began publication in 1631; the Swedish court paper started publication fourteen years later and has continued ever since, making it the oldest surviving newspaper. In 1665 the first journals appeared: the *Journal des Sçavans*, published in Paris by the Académie des Sciences, and the *Philosophical Transactions of the Royal Society*, published in London, where it still continues.

Major modifications to the fifteenth-century Gutenberg system of hand composition of type and printing on a wooden press did not come until the nineteenth century. In the first year or two of the nineteenth century, Charles, Third Earl Stanhope, invented the all-metal press. A dozen years later Friedrich Koenig built the first steam-powered press for the *Times*; Koenig's invention, which came to be known as the flatbed cylinder press, would make eleven hundred impressions an hour. In 1846 in the United States Richard Hoe invented the first rotary press,

which could print up to two thousand impressions an hour per "feeder." In 1886 Ottmar Mergenthaler produced the first really successful mechanized compositor, the Linotype linecasting machine. All four inventions were direct responses to societal pressure for increased speed in the dissemination of information. The twentieth century has seen remarkable increases in speed of composition and printing. Electronic phototypesetters, a recent development, can produce and compose 36,000,000 characters an hour; the offset press, invented in 1904, can now produce 20,000 sheet impressions an hour. During the last third of the century offset printing, the combination of these two techniques, has superseded letterpress printing from cast metal type.

The transition from the codex to the presently evolving electronic book, the fourth form of the book in history, will not happen overnight. With some preceding forms of the book, as will be seen in the early chapters of this history, the realization of all five elements necessary to effect a transition from an earlier form—namely, users' needs, adequate technology, new organizations, successful integration with existing systems, and cost effectiveness—was a matter of several centuries. Once operational, a system acquires momentum, but its replacement of the previous system is not immediate; to take one example, the roll-form book persisted for four centuries after the successful introduction of the codex. It is doubtful, therefore, that the electronic book, even when widely adopted, will immediately replace the printed book. Its principal initial function will be to fulfill existing societal needs not satisfied by printed books and periodicals.

The ever-increasing informational needs of society, which have driven the evolution of the book, do not admit of clear, simple, detailed analysis, nor have historical analyses been carried out. Indeed, Fritz Machlup's concept of a knowledge industry is but a third of a century old.[4] Nevertheless, the larger picture of knowledge growth is discernible. Since Aristotle men have been aware that the thought processes—meditation, judgment, creation, and invention—require knowledge input if they are to be productive. Learning from sources beyond one's personal experience requires accumulation of knowledge provided by others. The book, and its offspring the periodical, which hold more knowledge than one human memory can retain, have long served as extensions to human memories.

Technological developments in the physical and biological environment have enhanced access to information in books. Improvements in storage of book materials have progressed from the clay-tablet shelves at Ebla of the twenty-second century B.C. to the random-access electronic databases of today. Increases in illumination, from light admitted only through open doors to light admitted through windows, and from illumination provided by oil lamps, candles, and gaslight to that provided by electricity, have meant steadily increasing hours for reading.

Auxiliary marks and displays to facilitate finding information in text have appeared, disappeared, and reappeared throughout the history of the book. Numbering of columns, sheets, and pages is one of the most effective auxiliary markings, yet page numbering did not become common until the printed book. One of the very earliest uses of displays appears in the Edwin Smith Surgical Papyrus, in which the titles and diagnoses of the majority of cases discussed are written in red ink. A capital letter has long designated the start of a sentence, and it has sometimes been embellished with a tick of red ink, as in some copies of the Gutenberg Bible. Over the course of time other conventions have been added to the organization of texts to make them easier to use: headings for chapters and sections; signs, including blank spaces, to signal the beginnings of paragraphs and sentences and the separation of words; and punctuation marks to clarify meaning and separate grammatical structures. Additional helps to the user have been tables of contents and indexes. Computerized screen display of text has already created whole new families of aids, some helpful, some annoying (sparing use of color, for example, is helpful to the reader, but an excess can render a text almost unreadable). Other adjuncts, including audio signals, such as pronunciation of words in electronic dictionaries, impossible to conceive of in printing and hand-produced technologies, will surely follow.

Like biological evolution, technological evolution is predictable only for very short periods of time, largely because the elements required for successful innovation are many and complex. *The Evolution of the Book* cannot foretell informational systems of the twenty-first century except to say that they will be supplying information more effectively than the Gutenberg system.

5 The Codex 100–700

THE THIRD MAJOR PUNCTUATION of equilibria in the history of the book was the second-century invention of the codex, the modern form of the book. The clay-tablet book had become extinct in the previous century, having been almost nonexistent for several centuries preceding, and the papyrus roll, still in its two-thousand-year era of stability, was still as awkward to use as it had been in 2000 B.C. The codex, once introduced, came to stay for at least two thousand years. Today the codex-form book, of which the printed version of *The Evolution of the Book* is one example, occupies most of the space on our shelves, desks, and worktables. It has been praised as the most efficient technique in existence for storing and retrieving information, and until the 1980s that statement was unequivocally accurate. The need for readily available information, which had been steadily rising, was accelerated by the advent of Christianity. The establishment of congregations generated preaching, which in turn required searching out new information between meetings. Soon the priestly office of reader, a person who read aloud from Scripture, came into being, and readers were so proud of the title that they had it inscribed on their tombstones.

An outstanding example of the necessity for information and its use in the form of books at the time of the invention of the codex is to be found in the defensive and persuasive writing of the second-century Christian apologists, which reveal the use of many sources of information of every conceivable type, from the Bible to pornography (mostly the former). Written and oral attacks on Christians, although for the most part rhetorical, were occasionally hysterical. The African theologian Tertullian (c. 160–c. 230) described Christians as being blamed for

"every public disaster, every misfortune that happens to the people," and elaborated, "If the Tiber rises to the walls, if the Nile does not rise to the fields, if the sky is rainless, if there is an earthquake, a famine, a plague, immediately the cry arises, 'The Christians to the lion!'"[1] The apologists undertook the gargantuan task of changing this attitude, and although they, too, employed exaggerated rhetoric at times, the major part of their effort was in appeal to man's "love of learning" by organizing and presenting information. Robert Grant has analyzed the writings of eight second-century Greek apologists, and identified their sources.[2] Six of them made specific quotations or referred to a work, and at least 270 of their sources were identifiable; clearly these men both needed information and used books.

Codex technology has proved far more flexible than its second-century inventors could possibly have imagined. Twelve hundred years after its introduction the codex proved to be as hospitable to mechanical printing as it had been to manual writing, and it has been able ever since to respond to society's demands for greater numbers of books, and their offshoots, newspapers and magazines, at an ever-increasing speed of dissemination.

Wooden Tablets

The two precursors of the codex are depicted in a Pompeiian wall painting prior to 79 A.D. (fig. 5.1): in it a woman holds a polyptych—wooden, waxed tablets fastened together into a unit—and a man holds a papyrus-roll book with its title tag. Tablets were the physical model for the present-day book even though only a few, if any, could hold twenty pages of text. The codex forced the roll book into extinction by the seventh century A.D., but the polyptych lived on at least until the seventeenth century.

Wooden tablets, waxed and unwaxed, existed for many millennia. They were made in many shapes, sizes, and forms, and enjoyed many uses: as notebooks, for accounts, marriage vows, birth announcements, contracts, conveyances, and wills, and as the ubiquitous student writing surface. Some wooden tablets, of slices of wood less than an eighth of an inch thick, were written on with ink and served as letters when folded on center and tied closed. In the early second century A.D. folded individual tablets tied together end to end, with the whole folded into an accordion structure, served to record accounts of food supplies at Vindolanda, a Roman fort in north Britain.[3] Homer made an intriguing reference to the use of a tablet for a message from King Proetus to his father-in-law, the king of Lycia, requesting the latter to slay Bellerophon, the bearer of the message: "Many, of fatal import, all graved on a tablet infolded."[4] Homer's "infolded tablet" probably was a thin slice of wood like those found at Vindolanda. Another interesting but relatively recent wooden "book," containing texts thought to be East African chants, consists of a strip of wood 35.2 inches long and 2.2 inches wide folded into sixteen

Figure 5.1. Pompeiian wall painting of woman with tablet and stylus and man with papyrus roll and title tag. (Archaeological Museum, Naples)

sheets encased between two heavy blocks of wood.[5] E. M. Thompson recorded that tablets "inscribed with the names of the dead are found with mummies," and that "In England the custom of using wooden tallies, inscribed as well as notched, in the public accounts lasted down to a recent date."[6]

One example of a temporary record on a waxed tablet is in the British Library. As a courtesy to the author, and after two previous students of Greek had failed, Professor William H. Willis of Duke University succeeded in deciphering the writing in part. It proved to be a listing of agricultural products, such as fodder and flax straw, evidently written hastily and cryptically by an individual named Chairemon. Another temporary record, on the oldest known tablet, a diptych recovered from a

fourteenth-century-B.C. shipwreck off the southern coast of modern Turkey, is likely to have been the ship's manifest.[7]

To construct the commonly used waxed tablet a board was hollowed out to a depth of perhaps an eighth of an inch, leaving a narrow frame, and the depression was filled to about one-half with wax, which would be written upon with a hard stylus, often of metal. The woman in figure 5.1 is warming the sharp, inscribing end of the stylus at her lips to facilitate writing on the wax. Presumably the blunt, erasing end of a stylus would rub out writing more easily if it also were warmed. Two or more waxed boards, three-eighths or a quarter of an inch thick and held together with thread, formed a polyptych—two boards forming a diptych, three a triptych, four a quadriptych, and so on. For diptychs, only the inner side of each board was hollowed out; for triptychs and larger, the inner boards were hollowed and filled on both sides. Thompson reported, "On Greek vases of the fifth and fourth centuries B.C., tablets, generally triptychs, are represented, both open in the hands of the goddess Athena or others, and closed and bound with strings, hanging from the wall by slings or handles."[8]

In the fifth century Herodotus tells of the fascinating use of a waxed tablet by Demaratus to secretly inform the Lacedaemonians of the Persian king Xerxes' intended invasion of Greece:

> After it seemed good to Xerxes to lead an host against Greece, Demaratus, being in Susa and learning thereof, desired to send word to the Lacedaemonians. And there was no other way in which he could signify it, because of the danger lest he be discovered, except this which he devised. He took a folding tablet, and scraped off the wax thereof, and thereafter wrote the king's intent upon the wood of the tablet. And when he had done it, he spread the wax over the letters again, that the tablet being carried empty might make no trouble with the guards upon the road. But when at last it came to Lacedaemon, the Lacedaemonians were not able to comprehend the matter, until, as I learn, Cleomenes' daughter, who was the wife of Leonidas, to wit, Borgo, perceived it and advised them to scrape off the wax, and they should find writing upon the wood. And they did so, and found the writing and read it, and thereafter sent tidings to the other Greeks.[9]

Egypt, Herculaneum, Pompeii, and Romania have been fruitful sources of tablets. Twenty-five deeds dated A.D. 131 to 167 have been recovered from the vicinity of modern Verespatak in Romania. In 1875 a box that contained 127 tablets dated A.D. 15, 27, and 52–62 was unearthed at Pompeii. In all, more than 200 tablets have been retrieved in Pompeii and neighboring Herculaneum. Two polyptychs from Herculaneum differed from all the other Herculanean, Pompeiian, and Dacian finds in dimension, form, material, and structure; one is a pentaptych and the other an octoptych, both obviously dated before A.D. 79. Each is made of fine, compact boxwood (whereas most tablets were made of fir), skillfully fashioned and highly polished. Giovanni Pugliese Carratelli has described in detail the octoptych, which is held together by two sets of double threads so anchored in the front and back cover that they do not protrude on the outer surfaces.[10]

An Egyptian diptych of the Greco-Roman period used a similar technique for holding its two boards together.[11] Actually the back board duplicates the technique used in the Herculanean boards. However, all eight holes in the front board are drilled all the way through. The British Library possesses two external boards (Add Ms 33,797 and Add Ms 34,244) belonging to two different polyptychs that are missing; they have drill holes that are the same as those in the Herculanean and Egyptian board types. These four examples represent the model for the codex-form book.

The Technology of the Codex

A high degree of inventive imagination was required to develop the codex-form book from the waxed wooden polyptych and the papyrus-roll book. It would have been possible for any person to observe these two vehicles of writing, side by side, at any time during the fifteen hundred years that preceded the second-century invention (see fig. 5.1), but the transformation from columns written on only one side of a papyrus roll to single sheets of papyrus folded and written on both sides to replace the interior boards of a polyptych reflects the ingenuity and effective imagination of the codex's nameless developers. As Eric G. Turner put it, "The greatest benefactors of mankind are unsung and unknown—the inventor of the wheel, the deviser of the alphabet. Among their number we should place the inventor of the codex. In this form of book the sheets of papyrus or of cut and treated skin are not pasted or stitched together to form a long roll but are superimposed on each other, folded across the middle, and then secured by stitching so that they open into pages. The outside pages can be protected by binding covers and the whole ensemble then forms a durable, sturdy book, easy to store, easy to open and refer to, easy to carry about, and withal capacious since it uses both sides of the writing material."[12]

The quality of the papyrus itself diminished over time. Turner appraised papyrus of the Hellenistic age as "good," but compared it with that of a thousand years earlier as "heavier and thicker. Sheets of the Roman period tend to be clumsier and coarser still; but good . . . till the third century after Christ. Thereafter . . . the quality of ordinary papyrus deteriorates rapidly, and ends up by resembling cardboard."[13] Other shortcomings of papyrus were that it tore easily, became brittle after exposure to damp, disintegrated at a touch following repeated wetting and drying, and required a preservative, usually oil of cedar. In roll form it took two hands to hold it open, and if released by one hand, or both, could spring to the floor like a wild thing, twisting and turning. One Verginius Rufus fractured his hip trying to gather up a roll he had dropped.

The new codex was modeled on the waxen polyptych that preceded it; for example, the protective outer boards of codices have drill holes like those in the polyptych. There was, however, a major problem confronting the inventors of the codex: how to achieve a sturdy, solid block of pages that would also be pliable. The solution arrived at was to fold a papyrus sheet (or stack of sheets) into a single gathering to produce multiple leaves. The majority of the codices produced in the second, third, and fourth centuries were so constructed. At least fourteen early codices are known to have had more than one hundred pages, and two of them had more than two hundred. Other gathering formats varied from two sheets to seven, with four sheets, *quarterni*, from which the English word "quire" derives, eventually becoming the standard.

The single-quire codex lent itself to relatively easy construction. V-shaped slots that would pierce all sheets were cut in the back of the fold (or folds), and a piece of leather cut to enwrap the quire (or quires) was pierced with holes corresponding to the slots in the folds. Then the whole was bound together by threads running from the holes in one side of the leather cover, along the innermost fold from one set of notches to the other, and out through the holes in the second side of the cover. The British Library possesses a cover (PAR 1442) dated in the early eighth century that suggests such a binding.

