

THE ALPHABET EFFECT

The Impact of the
Phonetic Alphabet on the
Development of
Western Civilization

Robert K. Logan, Ph. D.

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From seminal work done in collaboration with Marshall McLuhan, Robert K. Logan creates an intriguing synthesis of ideas about the effect of alphabets on the development of civilizations.

Robert K. Logan's *The Alphabet Effect* is a fascinating study of the evolution of writing systems. It describes the dramatic role the phonetic alphabet has played in the development of Western Civilization, in contrast with the role of pictographic writing systems in China and elsewhere. From the use of notched sticks or symbols first used in ancient times, to the alphabets in common use today, he draws a variety of conclusions about how societies advance. Logan also shows how the advent of mass communications and the use of computers affect how we communicate.

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"Any reader who suspects that language is what makes us human will appreciate this excellent overview of linguistic, educational, and communications theory."

—*Booklist*

"*The Alphabet Effect* is a good book for thinking and very likely the basis for some heated discussions."

—*Schenectady Gazette*

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To the memories of
Marshall McLuhan and my father, Nathan D. Logan,
the two best communicators I ever knew

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THE ALPHABET EFFECT

"The alphabet was the most significant of the boons conferred upon mankind by Phoenicia. It is generally considered the greatest invention ever made by man."¹

1

Alphabet, Mother of Invention

Introduction

We live in an age of rapid technological change in which we feel the underpinnings of our society and culture are constantly being uprooted. This might explain the present concern for "roots" that grips contemporary thought. This book is about "roots" too, those of Western civilization, which we shall trace back to our unique writing system, the phonetic alphabet. As we explore the history of ideas we shall discover that many of the seminal ideas in Western science, mathematics, jurisprudence, politics, economics, social organization, and religion are intrinsically linked with the phonetic alphabet. The magic of the phonetic alphabet is that it is more than a writing system; it is also a system for organizing information. Of all mankind's inventions,

with the possible exception of language itself, nothing has proved more useful or led to more innovations than the alphabet. It is one of the most valuable possessions in all of Western culture, yet we are blind to its effects and take its existence for granted. It has influenced the development of our thought patterns, our social institutions, and our very sense of ourselves. The alphabet, as we shall discover, has contributed to the development of codified law, monotheism, abstract science, deductive logic, and individualism, each a unique contribution of Western thought. Through the printing press it has reinforced or encouraged many of the key historical events of modern Europe including the Renaissance, the Reformation, the Industrial Revolution, and the rise of democracy, mass education, nationalism, and capitalism.

The alphabet is one of the first things that children learn once they are able to speak. It is the first thing that is taught in school because it is the gateway to learning and knowledge. The twenty-six letters of the English (or Roman) alphabet are the keys not only to reading and writing but also to a whole philosophy of organizing information. We use the letters of the alphabet to order the words in our dictionaries, the articles in our encyclopedias, and the books in our libraries. These systematic approaches to coordinating information based on the medium of the alphabet have suggested other forms of classification and codification that are part and parcel of Western science, law, engineering, and social organization.

Not only has the alphabet performed admirably as a tool for literacy, it has also served as a model for classification. It has played an instrumental role in the development of the logical style of analysis that is characteristic of the Western way of thinking. Learning how to read and write with the alphabet has brought us more than literacy and a model for classification. It has provided us with a conceptual framework for analysis and has restructured our perceptions of reality. All of these effects take place independent of what we read. The information that is

coded is not important; it is the act of coding itself that has been so influential and acted as a springboard for new ideas. Other writing systems exist, but none have provided such fertile ground for abstract ideas nor such an efficient tool for organizing information.

The Alphabet as Phonetic Code

The phonetic alphabet is a unique system of writing in which a small number of letters or visual signs (twenty-two to forty) are used to represent the basic sounds or phonemes of a spoken language. The letters are used to code the sounds of each word phonetically.

The very first alphabet was invented over 3,500 years ago in the Near East by the Canaanites, a Semitic people, and contained only twenty-two letters. It became the model for hundreds of other phonetic alphabets including English, French, Latin, Greek, Latvian, Russian, Arabic, Turkish, Persian, Sanskrit, Hebrew, and Swahili. Each of these phonetic alphabets is descended from the first Canaanite alphabet through a complicated process of borrowing and adaptation. The English alphabet is derived from the Roman alphabet, which in turn can be traced back through the Etruscan, Greek, and Phoenician alphabets.

The letters of today's European alphabets and their sound values correspond to those of that first Semitic alphabet with some additions. (See Chapter 2.) The original alphabet invented by the Canaanites contained only consonants. The Greeks, however, improved on the Semitic alphabet by adding vowels. They also added a small number of new consonants to represent special sounds in their spoken language. In fact, each of the cultures that adopted an alphabetic writing system invariably added new letters to represent the unique sounds of their spoken language.

The order of the letters of modern alphabets is more or less the same as that of the original one. Even the names and shapes of the letters are in many cases recognizable from their original

ancestors. For example, our letter *B* evolved from the Greek letter *beta*, β , which in turn derives from *bet*, $\beth$ (or $\square$), which in the original Canaanite meant "a house" and was drawn as a box. The English letter *B* still stands for the same "b" sound and the upper case form, *B*, still looks a bit like its original except now the house is not so square and it has two rooms. This letter, whether as *b* or *beta* or *bet*, has always been the second letter of the alphabet.

Not only have the order, name, and shape of the letters remained the same for thousands of years but so too has the sound value of the letters. The "b" sound, which is represented in English or French with *b*, in Greek by β , in Hebrew by $\beth$, and in Canaanite by $\square$, are not exactly identical; each has its own unique flavor, but they are easily recognizable from one speaking group to another. It is possible to render the approximate pronunciation of a foreign language we do not understand if it is written with the Roman alphabet. This is the power of the alphabet, namely, its ability to phonetically code the spoken word independent of the language being transcribed.

The Alphabet Effect

The alphabet is not the only form of writing. Because the alphabet seems to us such a natural way to write, we tend to believe that all writing systems are alphabetic. This is not true. There are two other widely used systems of writing. One is logographic (or pictographic) writing in which each spoken word is represented by its own unique visual sign, which denotes or depicts the word symbolically or pictorially. It is the oldest form of writing, dating back to 3100 B.C. in Sumer, and is still the basis for the present form of Chinese writing.

A third form of writing is the syllabic system, in which each individual syllable in the spoken language is phonetically coded with its own unique sign. Syllabaries lie somewhere between logographic and alphabetic writing systems. Alphabets code each

individual phoneme, while syllabaries code each individual syllable, and logographic systems depict an entire word with one sign. The phonetic alphabet is the most recent of the three writing systems. It is also the most economical, with the fewest number of signs, and hence is the most abstract. It is these properties of the alphabet that have influenced the development of Western culture and contributed to what we shall call the "alphabet effect."

Because the alphabet is so much a part of our information environment, however, we often take its existence for granted and we are blind to its effects, much as fish are unaware of the water in which they swim. The alphabet effect is a subliminal phenomenon. There is more to using the alphabet than just learning how to read and write. Using the alphabet, as we shall soon discover, also entails the ability to: 1) code and decode, 2) convert auditory signals or sounds into visual signs, 3) think deductively, 4) classify information, and 5) order words through the process of alphabetization. These are the hidden lessons of the alphabet that are not contained (or at least not contained to the same degree) in learning the Chinese writing system. These are also the features of the use of the phonetic alphabet that give rise to the alphabet effect.

The extra lessons of alphabetic literacy explain why schoolchildren in North America take just as long to learn to read and write as Chinese children despite the fact they have to learn only twenty-six letters compared with the one thousand basic characters required to read Chinese. In both China and North America children begin school at age five and have learned how to read and write, more or less, by the time they are eight years old. Western children take the same time because along with reading and writing they are learning many other things.² What they learn are the intellectual by-products of the alphabet, such as abstraction, analysis, rationality, and classification, which form the essence of the alphabet effect and the basis for Western abstract scientific and logical thinking. The use of the phonetic alphabet

helps to explain why Western and Chinese thinking are so different (abstract and theoretical for the West versus concrete and practical for the East).

Original Hypothesis

This study of the alphabet effect emerges from and is based upon a tradition (known as the Toronto School of Communications) established by Harold Innis^{3,4} and Marshall McLuhan^{5,6} at the University of Toronto beginning in the early fifties in which they explored the ways in which media of communication, including the alphabet, have shaped and influenced human culture and its various social institutions. In particular, they showed that the use of the phonetic alphabet and the coding it encouraged led the Greeks to deductive logic and abstract theoretical science. (See Chapter 6.)

My own interest in understanding the alphabet effect arose from my research with McLuhan and my earlier attempts to understand the origins of abstract science in the West. The earliest form of science as it was practiced in ancient China, Egypt, and Mesopotamia was strictly phenomenological and concerned with practical questions. It was based exclusively on observation and not on some theoretical foundation. Joseph Needham,^{7,8} the China scholar, nevertheless argued that the Chinese contributed to the development of abstract science in the West because of their many practical inventions and the transfer of technology from East to West. His assertion leads naturally to the question: Why did abstract theoretical science not begin in China itself but rather in the West?

In an attempt to answer this question I once suggested that monotheism and codified law, two features of Western culture absent in China, led to a notion of universal law, which influenced the development of abstract science in ancient Greece. When I first shared this hypothesis with McLuhan, he agreed with me but pointed out that I had failed to take into account

the phonetic alphabet, another feature of the West lacking in China, which had also contributed to the development of Western science. Realizing that our independent explanations complemented and reinforced each other, we combined them in a paper entitled "Alphabet, Mother of Invention"⁹ to develop the following hypothesis:

Western thought patterns are highly abstract, compared with Eastern. There developed in the West, and only in the West, a group of innovations that constitute the basis of Western thought. These include (in addition to the alphabet) codified law, monotheism, abstract theoretical science, formal logic, and individualism. All of these innovations, including the alphabet, arose within the very narrow geographic zone between the Tigris-Euphrates river system and the Aegean Sea, and within the very narrow time frame between 2000 B.C. and 500 B.C. We do not consider this to be an accident. While not suggesting a direct causal connection between the alphabet and the other innovations, we would claim, however, that the phonetic alphabet played a particularly dynamic role within this constellation of events and provided the ground or framework for the mutual development of these innovations.

The effects of the alphabet and the abstract, logical, systematic thought that it encouraged explain why science began in the West and not the East, despite the much greater technological sophistication of the Chinese . . . the inventors of metallurgy, irrigation systems, animal harnesses, paper, ink, printing, movable type, gunpowder, rockets, porcelain, and silk. Credit must also be given to monotheism and codified law for the role they played in developing the notion of universal law, an essential building-block of science. Almost all of the early scientists . . . Thales, Anaximenes, Anaximander, Anaxagoras and Heraclitus . . . were both law-makers in their

community and monotheistically inclined. They each believed that a unifying principle ruled the universe.

Phonetic writing was essential to the intellectual development in the West. No such development occurred in the East.

The remainder of this book will be devoted to articulating this hypothesis, which McLuhan and I formulated in our original article. The hypothesis, however, will be extended to include the influence of the alphabet on the development of Western civilization after its first flowering in ancient Greece. To do this we will review the history of Western ideas from the invention of writing in Sumer 5,000 years ago to the most recent applications of computer technology. We will trace the role that the phonetic alphabet has played directly and indirectly (through science, logic, codified law, and monotheism) in the development of Western civilization. First we will review the history of writing and learn how the alphabet was first invented. We will then compare European and Chinese culture, showing how the differences in the two writing systems account for the many contrasts in these two civilizations. After this we will examine the historic accomplishments of various societies, studying the way in which the alphabet influenced the development of their thought and cultural patterns. Beginning with Mesopotamia we will examine in turn the following cultures: Hebrew, Greek, Roman, Arab, Medieval, Renaissance, Industrial, and Post-Industrial. We will show how each of these cultures was influenced by the alphabet effect and in turn developed its own unique application of alphabetic literacy.

A central theme in this study is the notion that a medium of communication is not merely a passive conduit for the transmission of information but rather an active force in creating new social patterns and new perceptual realities. A person who is literate has a different world view than one who receives informa-

tion exclusively through oral communication. The alphabet, independent of the spoken languages it transcribes or the information it makes available, has its own intrinsic impacts. These effects have changed the nature of Western civilization so that it differs both from nonliterate cultures and from those societies whose system of writing is nonphonetic, such as the Chinese.

Because the effects of media are so important, one cannot understand historical processes and cultural development solely in terms of what information has been communicated. One must also understand the way in which that information was mediated. In other words, one must also examine the effects of media themselves independent of the messages they transmit. Marshall McLuhan expressed this idea with his famous adage "the medium is the message." This one-liner can be taken literally to mean that the contents of the medium can be ignored or discounted. This is not what is intended. A balance will be achieved in which both the contents of a message and the way in which it is delivered will be studied. It is only by studying both the medium as a "message" and the messages that the medium transmits that a full appreciation of cultural and historical processes can emerge.

The Invention of the Mother of Invention

In order to study the origin of the alphabet by the Canaanites, we must first examine how writing was invented by the Sumerians some 1,500 years earlier. The story actually stretches back to the first forms of human notation, which were not writing but rather notches etched on animal bones to record quantitative data. This practice has been dated back to 30,000 B.C. in Western Europe. Other forms of tallying were also developed, including notched sticks, knotted strings, and counting pebbles (or shells or other markers). All of these notational devices recorded the number of items but provided no qualitative information about the item itself.

Accounting tokens that recorded both the number of items and their nature represented the next stage in the development of notational technology. Denise Schmandt-Besserat discovered

that the baked-clay artifacts found in a large percentage of the archaeological sites of the Middle East dating from 8000 to 3000 B.C. were used for accounting purposes.^{2,3,4,5,6,7} Her cataloging of the clay tokens has shown that these tiny artifacts two to three centimeters in size were used for the enumeration and accounting of specific commercial agricultural products such as grains, livestock, land, and labor.^{2,4}

Each quantity of a commodity was designated by its own unique, specially shaped token. The system, which began with twenty-four tokens sometime around 8000 B.C., grew to more than two hundred different types by 3300 B.C.⁴ The shapes included spheres, discs, cylinders, cones, biconoids, ovoids, triangles, and tetrahedrons and were further differentiated with markings, incisions, and punched holes. Tokens have been found that designate the following commercial products and commodities:

1. A ban (6 liters) or a bariga (36 liters) of grain, of which there were three varieties: barley, wheat and emmer
2. Jars of oil
3. Containers of foodstuffs such as butter, berries, or dates
4. Livestock, primarily sheep and goats, differentiated by age, sex, and breed in units of one, ten, and one hundred head
5. Wool, cloth, and different types of garments
6. Measures of land expressed in terms of the amount of seed required to sow it
7. Service or labor expressed in the time units of days, weeks, and months

The use of such tokens for accounting purposes in the commercial and administrative transactions of ancient Middle Eastern society began in 8000 B.C. at the very beginning of agricultural food production, long before the existence of any form of writing or counting with abstract numbers.

Because the tokens were three-dimensional miniaturized ana-

logical models of the physical objects they designate, they were man's first full literary metaphors. They functioned as metaphors in that they translated information in an abstract form into a new medium. Tokens designated economic quantities that required accounting, translating them into a form that could be grasped in the hand and manipulated. This facilitated the numerical calculations performed through using them. The tokens not only permitted new mathematical operations, they vastly improved record-keeping techniques because they denoted both the quantity and the quality of the objects they enumerated. They functioned as "an extrasomatic brain which was not liable to human memory failure"⁷ and hence represented an important breakthrough in human notation long before the advent of writing.

In order to form a permanent record, tokens had to be maintained together in a container such as a bowl, a pouch, or a basket or be strung together.² The lack of a permanent and secure container was probably the motivation for the invention of the clay envelope that sealed the tokens inside to form a permanent record of a particular tally or enumeration. This innocent technical improvement in the token system of accounting, inaugurated in 3300 B.C. in Sumer, was destined to lead within two hundred years to two major breakthroughs in information-processing techniques, namely, writing and abstract numerals.

The clay envelopes or *bullae* were more or less of a spherical or egglike shape with a diameter of five to seven centimeters.² The outer surfaces of the first envelopes were marked with cylinder seals to indicate the person for whom the accounting was being made. Because the clay was opaque, the contents of a sealed envelope could not be seen, which limited the usefulness of the *bullae*. To get around this shortcoming, a practice soon evolved of indicating on the outer surface of the envelope the tokens held within. At first an identical set of tokens were physically embedded in the outer wall of the envelope. This process was simplified later by merely imprinting or impressing the mark of

the tokens on the outer surface of the clay envelope while it was still moist and hence impressionable.²

It was not very long before the Sumerian administrator realized that there was no need to place the actual tokens inside the envelope, initiating² what appear to be the first written records on clay tablets. They were actually imprinted or impressed envelopes without tokens inside, which explains why they more closely resembled the spherical shapes of envelopes than the flat tablets that appeared later. These earliest inscribed tablets were not actually the first records of the written word as we regard it today but rather the last form that the token system took before its replacement with writing. At this stage there were approximately two hundred symbols⁸—all restricted, however, to the economic commodities and limited range of vocabulary mentioned earlier. These tablets, therefore, could not possibly have provided a notation for the spoken language; they were merely a mathematical notation for "concrete numbers" (numbers associated with the items being enumerated as opposed to undifferentiated "abstract numbers"). Writing, however, was just around the corner, awaiting the creation of incised signs to replace the impressed ones.

Schmandt-Besserat has shown that numerals representing abstract numbers, as well as writing, emerged from a common progenitor, namely, the clay accounting tokens.⁸ The breakthrough leading to incised signs seems to have been the use of the token impressions for a ban (small measure) and a *bariga* (large measure) of wheat to represent the abstract numbers one and ten, respectively. To represent ten jars of oil using the "bariga of wheat" and "jar of oil" signs would not have worked if both signs were impressed since the combination would have been read as "one bariga of wheat plus one jar of oil." To distinguish between "10 jars of oil" and "1 bariga of wheat plus 1 jar of oil," the sign for the commodity, the jar of oil, was incised. Once incised signs were created and liberated from the accounting tokens, true writing was able to develop and flourish.

The Beginning of True Writing

It is the transition from the impressed tablets with a vocabulary of two hundred token signs to the incised tablets with a proliferation of pictographic signs, created with the use of a stylus, that marks the advent of writing, mankind's greatest breakthrough in data processing. The new incised signs were used to communicate new forms of information. For the first time in the history of humankind the full spoken language could now be rendered in terms of written visual signs. Each of the visual signs in this new written language became a metaphor, a pictographic symbol of the word they represented. Although phonetic elements can be found in Sumerian writing right from the start, their use was restricted at first to rendering proper names for which no pictograms existed.

The first culture to make use of pictographs was that of the Sumerians. The Egyptian culture was the second to develop such a system.^{9, 10, 11, 12} It emerged shortly after that of the Sumerians. Three other cultures developed independent pictographic writing: the Chinese, the Harappa or Mohenjo-Daro culture of the Indus valley, and the precolumbian Mesoamerican Indian culture. All other writing systems of the world, including the phonetic alphabet, have been derived either directly or indirectly from contact with one of these five through borrowing and modification. The Mesoamerican writing system, only four hundred years old at the time the conquistadors arrived in the sixteenth century, never evolved beyond its original pictographic stage. The Harappa-Mohenjo-Daro system, still undeciphered, had apparently evolved into a mixed system of pictograms and syllabic signs before its demise. Like the Mesoamerican, it represents a dead end. The writing systems of modern India do not derive from the Harappa culture but rather from the Aramaic alphabet, a direct descendant of the original Canaanite Semitic alphabet that evolved under the influence of the Egyptian writing system. The Chinese writing system, basically unchanged

from its original form, is still purely pictographic. A number of the Oriental systems derived from Chinese (such as Japanese) use a mixture of Chinese characters and syllabic signs.

The Egyptian writing system underwent the most dramatic changes, evolving first syllabic elements and then twenty-four uniconsonantal signs that functioned as an alphabet for rendering proper names only. This system of uniconsonantal signs served as a model for the Canaanite alphabet, which eventually led to the totally phonetic Greek alphabet from which all European alphabets are derived. Although Sumerian and Egyptian writing represent two independent systems, it is possible that as a result of commercial and diplomatic contacts, the idea of writing was transferred from the Sumerians to the Egyptians. Similar arguments have been made to suggest that the Chinese also borrowed the idea of writing but developed their own unique system.

Mesopotamian Writing Systems

The Sumerian writing system was originally a primarily ideographic or pictographic system in which each and every word was represented by its own unique pictogram incised upon a clay tablet. The Sumerians soon developed the cuneiform writing system in which the pictograms became abstracted and were made by impressing wet clay with wedge-shaped reeds. The word *cuneiform* is derived from the Latin *cuneus*, meaning "wedge." Because of the fast-drying nature of the clay, the original pictograms became highly stylized to speed up the process of writing. After the clay was impressed, the tablets were baked to form permanent records, which have survived to this day.

As the Sumerian writing system evolved, the pictograms were used phonetically as well as pictographically. The Sumerian words for *arrow* and *life* are both pronounced "ti." As an example, let us consider the following pictograph for the word *arrow*, ↑. This pictograph can also be used phonetically by adding a de-

terminative sign, ' so that the sign ↑ no longer indicates *arrow* but rather the word that sounds like *arrow* ("ti"), namely *life*. This device was extended to polysyllabic words as well. Let "4" and "C" be pictograms for the English words *four* and *sea*. Let's use the determinative sign, ' to indicate that the pictograms should be treated as phonograms. The symbols "4C", which would be read as *four seas*, becomes "4'C" and is read as the polysyllabic word *foresee*. It was in this way that the Sumerians created their phonetic syllabary. They used over six hundred signs, phonographically, to represent the syllables of their spoken language. This new technique represented a new and higher level of abstraction because now smaller phonetic units, namely syllables, were being recognized and manipulated independently.

The Sumerians were conquered by the Semitic-speaking Akkadians who eventually founded the Babylonian empire. The Semitic language of the Akkadians was completely different from the non-Semitic language of the Sumerians, and hence, when the Akkadians took over the Sumerian writing system, they converted it to their language's needs. An ideogram for a given Sumerian word was no longer pronounced as it would have been in Sumerian. Instead, the pronunciation of the equivalent Akkadian word was read. The cuneiform symbol for the Sumerian word *ka* meaning "mouth," for example, was read as the Akkadian word *pum*, also meaning "mouth." The symbol, however, could also be used phonographically, with the proper determination, as an element of the phonetic syllabary, in which case it retained its original Sumerian sound value and was pronounced "ka" and not the Akkadian "pum." The Akkadians, because of the two languages, were forced to use the syllabic signs in a more abstract manner than did the Sumerians. Not long after adopting the Sumerian system, the Akkadian-Babylonians reduced the number of syllabic signs to sixty and used these signs phonetically. They still retained the use of their ideographic or pictographic signs, however, and hence made use of a mixed system of signs.

The Akkadian-Babylonian syllabic system had some of the features of our alphabetic system but lacked its uniqueness. The syllabic sign consisted of a consonant and a vowel in which either one might precede the other. Let us illustrate how the system worked by representing the word *level*, using a syllabary containing the syllabic elements *le*, *el*, *ve*, and *ev*. The word *level* could be rendered *le-ve-el*, or *le-ev-el*, and hence does not have a unique spelling as it does when it is rendered alphabetically in terms of the three letters *l*, *e*, and *v*.

Egyptian Writing

Egyptian writing was first carved on stone. In fact, its name, *hieroglyphics*, is derived from Greek and means "sacred carvings." The Egyptians later began to write on papyrus with brush and ink. At first purely ideographic like the Sumerian system, it later developed a syllabary, although the Egyptians were far more conservative than the Sumerians and Akkadians and hence used their syllabary to a lesser extent. In addition to these elements the Egyptians also introduced twenty-four or twenty-five uniconsonantal signs that spanned the sounds of their language and hence could have served as an alphabet. The consonants, however, were used only to render foreign proper names. Perhaps the Egyptians did not want to simplify their writing system, since a complex system allowed the priestly class to maintain its monopoly on reading and learning. The idea of using a small number of consonants as an alphabet was not lost to civilization, however, but was borrowed by the Seirites, a Semitic tribe living in the Sinai, who were the first people to write in a totally alphabetic manner.

The Advent of the Alphabet

Alphabetic writing first surfaced in the Sinai and Canaan in the first half of the second millennium B.C. This alphabet, known as

Proto-Sinaitic script, was first discovered¹³ in 1905 at the Serabit el Khadem temple in the Sinai. Other inscriptions have been found in or near copper mines in the Sinai and are thought to be left by the Seirites, who worked the copper mines for the Egyptians. Referred to in the Bible as the Kenites or the Midianites, these are the people with whom Moses sojourned in the desert of Sinai when he was forced into exile from Egypt. It has been conjectured^{14,15} that the Seirites borrowed the idea of alphabetic writing from the Egyptians. Because of the complexity of the Egyptian writing system, the uneducated Seirites chose to borrow the simplest aspect of the Egyptian system, namely, that involving the uniconsonantal signs.

In both systems, the signs operate according to a phonetic acrostic principle whereby each sign represents an object and the sound value of the sign is the same as the first consonant of the name of the object depicted. Words are spelled out phonetically using the names acrostically. For example *cat* would be spelled by picturing a can, an apple, and a table in sequence. Some of the signs in the Egyptian and Seirite systems were similar. The twenty-two Seirite signs, however, had their own Semitic names and sound values. As with the Egyptian uniconsonantal signs, the Proto-Sinaitic alphabet consisted solely of consonants. The vowels and vocalization of speech were not indicated and had to be filled in by the reader.

The first two letters of the Semitic alphabet are *aleph* and *bet*, the Semitic words for "oxhead" and "house." These letters were originally denoted by Θ and $\square$, which visually represented, in an abstract manner, an oxhead and a house respectively. These two letters gave rise to the first two letters of the Greek alphabet, *alpha* and *beta*, from which the term *alphabet* is derived.

The invention of the alphabet by the Seirites has been challenged by more recent finds of alphabetic inscriptions in Palestine, namely at Shechem, Gezer, and Lachish.¹⁶ These inscriptions seem to belong to the sixteenth and seventeenth centuries B.C., which makes them one hundred to two hundred years older than the Sinai inscriptions, which are dated to circa 1500 B.C. The

number of signs found in these three early sites in Palestine is quite limited, a total of fifteen signs altogether, representing even fewer letters. That these signs are earlier forms of the Sinai inscriptions is evident from the extreme pictorial way in which they are drawn. The Sinai inscriptions have already developed some form of abstraction. To conclude on the basis of this scant evidence that the writing system began in Palestine rather than Sinai is probably premature. It is possible that still earlier forms of the alphabet will surface. Nevertheless, this extant evidence led the renowned epigraphist Joseph Naveh¹⁷ to the conclusion that "although the Proto-Sinaitic inscriptions form a relatively large group, they are an integral part of the corpus of the early alphabetic inscriptions called Proto-Canaanitic." We shall conform to Naveh's convention and refer to both the Canaanite and Sinaitic scripts as the Proto-Canaanite, leaving open the formal question of their origin.

This thesis does not necessarily rule out the connection between the Canaanite alphabet and Egyptian writing suggested earlier. The Canaanites were also in close contact with the Egyptians, as indicated by the Amarna letters of the fourteenth century B.C. in which the rulers of Canaan corresponded with the pharaohs of Egypt, namely Amenhotep and Akhenaton. In fact Naveh¹⁸ acknowledges this possibility: "The Proto-Canaanite script . . . was invented circa 1700 B.C. by Canaanites who had some knowledge of Egyptian writing."

A third set of early alphabetic inscriptions, found in 1928 at Ras Shamra on the Mediterranean coast of North Syria, helped in the decipherment of the Proto-Canaanite scripts. This was the Ugaritic cuneiform alphabet, dated to the fourteenth or thirteenth century B.C.¹⁹ This system differs markedly from the earlier alphabets in two major ways: It contains thirty uniconsonantal letters rather than twenty-two, and it is written in clay, using the cuneiform technique of Akkadian-Babylonian writing. The cuneiform alphabet never evolved beyond its form at Ras Shamra. Its major historical interest is the help it rendered in deciphering earlier texts.

The Spread of the Alphabet

The alphabet proved to be such an efficient system for transcribing a spoken language that it spread from one culture to another, where it was modified each time to suit the different sounds of the local language. New letters were sometimes added to represent a new sound or an old letter was modified to represent a variation of an old sound. The Proto-Canaanite alphabet evolved into the Phoenician and Proto-Arabic alphabets, which in turn led to still other descendants, the grandchildren and great grandchildren of this original alphabet. The Proto-Arabic alphabet, which broke away from the Proto-Canaanite alphabet about 1300 B.C., added additional consonantal signs and evolved into the early scripts of the Arabian peninsula and Ethiopia.

The Phoenician alphabet, on the other hand, gave rise directly to two other West Semitic alphabets: the early Hebrew alphabet and the Aramaic alphabet. Hebrew and Aramaic are languages closely related to Phoenician. At first Hebrew and Aramaic were written with the Phoenician alphabet, even though this created an artificial circumstance for Aramaic because of the richness of its sounds. The Hebrew and Aramaic scripts soon developed their own national character, beginning in 850 B.C. for Hebrew and 750 B.C. for Aramaic. Despite the fact that these languages had a richer range of sounds, they both stuck with the original twenty-two letters of the Phoenician alphabet.

The Aramaic script gave rise to many more alphabets. Aramaic became the official language and script of the Neo-Assyrian Empire and later the Persian Empire (before the Arabic script developed). As a result of this, the Aramaic alphabet spread to Central Asia and the Indian subcontinent. After the fall of the Persian Empire, the peoples of these regions developed their own alphabetic writing systems based on the Aramaic alphabet but applied to Indoeuropean languages. Thus the alphabets of India, Afghanistan, and Turkestan are derived from Aramaic.

The Aramaic script also gave rise to a number of others in the Middle East. These include the Palmyrene script extant from 44

B.C. to A.D. 272 and used in Manichean texts, the Syriac script extant from A.D. 200 to the present, which serves as the sacred script of the "Assyrian" Christian Church, and the Nabatean script extant from 150 B.C. to the sixth century A.D., which led directly to classical Arabic. The Arabic script in turn gave rise to the contemporary Persian script. The alphabetic order of Arabic deviates from the original Canaanite order, probably because new letters had to be introduced to represent the richer sound system of Arabic, and the letters were regrouped according to similarities of sounds.¹²

The Phoenician alphabet was transformed by the Greeks and used to render their Indoeuropean tongue. The Greek alphabet then evolved to become the basis of all the other European alphabets. The Phoenician alphabet itself was unable to survive the ravages of time. Its use spread to Phoenicia's western colonies, principally to Carthage where it was known as Punic. After the destruction of Carthage in 146 B.C. the script survived in certain northwest African areas in a form known as Neo-Punic and then suddenly disappears somewhere in the early third century A.D.

The Proto-Canaanite alphabet began as phonetic pictograms, used to spell out words acrostically. The reason they must be identified as pictograms despite the fact they are used phonetically and acrostically is that they take their sound value and name from the object they depict. For example *aleph* is an ox head, *bet* a house, and *ayin* an eye.

In the first stages of the alphabet the letters retained their pictorial character, and their position or orientation was not fixed nor was the direction in which they were written. Sometimes the order was horizontal (right to left or left to right), sometimes vertical (up or down) or even boustrophedon. Boustrophedon, from the Greek word signifying "turning like oxen in plowing," is a style in which the script goes horizontally in one direction and then reverses direction in the next line like an ox plowing a field. The Proto-Arabic script was also pictographic and had no set direction of writing. "Horizontal boustrophidal writing

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was very common in the Old South Arabic monumental scripts. . . . Given the lengths of South Arabic monumental inscriptions which covered huge walls, the use of boustrophedon was virtually inevitable; the reader had to walk several yards in order to read a line, but he could read the next line when he retraced his steps and thus he could continue walking and reading."²⁰ As the proto-alphabetic scripts were used more and more, they became more cursive and abstract and less pictographic.²¹ "The twenty-two letters of the later Proto-Canaanite dropped all pictographic features. From the mid-eleventh century onward, we deal with stabilized, linear letters written in right-to-left, horizontal lines—this is the Phoenician script; its less developed ancestor is termed Proto-Canaanite."²² The fixing of the direction of Phoenician from right to left resulted in this direction for all those alphabetic scripts directly descended from it, including Hebrew (both ancient and modern), Arabic, which descended from Nabatean, and Aramaic.

The Ethiopic script, which descended from the South Arabic scripts, which in turn descended from Proto-Canaanite, does not read from right to left but left to right. Greek, which also reads from left to right, is therefore probably descended from Proto-Canaanite rather than Phoenician. The alphabetic order of the letters became fixed for the first time with the Ugaritic script of the fourteenth to thirteenth century. With rare exception all alphabetic scripts follow the same order, indicating their common origin.

The Introduction of Vowels in Alphabetic Writing

The first proto-alphabetic scripts, such as the Egyptian hieroglyphic script, had no provisions for vowels or vocalization. Reading a script correctly was a matter of good guesswork guided by context. The Phoenician alphabet never evolved any provision for vocalization nor was a separation between words

indicated. Both Hebrew and Aramaic made a separation between words and added vowels where necessary. This was achieved through *mater lectionis* which in Latin means "mother of reading," whereby the aspirant consonants are used to render vowels, at first at the ends of words, but later also in medial positions.²³

The lack of vowels or vocalization, while a shortcoming of Semitic alphabets, is not as serious a problem for a Semitic language as it is for an Indo-European language, because the roots of Semitic words are given by their consonants, usually three in number. The internal vowels are used to indicate "details, such as the parts of speech, the voice, the mood, the tense."²⁴ The English words *sang*, *sing*, *song*, and *sung* illustrate this use of internal vowels. The ambiguity caused by the lack of vowels is resolved either through context or, in the case of Aramaic or Hebrew, through *mater lectionis*, as indicated above. The Hebrew name "David," if rendered only in terms of its consonants, would be spelled *DWYD*. In order to indicate the "i" sound in "David," the letter *yod*, ך is used so that "David" is rendered as *DWYD*.²⁵

The Greeks developed their totally phonetic alphabet by modifying the Semitic alphabet they borrowed from the Phoenicians. Legend credits Cadmus with having made this gift to the Greeks. His name is thought to be derived from the Semitic word *kedem*, meaning "east." The Greeks borrowed the names, values, order, and shapes of the Phoenician alphabet. They modified it, however, by converting the five unstressed aspirant consonants: *aleph*, *bet*, *yod*, *ayin*, and *waw* into the vowels *a*, *e*, *i*, *o*, and *u* respectively. (See Table I.) In addition to these five vowels, the Greeks added two more completely independent vowels, *eta*, *η*, and *omega*, *ω*. The Greeks also added three new consonants, *theta*, *θ*, *phi*, *φ*, and *psi*, *ψ*, to represent sounds that occur in Greek but not in any of the Semitic tongues.

The explicit introduction of vowels into the Greek alphabet is another example of necessity serving as the mother of invention.

TABLE I: VOWELS

ENGLISH	HEBREW	GREEK
A	א aleph	α alpha
E	ה hey	η eta
I	י yod	ι iota
O	ו vav	ω omega
U	י ayin	ο omicron

It is almost impossible to render an Indo-European language like Greek unambiguously without vowels. Consider the difficulty we would have in English distinguishing between *bat*, *bait*, *bet*, *beat*, *bought*, *beet*, *bit*, *bite*, *boat*, *boot*, *but*, and *beauty* without vowels, or rendering words like *idea*, *eye*, or *iodine*.

By introducing vowels explicitly, the Greeks created the most accurate and unambiguous phonetic writing system ever known to man. The phonetic alphabet permits a one-to-one correspondence between the spoken and written language. "The original Greek invention achieved the essential task of analysis and it has not been improved upon."²⁶ The English alphabet, by rendering the forty phonemes (twenty consonants and twenty vowels) of the spoken language with only twenty-six elements, creates a host of ambiguities and hence represents a retrogression from the original Greek phonetic alphabet.

There are some scholars such as I. Gelb¹⁰ who claim that because of the lack of vowels, the Semitic alphabet is not truly an alphabet like the Greek and Roman scripts but a syllabary in which each consonant represents the syllable consisting of that consonant and a nonindicated vowel. While there is some validity to this statement, one cannot deny that the Semitic alphabet represents a major breakthrough in the development of phonetic writing. The Semitic alphabet provided the vital link between Egyptian syllabic writing and the totally phonetic Greek alphabet, which contains both vowels and consonants explicitly.

Naveh points out, "Only in Greek and in its offshoots does each letter stand for either a consonant or a vowel."²⁷ While admitting that "the Greek system is more evolved than the Semitic one," Naveh cannot accept Gelb's position. An alphabet is a system of writing with a limited number of signs (twenty to thirty) that have a fixed order, which, as Naveh reminds us, is basically the same for Greek, Latin, and Phoenician.

