LITERACY

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Introduction[1]

Cultural evolution

Most species of animals evolve slowly, adjusting to changes in their environment through genetic changes. In humans, however, alllllthough slow genetic changes are also present, there is a much more rapid method of adjustment to changed circumstances: cultural evolution. This rapid method of evolution was greatly aided by the invention of writing, which helped humans to hand down and spread new ideas and inventions. Thus, literacy became the foundation on which rapidly-developing human society was built.

Writing was developed in many parts of the world

Writing was developed independently in many parts of the world, in China, in Mesopotamia, in Egypt, and in Mesoamerica. The First Peoples of North and South America even had a method of keeping records using knotted strings, as well as decorative belts of Wampum.

The invention of printing

Paper was a Chinese invention. "India ink" was also iunvented in China, and the first known printed book. the "Diamand Sutra", was produced in China. However, printing with movable type was never successful because of the enormous number of characters in the Chinese language. Thus printing, a Chinese invention, was left to revolutionize the West.

In the 15th Century A.D., Johannes Gutenberg of Mainz, Germany, developed a practical method of printing with movable type. This invention revolutionized the western world. Scientific and technilogical progress became rapid. The population increased so much that it led Europeans to acquire colonies.

The Enlightenment

The "Enlightenment" or 'The Age of Reason" was made possible by the invention of printing. Sir Isaac Newton's orderly cosmos, where the planets

[1] This book makes use of some of my oreviously published book chapters, but much new material has also been added.

circled the sun following fixed laws of motion and gravitation, was the model for rationality during this period. But it was printing that made this possible. Newton himself said, “If I have seen farther than others, it is because I have stood on the shoulders of giants”. He was referring to Copernicus, Galileo, Tycho Brahe, and Johannes Kepler, but without the invention of printing, he could not have read their works.

Universal education

Most countries of the world aim at some level of education for their entire population. Hoever, there are a few where, even today, female education is discouraged. For example, in Pakistan on October 9, 2012, 15-year-old Malala Yousafzai was shot by the Taliban, whose aim it was to supress female education.

Computers revolutionize society

In the history of literacy, the invention of computers is as important as the invention of writing and the invention of printing. A chapter in this book is devoted to the invention of computers, starting with the hand calculators of Pascal and Leibniz, the mechanical calculators of Babbage, and electronic calculators, first with vacuum tubes and later with transistors. The social impact of the computer revolution have also been immense. One speaks of “computer literacy”. For example, girls in rural India complain that it is difficult for them to obtain computer literacy.

Contents

Chapter 1

ORIGINS OF WRITING AND PRINTING

1.1 Mesopotamia

In Mesopotamia (which in Greek means “between the rivers”), the settled agricultural people of the Tigris and Euphrates valleys evolved a form of writing. Among the earliest Mesopotamian writings are a set of clay tablets found at Tepe Yahya in southern Iran, the site of an ancient Elamite trading community halfway between Mesopotamia and India.

The Elamite trade supplied the Sumarian civilization of Mesopotamia with silver, copper, tin, lead, precious gems, horses, timber, obsidian, alabaster and soapstone. The practical Sumerians and Elamites probably invented writing as a means of keeping accounts.

The tablets found at Tepe Yahya are inscribed in proto-Elamite, and radio-carbon dating of organic remains associated with the tablets shows them to be from about 3,600 B.C.. The inscriptions on these tablets were made by pressing the blunt and sharp ends of a stylus into soft clay. Similar tablets have been found at the Sumerian city of Susa at the head of the Tigris River.

In about 3,100 B.C. the cuneiform script was developed, and later Mesopotamian tablets are written in cuneiform, which is a phonetic script where the symbols stand for syllables.

Figure 1.1: **Sumerian writing**

1.2 Egypt

The Egyptian hieroglyphic (priest writing) system began its development in about 4,000 B.C.. At that time, it was pictorial rather than phonetic. However, the Egyptians were in contact with the Sumerian civilization of Mesopotamia, and when the Sumerians developed a phonetic system of writing in about 3,100 B.C., the Egyptians were quick to adopt the idea. In the cuneiform writing of the Sumerians, a character stood for a syllable. In the Egyptian adaptation of this idea, most of the symbols stood for combinations of two consonants, and there were no symbols for vowels. However, a few symbols were purely alphabetic, i.e. they stood for sounds which we would now represent by a single letter. This was important from the standpoint of cultural history, since it suggested to the Phoenicia's the idea of an alphabet of the modern type.