Successful binding together of multiple gatherings was the key to the invention of the codex. The oldest known complete codex is a 490-page Book of Psalms, in a Coptic dialect, dating from the second half of the fourth century and discovered in an ancient Egyptian cemetery in 1984. It has been described as bound between wooden covers stitched with leather. Texts of other ancient codices are available, but their bindings have been lost or replaced, or else destroyed in the process of preserving the text by mounting the sheets between glass plates. However, enough has been saved of a fourth-century Gnostic manuscript binding to suggest that its nineteen gatherings were held together by two leather thongs, much as two threads held together the Herculanean and Egyptian tablets. This two-thread sewing technique for holding gatherings together was characteristic of the Near East and remained so until this century. Three sixth-century Coptic codices in the Chester Beatty Library in Dublin were sewn in this two-thread manner, which was used in the West at least until the eighth century.

The earliest such European binding is that of the Stonyhurst Gospel of Saint John, dated early in the eighth century (or at least after 698) and now in the British Library. The Cadmug Codex (Cadmug, an Irish monk, was the scribe) is now in the Land library at Fulda[14] and is dated slightly later than the Stonyhurst Gospel. Both books are pocket-size and have similar binding stitching. The sewing together of the gatherings began with the binder cutting four V-shaped slots in two pairs in the backs of the gatherings, and then he used two needles, one for each pair of slots, to sew the gatherings together with flaxen thread. After he attached one of the binding boards to the first gathering, he would then pass one needle in at A and out at B and one in at D and out at C, drawing the threads along the inside fold of the gathering. Next he would insert the needles through slots B and C of the second gathering and draw them out at A and D. Now the needles would go down under the threads from the board to the first gathering and up to the third gathering for insertion at A and D and along the interior for exit at B and C. This time the needles brought the threads back down and under the threads passing from B and C in the first gathering to B and C in the second and on up for insertion at B and C in the fourth, and so on. This stitch, called chain or kettle, when pulled tight sews the gatherings together in a solid block.

This two-thread sewing remained in use for manuscripts prepared for churches in Armenia and Syria until the nineteenth century and was still being used in Ethiopia as late as the mid–twentieth century. London's Victoria and Albert Museum possesses a large Ethiopic manuscript written in 1947 on vellum, measuring 19.2 inches high and 14.2 inches wide. Four sets of two holes were drilled through each cover, and four holes were drilled from the back edge of each board to intersect each set of double holes.

Production of Codices

The time and place of the invention of the codex are as unknown as the inventor, but it may be assumed that the construction and copying of codices took place at the bookstores described in the preceding chapters. Turner has described the acquisition of books by Egyptian Greeks in the first and second centuries A.D. and the rates of payment to scribes.[15] The vast majority of codices were found in the dry, sandy edges of the Fayyûm region of Egypt about 100 miles south of Alexandria and particularly from Oxyrhynchus (el-Bahnasa), another 60 miles further south. In total some twelve hundred codices and fragments have been recovered that were produced from the second through the seventh centuries.

Table 5.1 depicts the growth of numbers of codices during the first two centuries of their existence and at the same time records whether the codices were written on papyrus or parchment and whether the texts were literary and scientific or Christian. It also includes dates that span two centuries, such as second/third; editors assign such dates because of their uncertainty as to the century in which a codex was written. As can be seen in the total column, ten times as many codices were produced in the third century as in the second. Moreover, more codices are assigned to the span period, ii/iii, than to the second. Both of these observations suggest that production of codices did not start until the latter part of the second century.

Another revelation in Table 5.1 is that Christian literature comprised more than a third of codices produced.

Turner's "unknown, unsung" inventor of the codex may or may not have been a Christian, but no matter who the inventor or what his religion, the Christians manifestly seized upon the invention early, exploiting for their own benefit their recognition of the superiorities of the codex over the roll: the obvious savings of money in using both sides of the papyrus, the increased speed in production, and the greater ease in retrieving information from text.

Table 5.1. Codices dated before the fourth century

Century	Papyrus		Parchment		Total	
	G¹	C²	G¹	C²	G¹	C²
ii	6	5	3	0	9	5
ii/iii	14	7	1	0	15	7
iii	81	44	10	5	91	49
iii/iv	26	22	7	3	33	25
	127	78	21	8	148	86

Source: Table 13 on pages 89–94 of *The Typology of the Early Codex* by Eric G. Turner.
¹Greek, including Latin; ²Christian (see Turner).

Using several published sources, Colin H. Roberts and T. C. Skeat found "that there are approximately 172 Biblical manuscripts or fragments of manuscripts written before A.D. 400 or not long thereafter (i.e., including items that have been dated fourth–fifth century)"[16]; 98 were from the Old Testament, and 74 from the New. Of the texts 158 were from codices and 14 were from rolls; in other words, during the first three centuries 92 percent of the Bibles produced were codices and 8 percent were papyrus rolls. Examining nonbiblical Christian literature output during the same period, Roberts and Skeat found 118 items, 83 of which were from codices and 35 from rolls. They also collected evidence of the production of popular romances and Acts of the Pagan Martyrs during the first three centuries and found 60 examples, of which only three were codices, a sampling significant enough to conclude that these two types of literature played no role in the development of the codex.

There are more than a dozen third-, fourth-, and fifth-century codex Bibles in existence, all in Greek, all Alexandrine in origin or containing Alexandrine elements, and each ranging from several to many biblical texts. Each has been unbound or rebound several times over. The three most important for documenting the early biblical texts are the Codex Vaticanus and Codex Sinaiticus of the fourth century and the Codex Alexatrinus of the fifth. The first is in the Vatican and the others are in the British Library. Of the three, the Codex Vaticanus is thought to possess the most trustworthy text. The Bodmer Library in Cologny, Switzerland, has three third-century volumes, Bodmer II, XIV, and XV, and two fourth-century volumes, Bodmer VII and VIII. The first three contain most of the Gospels of Luke and John, and the last two, Jude and Peter. The Chester Beatty Library owns three third-century volumes; Chester Beatty I has the four Gospels and Acts, Chester Beatty II the Pauline letters, and Chester Beatty III, Revelation.

Roberts and Skeat have also explored comparative numbers of rolls and codices produced during the first three centuries of the existence of the codex, and they collected and organized dates of production. Table 5.2 is based on the data, which is

Table 5.2. Greek literary and scientific texts

Century	Rolls	Codices	Total	Percent Codices
ii	1133	24	1157	2.0
iii	608	127	735	17.3
iv	66	158	224	70.5
	1807	309	2116	

Source: Table on page 37 of *The Birth of the Codex* by Colin H. Roberts and T. C. Skeat.

in tabular form in their work *Birth of the Codex.* As can be seen in the table, the production of rolls declined and codices increased; apparently the number of codices began to exceed the number of rolls sometime toward the end of the third century or in the early decades of the fourth. Many reasons have been presented for the time it took the production of the codex to surpass that of rolls despite the codex's obvious superiority in usefulness, relatively low cost, and convenience, but certainly a reluctance to accept change was a major obstacle. Nevertheless, codices were much more popular by the fourth century and have remained so ever since.

The writing in most of the early codices was neither the capital nor the uncial discussed in the previous chapter. Turner reported that

> it may be readily admitted that it is not easy to find examples of calligraphy among papyrus codices of the second and third centuries. Their handwriting is in fact of an informal and workaday type, fairly quickly written, serviceable rather than beautiful, of value to a man interested in the content of what he is reading rather than its presentation. . . . These [dozen or so cited codices] give the impression of being "utility" books: margins are small, lines usually long. But the standard by which they are measured and condemned to second-class status is not the contemporary codex of parchment, but the contemporary papyrus roll.[17]

One wonders if uncial writing was used largely in books to be looked at, not read, recalling Seneca's ridicule of Romans who bought books "not for the sake of learning, but to make a show, . . . as decorations for the dining room."[18]

That early codices more often than not were written on papyrus sheets cut from blank rolls had been known by scholars at the beginning of the twentieth century, but it was Turner who discovered that the heights of early papyrus codices conformed to the heights of papyrus rolls.[19] No such uniformity exists among parchment codices, because the skins used to make parchment varied in size and it was economical to use as much of a skin as possible. There were two major reasons for parchment's replacement of papyrus: first, papyrus was harvested into near extinction in Egypt; and second, parchment could be produced locally, from the cattle, sheep, and goats at hand almost everywhere. With the resumption of Greek book production in Byzantium in the ninth century a mature uncial bookhand was written on the parchment, which continued to be used until the advent of paper.

8 Printing 1400–1800

IN THE LAST QUARTER OF the fourteenth century and the entirety of the fifteenth was a time of remarkable social change. Existing universities expanded in scholarship, size, and number, and several new universities were founded in northern Europe, greatly enlarging the need for information provided by books. Richard Rouse has described the "renewal of northern European spirituality," which brought new vigor to several hundred monasteries of a half-dozen different orders having in common a "practical, individual search for a direct rapport with God through his written word and the interpretation of it. These orders shape the book to serve their needs. What emerges is a book distinctly different from anything the Middle Ages had hitherto seen—a book which in some ways has more in common with the printed book than with the products of the manuscript that preceded it."[1] This innovative religious book wove together four characteristics, none in itself new: (1) access to information within texts via subject indexes, tables of contents, and pages or sheets numbered with arabic numerals; (2) accuracy of text based on codified rules first written out in 1428; (3) clarity of text achieved with a bookhand script named hybrida; and (4) enhancement of bibliographic descriptions in incipits and explicits from "one or two to eight or ten lines."[2] Demand for manuscript books continued to expand into the fifteenth century despite deadly epidemics, but although manuscript production had risen (in France it was 22 percent higher in the fifteenth century than it had been in the thirteenth), manuscript copying could not satisfy the hunger for books.

Printing, best defined as the mechanical production of multiple copies of writing or images, which began in the fifteenth century, twelve hundred years after the introduction of the codex, marks the beginning of the modern book. Printed products from the first half of the century included playing cards reproduced by stencils and engraved wooden blocks, image sheets and books produced from wooden blocks, and books and broadsides produced from cast type. While there was no direct progression from playing card to image print, or from block book to printed book, the printing of images and text from engraved blocks of wood must have encouraged and emboldened the half-dozen men, including Johannes Gutenberg, who sought for a more successful means of reproducing multiple copies of books.

The best evidence that there was a potential market for multiple copies is the number of books printed in the last third of the fifteenth century. In 1935 John Lenhart constructed an estimate "of 20,047,500 copies for the whole of Europe" (though he cautioned that the figure could not "be regarded as mathematically exact").[3] In 1958 Lucien Febvre and Henri-Jean Martin calculated that "about 20 million books were printed before 1500."[4] In 1970 Warren Chappell tallied "some 12,000,000 books,"[5] and in 1981 Richard Rouse estimated "some fifteen to twenty million copies . . . a very large number indeed—perhaps larger than the number of all the manuscripts produced in medieval Europe."[6]

Block Printing

Three single-image prints from wood blocks, impressed with dark brown ink on cut wooden blocks in a system known as xylography, are the earliest dated examples of a process for producing multiple copies: the Brussels Print (1418), the Berlin Print (c. 1420), and the Saint Christopher Print (1423). These and similar prints were all religious in character, portraying devotional scenes in the manner of stained-glass windows in churches, which almost certainly influenced block printing. The prints were inexpensive and could be taken home and put up on a wall for contemplation. Possession of a print of a saint provided protection: Saint Roche protected the owner from plague, Saint Appolina from toothache, Saint Sebastian from injury, and Saint Christopher, the patron saint of travelers, from sudden death (until the latter was decanonized in 1969 one could often see a Saint Christopher medal dangling from the rearview mirror of an automobile).

Block prints of the first half of the fifteenth century are all from south Flanders or south Germany. The Brussels Print is closely similar in design and cutting to the Berlin Print, which contains a poem in Flemish. The Saint Christopher Print was found at Buxheim, some fifty miles southeast of Augsburg in a mountainous region of south Germany. To the various pieces of circumstantial evidence suggesting that the latter print may have been produced in the vicinity of its discovery, a piece of internal evidence can be added. While anyone looking at the print might argue that the terrain depicted in the print seems mountainous only because the artist could not draw perspective (the ragged land masses could equally depict

the shores of a river) the waterwheel driving the mill in the lower-left corner of the print is the overshot wheel most often found in mountainous territory.

Block printing, like printing from cast type, is relief printing from an inverted image. The artist could draw the picture directly on the block, inverted right to left, but more likely he drew it on tissue paper and traced it face down on the block; probably text would have been treated in the same manner, to avoid having to write backward. The surface of the block (of a smooth-grained wood, such as pear, cherry, or apple) was usually cut running with the grain, unlike the surface of a wood engraving, which is cut across the grain. The woodcutter used a knife and a gouge, the knife to cut down into the block on both sides of a line and the gouge to hollow out areas between lines. A water-based brownish ink was applied to the block with an inking cushion; a sheet of paper (all single prints were on paper) was then placed on the block and pressure was applied to it by rubbing it with a firm tool, such as a burnisher, or by using a press. All the prints were colored, either freehand or by stencil.

Block books were the assemblage into codex form of sets of image prints that had been popular in manuscript. The Pauper's Bible and the Apocalypse of St. John (one or the other is thought to be the oldest block book) were composed of sets of pictures that had writing added within their borders after the printing. A second type of block book consisted of pictures and text external to the pictures; text might be above or below a picture, or both, or on opposite or consecutive pages. In a third type, text might appear both within and outside the borders of the pictures. Only one known fifteenth-century xylographic book had text with no pictures, the ever-popular *Donatus*, a fourth-century Latin grammar. It also was the only xylographic work printed on parchment, to make it resistant to schoolbook wear and tear; even so, only fragments of it survive.

The cutting of blocks for block books was the same as for single block prints, except that two pictures were cut side by side to be printed on a single sheet of paper to form two pages by folding. The size of the blocks seems to have been determined by paper size. An examination of the measurements of twenty-five editions of block books revealed that three groups each comprising five editions were printed on paper that varied by only one centimeter in height; in one group of five, for example, three editions were 21 cm. and two 22 cm. The leaves of most fifteenth-century block books were printed on one side only, but the catalog of the Rosenwald Collection in the Library of Congress contains one block book dated "1475?" with "leaves printed on both sides."

The water-based brown ink used for woodcuts was also used for block books until the introduction of the black sticky ink that Gutenberg also employed. Because of the extreme difficulty in keeping a sheet of paper motionless on a block with water-based ink, one experienced wood engraver has held that block-book sheets must have been printed on presses.[7] Some sixteenth-century block books were definitely printed on a press, with black ink and on both sides of the paper.

The printed sheets were bound so that facing pairs of printed and blank pages alternated, with the first and last pages being blank. The blocks for at least one book were cut with letters in alphabetical order, to guide the binder in assembling pages in correct sequence.[8] It is probable that block books were printed singly on demand, as were the manuscript books being produced individually by copyists at the same time; watermarked paper that can be dated gives evidence of individual blocks having been used over a long period of time.