Dating the Transfer of the Phonetic Alphabet from the Phoenicians to the Greeks

Naveh^{28,29} provides an even greater challenge to the scholars of Greek culture with his dating of the transfer of the Phoenician alphabet to the Greeks, based on his studies of Semitic epigraphy. Naveh contends that the transfer occurs as early as 1100 B.C., whereas earlier scholars had placed this event some three to four hundred years later.

Based on the Cadmus myth, the similarity of early Greek letters and Phoenician letters, the identical order of the two alphabets, the similarity of the names *alpha* and *aleph* (or *beta* and *bet*), and the similarity of sound values of these corresponding letters, scholars are in unanimous agreement about the Phoenician origin of the Greek alphabet. Only the date is a source of disagreement. The earliest known Greek inscriptions are placed in the eighth century B.C., which is the date many scholars believed that the transfer of the Phoenician alphabet took place. Rhys Carpenter³⁰ in 1933 was the first to set this date. His technique was simple. Obviously the Greek alphabet must have branched off from the Semitic at the point where the chronologically contemporary resemblances are strongest. He chose the period between 732 and 710 B.C.; however, his idea of a borrowing at one fixed point in time is probably too simple.

Naveh accepts the fact that the absence of evidence of a Greek alphabet before the eighth century B.C. argues strongly for its inception at this time. However, he points out a number of cases in Semitic epigraphy where no examples of known scripts have

been uncovered for periods varying from one hundred to two hundred years. To support his argument, he points out that the earliest Greek alphabetic inscriptions were written in both horizontal directions and also in boustrophedon. In fact, the term *boustrophedon* is a Greek term coined to describe early alphabetic writing. He also points out that by the eighth century B.C., the time of the purported transfer, all the Semitic scripts with which the Greeks could have had possible contact had settled into a right to left horizontal pattern.

He considers it highly unlikely that the Greek alphabetic script first began right to left, then evolved into boustrophedon, and then eventually reversed directions. There is no known case where an alphabetic script was transferred from one culture to another and reversed directions. Ethiopic, which is written from left to right like Greek, was derived from Proto-Arabic, which split off from Proto-Canaanite when both were written in either direction. Phoenician eventually evolved a right to left script and Ethiopic a left to right script. This, claims Naveh, is the likely pattern with Greek also. He contends that the transfer from Phoenician to Greek occurred when the Phoenician script was still in its Proto-Canaanite form and hence not yet settled in any direction. Greek and Phoenician then evolved into horizontal scripts written in opposite directions. Naveh places this transfer at about 1050 B.C.

He provides additional evidence for this dating by comparing letters and showing that the Archaic Greek letters resemble the Proto-Canaanite letters of 1050 B.C. more than the Phoenician letters of the eighth century B.C. "The Greek letters are considerably less cursive than the eighth- or even ninth-century Phoenician letters."³¹ He also points out that the Archaic Greek scripts show an enormous amount of local variation while the eighth century B.C. Phoenician script had already evolved into a single national form. This local variation, which persists until the fourth century B.C., when Ionian becomes the uniformly adopted Classical Greek script, argues for an earlier adoption than the eighth century B.C.

There is ample evidence of contacts between the Greeks and the Canaanites as early as 1050 B.C. These include two eleventh-century Canaanite inscriptions found at Nora in Sardinia and Teke near Knossos in Crete, plus evidence of a Greek settlement at Tell Sahas in Phoenicia as early as the late ninth century B.C. In the wake of recent inscriptions found at Qubur el-Walaydah and Izbet Sarta, F. M. Cross has concluded, "These new data must be said to give added support to the thesis of Joseph Naveh for this high antiquity of the earliest use by the Greeks of the alphabet, and remove obstacles to dating their borrowing to the time of the transition from Old Canaanite to Linear Phoenician toward 1100 B.C.E."³² We have traced the history of the development of alphabetic writing in the West from its roots in the Proto-Canaanite alphabet of twenty-two uniconsonantal signs to the totally phonetic Greek alphabet complete with vowels. Before turning to the study of the effects of this writing system on the West in comparison with the East we should pause to reflect on those factors that might have hindered the development of alphabetic writing in the East.

Why the Chinese Never Developed an Alphabet

Chinese writing has evolved so little from its pictographic origins that contemporary Chinese are able to read texts 3,500 years old. The Chinese writing system did not develop the phonetic aspects of Western alphabetic writing. The explanation lies partially in the conservative nature of Chinese culture and partially in the nature of their spoken language. All Chinese words are monosyllabic. There are no prefixes, no suffixes, only single-syllable words. This severely limits the number of possible sound combinations for forming words. Tone and redundancy are employed in order to accommodate the rich vocabulary of Chinese. Compound words are created by combining simple single-syllable words the way *bouseboy* or *ice cream* is formed in English. The use of tone or pitch also increases the number of possible word combinations. The four tones of Mandarin and five of Cantonese

increase the number of basic sounds to 1,380 and 1,868 respectively. It is only through redundancy, however, that these limited number of sounds are able to accommodate the large Chinese vocabulary. Virtually every Chinese word is a homonym with an average of ten different words for each sound. There are 2,365 different Mandarin words, each with its own unique pictogram or character, that are all pronounced *shih*. Part of the redundancy is resolved by tone and context, and part by using two words with similar meaning side by side, like the English expression of native Chinese speakers—"look see"—which is a literal translation from the Chinese.

Because of the tremendous phonetic redundancy of their words, there was little or no motivation until the advent of computers for the Chinese to develop a phonetic writing system, let alone an alphabetic one. In fact, there are good reasons to retain their pictograms. Chinese characters, with their unique representation of each word, reduce the redundancy of the spoken language, making it easier to read. Redundant combinations like *look-see* are no longer needed, since the character for *look* or *see* cannot be mistaken for its homonyms. The other advantage of the pictographic nature of Chinese writing is that it enables "those who speak mutually unintelligible idioms to converse together, using the pencil instead of the tongue."³³ This property of Chinese writing has helped Beijing exercise hegemony for many centuries over the vast geographical zone that comprises China.

The Runic Alphabet

Before bringing this discussion to a close we should briefly mention the runic alphabets that were used in Northern Europe from about the third to the sixteenth centuries A.D. Their exact origins are somewhat mysterious, but it is clear that they were derived from one or more of the Italo-Greco alphabets of the Mediterranean region such as the Greek, Latin, or Etruscan. One theory maintains that runes were an invention of the Goths,

who borrowed many of their letters from the Etruscans. Another proposal is that runes arose from the contact of the Goths with a Greek colony on the shores of the Crimean Sea.

Runes, as the etymology of the name implies, was a secret writing system used for religious and mystical purposes. The runic alphabet was suppressed by the Church for this reason. Runes were used primarily for making inscriptions on stones or coins and jewelry although some manuscripts have been found.

A number of varieties of runes evolved in the course of their history of which the three main branches were Anglo-Saxon, Scandinavian, and Germanic. The number of letters were approximately the same as in the Roman-based European alphabets. What distinguished the alphabet was the order of the letters, which was markedly different from the original Canaanite alphabet, and the fact that the script was written from right to left.

things and went beyond the world of concrete experience into the world of conceptual relations created within an enlarged time and space universe. The time world was extended beyond the range of remembered things and the space world beyond the range of known places. Writing enormously enhanced a capacity for abstract thinking which had been evident in the growth of language in the oral tradition. Names in themselves were abstractions. Man's activities and powers were roughly extended in proportion to the increased use and perfection of written records.⁴

If writing has had the impact that Innis suggests, then the particular form a writing system assumes should play a crucial role in shaping the thoughts of its users. Not only should one expect a major difference in the thought patterns of literate and preliterate people, but one should also expect comparable differences in the thought patterns of societies whose writing systems differ significantly, as has been pointed out by Innis,^{2,3} McLuhan,^{5,6} and Foucault.⁷ Differences in modes of communication according to our hypotheses will result in differences in thought patterns and social forms. Chinese and Western alphabetic literacy represent two extremes of writing. The alphabet is used phonetically to visually represent the sound of a word. Chinese characters are used pictographically to represent the idea of a word and hence are less abstract than alphabetic writing. Eastern and Western thought patterns are as polarized as their respective writing systems.

We will attempt to show in this chapter that the absence of Western-style abstractions and classification schemes in Chinese culture is related to the differences in writing systems. This is not to suggest that Chinese culture is inferior; quite the opposite is true. Chinese culture has created its own triumphs in arts, technology, philosophy, and religious thought, which have not been rivaled by any other culture.

Despite its sophisticated developments in the arts and science,

3

A Comparison of Eastern and Western Writing Systems and Their Impact on Cultural Patterns

East Versus West

There is widespread agreement among scholars that spoken language has had the single greatest influence of all factors on man's thought processes and is responsible for its very origin. Second only to the impact of speech on thought has been writing.¹

Harold Innis^{2,3} was one of the first scholars to study the way in which writing affected man's thinking patterns.

The art of writing provided man with a transpersonal memory. Men were given an artificially extended and verifiable memory of objects and events not present to sight or recollection. Individuals applied their minds to symbols rather than

Chinese thinking is considerably more concrete and less abstract than Western thought. Chinese logic is based on analogy and induction rather than matching and deduction. Chinese mathematics is more algebraic than geometric. Chinese technological inventiveness is unparalleled by that of any culture, yet China never exploited its technology in a systematic manner as was done in the West during the Industrial Revolution. The Chinese created an elaborate legal system but not a codified one. They developed their own unique way of dealing with space and time, but one that is not Cartesian. And they were deeply spiritual and mystical thinkers, yet they were not monotheists.

It is my thesis that these differences are in part due to the differences in writing systems: ideographic writing versus alphabetic (or phonetic) writing. Table II lists characteristics of these two worlds. Although this table is simplistic, it is useful because it allows us to see the overall patterns of Eastern and Western thought at a glance.

The characteristics listed in each column are not necessarily the exclusive property of that culture but rather represent the directions in which that culture has evolved. There are aspects of Western culture that are traditional rather than progressive or more inductive than deductive. By the same token, the East has at times been rational or abstract rather than intuitive or concrete. As we explore Chinese law, science, technology, logic, and philosophy, however, we shall see how the characteristics of the first column predominate over those of the second column. Later in this study we shall see that with the coming of electricity, the characteristics of the two cultures begin to merge.

Chinese Law

The role of law and attitudes toward it are quite different in Eastern and Western civilizations. Law in the West, for example, tends to take on a much greater importance than it does in the East.⁸ Another major difference is that Western law is codified

TABLE II:
COMPARISON OF EASTERN AND WESTERN
CULTURAL PATTERNS

EAST	versus	WEST
Ideograms		Alphabet
Right-brain oriented		Left-brain oriented
Nonlinear		Linear
Acoustical		Visual
Analogical		Logical
Inductive		Deductive
Concrete		Abstract
Mystical		Causal
Intuitive		Rational
Generalist		Specialist
Decentralized		Centralized
Local		Universal
Integrative		Fragmented
Space oriented		Time oriented
Traditional		Progressive
Cyclic time		Continuous time
Algebraic		Geometric
Concrete science		Abstract science
Order and pattern		Natural law
Craft		Technology
Invention		Exploitation
Technique		System
Customs-mores (Confucious)		Codified law
Harmony of nature (Tao)		Monotheism
Relativity		Absolutism

while Chinese law is based on custom and mores, as was pointed out by the great China scholar Joseph Needham:

The Chinese early acquired a great distaste for precisely formulated abstract codified law from the abortive tyranny of the politicians belonging to the School of Legalists during the period of transition from feudalism to bureaucracy. Then when the bureaucratic system was finally set up, the old conceptions of natural law in the form of accepted customs and good mores proved more suitable than any others for Chinese society in its typical form.⁹

There is no doubt that China's bad experience with the Legalists probably contributed to the rejection of codified law. There were also many bad experiences with codified law and tyrants in the West as well, yet somehow codified law survived in the West. Why? I believe it was the nature of the writing system. The Chinese developed two concepts of law: "fa" and "li."¹⁰ The proponents of "fa," the Legalists, believed in formalistic law. The thinkers associated with "li" were Confucians and adhered to the body of ancient customs, such as filial piety. Neither the concept "fa" nor "li," however, applied to nonhuman nature. This helps explain why the Chinese never developed the concept of scientific laws as laws of nature. Within the realm of law, no analogy was made between the world of nature and the world of human behavior.¹¹ The lack of formal law in China had another lingering effect on the development of science, namely, the lack of standard weights and measures in China until modern times.¹² "Their very aversion from codification was one of the factors which made the Chinese intellectual climate uncongenial to the development of systematized scientific thought."¹³

Chinese Science

What makes the lack of theoretical science in China so puzzling is the high level of technological progress achieved there. The list

of significant scientific and technological advances made by the Chinese long before their development in the West includes the equine harness, iron and steel metallurgy, gunpowder, paper, the drive belt, the chain drive, the standard method of converting rotary to rectilinear motion, and the segmental arch bridge.¹⁴ To this must be added¹⁵ irrigation systems, ink, printing, movable type, metal-barrel cannons, rockets, porcelain, silk, magnetism, the magnetic compass, stirrups, the wheelbarrow, Cardan suspension, deep drilling, the Pascal triangle, pound-locks on canals, fore-and-aft sailing, watertight compartments, the sternpost rudder, the paddle-wheel boat, quantitative cartography, immunization techniques (variolation), astronomical observations of novae and supernovae, seismographs, acoustics, and the systematic exploration of the chemical and pharmaceutical properties of a great variety of substances.

Having carefully documented through years of historical research the contribution of Chinese science and its influence on the West, Needham posed the following question: "Why, then, did modern science, as opposed to ancient and medieval science, develop only in the Western world?"¹⁶ The crucial term in the question posed by Needham, "modern science," really means abstract theoretical science based on experimentation and empirical observation, which began in Europe during the Renaissance.

Abstract theoretical science is thus a peculiar outgrowth of Western culture and is little more than three hundred years old. Nonabstract practical science as it occurs in China and the remainder of the world is a universal activity that has been pursued by all cultures as part of their strategy for survival. Claude Lévi-Strauss in *The Savage Mind*¹⁷ gives numerous examples of elaborate classification schemes of preliterate cultures, based on their empirical observations and demonstrating their rudimentary concrete scientific thinking.

China created what was probably the most sophisticated form of nonabstract science the world has known. But technological sophistication by itself does not guarantee the development of abstract theoretical science. Other factors (social, economic,

and cultural), obviously present in the West and not the East, must have played a crucial role.

Before delving into the impact of the Chinese writing system, let us first review the fundamental elements of Chinese science. According to classical Chinese thought the universe consists of five elements: earth, water, fire, metal, and wood. The five elements are ruled by the two fundamental universal and complementary forces of yin and yang, which represent, respectively, the following pairs of opposites: cold and warm; female and male; contraction and expansion; collection and dispersion; negative and positive. The five elements and the two forces of yin and yang form a blend of opposites in which a unity emerges more through harmony than through the fiat of preordained laws.¹⁸ Chinese science always had a mystical and mysterious aspect to it. Those thinkers who were most rational, the Confucians and Logicians, had little interest in nature. The Taoists who were interested in nature were mystics who mistrusted reason and logic.¹⁹ Chinese science was colored by the Taoist attitude toward nature, which is summarized by the following passage from the Huo Nan Tzu book (Ch. 9, p.1.b): "The Tao of Heaven operates mysteriously and secretly; it has no fixed slope; it follows no definite rules; it is so great that you can never come to the end of it; it is so deep that you can never fathom it."

It is not difficult to understand how the Taoist mystical attitude toward nature might preclude the development of abstract science. We are still left, however, with the question of why those who were rational, such as the Confucians and the Logicians, were not interested in nature and why those who were interested in nature, such as the Taoists, were mystical. In other words, why wasn't there a group in China that was both rational and interested in science and nature? Eberhard²⁰ offers an explanation: Science had only one function, namely, to serve the government and not its own curiosity. All innovations were looked upon as acts of defiance and revolution. The difficulty with the explanation provided by Eberhard is that it applies to the West

as well. Western scientists faced the same problems in Europe. The work of Copernicus was openly contested and then suppressed by the Church, yet the Copernican revolution succeeded.

Yu-lan Fung offers a philosophical explanation for the lack of theoretical science: "Chinese philosophers loved the certainty of perception, not that of conception, and therefore, they would not and did not translate their concrete vision into the form of science."²¹ The Chinese thinker was content to live in harmony with nature with no need to subdue it or have power over it as is the case in the West. Fung claims that this philosophical disposition provided no motivation to the Chinese to turn from their internal reflective state to the external active stance that the West adopted to develop scientific thinking. Her explanation is similar to that of Latourette,²² who claimed that Chinese thinkers were more interested in controlling their minds than nature itself, whereas in the West, it was the opposite.

The philosophical and ethical considerations cited by Fung²¹ and Latourette²² as well as the political and bureaucratic issues brought forward by Eberhard²⁰ are valid and provide critical background information against which one must consider the question of why abstract science did not develop in China. The central question that still must be addressed, however, is why the intellectual climate in China was not conducive to "science for science's sake," or to abstract laws, or to the "study of the process of thinking (logic)," or to the translation of a "concrete vision into the form of science."

The Influence of Writing Systems

Needham suggests where to look for the answer to this question: "The cause for the break-through [in science] occurring in Europe was connected with the special social, intellectual and economic conditions prevailing there at the Renaissance, and can never be explained by any deficiencies either of the Chinese mind or of the Chinese intellectual and philosophical tradi-

tion."²³ Needham, however, misses one of the key cultural factors that differentiates East and West, namely, the difference in their writing systems:

My view is that in Chinese civilization there were factors inhibitory to the growth of modern science, while in Western civilization, the factors were favorable. . . . Had the environmental conditions been reversed as between Euro-America and China, all else would have been reversed too—all the great names in the heroic age of science, Galileo, Malpighi, Versalius, Harvey, Boyle, would have been Chinese and not Western names; and in order to enter today fully into the heritage of science, Westerners would have to learn the ideographic script just as the Chinese now have to learn alphabetic languages because the bulk of modern scientific literatures is written in them.²⁴

I agree totally with the first part of Needham's remark that there were in China "factors inhibitory to the growth of modern science." I disagree with the second part because it is my contention that one of the "inhibitory factors to the growth of modern science," ironically enough, was the Chinese ideographic script. It is my belief that the first scientific literature, whether Oriental or Occidental, was destined to be written in an alphabetic script because the alphabet creates the environmental conditions under which abstract theoretical science flourishes.

It would be simplistic to suggest that it was the relative impact of the alphabet and ideographic writing alone that explains the emergence of abstract science in Europe and not China. On the other hand, this factor cannot be ignored as Needham suggests:

There is a commonly received idea that the ideographic language has a powerful inhibiting factor to the development of modern science in China. We believe, however, that this in-

fluence is generally grossly overrated. It has proved possible in the course of our work to draw up large glossaries of technical terms used in ancient and medieval times for all kinds of things and ideas in science and its applications.²⁵

Needham's assertion that an adequate vocabulary existed for expressing scientific ideas in Chinese is correct, but he fails to understand or take into account the subliminal or hidden effects of rendering scientific words in an ideographic script. An examination of the etymologies of the most important Chinese scientific words that he provides in his magnum opus, *Science and Civilization in China*,²⁶ illustrates our point. Table III, taken from Chapter 13 in Volume 2, provides a list of Chinese scientific terms along with their English meaning, romanization, modern and ancient Chinese character rendition, and an interpretation of the ancient Chinese character that indicates the etymology of the word. An examination of the table reveals that even the most abstract scientific term must be rendered in a concrete form when it is written. This, no doubt, has had a subliminal effect on Chinese scientific thinking.

It is not just the concrete nature of Chinese ideograms but the difficulty in classifying them that makes them less conducive to abstract scientific thinking than an alphabetic script. The alphabet, as we shall show in later chapters, is a natural tool for classifying and served as a paradigm for codified law, scientific classification, and standardized weights and measures. The relationship of science and classification is something that the Chinese recognized despite the difficulty that ideograms pose to this activity: *k'ho hsiieh*, the traditional and current Chinese term for science, means "classification knowledge." The European term for science has a similar meaning. Derived from the Latin word *scientia* from *scire*, "to know," *science* is defined in Webster's New World Dictionary as "systematized knowledge derived from observation, study, etc."

To understand which of the two types of script, alphabetic or

ideographic, is best suited to classification, one need only compare Western and Chinese dictionaries. The ordering of words in Western dictionaries is always alphabetical. The situation in the Chinese languages is much more complicated because of the ideographic, nonphonetic nature of their written characters. Chinese dictionaries can be organized on various principles. "The characters are classified according to their initial and final sounds, in others according to radicals and in still others by subject."²⁷ Even without a phonetic writing system the Chinese attempted to classify their words phonetically, but their ideograms discouraged this effort and as a result classification never reached the level of abstraction that it did in the West. And this despite the fact that there exist special words in the spoken and written language that classify words so as to avoid the ambiguities of the many homophones found in Chinese.²⁸

The failure to achieve standardized measures and weights might also be in part due to a writing system in which the characters (or at least the radicals) are composed of unique, nonrepeatable, nonstandardized components. The alphabetic writing system consists of standardized, repeatable elements from which words are composed. This system therefore provides a model for standardized components and hence the standardized weights and measures that contributed to the development of Western science.

The linking together of standardized repeatable elements to form words also enables the alphabet to serve as a paradigm for deductive logic in which ideas or statements are linked together to form arguments. This is not the case with Chinese writing and might partially explain why the Chinese never developed Western-style logic. Their thinkers favored dialectical forms rather than deductive ones,²⁹ and their reasoning tends to be inductive rather than deductive. It is not logical but rather analogical, much as Chinese characters are analogs of the words they represent.

The linear, sequential mode of building a system that the al-

TABLE III:
THE ETYMOLOGY OF CHINESE CHARACTERS
REPRESENTING SCIENTIFIC TERMS

OLD CHINESE SYMBOL	ROMANIZATION	CHINESE CHARACTER	SCIENTIFIC TERM
	shih	始	begin
	chih	止	stop
	ih	日	sun
	ming	明	brightness
	kuang	光	light
	hsueh	雪	snow
	sheng	生	life, birth
	shui	水	water
	huo	火	fire
	tu	土	earth
	se	則	law
	suan	算	count
	shih	始	begin
	ih	日	sun
	ming	明	brightness
	kuang	光	light
	hsueh	雪	snow
	sheng	生	life, birth
	shui	水	water
	huo	火	fire
	tu	土	earth
	se	則	law
	suan	算	count

phabet encouraged and Chinese characters discouraged also influenced industrial development in the East and the West. Despite their technological progress, the Chinese never linked their inventions together to create the assembly-line production characteristic of the Western Industrial Revolution.

The Chinese writing system also reinforced the conservative nature of the Chinese spirit. Because the Chinese characters can be read by people speaking different dialects of Chinese, they have a unifying and preserving effect on the culture.³⁰ This encouraged and reinforced the Chinese reverence for their past and their traditions while dampening their enthusiasm for scientific and technological innovation.

The lack of abstraction in the writing system reflects itself throughout Chinese thought and discourages the development of the abstract notions of codified law, monotheism, abstract science, and deductive logic. We see that once a culture begins to develop along concrete lines, this tendency is reinforced in all areas. The lack of abstract writing discouraged the development of monotheism, codified law, and deductive logic, all of which in turn made the development of abstract science more difficult. Having explored the limitation ideographic writing placed on the development of abstract Chinese thought, we will now examine in the following chapters the way in which phonetic writing or the alphabet created the conditions for codified law, monotheism, abstract science, deductive logic, the printing press, and the Industrial Revolution.

4

The Development of Phonetic Writing and Codified Law in Mesopotamia

Early Political and Cultural History of Mesopotamia

Writing systems, as we discovered in the last chapter, play an important role in the evolution of a culture and its thought patterns. The Chinese ideogram "retraces the meaning" of a word graphically while in the West the sound of a word is analyzed and reconstructed alphabetically. Phonetic writing has changed the character of its user's thought patterns. Through its impact on Babylonian, Hebrew, and Greek society, it helped create the conditions for abstract and rational thinking and prepared the ground for the development of codified law, monotheism, science, and logic. This process began in ancient Iraq or Mesopotamia where urban agriculture-based civilization first evolved and

where writing was used for the first time in the history of mankind.

The first city-states to form in Mesopotamia, such as Lagash, Nippur, Ur, Uruk, and Eridu, were populated by the Sumerians.¹ They settled the southern basin of the Tigris-Euphrates river system just before it empties into the Persian Gulf in what historians believe to be the setting of the biblical Garden of Eden.² Each city-state was ruled by a governor who also functioned as the high priest of the local god. The autocratic forms of government that arose in Sumer were in response to the need to maintain the irrigation systems of canals and dams that supported the agricultural economy.

The wealth that the irrigation-based farming created permitted the first flowering of urban civilization. The writing system was used as a tool to develop and promote commerce, government, diplomacy, religion, morality, justice, and the literary arts. The Sumerians built elaborate cities and temple structures from sunbaked mud bricks. Their towering temple structures or ziggurats (which Herodotus reported to be eight stories high) were the basis for the Hebrew legend concerning the Tower of Babel. According to Genesis, the Lord punished the builders of the Tower of Babel for their arrogance by confounding "their language, that they may not understand one another's speech." The Sumerians, who spoke a non-Semitic tongue, were in fact invaded in the second half of the third millennium B.C. by Semitic-speaking tribesmen whose language indeed confounded them.

One of these groups, who settled in Akkad under the leadership of Sargon, conquered the principal city-states of Sumer and succeeded in uniting the diverse regions of Mesopotamia into a single empire. The Akkadians conquered the Sumerians militarily, imposed their language, but adopted Sumerian culture including their arts, sciences, and religion. Akkadian, the language of the invaders, so dominated Mesopotamian life that Sumerian soon ceased to be spoken and became a dead language by the time of Hammurabi.³

Although the Akkadians were strongly influenced by the Sumerians and adopted most elements of their culture, they also introduced a number of new ideas of their own reflecting their attitudes toward government, economics, and religion. Their kings became progressively more authoritarian and absolute to the point that Naram-Sin, the grandson of Sargon, had himself declared a god during his own lifetime. Instead of a network of independent city-states, an imperial empire evolved in which vassal states were ruled by the emperor-king.

The Akkadians also introduced major changes in the economic system. The theocratic communalism of Sumer gave way to a quasi-capitalistic economy in trade and commerce, which augmented agricultural activities. These activities gave rise to a new social class of the bourgeoisie consisting of farmers, shopkeepers, and minor officials that came to be known as *mukēnum*.

In addition to these social, economic, and political changes, the Akkadians also brought to Mesopotamia a more profound conception of God. In place of allegiance to local gods who ruled the city-state in which they were resident, the universal worship of Marduk arose throughout the empire over which the Akkadians exercised political control. The Sumerian pantheon survived but played a minor role compared to the imperial role played by Marduk.⁴

The Development of Writing and Civilization

Sumer is the birthplace of both writing and civilization, two aspects of human culture that historically have always been interrelated. Writing promotes a relationship among standardization, abstraction, and symbolism—one of the fundamental characteristics of a civilized culture.

The writing system that developed in Sumer quickly spread to other cultures in the Near East including the Hittites (the Anatolians), the Elamites (the Persians), and the Cretans. We have noted that aside from Mesopotamia, writing developed independently in only four other cultures, namely, Egypt, the Indus

Valley, China, and Mesoamerica. As in Sumer, each of these societies was urbanized and had evolved an economy based on agriculture. A third common factor in each of these cultures was an extensive use of canals and irrigation systems.

Despite the small size of the sample, one is tempted to speculate that there exists a possible relationship between writing and irrigation systems. Perhaps the linear form of organization that canals and irrigation systems require creates an environment conducive to the development of writing, another system with a linear organization. Alternatively, possibly the organizational requirements needed for a system of irrigation channels and dams give rise to a direct need for writing. "In order to dig canals and build dams, and especially in order to maintain the vital irrigating system after it had been finished, a co-ordinated state organization was imperatively necessary. Without supervision and compulsory labour the canals silted up, the dams broke, and the increasingly necessary dikes burst."⁶ One of the tools that arose and permitted the "co-ordinated state organization" was writing. "The Sumerian writing owes its origin to the needs arising from public economy and administration. With the rise in productivity of the country, resulting from state-controlled canalization and irrigation systems, the accumulated agricultural surplus made its way to the depots and granaries of the cities, necessitating keeping accounts of goods coming to the cities, as well as of manufactured products leaving the cities for the country."⁷

Mankind's first writing system appeared in Sumer around 3000 B.C.^{8,9} and consisted basically of pictographic signs etched in clay.^{10,11} The first written signs found at Level IV of Uruk are highly irregular, indicating the peculiarities of individual scribes. The lack of standardization persists to the Shuruppak period, 2600-2500 B.C.⁹ The etching on the clay surface, however, was very shortly replaced by the cuneiform system of impressing the clay tablets with the wedge-shaped stylus. The purely pictographic nature of the original signs became more stylized and ab-

stract. This permitted the standardization of signs. Once signs were drawn approximately the same by everybody, universal literacy was possible.¹² The other development that promoted increased abstraction of writing was phonetization and the emergence of syllabic signs.

Syllabic signs were used phonetically to render words. The Sumerians were the first to initiate this technique but they exploited it only superficially. The real development in this direction occurred, paradoxically, when the Akkadians attempted to render their Semitic language using the Sumerian writing system that had been designed originally for a non-Semitic language.¹³

It should be remembered that the Akkadians used the same cuneiform signs to render both the Sumerian language and their own Semitic tongue. They retained the sacred texts of the Sumerians for religious purposes in much the same way that the Italians retained Latin texts and used the Roman alphabet to transcribe both Italian and Latin. The application of a single script to a dual purpose, namely to ideographic and syllabic writing, and to two totally different languages, had the result that almost every sign ultimately became a polyphone (i.e., had many different pronunciations and meanings), to the great confusion of the reader.

One sign depicting the rising sun came to represent over seventy words and twelve different syllables.¹⁴ The ambiguity introduced by this multiple use of signs caused confusion and reader error. Context helped resolve some of the ambiguity but finally two devices were invented to reduce the confusion. One was the determinative sign and the other was the phonetic complement.

The determinative sign was an ideographic sign added to another ideogram to indicate to what general class of objects or concepts that ideogram belonged. Determinative signs denoted deities, animals, plants, fishes, rivers, cities, material, or gender, among other things. The determinative sign was not pronounced; it acted purely as a classifier.

The phonetic complement, on the other hand, was a syllabic sign that determined which of the many phonetic values of the ideographic sign under consideration was intended by indicating what consonant the word began with. The phonetic complement, like the determinative sign, was not read but was a silent visual sign to resolve ambiguity.

The determinative sign and phonetic complement were two devices developed strictly for resolving the ambiguities of reading. But as we shall see later, they played an additional role in the development of Babylonian thinking by providing a model for classification. These two devices provided temporary relief and served as transitory strategies for resolving ambiguities during the period when the same signs were being used not only for two languages but also for a mixed system of ideographic and syllabic signs. The ultimate strategy for resolving ambiguities was to use signs in a purely phonetic way to denote syllables and drop ideographic signs altogether with a few minor exceptions. Another way to resolve the ambiguity was to use the signs for one language only.

Both of these developments occurred. After the conquest of Sumer by the Akkadians, Sumerian was still used for certain ritual and religious practices, but Akkadian became the lingua franca. This pattern of language use was interrupted for a period of approximately one hundred years when Sumerian became the official language once again and Sumerian culture experienced a renaissance and a final flowering. During this period Sumerian texts were translated into Akkadian and bilingual dictionaries were compiled. When the Akkadians regained political control of Mesopotamia, the process of translating suddenly came to a halt and Sumerian became a dead language.¹³ The language was used only by religious officials as is the case with Latin today. Sumerian texts were maintained in libraries but no active scholarship or new literature developed in the Sumerian tongue once the Ur III dynasty was overthrown in 2004 B.C.

By the time of Hammurabi in the eighteenth century B.C., the Akkadian tongue enjoyed total domination in the affairs of his

empire. As the Akkadians came to dominate the political and cultural life of Mesopotamia, they also shifted their style of writing into an increasingly phonetic mode of operation in which fewer and fewer word signs were used. Word signs never disappeared but they became less important.

With the transition to a greater use of phonetic writing, the Babylonian writing system became simpler, but the transition to a purely phonetic system or an alphabetic system never occurred in Mesopotamia. "At no time did any of the Mesopotamian syllabaries contain signs for all the possible syllables existing in the languages for which they were used. The principle of economy aiming at the expression of linguistic forms by the smallest number of possible signs, resulted in various economizing measures."¹⁶ There was no such thing as a "standard" Mesopotamian syllabary, but rather at different times and in different areas a particular syllabary was in use. The Mesopotamian syllabary systems consisted of signs that usually represented monosyllables ending in a vowel or a consonant. The writing system used for the Hammurabi Law Code can be resolved into eighty-three vowels and uniconsonantal syllabic signs of the form *a, i, e, u, ba, bi, be, bu, ab, ib, ub, da, di, ad, id, and ud*.¹⁷

The economic and simplified writing system used in the time of Hammurabi represents a major reform of the writing system, which in earlier times had been much more complicated. "It is estimated that the earliest Sumerian writing (Uruk IV-II) consisted of close to 2000 different signs, while in the later Fara period the number is only 800."¹⁸ The reform of the writing system and the reduction in the number of signs had an important impact on cultural development during Hammurabi's time, as we shall see once we examine the uses to which writing was put.

Writing and Civilization in Mesopotamia

The use of writing completely transformed the nature of Mesopotamian culture and created the conditions for civilization and

the other trappings of urban life. Writing created a pattern of cultural development that was to repeat itself throughout history.

There is no need to urge that the introduction of writing was the factor which was responsible for the birth of original civilizations. It seems rather that all the factors—geographic, social, economic—leading towards a full civilization simultaneously created a complex of conditions which could not function properly without writing. Or, to put it in other words, writing exists only in a civilization and a civilization cannot exist without writing.¹⁸

The first uses of writing in Sumer were modest and confined to economics and administration among a population of "priests, scribes, architects, artists, overseers, merchants, factory workers, soldiers and peasants and their religious rulers or war leaders."¹⁹ Once the art of writing had been mastered for economic and administrative purposes, it was then used for literary, religious, and historical purposes. Stories, fables, and literary creations about gods, heroes, kings, and even animals were composed and recorded. A wisdom literature developed as proverbs and inspiring sayings were collected and cataloged.

In addition to these religious, philosophical, and cultural texts, there also appeared practical collections of information. Among these were a collection of tablets that Kramer termed the world's first farmer's almanac because they guided a farmer through his annual agricultural activities. The almanac begins with the line: "In days of yore a farmer gave [these] instructions to his son."²⁰

Another collection of practical information is the world's oldest medical handbook, a clay tablet recovered from Nippur, which had been prepared by an anonymous Babylonian physician who collected more than a dozen of his favorite remedies. The tablet revealed that Mesopotamian pharmacology had made

considerable progress and was acquainted with "quite a number of rather elaborate chemical operations and procedures."²¹

Other collections of practical information were prepared for scribes and those studying to become scribes. Schools for scribes called "tablet-houses" were attached to the most important temple schools. Young people were taught how to read and write.²² Students were taught the forms, conventions, and principles of writing to ensure that the system could be universally understood.²³ These requirements of standardization contributed eventually to the development of scientific and legal thinking in Mesopotamia.

Grammar lists were prepared to make the student aware of different grammatical classifications and constructions. Word lists were compiled to teach the scribes the different pictographs and syllabic signs. Later, when Akkadian scribes were trained to translate Sumerian words into Akkadian and back again, dictionaries were prepared as well as other scribal tools. Lexical tables have been found in which ideograms are listed with their names, pronunciation, and their Sumerian and Akkadian word values or meanings. "There are lists of gods with their names in both languages, their titles or functions or temples, lists of countries and towns with their names in both languages, and so on. Other series contain lists of purely Akkadian synonyms in two columns or glossaries of Hittite, Cassite, and even Hurrian or 'Horite,' words and phrases."²⁴ It would appear that many of these school tablets were copied down by students through their teacher's dictations. The frequent variations of the spelling tends to confirm this supposition.²⁴

While education was not universal in Mesopotamia, "a fair number of laymen could read if not write the cuneiform script."²⁵ Because of the difficulties in learning how to read and the necessity for special training, however, literacy served as a barrier to deny most members of the society participation in certain decision-making activities. "The priests (who were also scientists, engineers and physicians) sustained their privileged

position by carefully retaining a monopoly of knowledge, which being literate they alone could read, record and transmit."²⁶

For those who could read and write, literacy provided a strong stimulus to learning and scholarship, particularly in science and law, two fields in which abstraction and classification are so important. Writing, particularly with syllabic signs, provides a natural model or paradigm for both abstraction and classification. The mechanism whereby visual signs are coded as phonetic elements, which are then combined together to form a word, is an exercise in abstraction and logic that the human mind had not experienced until the development of phonetic writing. Classification schemes arose naturally out of the structures of a phonetic writing system. This was reinforced by the word lists and catalogs of tablet titles that were created to help organize the scribes' activities. The organization of libraries containing collections of tablets contributed to the development of classification and organizational methods and techniques. Each large city had a school for scribes to train the local youth and each school had a library attached to it.