In Sumer, the pictorial quality of the symbols was lost at a very early stage, so that in the cuneiform script the symbols are completely abstract. By contrast, the Egyptian system of writing was designed to decorate monuments and to be impressive even to an illiterate viewer; and this purpose was best served by retaining the elaborate pictographic form of the symbols.

Figure 1.2: **The Phoenician alphabet**

Figure 1.3: **Hieroglyphics**

Figure 1.4: **Another example of hieroglyphics.**

1.3 China

Writing was developed at a very early stage in Chinese history, but the system remained a pictographic system, with a different character for each word. A phonetic system of writing was never developed.

The failure to develop a phonetic system of writing had its roots in the Chinese imperial system of government. The Chinese empire formed a vast area in which many different languages were spoken. It was necessary to have a universal language of some kind in order to govern such an empire. The Chinese written language solved this problem admirably.

Suppose that the emperor sent identical letters to two officials in different districts. Reading the letters aloud, the officials might use entirely different words, although the characters in the letters were the same. Thus the Chinese written language was a sort of “Esperanto” which allowed communication between various language groups, and its usefulness as such prevented its replacement by a phonetic system.

The disadvantages of the Chinese system of writing were twofold: First, it was difficult to learn to read and write; and therefore literacy was confined to a small social class whose members could afford a prolonged education. The system of civil-service examinations made participation in the government dependant on a high degree of literacy; and hence the old, established scholar-gentry families maintained a long-term monopoly on power, wealth and education. Social mobility was possible in theory, since the civil service examinations were open to all, but in practice, it was nearly unattainable.

The second great disadvantage of the Chinese system of writing was that it was unsuitable for printing with movable type. An “information explosion” occurred in the west following the introduction of printing with movable type, but this never occurred in China. It is ironical that although both paper and printing were invented by the Chinese, the full effect of these immensely important inventions bypassed China and instead revolutionized the west.

Figure 1.5: **Very early Chinese writing on a bone**

Figure 1.6: **Chinese writing in a later form**

1.4 The Americas

The Mayan system of writing is thought to have been invented in about 700 B.C., and this invention is believed to be entirely independent of the invention of writing elsewhere. Some of the Mayan glyphs represented entire words, but the could also represent syllables.

Knotted string systems of keeping records were used by the Andean peoples of South America, especially by the Inca civilization. In the Incan language collections of knotted strings were known as *quipus* or talking knots. Quipus could have only a few, or as many as 2000 knotted strings.

Belts made from shell beads (*wampum*) were used by the natives peoples of North America, both as currency and as a means of recording events.

Figure 1.7: **Mayan writing.**

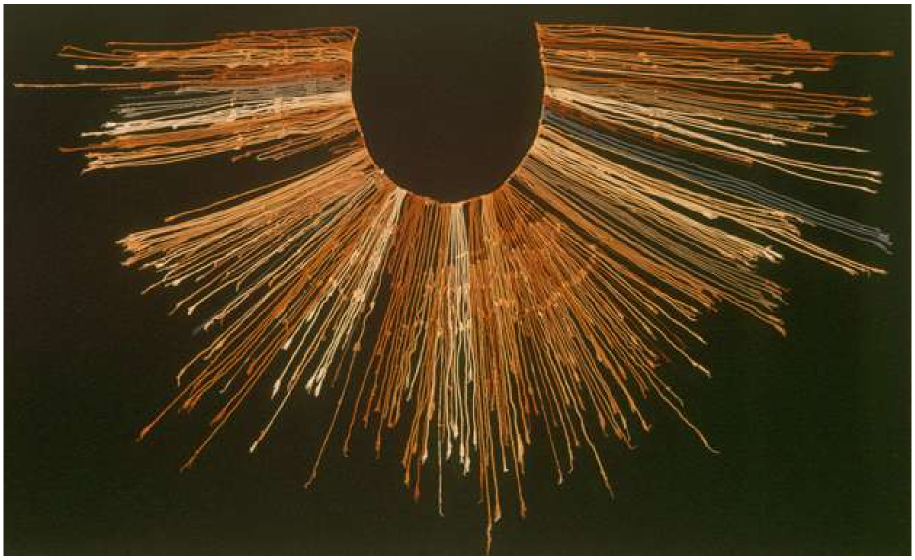

Figure 1.8: **Knotted string systems of keeping records were used by the Andean peoples of South America, especially by the Inca civilization.**

Figure 1.9: **Iroquois Chiefs from the Six Nations Reserve reading Wampum belts in Brantford, Ontario in 1871.**

1.5 The invention of paper

The ancient Egyptians were the first to make books. As early as 4,000 B.C., they began to make books in the form of scrolls by cutting papyrus reeds into thin strips and pasting them into sheets of double thickness. The sheets were glued together end to end, so that they formed a long roll. The rolls were sometimes very long indeed. For example, one roll, which is now in the British Museum, is 17 inches wide and 135 feet long.