Publication dates of block books are in dispute, with assigned dates varying by half a century. Heinrich Musper maintains, and I agree, that "What is decisive is the wood block itself with the drawing originally cut on it . . . to establish a date or narrow down the period of origin."[9] On the other hand, Allen H. Stevenson holds that "paper [with its watermarks] has proved an unexpectedly competent source of information towards dating."[10] Musper is "convinced that the woodcuts of the *Pauper's Bible* [in the Heidelberg University Library] should on stylistic grounds be placed in the 1420s," whereas Stevenson found that the paper of the "first edition" in the British Library should be dated 1465. Musper has stated that "The original *Apocalypse* could be dated about 1420 because its style corresponds to that of the Brussels woodcut . . . dated 1418."[11] Stevenson, however, dated it 1450–1452. Whatever the date of the earliest block-book may be, it is evident that the woodcutters of the early blocks had already gained extensive experience and acquired superior craftsmanship.

Block books displaying biblical events, thought to have been popular despite the scarcity of surviving copies, were probably produced for priests and other preachers as well as for laypersons. They were of assistance in sermon preparation and helpful in times of human stress. *Ars Moriendi* (Art of Dying), for example, enabled attendants to aid and comfort the moribund by assuring passage of the soul to heaven. *Ars Moriendi* is extant in ten different editions, although known copies are few. Of the Pauper's Bible, also known to have had ten editions, some fifty copies are extant, more than of the Gutenberg Bible. That the total copies of the three dozen known block-book titles number hardly more than a hundred could mean that only a few copies of each edition were printed, but it is much more likely that these picture books were used to extinction.

Xylographic printing preceded typographic printing by at least a quarter century, but it was not a direct technological predecessor. No aspect of xylography is antecedent to typecasting, and it was the casting of type in a mold that was the key to the invention of typography.

Printing from Cast Type

The success of block-book printing in the first two-thirds of the fifteenth century is one demonstration of the burgeoning demand for books. Better evidence is the astonishing number of books printed from cast type in the last thirty years of the fifteenth century, perhaps a larger number than that of all the manuscript books written in the previous nine hundred years.[12]

Five men, working independently, sought to develop a technique for mechanically producing multiple copies of books, but only one, Johannes Gutenberg, came up with a successful invention. The other four were Jean Brito of Bruges,[13] Prokop Waldvogel of Avignon,[14] Panfilo Castaldi of Feltre,[15] and Laurens Koster of Haarlem.[16]

Johannes Gutenberg was born in Mainz sometime during the last decade of the fourteenth century. Although the son of a patrician, he trained in metalworking and was associated with the goldsmiths guild, which led to his exile from Mainz in 1430 during a quarrel between guilds and patricians. He moved to Strasbourg, where he was associated with the goldsmiths guild from 1434 to 1444. Details of his activities in Strasbourg are meager, but he engaged in stone polishing and the manufacture of mirrors, and almost certainly carried out his initial development of printing. In 1442 he borrowed £80 from the Chapter of Saint Thomas in Strasbourg; it was a loan he never paid back. There is no trace of him from 1444 until 1448, when he was back in Mainz, where on October 6 he borrowed 150 gulden. Two years later he borrowed 800 gulden from Johann Fust, a lawyer and a member of a family of wealthy merchant bankers, "to finish the work"; Gutenberg's tools and equipment were security for the loan. In 1452 Gutenberg borrowed another 800 gulden from Fust, to whom he was now in debt for the equivalent of approximately a million 1990 dollars. One provision of this second large loan made Fust a partner of Gutenberg. Curt Bühler has calculated that "The sum which Fust had been willing to risk in this business amounted therefore to at least the equivalent of ten year's wages for a high-living city politician.[17]

Fust would not have risked even the first 800 gulden had Gutenberg not already invented printing from cast type; he was investing in what he foresaw as a profitable business. While still in Strasbourg and sometime before 1439, Gutenberg had engaged a carpenter to build a wooden press, and there is secondary evidence that he may have begun to develop the casting of type. In 1438 he formed a partnership with three other men to manufacture mirrors to sell to pilgrims who would go in the following year to Aachen, where sacred garments of the Virgin and Christ were to be displayed, the belief being that the mirrors would capture magical powers issuing from the garments. It is most likely that the small circular mirrors—mounted in the center of rectangular metal tablets measuring 4¼ to 6¾ inches in height and 2 to 3⅜ inches in width—were made of speculum metal.

A hundred years later Vannocchio Biringuccio described "the ancient method" of producing speculum metal as mixing "three-quarters of copper and one of tin, and in order to make it somewhat lighter in color . . . an eighteenth part of antimony."[18] It is also known that one of the four partners purchased "lead and other materials . . . necessary in this art."[19] Perhaps Gutenberg, the one partner who knew metalworking, substituted lead for copper or tin, both of which were more expensive than lead and more difficult to work. The manufacture of speculum mirrors required experience in making molds and casting metal, skills also required for casting type. The composition of Gutenberg's type metal is unknown, but a spectrographic qualitative analysis of five late-fifteenth- or early-sixteenth-century pieces of type from Lyons revealed that they were made of alloys of tin, lead, and antimony, all metals known since antiquity. One type character was rich in tin, another poor, and three of the five had a small amount of silver.[20] In 1540 Biringuccio described type metal as composed of three parts tin, one-eighth lead, and one-eighth antimony.[21] In 1683 Joseph Moxon reported type metal as being about nine tenths lead and one tenth antimony.[22] Type metal, the kind used for casting type for hand composition as in Gutenberg's day, is a lead-rich composition, approximately 60 to 70 percent lead, 10 to 20 percent tin, and 20 to 30 percent antimony. The main function of the antimony is to harden the type to resist wear. The literature contains frequent statements that antimony causes type metal to expand rather than contract upon solidification, but on this point Bruce Gonser and J. Homer Winkler state: "A common fallacy in accounting for the sharpness of definition of printing characters is to ascribe this excellent reproduction to a slight expansion of the type metal during solidification. . . . In reality . . . all type metals contract slightly."[23] In actuality the antimony in the alloy may inhibit contraction to some extent. An extremely long-lasting variety of a lead-tin-antimony alloy, in continuous use even through the twentieth century, was most probably devised by Gutenberg.

The crucial component of the invention of printing was the mold in which type was cast. As Theodore DeVinne, who was an experienced printer, put it, writing in 1876, "In this type-mould we find the key to the invention of typography. It is not the press, nor the types, but the type-mould that must be accepted as the origin and the symbol of the art. He was the inventor of typography, and the founder of modern printing, who made the first adjustable type-mould."[24] Gutenberg's mold was by far the most sophisticated metallurgical mold of its time and for several subsequent centuries. The function of the mold is to produce types with different raised characters, of uniform height and "body" (the measurement at right angles to the lines of printing), but varying widths, such as "l" and "L". A matrix bearing a reversed and indented letter to be cast is fitted into the mold and the sides of the mold adjusted for width. The typecaster (figure 8.1) then quickly pours molten type metal into the mold. At the same instant as pouring, the caster jerks the mold "to aid the melted metal in making a forcible splash against the matrix . . . the trick of making this throw or cast . . . at the right time and in the right manner, was slowly acquired . . . hand casting was hard work."[25] Relief did not come until 1838, when David Bruce invented a casting machine, but some hand casting continues.

The construction of Gutenberg's wooden-screw printing press was based on the simple screw press that had originally been produced in the first century A.D.

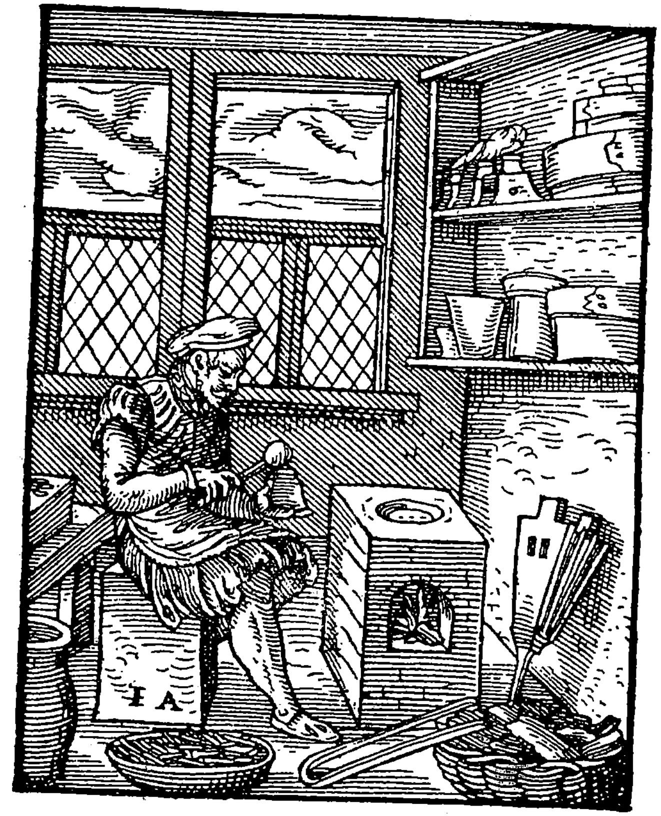

Figure 8.1. Jost Amman's typecaster. (Eigentliche Beschreibung, 1578)

In Gutenberg's time screw presses were used to crush olives, grapes, and other fruits, to compress cloth bales, to smooth and glossen cloths, particularly linen, and to dry freshly molded papers. Presses used for the latter two applications are often cited as precursors of Gutenberg's press. If either one had been, it was likely to have been the paper press, for it had a robust screw much like that in figure 8.2 and much like the one in the first depiction of a printing press in 1499. Both the linen and the paper press had a primitive platen (a flat plate that spreads the pressure of the press across the surface of material being pressed) fitted between the two main vertical press frames, which reveal the need to prevent circular platen motion but hardly suggest a sophisticated device.

The Gutenberg press possessed one important innovation, namely, a hose and platen device that pressed the paper onto the inked type. If the platen had been directly attached to the screw, the twisting action of the screw would have caused

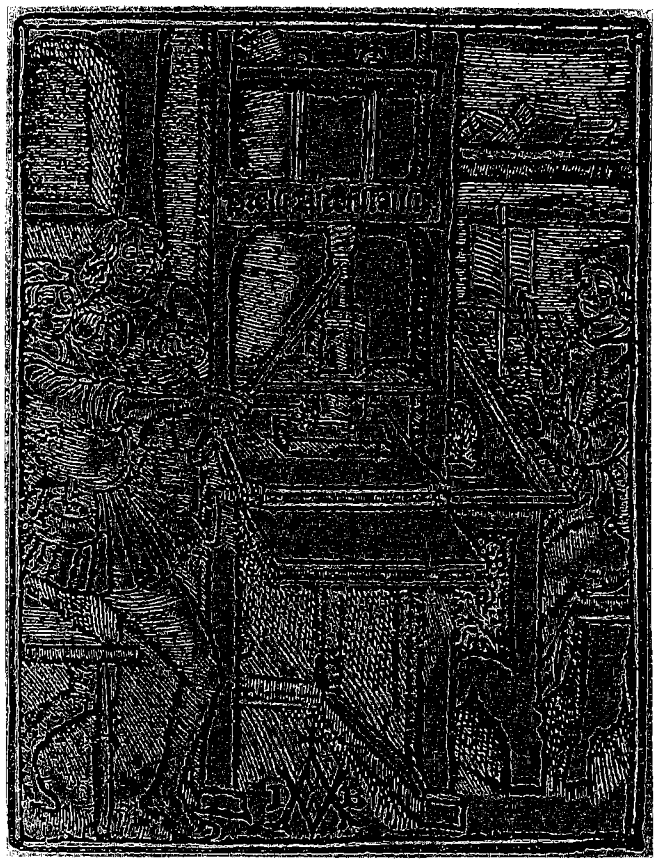

Figure 8.2. A 1507 printing press of Josse Badius.

the platen to smudge the impression. To prevent the platen from rotating with the turn of the screw, Gutenberg suspended a vertical wooden box, called a hose, through a cross-piece attached at each end to the main frame of the press. This hose structure can be seen in figure 8.2, which depicts a Josse Badius press of 1507. Hooks on the bottom corners of the hose and hooks on the platen were held tightly together with several turns of a cord between each set of hooks. The bottom end of the screw, shaped into a conical spindle with a rounded tip, fitted into a cup on the platen and turned independently of the hose as it transmitted the pressure of the screw to the paper. While there is no contemporary or subsequent textual or pictorial evidence that Gutenberg invented the hose and platen technology, the total absence of smudge or slur in the printing of the 42-line

Bible (the so-called Gutenberg Bible) is strong circumstantial evidence of a sophisticated device.

Gutenberg's press had a wooden bench with side rails on which a wooden bed, containing a single page of type locked up in a rectangular metal form (chase), could be moved back and forth. A tympan (frame) was hinged to the bed so it could be lifted up to rest on a support. To protect the margins of the paper to be printed from accidentally receiving ink smudges, another frame, a frisket, was hinged to the end of the tympan to be folded further out. Heavy paper, with a window the size of the type pages, was fitted onto the frisket.

The three men in figure 8.2 are a compositor (on the right), a pressman (pulling the bar), and a second pressman (holding the ink ball). The compositor is apparently about to start setting type in the composing stick that he holds in his right hand. The text he will be setting is in the book mounted on a support to his right. The first pressman, having moved the bed in under the platen, is pulling the bar to make the impression. Next he will rotate the crank in his left hand to move the bed back out from under the platen, unfold first the tympan, then the frisket, and remove the freshly printed sheet. As soon as the first pressman unfolds the tympan, the second pressman moves up to the bench and inks the type for the next impression.

Each sheet to be printed was folded along the center of the longer dimension so that it would contain four printed pages after four printings. To ensure accurate registration (the exact backing up of the type lines on both sides of a single sheet) the pressman pushed the sheet down on the tympan to prick fixed points; when the opposite side of the sheet was to be printed, the pricked holes would be placed over the same points. At first, ten points were used, four each at top and bottom and one in each outer margin; after several quires had been printed, the two middle points, top and bottom, were removed, leaving six. Some years later, when two pages were printed on one sheet of paper, only two points were used, fixed in the center of the sheet, so that the perforations would be hidden when all sheets were bound. When he was ready to print, the pressman would place a sheet of dampened paper on the tympan, fold the frisket over onto the tympan, fold both over onto the inked type, then move the bed into position under the platen and pull the bar to make the impression.

Although the top of the Badius press in figure 8.2 cannot be seen, there almost certainly were stays between the press and the ceiling. An illustration of the earliest known press (1499) shows three braces or stays extended from the head of the press to the ceiling beams to provide stability, and most subsequent illustrations on into the seventeenth century show stays being used. In the late seventeenth century, Joseph Moxon, in what was the original printing manual (1683–1684), described the placement of three stays, two so that "the *Press* will be sufficiently *Braced-up*" and a third to "resist the *Spring* of the *Bar*, if it slip out of the *Pressmans* hand."[26] This consistent use of braces strongly suggests that Gutenberg used them to maintain stability of his presses.