The influence of writing is reflected in the nature of Babylonian scholarship. Mesopotamian teachers "were keen observers of nature and the immediate world about them. The long lists of plants, animals, metals and stones which the professors compiled for pedagogic purposes imply a careful study of at least the more obvious characteristics of natural substances and living organisms."²⁷ The Babylonians' concern for classification extended also to their analysis of their own society, which they divided "into more than one hundred institutions, occupations, crafts, attitudes, and modes of action."²⁷

In addition to serving as a paradigm for classification, the Babylonian syllabary also provided a model for standardization, universality, and abstraction. These notions were reflected not only in the development of codified law and observational science but also in the arts and religion. Commenting on cylinder seals, W. F. Albright noted: "The design on these seals show that in

the fourth quarter of the fourth millennium B.C. art had already passed far beyond any stage previously attained. Native skills, empirically developed by generations of artists and craftsmen, had reached the point where it became standardized and where canons of proportion were established."²⁸

Abstract thought could also be found in Babylonian religious and philosophical ideas. Many of the ideas that were to characterize Greek thought, such as the notion of fate or destiny, are found in Babylonian literature. Another indicator of the abstractness of Babylonian religious thought is that the gods, unlike their Egyptian counterparts, were not represented as animals.²⁹ Not only were the religious ideas in Babylonian abstract but they also began to evolve a universal message. This is partly due to the existence of an imperial empire but is also a consequence of the paradigm of universality suggested by a national writing system. The spirit of universality is reflected in the following poem in praise of En-lil: "Unto En-lil do foreign lands raise their eyes (in adoration), Unto En-lil do foreign lands pay homage. The Four Quarters (of the earth) bloom like a garden for En-lil."

Introduction to Science

The elements of universality, abstraction, and classification that became part and parcel of Babylonian thinking under the influence of phonetic writing subliminally promoted a spirit of scientific investigation, which manifested itself in the scribal schools. The major aim of the scribal school quite naturally was professional training to satisfy the economic and administrative needs of temple and palace bureaucracies. "However, in the course of its growth and development, and particularly as a result of the ever widening curriculum, the school came to be the center of culture and learning in the Sumer. Within its walls flourished the scholar-scientist, the man who studied whatever theological, botanical, zoological, mineralogical, geographical, mathematical,

grammatical, and linguistic knowledge was current in his day, and who in some cases added to the knowledge."³⁰

The Age of Hammurabi marks the culmination of the regularization and reform of both the writing system and the legal system in the form of the Hammurabic code. These developments were not coincidental. Both reforms promoted the paradigms of abstraction, classification, and universality and thus encouraged the development of scientific activities.

The two centuries following the Hammurabic era represent the first great scientific age of mankind, in which a new spirit of empiricism and scholarly interest in astronomy, magic, philology, lexicography, and mathematics emerged. In mathematics a primitive place number system was invented as well as algorithms for arithmetic calculations. Mathematical tables were also created to simplify calculations. Achievements in algebra included the solution of quadratic equations by the method of false position. In astronomy lists of stars and constellations were compiled and the movements of the planets were charted. The scholars of the Hammurabic era "showed such taste and talent for collecting and systematizing all recognized knowledge that Mesopotamian learning nearly stagnated for a thousand years thereafter. . . . We find a pervasive idea of order and system in the universe, resulting in large part from the tremendous effort devoted to the systematization of knowledge."³¹

The Mesopotamians' spirit of order and system is reflected in their cosmology or concept of the universe.³² The Babylonian universe, *an-ki*, is divided into two major components: the heaven (*an*) and the earth (*ki*), which emerged from and remain fixed and immovable in a boundless sea, Nammu. Nammu acts as the "first cause" or "prime mover" of the universe. Between heaven and earth there moves Lil, a divine wind (also air, breath, or spirit) from which the luminous bodies (the sun, moon, planets, and stars) arose. The order of creation is as follows: 1) the universe, *an-ki* (heaven-earth), emerges from the boundless sea Nammu; 2) it separates into heaven and earth; 3) Lil

then arises between heaven and earth; 4) from which the heavenly bodies emerge; 5) followed finally by the creation of plants, animals, and human beings. The order of creation found in this cosmogony closely parallels the story of creation found in the Bible in the book of Genesis.

Mesopotamian cosmology and cosmogony, while polytheistic in nature, nevertheless evolved some rather abstract notions of the deities that created and controlled the universe. All the elements of the cosmos had been created by the four gods in control of heaven, earth, sea, and air. "Each of these anthropomorphic but superhuman beings was deemed to be in charge of a particular component of the universe and to guide its activities in accordance with established rules and regulations."³³

While Mesopotamian cosmology contains mythic elements, the core of its world picture is based on empirical observations of the natural environment including the heavens. Systematic astronomical observations were not part of the Sumerian tradition but were begun by the Akkadians, worshippers of the sun god Shamash. Their observations were somewhat crude³⁴ and it was only with the flowering of the Assyrian empire in approximately 700 B.C. that accurate quantitative measurements were made. The earliest records of astronomical observations in Mesopotamia are those made during the reign of Ammi-saduqa of the appearances and disappearances of Venus. Tablets recording these observations have been used to date the chronology of the Hammurabic period.³⁵ Part of the motivation for these observations was what we could term scientific and part astrological, though the Babylonians made no distinction between science and astrology. Observations made for the purpose of divination served science as well, and paradoxically, vice versa.

Sumerian and Babylonian mathematical tables provide further evidence for the development of scientific thinking in Mesopotamia. These tables were combined with tables of weights and measures indicating that they were used in daily economic life.³⁶ The clear influence of writing and a notational system

upon the development and organization of mathematical skills is easily discernible from these tables. Economics proved to be a motivating factor for both writing and mathematics, which mutually reinforced one another's development.

The results were tables of multiplication, reciprocals, squares, square roots, cubes, cube roots, sums of squares and cubes needed for solutions to algebraic equations and exponential functions.³⁷ The sexagesimal number system 60 was developed in response to the Babylonians' concern for astronomy. The parallel between the approximately 360-day year and the 360-degree circle are obvious.

Tables of quadratic and cubic functions were prepared for civil-engineering projects of dam building, canal dredging, and the construction of attack ramps to breach the ramparts of besieged walled cities. Certain Babylonian mathematical tablets indicate that astronomy, banking, engineering, and mathematics were practiced in a systematic and scientific manner. Two types of tablets were prepared. In one set, only problems are given, but each tablet contains problems related to the other and carefully arranged beginning with the simplest cases. The second set of tablets contains both problems and their solutions worked out step by step.³⁸ The achievement of Babylonian mathematics, which has been likened to that of the Renaissance,³⁹ is all the more remarkable when one considers the short period in which it developed and flowered: all within two hundred years or so of the major reforms in the writing system.

The existence of these tablets illustrates two important impacts of writing on science. The first is the impulse to organize information in an orderly and systematic manner. The ordering of individual words that the use of syllabic signs creates in the thought patterns of their users inspires a similar ordering of the contents of their writings. That this was critical for the development of science is beautifully illustrated by the Babylonian mathematical texts created as aids to various scientific and engineering activities.

The second impact of writing is the ability to preserve the accomplishments of one age so that they can form the basis of a later development. Little if no progress was made in Babylonian mathematics from the time of the Hammurabic explosion of knowledge to the Assyrian empire of 700 B.C. Yet the tablets preserved the knowledge that an earlier age had created and they served as the foundation for the Assyrian development.

The mathematical and scientific achievements of the Mesopotamian civilization we have just reviewed are certainly worthy of our respect and admiration. We must be careful, however, not to jump to the conclusion that this culture had solidly embarked upon the road of scientific thinking because of the progress in astronomy, mathematics, and engineering that has been described. The reader must bear in mind that the very same practitioners of this rudimentary form of science were also engaged in astrology, the reading of animal entrails, the interpretation of omens, and other forms of superstition. The early forms of science as practiced in Babylonia are not a scaled down or less advanced version of science as we know it today but rather a mixture of logic, superstition, myth, tradition, confusion, error, and common sense. No distinction was made between "religious" and "scientific" thinking. "Medicine grew out of magic, and in many cases was indistinguishable from it."⁴⁰ What is important about Babylonian science from a historical point of view was its influence on future generations, on the Hebrews, on the Greeks, on the Arabs, and eventually on Renaissance Europe.

The Babylonians made use of a logical mode of thought complete with abstract notions and elements of classification.⁴¹ Their approach was wholly empirical, however, unlike the theoretical and more analytic style of Greek science, which, according to Kramer, required "the influence of the first fully phonetic alphabet."⁴² For example, the Sumerians compiled grammatical lists and were aware of grammatical classifications, yet they never formulated any explicit rules of grammar. In the field of science, lists were also compiled but no principles or laws were ever

enunciated. In the field of law, a legal code was developed but never a theory of jurisprudence.⁴²

Codified Law

One of the major contributions of Mesopotamian culture was the codification of law, which led to our abstract notions of justice in the West and influenced both the formulation of Hebrew scriptural morality and Roman law. Sumerian literature is filled with examples of gods and earthly rulers who are defenders of the downtrodden and upholders of justice.

One example of this spirit is found in a Sumerian hymn found at Nippur. It sings the praises of the goddess Nanshe, who is described as she "who cares for the widow, who seeks out justice for the poorest. The queen brings the refugee to her lap, finds shelter for the weak."⁴³

Another example is Uru-ka-gina, the King of Lagash, "who reestablished the righteous laws of Nin-girsu."⁴² and "freed the citizens of Lagash from usury, monopoly, hunger, theft and assault; he established their freedom."⁴⁴ A votive inscription lists the many injustices that existed in the previous regime, explains how Uru-ka-gina was able to bring an end to these practices, and then describes in great detail how these injustices are to be corrected by listing the exact fees that are to be paid for services rendered to the public.⁴⁵ These inscriptions from Uru-ka-gina's regime, with their explicit statements of acceptable tariffs, served as a forerunner of the later legal codes, which also set acceptable rates for the services of a wagon driver or boatman or the price for products such as barley and sesame oil.

The Sumero-Akkadian concern for justice was reflected in the legal codes. The most famous legal code and the first to be discovered in modern times (at Susa in 1901) was that of Hammurabi, who ruled Babylonia from 1792 to 1750 B.C. This code is still the most complete that has been recovered from ancient Mesopotamia but it is not the oldest.

The oldest known legal code, dating back to 2100 B.C., is that of Ur-Nammu, described as "the king who observed the just laws of the sun-god." It consists of a prologue and a collection of at least twenty-nine laws.⁴⁶ Five of the twenty-nine laws concern themselves with the payment of fines as compensation for injuries caused in scuffles. "If a man to a man with a gesphu-instrument (copper knife) the nose has cut off, $\frac{2}{3}$ of a silver mina he shall pay."⁴⁶ This type of law represents a reform, by our standards, of the more primitive eye-for-an-eye principle, which ironically reappears in later Babylonian codes and in the Old Testament. The principle of making restitution through fines as compensation for wrongdoings such as perjury, property damage, deflowering, and divorce is found in twelve other laws in addition to the five dealing with injuries due to fighting. In addition to the laws⁴⁶ for compensation, there are also laws concerning marriage and divorce (laws 4-12) and slavery (laws 14, 21-23). The laws tend to be grouped according to categories, showing the first signs of codification.

The Bilalama code dates back to the city of Eshnunna in the later part of the twentieth century B.C. No prologue or epilogue was found and only fifty-nine of the sixty-one laws recovered were decipherable. The laws are codified in a somewhat systematic manner like the earlier Ur-Nammu code. They deal with prices, tariffs, sales, deposits, the valuation of damages sustained, family affairs, marriage, divorce, slavery, and theft.⁴⁷ This code also contains the principle of compensation for injuries.

A contemporary of Bilalama, Attakhushu, King of Elam (Persia), also established a legal code in the market of his capital. The stela, referred to as a "stake of righteousness," was surmounted by an image of the sun god and listed the "fair prices" for products to be bought and sold in the market.⁴⁹

The last of the pre-Hammurabic legal codes extant is that of Lipit-Ishtar who ruled the city-state of Isin from 1934 to 1924 B.C. This code,⁴⁸ written in Sumerian, consists of a prologue, an epilogue, and thirty-eight laws of which the first three and the

last are difficult to determine. The remainder are codified in the following manner: "hitting of boats (laws 4 and 5); real estate, particularly orchards (7-11); slaves and perhaps servants (12-33); rented oxen (34-37)."⁴⁹

The classical legal code of Hammurabi, which we shall shortly examine, marks the beginning of the widespread use of legal codes throughout all of Mesopotamia. Hammurabic legal codes remained in force as the basis of government throughout the history of Mesopotamia down to the last Chaldean dynasty (sixth century B.C.). Copies of the original Code of Hammurabi were made throughout this period of 1,200 years, and some of the laws even survived the demise of Mesopotamian civilization and found their way into Islamic law.⁵⁰ Hammurabi, descended from the Amorite invaders, inherited his father's tiny kingdom centered at Babylon in 1792 B.C. Through a series of piecemeal conquests and alliances over a period of thirty-eight years, Hammurabi conquered all of Mesopotamia from Persia to Syria and assumed the title of Mighty King of the Four Quarters of the World.⁵¹

At the same time that he was increasing the amount of territory under his control, Hammurabi was securing his conquered lands through a series of political, administrative, social, and religious measures and reforms. Among these reforms was that of the writing system in which he set a pattern for uniformity, regularization, and standardization. He created a central regime that was able to exercise control, yet he also gave a measure of self-rule through local assemblies of elders. While preserving local customs and traditions, he was nevertheless able to create a uniformity throughout his empire. A spirit of freedom and order coexisted in which the arts, science, religion, literature, and commerce flourished. It was a time of high civilization, the highest the world had known to that date.

At the foundation of this ordered kingdom or empire was a code of law that was most likely a collection of precedents from actual rulings by the king as well as laws from previous codes. These laws were based on the set of principles that constituted

the Akkadian and particularly Hammurabi's sense of justice or *mesarum*. The code itself, which was carved on stelae and placed in temples, consisted, like the earlier codes, of: 1) a prologue in which the deeds of the king are described; 2) the body of the law, which contained at least 282 individual laws; and 3) an epilogue that threatened divine punishment to any who defaced the code. It is interesting to note that the language of the prologue is more archaic and literary than is that of the body of the laws.⁵²

As to the purpose of the code, other than its ostensible goal of bringing justice to Sumer and Akkad, we can only speculate. The Hammurabic law represents a major expansion of the earlier codes we have examined and probably addresses additional concerns. This is not to underplay the ethical side of the Hammurabic code, however, which goes far beyond any of its predecessors in this regard. But the reforms introduced by Hammurabi have wider scope and deeper implications. There is another agenda at work in this code, hinted at in the prologue written in Akkadian where Hammurabi states, "I established law and justice 'in the language of the land.'"⁵³

It was in Hammurabi's reign that the Akkadianization of Mesopotamia, which began with Sargon and was interrupted by the Sumerian renaissance, was finally completed. Hammurabi also had the task of coordinating and uniting a vast multicultural, multiracial, and multilingual society consisting of previously semi-independent walled cities that had constantly warred against each other. In order to rule such an empire, coordinate its economic and agricultural activities, and command the loyalty of its diverse geopolitical entities, he had to appease each element of the society and satisfy them that they were being treated fairly and equally with all the rest. As a wise leader, Hammurabi utilized both justice and the appearance of justice to pacify his subjects and ensure their cooperation. The codification and public proclamation of laws contributed to both of these processes and at the same time continued the Sumero-Akkadian tradition of justice. Writing out the rules of the game and posting them in each city-state had the effect of ensuring uniformity

of measures, commodity prices, professional fees, and transport tariffs throughout the empire. "On the economic side, as on the administrative, the motive of law-giving at this period seems not to be reform but the need of forging a single government out of different elements."⁵⁴ Hammurabi set a pattern, one that was to be repeated by future administrators of large empires.

The Hammurabic code, while introducing many new ideas, still retains a number of the basic categories and actual laws of earlier codes. However, it contains many more laws, namely 282, and shows a much greater degree of systematic codification, no doubt due to the improved and simpler writing that came into use during this period. Table IV shows how the 282 laws of the Hammurabic code are organized.

Within these coarse categories one can detect finer subcategories. There also seems to be a system to the way in which new topics are introduced. Law No. 195, which serves as the transition from the section on children to that concerning injuries, overlaps these two categories: "If a son has struck his father, they shall cut off his hands."

Additional evidence for the systemization of justice is found in the accounts of the judiciary, law courts, and trials that are discussed in the code and in private letters. A separation of secular and religious courts took place during the time of Hammurabi, so that there emerged in addition to the temple officials, new judges who bore the name of "king's judges."⁵⁵ This separation of church and state foreshadows a similar separation that was to take place years later in other highly literate empires, for example, in Rome and in the U.S. Constitution in the eighteenth century. Additional parallels can be drawn between the Hammurabic code and later Western law because of the new emphasis on the rights and freedoms of the individual, particularly that of holding private property.⁵⁶ The emergence of the individual in a literate society, which occurs for the first time in Babylon, recurs over and over again in each of the Western cultures where a phonetic form of literacy arises.

While it is not possible to attribute a causal relationship be-

TABLE IV:
THE HAMMURABIC CODE

CATEGORY	LAW NUMBER
Perjury	1-5
Theft	6-25
Feudal obligations, land and the military	26-41
Feudal obligations, land and civilians	42-71
Housing	72-78
Lending and borrowing	88-126
Marriage	127-172
Children	173-195
Injuries—Compensation and punishment	196-214
Liabilities:	
Physicians	215-223
Veterinarians	224-225
Branders	226-227
Builders	228-233
Boatmen	234-240
Oxen	241-256
Tariffs and liabilities for farmhands	257-267
Tariffs:	
Animals and wagons	268-272
Laborers	273-274
Boats	275-277
Slaves	278-282

tween the advances in phonetic writing and the emergence of Mesopotamian science, mathematics, and codified law, their co-development is not coincidental. In order to continue our study of the alphabet effect we must examine the next revolution in the introduction of phonetic writing in the West, namely, the advent of the Semitic phonetic alphabet. Our story now passes to the Israelites whose ancestors wandered from the Mesopotamian city of Ur sometime during or just after the reign of Hammurabi to settle in the land of milk and honey.

the People of the Book, who expressed their culture almost exclusively through the written word and hence the alphabet.

An interesting feature of the Hebrew script is that as it evolved further and further away from Phoenician, it became more and more cursive. Almost all scripts evolve in two major forms, lapidary and cursive, corresponding to writing on stone and on papyrus (or parchment), respectively. The two forms influence each other so that the divergence between them does not grow too great. Hebrew is unique in that it did not develop a lapidary form but grew progressively more cursive once it separated from Phoenician. The epigraphic evidence indicates that as early as the ninth century B.C. the Hebrews were not given to carving on stone or creating monumental stelae or offerings to gods.

Writing among the Hebrews was used for both commercial and literary purposes. All Israelites were encouraged to read to fulfill their religious duties so that by the sixth or seventh century B.C., Hebrew society enjoyed a basic level of literacy. This is evidenced by the fact that seals denoting ownership were by this time purely literate, having shed all pictorial elements.

Because of the conservative nature of the use of the Hebrew script, its evolution was slow compared to that of Phoenician and Aramaic, and its evolution was abruptly interrupted by the destruction of the first Temple and the exile of the Hebrews in Babylonia where Aramaic had become the dominant writing form. When the Hebrews returned from exile they used Aramaic speech and writing for everyday affairs and Hebrew speech and writing for religious purposes. Slowly, however, they began to switch over to writing Hebrew in an Aramaic script, which by the time of the Diaspora had evolved into the square Hebrew now in use. The ancient Hebrew script came to a dead end in its evolution. It did not die, however, for it was preserved by the Samaritans, who live in the Palestinian town of Nablus (ancient Shechem) and use it to this day for their religious writings.

The Hebrews were the first people to create a nonmythologi-

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Alphabet, Monotheism, and the Hebrews, the People of the Book

The Hebrew Script

The appearance of the phonetic alphabet among the Semitic peoples in Canaan (Palestine) and Sinai in the middle of the second millennium B.C. marked the beginning of a new period of creativity that would take Western civilization beyond the Sumer-Babylonia cultural achievements of syllabic writing and codified law. The Proto-Canaanite (or Proto-Sinaitic) alphabet based on twenty-two uniconsonantal signs was adopted by a number of Semitic nations, including the Canaanites, the Phoenicians, the Midianites, the Aramaeans, the Nabateans, and the Israelites or Hebrews. Of all the peoples whose writing systems directly descended from the Proto-Canaanite alphabet, the Hebrews were most influenced by the alphabet effect. They became

cal history of themselves. All other histories—those of the Babylonians, the Egyptians, the Greeks—trace the origins of their people to the beginning of the universe. The story of the Hebrews as recorded in the Bible is more realistic. It begins with the departure of Abraham from his father, Terah, in the city of Ur of the Chaldees (Mesopotamia). Aside from its religious and metaphysical significance, the Bible is a fascinating, unique historical record that documents the transition of a people from an oral, traditional, and tribal society to a literate, highly organized nation engaged in international affairs.

The Contribution of Moses

The outstanding achievement of the Bible, however, is not its historicity but its abstract theology. The Bible represents the first expression and articulation of the concept of the belief in one god. Monotheism, the cornerstone of all Western religion (Judaism, Christianity, and Islam), is a unique invention of the Israelites, and its formulation by Moses, we shall show, was influenced by his use of the phonetic alphabet. In fact, it is our hypothesis that the phonetic alphabet, monotheism, and codified law were introduced for the first time to the Israelites by Moses at Mount Sinai in the form of the Ten Commandments.

Not only was the concept of monotheism a new idea for the Israelites but so were the use of writing and codified law. Individual Israelites such as Moses were acquainted with Egyptian writing but the general population, a nomadic people serving as slaves in Egypt, were nonliterate. We have therefore assumed that the introduction of monotheism, alphabetic writing, and codified law at Mount Sinai represented three separate innovations for the Hebrew nation.

The primary source of historical evidence upon which we have constructed our hypothesis is the Bible itself, backed by archaeological and epigraphic material that support the historical basis of the Scriptures. The historical validity of the Bible has been

confirmed by many scholars,^{1,2,3} including the material from the Patriarchal Age that has been preserved by the oral tradition. "The historical background of the Torah is authentic. Although its history is legendary, it is grounded on a tradition that has a sound basis. The Torah correctly represents Israel as a young nation."³

Only the earlier material, Genesis Chapters 1-11, containing the stories of the Creation and the Flood, are not historical material but are pure myth and folklore, parallels of which are found in Sumerian and Babylonian mythology.⁴ The stories of the Patriarchs, Abraham, Isaac, and Jacob, however, have a basis in reality and have been shown to be consistent with other non-scriptural historical evidence.⁵ The Hebrew people during the Patriarchal Age were a band of seminomadic tribesmen driving their herds from one favorable pasturage to another. Their passage from northern Mesopotamia to Canaan appears to have been motivated more by religious factors than by the need for new pasturage as Genesis 12:1-2 suggests: "Now the Lord said unto Abram, Get thee out of thy country, and from thy kindred, and from thy father's house, unto the land that I will show thee: And I will make of thee a great nation."

The Advent of Monotheism

The theism of the Patriarchs was not the same as the monotheism of Moses. The God of the Fathers, that is, the God of Abraham, the God of Isaac, and the God of Jacob, while a more sophisticated concept than those of their contemporaries, does not rival the abstractness of the Yahweh of Moses.

One of the unique features of the Patriarchal God that distinguishes him from his more mundane rivals is the fact that this God is not tied down to a fixed spot or geographical feature like the other gods but is already of a more universal nature. "Abraham's god . . . is a wanderer like himself. He has no fixed spot, no 'house'; he wanders hither and thither."⁶ The seminomadic

existence of the Patriarchs affected their conceptualization of their deity. Their idea of a wandering god, a god of no fixed place, was incorporated into the monotheistic notions of god developed later by Moses under the influence of literacy.

The God of Abraham, the God of Isaac, and the God of Jacob are not necessarily the same God. The Bible provides us with a number of examples that the Israelites worshiped idols both during the Patriarchal Age and during the time leading to the giving of the law on Mount Sinai. In Genesis Chapter 31 we find the episode in which Rachel successfully steals her father's idols. Evidence that idol worship was part of the common practice of the Israelites is found in Exodus 32 when the people, despairing of Moses' return from the mountain, ask Aaron: "Make us gods, which shall go before us; for as for this Moses, the man that brought us up out of the land of Egypt, we know not what is become of him." Aaron complied with their wishes and fashioned them a golden calf, which they worshiped.

Further evidence for the polytheistic practices of the Hebrews during the Patriarchal Age is found in the Haggadah, which is recited each year at the Jewish Passover feast: "In the beginning our fathers were worshippers of idols, but now the Ever-Present has brought us to His service, as it is said: And Joshua spoke to the whole people: Thus has the Lord, God of Israel spoken: Your fathers dwelt in olden times beyond the River Euphrates, Terah, the father of Abraham and the father of Nachor, and they served other gods."

The Hebrews were still serving other gods in the time of Moses as indicated by the following passage from Leviticus 17:7: "And they shall no more offer their sacrifices unto devils, after whom they have gone awhoring." The use of the wording "they shall no more" indicates that idol worship was once a common practice among the Israelites.

Additional evidence that Moses introduces a new form of worship can be deduced from the fact that in the biblical accounts of the Patriarchs, the deity is always referred to in the

original Hebrew as Elohim, which etymologically derives from the plural term for "god" and hence translates literally into "gods." Beginning with Moses the deity is referred to by the tetragram YHWH (sometimes written as Yahweh or Jehovah). It is in Exodus 6:2 that God reveals this new name to Moses: "And God spake unto Moses, and said unto him: I am the Lord; and I appeared unto Abraham, unto Isaac, and unto Jacob, as God Almighty, but by my name YHWH was I not known to them." Not only are the Patriarchs ignorant of His name but they do not follow the pattern of the later leaders of the Israelites who prophesy and preach against idolatry.

The role of Abraham was not that of the founder of the Israelite religion; that belongs to Moses. The Patriarchs are rather a historical link of godfearing men that joins the Hebrew nation to the first generation of men, the legendary generation of Adam, Enoch, and Noah. Abraham is portrayed as a moral and just person but not really as a "fighter for YHWH." While legends have conferred upon Abraham the honor of Patriarch of Israel, historical analysis reveals that he is not the founder of monotheism. "The absence of the essential motifs of Israelite religion in patriarchal times indicates that it was not then that the monotheistic idea came into being."⁷

The Written Law

Having established the absence of monotheism during the Patriarchal Age, we must also show that writing and codified law were also absent. No reference to writing is ever made in Genesis, even on a number of occasions when one would expect a written record to be made if writing were part of the culture. Abraham's purchase of a burial place for Sarah from Ephron the Hittite in Genesis 23 provides one such example. The deal is sealed by the exchange of 400 shekels of silver "in the hearing of the children of Heth." No receipt is drawn up. Another example is provided in Genesis 31:48 where Jacob and Laban record a cov-

enant between them by building a heap of stones. "And Laban said, This heap is witness between me and thee this day." The absence of writing also precludes the possibility of a system of codified law. No mention is ever made of any laws in Genesis. Summarizing our results, the evidence from the Bible suggests that the Israelites whom Moses led out of slavery in the land of Egypt were a preliterate nomadic people without a codified system of law, who worshiped more than one god.

Before beginning the story of how Hebrew culture was radically transformed by the innovations of alphabetic writing, codified law, and monotheism introduced by Moses, we must first examine the context of the rich cultural milieu in which the Israelites operated. There were many influences at work that prepared the ground for the ideas Moses was to introduce. The three principal sources of cultural influence were Mesopotamia, from which Abraham departed; Canaan, where the Patriarchs first settled; and Egypt, the land where Israel was in bondage and where Moses was born and educated.

From Mesopotamian culture the Israelites derived "Biblical legend (especially concerning primeval times), law (especially the Covenant Code, Ex. 20:19-23:33), hymnody, and wisdom literature."³

From the Canaanites they derived alphabetic writing, a linguistic transformation from the Canaanite to the Aramaic dialect, the type of poetry found in Psalms, divine names (*el*, *baal*, and *adam*), sacrificial practices and terminology, and a number of legends including those of David, Noah, and Job.

From the Egyptians are derived many stories, hymns, names, and a concern with magic. Another possible influence, less easy to trace but often mentioned, is the religious ideas developed during the time of Akhenaton, particularly the worship of the sun disk, Aton. While Aton worship was not exactly monotheistic, some parallels with the religious ideas of Moses are apparent.

Moses did more than bring the Hebrews out of slavery in the land of Egypt, he brought them a new concept of God, a codi-

fied system of law and alphabetic writing. As related in Exodus, the Israelites enter a covenant with their deity under the leadership of Moses and receive a written form of the law: "And he gave unto Moses, when he had made an end of communing with him upon Mount Sinai, two tables of testimony, tables of stone, written with the finger of God" (Ex. 31:18).

It is our claim that the events on Mount Sinai represent the historic transition of three separate innovations in the cultural and religious life of the Israelites, namely:

1. Their first use of an alphabetic script
2. Their first adherence to a codified system of law and morality
3. Their first acceptance of a true and complete form of monotheism

The concepts of codified law and alphabetic writing were ideas that the Hebrews borrowed from other cultures but the introduction of monotheism at Mount Sinai represents a historic first for all of mankind.

The occurrence of monotheism, codified law, and the alphabet all at the same moment in history cannot have been coincidental. While not suggesting a causal link, it is possible that these ideas influenced each other. The abstractness of the three innovations were mutually reinforcing: "The written letter replaced the graven image. Concentration on the abstract in writing opened the way for an advance from blood relationship to universal ethical standards, to the influence of the prophets in opposition to the absolute power of kings, and to an emphasis on monotheism."⁸

Y. Kaufman,³ the noted historian of the early Israelite religion, saw another link between monotheism and the written law. It was not the content of the law that was the new element, since the laws of the covenant can largely be traced back to Sumerian and Babylonian codes. What is new and unique is the manner of the presentation, namely, directly from God—in fact,

"written with the finger of God" (Ex. 31:18). "This law was the command of a God, his absolute will."⁹ Before providing the case for our hypothesis that the stone tablets Moses brought down from Mount Sinai were inscribed with an alphabetic script, let us first make the case that literacy among the Israelites as a nation begins with Moses. As mentioned earlier, there are no biblical references to writing until we come to the time of Moses, at which point there are a large number of such references including those in which Moses is actually writing down the law: "And Moses wrote all the words of the Lord" (Ex. 24:4; see also Deut. 31:9 and 24).

Or where God instructs Moses to write down the law: "And thou shalt write upon them all the words of this law" (Deut. 27:3; see also Ex. 34:27).

There are other instances in which God is credited with having written the law himself:

1. I will give thee tables of stone, and a law, and commandments which I have written; that thou mayest teach them (Ex. 24:12).
2. And the tables were the work of God, and the writing was the writing of God (Ex. 32:16).
3. See also Ex. 31:18, Ex. 34:1, Deut. 4:13, Deut. 5:22, Deut. 9:10, Deut. 10:2-4, Deut. 28:58 and 61, Deut. 29:27, Deut. 30:10.

And finally we find the following three passages that make the first references to the reading of the law:

1. And he [Moses] took the book of the covenant, and read in the audience of the people (Ex. 24:7).
2. And Moses commanded . . . thou shalt read this law before all Israel (Deut. 31:10-11).
3. And afterward he [Joshua] read all the words of the law (Josh. 8:34).

The Hebrew tradition of reading out the law before the assembled nation, which began with Moses, persists to this day in the form of Torah readings in synagogues.

In addition to its association with the law other references to writing appear for the first time in the account of the life and times of Moses. These include:

1. The use of the metaphor of the book (Ex. 17:14 and 32:32)
2. Signet engravings (Ex. 28:21 and 36)
3. Written names (Num. 17:2-3)
4. Records of events (Num. 33:2)
5. A written bill of divorce (Deut. 24:1 and 3)
6. A written song (Deut. 31:19 and 22)

The references to writing in Exodus are more significant as evidence for Hebrew literacy at the time of Moses than those in Deuteronomy because the oldest strands of the Torah are contained in Exodus.¹⁰ The claim that the description of the events at Mount Sinai was composed five or six hundred years later, after the Hebrews returned to Israel from exile in Babylonia, is not valid. Kaufman¹⁰ has carefully analyzed the complex set of laws on tithing and has been able to unscramble the various bodies of law in the Pentateuch. He was led to the conclusion that although the Torah was first compiled in the beginning of the Second Temple period, the laws had already crystallized and therefore the compilers "did not alter anything of what they found written much less add to it." The accounts in Exodus referring to the first appearance of writing and to the key role it plays in the revelations that take place at Mount Sinai have a valid kernel of historic truth. Next we must establish that this writing was alphabetic.

This hypothesis is consistent with epigraphic records that indicate that at the time of Moses the Proto-Canaanite (or Proto-Sinaitic) alphabet was in use in both Canaan and the Sinai pen-

insula.¹¹ As mentioned, some of the earliest inscriptions were found in and near the Egyptian copper mines in the Sinai. The people who made these first alphabetic inscriptions are none other than the biblical Midianites.¹² (In the Bible [Num. 10:29 and Judges 4:11] they are also called Kenites, a term that means "belonging to the coppersmiths"; Midian is rich in copper ore.¹³) In fact, Sprengling has hypothesized it is they who actually invented the original phonetic alphabet after borrowing a number of ideas about writing from the Egyptians.¹²

Moses lived with the Midianites for a number of years. He married Zipporah, the daughter of the Midianite leader, Jethro, with whom he had two sons. Moses could have easily learned alphabetic writing from his father-in-law, who was the high priest of the Midianites. Moses, having grown up in the house of the pharaoh, was probably already familiar with Egyptian writing. Learning the simpler alphabetic system would have been an easy task. It is therefore not difficult to believe the biblical account of Moses delivering the law to the Hebrew people in a written form. Other references to writing appear for the first time in the scriptural account of the life and times of Moses, from which we may conclude that writing had been adopted by the Hebrews by this time.

No mention of laws or commandments is found in the Torah until we encounter Moses. According to these accounts, he is solely responsible for the transmission of God's commandments. No other lawmaker is mentioned during the period of the Exodus other than Moses. It is apparent from the consistency of all these accounts that he is in fact the historical figure who gave the Israelites the concept of law. While not all aspects of the Mosaic law we encounter in the Torah are original, the Ten Commandments are without a doubt a unique element, which created a new level of morality not previously known to mankind.

The law of the Torah parallels in many ways the second-millennium Mesopotamian law codes such as those of Hammurabi

and others. Some connection must be assumed between the Israelite and Mesopotamian legislation. "But that Moses was the great law giver need not be questioned. Though he did not write all the laws of the Pentateuch as tradition had it, he laid down the constitutive stipulations of covenant to which all specific law must conform, and whose intent it must seek to express."¹⁴

The Mosaic God

Next we come to the question of establishing the historical uniqueness of the Mosaic concept of monotheism. "It is not an arithmetic diminution of the number of gods, but a new religious category that is involved."¹⁵ Many new features incorporated in the Mosaic God never appeared until the revelation at Mount Sinai. As we shall show below, these new aspects of the deity and the way in which he is worshiped reflect the effects of alphabetic literacy. The God of the revelation and the covenant on Mount Sinai represents a new concept of the deity as is reflected in the name YHWH.

The God of the Patriarchs was not tied down to a physical place or shrine. He wandered with his people. The God of Moses takes on an even more abstract formulation, reflecting the abstraction of alphabetic writing. As was pointed out by Innis,⁸ YHWH is invisible to his people. He cannot be looked upon or the people will perish (Ex. 19:21). The people are forbidden to make any images of their God or any gods for that matter (Ex. 20:4). Yahweh sits in his tabernacle upon the mercy seat situated on the wings of the two cherubim, which is placed upon the ark containing the testimony of his law, but he is invisible (Ex. 25:17-22). This extremely abstract formulation of the deity produces tremendous strains in the spiritual life of the Israelites. They are constantly returning to the worship of idols, as the story of the golden calf illustrated. Throughout their history they have to be reminded by their prophets to put aside their graven images.

A frequent representation of deities in preliterate cultures is in terms of a force of nature such as a storm god or a fertility god. "Yahweh, on the contrary, was a God of a wholly different type. He was identified with no natural force, nor was he localized at any point in heaven or on earth."¹⁶ Although he controls storms (Psalm 29), the elements (Judg. 5:4, 21); the heavenly bodies (Josh. 10:12ff.), and fertility (Gen. 49:25, Deut. 33:13-16), he is not a storm god, a sun god or a fertility god.

"Yahweh was powerful over all of nature, but no one aspect of it was more characteristic of him than was another."¹⁶ The relationship between God and nature changes with the monotheism introduced by Moses. In the pagan belief systems, no matter how powerful a god became, even if he was able to dominate momentarily over all the other gods, he was still not in control over his own fate. There were always mysterious or magical forces to which he was subject and which could frustrate his will. With Moses a new concept of the deity develops and creates a new religious idea that will later come also to shape Christianity and Islam.