(Paper of the type which we use today was not invented until 105 A.D.. This enormously important invention was made by a Chinese eunuch named Tsai Lun. The kind of paper invented by Tsai Lun could be made from many things: for example, bark, wood, hemp, rags, etc.. The starting material was made into a pulp, mixed together with water and binder, spread out on a cloth to partially dry, and finally heated and pressed into thin sheets. The art of paper-making spread slowly westward from China, reaching Baghdad in 800 A.D.. It was brought to Europe by the crusaders returning from the Middle East. Thus paper reached Europe just in time to join with Gütenberg's printing press to form the basis for the information explosion which has had such a decisive effect on human history.)

Many centers of paper production were established throughout the Muslim world, and their techniques were eventually transmitted to Christian Europe. Not only was paper convenient to use, transport, and store, it was, most importantly, considerably cheaper than papyrus and parchment, probably partly because of the use of recycled rags as raw material in its manufacture. Whereas an early Qur'an copy on parchment is reckoned to have required the skins of about 300 sheep, an equivalent amount of paper could be produced much more rapidly, in much greater quantities, and at much lower cost. This transformed the economics of book production, and made possible a greatly increased production of manuscript books, on a scale which was unprecedented and unmatched in Europe at that time.

The career of Leonardo da Vinci illustrates the first phase of the "information explosion" which has produced the modern world: During Leonardo's lifetime, inexpensive paper was being manufactured in Europe, and it formed the medium for Leonardo's thousands of pages of notes. His notes and sketches would never have been possible if he had been forced to use expensive parchment as a medium. On the other hand, the full force of Leonardo's genius and diligence was never felt because his notes were not printed.

Copernicus, who was a younger contemporary of Leonardo, had a much greater effect on the history of ideas, because his work was published. Thus, while paper alone made a large contribution to the information explosion, it was printing combined with paper which had an absolutely decisive and revolutionary impact: The modern scientific era began with the introduction of printing.