The water-based inks that had been used for four thousand years, including for the printing of block prints and block books, merely forms globules on a metal surface, making them useless for printing from cast type. In 1499 Polydore Virgil thought that Gutenberg had been the inventor of printing ink, but actually the person is unknown. Whether or not he was the inventor, Gutenberg was certainly the first to use it. It is likely that he learned the technique for making it (by grinding a black pigment, such as lampblack, into a boiled-linseed-oil varnish) from Flemish and German painters who were using linseed-oil varnish paints (the familiar "oil" on canvas) in the early fifteenth century.

When did Gutenberg do all the development required to produce cast type, a printing press, and printing ink? The earliest evidence is contained in testimonies given by witnesses in 1439 in an unsuccessful suit brought against Gutenberg for admission to a partnership by a brother of a deceased partner. The evidence of Gutenberg's activities was minimal and circumstantial, to say the least. A "press" was mentioned by five of the witnesses. The second witness to do so was recorded as follows: "Cumrat Sahspach said that Andres Heilman [one of Gutenberg's partners] . . . said to him: Dear Cumrat . . . you made the press and know about the matter; now go there and take the pieces out of the press and separate them, then no one will know what it is."[27] Four other witnesses also mentioned the press, one referring to "four pieces lying in a press" and another to "four pieces lying at the bottom in the press." There has been much speculation about these four pieces being a mold, but they may well have been a device for some other function, such as stabilization of the platen. Three witnesses made statements that referred to "mirror-maker" and "mirrors for the Aachen pilgrimage." Two witnesses spoke of "lead," one of them also stating that Gutenberg "had sent his servant to fetch all the forms; and they were melted down so that he saw it and felt regret for some forms." Finally, "Hanns Dünne the goldsmith said, that about three years ago he earned from Gutenberg approximately [one] hundred *gulden*, solely [for] what pertained to printing [*trucken*]."[28] Aloys Ruppel has pointed out that in 1439 the word *trucken* did not necessarily mean printing in the modern sense. One thing is clear: Gutenberg was not printing books, or anything else, by 1439.

The earliest example of printing from cast type is known as the Fragment of the World Judgement, thought to have been printed by Gutenberg in Mainz in 1445. He had obviously accomplished much since 1439. The fragment is only 3.6 by 5 inches, but it has been possible to calculate that the original (copies of earlier manuscripts and later printings are known) had twenty-eight pages, with twenty-one lines of print on all but one, and was 6.4 by 8.8 inches in size. Gutenberg also printed four editions of the Donatus, a Latin grammar, between 1446 and 1448, and an astronomical calendar in 1447.[29] Hence Johannes Fust had at least a half-dozen printings on which to judge in part the wisdom of making the major investment in 1450.

By 1448 Gutenberg had advanced to the second of the three stages of successful

mechanical invention. The first is an intellectual event wherein the invention is conceived and thought through; the second is an area of development in which a prototype is constructed to demonstrate that the new machinery will run; the third is building a machine that will work, in the sense that it will put out a product that is successful in the marketplace. Most of the time the sequence yields a product that is better and cheaper than existing ones for which there is already a well-established market. In Gutenberg's case there was no market mechanism available in which a pent-up demand for books could express itself.

After receiving the first loan of 800 gulden from Fust, Gutenberg launched himself into the third stage of invention without having clear foresight as to the requirements. In the period when he initiated printing of his great 42-line Bible he also printed two single-sheet papal indulgences, some on parchment. The earlier indulgence, the first printed work to bear a date of printing, appeared in 1454, and Gutenberg printed the second in 1455. Aloys Ruppel was of the opinion that work on the Bible went on from 1452 to 1455,[30] and that may well have been the case. Gutenberg was not an experienced book designer, but someone who had presumably had experience with manuscript books laid the Bible out in sixty-six sections, most with ten leaves, to facilitate binding in multiple volumes if desired. All pages have two columns and most of them have forty-two lines of type; the first nine pages, and pages 157 to 164, have forty, and page 10 has forty-one. Every page has spacious margins to allow for illumination. Most copies were on paper, but some were on parchment. As for the pages themselves, "there is something pleasing in their boldness and solidity."[31] The composition, presswork, and inking were well done. Skillful craftsmen produced the great Bible; it was not the product of haste and inexperience.

By 1455 Fust had not received any interest payments or loan repayments. In despair of ever receiving anything, he brought suit against Gutenberg for payment of the loans, as well as the interest, compounded, and the cost of the loans to himself, for he had borrowed the money to lend to Gutenberg and was paying interest on it. The court found in Fust's favor and enjoined Gutenberg to repay the 800 gulden of the first loan, a percentage of the second loan that was to be determined later (the percentage is unknown), and 426 gulden in various kinds of interest. Even if Gutenberg had to repay none of the second loan, he still needed to pay 1,226 gulden—a half-million 1990 dollars or more—which he certainly did not have. Hence Fust received all the tools, equipment, parchment, paper, ink, and books that had been purchased or produced after 1450. Gutenberg retained only the typecasting equipment, the type, and the press or presses that he had possessed before 1450.

From 1455 until his death in 1468 little is definitely known of Gutenberg and still less of his activities. Certainly the type used to print the *Donatuses* and the calendar in 1446–1448 was used to print broadsides and the so-called 36-line Bible, in three volumes with 1,768 pages. Aloys Ruppel was certain that Gutenberg printed this Bible and that he printed it in Mainz,[32] whereas others "presume" that it was printed in Bamberg by Albrecht Pfister and Heinrich Keffer (the latter was one of Gutenberg's witnesses at the proceedings associated with Fust's suit in 1455).[33] However, it is generally agreed that the 36-line Bible was printed in 1457–1458. In 1465, at the time of the so-called Bishops War in Mainz, Gutenberg was again exiled; this time he went to nearby Eltville, west of Mainz. In 1465 the archbishop of Mainz appointed him "Courier," a sinecure that supported him for the last three years of his life. He died in 1468.

Without a doubt, Gutenberg, one of history's greatest inventors and the first of the great ones that we know by name, provided the fourth punctuation in the history of the equilibria of the book by his invention of printing from cast type. His method of book copying had a clear advantage over its predecessors in that it reproduced many copies in a shorter time than had been required to reproduce a single copy manually. The technology he developed, comprising cast type, lead-tin-antimony type metal, wooden press, oil-based inks, and paper vehicle, ushered in a period of stability in book production extending more than five hundred years.

Incredibly, Gutenberg's method of casting type prevailed until 1838—nearly four centuries. His wooden printing press remained the only printing press until 1800—three and a half centuries. And, although he probably never thought of it as such, his method of book manufacture—in which every signature would fit in any copy of a book—signaled the invention of manufacturing with interchangeable parts. The kind of printing equipment Gutenberg had turned over to Fust at the end of 1455 persisted essentially unchanged for the same length of time. His flexible typecasting mold, his crucial invention, experienced no significant improvement for the nearly four centuries that it was the sole source of cast type. The qualitative composition of type metal has remained the same to the present day, almost certainly since Gutenberg and certainly since 1500. In 1800 the wooden press had the same design as the Badius press of 1507 (fig. 8.2) with one seventeenth-century improvement, the substitution of iron for the wooden hose through which the spindle of the screw passed and from which the platen hung.

The most important development following Gutenberg's invention was the establishment in the sixteenth century of independent type foundries, and perhaps the most significant innovation was the introduction of new typefaces. The first departure from gothic was a roman typeface designed by Conrad Sweynheym and Arnold Pannartz in 1465 that was destined to become a standard kind of typeface design throughout the Western world. In 1483, in Venice, Andrea Torresani printed a work in Cyrillic characters, the first book to be printed in a non-Latin alphabet; in 1501 Aldus Manutius, son-in-law of Torresani, issued an edition of Aristotle's *Metaphysics* in a Greek typeface, opening the way to printing in a nonroman alphabet. In the same year, he also printed a Virgil and a Juvenal in a cursive typeface known as italic.

Publishing and the Book Trade

When he took over Gutenberg's assets Johann Fust also acquired Peter Schoeffer, a superb technician who had worked with Gutenberg. Together they created a business, printing and publishing books that would find a market, and they established a distribution network of agents and traveling salesmen. By the time of his death, on a bookselling trip to Paris in the spring of 1466, Fust had already established a bookselling agent in Lubeck. Schoeffer engaged an agent in Paris in 1468, two years before the first book was printed in that city, and in 1470 a traveling salesman selling Schoeffer's books was in Nuremberg. Since it would certainly have cost less to supply a traveling salesman with books than to stock an agency, it is likely that Fust began to retain salesmen as early as 1462, after he and Schoeffer had published four books.

Peter Drach of Speyer, a printer, publisher, and bookseller who had established a large printshop by the 1480s, built a network of agencies and outlets in Strasbourg, Frankfurt, Cologne, Leipzig, Augsburg, Landshut, Prague, Brno, Halberstadt, Stendal, and Basel. Anton Koberger of Nuremberg, a patrician whose family included wealthy bankers, was the largest printer-publisher of the fifteenth century. Koberger, whose business network extended as far south as Lyons, was one of the early printers to contract with other printers to print his books as a technique of maintaining steady work for his own shop, which at times had more than a hundred employees. He exemplified the great printer-publishers who dominated the German market for decades.

Printing spread across Europe with amazing rapidity. More than 110 towns had presses by 1480. Venice became the "capital of printing," with 156 editions published in 1480–1482, followed by Milan (82), Augsburg (67), Nuremberg (53), Florence (48), Cologne (44), Paris (35), and Rome (34). The years 1495–1497 produced 1,821 editions, 447 (24.5 percent) of which came out of Venice; Paris produced 181 and Lyon 95. By the century's end 236 towns had printing presses installed and 35,000 editions of books had been published.[34]

Clearly an effective trade organization for the sale of books had been established by the 1490s. The major expositions for the new trade in books were the great international fairs, particularly those in Lyons and Frankfurt, both of which existed before the invention of printing. Publishers brought books to sell, as well as lists of books yet to appear, and drew up agreements with one another for future sales whereby they gained access to each other's outlets—peddlers, agents, and bookstores. In the sixteenth century the Frankfurt book fair established Frankfurt as the center of publishing in Germany, but in 1597 the imperial censorship commission began to supervise the fair, which led to its slow demise. In the mid–seventeenth century the fair moved to Leipzig, where it flourished until the Second World War, after which it moved back to Frankfurt and became outstandingly successful.

A barter system made possible the widespread distribution of books throughout Europe without transfer of money. Ideally the barter of books for books was negotiated in advance of printing, so that copies could be speedily dispatched, literally as soon as they came off the press, for they often were shipped as sheets. The system was based on trust, confidence, and credit, and its participants realized that if one node of the network suffered financial collapse it could bring down most if not all of the other nodes. Although a primitive system, it built and maintained a book trade.

Title Pages, Pagination, and Illustration

Pagination makes a book easier to use for reference, illustration provides information that complements text, and a title page indicates what the book is about. The first printed title pages were on pamphlets of six sheets containing Pope Pius II's Bull against the Turk, which Fust and Schoeffer published in 1463, some copies of which were printed in Latin and others in German. On their title pages the title stood alone, as did titles on the majority of subsequent fifteenth-century title pages. The first complete title page (title, author, place, publisher, and date) appeared in Venice in 1476, but it wasn't until the 1530s that full title pages appeared regularly. Since the second quarter of the sixteenth century the title page has gone through all manner of variations, from a page completely full of decoration and type to one that is almost blank. Some title pages have been burdened with a table of contents, or with a biography of the author, or crowded "to a point not only of unsightliness but even of illegibility."[35]

Only a few books printed before 1500 possessed numbered pages, although a tenth of fifteenth-century books had numbered folios. By the end of the sixteenth century four-fifths of printed books had arabic-numbered pagination.[36] Ultimately most books were printed with numbered pages, which facilitated indexing and citation.

Book illustration comprises two principal types of graphic representation. The most common is pictorial description, often of high artistic quality, referenced in text; the second type communicates non-verbal information impossible to impart by expository prose, such as the information in maps. Xylographic printing, with elevated lines as in woodblocks, and intaglio printing, with engraved or etched lines below the surface of a plate usually of copper, were the two most often employed techniques for book illustration before 1800.

Albrecht Pfister of Bamberg was the first printer to use woodblocks, incorporating 101 of them in his printing of Ulrich Boner's *Edelstein* (1461), the first book printed with cast type and illustrated; it was also the first dated book to be printed in German.[37] The woodblocks were impressed separately from the type. By 1464 Pfister had produced four or five additional illustrated books using the separate impression technique. The next printer to produce an illustrated book was Günther Zainer of Augsburg, in 1470. He also used separate impressions, but by 1472 he was able to develop a technique for printing woodcuts and type with a single impression, whereby he continued to print illustrated books for the next half-dozen years. Woodblock printing prevailed in book illustration until the end of the sixteenth century.

Artistic and scientific book illustration began to bloom in the first half of the sixteenth century. Albrecht Dürer led the way with his magnificent Apocalypse printed in Nuremberg in 1498. In 1530 Otto Brunfels and his illustrator, Hans Weiditz, published *Herbarium Vivae Eicones*, in which the plants had been drawn from direct observation, rather than copied from stylized representations as they had been since Dioscorides in the fifth century. (Not everyone has admired this artistic as well as scientific achievement. According to William Ivins, Weiditz's "remarkable woodcuts have been adversely criticized as being portraits of particular plants, showing not only their personal forms and characters but the very accidents of their growth, such as wilted leaves and broken stems, rather than being schematic statements of the distinguishing characteristics of the species and genera.")[38] Leonhart Fuchs produced the second of the magnificent herbals based on nature in 1542.