The basic idea of Israelite religion is that God is supreme over all. . . . He is utterly distinct from, and other than, the world; he is subject to no laws, no compulsions, no powers that transcend him. He is, in short, nonmythological. This is the essence of Israelite religion, and that which sets it apart from all forms of paganism.¹⁷

Within the context of Hebrew religious thought, "nature," while still regarded as a living entity, was robbed of its personality and "de-mythed." Once the Greeks became literate, they also "de-mythed" nature and developed a notion of causality to explain its actions. This led to their scientific approach to the description of nature. A similar development occurred with the Hebrews but with different consequences. They also developed a notion of causation, but the prime cause they attributed to Yah-

weh. In fact, the name Yahweh incorporates the notion of causing to come into being. "The enigmatic formula in Ex. 3:14, which in Biblical Hebrew means 'I am what I am,' if transposed into the form in the third person required by the causative Yahweh, can only become 'Yahweh asher yihweh' (later yihyeh), 'He Causes to Be What Comes into Existence.'"¹⁸ The Hebrew notion of causation did not develop along the logical scientific lines of the Greeks. Rather, they incorporated it into their unique sense of history, with its promise of the future, the Promised Land, and their role as the Chosen People.

The Alphabet and Hebrew History

Israel's religion and notion of God are deeply rooted in her historical experiences, in her deliverance from slavery in Egypt and the theopolitical covenant she reached with God under the leadership of Moses. The idea of the covenant and the promise of the future dominated the religious life of Israel and shaped her notion of nationhood.

The sense of striving for a future promise is reinforced by the prophets. The sense of history is reinforced by the forms of worship in which there are constant reminders of the historic events of faith through the periodic reading of the law as required by Deuteronomy 31:11. There is also the biblical injunction to the Israelites to celebrate the feasts in which the covenants of the past are renewed (Deut. 16:16), and through the commandment to teach the young. "And these words, which I command thee this day, shall be in thy heart; and thou shalt teach them diligently unto thy children" (Deut. 6:6-7).

The teaching of the young took two forms, one oral and the other literary. Each Hebrew son was to be taught to read the law. The Israelites were the first people to achieve a universal level of literacy, an accomplishment that required a relatively easy system of writing. This is exactly the role that the phonetic alphabet fulfilled. Only twenty-two signs had to be learned, plus

the principle of phonetics. Any child could learn to read at a very early age (three to eleven years).

Alphabetic literacy helped the Hebrews develop a historic sense. The other literate cultures of the ancient world, the Sumerians, the Babylonians, the Assyrians, the Hittites, and the Egyptians, also recorded historical events, but their historiography was very crude. Events were recorded in isolation. The Hebrews connected the events and imbued them with purpose. They also had a measure of objectivity, recording both the events of which they were proud and those of which they were ashamed. The Egyptians, on the other hand, recorded only their victories, never their defeats. (The Greeks eventually developed objective methods similar to those of the Hebrews after they adopted the alphabetic writing system.) The outstanding pioneer of Hebrew history was Ahimaoz, the author of the Book of Samuel. "Ahimaoz . . . is [the father of history] in a much truer sense than Herodotus half a millennium later. Without any previous models or guides, he wrote a masterpiece, unsurpassed in historicity, psychological insight, literary style and dramatic power."¹⁹ The influence of alphabetic writing is reflected in the codification of the law introduced by Moses and the historiography that follows this development with its new spirit of analysis and objectivity. A similar influence is felt in the political structures that begin to emerge with the political leadership of Moses.

The Impact of Writing on Hebrew Political Organization

During the Patriarchal Age, the Hebrews were a seminomadic tribal people organized by clans and following a charismatic leader. Under the leadership of Moses, a similar structure persisted; Moses served as a leader, a lawmaker, and a judge. However, there was now an awareness that these were three separate activities. One of the effects encouraged by the phonetic alphabet discussed earlier is the fragmentation of social roles and activ-

ities, including the separation of the executive, legislative, and judicial aspects of government and the bureaucratization of these functions. Moses at the suggestion of his father-in-law, Jethro, created the first bureaucracy in the history of the Hebrew nation. Finding that too much of his time was occupied in settling the disputes between neighbors that require an interpretation of law, Moses divided the caseload by creating a hierarchy of rulers and judges to help him. "And Moses chose able men out of all Israel, and made them heads over the people, rulers of thousands, rulers of hundreds, rulers of fifties, and rulers of tens. And they judged the people at all seasons: the hard cases they brought unto Moses, but every small matter they judged themselves" (Ex. 18:25-6). And in this manner Moses ruled and judged over the Israelites until he died and his leadership passed to Joshua who had served as his chief military lieutenant.

The Hebrews entered Canaan, the Promised Land, under the leadership of Joshua. Through military conquest they acquired a modest foothold in the land. The Hebrews returning from Egypt formed an alliance with those Hebrews who had remained in the land during the time of the enslavement in Egypt. Together these tribes formed a loose decentralized confederation. The twelve tribes of the confederation would sometimes cooperate on ventures of mutual interest and at other times fought among themselves. Their structure was somewhat like that of ancient Greece during its tribal period. Disputes between tribes were settled by a judge. The judge was often chosen, as was the case with Joshua, because of his charismatic qualities, but he was not always followed. In times of war he would lead a coalition of tribes, but there was a reluctance on the part of the fiercely independent tribes to have a centralized authority like a king. Gideon, a very popular judge, was once offered the crown but refused it because he believed it was not in the spirit of YHWH.

The threat of conquest by the Philistines, who held the coastal regions, required extreme action on the part of the Israelites. Under the prompting of Samuel, the prophet and priest, Saul, a

charismatic leader, was made king over Israel. Saul defended Israel but tribal structures remained strong during his reign because he failed to develop a rational administrative machinery or bureaucracy.

During this period there arose another charismatic leader, David, of whom Saul was greatly jealous. David, forced into exile, became a vassal of the Philistines and created his own private army. When Saul was killed in battle against the Philistines, David was elected king by his native tribe of Judah. Saul's son Eshbaal became king of the remainder of the Hebrew tribes, a kingdom that took the name Israel. Internal strife within the house of Saul brought down Eshbaal, and David soon became king of both Judah and Israel. David then embarked on an extremely successful campaign of conquest in which he defeated the Philistines, the perennial enemies of Israel, and destroyed the remaining pockets of Canaanite power including that housed in Jerusalem. He also conquered the surrounding states such as Ammon, Moab, Edom, and Aram. David's success was due largely to his private army although the other tribes fought alongside him. David made Jerusalem the capital city and created machinery that divided the kingdom into taxation and administrative districts. There was a great deal of court intrigue and feuding, which David kept in check with his private army. Israel was no longer a tribal confederacy but a centrally ruled monarchy.

During King David's time writing was no longer used merely for ceremonial or legal purposes but for literature. David's reign marks the beginning of the compilation of the Scriptures. The correlation between the increased use of alphabetic writing and the beginnings of an administrative bureaucracy is not accidental.

King David was succeeded by one of his younger sons, Solomon, who was able to politically outmaneuver his rivals. Solomon did not increase the size of David's empire but consolidated his holdings and exploited them for economic gain. Making use of diplomatic channels opened by his father, King Solomon en-

tered into an alliance with the Phoenicians under King Hiram of Tyre. He opened trade routes to southern Arabia and Africa using ships built by the Phoenicians. Other large-scale operations such as development of the copper industry and the establishment of a monopoly in horse and chariot trading were established. Solomon displayed brilliant organizational skills, which no doubt were aided by the increased level of literacy that developed during his regime. Solomon's projects were examples of state capitalism in which capital was raised by heavy taxation. Labor was conscripted by the government from among conquered people. An urban proletariat was created and class structure developed. King Solomon maintained control of his political-economic empire by using repressive Machiavellian techniques. Tribal democracy was destroyed by Solomon and people were no longer equal. Literacy seems to have created privilege.

In addition to the increased economic activity, culture flourished under King Solomon. A large-scale building program produced both the imperial residence and the Temple. Psalmody, music, wisdom literature, and historical writing flourished. The centralization of the political structures and religious activities in Israel that begins with the reign of David parallels the development that occurred in other cultures as they became literate.

Literacy, particularly alphabetic writing, with its stress on linearity and uniformity encourages centralization of social functions such as religion. This process is described in Deuteronomy, which was written during the time of King David. The other books of the Pentateuch do not stress the importance of Jerusalem, since they were written (but not compiled) before the time of David and reflect the attitudes then prevalent in Israel. With David's conquest of Jerusalem and the setting up of the Ark of the Covenant on the Temple Mount in Jerusalem, the centralization of Israel's spiritual life began. This was further reinforced by the prohibition against certain practices such as making sacrifices

in the former holy places scattered about in Israel and Judah, including such sites as Shechem, Bethel, Dan, Gibcon, and Beer-sheba. These restrictions first appear in Deuteronomy: "Take heed to thyself that thou offer not thy burnt offerings in every place that thou seest; but in the place which the Lord shall choose in one of thy tribes" (Deut. 12:13-14).

6

The Phonetic Alphabet and the Origins of Greek Science and Logic

Alphabet: Fount of Western Civilization

The Greek alphabet is directly derived from the North Semitic alphabet as a result of commercial contacts with the Phoenicians. This fact is recorded by Herodotus in the fifth century B.C.:

Now the Phoenicians who came with Cadmus introduced into Greece upon their arrival a great variety of arts, among the rest that of writing, whereof the Greeks till then had, as I think, been ignorant. And originally they shaped their letters exactly like all the other Phoenicians, but afterwards in course of time, they changed by degrees their language, and together with it the form likewise of the characters. Now the Greeks who dwelt about those parts at that time were chiefly the Ionians. The Phoenician letters were accordingly adopted by

them, but with some variation in the shape of a few, and so they arrived at present use, still calling the letters Phoenician, as justice required, after the name of those who were the first to introduce them into Greece (Herodotus 5.58).

The Greek alphabet complete with vowels represents a unique achievement in man's capacity for rendering his spoken language into a totally accurate written form; it went beyond anything that preceded it and has not been equaled since.

The five or six hundred years that followed the transfer of the phonetic alphabet from the Phoenicians to the Greeks was one of the most creative periods in man's existence. Within this short period there appeared many of the elements of Western civilization—abstract science, formal logic, axiomatic geometry, rational philosophy, and representational art. It is not an accident that this unparalleled intellectual development occurred immediately following the transfer of the phonetic alphabet. While a causal connection is not being suggested, it is apparent that the alphabet helped create the unique conditions for this development. In the next two chapters we will look at how the alphabet stimulated the abstract and rational system of thought that characterized ancient Greek culture and subsequently all of Western civilizations.

The Greek Alphabet:

The Penultimate in Phonetic Literacy

How did the Greek phonetic alphabet differ from the Phoenician alphabet and why did it have such an enormous impact on Western thought? The Greeks modified the Phoenician system of twenty-two uniconsonantal signs by adding vowels and three extra consonants to duplicate sounds that occur in Greek but not in Semitic tongues. Seven vowels signs were created by converting five unstressed Semitic consonants (which sometimes served as vowels in Semitic writing) into pure vowels and by

adding two new letters. Otherwise the Greek alphabet took on the same names, sound values, and order as the Semitic alphabet: The Semitic letter *aleph* became *alpha*; *bet* became *beta*; *gimmel* became *gamma*.

These seemingly minor changes completely revolutionized writing and enabled the Greeks to accurately and completely transliterate every spoken word into a unique visual sign and each array of visual signs into an unique spoken word. "The original Greek invention achieved the essential task of analysis and it has not been improved upon."¹ Havelock makes this claim for the Greek alphabet because it satisfies the three conditions² necessary for an efficient and passive writing system of which the reader is unaware: 1) coverage of all linguistic sounds, 2) lack of ambiguity, and 3) a restricted number of elements or letters (twenty to forty). While the North Semitic alphabet comes close to this ideal, it contains a number of ambiguities due to its lack of vowels.

Havelock attributes the success of the Greek system to the fact that reading could be taught to young children before they learned other skills.³ This is one of the advantages of the Greek alphabet over the North Semitic alphabet. In fact, after the invention of vowels by the Greeks, the Hebrew writing system was modified to include vowels as subscripts under the consonants largely for the purpose of teaching reading to children. The sub-scripted vowels are not used in adult literature. The Greek alphabet completely revolutionized reading and writing and its instruction by simplifying and speeding up these processes. The changes that the Greek alphabet produced, however, extended beyond the boundaries of literacy into all aspects of Greek intellectual life.

Techniques of Education and Information Storage in a Preliterate Society

Before examining the effects of the alphabet on Greek culture and society, let us first see how cultural continuity was main-

tained and how information was transmitted from one generation to another before the advent of literacy. Essentially the learning and the wisdom of a society were passed on through epics, sagas, or myths that were recited from memory.

The bard Homer, for example, was "at once a storyteller and also a tribal encyclopedia,"⁴ who provided all the information necessary for life in tribal Greek society. From Homer the listener could learn how to rig a sailing ship, how to dress for battle, and how to behave in court. Woven around the tales were the essential lore and wisdom of the culture. The customs of the society were taught by example, not by prescription. "The warp and woof of Homer is didactic, and . . . the tale is made subservient to the task of accommodating the weight of educational materials which lie within it."⁵

The reason the "tribal encyclopedia" took the form of poetic epics was to ensure the preservation of this vital information through memorization. The imagery, story lines, meters, rhythms, and rhymes of the epics all served as devices aiding this process. The poetic conventions and standardized imagery that were essential to the memorization of the myths and sagas had the hidden effect of severely limiting the kinds of things that the culture could transmit and hence could think about. Let us consider the personification of the natural forces in the form of the Greek gods as one example. This device, which made the Greek myths so vivid and hence easily recallable, severely limited the preliterate Greek's capacity to conceptualize natural forces. Consider how far science would have developed if the natural forces had never been abstracted but continued to be personified and represented as gods.

Nursery rhymes and nonsense verses are another example of material easily remembered because of its rhymes and meters but limited in content by its form. Nursery rhymes serve an important role in an oral society. They prepare children for the more arduous task of memorizing more meaningful and lengthier material. Nursery rhymes are the ABC's of an oral culture.⁶

The Transition to Alphabetic Writing

From a comparison of the early Greek scripts with the Phoenician scripts, Rhys Carpenter⁷ claimed that the Greek alphabet first appeared in Rhodes or Cyprus somewhere around 700 B.C. Joseph Naveh in a more recent study⁸ has determined that the transfer occurred much earlier than this and pushes the date of the borrowing as far back as 1100 B.C. If Greek tradition be any guide to the dating of the transmission of the Phoenician alphabet, then the date of 1300 B.C. assigned to Cadmus by the Greeks would favor Naveh's dating rather than Carpenter's.⁹ Independent of the actual date of this borrowing, we know that the Greek phonetic alphabet spread from the Greek Islands and Ionia to Athens and the remainder of the Greek mainland, and then to the western colonies in Italy. The Etruscans used the Greek alphabet to transcribe their language in the seventh century B.C. and eventually passed the alphabet on to the Romans. Given this early date for the Etruscan use of the alphabet, the Naveh chronology makes more sense than that of Carpenter, considering the time that would be required for the alphabet to develop and spread from Ionia, to Italy, and possibly through mainland Greece.

The tremendous impact of alphabetic writing on Greek thought was not uniform. Its impact on Ionia and Athens was much greater than elsewhere. We may thus conclude that while the alphabet served as a model for several intellectual breakthroughs, it was only a *sufficient* condition for these breakthroughs, not a *necessary* one. Not all communities that adopted the alphabet were affected by it as much as the Greeks. Nor was the impact of the North Semitic alphabet uniform. The Hebrews were more affected by it than the other Semitic peoples who adopted it. And the impact of the alphabet was not immediate. It took about five hundred years for literacy to take hold of the Greek mind, and a similar period elapsed between the introduction and widespread use of literacy among the Hebrews.

The psychic habits of centuries could not be broken quickly, especially when—and this is very important—they had exploited all the resources of sensory pleasures.¹⁰

The Effects of Alphabetic Writing on the Greeks

With the advent of literacy and the use of the alphabet, the transmission of ideas from one generation to another no longer required thoughts to be expressed in stylized poetry for the sake of memorization. The alphabet made possible the preservation of prose, which imposes no formulae or conventions on the ideas expressed. This fact, coupled with the model of abstraction that the alphabet provides, produced an enormous change in the nature of Greek thought.

Perhaps the most striking effect of the alphabet was the great number of new abstractions that appeared almost simultaneously. All spoken words are abstractions of the things they represent. The written word is a further abstraction of the spoken word, and phonetic letters give it an even greater abstraction than ideographs or pictographs. The use of the alphabet thus involves a double level of abstraction over a spoken word because the transcription of a spoken word takes place in two steps. A spoken word is first broken up into semantically meaningless phonemes or sounds, and the sounds are then represented by semantically meaningless signs, the letters of the alphabet.

The impact of alphabetic writing can be traced by noting the increase in abstract thought and language that occurred as Greek literature progressed from Homer to Hesiod to the Pre-Socratic philosophers and then to Plato and Aristotle. There are abstract notions in Homer such as the goddess Memory or the Furies. These abstractions, however, must always be visualized, personalized, and cast within the context of the narrative of local events that limit their universality. This lack of abstraction and universality is to be expected with Homer because his poetry is composed strictly within the oral tradition. With Hesiod, how-

ever, the alphabet begins to make its mark as a new level of abstraction first takes hold of the Greek mind.

With literacy they [the Greeks] suddenly saw their universe as ordered. Their new world view, however, was in conflict with the vocabulary they inherited from their oral tradition.¹¹

Under the influence of alphabetic literacy, Greek writers created the vocabulary of abstract thought that is still in use to this day, notions such as body, matter, essence, space, translation, time, motion, permanence, change, flux, quality, quantity, combination, and ratio. These terms and concepts became the language of philosophy. A rational approach to analyzing problems logically and finding solutions to them developed. Ideas such as truth, beauty, justice, and reason took on new meanings and became the subject of a new type of discourse.

Havelock notes that the way in which statements of knowledge are made in the oral and literate tradition are quite different.¹² Statements in the oral tradition must be made in the context of events in real space and real time. It is only with alphabetic literacy that timeless analytic statements emerge that can express universal truths independent of the context in which they occur. The statement "Two plus two is four" is an example of an analytic statement. The same information contained with the context of a narrative would not have the same impact.

Another important difference between the oral and literate tradition is the way in which information is organized. Homer's epic served as a "tribal encyclopedia," but there was no attempt to systematize the information contained in his hidden curriculum. The order in which information useful to everyday life appeared was determined by the story line of the narrative. The Greek philosophers of the classical period, in contrast, took extreme pains to systematize their material and present it in a particular order dictated by logic or reason.

Science Takes Root

Hesiod, thought to be the first Greek author to write down his compositions, represents the transition point between Greek philosophy and science on the one hand and the tribal and oral tradition on the other hand.^{13,14} "Hesiod, though he knows Homer, belongs to a different intellectual and economic climate."¹⁵ Kenyon presents a very compelling argument for the thesis that Hesiod's poems were composed in a written rather than an oral form. He argues that Greek bards would have taken the trouble to memorize Homer's popular legends of the gods and heroes. They would not have done the same, however, for Hesiod's *Works and Days*, with its "combination of a purely personal quarrel with agricultural precepts."¹⁶

Although he deals with the same mythic material as Homer, Hesiod orders his material into a definite pattern. Hesiod introduces the gods to the Pantheon systematically at the beginning of his *Theogony* and then goes on to explain the creation of the universe, whereas Homer introduces the gods as they arise in the course of his narrative. Hesiod's systematic treatment of nature represents the beginning of Greek scientific thought, even though Hesiod still holds to traditional views of creation. "He was an innovator in theology and science. His systematization and his presentation . . . of a process of reasoning rather than a statement of conclusions, made him a significant pioneer in the field of Greek science."¹⁷ Hesiod is best known for his stories about the gods, but he also wrote extensively about astronomy, agriculture, and even metalworking.¹⁸ His major innovation was the literary style he employed. Although he wrote poetry, he led the way toward a prose style through his careful and systematic organization of his narrative material. This innovation and achievement of Hesiod, however, was only partial since he still developed his narrative as a series of events or happenings. The creation of the world is portrayed in terms of the activities of the gods, albeit the language in which the tale is cast is abstract and elements of classification abound.

The device exploited by the poet for organizing his panorama of living forces is the family—the genos, or genece. This concrete device is used to arrange a hundred phenomena in congruent groups. A step has been taken towards classification and even towards establishing a chain of cause and effect. The genos is on the way to becoming the "genus" or class.¹¹

The contribution that Hesiod made under the influence and the impact of the alphabet was classification or systematization. The alphabet is a natural classification scheme for words as anyone who has used a dictionary or a filing system is well aware. What distinguishes science, a term derived from the Latin word *scire* "to know," from knowledge is the organization of that knowledge. We shall encounter many examples of systematization and classification in early Greek science.

In addition to serving as a paradigm of abstraction and classification, the alphabet serves as a model for division and fragmentation. With the alphabet every word is fragmented into its constituent sounds and constituent letters. The Greeks' idea of atomism, that all matter can be divided up into individual distinct tiny atoms, is related to their alphabet: "Atomism and the alphabet alike were theoretical constructs, manifestations of a capacity for abstract analysis, an ability to translate objects of perception into mental entities."¹⁹

The capacity for fragmentation and separation extends far beyond the Greek concept of the atomism of matter. With writing, what is recorded or remembered becomes separate from the writer. It stands alone in a book or a scroll independent of the context of the person who originated the ideas or the information. Knowledge begins to take on an identity separate from the knower. The Greeks through writing developed a notion of objectivity—the separation of the knower from the object of his study. This is the beginning of the scientific method and the source of the dichotomy the Greeks created between subjective and objective thinking. Poetry and art are examples of subjective

thinking, whereas philosophy and science are examples of objective thinking.

In addition to objectivity, the alphabet provided the Greeks with a number of other paradigms that proved useful to their development of science. The abstraction and systematization that the use of the alphabet encouraged were two of the characteristics that distinguished Greek science from that of its predecessors. The Greeks borrowed a great deal from the primitive science of their neighbors, the Egyptians and the Babylonians, but they totally transformed this material in line with their new standards of scientific and logical thought.

Logic Takes Root

The transformation of empirically based Egyptian geometry into an abstract and axiom-based science is a perfect example of the impact alphabetic writing had on the Greeks. Geometry arose out of the Egyptian need to measure the area of land in the possession of a landowner before the yearly inundation of the Nile. Rather than restore the boundary lines between properties that were destroyed by the flooding, each landowner was provided with a new plot of land more or less in the same location as before and with a total area exactly equal to the amount of land in his possession before the flood. Because of this need to measure the area of land accurately, an empirical science arose called geometry, which literally means earth (geo) measuring (metry). Egyptian geometry is not derived from a set of axioms. There are no theorems or proofs or propositions. There are merely a set of rules that are used strictly for practical applications such as land measuring or construction calculations.

The Greeks, on the other hand, almost from the instant they became involved with geometry, were interested in systematizing and formalizing the Egyptian results. Greek geometry began with Thales, one of the seven wise men of antiquity, who was the first to devise formal proofs of Egyptian geometric results.

Proving geometric theorems was one way that the Greeks developed deductive logic. "But whereas in Egypt mathematics like ethics and medicine had been developed empirically and stopped short of philosophy, it became to Thales a means of discarding allegory and myth and advancing universal generalization."²⁰

The use of the alphabet serves as a model for matching, an activity crucial for the development of logic. Each letter of the alphabet is matched with a sound and vice versa. Every time a word is read, a match between a visual sign and a spoken sound is made. Matching forms the basis of rationality or logic. Rationality grew out of the concept of ratios, which in turn involves matching. *A* is to *B* as *C* is to *D* is an example of a ratio achieved by matching.

The linking together of the elements of the alphabet, the letters, to form words provided a model for the linking together of ideas to form a logical argument. Arguments are linked together in order to reach a conclusion. The deductive reasoning implicit in formal logic and geometry also formed the basis of early Greek science, which attempted to derive its description of nature from first principles.

The Ionian Physicists

The use of the alphabet also promoted the development of logic because it promoted the skills of analysis. Each rendering of a spoken word by a combination of the letters of the alphabet represents a process of analysis. In order to render a spoken word alphabetically it is first necessary to analyze the sound or phonic structure of the word and hence break down the word into its basic sounds or phonemic elements. Once this is done, the matching of the letters of the alphabet with the phonemic elements can take place to render a spelling of the word. It is our claim that the constant repetition of the process of phonemic analysis of a spoken word, every time it is written in an alphabetic form, subliminally promotes the skills of analysis and

matching that are critical for the development of scientific and logical thinking.

Kalgren writing in 1926 on ancient Chinese philosophy and contrasting Chinese and Western writing systems makes a similar point. "We look upon the alphabetical, *analyzing* script as something very simple and natural, the system to write a word by successively adding one sound symbol after another, *analytically*, as in c-a-t. This system, though it may sound simple, is one of the most ingenious ever evolved by humanity, and it is entirely foreign to the Chinese mentality."²¹

Thales, the first to formalize geometry, was also the first Greek physicist. The term physics comes from the Greek word for nature, *phusis*. Thales was the founder of the Ionian school of science upon which the entire foundation of Western science rests. He derived all of nature or *phusis* from a single principle, namely water.

Thales and his followers arrived at their conclusions on the basis of their observations and their use of deductive reasoning. They laid the foundations of scientific methodology and thought. They believed that change and movement are caused by physical forces. They believed in the existence of atoms, the concept of a void, and the conservation of mass. They correctly held that ice, water, and steam are different phases of the same substance.

In addition to their use of logic, the Ionians also began to develop an empirical tradition. This tradition, unfortunately, did not fully flower with the Greeks but only some 2,000 years later during the Renaissance. The story that best illustrates the new empirical spirit that emerged in Ionia concerns the philosopher and physicist Anaxagoras. Upon hearing of a report of the landing of a shooting star, he mounted an expedition to Anatolia to investigate the matter. On the basis of his findings, Anaxagoras concluded that the heavenly bodies, including the moon, were made of rock. This idea offended the popular religious belief in the divinity of the heavenly bodies and almost cost Anaxagoras

his life. It was not until Galileo's telescopic observations of the mountains on the moon that Anaxagoras's ideas were finally verified.

Ionian physicists even anticipated evolution some 2,500 years before Darwin. Anaximander argued that since the newborn human child is completely helpless, man must have descended from a more primitive form of life whose young are self-sufficient. Anaximander's argument for evolution might have been influenced by his observations of gills on the human embryo as well.

Each of the Ionian physicists had a unifying principle from which he derived his description of nature. This principle was different for each philosopher, but it established very early in the history of science an important pattern. From the very beginnings of Greek science, an explanation for the operations of nature had been sought through some universal and unifying principle or principles. For Thales the unifying principle was water, out of which the entire universe was created. Anaximander, a student of Thales, believed the unifying material of which all matter was composed and from which opposites like hot and cold emerged was a gray neutral substance he called *apieron*, "the boundless":

The Unlimited (*apieron*) is the first principle of things that are. It is that from which the coming-to-be takes place and it is that into which they return when they perish, by moral necessity, giving satisfaction to one another and making restitution for their injustice, according to the order of time (Anaximander, fragment).

Anaximenes, a student of Anaximander, believed that all matter was composed of air and that the difference in materials is due to the difference in their densities. Although modern science has shown that matter is not composed of air but of protons, neutrons, and electrons, part of Anaximenes's idea is still true. All matter is made of the same components—namely, atoms—all

of which are approximately the same size. What distinguishes one type of atom from another and hence one type of material from another is the number or density of the protons, neutrons, and electrons they contain.

Heraclitus believed that fire was the unifying principle that explained nature:

This universe, which is the same for all, has not been made by any god or man, but it always has been, is, and will be—an ever kindling fire, kindling itself by regular measures and going out by regular measures. There is exchange of all things for fire and of fire for all things, as there is of wares for gold and gold for wares (Heraclitus, fragment).

If one identifies fire with energy, Heraclitus's saying reads like a statement of the principle of the conservation of energy—some 2,400 years before it was first formulated and scientifically established.

Universal Law

Each of the early Ionian physicists based his description of nature on one universal substance. Heraclitus was no exception, but like Anaximander he also emphasized the processes of strife and justice by which the material world is ruled. Explicit in the systems of Anaximander and Heraclitus and implicit in the other Ionian systems is the notion that nature is ruled by law or Logos: "All things come to pass in accordance with this Logos" (Heraclitus, fragment).

Behind the Heraclitean notion of Logos was the idea of cause and effect, which became the basis of all Western science. The alphabet provided a positive influence for the development of the linear notion of cause and effect by providing a model for sequence and succession. "Our ideas of cause and effect in the literature West have long been in the form of things in sequence and succession."²²

The concept of universal law developed by the Ionian physicists forms one of the fundamentals of modern science. Universal law also appears as a product of Hebrew monotheism and Babylonian codified law. Before Hebrew monotheism the law or rule of a god was limited to the geographical zone over which he held sway. With the advent of an omnipresent god whose law applied everywhere the idea of a universal law developed.

One can only speculate as to whether the early Greek physicists borrowed the idea of universal law directly from the Hebrews. They were certainly in a position to develop the concept on their own, since each of the Pre-Socratic philosophers was a lawmaker in his own community and was monotheistically inclined. Each believed that the universe was ruled by a single principle, which for Anaximander was *apieron*, for Heraclitus, Logos, and for Anaxagoras, Mind. "Mind set in order all that was to be, all that ever was but no longer is, and all that is now or ever will be" (Anaxagoras, fragment). The Greeks were in contact with Hebrew literature, however, and some degree of borrowing no doubt took place.

Why Science Began in the West

Having examined the influence that the alphabet, codified law, monotheism, and logic had on the formulation of science, we are in a better position to see why science began in the West and not the East despite the technological superiority of the Chinese. The alphabet, codified law, monotheism, and logic are all unique to the West where they were first formulated. They prepared the ground for the development of abstract science.

The alphabet provided a model for abstraction, classification, and analysis. The linking together of the repeatable elements of the alphabet also provided a model for analytic deductive logic, which also played an important role in the invention of abstract science.

With the alphabet a new style of writing developed, namely, prose, with which it is possible to create analytic statements. Ab-

stract science without prose and analytic statements would be impossible. The Chinese never developed prose style. It is only recently that they have begun to imitate the Western novel. Their lack of alphabetic writing and a prose style, I believe, handicapped their development of abstract science despite their impressive technological achievements.

Without an alphabetic writing system to encourage analysis, logic, and classification, without a system of codified law to encourage a belief in natural law, and without monotheism to encourage abstraction and universality, the Chinese were never able to achieve Western-style science. Chinese ideas and inventions carried to the West by traders were incorporated in Western science,²³ but the Chinese were unable to create their own scientific revolution simply because they lacked these tools to do so.

How Logical Double-talk Dampened the Empirical Spirit of Greek Physics

Although Greek science contained many of the elements of modern abstract science, it took 2,000 years for a fully mathematical description of nature à la Newton to develop. Because two major factors were missing from Greek science, full flowering was held back until the European Renaissance. One factor was the lack of an experimental orientation and the other was the absence of the concept of zero. Paradoxically, the same rational, logical way of thinking that contributed to the early development of abstract science also inhibited both these factors.

The importance of zero to science is twofold. First, it led directly to a place number system (Arabic numerals) and as a consequence to simpler arithmetical calculations. Second, zero also encouraged the development of algebra. The Greeks precluded the possibility of inventing zero when they accepted Parmenides's arguments for the impossibility of non-being as described below. (The story of how the Hindus were able to make this discovery is discussed in Chapter 10.)

The early Greek physicists were all strong supporters of the empirical approach of observation. Anaxagoras's arduous expedition to observe the remains of a shooting star was a testament to that spirit. So are the following fragments from Heraclitus: "The things of which there can be sight, hearing and learning—these are what I especially prize." "Eyes are more accurate witnesses than ears." Despite these early encouraging signs, an attack on empiricism was mounted by Parmenides, who forced Greek thinkers to choose between trusting their senses and trusting logic. They chose logic. Parmenides was historically the first philosopher to construct a logically self-consistent argument. Reacting strongly to the Heraclitean notion of change and flux, which held that one cannot step twice into the same river, Parmenides set out to show, using logic, that change was impossible.

Parmenides started with the premise that the concept of non-being is logically self-contradictory and therefore non-being cannot be. If non-being cannot be, then nothing can change, for if something changes from state A to state B, then A would "not-be." But according to Parmenides's original premise, A cannot not-be; therefore nothing can change. Q.E.D.

Parmenides's proof demonstrating the impossibility of change was extended by his disciple Zeno to show that motion was also not possible: Either a thing is in its place or it is not in its place. If it is in its place, then it cannot move, and it is impossible for a thing not to be in its place; therefore nothing moves.

Resolving the Paradox

The arguments of Zeno and Parmenides would be dismissed today as logical double-talk or sophistry. Unfortunately for the progress of science, they were taken very seriously by the Greek thinkers of that day, who were unprepared to deal with the new system of rational thought that logic made possible. As with any new technology, there are always abuses at the beginning when, through a lack of experience and understanding, the new tech-

niques are used in an inappropriate manner. Such was the case with the first scientists and philosophers who, when confronted with the either-or choice between logic and observation, chose logic. Even the empirically minded Anaxagoras wrote: "Because of the weakness of our senses we are not able to judge the truth."

Parmenides presented a paradox to Greek philosophy and physics, namely, the contradiction between the commonsense observations of change in the everyday world of experience and his logically consistent arguments against change. Each of the Greek thinkers responded to this challenge by finding a way to resolve this paradox, in each case by carefully inserting into his world view some element that did not change.

The empiricist Empedocles constructed a universe composed of four basic and immutable substances that no change could invade. These are the four elements of Earth, Air, Fire, and Water, of which every material substance in the universe is composed in some unique ratio. Change consists simply of the rearrangement of these four basic elements into new combinations. The combinations change but not the four basic elements of which these combinations are composed. Change is also motivated by the desire of these four basic elements to form pure states. This explains why heavy things fall back to earth and air and fire rise up. The universe, in this picture, therefore strives to return to an equilibrium position composed of four pure layers of matter consisting of earth, water, air, and fire, which approximates the physical world as we observe it. The bottom layer is the earth upon which sits the ocean or water, above which floats the atmosphere or air. Fire in this picture is represented by the heavens with their luminous bodies, the sun, the moon, and the stars.

Empedocles's division of the material universe into four basic, immutable, and repeatable elements parallels the division of the phonetic universe into the twenty-six basic, immutable, and repeatable letters of the alphabet from which all words are composed. Empedocles's system eventually evolved into the

classification scheme of modern chemistry, in which all material substances are described in terms of the approximately one hundred immutable atoms or elements of which they are composed. An intermediary step in this evolution was that of the alchemists, who added mercury, salt, and sulfur to Empedocles's four elements to describe the material world. The alchemists were on the right track in the way they described nature in terms of elements and compounds. They made the simple error of assuming that gold was an amalgam rather than a pure element. The dream of the alchemists of transmuting elements was realized in the twentieth century with the use of nuclear reactions.

The desire to resolve the paradox posed by Parmenides and to accommodate change within a static world also led to the formulation of the concept of atoms by the two Greek physicists Leucippus and Democritus. According to these philosophers, the process of dividing and subdividing matter could not be carried out *ad infinitum* but would eventually lead to particles called atoms, which could no longer be subdivided. They were right! The universe is composed of tiny indivisible immutable atoms or particles invisible to the human eye. The Greek word *atom* literally means "uncut." According to the atomists, there are a finite number of different types of atom, which differ from one another, like the letters of the alphabet, by their size and shape. Each object of the universe is composed of a different combination of atoms just as each word is composed of a different combination of letters. "They saw the analogy with what the alphabet had done to language and likened their atoms to letters."²⁴ The atomists explained change as the formation of new combinations of atoms. The individual atoms, however, did not change—consistent with Parmenides's idea of immutability. The prediction of atoms some 2,500 years before their actual discovery is a tribute to the imagination of the early Greek physicists. The first modern proponents of the atom, Boyle and Dalton, borrowed the idea directly from them.

While the effects of the Parmenidean paradoxes on Empedo-

cles and the atomists was a creative spur to their imagination, the influence on other thinkers was not always so positive. The impact in the long run proved to be destructive to the empirical spirit of Greek philosophy and science. Plato, for example, resolved the Parmenidean paradox by creating the concept of two worlds. There is the World of Perceptions, where things appear to change, and there is the World of Ideas, where all is static and unchanging as Parmenides had proved. The artificial separation of these two domains, the empirical and the theoretical, reinforced by alphabetic writing, discouraged the empiricism of the Pre-Socratic philosophers and reinforced the theoretical bias of Greek thinking.

