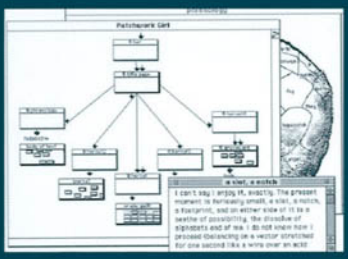
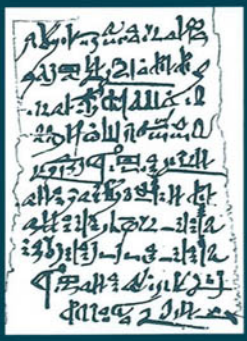
The EVOLUTION *of the* BOOK





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

For
Eleanor

companion
on the
journey

with love,
gratitude,
and
appreciation

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Contents

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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

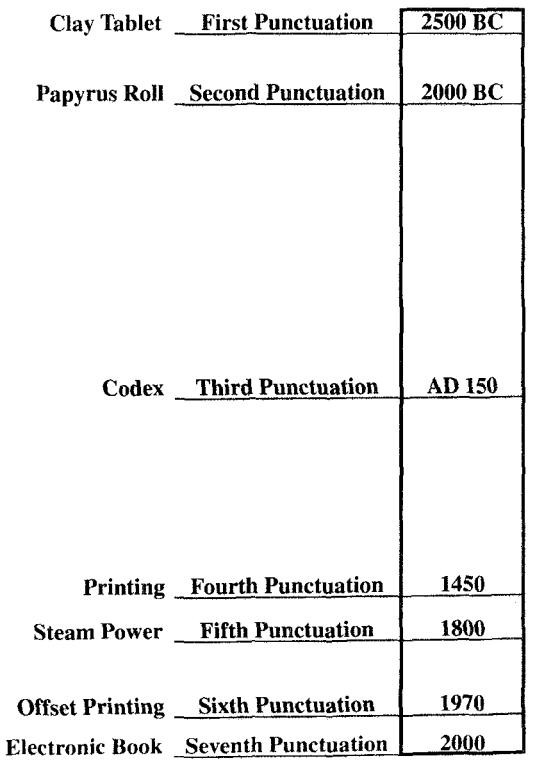

Figure 1.1. Seven punctuations of equilibria of the book over forty-five hundred years.

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 his-

tory 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.