The next year saw the publication of two of the greatest works in the history of science: Nicolaus Copernicus's *De Revolutionibus Orbium Coelestium*, which established the heliocentricity of the solar system and the astronomy of subsequent centuries; and Andreas Vesalius's *De Humani Corporis Fabrica Libri Septem*, the foundation of modern anatomy. The greater part of each book is based on illustration, with Copernicus explaining geometric figures in his text and Vesalius describing the details of his dynamic anatomical drawings. Vesalius actually invented a new technique for communicating scientific observation in books. As J. B. Saunders and Charles O'Malley have put it,

> the last act [of preparing the book for printing] was the addition to the proof of the elaborate system of cross references between the printed text and the illustrations which made the *Fabrica* unique in the history of the printed book as a medium for the communication of a descriptive science. It was by means of this system that text and picture were woven into an integrated whole. . . . Through many hundreds of cross references Vesalius employed the illustration to eliminate ambiguity and to delimit the verbal statement.[39]

Copperplate engravings replaced woodcuts beginning with the seventeenth century (although intaglio printing had been used as early as 1477, in a copy of Ptolemy's *Cosmographia* printed in Bologna); the finer and closer lines of copperplate engraving permitted more pictorial information to be recorded in a given area. As Ivins put it, "by the end of the century the engraving had taken the place of the woodcut in all but very few of the books made for the educated classes. This . . . was a basic change in modes and techniques made in response to an insistent demand for fuller visual information."[40]

Newspapers and Journals

Newspapers suddenly came into being during the first quarter of the seventeenth century in response to the desire for timely information. Precursors were manuscript newsletters prepared by late-medieval trading companies, such as the Fuggers in Augsburg, that contained commercial and political news. The *Nieuwe Tijdinghen*, thought to have begun publication in Antwerp in 1605, apparently had a commercial newsletter as a progenitor and is often cited as the first newspaper. However, a monthly news publication had appeared in the Swiss town of Rorschach in 1597.[41] By 1610 three German cities and one Swiss city had newspapers; by 1622 the Dutch had two newspapers and the Austrians and British had one apiece. The first Paris newspaper, a weekly, appeared in 1631. Beginning in 1643 the British *Mercurius Civicus* was the first newspaper to use illustrations regularly, but little attention was given to ease of reading until 1787, when John Bell designed an attractive type and a layout with adequate space between lines to improve legibility of his *World*. Two of London's many eighteenth-century newspapers still flourish: *The Times* (1787) and *The Observer* (1785).

Censorship of newspapers was a strong force that worked against the desire and need for news. The Catholic Church had long played the major role in censorship, ever since Pope Gelasius I (d. 496) issued the first list of banned books, in the last decade of the fifth century. A thousand years later, in 1559, the Sacred Congregation of the Roman Inquisition issued the first list that included the word "Index" in its title. The *Index Librorum Prohibitorum*, as it came to be known, was issued and reissued occasionally through the last printing, the twentieth edition, which appeared in 1948; the church suppressed the *Index* in 1966 before further publication.

Various continental emperors and kings enforced the church's decrees, and King Henry VIII of England assumed all censorship powers after his separation from the church. In 1632, a dozen years after the first British newspaper appeared, the infamous Star Chamber decreed that all "newsbooks" be banned, a decree that was removed in 1638. In 1711 a stamp act was passed that increased the price of newspapers, thereby keeping them out of the hands of the lower classes; it was not rescinded until 1854. The American Revolution freed the United States from the Stamp Act of 1765, but in 1798 the United States Congress passed the Sedition Act (one of the four Alien and Sedition Acts), which provided that "if any person shall write, print, utter, or publish . . . writings against the government of the United States . . . then such person being thereof convicted . . . shall be punished by a fine not exceeding $2,000 and by imprisonment not exceeding two years." Twenty-five men were arrested, their newspapers were forced to close down, and ten of the men were convicted. The potential power of newspapers can terrorize governments. All four of the Alien and Sedition Acts were repealed or expired in 1800–1802.

The first periodical journals, five of them, were born in the 1660s. Two had

ceased to exist before the decade was out, and a third lived for only a dozen years, but the other two—the *Journal des Sçavans* (Paris, 1665) and the *Philosophical Transactions of the Royal Society* (London, 1665)—are still very much alive. Other countries producing journals in the seventeenth century were Germany, Italy, and the Netherlands. England produced the first magazine designed for women, *Ladies' Mercury*, in 1693. It also produced the first periodical with the word "magazine" in its title, *The Gentleman's Magazine*, established in 1731 and destined to live on until 1907.

The numbers of periodicals grew rapidly throughout the eighteenth century. David Kronick has compiled a table that depicts the growth. There were 4 new titles in 1700–1710, 12 in 1730–1740, 41 in 1760–1770, and 118 in 1790–1800.[42] One observer as early as 1715 "claimed that bookstores were no longer bookstores but journal stores and that bookdealers had become journal-dealers," while another in the 1790s found those years to be "truly the decade of the journal" and felt that "one should seek to limit their number rather than to increase them, since there can also be too many periodicals."[43] One still hears these complaints repeated over and over.

Recapitulation

Gutenberg's concept of the mechanization of copying and his invention of printing from cast type in the mid–fifteenth century are the major innovations of the three centuries covered in this chapter. Lesser innovations, the establishment of publishing as a profession and a book trade network throughout Europe, were followed two centuries later by the birth of newspapers and journals. All books, seventeenth- and eighteenth-century newspapers and periodicals were printed with the same kind of equipment that Gutenberg used. However, the next century was to witness change in almost every aspect of printing technology except the qualitative composition of type metal.

12 The Electronic Book

THE ELECTRONIC BOOK production system, although it also came into being in the last quarter of the twentieth century, has nothing in common with the three late-century printing systems, offset printing, flexography, and electrostatic printing, discussed in the previous chapter. It uses neither ink, paper, nor press, and it does not permanently print on anything; the format of the electronic book in no way resembles that of the convenient codex that has been traditional for nearly the last two thousand years, and it has met with unenthusiastic reception, chiefly because it presents a radical physical change for the user: from the familiar bound book in the hand to the monitor screen of a desktop computer or the flat-panel display of a laptop machine. The present situation with respect to electronic books is analogous to that of most late-nineteenth-century automobiles, which for nearly a decade after Karl Benz's successful 1885 motorized tricycle were "horseless carriages," until the French firm of Panhard and Lavassor built a machine having a design that has lasted more than a century: an engine in front under a hood instead of over the rear axle, a slanted post with steering wheel in place of a vertical post with tiller, and floor pedals rather than hand levers. The electronic book of the latter 1990s might be described as still being in the "horseless-carriage" stage.

Like the clay tablet and the papyrus-roll book, the electronic book employs a technology that was brought into being primarily to resolve problems of record keeping by administration and commerce. The first computer (1945) was built for the U.S. Army and the second (1949) by Cambridge University. Sales of early computers were a BINAC to the Northrup Aircraft Company and an ERA 1101 to the Georgia Institute of Technology, both in 1950; a Ferranti Mark I to Manchester

University and a UNIVAC I to the U.S. Bureau of the Census in 1951; and three ERA 1102s to the U.S. Air Force in 1952. In April 1953, IBM announced its 701 Calculator, and later that year J. Lyons and Company, a British catering firm, announced full business data processing services, such as accountancy and inventory control, by its LEO computer. Once again, the needs of business and government fostered a basic technology for book production.

Although books in electronic form have been with us for a quarter century, one can hardly say that there is yet an electronic-book industry. The reason is clear. In their present form electronic books have no appeal whatsoever for the vast majority of book users and readers, and they will not be widely accepted until at least two major innovations have appeared: first, an electronic reading device that must be even easier to use than the printed book; and second, an easy-to-use system, containing large and continuously updated databases, both remote and local, that will supply information whenever and wherever users may need it and from which they may withdraw items either for retention or onetime use. The databases must include digitized books, journals, reports, brochures, dramatic presentations, musical scores, concerts, audio and video material, and other forms of information not yet thought of. The overall system should also be hospitable to future functions.

The unacceptability of the present electronic book is often expressed in what has come to be known as the "can't curl up in bed with it" syndrome, closely followed by the "can't read it at the beach" complaint. Both protests are valid, but it may be supposed that advances in technology and design will soon overcome these insufficiencies as they have overcome others in the history of the book. After all, second- and third-century codices, many a foot or more tall, hardly constituted bedfellows, any more than did the seventeen-inch-tall 42-line Gutenberg Bible, or the taller-than-a-foot folios that followed in 1457, 1459, 1460, and 1462.

Electronic Book System

To be acceptable, the future electronic-book device should possess at least six specifications: (1) its legibility should be better than that of the most legible books; (2) its display should accommodate at minimum the five hundred words printed on an average six-by-nine-inch book page; (3) its size and weight should both be less than those of an average novel; (4) it should be possible to hold, manipulate, and read with one hand; (5) its one-time cost should be less than the average price of a novel; and (6) it should be able to access text in any one of millions of databases anywhere and at any time. Wireless telephony in the form of personal communications networks might make the last specification possible, but there will also need to be further technological changes in the entire system for producing, disseminating, and storing electronic information. All of the foregoing specifications must be met before the electronic book will become widely acceptable.

At the time of this writing, in the last decade of the twentieth century, there are a significant number of electronic-book publishers in existence. Although they are not threats to the current publishing community, they cause unease among traditional publishers. Electronic books will not be serious competitors of printed books, however, until a new publishing and distribution system has been established and electronic books have become far more attractive to the general community of book readers and users, which is not thirsting for a book that at present is decidedly less easy to read than a printed one.

The word "system" has acquired so many meanings (there are binary, mountain, railway, and solar systems, for example) that it has become a coat to fit any wearer. As used in this discussion "system" describes an ongoing process that produces some wanted operation and is thought of as a whole rather than as an assemblage of pieces and procedures. An electronic-book system might have as its purpose to promote the availability of information and knowledge to individuals, and one of the several goals to attain that purpose might be to make it possible for anyone to have access to a personalized database unit in the system.

A simplified electronic-book system, if it were to mimic the present flow of books from authors to users, would operate somewhat as follows: authors would submit manuscripts in electronic form to publishers, who would edit and "print" them, and then sell the electronic "books" to book clubs, bookstores, and libraries, which would distribute, sell, or lend, copies to individual users. All routes would end with the user, without whom there would be no justification for any of the system; hence, a system designer or analyst must start with the user, which should not be news to anyone engaged in the selling or lending of books. The primary goal of an electronic-book system should be to enable users to assemble personal libraries for their own purposes from material stored in remote databases, or on their own reading devices, or from compact discs.

Development of the Electronic Book

The advent of the computerized electronic book began in laboratories in the 1960s, with images on CRT screens replacing printed images on paper bound into codex form and computer power making it possible to enhance text with active images and audio projection in a manner hitherto impossible. Computerization also enabled the birth of hypertext, an intellectually revolutionary type of nonsequential literature, to be described in a following section.

In 1971 Project Gutenberg began converting to electronic form classic texts that had passed out of copyright; these were the earliest electronic books generally available. A quarter century later some 250 titles had been transcribed, entirely by volunteers, and made available on the Internet. A few examples of Project Gutenberg titles are *The Oedipus Trilogy*, the *Rubaiyat of Omar Khayyam*, *The Complete Works of William Shakespeare*, *The Federalist Papers*, *Treasure Island*, and *Tess of the* d'Urbervilles. A similar conversion activity is being conducted by Project Bartleby at Columbia University, which describes itself as "the public library of the Internet." Some traditional publishers have formed partnerships with software houses to convert their already printed books to digital form.

Portability of electronic books was becoming a feature in the mid-1980s with the appearance of display screens on handheld devices containing computerized spelling checkers, dictionaries, and thesauruses; by the early 1990s some of these little machines also contained encyclopedias. Their major disadvantage was that they lacked the capacity to display multiple works. However, in 1991 Sony introduced in the United States the Electronic Book Player, a palm-held device, measuring 4½ by ¹¹⁄₁₆ by 6⅜ inches and weighing less than two pounds, that displays the contents of an 8-centimeter (approximately 3⅜-inch) CD-ROM disc having a capacity of "100,000 pages of printed text." At the time of its introduction there were a dozen or so discs available, among them a disc containing the twenty-six-volume *Compton's Concise Encyclopedia* and another containing *The American Heritage Electronic Dictionary* together with *Roget's Electronic Thesaurus*. Reference works like these were the first popular electronic books. The Sony device, the first of its kind, is a true incunable and, like the incunables of the mid–fifteenth century not easy to use, but with it one can search for information in several ways: for a topic by word, for broad topics listed in a menu, for an article by the keywords in a title, or by using hypertext links, which are "see" references.

In 1991 the Apple Computer Company introduced a personal computer entitled PowerBook, which had a larger and more readable screen than that of Sony's Electronic Book Player; it was free of flicker and had a contrast ratio (the range between the blacks and whites in an image) of 95:1 approaching that for print on white paper. Early the next year the Voyager Company began publishing a series of multimedia works on CD-ROMs (Compact Disc-Read Only Memory) to display on the PowerBook, which the company referred to as "expanded books," because they provided sound and motion. As the *Economist* put it: "In Michael Crichton's 'Jurassic Park,' for instance, you can gawk at the picture of a cuddly tyrannosaurus while it briefly roars at you from the screen."[1]

The best known of compact discs is the CD-ROM, an enhancement of the original CDs introduced in 1982 by co-inventors Sony Corporation and Philips Electronics. Since that date 6 billion 12 cm CD-ROM discs have been sold, and more than 400 million CD-ROM players. Beginning in the early 1990s, the number of players installed in the United States each year was more than 100 percent higher than the number installed the previous year; for example, the 6.5 million installed in 1993 was nearly 170 percent more than the 2.4 million installed in 1992.

Research and development has led to new disc products named DVD-ROMs (Digital Versatile Disc-Read Only Memory), that were expected in mid-1996 to be first introduced in 1997, whose capacity is fourteen times that of CD-ROMs. DVD players can also read existing CD-ROMs. Continuing research will produce within a few years DVD-RAMs (Random Access Memory) whose memories will greatly

facilitate retrieval of books and journal articles. Anticipated further research may lead to DVD derivatives that might have the capacity to house "a small library on a single disc."[2]

In the production of CD-ROMs the analog of the press in paper printing is a disc duplicator, a computer-driven device. The copying process is essentially the same as in a personal computer, but the large commercial disc duplicators have quality control capabilities smaller machines lack. In the mid 1990s there were nearly two dozen major commercial firms duplicating discs not just for publishers but also for various types of organizations selling or providing online and other computer services. By 1993, there were so many publishers of electronic works that the Frankfurt Book Fair devoted one of its large halls to some 170 publishers of electronic books, journals, and multimedia. The *Economist* reported, "With its display of colourful technical gadgetry that moved, spoke and sang, the electronic publishing hall looked more like a slot-machine arcade than a show-case for what some see as the greatest revolution in publishing since Gutenberg."[3] In June of the following year, the American Booksellers Association for the first time devoted a section of its exhibit hall to electronic publishing.

Ulrich's International Periodicals Directory began to list electronic journals in its 1986–1987 edition, with 1,200 titles being recorded. Nine years later there were 5,517 listed, a 360 percent increase; however, that figure was a mere 3.3 percent of the nearly 165,000 serials listed in *Ulrich's*. A significant portion of electronic journals have been produced in the so-called bit-mapped form rather than in ASCII, the American Standard Code for Information Interchange, apparently because some journal publishers were hoping to thwart piracy. Unfortunately, bit mapping also thwarts computer searching of text to obtain content information. As one of the major expectations for the near future is the development of retrieval of content information from both books and journals, texts for the latter will also have to be in ASCII.

Table 12.1 succinctly summarizes the three sets of technologies employed for the mechanical reproduction of copies of books in the last five and one-half centuries. Interestingly, the table reveals that of the six related processes of Gutenberg and offset technologies only one, binding, is the same in both, whereas of the five related major processes of offset and electronic book technologies four are the same, with only one pair, "presses," having unlike components, in that one produces printed and bound codices and the other CD-ROMs. To anyone aware that computer technology is the fundamental component of both offset and electronic book technology, the similarity of their related components is not surprising.