Aristotle, also responding to the Parmenian challenge, created an artificial separation between the imperfect changing sublunar world and the ethereal unchanging heavens, the domain that lies beyond the moon. Aristotle's a priori assertion that the heavens are unchanging and a physical domain distinct from the earth provided an obstacle to the development of empirical astronomy against which Copernicus and Galileo had to struggle some two thousand years later. Plato and Aristotle diverted the Greek spirit away from learning through empirical observation to speculation and philosophizing by means of logic and rationality. Logic and rationality later proved to be critical ingredients in the development of modern science—but only when integrated with empiricism and experimentation.

7

The Impact of Alphabetic Writing on the Greek Spirit

The Greek Reading Public

We have traced the influence of alphabetic literacy on the Greek intellectual achievements of science, logic, and philosophy. Now we will focus on its effect on social, cultural, economic, and political affairs in ancient Greece.

At first the impact of the alphabet was confined to a few elite in the society who were able to read and write. A reading public did not emerge in Greece until over five hundred years after the first introduction of the alphabet. There are very few references to the reading of books or to libraries during the "golden age of Greek literature. Those rare libraries that did exist were small private collections consisting of less than 100 scrolls each."¹

In the transition from Plato to Aristotle's generation, an in-

creased use of books became evident. It is obvious from the study of Aristotle's writings that he had access to a library of philosophical works. Many of his own works represented compilations of the ideas of other philosophers or collections of empirical evidence published in earlier works. Reference to Aristotle's library is found in the writings of Strabo (XIII, 1. 54). By the time of Aristotle, the habit of reading was being established.

This development completely changed the nature of Greek society, particularly Athenian society. The Greek spirit before the golden age was deeply rooted in the oral tribal traditions as epitomized by Homer. The new literature as represented by Plato and Aristotle actively opposed this particular mind-set and attempted to create a new mentality and a new mode of education based on rationality and the preeminence of the individual.

Their position eventually prevailed, due more to the activities of the book publishers and booksellers than to the actual arguments they presented in their books. Even the written forms of Homer's oral poetry contributed to the downfall of the oral tradition. The medium was the message even in ancient Greece. Homer in book form had a much different impact on Greek culture than it had when it was presented in its original oral form. Plato had a sense that the impacts of writing were complex as the following passage from his dialogue *Phaedrus* indicates:

[Letters,] said Theuth, will make the Egyptians wiser and give them better memories; it is a specific both for the memory and for the wit. Thamus replied: O most ingenious Theuth . . . this discovery of yours will create forgetfulness in the learners' souls, because they will not use their memories; they will trust to the external written characters and not remember of themselves. The specific which you have discovered is an aid not to memory, but to reminiscence, and you give your disciples not truth, but only the semblance of truth; they will be hearers of many things and will have learned nothing; they will appear to be omniscient and will generally

know nothing; they will be tiresome company, having the show of wisdom without the reality.

The Visual Bias of the Alphabet

The alphabet by separating the sound, meaning, and appearance of a word separated the eye from the rest of the senses, especially the ear. Preliterate man is multisensual whereas alphabetic man is highly visual. "Between Homer and Plato, the method of storage began to alter, as the information became alphabetized, and correspondingly the eye supplanted the ear as the chief organ for this purpose."²

The Greeks created visual space, the geometric space treated in Euclid's elements. With alphabetic literacy visual metaphors for knowledge crept into usage in the Greek language. We use similar metaphors in English as the following examples illustrate. Our word *idea* derives from the Greek word *eidos*, "the appearance of a thing." *Theory* derives from the Greek word *theorin*, "to view" (the word *theater* has the same root). The term *speculate* derives from the Latin *specere*, "to look."

The English word *see* can refer to either knowledge or sight by eye. The terms *vision* or *sight* (insight, foresight) connote knowing. Other visual metaphors abound; *light* refers to knowledge and *darkness* to ignorance; while to *reflect* is to think. The term *contemplate* comes from the Latin *contemplare*, "to observe." Terms such as *bright*, *brilliant*, *illuminate*, *clear*, *lucid* also link knowing and seeing. The Greek words *idea* and *theory* cannot be found in Homeric Greek. Both these words are products of the alphabet and the new visual stress it fostered.

Plato acknowledged the new role of the eye in the postliterate revolution of rationality and learning.

The sight in my opinion is the source of the greatest benefit to us . . . given us a conception of time, and the power of enquiring about the nature of the universe; and from this source

we have derived philosophy, that which no greater good ever was or will be given by the gods to mortal man. This is the greatest boon of sight (Plato, *Timaeus* 47a).

The visual bias of the Greeks reflected itself in the special emphasis placed upon geometry. It is reported that above the doorway into Plato's Academy hung the sign LET HIM NOT ENTER WHO KNOWS NOT GEOMETRY. "Geometry was used to develop a conception of the earth and of the universe. . . . Science found its ideal in geometry."³

The Invention of Nature

With the alphabet the Greeks began to see things differently, in a more fragmented manner. They invented the idea of nature, which they called *physis* (or physics). The Greeks separated man and his artifacts from nature. Nature for the Greeks was simply the totality of the universe minus man and his culture. Once the Greeks had objectified nature, they treated it as something to be studied scientifically. "The discovery of nature has been described as one of the greatest achievements of the human mind since it was the basis of the idea of universal law."³

The objectification of nature by the Greeks has had implications in the West far beyond the development of natural science. It soon became an object to be exploited, subdued, and conquered for man's economic benefit. This parallels the similar attitude of the Hebrews whose deity is quite separate from his creation. Man is also considered separate from the rest of creation over which he was given dominion:

And God created Man in His own image. . . . And God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air and over every living thing that moveth upon the earth (Genesis 1:27-28).

The Hebrews considered themselves created in the image of the Creator with license to subdue the earth for their own needs. A nonliterate people would never conceive of this role for themselves. Tribal people are unable to separate themselves from nature; they are nature, an integral part of the environment. Wilfred Pelletier, a Canadian Indian, claims that Western-trained environmentalists, no matter how sophisticated their training and how earnest their concern, can never have the same feeling, understanding, or concern for the environment as a native person. "We are the trees, we are the rivers," he exclaims. "You can never know them the way we do."

The separation of man and his artifacts from nature explains why the Greeks never studied the effects of their own tools or artifacts despite their avid interest in nature itself. Unfortunately, this tradition has become part of our Western heritage—to ignore the impacts of our technology. Hall observed the inability of science to grasp environmental forms. "Quite simply the Western view is that human processes, particularly behaviour, are independent of environmental controls and influence."⁴ The specialization that the alphabet encourages discourages one from thinking holistically or environmentally.

Another reflection of the fragmentation and specialization that alphabetic literacy encourages is the way the Greeks subdivided knowledge. They separated their studies by subject and created the fields of geometry, logic, physics, cosmology, astronomy, metaphysics, ontology, epistemology, aesthetics, ethics, politics, rhetoric, dialectics. This spirit also influenced the way in which social, political, and economic activities were organized in Greek society and the new role played by the individual.

The Emergence of the Individual with Alphabetic Literacy

With the emergence of a reading public through the increased access to books, a new attitude developed in Greek society re-

garding the way in which an individual related to his society and his family. The fragmentation that alphabetic literacy encouraged led to the separation of man from nature and also the individual from his society and his family.

They [the Greeks] created the Individual Man. Individualism was born, where alone perhaps it could have been born, in the narrow cradle of the diminutive republic founded by a people endowed with unique social and intellectual gifts.⁵

One of the unique intellectual gifts Robinson is referring to was alphabetic literacy. Greek individualism was spread first by Alexander's conquests and then by those of Rome until it became the norm in the Western world.⁶

Before literacy the Greeks had very little notion of the individual, as the epics of Homer indicate. The *Iliad* celebrates glory even at the price of death. The Homeric heroes put the well-being of Hellas or their tribe before their own personal well-being. Homeric man is judged solely on the basis of his success, independent of his volition or intentions. Homeric man has no conception or experience of knowledge. Knowledge is never separated from action nor is it separated from the emotions into the subjective and the objective. There are few boundaries in the Homeric world that separate the individual from his society.

It is only with Hesiod that we first encounter an individual who speaks for himself. Homer never refers to himself in all of his works. Hesiod, on the other hand, provides autobiographic details, admonishes his reader in the first person, and develops his own unique literary style.⁶ The individuality that arises is not based on selfishness but shares the acceptance of individual moral responsibility that parallels the developments in Hebrew Scriptures. "Hesiod too has a Fall, and if man himself escapes divine retribution for wrongdoings, yet his house will pay the penalty. Men have a moral responsibility which animals do not."⁶

Hesiod was followed by a number of lyric poets, Archilochus,

Alcman, and Sappho, who gave expression to their individual experiences and personal feelings. Seventh-century Greece was characterized by two developments, the gradual rise of "free non-nobles" and of the "individual."⁷ The cause of the non-nobles was championed by the tyrants who exploited the discontent of this class to usurp power. Codified law was introduced to meet the demands of individuals for greater justice. It also introduced a separation between "nomas" or public law and "ethos" or private practice and personal habit. In the oral tribal world of Homer no such separation existed. With the emergence of individualism, the uniformity of a shared ethos is replaced with the enforced uniformity of nomas through codified law.

Individualism also influenced religious practices and created a new religious movement among the Greeks of the sixth century B.C. Orphism provided a "new consciousness of the self and a new feeling for human life."⁸ The Orphic religion gave impetus to the concept of the soul, which was later elaborated by Heraclitus, Socrates, and Plato and formed the basis of their humanism and individualism.⁹ The Ionian philosophers contributed greatly to the development of the idea of the individual. The empirical and rational approach of these early philosophical physicists increased the individual sense of self-sufficiency. Heraclitus, who believed that man shared in the Logos that ruled the cosmos, strongly supported the aspirations of the individual over the masses. "To me one man is ten thousand if he be the best."

Heraclitus looked to himself as the source of his strength: "Man's character is his 'daemon,' his destiny. I searched for myself." With Heraclitus the meaning of the Delphic saying "Know thyself" changed. The Homeric interpretation was that the Greek should realize his limitations as a mortal by pursuing the golden mean of moderation and following the gods. With Heraclitus, "Know thyself" becomes an indispensable part of a program of individual self-enhancement. This goal overlapped

with part of the program pursued by the Sophists. The Sophists were private tutors who taught young men the art of self-improvement and self-sufficiency. Their credo was expressed most succinctly by Protagoras: "Man is the measure of all things, of those being, that they are, of those not being, that they are not."

The Sophists carried their individualism to extremes. They believed that truth and morality were relative and depended on the individual. It was for this reason that they were opposed by Socrates and Plato. Aside from his opposition to their relativism, Socrates actually shared many of the concerns of the Sophists. For Socrates, man was also the measure of all things, but his concerns were more spiritual than those of the practical-minded Sophists. He is credited with shifting the emphasis of Greek philosophy from natural science and materialism to humanism and ethics. At the core of Socrates's teaching was the idea of improving the individual by improving his soul.

The concern for the individual expressed by Socrates and the Sophists also manifested itself in the arts. The painters, sculptors, poets, and playwrights continuously chose man as the subject of their artistic works. "Wonders are many in the world, and wonder of all is man" (from Sophocles's *Antigone*). The tragedies of the fifth century concerned themselves with the problem of the individual vis-à-vis religion, the state, and society.

With the conquests of Alexander the Great and the creation of an empire consisting of racially mixed groups, a new era in Greek politics was born in which the individual plays an even more prominent role. "Man as a political animal, a fraction of the polis or self-governing city had ended with Aristotle; with Alexander begins man as individual" (A. J. Carlyle). Within the confines of the Greek city-state in which all the citizens shared a common racial origin, language, religion, and cultural background, elements of tribal traditions survived despite the rise of the rationalistic, individualistic, alphabetic man. With the Alexandrian conquests a new mosaic of races, religions, and creeds was created in which cultural uniformity could not be taken as

the norm. In order to facilitate the administration of such a continuity, a new form of uniformity was required. Alexandrian officials created the notion of an empire of subjects who, though culturally and linguistically diverse, were nevertheless distinct individuals and hence were equal before the law.

The Hellenistic solution for administering a diverse empire based on the rights of the individual within the context of a codified law became a pattern that was to be imitated by other administrations. The Roman, Byzantine, Islamic, and modern European empires provide a number of examples of this pattern.

The Search for Truth and Beauty

One of the most dramatic impacts of alphabetic literacy was an increase in the level of abstraction of Greek thought as reflected in religious and legal practices and in the development of abstract science, deductive logic, axiomatic geometry, and rational philosophy. This abstraction is also seen in a new vocabulary not found in Homer, which spontaneously emerges with alphabetic literacy and includes the notions of truth, beauty, and art.

In Homeric society, as in all other preliterate societies, no distinction was made between art and technique. The Balinese, for example, have the expression: "We have no art; we do all things well." The Greeks, however, under the impact of alphabetic literacy, which encourages analysis and other forms of fragmentation, abstracted the notion of art and objectified it. They invented art just as they invented nature.

The Greek concept of art incorporated the abstract notion of beauty, which was distinguished from skills or crafts. The word *art* still retains both of its original meanings: the original pre-literate idea of technique and the newer notion of a beautiful object or performance, as reflected in its *Webster's New World Dictionary* definitions: 1) skill, 2) any craft or its principles, 3) a making of things that have form as beauty.

Another abstraction pursued by the Greeks was truth. The

Hebrews had also been concerned with truth, but from a moral point of view as in the admonition in the Ten Commandments: "Thou shall not bear false witness against thy neighbor" (Ex. 20:16). The Greeks developed a much more abstract and objectified notion of truth. The truth for the Hebrews was more intuitive and self-evident. It stemmed directly from their faith in God and the maintenance of their covenant with him.

For the Greek, a new form of truth emerged, based on rationality and differing from traditional values of tribal solidarity. Plato attacked poets like Homer because they epitomized the old style of education based on imitation or mimesis rather than his new style, which entailed training young people to reason through each problem on its own terms. "Once [Plato's] Republic is viewed as an attack on the existing education apparatus of Greece, the logic of its total organization becomes clear."¹⁰

Plato encouraged his students to use logic, science, and rationality¹¹ to find fresh solutions to problems instead of relying on the traditional remedies of the past. Together with a training in mathematics and logic, Plato encouraged his students to formulate the problems of human existence in scientific terms.¹²

The impact of the alphabet was to introduce both a new style of education and a new approach to problem solving. The new rational philosophers such as Plato could feel only disdain for the poets whose roots extended back to the oral tradition. "The oral state is still for Plato the main enemy."¹³

The imitative poet who aims at being popular is not by nature made, nor is his art intended, to please or to affect the rational principle in the soul; but he will prefer the passionate and fitful temper, which is easily imitated (Plato, *Republic*, 605).

"Plato attacked the pedagogical value of poetry and of Homer by pointing to the contrast between philosophy and poetry, truth and sham, and expelled poets from the state."² He believed

that there existed "an ancient quarrel between philosophy and poetry" and that the only salvation for society was the triumph of philosophy and rationalization over the poets. In other words—the triumph of alphabetic literacy over the oral tradition.

Until philosophers are kings, or the kings and princes of this world have the spirit and power of philosophy . . . cities will never have rest from their evils; no, nor the human race as I believe (Plato).

The Hellenistic and Roman World Empires

The Hellenistic World

One of the influences of the alphabet was to establish a uniformity of the written word and hence of administrative procedures. It was in this climate that the Greeks began to implement their policy of cultural uniformity. They attempted to Hellenize the rest of the world through colonization and military conquest. Alexander the Great, a student of Aristotle, conquered the entire-civilized world, from the eastern end of the Mediterranean to India, establishing outposts of Greek culture wherever he went. However, his world empire did not survive beyond his own untimely demise when it split into four dynasties: the Antigonids in Macedonia, the Attalids in Pergamum, the Ptolemies in Egypt, and the Seleucids in Persia. The dispersal of

Greek ideas and administrative forms was facilitated by the easy transport of books and documents made possible by the use of papyrus and the alphabet.

Alexandria was a particularly active center and became the focus of Hellenistic learning through the growth of the famous library there. The library also functioned as a university, a center of research, and a museum housing the greatest number of scientific specimens that had ever been assembled up to that point in history. It was here that Euclid developed his famous *Elements of Geometry* in 300 B.C. Alexandria was also famous for its systematic study of astronomy. Aristarchus showed that the distance from the earth to the sun was much greater than that to the moon and proposed a heliocentric theory of the universe 1,800 years before Copernicus. The quality of astronomical data collected at Alexandria was so accurate that it was not equaled or surpassed until the observations of Tycho Brahe. Other notable scientific accomplishments included the biological classification schemes and the geographical studies of Strabo.

At its height, the library at Alexandria contained 700,000 volumes. Books were collected from all over the world. The Hebrew Scriptures were translated into Greek. Educated slaves serving as scribes were organized to produce large numbers of books. In fact, book publishing became such a lucrative enterprise that the Ptolemies banned the export of papyrus to Pergamum where another library had been organized to rival the one in Alexandria. This led to the large-scale production and use of parchment as a medium for writing in Pergamum.

As a result of the publishing activities at Alexandria and Pergamum, a mass reading public emerged for the first time in history, which created an even greater demand for books. The existence of a widely distributed reading public in both Hellenistic and Roman Egypt has been deduced from the examination of papyrus fragments representing a broad range of literary works found in archaeological ruins of a large number of provincial towns of ancient Egypt.¹

Greek Origins of Latin Culture

The spread of Greek culture through conquest took place to the east, while its spread to the west was through colonization. Cumae, the first historical Greek colony in Italy, was founded by the Chalcidians about 740 B.C. and soon thereafter became a center of civilization. The Etruscans and the Romans both received their alphabets from this Greek colony.² The achievements of the Greek settlements in Italy in turn influenced the mother country and contributed to the Hellenization of the southern Italians and the spread of Greek influence to the Romans, Etruscans, and other peoples of northern Italy.

Greek influences not only entered Rome directly from the Greek settlements to the south but also from the Etruscans, a partially Hellenized culture that exerted the greatest influence on the development of early Rome of all the non-Latin cultures in Italy.² They taught the Romans many of the practical skills of organization and engineering that later proved to be Rome's greatest strength.

The Romans freed themselves from the Etruscans through conquest in 510 B.C. after which they gained military control of Italy. They then turned their attention to the remainder of the Mediterranean world, successfully invading and conquering all of these states, including Carthage and Greece, and establishing a world empire.

Like the Akkadians who had conquered the Sumerians and then adopted their culture, the Romans absorbed Greek culture. "Captive Greece took her fierce conqueror captive and introduced her arts into rude Latium" (Horace, *Epistles* 2.1.156). The Romans connected their history with that of the Greeks by relating their origins to Greek mythology. They claimed they were descendants of the Trojans through Aeneas. "No observer ancient or modern, could fail to be impressed by the extent of Roman indebtedness to Greece."²

Roman Letters and Literature

The Romans borrowed their alphabet directly from the Greeks, just as the Greeks had borrowed theirs from the Phoenicians. As with the Greeks, the Romans transformed the alphabet to serve their own needs. They retained the same order of the letters as well as their sound value but changed their names, shortening them for convenience. *Alpha* became *A*; *beta*, *B*; *gamma*, *C*; *delta*, *D*. They also inserted a newly divided letter *G* to replace *Z*, for which they had no use. During the first century B.C. they reintroduced *Y* and *Z*, which they placed at the end of the alphabet. Our English alphabet is based almost exactly on the Roman alphabet. The letters *J*, *U*, and *W*, however, were added during the Middle Ages. The *J* is a variant of *I* and hence was placed just after it. *U* and *W* are variants of the *V*, which explains their position just before and after this letter.

Roman literature, which did not appear until the end of the third century, began as little more than translations of Greek sources.² Because Rome stood as the transmitter of Greek culture to the rest of Europe in later times, Roman literature was destined to have an important impact on the development of Western or European culture. Latin literature, even according to the standards of the Romans, never equaled that of the Greeks. Literature served a different function for the Romans. It was not a central concern but rather an adornment of cultivated life.²

The Romans made their mark on Western civilization not on the basis of their writings but on the basis of their accomplishments in the practical arts including architecture, civil engineering (roads, aqueducts, bridges, and water mills), town planning, civil administration, law, and military technology and organization. Their bias to the practical is reflected in the words Virgil used in describing Rome's destiny through the speech of Aeneas's father, Anchises:

"Others, I doubt not, shall beat of the breathing bronze with softer lines, shall from marble draw forth the features of life;

shall plead their causes better; with the rod shall trace the paths of heaven and tell the rising of the stars: remember thou, O Roman, to rule the nations with thy sway—these shall be thine arts—to crown Peace with Law, to spare the humbled, and to tame in war the proud" (*Aeneid*, 6.847).

The Romans clearly looked upon the practical arts as the fulfillment of their destiny and the fine arts as only an afterthought. In some cases they actually express disdain for literature, as in a saying of Cato the Elder: "The art of poetry was not respectable; if a man engaged in it or applied himself to junketings he was called a wanton." The Latin term for poet, *poeta*, is not native, and the same term, *scriba*, was used for both poets and scribes.

Despite the Romans' disdain for the arts and the paucity of their literary output compared to the Greeks', the technology of the alphabet nevertheless had an important impact on the development of their culture vis-à-vis the practical arts to which they applied their energies. The alphabet provided a model for the organized and systematic way in which they pursued their practical arts.

While the Romans did not excel at literary creativity, they did make considerable use of writing. As in Alexandria, there was an active trade in books^{3,4} and publishers made use of slaves as readers and copyists⁵ to mass-produce (by the standards of those days) books for commercial sale to supply the private libraries that, according to Seneca, "had become as common as baths in the houses of the rich."⁴

There is also evidence from a number of literary sources that Roman schoolboys were taught the art of reading and writing. "Boys learn in accordance with a written model (*praescriptum*); their fingers are held, and they are guided by the hand of another through the forms (*simulacra*) of the letters, then they are told to copy what is put in front of them and improve their handwriting by comparison with it" (Seneca, *Epistulae Morales*, 94.51).

A more elaborate passage of Quintilian⁶ suggests an improve-

ment on the technique described by Seneca as well as the importance of penmanship:

As soon as the child has begun to know the shapes of the various letters, it will be no bad thing to have them cut as accurately as possible upon a board, so that the pen may be guided along the grooves. Thus mistakes such as occur with wax tablets will be rendered impossible; for the pen will be confined between the edges of the letters and will be prevented from going astray. Further by increasing the frequency and speed with which they follow these fixed outlines we shall give steadiness to the fingers, and there will be no need to guide the child's hand with our own. The art of writing well and quickly is not unimportant for our purpose, though it is generally disregarded by persons of quality. Writing is of the utmost importance in the study which we have under consideration and by its means alone can true and deeply rooted proficiency be obtained. But a sluggish pen delays our thoughts, while an unformed and illiterate hand cannot be deciphered, a circumstance which necessitates another wearisome task, namely the dictation of what we have written to a copyist.

Another technique apparently employed by the Romans, according to Quintilian, was the fashioning of ivory letters to be used as toys by young children to acquaint them with the alphabet.⁵

One measure of the importance of writing to the Romans was the fact that they developed a technique of shorthand stenography, which they used to provide written minutes and proceedings of the Senate, the *acta diurna* and the *acta senatus*.⁶ The practice of using shorthand was introduced by Cicero and taught to his secretary, a freedman named Tiro.⁷

The widespread use of writing in Rome is attested to by the frequent references to this form of personal communication and

the description of a number of schemes for writing in codes or ciphers. Suetonius,⁸ describing Augustus's private communications, wrote, "Whenever he wrote in cipher he wrote B for A, C for B and the rest of the letters on the same principle, using AA for X." (Note that X was the last letter of the Roman alphabet in those days.)

Roman Organization

The impact of the alphabetic writing with which all educated men in Rome were acquainted can be seen more in the nonliterary practical affairs in which the Romans prided themselves than in their actual literary output. The influence of the uniformity, regularity, and linearity that the alphabet subliminally promotes is reflected in all Roman forms of organization, from their military and their civil administration to their architecture and town planning. As with the Greeks, literacy greatly influenced all aspects of Roman life, transforming an oral tribal society into a civilized one. "They extended linearity into an Empire and homogenization into the mass processing of citizens, statuary, and books."⁹

This highly visual bias of the Roman spirit is reflected in town planning and road building. "Roman roads and Roman streets were uniform and repeatable whenever they occurred. There was no adaptation to the contours of local hills or custom."¹⁰ The roads that carried the messages, the papyrus upon which the messages were written, and the alphabetic code in which they were written all contributed to the vast administrative apparatus that constituted the Roman Empire. "The spread of writing contributed to the downfall of the Republic and the emergence of the Empire. With the growth of administration the power of the emperor was enhanced."¹¹

Uniformity and fragmentation also influenced the organization of the military. "The phonetic alphabet was the greatest processor of men for homogenized military life that was known

to antiquity."¹² The Roman legions not only defended Rome but became a public-works machine re-creating the pattern of Roman organization all over the world.

Rome further exploited the principle of fragmentation by using its military to "divide and conquer," and once that was accomplished, to "divide and rule." The Romans perfected the military techniques of division through the creation of the "legions," which today go by the names of battalions and divisions.

One of the paradoxical aspects of this fragmentation is that, looked at another way, it becomes centralization, in which all of the fragments are controlled by one authority. "All roads lead to Rome" expressed the extreme form of centralization that constituted Roman administration of its empire.

Roman Law

The organization of a bureaucracy based on writing influenced other aspects of Roman life such as the codification of the law and the rise of individualism, and these have survived to become an integral part of Western civilization. Roman law did not begin as a written code but rather arose out of an oral law whose roots can be traced back to the time before writing had been introduced to the Italian peninsula. Law was at first in the hands of the priests, who had absolute control over its enactment and administration.

As democratic institutions developed, deliberative assemblies demanded that the law be made accessible by reducing it to a written form. The codification of Roman law followed the patterns established by the Greeks. The Romans, however, placed a greater importance on law than did the Greeks and soon developed legal forms far more sophisticated than their predecessors. The importance of law to the Romans was alluded to in the earlier quotation of Virgil in which he states that Rome should "crown Peace with Law." Cicero also stressed the importance of

law to Romans: "We are servants of the law in order that we may be free."

One of the innovations and achievements of the Romans was the development of contract law, which dealt with both the conveyance of property rights and the entering into of mutual obligations on the part of the contractors. Roman law tended to be more practical and less abstract than Greek law. "The reasons underlying the legal system should not be inquired into, otherwise much that is certain would collapse" (Neratius). As a result of this spirit, a great deal of emphasis was placed on precedents, and as a consequence compendia and digests of the law and legal decisions were needed, a factor that led to the organization of law libraries.

A natural consequence of the emphasis on law was the rise of the individual. "The development of the Empire and Roman law reflected the need for institutions to meet the rise of individualism and cosmopolitanism which followed the breakdown of the polis and the city state."¹³ The new emphasis the law placed on the individual as distinct from his society or his family had consequences in Rome in terms of religion as well.

The law carefully distinguished between the civil and religious responsibilities of the Roman citizen. Jesus, who lived under Roman law in the province of Judea, invoked this principle when he was forced by his interrogators to choose between his religious beliefs and civic duty. "Render therefore unto Caesar the things which be Caesar's and unto God the things which be God's" (Luke 20:25).

9

The Arabs and Islamic Culture

The Prophet and Literacy

In each of the cultures we have studied, the acquisition of alphabetic literacy has had a major impact on the social interactions and intellectual development of the society. This pattern is dramatically repeated in the case of the Arabs. The roots of Islam and the rise of Arab culture can be traced back to the introduction of alphabetic literacy to this people. The Arabian peninsula before the arrival of the Prophet Muhammad was the home of a preliterate polytheistic society ruled by tribal mores and traditions, particularly in the northern and central regions. In the fertile areas of the south in what is presently Yemen there thrived a prosperous culture, the Sabeans, with a literary tradition. The Sabeans utilized an alphabetic script but it was not destined to

become the predecessor of classical Arabic. This honor fell to the Nabatean script developed from the Aramaic writing system by the Nabateans who occupied that part of the Fertile Crescent bordering on the northern edge of the Arabian peninsula. Through trading activities, the nomads of northern and central Arabia came in contact with the Nabateans and borrowed their script, which they used primarily for economic activities in their trading cities. This script, however, eventually evolved into the classical Arabic into which the Koran was eventually transcribed.

According to tradition, this script was also used in pre-Islamic times to transcribe special poems that were the prizewinners of the famous poetry contests held yearly at the sacred stone in the Ka'bah at Mecca. Seven odes, the al-Mu'allawat, were honored by being inscribed in golden letters and hung on the walls of the Ka'bah,¹ originally the Arabian center for polytheistic worship.

Aside from the few instances of writing just referred to, communications in pre-Islamic Arabia were totally oral. The people were basically nomadic and mistrustful of the written word.² The Prophet Muhammad changed all of this through the Koran, a collection of the transcriptions of his prophecies and revelations. The Koran became the centerpiece of Islamic culture and transformed the Arabs from an oral people to a literate one.

Some scholars such as Hirti believe that Muhammad specifically wanted to create a literary tradition. "Evidently what was primarily weighing on Muhammad's heart was the observation that the Jews had a book, a revelation, and the Christians had a book and were all progressive and prosperous, whereas the Arabs had no book and were comparatively backward."²

Hirti's assertion is partially true but his statement must be qualified. The Koran was not composed in the same way that the other books were written. It contains revelations and teachings of the Prophet that had originally been transmitted orally directly to the people.³ The elements that now constitute the Koran were collected over the period of the Prophet's lifetime

and were only canonized after his death. All unauthorized versions were burned, leaving one single authorized version, which has remained unchanged to this day.

The following passage describes the Prophet's first vision, which took place in a cave on Mount Hira when Muhammad was forty years old. It reveals the subtle tension that exists between the literate and the oral traditions in Islam. "One night in the month of Ramadan the Angel appeared to him and said, 'Read.' He answered, 'I am no reader.' Then the Angel seized him with a strong grasp, saying, 'Read,' and as Muhammad still refused to obey, gripped him once more and spoke as follows:

The Sura of Coagulated Blood (XCVI) Read in the name of the Lord who created man of blood coagulated. Read! Thy Lord is the most beneficent who taught by the Pen. Taught that which they knew not unto me.

"The prophet was frightened and thought it a dream at first. 'I awoke,' said the Prophet, 'and me thought it was written in my heart.'"⁴

The two episodes indicate that perhaps the Prophet was not literate, or at least wished not to appear so, as has been suggested by some scholars. "He himself is said to have been illiterate, and merely to have 'recited' the words he heard out of heaven."

The epithet *ummi*, which is applied to Muhammad in the Koran and is translated as "illiterate," does not necessarily indicate that he was unable to read and write, but only that he was not acquainted with Hebrew Scriptures. The Koran suggests that he may have had other reasons to appear illiterate.⁶ "Thou [Muhammad] didst not use to read any book before this [the Koran] nor to write it with thy right hand; else the liars would have doubted" (Koran XXIX, 47).

Despite the possibility that the Prophet may have been illiterate, it is still evident that writing was an important part of the new tradition, as the use of the many metaphors referring to

reading and writing indicate. The reference in Sura XCVI to the Lord "who taught by the Pen" is rendered by some translators as "who taught the use of the Pen."^{7,8}

Islam and the Introduction of Writing into Arabia

Further evidence for the integral part played by writing in Islam is the historical correlation between those who introduced writing into Arabia and those who played a role in the development of Islam in its earliest days. Many of these figures were the students of Harb, the man who popularized writing among the aristocracy of Quraysh, the tribe of the Prophet Muhammad. One such figure was Muawiyah, the founder of the Umayyad dynasty, which ruled the first great Muslim empire.

Shortly after its establishment in Mecca, writing spread to the nearby town of Medina. It was the Medina scribe Zayd ibn Thabit who became the Prophet's most famous secretary and was entrusted with the task of collating and writing the first codex of the Koran.⁸ There is a clear association between the earliest scribes of Islam and those who introduced writing into Arabia. It is obvious that writing played a vital role in the spread of Islam and that in turn Islam played a vital role in the spread of literary in Arabia and many of the lands that the Arabs conquered in the name of Islam.

The following story of the Umm al Kirab illustrates the important role that writing and the notion of the book play in Islamic tradition. "According to tradition God sent the Book to the Jews but they distorted its true meaning. He then sent it to the Christians who also distorted its meaning. Finally he sent it to the Arabs and they got it right." This story also reflects the Islamic belief that Moses and Jesus were also prophets of God but Muhammad was the final Prophet who completed the divine revelation to man.

Islam and the Preservation of the Oral Tradition

Despite the importance of written communication to the advent of Islam, the oral tradition remained vital. The Koran was not first transmitted through the written word but by the oral tradition. In addition to the Koran, the comments on the Koran, known as the Hadith, were also transmitted orally at first, but later they were eventually transcribed and transmitted in a written form. A mixture of both the written and oral tradition has always coexisted in Islamic culture. The very name of the Koran is derived from *karā'a*, "to read, recite, or discourse," which indicates the oral manner in which these writings are interpreted. "In Sura XVII 92 it [*karā'a*] certainly stands for 'to read,' but the most frequent meaning is rather to recite, to discourse."⁹ Even the written transmission of the Koran and the Hadith was achieved through a combination of oral and written activity. The professor or teacher would read aloud his written copy, which the students would copy down. They would then tidy up their versions through further study and then present them to their professor for his signature to testify that the copy was an authorized version.

The Koran, as the sole source of authority in the Islamic world, was subject to careful reading and study. Despite the intimate connection with the oral tradition, the Koran became the vehicle whereby the Arabs acquired alphabetic literacy. "The Koran is the most widely read book ever written."¹⁰ In addition to its use for religious purposes, it also became the textbook from which almost all young Moslems learned to read Arabic.

The Islamic World Empire

Inspired by the Prophet and fired by the zeal of Islam, the Arabs soon conquered and controlled a world empire stretching from Spain and North Africa in the West to Indonesia and the Chinese border in the East. Within a couple of centuries, the no-

madic polytheistic preliterate tribal people of Arabia were world rulers, making use of a well-organized administrative bureaucracy that governed with the aid of a legal code based on the abstract ethical principles of monotheism. Part of this transformation was due to the alphabetic literacy encouraged by the Koran and part was due to borrowings from the sophisticated cultures of Egypt, Syria, Iraq, and Persia, all of which had employed one or another of the alphabetic scripts in pre-Islamic times.

In the earliest days of Islam, a distinction was made between Arabs and foreigners. Most of the administrators were actually members of these conquered cultures and hence foreigners. As time passed, the distinction between Arab and foreigner began to diminish under the egalitarian principle fomented by Islamic law, in much the same way that the distinction between Greek and barbarian disappeared in Hellenistic culture. Cultural uniformity was reinforced by the uniformity of a common language and script. A universal culture emerged whose capital moved from Mecca to Damascus under the Umayyad caliphs and then to Baghdad under the Abbasid caliphs. In our ensuing discussion we will use the term Arabic to refer to the world culture based on the Arabic language rather than restricting the term to the culture of the Arabian peninsula.

We turn now to an examination of the influence of alphabetic writing on the development of Islamic or Arabic culture. It is not possible to establish any causal relations or direct impacts. As with the other cultures we have studied, we shall find, however, that the alphabet provided a climate in which abstract notions such as monotheism, codified law, science, and logic could flourish.

Islamic Law

One of the areas where the alphabet had a particularly dramatic impact on Arab culture was in the administration of justice and

the formulation of law. While the form of the law was influenced by alphabetic writing, its authority was derived directly from the Prophet and the divine origin of his revelations. "In the eyes of a Muslim, the law is an integral part of his religion; in Islam, law is more important even than theology."¹¹

This attitude toward law represented a major change in Arabic culture when contrasted with pre-Islamic values. In pre-Islamic Arabia the tribe was preeminent, and the rights of the individual were secondary. Any legal rights an individual had were vested in his family and in his tribe, the tribe being an extension of the family. The family and tribe looked after "his rights, avenged his wrongs, inherited his property, and answered for his crimes."¹¹

Another element in this legal transformation was the increase in the abstract and universal character of an individual's ties to his community. The blood tie of family and tribe was abandoned and replaced by loyalty to the Muslim community. All Muslims were equal in the sight of God and the law. The aristocratic structure of pre-Islamic society disappeared. "The personal life of the individual emerged—even though, in certain respects, the community assumed legal and social rights which were formerly vested in the tribe."¹²

What is important about this development from the point of view of our study is the parallel with the transformation that occurred in Mesopotamia, ancient Israel, Greece, and Rome in which the alphabet (or phonetic writing) was accompanied by three developments:

1. The demise of tribal society
2. The rise of law based on the rights and the responsibilities of the individual
3. The creation of a universality of mankind that transcends family and tribal links

The transformation of the system of justice was not immediate. Although religion became the sole authority for law in the

Muslim world, only eighty verses of the Koran deal with legal matters. At first Islamic society did not possess a formal legal code or system of justice. But as with the Mesopotamians, Hebrews, Greeks, and Romans, phonetic writing soon suggested a codified pattern of legislation that in the latter part of the eighth and the ninth centuries manifested itself in a body of religious law, the Shari'ah, which regulated all aspects of Muslim life.¹²

Law schools at Medina and Kufah in Iraq were established to study, expand, interpret, and administer this body of law. At first the different schools caused a fragmentation of interpretation of the law as each school developed its own unique point of view. This situation was soon rectified and a unification of the law and its interpretation was realized by Al-Shafi'i, "the father of Islamic jurisprudence." He enunciated four principles as the basis of his legal system:

1. The Koran
2. The accepted doctrine of the Prophet
3. The consensus of the Islamic community
4. Analogical reasoning¹³

The first two principles were key. However, it is interesting to note that as with the Greeks and Romans, logic entered into the consideration of jurisprudence.

In addition to the religious law and courts covered by Shari'ah, there also developed a secular system of jurisprudence administered by the Mazalim courts, which dealt with civil and criminal matters not covered by the Koran.

Arabic Literature and Science

The influence of alphabetic literacy on the development of Arabic literature followed a pattern similar to that of other cultures. Poetry appeared before prose in pre-Islamic Arabia in a form highly developed linguistically, metrically, and artistically.¹⁴ Arabic prose did not emerge until the eighth or ninth century. Be-

fore this time, prose was confined to the Koran, the Hadith, and oratory, which is largely an oral form. The links to prose are through the Koran, i.e., religious thought based on monotheism, as was the case initially for Hebrew prose and to some extent for Greek prose. At first the alphabet, monotheism, and codified law developed together in Islamic culture following a pattern similar to that of the Hebrews. There then followed the introduction of science, logic, and philosophy, which were borrowed from ancient Greek sources through Jewish, Syriac, Christian, and Persian mediators.

Baghdad, the capital of the Abbasid dynasty from 750 to 1258, became a center of learning. The philosophical and scientific works of the Hellenistic world were translated and introduced to the Muslims. This stimulated new and original research and study in which the Arabs made significant and lasting contributions.¹⁵ Baghdad became, as an Arab historian described it, "the market to which the wares of the sciences and arts were brought, where wisdom was sought as a man seeks after his stray camel, and whose judgement of values was accepted by the whole world."¹⁶ Baghdad soon possessed a library and an academy that in many ways rivaled the original library at Alexandria.¹⁷

One of the factors that contributed to the intense literary activity in the Arab world was the sudden availability of paper in the mid-eighth century, replacing the more expensive media of parchment, papyrus, and leather.¹⁸ The Arabs borrowed this know-how from the Chinese and eventually passed it on to the West.

The contribution of the Arabs to the overall development of modern science was twofold. First, there are the advances and discoveries they made totally on their own. And second, there is the role they played in the preservation of and transmission to Europe of the scientific accomplishments of ancient Greece, India, Persia, and China. The Arabs built upon the base of Greek learning contained in the Syriac and Persian literature both in translation and in the original Greek.¹⁹

One area of Arab success was the field of chemistry, a term

that derives from the Arabic *alkimiya*, "alchemy" (the prefix *al* means "the"). While alchemy eventually came into disrepute in Europe, historians of science recognize that alchemy as practiced by the Arabs laid the foundations for modern chemistry.

Another area where Arabic science was extremely successful and went far beyond the Greeks was medicine and pharmacology, particularly in observation, diagnosis, and treatment with drugs.²⁰ "It was they who established the first apothecary shops, founded the earliest school of pharmacy and produced the first pharmacopoeia."²¹ Important contributions were also made in agriculture, magnetism, geography, optics, ophthalmology, astronomy, and mathematics.

Arab mathematicians transmitted the Hindu place number system to Europe and made significant advances in algebra.²⁰ Arabic astronomical observations were more accurate than those previously made because of improvements in the instruments of astronomical observation. They increased the size of the armillary sphere and astrolabe and thus reduced the errors of observation. They were able to calculate the radius of the earth and the meridian degree with only 1 percent error, by A.D. 820.²² In the meantime, Europe still slumbered under the illusion that the earth was flat.

Although the Arabs made vital contributions, they fell short of the development of modern science. "They introduced the objective experiment, a decided improvement over the hazy speculations of the Greeks. Accurate in the observation of phenomena and diligent in the accumulation of facts, the Arabs nevertheless found it difficult to project proper hypotheses and draw truly scientific conclusions."²³ They did, however, lay the foundations for modern science, which they transmitted to Europe.

10

Numerical Notations and the Mystery of Zero

The Mystery of the Discovery of Zero

In our review of Mesopotamian, Hebrew, Greek, Roman, and Arab cultures we have seen how the abstract nature of alphabetic writing has provided an environment in which abstract intellectual ideas and social institutions could flourish. The only other notation or system of visual signs that has played as important a role in promoting abstract thought has been the place number system whereby all numbers can be represented by ten numerical signs, the Hindu-Arabic numerals: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The key to the whole place number system is the zero element or sign, 0, whose invention was an achievement of Hindu mathematics and thought.

Numerical notation and writing systems have always been

closely linked. In fact, the first forms of notation were numerical and took the form of tallies etched on bones. This might explain the fact that in the Semitic languages the words for "scribe" and "count" are the same, i.e., *SPR*. Writing and the notation for abstract numbers emerged in Sumer at precisely the same moment in history, from a common progenitor, clay accounting tokens. In the earliest alphabetic scripts, Semitic and Greek, for example, the letters of the alphabet were also used to represent numbers. The first ten letters represented one through ten respectively. The next nine letters represented 20, 30, and so on to 100. This system of numerical notation required virtually all of the letters of the alphabet.

The Romans also developed a number system using the letters of the alphabet, but in a more abstract manner. A much smaller number of letters was needed, namely, I, V, X, L, C, D, and M. The system was also more abstract because the numerical values depended to some extent on the placement of the signs. For example $IV = 4$ whereas $VI = 6$. There is no zero element in this system and numerical calculations are extremely clumsy. Consider the product $56 \times 6 = 336$ using Hindu-Arabic and Roman numerals:

$$\begin{array}{rcl}
 56 & & LVI \times VI = L \times V + V \times V + I \times V \\
 \times 6 & \text{VERSUS} & + L \times I + V \times I + I \times I \\
 336 & & = L + L + L + L + L + V + V \\
 & & + V + V + V + V + V + L + V \\
 & & + I \\
 & & = CCCXXXVI
 \end{array}$$

The calculations involving long division or fractions become even more complicated with Roman numerals. The advantages with Hindu-Arabic numbers are obvious.

Arabic numerals are obviously the most abstract numerical notation possible just as the alphabet is the most abstract form of writing. It is ironic that the alphabet achieves its abstraction through phonetization whereas the Arabic numerals are logo-

grams or ideograms that represent ten numerical values including zero. The letters of the alphabet and the Arabic numerals, however, share four important features that enable them to act abstractly:

1. Each system contains a small number of elements; twenty-six letters (for the English alphabet) and ten numerals.
2. Both systems form a complete set. The total set of possible spoken words can be represented alphabetically and any number, no matter how large it may be, can be represented in terms of some combination of the ten numerals 0 through 9.
3. The individual elements of the two systems, the letters and the numerals, are atomic. That is, they are identical and repeatable.
4. The values (sound or numerical) of the aggregate elements (the words or numbers) of the system depend not only on the atomistic components (the letters and numerals) of which they are made up but also on their order. In other words, both the letters and their order determine a word and both the numerals and their order determine a number. For example ON is not the same as NO nor is 18 the same as 81.

The development of the place number system depended on the invention of the concept of zero, an idea that seems extremely simple and yet is quite sophisticated. For this reason, the discovery of the concept of zero is often taken for granted. Many assume that the Greeks, the originators of formal geometry and logic, made use of it. We are taught about zero in elementary school, geometry in high school, and logic in college. Therefore, many people believe logic and geometry are mathematically more sophisticated than the concept of zero.¹ This is not true. The Greeks never developed the operational notion of zero, yet their achievements in geometry and logic were unparalleled. But as a result of not having a concept of zero, their arithmetic cal-

culations were laborious and their development of algebra was stunted.

Hindu mathematicians invented zero more than 2,000 years ago. Their discovery led them to positional numbers, simpler arithmetic calculations, negative numbers, algebra with a symbolic notation, as well as the notions of infinitesimals, infinity, fractions, and irrational numbers.

The historians of mathematics have always been puzzled that the germinal idea of zero was a discovery of the Hindus and not the Greeks. Laplace, the great mathematician of the eighteenth century, wrote:

It is India that gave us the ingenious method of expressing all numbers by means of ten symbols, each symbol receiving a value of position as well as an absolute value, a profound and important idea which appears so simple to us now that we ignore its true merit. But its very simplicity and the great ease which it has lent to all computations put our arithmetic into the first rank of useful inventions, and we shall appreciate the grandeur of this achievement the more when we remember that it escaped the genius of Archimedes and Apollonius, two of the great men produced by antiquity.²

More recent historians of mathematics have been equally surprised. Particularly puzzling to Tobias Dantzig was the fact "that the great mathematicians of Classical Greece did not stumble on it."³ For Constance Reid, the great mystery of zero is that "it escaped even the Greeks."⁴

Why did the ideas of zero and algebra develop in India and not ancient Greece? The explanation of this phenomenon does not lie in an examination of Greek mathematics but rather in a comparison of Greek and Hindu philosophy. Paradoxically, it was the rational and logical thought patterns of the Greeks that hindered their development of algebra and the invention of zero.

The Inhibition of Greek Imagination Due to Logical Rigor

As we discovered earlier, it was the ancient Greeks who invented and developed formal logic. Their achievement has only been surpassed within the past three or four hundred years by logicians and mathematicians who based their work on the foundations laid by the Greeks. Logical arguments permeated all areas of Greek scientific and philosophical thinking. A high value was placed on analytic thought, which the Greeks applied to almost all fields of human knowledge. The Greek thinkers, however, became captives of their own methods. They rejected the validity of empirically observed phenomena such as motion and change because of the logical arguments of Parmenides. Certain other theoretical ideas such as infinity, infinitesimals, atoms, and the vacuum were similarly rejected because of logical considerations. The Greeks in a sense became slaves to the linear either-or orientation of their logic. And as a result, their imagination was limited, making it difficult for them to conceive of the concept of zero.

The Hindus, on the other hand, had no such intellectual tradition of formal logic. They were less constrained in their thinking and more imaginative, which proved to be an invaluable asset and led to the development of zero.

The history of zero actually begins with the Babylonians long before Greek or Hindu mathematics. The Babylonians used a very primitive notion of zero for very special applications. They were never able to develop this concept any further, however. The Babylonian scribes used a symbol as a place holder to denote a blank space.⁵ Zero in their system never became a number to be added or subtracted or to be used to simplify their calculations as was the case with the Hindus.

The only other independent development of zero was that of the Mayans. They used zero for place numeration but zero never entered into mathematical calculations such as multiplication or

division. Like the Babylonian zero, the Mayan zero represented a dead end, a mere historical curiosity.

The Mayan zero was a completely independent discovery but there is a possible connection between the Hindu zero and that of the Babylonians. Since commerce existed between Mesopotamia and India, there could be a link, but finding historical evidence to support this hypothesis is not easy. However, even if it is true that the Hindus borrowed the idea, the question remains of why the Greeks were unable to borrow the Babylonian idea and develop it in the same way. The ancient Greeks were, in fact, nearer in time and closer geographically to the Babylonians and hence would have been in a better position to borrow the idea than the Hindus. The transmission of other mathematical ideas from the Babylonians to the Greeks during the Seleucid period of the third century B.C. takes place a full century before the first appearance of zero in the Hindu literature. Neugebauer indicates that Babylonian material was available to both Greeks and Hindus.⁶

Whether borrowed or invented, we are still left with the mystery: Why were the Hindus able to deal with zero, and not the Greeks? In order to gain insight into "the great mystery" of why zero "escaped" the mathematically sophisticated Greeks, let us recall the impact that the alphabet had on the development of Greek thought. Soon after the introduction of alphabetic writing into Greece, a unique transformation of its intellectual life began.⁷ Thales marks the beginning of the Greeks' use of the deductive logic and rationality that within a very short time invaded all areas of Greek thinking, unleashing new powers of analysis. Rationality became the be-all and end-all of Greek thought, but it eventually hamstrung its development by restricting its creativity to the narrow confines of logical rigor.

Parmenides's logical arguments against change and the notion of non-being poisoned the intellectual climate for nurturing the ideas of zero. (See Chapter 7.) In contrast to the Greeks, Hindu thinkers accepted non-being.⁸

In Buddhism, negativity and non-being are positive and good because the Buddhist takes his point of departure in the negative side of life and the world. For him the being of existence is a "nothing"; likewise non-being is the negation of something negative and is, therefore, something positive. The Greeks and the Hebrews were united in the idea that non-being is something dreadful; being, however, is a genuine reality and the true good.

Non-being was a state that Hindus and Buddhists actively sought in their attempt to achieve Nirvana, or oneness with the whole cosmos. Non-being was something concrete, a state that could be discussed. The concept of zero was therefore totally consistent with Hindu philosophy, and hence presented no problems to Hindu mathematicians. The Hindus did not have any logical cultural stumbling blocks to overcome, as the Greeks did. Nothing stood in the way. In fact, their religious ideas reinforced their notion on non-being and hence zero. In conclusion, my hypothesis is that Greek thought, particularly that of Parmenides, discouraged the conceptualization of zero, whereas Hindu thought encouraged this notion.

Our explanation of why the Hindus, and not the Greeks, invented zero solves only one mystery. There remains the question of why the Hindus also developed the notions of negative numbers, simple arithmetic computational methods (algorithms), algebra with a symbolic notation, infinitesimals, and infinity. While the Greeks made progress in these areas, they never developed them as fully as did the Hindus. They had no notation for an unknown quantity in their algebra. Dantzig suggests that the Greeks were at a disadvantage in developing a symbolic notation because they used their letters to denote numbers and hence had no symbols available for representing unknown variables.⁹ This excuse is lame. The reason that the Hindus developed algebra, negative numbers, and infinity is simply that the Hindus pioneered the concept of zero and the Greeks did not. Each of these

mathematical concepts, as we shall show, is related to the concept of zero.

First Appearance of Zero

One of the first uses of the zero symbol was made by the Hindu mathematician Pingal sometime before 200 B.C.¹⁰ The use of zero in calculations appears for the first time in the Bakhshali manuscript (A.D. 200), where use of place value is also found. The treatment of zero as a number, with equal status to other numbers such as 1 or 2, is found in the *Pancasiddhantika*: "In Aries the minutes are seven, in Gemini they are three, two, one, zero [*sunya*] each repeated twice."¹¹ The name for zero used in this and later texts is *sunya* (pronounced "shunya"), which literally means "empty space" or "blank." Zero was first symbolized as dots in the Bakhshali manuscript, and later as small circles or *o*'s. The use of dots to represent zero is used as a metaphor in the *Vasavadatta*: "The stars shone forth . . . like *sunya*-bindu [zero-dots]."¹²

The Hindus developed all the arithmetic and algebraic properties of zero. The operations of addition and subtraction with zero first appeared in A.D. 505 and a century later the definition of zero as $a - a = o$.¹³ By A.D. 750 multiplication with zero emerged: "Multiplication of a number by cipher also gives zero."¹⁴

Place Numeration

The development of place numeration, whereby all numbers can be represented by the ten symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 is probably the most important application that was made of the zero or *sunya* symbol. Our present number system was invented by the Hindus and transmitted to Europe by Arab and Persian scholars. The mathematicians of Baghdad adopted the Hindu system around A.D. 1000. They translated the Hindu term *sunya* into the Arabic *sifr*, which also means "empty space."

Originally, the term *cipher* was intended to denote only the zero element, the unique element of the number system, but eventually the entire number system became known as the cipher system. As with other innovations, the new number system was forbidden in some cities in Europe and, as a consequence, had to be used secretly. The word *cipher* soon came to mean "a secret code," as indicated by the word *decipher*. In order to distinguish between the entire number system and its unique element, 0, the term *zero*, short for *zephairno* (the Latinized form of *cipher*), came into use to denote 0.

Place numeration not only simplified the expression of numbers; it made possible a tremendous simplification of arithmetic calculations. All present-day procedures of multiplying, dividing, square and cube rooting were developed using the place number system invented by the Hindus. Many of the Hindu techniques were transmitted to Europe by the Arab mathematician, al-Khwarizmi, from whose name is derived the term *algorithm*, meaning a procedure for performing a mathematical calculation. The scientific revolution of the Renaissance could never have taken place if these simpler modes of calculation had not been made possible by the Hindu place number system.

The scientific revolution also benefited from the Hindu development of algebra. The Hindus' successes in developing algebra stemmed, like their success with zero, from their ability to work intuitively without being unnecessarily held back by the need for logical rigor. The essential element in their development of algebra was their invention of zero, which proved to be a powerful mathematical concept.

Algebra, or *Aryakat-Ganita*

Algebra, or *aryakat-ganita* (literally, the science of calculation with the unknown), first appears in Hindu literature in the Bakhshali manuscript, one of the first works in which the concept of zero appears. It is here that we also first find the concept of negative numbers.¹⁵ The number -7 is denoted by $7 +$. It is

believed that the + sign represents the letter *kha*, the first letter of the Hindu word *karya*, which means "to diminish." In later works - 7 is denoted by 7 or 7 where the . sign or 0 sign stands for zero. The numeral 7 lies below the zero sign to explicitly denote that - 7 is seven less than zero.

The first representation for the unknown is also found in the Bakhshali manuscript. The expression used was *yadrcha veryase surya*, which literally means "put a zero [*surya*] in the place of the unknown or desired quantity."¹⁶ The symbol 0 was also used to represent the unknown, sometimes in an elongated version, , to distinguish it from zero. The representation of the unknown took many different forms in addition to the symbol for zero;¹⁷ among these was the use of the abbreviations of the colors, red, blue, and black.¹⁸ This latter device was particularly useful for problems with multiple unknowns.

Infinity, Infinitesimals, Fractions, and Irrational Numbers

The mathematics of infinitesimals and infinities was first pioneered by the Hindus and then later refined by the mathematicians of the Renaissance. The concept of infinity arose through the consideration of the division of a finite number by zero.¹⁹ The Hindu mathematical concept of infinity was related to and reinforced Hindu theological notions:²⁰

At the time of the world's creation, the Infinite and Indestructible Lord Almighty created crores [1 crore = 10 million] of beings. At the time of the great Deluge, all these beings go back to His form and are immersed in Him. Neither process makes any change in Him.

This passage illustrates the notion that the sum of a finite quantity and infinity is still infinity: $X + \infty = \infty$.

The Greeks, on the other hand, were very uncomfortable with the notion of infinity, which they rejected out of hand as mean-

ingless, irrational, and logically impossible.²¹ The concept of infinity leads naturally to the idea of an infinitesimal, through the division of a finite quantity an infinite number of times. The Greeks came close to the idea of the infinitesimal as expressed by:

1. Zeno's paradoxes
2. Eudox's method of exhaustion
3. Archimedes's method of determining pi by successively inscribing and circumscribing polygons to a circle.

In the end, the Greeks *horror infiniti* led to their rejection of the notion. The Hindus, however, felt no such revulsion and evidence for a primitive form of the infinitesimal is found in the Bhaskara II manuscript of A.D. 1150: "The product of [a number and] zero is zero, but the number must be returned as a multiple of zero if any further operations impend."²²

The Greeks rejected fractions, arguing that the "unit was indivisible" although they did make use of ratios.²³ They had a similar aversion to irrational numbers. There is a legend that a member of a Pythagorean society was thrown overboard on a voyage for revealing to a member of the crew the darkly held secret that the length of the hypotenuse of a right triangle whose sides were each of unit length could not be expressed as the ratio of two integers. This fact, which was so disturbing to the Greek mathematical mind, posed no problem to the Hindus. They felt comfortable with and made use of both fractions²⁴ and irrational numbers.²⁵

Conclusion

We have considered a number of examples of how the logical rigor of Greek thought hampered mathematical development and led the rejection of (or failure to develop) a number of ideas such as zero, place numbers, fractions, negative numbers, irrational numbers, infinity, infinitesimals, and a symbolic notation for

algebra. These concepts were embraced and developed by the Hindus, who were logically less rigorous than the Greeks but were, perhaps as a consequence, more intuitive. These Hindu discoveries have played a key role in the subsequent development of Western science and mathematics.

It is ironic that the evolution of Western theoretical thought required a detour into the East in order to develop the essential mathematical tools of place numbers and algebra so essential for the development of modern science. We have explained the necessity of this detour in terms of the logical rigidity that took hold of the minds of the Greeks as they developed their tools of rationality and logical analysis under the influence of the phonetic alphabet. If our hypothesis is correct we must explain why the alphabet had such a negative effect on the Greeks and not on the Hindus.

The Hindus also made use of an alphabetic script but did not seem to be overwhelmed by logic although they made use of it. There are several factors that might explain the difference in the impact of logic. First of all, the Greeks were the first to develop a totally phonetic alphabet complete with vowels, which exactly and precisely rendered their spoken language into a written form. The Hindu alphabet was derived from the Aramaic alphabet, an offshoot of the original twenty-two consonant Semitic alphabet, and, as a consequence, did not incorporate the vowels in the same explicit way as the Greek alphabet did. Second, Hindu society retained its oral traditions much more strongly than the Greeks did, and as a consequence the alphabet effect was not as powerful as it was in Greek society. In fact, it can safely be said that no other culture was as strongly affected by the alphabet as was ancient Greece. Perhaps this is the case because it was the very first society to develop three radically new techniques for organizing information; 1) the totally phonetic alphabet complete with vowels, 2) deductive logic, and 3) abstract science. The Greeks were simply unprepared for some of the negative side effects of being logically too rigorous.

11

The Middle Ages and the Return of Alphabetic Literacy

The Fall of Rome and the Rise of Christianity

After the fall of Rome, alphabetic literacy underwent a sudden eclipse popularly known as the Dark Ages. This was followed by a slow but steady recovery that culminated in the High Middle Ages and finally the Renaissance. To understand the role of literacy during this vast historic period stretching from A.D. 400 to 1400, we must study the collapse of the Roman Empire in the West and the rise of Christianity in Europe. These two major historic events are linked and can be traced back to the actions of Constantine who became the emperor of Rome in A.D. 312.

Up to the time of Constantine, the practice of Christianity was regarded as a subversive activity that undermined the authority of Rome. As a result of the influence of his mother, Helena, a devout follower of Christ, Constantine put an end to the perse-

cutions of the Christians. He also lent his support to the religion to which he finally converted at the end of his life. His actions led directly to the eventual adoption of Christianity as the official religion of the Roman Empire in A.D. 380.

Equally significant was Constantine's founding of Constantinople (city of Constantine) as the capital of the eastern half of the Roman Empire in A.D. 330. Constantinople became a great center of political power and has remained, to this day, one of the great cities of the world. Constantine's action, however, led directly to the split of the Roman Empire. When Constantine's successor, Theodosius, died sixty-five years after the founding of Constantinople, he left one half of his empire to each of his two sons. The division of the Roman Empire into two halves led eventually to the foundation of the Byzantine Empire and the fall of Rome. The Roman Empire at this time was economically exhausted from overtaxation to support its military adventures, decadent life-style, and other excesses. The resources of the western part of the Empire were particularly depleted, whereas Constantinople still thrived through its trade with the East. Rome survived less than one hundred years after being severed from its richer eastern provinces. It was sacked by the Visigoths in 410 and again by the Vandals in 455. Its last emperor was deposed in 476 by the barbarian general Odoacer, who declared himself King of Italy. Italy was then conquered in quick succession first by the Ostrogoths and then by the Lombards.

The Byzantine Empire and the Greek Orthodox Church

Before returning to our discussion of the plight of Europe after the fall of Rome, let us first examine the developments in the eastern part of the Empire, which continued to prosper after its separation from Rome as the Byzantine Empire. The capital city, Constantinople, was in an extremely favorable geographic position to profit from trade between Europe and Asia. At first Byzantium competed with Persia for the control of Asia. It was

then challenged by the Islamic empires that arose. Although the Arabs totally conquered the Persians and completely dominated the Near and Middle East, Byzantium was able to withstand their repeated attacks until it was eventually defeated by the Turks after a reign of over 1,000 years.

At first Latin was the official language of Byzantium, but gradually Greek assumed this role, becoming the official language during the reign of Heraclius (610-641). Christianity was from the first the official religion, with Constantinople serving as the seat of the Chief Patriarch of the Greek Orthodox Church. Christianity spread to Russia and the rest of Eastern Europe through the office of the Patriarch.

The relationship between Constantinople and Rome was complicated. The Roman emperor Honorius had moved his capital to Ravenna in 400. The Germanic tribes that took over Italy also set up their capital in this city. They were Christians but adhered to the heretical Arian sect, which did not accept the concept of the Trinity. The Bishop of Rome, who wished to maintain political independence from these Arian regimes, accepted the overlordship of the Byzantine Empire. This resulted in a somewhat paradoxical relationship between these two cities in which Rome claimed religious authority over Constantinople but at the same time accepted its political or temporal authority. Rome played a double role of supreme religious authority of the Christian world and that of a small geopolitical state in Italy. Its political fealty to Constantinople continued until the eighth century, after which Rome looked to France for its political protection.

The Roman Catholic Church

With the passing of Imperial Rome, followed by many years of chaos and military conquests, the only source of moral authority that remained in Italy was the Roman Catholic Church. The Pope, or the Bishop of Rome, as the head of the Church in the capital city of the Empire, had historically been in a special posi-

tion as far back as the second century. Tradition held that Christ had entrusted the care of the Church to Peter, the first Bishop of Rome, and hence to his successors. In the early years of the Church, the Pope's authority was challenged by other bishops who claimed to be his equal. Ambrose, Bishop of Milan, in the fourth century was in fact the most influential bishop of his time. But eventually the Pope came to be regarded as the leader of the Church and there soon developed in Rome a bureaucratic apparatus to administer the Church.

With the fall of Rome there was a total discontinuity in the form of political organization and a natural displacement of the Roman autocracy or ruling class, which no longer held temporal power.¹ In an attempt to preserve their way of life this political elite became members of the hierarchy of the Roman Catholic Church. They borrowed many of the organizational forms of Imperial Rome, which they incorporated into the Church structure. These legacies included the Curia and the office of Pontifex Maximus (the Pope). The canon law by which the affairs of the Church were administered and by which many civil matters were governed were all based on the principles of Roman law.

Although the content had been changed, the literary medium was the same and its message was that of strict adherence to the letter of the law. As had Imperial Rome, the fathers of the Church organized and regulated human affairs through written legal codes. The medieval Christian Church, which became the dominant social institution of its time, inherited this tradition and synthesized Oriental mysticism, "Hebrew justice, Christian love, Greek belief in intellect, Roman organization and Hellenic asceticism."²

The Middle Ages and the Oral Tradition

The Roman Catholic Church in Europe maintained the tradition of alphabetic literacy prevalent during the classical period. Christianity, like Judaism and Islam, was a religion of the Book, in this case of both the Hebrew Scriptures (or Old Testament)

and the Gospels (or New Testament). The preservation of literary skills was absolutely necessary to maintain this tradition. Literary forms were also used in canon law and in the administration of the Church.

The use of literary media in the secular world of medieval Europe, however, did not survive the fall of the Roman Empire. Political power was constantly changing hands as the various Germanic tribes vied with one another to establish their kingdoms throughout what is now modern Europe, including the Italian peninsula. This was such a chaotic and volatile period that the forms of civil administration the Romans had established over most of Europe could no longer be maintained. They gave way to a new form of government based on the older oral traditions of the Germanic tribes, which had incorporated a personal relationship between a ruler and those he governed. Loyalty to a liege was symbolized by a verbal oath of allegiance and fealty by the vassal, a term derived from the medieval Latin word *vassus*, "servant."³

The personal nature of government is illustrated by the fact that the highest offices in the land were held by the personal household servants of the king, such as the chamberlain, master of the castle, or the marshal, master of the stables and hence the military leader of the state. The household offices would have been relegated to servants in Roman times and the duties of the chamberlain and the marshal carried out by consuls and generals.

The system of personal loyalties extended throughout all civil interactions in medieval society. The landlord-tenant relationship of the Roman period was transformed through the infusion of the Germanic sense of personal fealty and resulted in the feudal system with its intricate web of personal relations connecting everyone in the society from the lowliest serf to the king.

The economic unit of feudal life was the manor, which was a fundamentally self-sufficient household. Without the imperial order to maintain the road system and trade routes, the regions of Europe became more isolated from each other and came to depend only on their own resources to satisfy their needs. This

decentralized economic order was closer to that of the tribal society of Europe before Roman rule than to the highly centralized mode of organization that characterized imperial times.

Another index of importance of the oral tradition in medieval life is the role played by the poets and minstrels who gave expression to the secular and religious values of the culture. It was the *trouvères* of northern France, the troubadours of southern France and Spain, and the minnesingers of Germany who created and then promulgated medieval notions of nobility and chivalry.

The Dark Ages: Myth or Fact?

The collapse of the Roman Empire marked the end of an era and resulted in a dramatic discontinuity in the political and social structure of Europe. As the literate forms of organization gave way to those of a more oral nature, the civil servants who processed the paperwork in the Roman bureaucracy were suddenly unnecessary. One of the major incentives to learn reading and writing suddenly disappeared. There was a dramatic drop in the level of literacy in the general population and scholarly activities came to a virtual standstill.

Historians have branded this period the Dark Ages and have tried to characterize it as a time of ignorance and little learning. More careful scholarship has revealed that only book learning atrophied. Mechanics and agriculture actually thrived with steady but modest advances being made throughout the Middle Ages.

The entire notion of the Dark Ages becomes even more absurd when one considers the steady level of accomplishments in that time.⁴ These include such outstanding achievements as the evolution of the vernacular languages of Europe and the first fruits of their respective literatures. During this period significant steps toward the establishment of Western democracy included the proclamation of the Magna Carta and the formation of the Swiss cantons. The Middle Ages also saw numerous break-

throughs in the invention and/or application of mechanical devices, especially in the harnessing of power, and tremendous improvements in agricultural techniques such as the development of the heavy plow and crop rotation suited to northern European farming. Finally, there were innovations even in the field of learning and scholarship, including the founding of universities still extant.

It was the practical arts that flourished in the Middle Ages and eventually set the stage for the Renaissance. In fact, it is very difficult to distinguish the boundary between the Middle Ages and the Renaissance.⁵ To characterize the period as the Dark Ages simply because of the decline of book learning reflects the literary bias of historians.⁶

The Transition from Ancient Learning to Modern Science

There exists a popular misconception that modern science arose directly from Greek science due to the revival of learning in the Renaissance after a thousand years of inactivity. Not only does this analysis ignore the accomplishments of the Middle Ages alluded to above but it also fails to take into account some of the negative effects of the alphabet on classical learning. The abstractness of the phonetic alphabet promoted a divorce of brain and hand, a disdain of empiricism, and excessive adherence to logical rigor among Greek thinkers, each of which inhibited the development of modern science. Greek and Latin learning, rather than being two thousand years ahead of its time, had in fact run its course and had exhausted its possibilities for further development. The decline of book learning and the channelling of intellectual activity into the practical arts during the Middle Ages had a positive effect on Western learning. It permitted an infusion of new ideas from the so-called barbarian cultures. As a result, classical learning was revitalized when it resurfaced during the Renaissance.

With the political chaos and economic depression that followed the collapse of Rome, the luxury of abstract scholarship could no longer be indulged. Men turned their minds to the practical questions of survival and as a consequence made significant breakthroughs in technology. They built upon the foundations of Greco-Roman technology to which they added their native innovations or those borrowed from the Islamic world or from China. When Western Europeans finally returned to the tradition of Greek learning, they no longer divorced the practical arts from scholarly activity. A new amalgam had been created that combined the logical rigors of classical Greek learning and the mathematical achievements of the Arabs with the empirical spirit of medieval mechanics. This led to the work of Galileo, Torricelli, Brahe, and others.

Medieval Technology

The historical scholarship of Lynn White has shown that the Middle Ages was a period of great technological progress,^{6,7} which resulted in a steady increase in the standard of living of the ordinary peasant. "In technology, at least, the Dark Ages mark a steady and uninterrupted advance over the Roman empire."⁸ A steady increase in the level of prosperity was realized through a string of improvements in metallurgy and mechanical devices⁶ applied to agriculture and the harnessing of animal, water, and wind power. Health standards also improved as a result of the increasing level of technological sophistication.⁹

Oddly enough, the motivation for improvements in metalworking likely grew out of the increased violence of warfare made possible by another medieval invention, the stirrup.¹⁰ The metal stirrup that was developed from the Asian toe stirrup permitted a mounted warrior to hold a lance in his arms and use the full momentum of the horse to deliver a mortal blow instead of relying upon the strength of his arms. This innocent enough in-

vention had many implications. In order to protect the mounted warrior, metal armor became very sophisticated and techniques for metalworking improved. The high cost of equipping a mounted warrior or knight was one of the key motivations for the inauguration of the feudal system in which an estate was granted to a landlord so that he could supply a number of knights to the king's army.¹⁰

Another medieval invention, the heavy plow, permitted large tracts of land to be plowed at once and gave rise to the manor as a cooperative agricultural community.¹¹ The heavy plow changed the face of Europe both literally and figuratively. First, it altered the shape of fields from small square plots to long narrow tracts, and second, it increased the prosperity of those fields through the improvement of field drainage. The opening up of the most fertile soils by the heavy plow increased production and made possible the accumulation of surplus food. Other technological improvements also increased the prosperity of farming in the Middle Ages, including the use of open fields, the rotation of crops on the basis of a three-year cycle, the modern harness, and the nailed horseshoe.

The net effect of the increased agricultural yields was "population growth, specialization of function, urbanization and the growth of leisure."¹¹ It also provided a base for the beginnings of an industrial way of life. The improved standard of living allowed peasants to buy manufactured goods. "In the new cities there arose a class of skilled artisans and merchants, the burghers who speedily obtained control of their communities and created a novel and characteristic way of life, democratic capitalism."¹²

Capitalism with its emphasis on profit and efficiency proved an ideal climate for the harnessing of power for human purposes, which in the later Middle Ages took many forms:

Animal Power: The collar harness permitted the use of horses for plowing and hauling, a task that had been relegated

to the slower-moving oxen before this development. The importance of horsepower is reflected in our use of the term, to this day, as a measure of power.

Waterpower: The harnessing of waterpower dates back to the Roman period, but it is not clear where the idea originated as water mills seem to have simultaneously appeared in the Mediterranean region, northern Denmark, and China.¹³ The Middle Ages saw the widespread diffusion of waterpower and its application to a number of different activities, including grinding grain, cutting marble, cutting wood, fulling, tanning, beer making, laundering, metal polishing, forging, and knife sharpening. The Domesday Book of 1086 indicates the existence of 5,624 mills in approximately 3,000 English communities.¹⁴ The water mills became the laboratory in which the mechanical skills of the Middle Ages developed a proficiency in the use of gears (star, crown, and worm types), cams, axles, wheels, screw mechanisms, cranks, trip hammers, and the like.

Wind power: The principles of harnessing waterpower were applied to the wind in Europe and resulted in the windmill.¹⁵

The harnessing of power in the Middle Ages, with its by-product of mechanical inventions, led directly to a number of subsequent innovations that affected the use of the alphabet and enhanced alphabetic literacy and the learning associated with it. Among these were the invention of the printing press and the advent of the Industrial Revolution, which is the subject of our next chapter. It also affected the nature of scientific thinking and the revitalization of classical learning to which we now turn our attention.

One influence of alphabetic literacy on the harnessing of energy was the way in which the components of a system were linked together to form a whole so that energy could be transmitted from its source to where it was needed. This achievement set the stage for the industrialization of Europe.

Classical Scholarship

Although the level of abstract scholarship declined during the Roman period as compared with Greek learning, there was a general increase in the number of people who acquired alphabetic literacy. With the collapse of the Roman Empire, its bureaucratic structures, and the level of literacy, classical learning almost totally disappeared.

The only organized group to carry on the literary tradition of classical scholarship was the Church, which had a very narrow set of interests and which was not a very innovative institution. Not many new scholarly works arose out of this milieu except those of a theological nature such as the philosophical writings of Saint Augustine. His *Confessions* and *The City of God* expressed the spirit of his time. Other purely scholarly works were those of Isidore of Seville, Boethius, and the English Benedictine monk Bede, but their quality was not very high.

The one valuable service the Church provided to scholarship was preservation. Cassiodorus in the fifth century directed his monks to collect and copy Greek and Latin manuscripts, which started the Benedictine tradition of preserving classical learning. The efforts of the Church, together with the preservation of texts by the Islamic and Byzantine cultures, permitted the eventual transmission of Greek and Latin learning to Renaissance scholars.

The Church also preserved the Latin language, albeit in a medieval form. It served as the vernacular and *lingua franca* among both churchmen and scholars. As time passed, the vernacular forms of medieval Latin evolved into the early versions of the Romance languages French, Italian, Spanish, and Portuguese. The use of Latin as a *lingua franca* of scholarship became even more valuable as a result.