Hypertext

The most remarkable species of book to punctuate the equilibrium of the twentieth century was the entirely new literary form of hypertext. Vannevar Bush, director of the United States Office of Scientific Research and Development during

Table 12.1. Multi-copy printing technologies and products, 1450–2000

Gutenberg	Offset	Electronic Book
character matrices	digitized characters	digitized characters
type casting	keyboarding	keyboarding
type case	computer memory	computer memory
typesetting	keyboarding	keyboarding
hand press	offset press	disc duplicator
binding	binding	
bound codex	bound codex	CD-ROM

the Second World War and former professor at the Massachusetts Institute of Technology, is generally credited with heralding hypertext. In his much-cited article "As We May Think," which appeared in July 1945 in *The Atlantic Monthly*, Bush proposed a machine, which he called Memex, that has been described as "An aid to memory. Like the brain, Memex would file material by association. Press a key and it would run through a 'trail' of facts," to which one could add one's own observations. Bush described the operation of Memex: "when numerous items have thus been joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a book." Statements like this one suggested a new kind of literature.[4]

One person motivated by Bush's article was Douglas C. Engelbart at Stanford University, who wrote to Bush on May 24, 1962, requesting permission to quote lengthy passages. Engelbart told Bush that "this article of yours has probably influenced me quite basically. I remember finding it and avidly reading it in a Red Cross library on the edge of the jungle on Leyte . . . in the Fall of 1945." Engelbart also wrote that he was working toward "launching a serious research program on 'human intellectual effectiveness,'" and in 1991 he could report that "the possibilities we are pursuing involve an integrated man-machine working relationship, where close, continuous interaction with a computer avails the human of radically changed information-handling and portrayal skills, and where clever utilization of these skills provides radical changes in the way the human attacks problems."[5]

One of the "radical changes" to come from the work of Bush and Engelbart was apparent in the early 1960s: nonsequential, linked writing produced and read only on a computer, for which Theodore H. Nelson coined the term "hypertext" in 1965. Hypertext comprises blocks of text interconnected by electronic links that give the reader freedom to construct his own pathway through the assemblage of blocks. It "blurs the boundaries between reader and writer,"[6] the reader becoming a reader-producer in contradistinction to being only a passive consumer of the product of print technology.

Brown University has been home for a group doing research and development on hypertext writing and reading, and their use in university instruction. In 1985 three members of the group described approximately two decades of activity and accomplishment in a journal article on Brown's File Retrieval and Editing System (FRESS), a text-only hypertext document system developed in the late 1960s that had both one-directional and bidirectional links. FRESS attracted considerable interest and was in operation for more than a decade, but beginning in 1982 it began to be superseded by Brown's Electronic Document System, a hypermedia system of communication that incorporated text, animation, and high-resolution color.[7]

Commercial publishers of hypertext books did not start operation until the latter half of the 1980s. For example, Eastgate Systems, which boasts of having "the largest catalog of top-notch hypertexts available anywhere," marketed its first title in 1988. Five years later creative writers had produced enough hypertext fiction, readable only on a computer, for the *New York Times Book Review* (August 29, 1993) to devote a half-dozen pages to description and reviews by Robert Coover. The description on page 8 reads, "Hypertext, in effect, introduces 'purpose' or 'design' into the scatter of electronic writing, and its principal tool for doing this is its linking mechanism: in place of print's linear, page-turning route, it offers a network of alternate paths through a set of text spaces by way of designated links." As Coover subsequently put it, "Reading through a hypertext, one senses that just under the surface of the text on the screen is a vast reservoir of story waiting to be found." Coover listed seven publishers of hypertext fiction, perhaps all of which were publishing hypertext nonfiction as well. At this writing anyone wanting to read hypertext books on a screen must buy them in the form of 8-centimeter discs or have access to one of the several universities establishing collections of them.

Multimedia and Hypermedia

Multimedia technology combines and displays several media at once, such as text, synthesized voice, sound, music, video, animation, and graphics. Hypermedia, like hypertext, has bidirectional links, but the links are for full-motion video, images, graphics, and sounds in addition to text. In the mid-1980s a third Brown University system, the Intermedia Project, explored and developed linkage among text, two-dimensional graphics (such as photographs and paintings), and three-dimensional models. Students watching a musical score on a screen while the music is being rendered by an orchestra, is one example of hypermedia use in education. Another type of example of a teaching tool is the Perseus Project at Harvard University, that provides digitized Greek texts, translations, topographical drawings, and photographic images of archaeological objects. A user finding in a text mention of a theater in which he is interested can click on the name of the theater to obtain a floor plan; placing the arrow control so that it points to the stage and clicking again will yield a photographic display of it. Links within Perseus are bidirectional, so that the user can readily return to the text.

Like printed books, some multimedia presentations are designed for different levels of viewers and listeners, including both young learners and advanced students. A viewer wishing to hear words displayed on a screen can click on the icon preceding the first word to bring forth a voice reading the sentence. If the viewer then wishes to go to the next two pages, clicking on the turned-up, lower right-hand corner will display them. An example of secondary instruction is "A hypermedia biology package [that] will let a student or teacher select by kingdom, class, phylum, species, or common name from over 50,000 slides stored on a videodisc. The user can save a list of slides selected in a computer file, then use the file to recall and project the images to accompany a lesson or a report at a later date."[8]

Publication of multimedia titles appears to involve many or all of the following three enterprises: (1) publishing houses of all types; (2) software houses; and (3) television and movie studios. There are already some contractual arrangements between publishing and software houses. Sales channels vary according to whether the publisher's customary product is books, videos, music, or software; interestingly, software stores appear to have been the first to stock multimedia, preceding the book and video stores. In a 1994 special supplement, *Publishers Weekly* listed eighty publishers and producers of multimedia, of which a quarter were software houses and twenty-one were wholesalers and distributors; altogether they published and distributed nearly four thousand titles. These firms are in the process of building a new industry.

Anticipation

Untold millennia of unrecorded oral presentations preceded the appearance, about 2500 B.C., of the clay literary works described in chapter 2, the first punctuation of equilibria in the history of the book. Five hundred years later the advent of the papyrus-roll book produced the second punctuation. Clay tablets and papyrus-roll books co-existed for two thousand years, much as two biological species may live together in the same environment. The codex book, however, coming into being in the second century A.D. as the third punctuation, rapidly became the dominant form of the book, the status that it still enjoys today. Moreover, the codex proved hospitable to the three further punctuations in the equilibria of book production: (1) the Gutenberg mechanization of copying books in the fifteenth century; (2) the introduction of nonhuman sources of power to cast type, drive presses, and manufacture paper in the early nineteenth century; and (3) the replacement of printing from cast type with computer-driven composition

and offset printing early in the last third of the twentieth century. The seventh and most recent punctuation, in the form of the electronic book, also began in the last third of the twentieth century, and it may be presumed that books on paper and books on electronic screens, will, like clay tablets and papyrus books, co-exist for some time, but for decades rather than centuries.

Meanwhile, the printed book continues to flourish. Preliminary figures for new book titles produced in 1995 suggest not only that there will be an increase over the 1994 total, but also that it may be in the vicinity of the 9.1 percent average annual increase experienced from 1960 to 1987. The rate of rise from 1993 to 1994 was very similar to that from 1985 to 1987, apparently because publishing recovered from the 1988–1992 recession. If recessions were the only factor causing decline, one might look forward to an average annual rate of 9 percent until the next decline in the economy. However, there are a variety of other factors to consider, one of which is the size of the population segment per title. From 1960 to 1987 U.S. population per new title declined from 1,195 to 468; in 1994 the figure was 505, which is dramatically lower than that for 1900—11,989 per new title.

As this book winds down, we are in the punctuation of a century and a half of power-press, cast-type equilibrium, in which the so-called traditional printing of the last twenty years will continue to evolve in the direction of digital books. It should be pointed out that the great majority of printed books are already digitized, in that photocompositors require digital format to produce offset plates for printing. Kodak's LionHeart and Xerox's DocuTech, discussed in the previous chapter, have already undergone improvement and enhancement and will continue to benefit publishers by making short-run printings increasingly economical, particularly of the journals whose subscribers are mostly institutions. The probable advent of direct-digital printing by high-speed photocompositors will also significantly reduce printing costs to publishers.

The new technologies of the last quarter century were initiated largely by the introduction in 1971 of the powerful microprocessors that do all the computing in modern computers and are the sources of most of the advances in computer capabilities. Interestingly enough, it is the print lithography process of the last century and a half that produces the tiny integrated circuits of microprocessor chips. Other technologies that will almost certainly play a new role in the production of various types of books are direct-digital printing, increased diversity in microchips, intelligent software, blue laser CD-ROM technology, electronic book readers, and the wireless networks that already service cellular telephones. In 1995, market analysts were projecting that three-quarters of the households in the United States will be subscribers to wireless service by 2001; the worldwide projection was that nearly half a billion people would be subscribers. Wireless networks will make it possible for electronic book readers to access databases of electronic books, as well as other types of information databases, from almost anywhere in the United States at almost any time. The new blue-laser CD-ROM technology is still in development; it will greatly increase the amount of information provided. Miniaturization of DVD pits and of track separation, the shorter wavelength of the DVD blue laser as compared with the red laser of CDs, together with innovative disc structure, has yielded a DVD capacity fourteen times greater than that of CDs.

Several software development projects are proceeding in the direction of enabling an individual to assemble virtual libraries for specific purposes. As an example, a scholarly user might consult a specific library for a university research project, and also consult a personalized database to retrieve information that would help him decide whether to accept a position in a for-profit corporation with which he is unfamiliar, located in an area of the country with which he is equally unacquainted. Three software projects, while not specifically related to retrieval of content information from electronic publications, will play a significant role in the easy assembly of such personalized, temporary, virtual libraries in only a few hours that formerly would require weeks to bring together. The three software projects are artificial intelligence, which apparently is becoming productive after forty years of development; genetic programming, whose disciples held their first conference in 1996; and intelligent software, also a recent field of investigation.

It is not possible to anticipate the demise of the printed book in terms of dates, but one can anticipate that the acceptance of the yet to be introduced successful electronic book will bring it to an end. We are not able to trace the events that marked the change from papyrus roll book to codex, but we do know that the former survived for four centuries after the advent of the latter. It may take less than four decades for electronic publications to share equal popularity with printed books.

Notes

Chapter 1: Dynamics of the Book

1. Niles Eldredge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in *Models in Paleobotany*, ed. T. J. M. Schopf (San Francisco: Freeman Cooper,1972), 82–115. Reprinted in Niles Eldredge, *Time Frames* (New York: Simon and Schuster, 1985), 193–223.
2. Ibid., 106.
3. Kurt Weitzman, *Illustrations in Roll and Codex* (Princeton, N.J.: Princeton University Press, 1970), 69.
4. Fritz Machlup, *The Production and Distribution of Knowledge in the United States* (Princeton, N.J.: Princeton University Press, 1962).

Chapter 2: Incunables on Clay

1. James H. Breasted, *Ancient Times: A History of the Ancient World* (Boston: Ginn, 1916), 102–3.
2. Denise Schmandt-Besserat, *Before Writing* (Austin: University of Texas Press, 1992).
3. Ibid., 10.
4. Ibid., 108.
5. Niles Eldredge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in *Models in Paleobotany*, ed. T. J. M. Schopf (San Francisco: Freeman Cooper, 1972). Reprinted in Niles Eldredge, *Time Frames* (New York: Simon and Schuster, 1985), 193.
6. Jean Bottéro, *Mesopotamia* (Chicago: University of Chicago Press, 1992), 70.
7. Samual Noah Kramer, *History Begins at Sumer* (Philadelphia: University of Pennsylvania Press, 1981), 5.

8. Seton H. F. Lloyd, "History: The Origin of Mesopotamian History," in *Encyclopaedia Britannica* (Chicago: Encyclopaedia Britannica, 1987), 21:907.
9. Giovanni Pettinato, *Ebla: A New Look at History* (Baltimore: Johns Hopkins University Press, 1991), 54.
10. Samuel Noah Kramer, "Three Old Babylonian balag-Catalogues from the British Museum," in *Societies and Languages of the Near East: Studies in Honor of I. M. Diakonoff* (Warminster: Aris and Phillips, 1982), 206.
11. Kramer, *History Begins*, 3–9.
12. George Sarton, *A History of Science: Ancient Science through the Golden Ages of Greece* (Cambridge: Harvard University Press, 1952), 71.
13. Kramer, *History Begins*, 45–50.
14. Ibid., 36–44.
15. Ibid., 54.
16. *Glass and Glassmaking in Ancient Mesopotamia* (Corning, N.Y.: Corning Museum of Glass, 1970).
17. Niles Eldredge, *Time Frames* (New York: Simon and Schuster, 1985), 168.

Chapter 3: Papyrus Rolls

1. Alan H. Gardiner, "Ramesside Texts Relating to the Taxation and Transport of Corn," *Journal of Egyptian Archaeology* 2 (1941): 19–20.
2. Alan H. Gardiner, *Egypt of the Pharaohs* (London: Oxford University Press, 1964), 297.
3. Ibid., 393.
4. Ibid., 404.
5. Georges Posner, "Sur l'emploi de l'encre rouge, dan les manuscrits Égyptians," *Journal of Egyptian Archaeology* 37 (1951): 75–78.
6. *The Edwin Smith Surgical Papyrus*, trans. James Henry Breasted (Chicago: University of Chicago Press, 1930).
7. Frederick G. Kilgour, "Locating Information in an Egyptian Text of the Seventeenth Century B.C.," *Journal of the American Society for Information Science* 44 (1993): 292–97.
8. *The Ancient Egyptian Book of the Dead*, trans. Raymond O. Faulkner, ed. Carol Andrews (London: British Museum Publications, 1985).
9. Gay Robins and Charles Shute, *The Rhind Mathematical Papyrus: An Ancient Egyptian Text* (London: British Museum Publications, 1987), 10.
10. Ibid., 10–11.
11. Kurt Weitzmann, *Illustrations in Roll and Codex* (Princeton, N.J.: Princeton University Press, 1970), 68.
12. Alfred Lucas, *Ancient Egyptian Materials and Industries* (London: Edward Arnold, 1962), 15.
13. Walter B. Emery, *Archaic Egypt* (Baltimore: Penguin Books, 1971), 235.
14. Tsien Tsuen-Hsuin, *Paper and Printing* (Cambridge: Cambridge University Press, 1985), 2.
15. *Ancient Egyptian Book of the Dead*, 11.
16. Francis Llewellyn Griffith, *The Petrie Papyri* (London: B. Quaritch, 1898).
17. Gardiner, *Egypt*, 130.

18. *Ancient Egyptian Book of the Dead.*
19. Henry E. Sigerist, *A History of Medicine* (New York: Oxford University Press, 1951), 1:301.

Chapter 4: The Greco-Roman World

1. John Boardman, Jasper Griffin, and Oswyn Murray, eds., *The Roman World* (Oxford: Oxford University Press, 1991).
2. George Sarton, *Introduction to the History of Science* (Baltimore: Williams and Wilkins, 1927), 1:172.
3. Joseph Naveh, *Early History of the Alphabet*, 2d. ed. (Jerusalem: Magnes Press, Hebrew University, 1987), 42.
4. Ibid., 53–54, 175–86.
5. Ibid., 181–82.
6. I. J. Gelb, *A Study of Writing*, 2d ed., rev. (Chicago: University of Chicago Press, 1963), 173.
7. Ibid., 179.
8. Naveh, *Early History*, 185.
9. John Noble Wilford, "Scholars Track the Alphabet with New Precision," *New York Times*, November 8, 1988, C1, C2.
10. Frederic G. Kenyon, *Books and Readers in Ancient Greece and Rome* (Oxford: Clarendon Press, 1951), 66–67.
11. Eric G. Turner, *Greek Papyri* (Oxford: Clarendon Press, 1980), 79.
12. Cicero, *Letters to Atticus*, vol. 1, 4, 4a, 283.
13. W. John Hackwell, *Signs, Letters, Words: Archaeology Discovers Writing* (New York: Scribner's, 1987), 52.
14. Eric G. Turner, *Greek Manuscripts of the Ancient World*, 2d ed. (London: University of London Institute of Classical Studies, 1987), 2.
15. Ibid.
16. R. Reed, *Ancient Skins, Parchments, and Leathers* (London: Seminar Press, 1972), 90.
17. Ibid., 119.
18. Reed, *Ancient Skins*, 88.
19. Herodotus, *The Histories of Herodotus* (New York: Heritage Press, 1958), 323.
20. Paul-Marie Duval, "Antiquité Mediterranéenne," in *Les origines de la civilisation technique*, ed. Henri Dauman, vol. 1 (Paris: Press Universitaires de France, 1964), 249.
21. K. D. White, *Greek and Roman Technology* (Ithaca, N.Y.: Cornell University Press, 1984), 192.
22. Hero of Alexandria, *Les Mécaniques* (Paris: Les Belles Lettres, 1988), 199–214. (This work had been translated from Arabic because no Greek version existed.)
23. White, *Greek and Roman Technology*, 34–35.
24. Pliny, *Natural History*, vol. 9 (Cambridge: Harvard University Press, 1989), 114.
25. Paul Saenger, "Silent Reading: Its Impact on Late Medieval Script," *Viator* 13 (1982): 367–414, 371.
26. William V. Harris, *Ancient Literacy* (Cambridge: Harvard University Press, 1989), 114.
27. William Harlan Hale, *Ancient Greece* (New York: American Heritage Press, 1970), 121.

28. Plato, *Phaedrus*, (Cambridge: Harvard University Press, 1977), 565, 567.

29. Harris, *Ancient Literacy*, 236.

30. Ibid., 259, 267.

31. Colin H. Roberts and T. C. Skeat, *The Birth of the Codex* (London: Oxford University Press, 1983), 37.

32. Kenyon, *Books and Readers*, 24.

33. Ibid., 23–24.

34. Turner, *Greek Papyri*, 87.

35. Luciano Canfora, *The Vanished Library* (Berkeley: University of California Press, 1987), 63.

36. Ibid., 141.

37. For examples see David Diringer, *The Book before Printing* (New York: Dover Publications, 1982), 270; Karl Dziatzko, "Bibliotheken," in *Paulys Real-Enclopaedie der Classischen Altertums-wissenschaft* (Stuttgart: J. B. Metzlerscher, 1899), vol. 3, col. 410; Edward Edwards, *Libraries and Founders of Libraries* (London: Trubner, 1864), 7; Elmer D. Johnson and Michael H. Harris, *History of Libraries in the Western World*, 3d ed., rev. (Metuchen, N.J.: Scarecrow Press, 1976), 49; Edward Alexander Parsons, *The Alexandrine Library* (London: Cleaver-Hume Press, 1952), 172.

38. Christian Callmer, "Antike Bibliotheke," *Opuscula Archaeologica* 3 (1944): 152–53.

39. Alan Rowe, *Discovery of the Famous Temple and Enclosure of Serapis at Alexandria* (Le Caire: Institute Francais d'Archéologie Orientale, 1946), 25.

40. Peter Marshall Fraser, *Ptolemaic Alexandria*, 3 vols. (Oxford: Clarendon Press, 1972), 1:323.

41. Canfora, *Vanished Library*, 63.

42. The last four paragraphs are based on Clarence Eugene Boyd's *Public Libraries and Literary Culture in Ancient Rome* (Chicago: University of Chicago Press, 1913).

43. Lawrence Richardson, *Pompeii: An Architectural History* (Baltimore: Johns Hopkins University Press, 1988) 273–75; and "The Libraries of Pompeii," *Archaeology* 30: 400–402.

44. Canfora, *Vanished Library*, 196.

45. Carl Wendel, "Die Erst Kaiserliche Bibliothek in Constantinople," *Zentralblatt fur Bibliothekwesen* 59 (1942): 193–209.

46. Jean Irigoin, "Centres de copie et bibliotheques," in *Byzantine Books and Bookmen* (Washington, D.C.: Dumbarton Oaks, 1975), 19.

47. Cyril Mango, "The Availability of Books in the Byzantine Empire, A.D. 750–850," in *Byzantine Books and Bookmen* (Washington, D.C.: Dumbarton Oaks, 1975), 39, 43.

48. Nigel Guy Wilson, *Scholars of Byzantium* (Baltimore: Johns Hopkins University Press, 1983), 120–29.

49. Sarton, *Introduction*, vol. 2, pt. 1, 403.

50. *Announcing New Editions in The Loeb Classical Library 1992* (Cambridge: Harvard University Press, 1992), 2.

Chapter 5: The Codex, 100–700 A.D.

1. Terturian, *Apology*, 40, 1–2, quoted in Robert M. Grant, *Apologists of the Second Century* (Philadelphia: Westminster Press, 1988), 10.

2. Grant, *Apologists of the Second Century*, 30.

3. Alan K. Bowman, *The Roman Writing Tablets from Vindolanda* (London: British Museum, 1938).

4. Homer, *The Iliad of Homer* (New York: Macmillan, 1945), 129.

5. Courtesy of the Ohio State University Library.

6. Edward Maunde Thompson, *An Introduction to Greek and Latin Paleology* (Oxford: Clarendon Press, 1912), 13, 14.

7. George F. Bass, "Oldest Known Shipwreck Reveals Splendors of the Bronze Age," *National Geographic Magazine* 172 (1987): 730–31.

8. Thompson, *Introduction*, 15.

9. Herodotus, (Oxford: Clarendon Press, 1949), v. 2, book 7, chapter 239, 569.

10. Giovanni Pugliese Carratelli, "L'Instrumentum Scriptorium Monumenti Pompeiana ed Ercolanesi," *Pompeiana* (Naples: Gaetano Macchiaroli, 1950), 270–73.

11. Berthe van Regemorter, "La Reliure des Manuscrits Grecs," *Scriptorium* 8 (1954): 17.

12. Eric G. Turner, *The Typology of the Early Codex* (Philadelphia: University of Pennsylvania Press, 1977), 1.

13. Eric G. Turner, *Greek Papyri* (Oxford: Clarendon Press, 1980), 2.

14. Berthe van Regemorter, "Le codex relié depuis son origine jusqu'au Haut Moyen-Age," *Le Moyen Age* 61 (1995): 15.

15. Turner, *Greek Papyri*, 87–88.

16. Colin H. Roberts and T. C. Skeat, *The Birth of the Codex* (London: Published for the British Academy by the Oxford University Press, 1983), 38.

17. Turner, *Typology*, 37.

18. Seneca, "On the tranquillity of mind," in *Moral Essays* (Cambridge, Mass.: Harvard University Press, 1965), vol. 2, 247–49.

19. Turner, *Typology*, 50, 51.

Chapter 6: Islam, 622–1300

1. George Sarton, *Introduction to the History of Science* (Baltimore: Williams and Wilkins, 1927), 1:7.

2. Tsien Tsuen-Hsuin, *Paper and Printing* (Cambridge: Cambridge University Press, 1987), 297–99.

3. Dard Hunter, *Papermaking through Eighteen Centuries* (New York: William Edwin Rudge, 1930), 186–90.

4. Ibid., 159.

5. Ibn Badis, Al-Mu'izz, "Staff of the scribes and implements of the discerning, with a description of the line, the pens, soot inks, *LIQ*, gall inks, dyeing, and details of bookbinding," in *Mediaeval arabic bookmaking and its relation to early chemistry and pharmacology*, by Martin Levey. *Transactions of the American Philosophical Society* 52 (1962): 3–79, 13.

6. Ibid., 14.

7. Sarton, *Introduction*, vol. 1, 666.

8. Cited in Gulnar Bosch, John Carswell, and Guy Pethridge, *Islamic Bindings and Bookmaking* (Chicago: Oriental Institute, University of Chicago, 1981), 6.

9. George Makdisi, *The Rise of Humanism in Classical Islam and the Christian West* (Edinburgh: Edinburgh University Press, 1990), 72, 74.

10. Ibid., 72.

11. Ibid., 74.

12. Ibid.
13. Ibid., 79.
14. Johannes Pedersen, *The Arabic Book* (Princeton, N.J.: Princeton University Press, 1984), 27.
15. Makdisi, *Rise of Humanism*, 246.
16. Ibid., 245.
17. C. E. Bosworth, "Administrative Literature," in *Religion, Learning, and Science in the ʿAbbāsid Period* (Cambridge: Cambridge University Press, 1990), 159.
18. Pederson, *Arabic Book*, 101–2.
19. Martin Levey, *Mediaeval Arabic Bookmaking and its Relation to Early Chemistry and Pharmacology* (Philadelphia: American Philosophical Society, 1962), 13.
20. Ibn Badis, "Staff," 13–50.
21. Al-Sufyānī, Abul-Abbas Ahmed ibn Muḥammed, "Art of bookbinding and of gilding." From the Arabic text published by P. Richard, 1925, in "Mediaeval arabic bookmaking and its relation to early chemistry and pharmacology, by Martin Levey, *Transactions of the American Philosophical Society* 52 (1962):3–17, 51–55.
22. Ibn Badis, "Staff," 42.
23. Al Sufyānī, "Art of Bookbinding," 52.
24. Pedersen, *Arabic Book*, 50.
25. Ross E. Dunn, *The Adventures of Ibn Battuta* (Berkeley: University of California Press, 1986), 37.
26. Pederson, *Arabic Book*, 52, 50.
27. L. E. Goodman, "The translation of Greek materials into Arabic" in *Religion, Learning, and Science*, 495.
28. Pedersen, *Arabic Book*, 120.
29. Bayard Dodge, *Muslim Education in Medieval Times* (Washington, D.C.: Middle East Institute, 1962), 23.
30. Pedersen, *Arabic Book*, 121–24.
31. Adam Gacek, "Some Remarks on the Cataloguing of Arabic Manuscripts," *Bulletin of the British Society for Middle Eastern Studies* 10 (1983): 173, 179 n. 9.

Chapter 7: Western Christendom, 600–1400

1. Helmut Georg Koenigsberger, *Medieval Europe 400–1500* (Harlow, U.K.: Longman, 1987), 42.
2. Henri-Jean Martin, *The History and Power of Writing* (Chicago: University of Chicago Press, 1994), 121.
3. Mark Alfred Schroll, *Benedictine Monasticism As Reflected in the Warnefrid-Hildemar Commentaries on the Rule* (New York: Columbia University Press, 1941), 122.
4. Rosamond McKitterick, *The Carolingians and the Written Word* (Cambridge: Cambridge University Press, 1989), 166, 169, 170, 173, 179, 183.
5. Saint Benedict, *The Rule of St. Benedict in Latin and English with Notes* (Collegeville, Minn.: Liturgical Press, 1981), 48, 15, 16.
6. Schroll, *Benedictine Monasticism*, 54, 206.
7. Cassiodorus, *An Introduction to Divine and Human Readings* (New York: Octagon Press, 1966), 133–35.
8. Florence Edler De Roover, "The Scriptorium," in *The Medieval Library*, ed. James Westfall Thompson (New York: Hafner Publishing, 1965), 595.

9. *Registrum Anglie de Libris Doctorum et Auctorum Veterum* (London: British Library, 1981), xiii.
10. Richard H. Rouse, "Bostonus Buriensis and the Author of the *Catalogus Scriptorium Ecclesiae*," *Speculum* 66 (1966): 493.
11. Roover, "Scriptorium," 610–11.
12. Ibid., 607–8.
13. Leila Avrin, *Scribes, Script, and Books* (Oxford: Phaedon Press, 1991), 224.
14. Roover, "Scriptorium," 601.
15. Falconer Madan, *Books in Manuscript* (New York: Haskell House, 1968), 42.
16. Paul Saenger, "Silent Reading: Its Impact on Medieval Script and Society," *Viator* 13 (1982): 377.
17. Janet Backhouse, *The Illuminated Manuscript* (Oxford: Phaedon Press, 1979), 7.
18. David Diringer, *The Book before Printing* (New York: Dover Publications, 1982), 501.
19. Jean Vezin, "La reliure occidentale au moyen age," in *La reliure médiévale* (Paris: Presses de l'École Normale Supérieure, 1978), 38.
20. Koenigsberger, *Medieval Europe*, 215.
21. Marcel Thomas, "Manuscripts," in Lucien Febvre and Henri-Jean Martin, *The Coming of the Book* (London: Verso, 1984), 22.
22. David C. Lindberg, *The Beginnings of Western Science* (Chicago: University of Chicago Press, 1992), 203.
23. Saenger, "Silent Reading," 387.
24. Richard H. Rouse and Mary A. Rouse, *Preachers, Florilegia, and Sermons* (Toronto: Pontifical Institute of Medieval Studies, 1979), 7, 8.
25. Ibid., 8.
26. Ibid., 9.
27. Ibid., 23.
28. Edward Rosen, "The Invention of Eyeglasses," *Journal of the History of Medicine and Allied Sciences* 2 (1956): 29, 217, 214, 204, 203.
29. Michael Rhodes, "A Pair of Fifteenth-Century Spectacle Frames from the City of London," *Antiquaries Journal* 62 (1982): 57–73, 66, 73, n. 71.
30. Horst Appuhn, "A Memorable Find," *Zeiss Werkzeitschrift* 27 (1958): 4, 5.
31. Rhodes, "Fifteenth-Century Spectacle Frames," 57.
32. Richard de Bury, *Philobiblon* (Oxford: Shakespeare Head Press, 1960), 161.
33. Oriel Valls i. Subirà, *La Historia del papel en España* (Madrid: Empresa Nacional de Celulosa, 1978), 3:129–33.
34. Marius A. Péraudeau and Ernst Maget, *Le moulin à papier Richard-de-Bas* (Paris: Pierre Gaudin, 1985), 10.