Carolingian Renaissance

Certain secular authorities also kept alive the Roman tradition of learning and literacy. After a period of extreme anarchy and chaos, some order began to return to Europe during the reign of Charlemagne (Charles the Great), whose empire included most of France, Belgium, the Netherlands, Germany, Switzerland, Austria, and northern Italy. Although he himself was illiterate, he created cathedral schools and encouraged the monasteries to spend more time on teaching and studying.

One of the immediate impacts of this short-lived Carolingian Renaissance was the development of an extremely legible and neat hieratic script known as Caroline minuscule alphabet from which we derive our modern-day lower-case "Roman" letters.

Another fallout of this revival of learning was the medieval school curriculum of the seven standardized liberal arts consisting of the trivium of grammar (literature), rhetoric, and logic and the quadrivium of arithmetic, geometry, astronomy, and music. The trivium taught the students to read and write using the alphabet. They also learned to express themselves orally. The quadrivium focused on mathematics, including music, which consisted of the study of the ratio of the frequencies of notes. Taken together, the trivium and quadrivium basically amount to what, today, we might call the 3R's, reading, writing, and arithmetic. After a student had mastered the trivium and quadrivium, he was allowed to go on to study theology.

The Carolingian Renaissance unfortunately was short-lived and did not survive much beyond Charlemagne's reign of peace, prosperity, and good order. One reason for this was the absence of printing to sustain the revival. Charlemagne's cathedral schools, however, eventually evolved into the medieval universities, and learning was initiated in other places. Alfred the Great began a similar revival of English literature.

Johannes Scotus Erigena created a system of Neoplatonic metaphysical thought. Benjamin of Tours, studying at the cathe-

dral school in Chartres, applied the lessons of logic from the quadrivium to his theological speculations. He argued that reason should be used by man to reinforce his faith in certain theological issues. He used logic to attack the doctrine of transubstantiation. Saint Anselm carried the use of logic further in his attempts to develop proofs for the existence of God. He also entered into a debate regarding the nature of abstractions such as universals. Although he was an advocate of the use of logic in theology, Saint Anselm always put faith before reason. This was not the case with Abelard, a logician, who attracted a very strong following of students in Paris. Although Abelard's activities were thwarted by reactionary churchmen such as Saint Bernard, who accused him of heresy, Abelard in the end triumphed through his students who later rose to positions of influence. They included the theologian Peter Lombard and Pope Alexander III.

It was at this point in history, when alphabetic literacy was reinforcing an interest in logic, that Europe rediscovered classical learning. Scholars became particularly interested in Aristotle through contacts with the Arabs. Greek works were retranslated from Arabic into Latin although some Greek manuscripts survived and were translated directly into Latin.¹⁶

The works of Aristotle were at first ignored by the Church. As they came to have an increasingly greater influence in the universities, the Church tried unsuccessfully to suppress their use. When the works of Averroës, the Islamic theologian, challenging Christian dogma, were translated into Latin, the Church defensively embraced Aristotle. His ideas were incorporated into its theology, first through the works of Albertus Magnus and then through those of Thomas Aquinas. At first the acceptance of Aquinas's Aristotelian-based theology was opposed by mystics, but it eventually triumphed to become part of the official doctrine of the Roman Catholic Church. Aquinas himself was made a saint.

The victory and acceptance of Aquinas had an impact on sci-

ence and scholarship that was as great as that on religion and theology. Aristotle's ideas moved into the mainstream of European thought. The slavish adherence to his ideas that had characterized much of classical learning, however, was challenged, paradoxically enough, by the Church itself. Catholic clerics challenged a number of Aristotle's positions in physics on the grounds that they seemed to limit the powers of the Creator. Aristotle's contention that a vacuum cannot exist or that the universe is finite were ruled by the Bishop of Paris in 1277 to be null and void.

This challenge to Aristotle's authority led to secular arguments repudiating elements of Aristotle's physics such as his theory of motion that held that a body must have a force continually acting upon itself to remain in motion, contrary to our modern ideas on inertia. Shortly after the ruling of the Paris bishop, Jean Buridan, a philosopher at the University of Paris, proposed a theory of impetus that was a direct forerunner to Galileo's and Newton's ideas of inertia.

Buridan's work was important because it had converted a scientific question based on empirical observations into a valid topic of philosophic discourse. Buridan's investigations were carried out in a new empirical philosophical climate where the idea of putting theoretical questions to an experimental test was first taking root.

This new attitude was inspired by the work of the medieval scientist and philosopher Robert Grosseteste and his pupil, the friar Roger Bacon, who were active at the University of Paris. Bacon actively lobbied the Pope to support the testing of scientific theories through the "science of experience." Bacon's actual experiments were rather small in number and limited to optics, and his science of experience was based more on observation than on controlled repeatable experiments. Nevertheless he helped create a new attitude toward science that eventually did lead to the experimental work of Galileo and others.

In addition to encouraging empiricism, Bacon also promoted

the notion that science and technology would increase mankind's material well-being:

Machines may be made by which the largest ships, with only one man steering them, will move faster than if they were filled with rowers; wagons may be built which will move with unbelievable speed and without the aid of beasts; flying machines can be constructed in which a man may beat the air with mechanical wings like a bird . . . machines will make it possible for men to go to the bottom of seas and rivers.

Roger Bacon's faith in science and experimentation was motivated by the desire to solve practical problems and drew little support or inspiration from theoretical science itself. He correctly foresaw that empiricism would transform science. His vision was realized with the rise of modern science during the Renaissance as a marriage of the empirical, technology-based mechanics of the Middle Ages with abstract science based on mathematics and deductive logic as originated by the Greeks operating under the influence of the alphabet effect.

12

The Printing Press: Enhancing the Alphabet Effect

With the printing press we finally encounter a technology whose impact on the use of the alphabet is so great that it must be ranked in importance with the alphabet itself. For not only did the printing press greatly multiply access to alphabetic texts, it also, through the regularity it introduced, transformed the way in which the alphabetic text was placed on the page and was perceived by its readers. The differences between the handwritten manuscript and the machine-manufactured, printed artifact are so great that these two forms of alphabetic text must be considered as completely different media. This fact is reflected in the dramatic change in European civilization and society that the printing press effected. The impact of the printing press was of the same order of magnitude as the impact of the alphabet itself approximately 3,000 years earlier. The impact of the printing press, however, was more sudden and hence more dramatic.

The discovery of printing was one of the great turning-points in the history of mankind. . . . It changed the very warp and woof of history, for it replaced precarious forms of tradition (oral and manuscript) by one that was stable, secure, and lasting.¹

The Invention of the Printing Press

Before examining the dimensions of this turning point in the history of mankind, let us first review the history of printing from its earliest origins before the invention of the alphabet itself. The very first form of printing can be traced back to the cylinder seals used by the Sumerians to make impressions on wet clay. The first large-scale use of the technique was made by Buddhists in sixth-century China to print religious texts. They would carve a page of text in reverse on a wooden block that was then used to create multiple copies of a printed page on paper. This system did not prove to be economical in either China or Europe. By the eleventh century a system of movable type had

In our study of the alphabet effect we have for the most part taken the media for the transmission of the alphabet for granted. These media included papyrus, parchment, paper, pens, brushes, and ink. These adjunct technologies naturally have had an important impact on the way in which the technology of the alphabet itself has been deployed. It is perhaps no accident that the greatest library in the Greek world was built in Alexandria near the Nile River. The Nile was a source of an abundant supply of papyrus, a much cheaper writing material than parchment. The invention of paper in China and its transmission to Europe in the late Middle Ages had a greater impact on the spread and use of alphabetic literacy than any other development up to that time. A good supply of paper, as we shall soon see, was also instrumental in the development of the art of printing.

been created in which there was one Chinese character per type font.

The use of movable type in China never reached the stage of development it eventually did in the West because of the large number of characters or type fonts required. The idea of printing with block prints and movable type spread to Europe, however, where it met the more receptive environment of alphabetic literacy. At first block prints were carved in wood as the Chinese had done. Within a short period of time there arose a technique for printing with movable type in which each font carried one letter of the alphabet. The success of the printing press and movable type was due to the unique character of the alphabet, which permitted the mechanical production of large numbers of the same type fonts at relatively low cost, encouraging mass production. Relatively small-scale entrepreneurs were able to set up printing shops in every major urban center in Europe. In China, however, it was only in government-sponsored enterprises that printing could be managed.²

The timing of the introduction of print³ was fortuitous because it coincided with the arrival in Europe of another Chinese invention, namely, paper manufacturing. Without a cheap supply of writing materials, the printing press might not have been invented nor become the commercial success that it was.

The impetus for the invention of printing was commercial. With an increased supply of paper in Europe there was a marked increase in the manufacture of books in *scriptoria* and *stationarii*, where copyists were employed and organized to mass-produce books. As the market for books increased, especially for the Bible and other religious texts, the early printers were economically motivated to expand their operations. Economic factors also contributed to the success of the printing press and the book trade it gave rise to. The phonetic alphabet, with its limited number of elements, was capable of an infinite number of combinations and allowed the printing press to serve a variety of markets.⁴

The market for manuscripts or books existed before the invention of the printing press and was in fact one of the factors leading to this innovation. The widespread literary interest and popular demand for books increased even more once printing reduced their price.⁵

The demand for books began in the Middle Ages and we can trace three distinct periods for the production of manuscripts. The first, stretching roughly from A.D. 550 to 1200, involves exclusively the activities of the monasteries in the preservation of classical texts and the organization of scriptoria to carry out the copying tasks.

The second stage, roughly from 1200 to 1400, corresponds to the period when production of books was dominated by academics and the university booksellers or *stationarii*. The *stationarii* were licensed by the universities and were charged with the responsibility of stocking those books required for particular courses of study at the university.⁶ Students obtained their books either by renting manuscripts through the offices of the *stationarii* or by making their own manuscripts from dictations read out to them by lecturers at the university.

The third period, starting in 1400 and running until print took over manuscript production, began when publishing activities were commercialized outside the university.⁷ Three major markets for manuscripts can be identified in this period:

1. The market for Bibles and other religious books
2. The market for the newly emerging vernacular literatures
3. The university market

The vernacular movement in literature began with Dante's *Divine Comedy* in 1300 and Boccaccio's *Decameron* later in the century. This movement spread from Italy north to France, Germany, and England. One measure of the popularity of vernacular literature is the fact that eighty handwritten manuscripts of Wolfram von Eschenbach's *Parzival* and sixty of Chaucer's *Can-*

terbury Tales have survived to this day.⁷ Another index of the extent of the book market in Europe is the fact that approximately 10,000 scribes or copyists made their living through the production of manuscripts.⁸

What contributed to the economic success of printing with the alphabet was the use of type fonts that could be mass-produced because there was such a small number needed, approximately one hundred, which included the upper and lower cases of the alphabet, the ten numerals, and punctuation marks: !, ? ;. The other factor is the constant repeatability of these elements so that once a page was composed with type and printed, the type fonts could be disassembled and used again for another page. The reassembling of already manufactured typecast fonts was naturally much faster than having to carve a page in reverse from scratch.

The true innovation of the European printing press, the invention of which is usually ascribed to Johann Gutenberg, was not the press so much as the idea of using movable type. A certain amount of controversy surrounds the question of who should be honored as the first inventor of the printing press, if indeed such a person exists. It would seem that the printing press arose as a consequence of a number of experiments and innovations carried out in different places by different individuals.⁹

Laurens Janszoon, surnamed Coster (or Koster "sacristan") of Haarlem in the Netherlands who originally worked with block prints was certainly one of the pioneers of movable type as documented by Hadrian Junius who wrote a history of Holland a century later.^{10,11} Koster used wooden type fonts together with wooden block prints for the production in 1428 of *Speculum Humanae Salvationis* (*The Mirror of Human Salvation*), a religious prayer book popular among the Benedictines. Junius also reported that Koster's workshop closed its activities after his death but that one of his workmen conveyed his ideas to Germany where they presumably reached Gutenberg.

The development of the printing press depended on a number of other innovations in addition to the two supposedly intro-

duced by Gutenberg. These were the use of movable, mass-produced, cast-metal type fonts and an improved mechanism for the handpress, which permitted large sheets of paper to be printed. The original handpress itself was derived directly from wine and cloth presses. Among the most important supporting innovations for print were paper manufacturing and an oil-based ink that was derived from the work of oil painters.

Perhaps Gutenberg's true contribution was to organize all of these innovations and create a commercial enterprise that made printing possible. Prior to his work on the press Gutenberg was not concerned with manuscripts but with the manufacturing of mirrors, according to local records. These historic records reveal that at the same time Gutenberg was engaged in activities involving mirrors he also was working on a printing press. He was engaged for a number of years in research and development. Gutenberg required investment capital for this activity and entered into a joint venture with Johann Fust. A misunderstanding ensued between the two, followed by a lawsuit in which Fust gained control of one of Gutenberg's presses.

Fust not only became a printer like Gutenberg, but being a more astute entrepreneur, he also became Europe's first publisher and set about systematically marketing the products of this new invention. He traveled to Paris to sell his printed edition of the Bible at one-fifth its normal price, causing a total panic among the copyists who claimed he was in league with the Devil because he was able to produce as many copies of a manuscript as he wanted.

Gutenberg received credit as the inventor of the first printing press as early as 1499 in the *Chronicle of Cologne*.¹² "The first inventor of printing was a burgher at Mainz, and he was born at Strassburg, and named Johan Gutenberg." Gutenberg deserved the credit he received, given the lack of reward or commercial success he enjoyed during his lifetime. He gave up successful business interests and devoted all his energies and resources to perfecting his invention. We are indebted to him for his contribution, which totally transformed Western civilization.

The Printing Press and the Renaissance

The main market to which the printers addressed themselves was not the nobility (who prior to the press were the only class who could afford books) but rather the newly emerging middle class.^{13,14} They were able to afford the new books and also had the time to learn how to read.

The early critics of print were unable to gauge the truly revolutionary impact this medium was to have on their society and their culture. In order to understand the magnitude of the impact of the printing press, we must carefully analyze the vast differences between the handwritten manuscript and the mechanically mass-produced printed book despite the fact that the content of these two media was virtually identical. The first books printed were those available in manuscript form. The printers basically provided a duplicating service that reproduced existing manuscripts in larger numbers and at lower prices.¹⁵

McLuhan¹⁶ has pointed out that despite the fact that the handwritten manuscript and the printed book are quite different media of communication, the first producers and consumers of the printed pages considered print a continuation of the manuscript. This was the only perception the first users of print could reach since the contents of the first printed books and handwritten manuscripts were the same. They could not fathom the effects the printing press, through increased accessibility, reduced cost, and multiple copies, would have on the spread of culture and education. They could not imagine the ways in which information was to be organized or how it would be influenced by the regularity and uniformity of the printed page, or that it would introduce a visual bias into their thinking. They did not foresee how the permanency of the multiple copies of printed texts would affect the preservation of both scientific data and literary texts.

Each of these features of the printing press—its uniformity and regularity, the visual bias it encourages, the permanency of

its record, the increased literacy it permits—are all features the alphabet promoted before the advent of print, albeit to a lesser degree. The printing press, however, enhanced and multiplied each of these features of the alphabet, unleashing a powerful new force that completely transformed Western civilization, leaving in its wake the Renaissance, the rise of science, the Reformation, individualism, democracy, nationalism, the systematic exploitation of technology, and the Industrial Revolution—in short, the modern world. "It brought about the most radical transformation in the conditions of intellectual life in the history of western civilization."¹⁷

One of the major impacts of the printing press was to reinforce or enhance a transition that was already in progress when it was first invented, namely, the transition from the Middle Ages to the Renaissance. The exact point when this transition took place is impossible to determine. However, there is no doubt that the revival in learning that took place in Italy in the fourteenth century, the "quattrocento revival," occurred well before the advent of the printing press in the middle of the fifteenth century. Therefore the printing press cannot be said to have been a causative agent of the Renaissance. Nonetheless, many historians regard the printing press as the dividing line between the Middle Ages and the Renaissance. "Four men, Gutenberg, Columbus, Luther and Copernicus, stand at the dividing line of the Middle Ages."¹⁸ The printing press marked the end of the literary style associated with the Middle Ages and the beginning of a new one.¹⁹ It also represented a new beginning for science and technology. "The development of printing, more than any other single achievement, marks the line of division between medieval and modern technology."²⁰

Scholars regard the advent of the printing press as a significant transition point, despite the fact that it arrived on the scene after the quattrocento revival, because of the way in which it reinforced this revival of learning. The printing press allowed the Italian Renaissance to sustain itself (unlike the two previous re-

nascentes: the ninth-century Carolingian revival and the so-called twelfth-century renaissance).²¹ These two earlier revivals were dependent on the spoken word and handwritten manuscripts for the transmission of their spirit. With the advent of print, the quattrocento revival could continue to gain momentum because the printing press provided a reliable medium for preserving the fruits of alphabetic literacy, freeing the energy of scholars for production of new ideas rather than merely preserving those of the past.

The printing press also encouraged a greater retrieval of manuscripts from the past, as publishers looked for new grist for their mills. The new means for disseminating texts ensured that documents retrieved from the past would remain in circulation.²² The printing press not only increased the number of titles available but also increased access to them. Scholars were no longer limited to the few libraries that existed during the Middle Ages; they were now in a position to create private libraries, which permitted a much greater amount of scholarship to take place. Scholarship was no longer restricted to the monasteries and the universities. In fact, the most innovative and successful scientific and scholarly work took place outside these two medieval institutions.²³

Printing allowed the impetus of the quattrocento revival to be preserved so that the Renaissance could come to full bloom rather than dying in the bud as had happened with the revivals in the ninth and twelfth centuries. Printing allowed a critical mass to develop, which led to a lift-off of the spirit of learning and created what Eisenstein and Panofsky refer to as the "permanent Renaissance."²⁴ "To put it briefly, the two medieval renaissances were limited and transitory; the Renaissance was total and permanent."

In attempting to describe the interaction of the printing press and the Renaissance, there are those who claim that the Renaissance inspired the printing press while others take the opposite view. Eisenstein claims that "the Renaissance probably did less to spread printing than printing did to spread the Renaissance."

sance."²⁵ Putnam, on the other hand, argues that the Renaissance must have had an enormous influence in furthering the speedy development and diffusion of the printing press.²⁵

In fact both positions are correct. The message of the printing press was the Renaissance and likewise the medium of the Renaissance was the printing press. In other words, a bootstrap operation was in effect in which the printing press and the Renaissance created the conditions for their mutual development.

Visual Bias

The influence of the printing press was not limited to the dissemination of ideas; rather, it shaped the character of the Renaissance itself. As a multiplier of alphabetic literacy, the printing press tended to reinforce many of the patterns that emerged with the alphabet.

One of the effects of the alphabet was to transform the oral bias of spoken communications to the visual bias of the written word. "When words are written, they become, of course, a part of the visual world. Like most of the elements of the visual world, they become static things and lose, as such, the dynamism which is so characteristic of the auditory world in general and of the spoken word in particular."²⁶ Of all writing schemes, the alphabet enhances the visual bias the most because of the abstract nature of alphabetic coding and the repetition of the same twenty-six elements. Print reinforces the visual bias of the alphabet. It makes literary material more available and hence creates a greater dominance over the spoken word than manuscript writing does.

Print also reinforces the visual element through standardization of the written text. The printed page is a much more regular arrangement of alphabetic script than the manuscript form. The letters appear in neat rows straight as an arrow. Each line begins at the same place on the left hand side of the page and ends at the same place at the right hand side of the page, two neat, absolutely straight margins sandwiching the text. The

words in the text themselves are evenly spaced. Paragraphs are indented so that the reader is aware each time a new set of ideas is begun. Each page is numbered, making reference back to the text easy. All of these devices enhance the visual appeal of the text and reinforce the visual bias of alphabetic writing.

The regularity of the printed page also allows silent reading, which increases the speed by which the text may be read as well as its visual character. Handwritten manuscripts are irregular and more difficult to read. In order to increase the comprehensibility of the text, the handwritten manuscripts were read aloud, as is done by youngsters just learning to read. This practice stressed the oral rather than visual character of the text.

Another factor contributing to an increased rate of silent reading was the use of serifs on the letters of the type fonts. The serifs are the little horizontal marks at the bottom and/or top of the letters. Before print, these served as decoration, but after print, they facilitated the reading of the text. The serifs at the top and bottom of the letters serve as guides to move the eye along the printed line of text more rapidly, much the way railroad tracks guide a train. The tunnel vision and linear thinking characteristic of the highly literate are, in part, due to the railroading that the serifs create, which enhances the linearity of the page. They keep the eyes from wandering off. The readers of the first printed pages with serifed type fonts were history's first speed readers. The alphabet, and in particular the printed alphabet, according to Innis and McLuhan, creates a visual bias on the part of the reader. "A decline of the oral tradition meant an emphasis on writing (and hence on the eye rather than the ear) and on visual arts, architecture, sculpture and painting and hence on space rather than time. . . . The discovery of printing in the middle of the fifteenth century implied the beginning of a return to a type of civilization dominated by the eye rather than the ear."²⁷

Printing brought back the visual bias of the Greeks with their strong emphasis on geometry in mathematics and realism in the arts.^{28,29} During the period following the introduction of the printing press, the first significant new progress was made in geometry since the time of Alexandria. The algebraic advances made by the Hindus and Arabs were integrated with geometry, leading to the analytic geometry of Descartes.

The Renaissance also gave rise to realism and the classical Greek sense of aesthetics. Not only did the Renaissance artists recapture the tradition of sculpture, they also mastered perspective, which enabled them to portray three dimensions on a two-dimensional canvas. The new fascination with portraying accurate three-dimensional visual images led to the invention of the "camera obscura" or pinhole camera.

Another reflection of visual bias was the division by scientists and philosophers of the perceptions into primary and secondary qualities. The primary qualities are those that can be apprehended with the visual sense. The secondary qualities, with the exception of color, are apprehended with the nonvisual senses. "As with Galileo, extension and movement were the only physical realities that he [Descartes] recognized as 'primary'; other aspects of existence such as colours, tastes and smells were referred to as 'secondary qualities.'"³⁰

The visual bias of the printed page and the linear succession of the letters of the alphabet created a new sense of order that contributed to the systematic way in which science and other forms of scholarship came to be practiced during the Renaissance. This spirit manifested itself in Newtonian mechanics and the metaphor of God as the clockmaker who set his ordered universe into a predictable form of motion.

Alphabetization

Another factor contributing to this sense of orderliness was that the alphabet and the printing press, working together, unleashed new ways of organizing information to cope with the "informa-

tion overload" they had created. One of the techniques employed for catalogs, indexes, and encyclopedias or compendia of information was alphabetization, that is, the arrangement of topics or book titles or authors in alphabetic order.

Alphabetization occurred before the introduction of printing and dated back to the Alexandrian library. However, it was not very commonly used during the Middle Ages or in ancient Greece or Rome.³¹ At first, alphabetizing was a matter of arranging words according to their initial letters and ordering them according to the alphabet. It was only later, around A.D. 200, that absolute or near absolute alphabetization was practiced, and it was only after the introduction of printing that the practice became widespread. It would seem that alphabetization was first used by the librarians at Alexandria for cataloging purposes.^{32,33}

Alphabetization, however, can be traced back to the period before Greek literacy to the Semitic peoples. One of the prime pieces of evidence for the borrowing of the phonetic alphabet by the Greeks from the Phoenicians is the fact that the names, sound values, and order of the letters of the alphabet were preserved. Although the names of the Phoenician letters were meaningless and the order of their presentation arbitrary, the Greeks nevertheless preserved these two features of the alphabet. This would indicate that the order of the letters was important to the Semites. In fact, it is known that the order of the letters dates back to the earliest abecedarian. If the order was preserved by the Semites, then it is altogether possible that they too might have resorted to alphabetic ordering. There are, in fact, a number of places in the Hebrew Scriptures in Psalms, Proverbs, and Lamentations where the letters of the alphabet are used to order the verses of a chapter.

The order of the letters of the alphabet was retained by the Greeks and exploited to create their number system. The first nine letters of the alphabet stood for the numbers 1 to 9 and so on as described earlier. The Hebrews also used this number system but it is believed that they borrowed the idea from the

Greeks. The ordering of the letters of the alphabet was also retained by the Romans despite the fact they changed the names of the letters.

Alphabetization in Semitic, Greek, or Roman culture did not become important until the period of the Alexandrian library in the third century B.C. when the techniques of organization used by the librarians spread to other sectors of the information industry such as authors and public administrators. One of the earliest uses of alphabetic order is found in a late third century B.C. inscription from the island of Cos in which the participants in the cult of Apollo and Heracles are listed alphabetically.³⁴

Alphabetization, once introduced in Alexandria, was used primarily by scholars for glossaries and lexica. Although there was a transfer of the technique of alphabetization to Roman scholars, it was not in actuality very widespread. Pliny makes use of it in his *Natural History* but this is thought to be a direct translation from the Greek reference material he copied. Only certain lists are alphabetical, namely, those of botanical specimens, gems, sea fish, and artists. Plautus and Virgil also made use of alphabetization as did a limited number of Roman administrators, who tended to file information topographically or chronologically. The use of alphabetization during the Middle Ages and Byzantine period was also sporadic. In the Latin West, Isidore of Seville prepared an etymology in alphabetic order and Photius a lexicon in the ninth century. A number of Latin glossaries, a bilingual Greek-Latin lexicon attributed to the circle of Robert Grosseteste, and a biblical concordance by Hugh of St.-Cher, all alphabetized, appeared in scattered European libraries. Papias in 1053 explains the organization of his dictionary in the earliest known description of alphabetization: "Anyone who wishes to find anything quickly must also notice that this whole book is composed according to the alphabet, not only in the first letters of the parts but also in the second, third and sometimes even in the further determinative arrangements of the letters."³⁵

Giovanni of Genoa, the author of the popular thirteenth-cen-

tury encyclopedia, the *Catholicon*, also made the effort to describe his organizational principle to his readers hoping that they would appreciate the efforts he had made.

You may proceed everywhere according to the alphabet. So, according to this order you will easily be able to find the spelling of any word included here. For example I intend to discuss amo and bibo. I will discuss amo before bibo because a is the first letter of amo and b is the first letter of bibo and a is before b in the alphabet. [He then explains why abeo appears before adeo, amatus before amor, etc.] Now I have devised this order at the cost of great effort and strenuous application. Yet it was I, by the grace of God working with me. I beg of you, therefore, good reader, do not scorn this great labour of mine and this order as something worthless.³⁶

Alphabetization did not become a standard procedure for organizing textual material until after the advent of the printing press. One of the reasons was that creating an alphabetic list was not easy because of the high cost of paper or parchment. The standard way to create an alphabetic listing is to list each item on a card and then order the cards. There seems to be no evidence of this technique before printing. Another method was to write the items to be ordered on a sheet of paper one line at a time. The paper was then cut up into individual slips each containing one item. They were ordered alphabetically and then pasted back onto a piece of paper. Another technique for ordering items was to write them out in a long list and then number each item according to their order, starting with the first letter of the first word and proceeding to the second, third, etc. A third technique was to set aside so many pages for each letter of the alphabet and then place items according to the first letter in the title. This resulted in cases where there were blank spaces between pages because too much space had been allocated or where the text was crowded and cramped because not enough space had been allocated.

Once printing was introduced and multiple copies were to be made, the expense of creating an alphabetic ordering could be absorbed. Also, as the amount of information rapidly exploded, alphabetization became a necessity once again as it had at Alexandria.

Still, the technique of alphabetization remained a novelty as late as 1604 when Robert Cowdray tendered the following advice in his dictionary, *Table Alphabetical*: "If thou be desirous . . . rightly and readily to understand, and to profit by this Table, and such like, then thou must learne the alphabet, to wit the order of the letters as they stand, perfectly without booke, and where every letter standeth."³⁶

The learning of the order of the letters of the alphabet, the ABC's, is to this day the child's first step in becoming literate. It is ironic that this first step to literacy, the memorization of the alphabet, takes place totally in the oral mode. Children reciting the alphabet employ a rhythmic cadence just as they do with a nursery rhyme.

The commercial considerations of the printers further enhanced the natural orderliness that the printing press promoted. In order to compete with each other, they prepared carefully organized catalogs. "The competitive commercial character of the printed book-trade when coupled with typographic standardization made more systematic cataloguing and indexing seem not only feasible but highly desirable as well."³⁷ The publishers were also careful to prepare their texts in a systematic way to make their products more desirable in the marketplace. They used title pages, tables of contents, and in some cases an index. As a consequence of this, the reading environment in which scientists and scholars operated was a well-organized one and this affected their thinking and their scholarship. The medium is the message and the message of print was organization, alphabetization, systemization, and standardization.

Accuracy also became an important factor in the preparation of texts, and when publisher-printers discovered their errors, they

printed errata so that their errors would not be propagated. They also put much more effort into editing and correcting texts before they were typeset, since any error they made would be multiplied many times over on the press.

"Clarity and logic, the disposition of matter on the printed page became . . . a preoccupation of editors."³⁷ The scholars and the printers influenced each other, each reinforcing the tendency in the other to become more organized, accurate, standardized, and systematic until these values became the norm of modern science, scholarship, and publishing.

13

Print, the Alphabet and Science

The Printing Press as a Medium for Scientific Thought

The phonetic alphabet played a major role in ancient Greece in the development of deductive logic and abstract science. The new system of writing induced in its users the powers of abstraction, uniformity, classification, and analysis. The printing press, as we have noted, enhanced the effects of the alphabet. Written material became even more abstract because of the ease and speed with which it could be read. The reader no longer needed to sound out each word but could read phrases and sentences in a single glance. The printed medium became transparent and hence its effects more abstract. Because of the neat and uniform way in which information could be organized on the printed

page, typography also increased the trend toward uniformity, classification, and analysis.

It is for these reasons that the printing press exercised such a stimulating effect on the whole field of science and mathematics. "If science helped give birth to the printed book, it was clearly the printed book that sent science from its medieval habits straight into the boiling scientific revolution."¹

The rapid dissemination of information and knowledge to a mass audience was one of the essential elements in the use of modern science. One indication of the importance of the printed book in this respect was the close association of the scientists with printer-publishers. In some instances, scientific pioneers were themselves printers.² Scientists were anxious to publish their results and they were also avid readers of scientific materials. Newton was a prime example of this spirit, as revealed in the notebooks that catalog his readings of Boyle, Hooke, Galileo's *Dialogues*, and Descartes's *Principles of Philosophy*. These summaries show how he arrived at many of his own new principles and results.³

The printed book was important not only because it served as a medium for the diffusion of ideas but also because it provided a way to preserve scientific data through the rapid creation of multiple copies. This is probably what motivated Tycho Brahe to assemble a printing press on the remote island of Hven, where he had established his astronomical observatory. He also built a paper mill on the island to accommodate his steady stream of publications.^{4,5,6}

The printing press had a role to play in the overall revival of ancient learning, and the resurrection of an ancient scientific text would often provide the medical student or practitioner with new information and new insights. In fact, reading through ancient texts was a valid form of medical research, and in the early days of modern science, it often yielded more knowledge than practical laboratory experiments.

The medical field was not the only one to benefit from the lit-

erary research that the new humanist's literary tradition promoted. The spinoff into the science of classical Greek and Latin scholarship was formidable. The humanists simplified and clarified language. They made available the great wealth of Greek mathematics and science. The study of biology was stimulated by the desire to identify the plants, animals, and minerals that classical authors mentioned in their texts.⁷

Print promoted self-learning and hence provided would-be scientists with an independent point of view for evaluating hypotheses and the validity of empirical data. Jacobo Foresti in the *Supplementum Chronicarum* published in Venice in 1483 expressed this spirit with the question "Why should old men be preferred to their juniors now that it is possible for the young by diligent study to acquire the same knowledge?"

This spirit led to a great deal of research and scholarship outside the university where a slavish conformity to the ideas of the ancients created an environment hostile to innovation. For example, the university community first attacked Galileo long before the Church did. The spirit of true science was carried out by "self-educated men and talented amateurs of liberal education." The academic monopoly on science during the Middle Ages was broken by the printed book.²

The university with its small body of students and teachers had been just about the only medium for the exchange of scientific ideas. Because of its insularity, the conservative academic community was able to police any unorthodox ideas it wished to squelch. The printing press broke this monopoly of knowledge and allowed the reading public to participate in the exchange of ideas. The Velikovsky affair, in which academics in the 1960s tried to suppress publication of his books, shows that the academic monopoly of knowledge is still a force to be reckoned with.⁸

The search for larger markets resulted in publications in the vernacular tongues, including work of a scientific and mathematical nature. This dramatically increased the number of those who

had access to technical ideas. Prior to the printing press, a knowledge of Latin acquired through the Church or the university was the only key to learning. The printing press allowed works that were translated by university-trained scholars to be disseminated to the general public.

The story of Tartaglia, who published the first vernacular translation of Euclid in 1543, captures the spirit of the new kind of scientists that the printing press made possible. Tartaglia, a gifted mathematician, despite his publications and the notoriety he won in his famous dispute with Cardano, failed to win a place in the university system. He had a tremendous impact on science, however, training Benedetti, one of Galileo's most important Italian predecessors, and Ostilio Ricci, Galileo's teacher of mathematics.²

Another positive effect of the printing press was the dramatic way in which it changed the patterns of scholarship, increasing the time available for developing new ideas. Instead of being forced to wander from one center of learning to another to view the limited number of manuscripts available, a scholar could remain in one place and collect printed editions of the books he wanted to study. And once the ancient texts appeared in printed editions, scholars were released from the task of recovering and preserving and copying them. They were free to work or develop new ideas.

The same applied to the recovery and preservation of astronomical data. Once these tasks were taken over by printers, the astronomers had more time for observations. Tycho Brahe made more observations than any other astronomer before this time. Printed mathematical tables of logarithms and trigonometric functions also saved astronomers and other scientists vast amounts of labor, freeing them for more creative work. They could collect and organize much larger amounts of data in a systematic and orderly fashion. Naturally, new patterns emerged with the new visualization of information that print made possible.

Copernicus, for example, developed his ideas after print had been introduced but before the vast amount of new data collected by Brahe was available. He analyzed basically the same data as Ptolemaean astronomers 1,300 years earlier. However, Copernicus saw the data differently. This was due in part to the new print format, which made handling the data so much easier. Copernicus was able to analyze the vast amounts of data virtually on his own whereas Ptolemaean had had all of the vast resources of the great library at Alexandria at his disposal.

The printing press provided an easily accessible format not only for data but also for scientific ideas. Print, by making it possible to reproduce thousands of copies of a text cheaply and quickly, made the diffusion of ideas over space and time simple. Kepler, one of those most affected by print, was well aware of its impact:

Do we not today by the art of printing bring to light all the ancient writers? . . . Through them a new theology has been created today, and a new jurisprudence; the followers of Ptolemaeus have created a new medicine, and the followers of Copernicus a new astronomy. For my part, I believe that now at last the world is alive, and indeed is in a state of intense excitement.⁹

Not only were the scientific works of the ancients available but also those of the more practical medieval scientists. The ancient writers excited and inflamed the imaginations of Renaissance thinkers but it was the more down-to-earth thinkers of the Middle Ages who steered science in the direction of empiricism and practicality. The early printing presses made medieval scientific ideas available to Renaissance scientists.¹⁰

Printing also provided a mechanism whereby new ideas spread even when attempts were made to suppress them by the Church or the State. Copernicus did not publish his famous *De Revolutionibus* until the very end of his life, receiving the first printed

copy, according to tradition, on his deathbed. He wrote the book using a highly technical language so that only the community of astronomers could read it. It was for this reason that at first it was ignored outside of scientific circles. This permitted its superior mathematical techniques to become indispensable to all astronomers before the formidable lay and clerical opposition to its central thesis developed. By then it was too late to suppress it, for Copernicus's ideas had penetrated or perhaps more accurately had infiltrated the spirit and imagination of European thought. A revolution in scientific thought had been launched through a printed book that had experienced a rapid and wide dissemination throughout Europe.¹¹

In addition to the book, the printing press created another medium for the dissemination of scientific ideas, namely, journals in which scientists were able to report on the results of their research periodically rather than after a line of research was completed after many years of work. This enabled a much more rapid turnover of new ideas through the feedback of readers and authors. It also promoted cooperation among scientists who could feel they were contributing to a joint venture. Because of the preservative power of print and the cooperative spirit it fostered, a critical mass of scientific activity soon emerged. The scientific community that the printing press created at first rivaled and then surpassed the size of the community at the great library in Alexandria.