Chapter 8: Printing, 1400–1800

1. Richard H. Rouse, "Backgrounds to Print: Aspects of the Manuscript Book in Northern Europe of the Fifteenth Century," *Proceedings of the PMR Conference* 6 (1981): 38.
2. Ibid., 40.
3. John M. Lenhart, *Pre-Reformation Printed Books: A Study in Statistical and Applied Bibliography* (New York: Joseph P. Wagner, Inc., 1935), 26, 28.
4. Lucien Febvre and Henri-Jean Martin, *The Coming of the Book* (London: Verso, 1984), 248.

5. Warren Chappell, *A Short History of the Printed Word* (New York: Dorset Press, 1970), 84.
6. Rouse, "Backgrounds," 48.
7. Theodore L. DeVinne, *The Invention of Printing* (New York: Francis Hart, 1876; reprint, Detroit: Gale Research, 1969), 204–5.
8. Ibid., 203.
9. Heinrich T. Musper, "Xylographic Books," in *The Book through Five Thousand Years*, ed. H. D. L. Vervliet (London: Phaidon, 1972), 346.
10. Allen Stevenson, "The Quincentennial of the Netherlandish Blockbook," *British Museum Quarterly* 21 (1966–67): 84.
11. Musper, "Xylographic Books," 341, 345.
12. Rouse, "Backgrounds," 48.
13. Karl C. Bochenheimer, *Johann Brito aus Brügge* (Mainz: Verlangsaustalt und Druckerei, 1898).
14. Pierre Henri Requin, *L'Imprimerie à Avignon en 1444* (Paris: Alphonse Picard, 1890).
15. Antonio Valsecchi, *Intorno a Panfilo Castaldi da Feltre e alla Invenzione dei Caratteri Mobile per la Stampa* (Milan: Pietro Aquelli, 1866).
16. Jacobus Scheltema, *Levens-schets van Laurens Janozorn-Koster* Utrecht: J. G. van Terveen en zoon, 1834).
17. Curt F. Bühler, *The Fifteenth-Century Book* (Philadelphia: University of Pennsylvania Press, 1960), 51, 52.
18. Vannoccio Biringuccio, *The Pirotechnia* (New York: Basic Books, 1959), 388.
19. DeVinne, *Invention of Printing*, 380.
20. Maurice Audin, "Types du XVᵉ Siècle," *Gutenberg Jahrbuch* 18 (1954): 92.
21. Biringuccio, *Pirotechnia*, 374.
22. Joseph Moxon, *Mechanik Exercises on the Whole Art of Printing* (New York: Dover Publications, 1978), 165, 167.
23. Bruce Gonser and J. Homer Winkler, "Type Metals," in *Metals Handbook*, ed. Lyman Taylor (Cleveland: American Society for Metals, 1948), 958. I am grateful to Professor H. H. Stademaier for bringing this work to my attention.
24. DeVinne, *Invention of Printing*, 66–67.
25. Ibid., 60.
26. Moxon, *Mechanik Exercises*, 254.
27. Douglas C. McMurtrie, *The Gutenberg Documents* (New York: Oxford University Press, 1941), 105.
28. Ibid., 116, 117.
29. Aloys Ruppel, *Johannes Gutenberg*, 3d ed. (Nieuwkoop: B. de Graaf, 1967), 116–22.
30. Ibid., 137.
31. DeVinne, *Invention of Printing*, 422.
32. Ruppel, *Gutenberg*, 132.
33. Albert Kapr, *Johannes Gutenberg* (Munich: Verlag C. H. Beck, 1987), 220–24.
34. Febvre and Martin, *Coming of the Book*, 182–86.
35. Douglas C. McMurtrie, *The Book* (New York: Dorset, 1943/1989), 568.
36. Margaret M. Smith, "Printed Foliation: Forerunner to Printed Page Numbers?" *Gutenberg Jahrbuch* 63 (1988): 54–70.
37. Ulrich Boner, *Der Edelstein* (Bamberg: Albrecht Pfister, 1461).

38. William M. Ivins, *Prints and Visual Communication* (Cambridge: Harvard University Press, 1953), 43–44.
39. Andreas Vesalius, *The Illustrations from the Works of Andreas Vesalius*, with annotations and . . . a discussion . . . by J. B. de C. M. Saunders and Charles D. O'Malley (Cleveland: World Publishing, 1950), 20–21.
40. Ivins, *Prints*, 166.
41. Adolf Dresler, *Die Älteste Periodische Zeitung und Zeitschrift: Die Rorschacher Monatsschrift* (Munich: Pohl, 1963).
42. David A. Kronick, *A History of Scientific and Technical Periodicals* (Metuchen, N.J.: Scarecrow Press, 1976), 90–91.
43. Ibid., 171.

Chapter 9: Power Revolution, 1800–1840

1. Robert Luther Thomson, *Wiring a Continent* (Princeton, N.J.: Princeton University Press, 1949), 91, 74.
2. William Turner Berry, "Printing and Related Trades," in *A History of Technology*, vol. 5 (Oxford: Clarendon Press, 1958), 702.
3. Harvey J. Graff, *The Legacies of Literacy* (Bloomington: Indiana University Press, 1987), 353.
4. Harvey B. Weiss, "A Graphic Summary of the Growth of Newspapers in New York and Other States, 1704–1820," *Bulletin of the New York Public Library* 52: 184.
5. Raymond Irwin, *The English Library* (London: George Allen and Unwin, 1966), 282.
6. Jesse H. Shera, *Foundations of the Public Library* (Hamden, Conn.: Shoe String Press, 1949), 231, 232.
7. Frederick G. Kilgour, "Modern Medicine in Historical Perspective," *Bulletin of the Medical Library Association* 50: 42–56. Reprinted in *Collected Papers of Frederick G. Kilgour*, vol. 1 (Dublin, Ohio: Online Computer Library Center, 1984), 161–69.
8. Graff, *Legacies of Literacy*, 303–14.
9. Leslie Howsam, *Cheap Bibles* (New York: Cambridge University Press, 1991), 79.
10. Ibid., 117–18.
11. James Moran, *Printing Presses* (Berkeley: University of California Press, 1973), 39.
12. Michael Turner, "Reading for the Masses: Aspects of the Syndication of Fiction in Great Britain," in *Book Selling and Book Buying: Aspects of the Nineteenth-Century British and North American Book Trade*, ed. Richard D. Landon (Chicago: American Library Association, 1978), 33.
13. This paragraph and the following five paragraphs are based on Moran, *Printing Presses*, 50–97.
14. *Printing The Times* (1953), 30, 31.
15. *The History of The Times*, (New York: Macmillan, 1935), 1:112.
16. Moran, *Printing Presses*, 106.
17. Ibid., 116, 117.
18. Lucien Alphonse Legros and John Cameron Grant, *Typographical Printing-Surfaces* (New York: Garland Publishing, 1916; reprint, 1980), 471–72.
19. Ibid., 581.
20. John Carter, "William Ged and the Invention of Stereotype," *Library* 15: 163.

21. Howsam, *Cheap Bibles*, 3.

22. David Paul Nord, *The Evangelical Origins of Mass Media in America 1815–1838* (Columbia, S.C.: Association for Education in Journalism and Mass Communications, 1984), 8, 19.

23. Ibid., 12.

24. Legros and Grant, *Typographical Printing*, 302.

25. Aloys Senefelder, *A Complete Course of Lithography* (London: R. Ackermann, 1819), v.

26. Ibid., 7–8, 9.

27. Douglas C. McMurtrie, *The Book* (New York: Dorset, 1943/1989), 551.

28. Senefelder, *Complete Course*, 9–11, 38.

29. Terry Belanger, "From Bookseller to Publisher: Changes in the London Book Trade, 1750–1850," in *Bookselling and Book Buying: Aspects of the Nineteenth-Century British and North American Book Trade*, ed. Richard G. Landon (Chicago: American Library Association, 1978).

30. Henri-Jean Martin, *The History and Power of Writing* (Chicago: University of Chicago Press, 1994), 259–60.

31. James Lackington, *Memoirs of the First Forty-Five Years of James Lackington, 1794* (New York: Garland Publishing, 1974), 335–36.

32. Martin, *History and Power*, 438.

Chapter 10: Climax of Books Printed from Cast Type, 1840–1940

1. Lucien Alphonse Legros and John Cameron Grant, *Typographical Printing-Surfaces* (London: Longmans, Green, 1916), 577–78.

2. Henry Bessemer, *Sir Henry Bessemer, F.R.S., An Autobiography* (London: Offices of "Engineering," 1905; reprint, 1989), 47.

3. Ibid.

4. James Moran, *Printing Presses* (Berkeley: University of California Press, 1973), 176–77.

5. Theodore L. DeVinne, "Perfecting the Press," *Scientific American Supplement* 1380 (June 14, 1902): 22,122.

6. Moran, *Printing Presses*, 190.

7. James Moran, "Printing," in *A History of Technology, vol. 7* (Oxford: Clarendon Press, 1978), pt. 2, 1,268.

8. Victor Fouque, *The Truth Concerning the Invention of Photography* (New York: Tennant and Ward, 1935), 37.

9. Frank E. Comparato, *Books for the Millions* (Harrisburg, Pa: Stackpole, 1971), 184.

10. William Turner Berry, "Printing and Related Trades," in *A History of Technology*, vol. 5 (Oxford: Clarendon Press, 1958), 714.

11. Henri-Jean Martin, *The History and Power of Writing* (Chicago: University of Chicago, Press, 1994), 414.

12. John Feather, *A Dictionary of Book History* (New York: Oxford University Press, 1986), 186.

13. Ibid., 187.

14. Berry, "Printing and Related Trades," 686.

15. Legros and Grant, *Typographical Printing-Surfaces*, 480.

16. Matthew Schneirov, *The Dream of a New Social Order: Popular Magazines in America 1893–1914* (New York: Columbia University Press, 1994), 92.

17. Theodore Peterson, *Magazines in the Twentieth Century* (Urbana: University of Illinois Press, 1956), 58.

18. William J. Thorn and Mary Pat Pfell, *Newspaper Circulation* (New York: Longman, 1987), 48.

19. Peterson, *Magazines*, 90–91.

20. Wilfred A. Beeching, *Century of the Typewriter* (London: Heinemann, 1974), 36.

21. Mark Twain, *Mark Twain-Howells Letters* (Cambridge: Harvard University Press, 1960), 133.

22. Donald Hoke, *Ingenious Yankees* (New York: Columbia University Press, 1990), 133.

23. Paul Kaufman, *Libraries and Their Users* (London: Library Association, 1969), 143.

24. Sir Allen Lane, "Penguins and Pelicans," *The Penrose Annual*, 1938. Reprinted in *Printing in the Twentieth Century*, ed. James Moran (London: Northwood Publications, 1974), 160.

25. Ibid.

26. John Tebbel, *A History of Book Publishing in the United States* (New York: R. R. Bowker, 1978), 3:510.

27. Jean Hassendorfer, *Développement comparé des bibliothèques publiques en France en Grande-Bretagne et aux États-Unis dans la seconde moitié du XIXᵉ siècle (1850–1914)* (Paris: Cercle de la Librairie, 1967), 44–56.

28. Ibid., 46.

29. Arthur T. Hamlin, *The University Library in the United States* (Philadelphia: University of Pennsylvania Press, 1981), 230, 234.

Chapter 11: Computer-Driven Book Production

1. Henry Whetton, ed., *Practical Printing and Binding* (London: Oldham Press, [1946]; reprint, 1948), 230–42.

2. Stephen H. Horgan, "Twenty-five years of processwork," *The Inland Printer*, 63 (July 1919): 408.

3. James Moran, "Printing," in *A History of Technology*, vol. 7 (Oxford: Clarendon Press, 1978), pt. 2, 1,269.

4. Albro Tilton Gaul, *The Wonderful World of Insects* (New York: Rinehart, 1953), 291.

5. Moran, "Printing," 1,279.

6. William H. Taft, *American Magazines for the 1980s* (New York: Hastings House, 1982), 318.

7. Joseph Blumenthal, *Typographic Years* (New York: Frederic C. Beil, 1982), 126.

8. Lloyd P. DeJidas and Thomas M. Destree, *Sheetfed Offset Press Operating* (Pittsburgh: Graphic Arts Technical Foundations, 1995), 14–15, 214–15.

9. Ernest A. Hutchings, *A Survey of Printing Processes*, 2d ed. (London: Heinemann, 1978), 169.

10. Jill Roth, "Book Marks," *American Printer*, January 1991, 44–45.

11. Xerox Corporation, *Xerox Launches DocuPrint 6135* (Chicago: Xerox Production Systems, 1995).

12. *University Libraries and Scholarly Communication* (Washington, D.C.: Published by the Association of Research Libraries for the Andrew W. Mellon Foundation, 1992), 200.

13. Frank L. Schick, *The Paperbound Book in America* (New York: R. R. Bowker, 1958), 104.

14. *University Libraries*, 75.

15. Ibid., 67.

16. Curtis G. Benjamin, "The High Price of Technical Books," *ALA Bulletin*, 1965, 62–63.

17. Janice A. Radway, *Reading the Romance* (Chapel Hill: University of North Carolina Press, 1991), 33–34.

18. John Tebbel, *Between Covers* (New York: Oxford University Press, 1987), 448.

19. *University Libraries*, 4, 5.

20. Lisa A. Wright, "Public Library Circulation Rises along with Spending," *American Libraries* 27 (Oct. 1996): 57–58.

Chapter 12: The Electronic Book

1. "Roll Over Gutenberg," *Economist*, Oct. 18, 1993, 105.

2. Alan E. Bell, "Next Generation Compact Discs," *Scientific American* 275 (July 1996): 42, 44, 46.

3. "Roll Over Gutenberg," 105.

4. Vannevar Bush, "As We May Think," *Atlantic Monthly* (July 1945): 641–49. Reprinted in *From Memex to Hypertext*, ed. J. M. Nyce and P. Kahn (Boston: Harcourt Brace Jovanovich, 1991), 87, 104.

5. Douglas C. Engelbart, "Letter to Vannevar Bush and Program on Human Effectiveness," in *From Memex to Hypertext*, ed. J. M. Nyce and P. Kahn (Boston: Harcourt Brace Jovanovich, 1991), 235, 236, 237.

6. George P. Landow, *Hypertext: The Convergence of Contemporary Critical Theory and Technology* (Baltimore: Johns Hopkins University Press, 1992), 5.

7. Nicole Yankelovich, Norman Meyrowitz, and Andries van Dam, "Reading and Writing the Electronic Book," *Computer*, Oct. 1985, 15–30.

8. Donna Baumbach, "Hypermedia," *Macmillan Encyclopedia of Computers* (New York: Macmillan, 1992), 508.

Index