Print Sets the Standard for Science

Typography made possible a new level of standardization of textual material, which in turn promoted much greater accuracy. Contradictions or errors stood out like sore thumbs in the visually uniform format of the printed page. The repeatability of print and its powers of preservation also promoted greater accuracy and precision in the data captured in textual material, and this had a positive impact on mathematics and science. "A new confidence in the accuracy of mathematical constructions, fig-

ures and numbers was predicated on a method of duplication that transcended older limits imposed by time and space and that presented identical data in identical form to men who were otherwise divided by cultural and geographic frontiers."¹²

The printing press by creating a standardized format for the presentation of textual material encouraged a similar standardization in the way all information was handled and presented. Each sheet printed from the same plate was identical to all the others and the information on it was arranged in exactly the same way. This permitted an author to refer to the exact line and page of another's work without ambiguity. The cross-referencing from one text to another allowed comparisons between ideas or similar sets of empirical data.¹³

The printing press not only permitted and promoted greater accuracy with alphabetic texts and numerical figures but also with pictorial representations. This was of prime importance for the transmission of scientific drawings and diagrams. "Hand-drawn illustrations were replaced by woodcuts and engravings which could be more easily reproduced. Repeatable pictorial statements revolutionized technical literature reinforcing the uniformity and standardization that the printed word had created."¹⁴ The fact that identical images, maps, and diagrams could be viewed simultaneously by scattered readers constituted a kind of communications revolution in itself, which impacted most on medicine, botany, zoology, geography, and astronomy.

The repeatability of visual images and diagrams is not explicitly part of the alphabet effect. However, alphabetic literacy helped make the printing press a success and hence contributed to the development of a medium for the lithograph and engraving. And the visual bias that the alphabet and print encouraged also created an environment in which printed pictorial images could thrive.

The importance of the role of the printed book in the development of science is reflected in Galileo's use of the metaphor of the book to describe the physical universe.

Philosophy is written in that vast book which stands forever open before our eyes, I mean the universe; but it can not be read until we have learnt the language and become familiar with the characters in which it is written. It is written in mathematical language, and the letters are triangles, circles, and other geometric figures, without which means is it humanly possible to comprehend a single word (*Saggiatore*).

The Rise of Empiricism and the Divorce of Science from Its Literary Past

The initial interest in science, its diffusion to a large audience, and its development into a systematic study were all due in part to the printed book. Literary activities, however, came to dominate scientific thought as they had during the classical Greek period. In order to create the experimental spirit that characterizes modern science today, Renaissance scientists had to rebel against the literary tradition that permeated their study of nature and develop a more empirical approach to physics, chemistry, biology, and medicine.

The alchemists, despite their use of certain magical practices, laid down many of the foundations for empirical research that evolved directly into modern chemistry. Alchemists today are more remembered for their allegorizing and mysticism than for the new emphasis they placed on observational evidence. Paracelsus called upon alchemists to learn from nature rather than from books.¹⁵ The empirical tradition of alchemy can be traced back to its roots, which was the practical goal of the transmutation of base metals into gold.

If you wish to know that pepper is hot . . . that the magnet attracts steel, that arsenic whitens brass, you have to verify the assertion by experience. It is the same in Geometry, Astronomy, Music and Perspective, and other sciences with a practical aim and scope. A like rule applies with double force in alchemy.¹⁶

The spirit of turning from books to the empirical observation of nature was also encouraged by Severinus, a Danish physician and follower of Paracelsus. In his book *Idea Medicinae Philosophicae*, published in Basel in 1571, Severinus writes:

Search the valleys of the deserts, the shores of the sea, and the deepest recesses of the earth; mark well the distinctions between animals, the differences of plants, the various kinds of minerals, the properties and mode of origin of everything that exists. Be not ashamed to learn by heart the astronomy and terrestrial philosophy of the peasantry. Lastly, purchase coal, build furnaces, watch and experiment without wearying. In this way and no other, you will arrive at a knowledge of things and of their properties.

The empirical spirit that developed in the Renaissance was due in part to the increased interest in mechanical devices in the late Middle Ages. The invention of the printing press, which marked a dramatic transition to modern technology, also promoted an interest in empiricism, especially among the educated who were associated with the book trade. The operation of publishing books and using a printing press involved a wide range of technical matters in addition to the mechanical aspects of the press such as the use of screws and levers. Knowledge concerning the production of paper and inks and the chemistry associated with them and a number of issues in metallurgy and metal casting associated with the production of the type fonts were also required.²

The groundwork for the Industrial Revolution was also laid at this time. The printing press represented the first large-scale mass-production manufacturing operation and the first reduction of any handcraft to mechanical terms.¹⁷ The printing press with movable type provided the first uniformly repeatable commodity, the first assembly line, and the first mass production. "Printing marked the first stage in the spread of the industrial revolution."¹⁸

The Printing Press Reinforces the Abstraction of Alphabetic Literacy

The alphabet naturally played an important role in the birth of modern science. Its effects were even more pronounced in the print form than in the manuscript form. Many of the features of the alphabet that contributed to creating a positive environment for the birth of abstract science in ancient Greece, such as abstraction, regularity, uniformity, and linearity, were enhanced by the print format. The powers of the alphabet as a tool for analysis and classification were strengthened with print because of:

1. The greater amount of data that could be accommodated on a single page of print
2. The increased uniformity of print
3. The stronger visual bias of the printed page
4. The increased capability for cross-referencing

One of the primary characteristics of the modern physics that followed on the heels of the printed word was a new level of abstraction. The Copernican revolution did more than replace the earth with the sun as the center of the universe. It was a triumph of abstract thinking in which the dictates of logic triumphed over common sense. In the Copernican system, the earth was required to move through the heavens, a notion that totally violated all the sensibilities of contemporary thought. The motivation for this bizarre system was Copernicus's abstract reasoning that a world system that required fewer epicycles to describe the movement of the planets was more logical. He also argued on equally abstract grounds that the Ptolemaic system must be wrong since the earth was not really in the center of the universe but ever so slightly displaced from the center.

Galileo was extremely impressed by the abstractness of Copernicus's thinking. This, no doubt, influenced his own thinking and gave him the courage to develop his ideas along abstract

lines of his own. He wrote in his *Dialogue on the Two Principal Systems of the Universe*:

I cannot find any bounds for my admiration how reason was able, in Aristarchus and Copernicus, to commit such a rape upon their senses and in spite of them, to make herself mistress of their belief.

Descartes captured the new spirit of abstraction in philosophy with his dictum "Cogito, ergo sum" ("I think, therefore I am") and in mathematics with his analytic geometry. The latter led directly to Newton's breakthroughs in which classical mechanics was described in terms of three mathematical laws of motion. This achievement represented perhaps the greatest leap in abstract thought in our intellectual history. The following passage from Query 31 in Newton's *Opticks* captures the spirit of this new attitude in which he rejects all occult explanations for motion and seeks "to derive two or three general Principles of Motion from Phenomena, and afterward to tell us how the Properties and Actions of all corporeal things follow from those manifest Principles."

Print: The Medium of Classification and Specialization

It was the new level of abstraction of Newton's Laws that provided a measure of the depth of the new science. It was the work of the catalogers and classifiers of scientific information, however, that provided an indication of the scope and breadth of the new thirst for knowledge. Scholars collected and compiled information in the fields of botany, zoology, philology, linguistics, library science, geology, and astronomy. Catalogs, dictionaries, encyclopedias, data collections, and compendia of all sorts appeared in increasingly larger numbers during the Renaissance, stimulated by the organizational possibilities that the printing press made possible.

The large compilations or catalogs of data were more systematic and orderly in the printed format than they had been when they were compiled by scribes. The accuracy of printed compendia of data and information increased because of the increased ability of scholars to visibly spot errors and inaccuracies. Readers were often invited to correct any errors they found or to supplement the information provided. Print permitted a rather rapid feedback from many readers because of the speed at which multiple copies of a text would be distributed to interested scholars and also because the reader was readily able to identify the author and the printer and hence transmit his views to the author. David Hume recognized this advantage of print in a letter to his publisher: "The Power which Printing gives us of continually improving and correcting our works in successive Editions appears to me the chief Advantage of that art."¹⁹

The manner in which the printing press promoted the classification of scientific data is illustrated by the work of the sixteenth-century Swiss scholar Konrad von Gesner. He produced the first comprehensive bibliography, the *Bibliotheca Universalis*, in 1545, which listed approximately ten thousand titles by some three thousand authors writing in Greek, Latin, and Hebrew. Three years later he released the *Pandectarum*, which cataloged thirty thousand titles cross-referenced and classified by topic. Gesner's passion for cataloging and systematizing went well beyond library science. He worked in the fields of botany and zoology and with the help of fifty correspondents compiled vast amounts of information including illustrations, which earned him the title "father of zoology." Other botanists were collecting information from India, from the New World, from all variety of countries and climates.²⁰

The printing press unleashed and stimulated the gathering of scientific information in a number of fields in the natural, social, and linguistic sciences. Scholars and printers developed organizational tools to deal with the sudden surge in information. The alphabet served as a model for the various orderings of data,

which included alphabetization, chronological ordering, geographic ordering, typologies, indices, and registers.

In response to the flood of information an old institution from the classical period was resurrected and revitalized, namely, the encyclopedia. A typical sixteenth-century example of such a compendium of knowledge and information was Sebastian Münster's *Cosmography*, which went through thirty-five editions, twenty in German, five in Latin, six in French, three in Italian, and one in Czech. In his preface, Münster explained the nature of his encyclopedia:

The art of cosmography concerns itself not only with the countries, habitations, and lives of various peoples of the earth, but also with many other things, such as strange animals, trees, metals, and so on, things both useful and useless, to be found on land and in the sea; [also] the habits, customs, laws, governments of men, the origins of countries, regions, cities and towns, how nature has endowed them and what human inventiveness has produced in them, [also] what notable things have happened everywhere.²¹

During the course of its thirty-five editions over a period of eighty-four years from 1544 to 1628 the volume of the *Cosmography* exploded. It began with 650 folio pages but by the time of 1575 the French edition contained over 4,000 pages.¹⁷

Not only did this new encyclopedia enjoy public acclaim, but Pliny the Elder's *Natural History* in a printed edition enjoyed a greater popularity than the original edition had in Rome 1,500 years earlier. Over forty editions appeared during the fifteenth and sixteenth centuries.

The printing press encouraged an explosion of new information, which in turn led to the specialization and fragmentation of knowledge. The alphabet by itself had encouraged a specialization and division of subjects or topics in classical Greece, in sharp contrast to the holistic approach of the oral tradition of Homer.

This encyclopedic division of knowledge into special topics was a continuation of the tradition of specialization that began in classical Greece, where Aristotle had divided philosophy into specific topics. The print format reinforced these divisions, which were elaborated by Renaissance scholars such as Ramus. As the cost of books fell, specialized monographs were published, which could support a small community of experts interested in a fairly narrow range of study. The disciplines of science, including mathematics, astronomy, geology, physics, chemistry, and zoology, evolved because they were more sharply differentiated as a result of print.

The use of the alphabet through the medium of print served as a paradigm for classification and organization within each of these individual fields. For example, in physics the principle of linear superposition by which the components of motion in the x , y , and z directions can be separated and treated as individual problems is a direct fallout of the type of analysis that alphabetic literacy inspired. It is probably no accident that the letters of the alphabet are used to designate the three dimensions of space into which all motion can be subdivided and analyzed.

The Cartesian coordinates x , y , and z that Newton employed enabled him to abstract and simplify the description of the dynamic interactions of mechanical systems. It also set the tone for the age of mechanization that the printing press had ushered in. The division of all systems into their basic components parallels the way in which words can be broken down into their basic sounds and then represented by the letters of the alphabet. This form of organization encourages or invites a linear cause and effect analysis of the relationships between the components of a system. Newton's formulation of mechanics in terms of forces (causes) and accelerations (effects) can therefore be traced directly back to the linear form of analysis inspired by the alphabet.

This same spirit infused the engineers and mechanics who built the machinery of the Industrial Revolution, basing it on

the same principles of piecing together the repeatable uniform elements of gears, screws, and levers in linear configurations to achieve specific mechanical tasks. The waterwheels, windmills and other devices from the Middle Ages provided the early impetus for the mechanical revolution. It was the printing press, however, where the repeatable uniform type fonts were used and reused in an infinite number of permutations that inspired the transformation to the semi-automated machinery of the Industrial Revolution.

In the field of chemistry, the analog between the ninety-two elements out of which all chemical substances are composed and the letters of the alphabet out of which all words are built is immediately apparent. The parallel is further strengthened by the fact that the elements in chemical equations are referred to by the letters of the alphabet, such as H for hydrogen or C for carbon. For each element there corresponds an atom, which is the smallest building block or unit of chemistry just as the phoneme and the letter of the alphabet are the smallest building blocks or units of speech and writing, respectively. Molecules, which are composed of various combinations of atoms, are like words composed of different combinations of letters. The atoms that form these combinations are guided by the syntax of the chemical forces. The symbols used to describe the molecules also involve the letters of the alphabet in that an individual molecule is represented by the atoms of which it is composed. Water, for example, is written as H_2O (two hydrogen and one oxygen) and hydrogen peroxide as H_2O_2 .

The atoms themselves are made up of still smaller bits of matter called elementary particles, which include electrons, protons, neutrons, and mesons (the nuclear glue that keeps the nucleus together). These building blocks of the atoms, the elementary particles, also operate like the letters of the alphabet, combining according to the syntax of nuclear and electric forces to form individual atoms. The symbols used to represent them are also the letters of the Roman or Greek alphabet: for example, e for the

electron, p for the proton, and π , ω , and ρ for the mesons.

Recent experimental studies in particle physics seem to indicate that the proton, neutron, and mesons are themselves composed of still smaller bits of matter referred to as quarks, of which there are at least six different types. The up, down, strange, charmed, beauty, and truth quarks are also represented by the letters of the alphabet, namely, u , d , s , c , b , and t .

In the fields of zoology and botany, the letters of the alphabet are not used to represent the various categories of classification. However, an elaborate system based on the work Linnaeus is employed. All the flora and fauna that have ever been observed have been classified according to species, genus, class, and order in a systematic logical and linear fashion based on principles that arose under the influence of alphabetic literacy. Linnaeus's scheme dates back to Aristotle, the first to systematically classify plants and animal.

In drawing the parallel between the various classification schemes used in science and the phonetic alphabet, we do not wish to suggest a naïve causal relationship between these schemes and alphabetic literacy. Rather, we suggest that as scientists pursued their ideas in their particular fields, the alphabet served as a model for organization. The fact that they consistently use the letters of the alphabet to designate their categories is one hint of this influence. The fact that the linear classification schemes are a unique product of alphabetic cultures is another hint.

Preliterate and nonalphabetic literate cultures have means for categorizing information, but they do not use the same linear systematic rational systems that are used in modern science. The Chinese and preliterate cultures use analogy as a way of classification instead of the deductive logical techniques of Western science.

Once again we are not suggesting a causal link between the alphabet and the techniques of modern science and deductive logic, but the correlation between the two is not an accident

either. The alphabet and scientific thought provide an environment in which both are able to thrive and reinforce one another. Our study has revealed that the printing press played an important role in promoting the use of the alphabet and hence created an environment in which the logical, analytic, rational techniques of modern science could evolve and thrive.

The Social and Cultural Impacts of the Printing Press

Just as the printing press changed the nature of science and technology, it also transformed the social, political, and economic institutions of Western civilization. Many of the social impacts of the printing press were the same as those of the alphabet, intensified by the way in which the printing press reinforced or enhanced the alphabet effect. This might explain the many similarities between the Renaissance and classical Greece. The humanism, individualism, artistic naturalism, capitalism, democracy, and nationalism of the Renaissance paralleled similar movements in ancient Greece. The Renaissance virtually replayed classical learning through the revival of Greek and Latin scholarship.

Print: The Technology of Individualism

One of the hallmarks of the Renaissance and the print revolution was a vibrant and active form of humanism and individualism similar to the one that accompanied the introduction of alphabetic literacy in ancient Greece. The printing press, by allowing a greater dissemination of reading material and by regularizing the format of textual material, had a stronger impact in promoting individualism than the handwritten alphabetic texts of the Middle Ages and the classical period.¹ "Print is the extreme phase of alphabet culture that detribalizes or decollectivizes man in the first instance. Print raises the visual features of alphabet to highest intensity of definition. Thus print carries the individuating power of the phonetic alphabet much further than manuscript cultures ever do."² Also, the printing press made available more texts from the classical period, which extolled individualism. The effects of the medium were reinforced by its contents.

The printing press permitted a new medium to come into existence that provided the opportunity for an individualistic expression of ideas and opinions and the emergence of the modern concept of an author. During the era of manuscript, learning was a collective activity in which each individual writer had to invest enormous amounts of energy strictly to preserve learning rather than to create new ideas. The lack of originality in the writers of the Middle Ages is beautifully illustrated in the following passage from the thirteenth-century Franciscan Saint Bonaventura:

A man might write the works of others, adding and changing nothing, in which case he is simply called a scribe [scribe]. Another writes the work of others with additions which are not his own; and he is called a compiler [compiler], another writes both others' work and his own, but with others' work in the principal place, adding his own for purposes of

explanation; and he is called a commentator [commentator]. . . . Another writes both his own work and others' with his own work in the principal place, adding others for purposes of confirmation; and such a man should be called an author [auctor].

The most interesting aspect of this classification of writers is the omission of our modern notion of an author as one who creates totally new and original material. The reason for this omission is simple. The modern author did not emerge until after the introduction of print. The identity of the scribe, compiler, commentator, or author of a manuscript was, therefore, unimportant to the medieval reading public. The medieval student did not regard the "contents of a book as the expression of another man's personality and opinion."³ No attempt was made to identify the author or scribe of a medieval text, or even its title. Manuscripts were referred to by the opening words of the text, following a tradition that dated back to the cuneiform clay tablets in Babylonia.

With the advent of printing and the cheaper costs for paper, title pages emerged on which the author, title, and printer-publisher of the book were all identified. With the possibility of new literary fame and financial gain, authors began to take pride in their literary output. The commercialization of publishing led to a new concept of literary property, in which the identity of the author became an important issue. "To copy and circulate another man's book might be regarded as a meritorious action in the age of manuscript; in the age of print such action results in lawsuit and damages."⁴ The concept of copyright to protect the literary property rights of the individual author further reinforced individualism. We see a return to the manuscript tradition with computer software in which the identity of the author is totally unimportant.

Not only did the printing press, together with the title page, give rise to a notion of literary fame and individual achievement

in letters, print also, as a medium of fixity, gave recognition to other fears of personal accomplishment. It was only after the advent of print that disputes arose regarding claims over individual achievement in terms of inventions, innovations, and discoveries. The rival claims of the Gutenberg and Koster camps with respect to the invention of the printing press was the first example of such disputes.⁵

The printing press, by making the production of textual material easier, broadened the kinds of topics and concerns to which authors addressed themselves. One of the new themes that emerged during the Italian Renaissance with writers such as Ficino, Pico, and Pomponazzi was the glorification of man and the dignity and freedom of the individual.⁶ The concerns of these early Renaissance humanists eventually evolved into the modern European liberal tradition in which the rights of the individual are of prime importance.

The individualism that the printing press and the humanists promoted was reinforced by and gave support to other cultural innovations that characterized the Renaissance:

1. The use of vernacular language as a medium of literary expression.
2. An increase in the number of democratic institutions.
3. The Reformation, which extended democratic ideals from the secular domain to the spiritual one.
4. The system of capitalism in which free enterprise based on individual initiative replaced the restrictive trade practices of the Middle Ages.
5. Increased opportunities for self-education and hence upward mobility and the emergence of the middle class.

Vernaculars

One of the dramatic and direct results of the printing press in Europe was the establishment of several vernacular tongues as

normative languages. "Typography arrested linguistic drift, enriched as well as standardized vernaculars, and paved the way for the more deliberate purification and codification of all major European languages."⁵ This development occurred only for those vernaculars for which a printed literature arose. "The Lithuanian, Latvian, Estonian, and Finnish languages might in the course of the sixteenth century have been absorbed by German, Polish, and Swedish, as were the languages of the Prussians, Pomeranians, and Courlanders, and other tribes before them, had they not been preserved in print."⁶

Steinberg⁷ provides a number of other examples where the printing press permitted the survival of the vernacular tongue of a national group with a small population. In the British Isles, the printing press ensured both the linguistic and political domination of English. However, Welsh and Irish Gaelic, which appeared in print in the late sixteenth century, have survived whereas Cornish has disappeared. In the Iberian peninsula Spanish and Portuguese have dominated politically, but Basque, first printed in 1545, and Catalan, one of the first languages to find itself in print in 1474, have both survived to this day and are enjoying a revival of nationalistic fervor.

The Germanic languages provide another example. Both Dutch and Swiss German before the advent of print were of equal status as other Germanic dialects. Because of the pioneering work of the Dutch in printing and publishing in their vernacular tongue including the 1477 translation of the Old Testament at Delft, Dutch or Netherlandish now has the status of a language distinct from German. However, "The Swiss edition of the New Testament followed Luther's [German] text closely, using only a few Alemannic words and phrases."⁸ As a consequence, Swiss German has remained a dialect, often looked down upon by those speaking High German.

In the same way, a number of Middle Eastern languages, like Syriac and Coptic, were almost totally replaced by Arabic as a result of the conquest of their native speakers by Islam and because

of the central role the Koran plays in these cultures. The absence of printing to fix these languages also contributed to their demise.

The printing press, by bringing the vernacular languages into print, created more activities for itself by dramatically increasing the number of potential readers and new authors. Not only did the absolute numbers increase, but the impact of the printed page on the individual reader was also greater because the visual cues of the printed words were reinforced by the daily aural impressions of the spoken language. The use of vernacular tongues in printed form reinforced and promoted many of the individualistic trends of the print era such as the increased level of education, new democratic institutions, capitalism, the Reformation, and nationalism.

Print and the Beginning of Mass Education

Once vernacular texts were published, the exposure to print material no longer required a proficiency in a second language. The number of people who could read and hence learn on their own increased dramatically. It was only in the age of print that the notion of the self-educated man arose. The story of every self-educated man from Niccolò Tartaglia, born at Brescia in 1500, to Abraham Lincoln, born in Kentucky in 1809, is the same in that books provided their entry into the world of learning and eventually allowed them to make their own unique contributions.

Latin was dethroned as the universal language of educated men.⁹ With the increasing number of books in vernacular tongues, particularly material of a learned nature, the traditional monopolies of knowledge by the Church and the universities broke down. Both institutionally educated and self-educated individuals arose to successfully challenge these two monopolies of learning through the Reformation and the scientific revolution.

New patterns of education took advantage of the new medium. "The printed book was a new visual aid available to all

students and it rendered the older education obsolete. The book was literally a teaching machine where the manuscript was a crude teaching tool only."⁹ The new medium with its visual bias and its propensity to compartmentalize and specialize information colored the new methods of education that arose partly due to the inspiration of Peter Ramus. Ramus spearheaded many of the curriculum reforms made by the sixteenth-century French academics who "were affiliated with scholar-printers and editors."¹⁰ These reforms form the basic structure of today's modern educational curriculum.

The democratization of knowledge that the printed word inspired was not limited to the training of professionals at universities, which could accommodate only a small minority of the population. "It was the dissemination of literature through the new art of printing rather than the diffusion of education through the university lecture rooms, which brought to the masses of the people the consciousness of mental existence."¹¹

One of the goals of the philosophers of the Enlightenment was a desire to bring learning within reach of artisans, as suggested by Floris. "Learning cannot be too common and the commoner the better. . . . Why but the vulgar should not know all."¹²

These aspirations of the Enlightenment were realized with the help of reasonably priced mass-produced books that served as the backbone of the system of publicly supported schools and libraries that arose with the Industrial Revolution. The actual foundations of the public school system can be traced back to the Czech educator, John Amos Comenius, who outlined the principles of primary education that have been followed by teachers ever since. He published the *Orbis Sensualis Pictus* in 1654, the first picture book designed to teach children Latin.¹³

The Printing Press and the Rise of Capitalism

The printing press, the use of vernaculars, and the popularization of learning all contributed to the increased sale of books.

Book printing and publishing contributed directly to the development of Western capitalism, since it was one of the first industries that required a capital investment to procure the means of production. It was also one of the first enterprises in which speculation played a prominent role. Publishing involved the marketing of a mass-manufactured product. It was a highly competitive field, where price was dictated by the laws of supply and demand. The book, according to McLuhan, became a commodity. "It created the price system. For until commodities are uniform and repeatable the price of an article is subject to haggle and adjustment. The uniformity and repeatability of the book . . . created modern markets and the price system. . . . Print was in itself a commodity, a new natural resource which also showed us how to tap all other kinds of resources including ourselves."¹³

Print provided its users, both authors and readers, with a new organizing principle that applied with equal effectiveness to science, technology, and commerce and led to the Industrial Revolution and to our present technology-based industrial system. The medium of the alphabet and the printing press working in consortium provided a model for entrepreneurs and industrialists to create modern Western efficiency and manufacturing.

The Printing Press and the Reformation

The printing press helped to bring about the Reformation. It contributed directly as a medium for the rapid and wide dissemination of information and opinions and indirectly by promoting the use of vernacular literature and the spirit of individualism. The translation of the Bible into vernacular languages removed the need for mediation through the Church.

Erasmus, together with the Basel printer Froben, published a Greek Testament in 1516 which "contributed more to the liberation of the human mind from the thralldom of the clergy" according to Partison,¹⁴ "than all the uproar and rage of Luther's many pamphlets." In his introduction to this translation Erasmus wrote: "I wish that every woman would read the Gos-

pel and the Epistles of Paul. . . . I wish these were translated into each and every language."¹³

Part of Erasmus's dream came true but at a price he could not have foreseen. The role that vernacular translations and the printing press would play was totally unknown to those first innocent churchmen who advocated their deployment in the service of God and his one true Church. In 1499, during that short period just after the first appearance of print and just before the first rumblings of the Reformation, the following passage was published in the *Chronicle of Cologne*: "The eternal God has out of his unfathomable wisdom brought into existence the laudable art, by which men now print books, and multiply them so greatly that every man may for himself read or hear read the way of salvation."

Within the short space of eighteen years after the publication of that sentiment Luther set in motion the greatest civil war and revolution that Christendom would ever experience when he posted his Ninety-five Theses on the church door in Wittenberg. The miscalculation by churchmen of the impact that printing would have on their religion serves as one of the classical examples of how difficult it is to understand the consequences of a new technology. The mechanism whereby print brought about the revolution and civil war that came to be known as the Reformation is complicated.

The ability of laymen to read the Bible directly in their own vernacular made them less dependent on the clergy. The spirit of humanism and individualism that print promoted also made those who were literate inclined to be more independent in forming their own opinions on spiritual and moral matters. "Prior to the printing-press, the responsibility [for individuals arriving at sound conclusions] had been left by the people with the 'spiritual advisers,' who were charged with the duty of doing the thinking for their flocks."¹⁴ Books taught people to think for themselves and this extended to religious matters. This practice had already begun in the Middle Ages with the scholastic

philosophers such as Abelard. Publication of the Scriptures in the vernacular was followed by new interpretations and by the intensive controversies conducted in pamphlets and broadsheets that led directly to the establishment of Protestantism.

Although the internal organization of the Church was hierarchical and based on literary forms and codified law, the actual teaching provided to its parishioners was almost totally oral. Most of the Mass in which the parishioner participated consisted of the recitation of oral formulae that they memorized and repeated frequently throughout the service. The flock was not encouraged to read for themselves. Whenever any use was made of written material, the congregation sat passively listening to the reading. The oral bias of the Church's services tended to reinforce the corporate tribal spirit of compliance to the authority of the storytellers or bards, namely, the priests. Just as it had never occurred to a member of tribal Greek society to challenge the ideas expressed by a bard reciting the epic poems of Homer, so the flock of the Catholic Church had remained passive over the centuries.

Before the advent of the universities, the Church had an almost total monopoly on the production and dissemination of written material. Even after the founding of the universities the Church exercised careful control of these institutions, tempering the activities of those like Abelard who championed ideas that challenged their authority. Just as the alphabet in Greece had encouraged the separation of religion and government, so the printing press encouraged a division between civil authority and faith. Alphabetic literacy and the press permitted faith to become an individual matter of conscience rather than a slavish adherence to corporate authority. With the advent of printing and the spread of learning outside the Church and universities, control of literary activities could no longer be maintained. It did not take long for the literate to challenge the ideas of the oral-based Church just as the educated and literate Greeks had challenged the ideas of Homer and Hesiod.

Once the challenge to the older oral order had begun, it spread like wildfire through the medium of the printing press. The lack of such a tool had limited the literary revolution of Plato and Aristotle and had permitted many of the tribal traditions of ancient Greece and Rome to survive even under Christianity. The analog of the Christian church with its many "plastic" icons and the Greek and Roman temples is clear. The Protestants reversed these tendencies and reverted to the strict iconoclasm of the Hebrews. Judaism was a far more literary religion than Christianity because of its scriptural obligation to read the law. Part of the Protestant revolution was the incorporation of Bible reading into the daily life of the family. As with the Hebrews, literacy became a religious tool for the Protestants. This helps to explain why the Protestants returned to many of the practices of the Old Testament and took as much comfort in this work as in the New Testament.

The influence of alphabetic literacy and the printing press in bringing about the Reformation is a complicated one but their role in its dissemination is straightforward. It has not been historically verified¹⁶ that Luther, in fact, nailed his Ninety-five Theses to the door of the Castle Church in Wittenberg in 1517 as tradition teaches us but it is certain that he used the printing press liberally to publish and publicize his ideas with lightning speed. "The theses . . . were said to be known throughout Germany in a fortnight and through Europe in a month."¹⁷ Never before in the history of ideas had a challenge to authority been so rapidly and widely disseminated as Luther's crusade against the Church, thanks to the printing press. Luther acknowledged his debt to the press, describing it as "God's highest and extremest act of grace, whereby the business of the Gospel is driven forward."

It was through the Reformation that the power of the printing press as a medium of publicity and propaganda was revealed. The press had fomented international revolt against authority and had totally transformed communication. In the three years

after posting his Theses, Luther issued thirty publications, which sold in excess of 500,000 copies. "Luther was able to make exact, standardized and ineradicable impressions on the mind of Europe. For the first time in human history, a great reading public judged the validity of revolutionary ideas through a mass-medium which used the vernacular languages together with the arts of the journalist and the cartoonist."¹⁸ Not only did Luther's publicity campaign set a precedent, it was not equaled in magnitude until the advent of large-circulation newspapers and electronic media.

In exploring the relationship of the Renaissance and the printing press, we discovered that there had been other renaissances before, but that print had served as the medium to establish the revival of learning on a global scale and on a permanent basis. The relationship between the press and Reformation follows a similar pattern. There were other challenges to the authority of the Church before Luther, dating back to the very origins of the institution. But until the time of the printing press and the Renaissance, the conditions and logistics did not exist for a massive revolution on the scale of the Protestant Reformation.

Once the extent of the revolt had been properly gauged, the Church hit back very aggressively against the Protestant uprising and launched the Counterreformation. One of the main targets of its counterattack was the printing press, which it hoped to control through censorship. The use of censorship began even before Luther's broadside attack at Wittenberg. Two years earlier, following the May 4, 1515, session of the Lateran Council, Pope Leo X issued a decree imposing censorship on all translations, presumably because of the fear that inaccuracy would promote errors in faith and daily life. In fact, the Church probably wanted to prevent the further dissemination of vernacular versions of the Bible, which were obviously fueling the revolt. In 1520 papal and imperial edicts focused on the Lutheran tracts for censorship and prohibition. This eventually led to the institu-

tion of the papal Index and the prohibitions against Bible reading as well as Bible printing. This was tantamount to prohibiting reading and the use of the alphabet itself. The very tool that had stimulated the development of monotheism, the alphabet, was perceived by the Church as a weapon attacking its moral foundation. It is little wonder then that the Church rejected the concept of vernacular Bibles, preferring that all religious literature remain in Latin so that it could exercise greater control.

The Protestant churches, on the other hand, encouraged Bible reading and the printing of vernacular editions. "In marked contrast to Catholic policy, vernacular Bibles, prayer books and catechisms were adopted by all reforming churches. Sooner or later, scriptural translations were officially authorized by all rulers who broke with Rome, and thus entered into the mainstream of national literary cultures in Protestant lands."¹⁹ Thus the Reformation and use of vernacular printing worked together to promote the spirit of nationalism.

I have argued that the publication of the Bible in vernacular tongues was one of the factors leading to the Reformation. Apropos of this hypothesis, it is interesting to note the following pattern among the national groups that adopted or rejected Protestantism. Those national groups whose mother tongue was one of the Romance languages and hence closely related to Latin remained Roman Catholic. These include the Italians, Spanish, Catalans, Portuguese, and French. Those national groups whose vernaculars were in no way related to Latin for the most part became Protestant, such as the Germans, Swiss, Dutch, English, Scots, Welsh, Danes, Norwegians, Swedes, Finns, Latvians, Estonians, and Czechs. There are some exceptions to the rule. The Irish, Polish, Lithuanians, Hungarians, and Austrians do not speak a Romance language but remained Roman Catholic and the French-speaking people of Switzerland became Protestant.

One possible explanation for the pattern is that of geographic proximity. While not denying that geography might have con-

tributed to the pattern I would argue that the following mechanism was also important. In those lands in which a Romance language was spoken, the need for a vernacular translation of the Bible was not as great, since Latin bore some resemblance to the spoken language. In those cases, however, where the vernacular language did not resemble Latin at all, translations were an absolute necessity and hence a greater percentage of the population made use of them. Vernacular translations contributed to the spirit of independence described earlier and hence might have contributed to the correlation of the Romance countries with Roman Catholicism and the non-Romance countries with Protestantism.

Print and Nationalism

The spirit of nationalism that engulfed Europe and led to the formation of today's modern nation-states was the product of the printing press and the many fallouts of this new technology, including the translation of the classical works into vernaculars, the establishment of vernacular literature and culture, the Reformation, and the public education system. The printing press played the central role in the rise of nationalism, first by releasing the forces that generated the movement and then by providing the medium whereby the movement took hold. This parallels the role it played in the Reformation. "By the end of the sixteenth century the flexibility of the alphabet and printing had contributed to the growth of diverse vernacular literatures and had provided a basis for divisive nationalism in Europe."²⁰ Print, through the promotion of the use of vernaculars, gave rise to national languages and cultures through which the aspirations of nationalism could be expressed and in which a national consciousness could emerge.

Many national literatures grew out of the vernacular translations of the Bible, which lent them a new dignity.²¹ Authors writing in their native tongues—Chaucer, Dante, Luther, Mon-

taigne, Cervantes—were quietly building nations and national loyalties more effectively than all the generals, kings, and statesmen of Europe. These writers and the printer-publishers who disseminated their literary output provided a medium for the expression of national sentiment and identity. The relationship between this literature and the creation of new loyalties based on ethnic identification once again illustrates McLuhan's aphorism that "the medium is the message." In this case the vernacular language and the printing press were the medium and nationalism was the message.

Another medium for the expression of nationalistic feelings was the Protestant churches that came into existence during the Reformation. These churches authorized vernacular versions of the Bible and hence were organized along national lines.²² These churches opposed the authority of Rome and promoted local or national control of religious and moral matters. The practice of the same religious belief, which was identified uniquely with a people with a common language, reinforced their national identity.

The Reformed churches were not the only public institutions that reinforced nationalistic feelings. The school system, another by-product of the printing press, also inculcated the spirit of national uniformity in its attempt to create a homogeneous population of national citizens. Access to the education system was not universal and only a small percentage of the population learned to read and write. It was precisely this population, however, who mounted the various campaigns for nationhood in Europe. "Nor is it at all certain that the 'masses' in any country have been directly responsible for the rise of modern nationalism. The movement appears to have gotten under way first among the 'intellectual' classes and to have received decisive impetus from support of the middle classes."²³ It was the middle class who became literate in their vernacular and who championed the Reformation and nationalism. The peasants were tied to their land and their mentality to their local district. Only the

literate were in a position to appreciate that there were nationalities and languages other than their own.

Printing and Democracy

The advent of the printing press contributed to the growth of the democratic spirit that the Italian humanists had promoted at the start of Renaissance. In addition to the Reformation and mass education, the printing press inspired the capitalistic and mercantile economic system that helped democratize economic opportunities. It also created the bourgeoisie, or middle class, which became the main pressure group for democratic reforms. The printing press also provided the medium through which those who campaigned for democratic institutions could rally support.

One of the impacts of alphabetic literacy in ancient Greece had been to promote a spirit of democracy. The printing press had the same influence, but because of the greater sense of uniformity that print inspired, there was an even greater emphasis in modern democracy on equality and uniform treatment before the law. The uniformity of the printed page was reinforced by the uniformity that the school system incorporated into its hidden curriculum and the common worship that a national church encouraged.

There emerged in this climate the idea of a uniform citizenry living in a national state united by a single language, mode of worship, and philosophy of government. The printing press and the various institutions that sprang up around it promoted the notion of the "equal rights of individuals to determine the state and government to which they would belong" and the "equal rights of individual nations to self-determination."²⁴ The Italian humanists' early notions of individual liberty evolved in this intellectual environment of nationalism and social uniformity into the modern ideas of parliamentary democracy based on an electoral system of equal representation and equality of treatment

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The Impact
of the Phonetic Alphabet
on the Development
of Western Civilization

ROBERT. K. LOGAN, Ph.D.