Figure 1.10: **Papyrus**

Figure 1.11: **Paper is a Chinese invention**

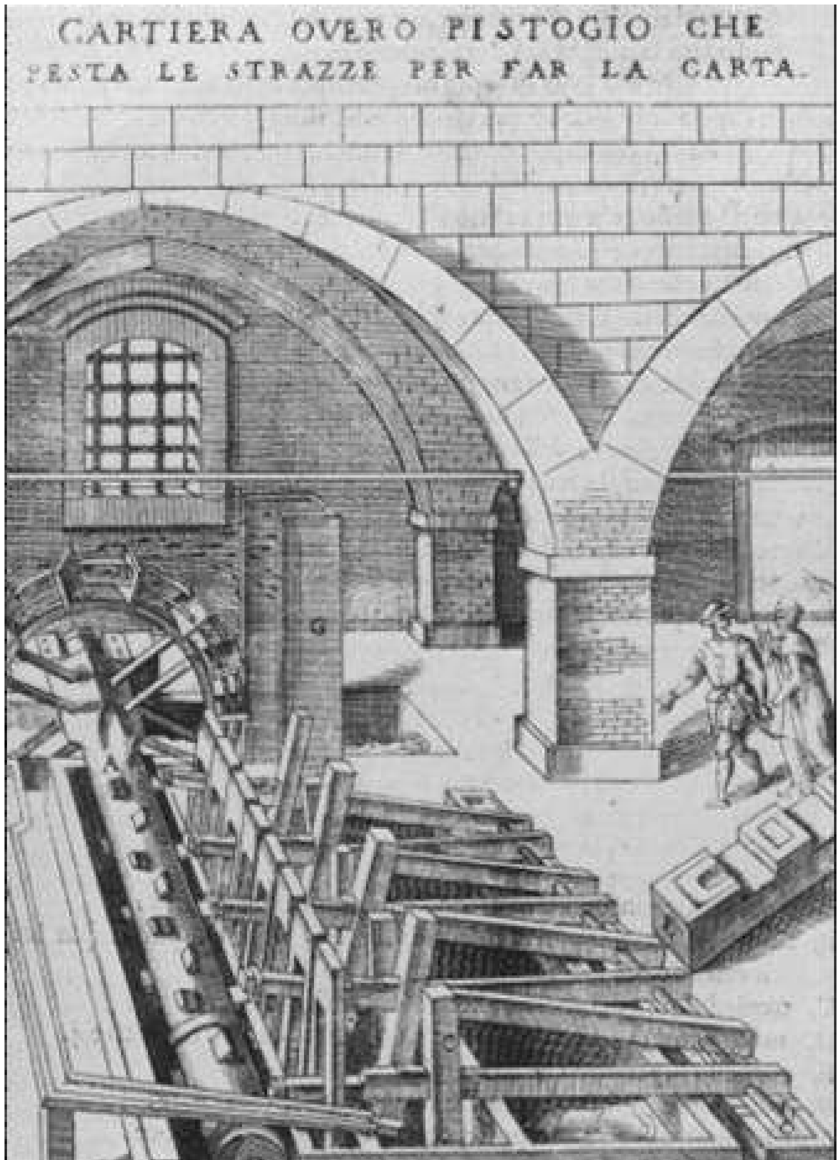

Figure 1.12: **Italian paper-mill, probably from the 16th century.**

Figure 1.13: **The impact of Leonardo da Vinci's genius would have been far greater if his thousands of pages of notes had been printed.**

1.6 Printing

It was during the T'ang period that the Chinese made an invention of immense importance to the cultural evolution of mankind. This was the invention of printing. Together with writing, printing is one of the key inventions which form the basis of human cultural evolution.

Printing was invented in China in the 8th or 9th century A.D., probably by Buddhist monks who were interested in producing many copies of the sacred texts which they had translated from Sanskrit. The act of reproducing prayers was also considered to be meritorious by the Buddhists.

The Chinese had for a long time followed the custom of brushing engraved official seals with ink and using them to stamp documents. The type of ink which they used was made from lamp-black, water and binder. In fact, it was what we now call "India ink". However, in spite of its name, India ink is a Chinese invention, which later spread to India, and from there to Europe.

We mentioned that paper of the type which we now use was invented in China in the first century A.D.. Thus, the Buddhist monks of China had all the elements which they needed to make printing practical: They had good ink, cheap, smooth paper, and the tradition of stamping documents with ink-covered engraved seals. The first block prints which they produced date from the 8th century A.D.. They were made by carving a block of wood the size of a printed page so that raised characters remained, brushing ink onto the block, and pressing this onto a sheet of paper.

The oldest known printed book, the "Diamond Sutra", is dated 868 A.D.., and it consists of only six printed pages. In was discovered in 1907 by an English scholar who obtained permission from Buddhist monks in Chinese Turkestan to open some walled-up monastery rooms, which were said to have been sealed for 900 years. The rooms were found to contain a library of about 15,000 manuscripts, among which was the Diamond Sutra.

Block printing spread quickly throughout China, and also reached Japan, where woodblock printing ultimately reached great heights in the work of such artists as Hiroshige and Hokusai. The Chinese made some early experiments with movable type, but movable type never became popular in China, because the Chinese written language contains 10,000 characters. However, printing with movable type was highly successful in Korea as early as the 15th century A.D..

The unsuitability of the Chinese written language for the use of movable type was the greatest tragedy of the Chinese civilization. Writing had been developed at a very early stage in Chinese history, but the system remained a pictographic system, with a different character for each word. A phonetic system of writing was never developed.

The failure to develop a phonetic system of writing had its roots in the Chinese imperial system of government. The Chinese empire formed a vast area in which many different languages were spoken. It was necessary to have a universal language of some kind in order to govern such an empire. The Chinese written language solved this problem admirably.

Suppose that the emperor sent identical letters to two officials in different districts.

Figure 1.14: **The Diamond Sutra, 868 A.D., is the first known printed book.**

Reading the letters aloud, the officials might use entirely different words, although the characters in the letters were the same. Thus the Chinese written language was a sort of "Esperanto" which allowed communication between various language groups, and its usefulness as such prevented its replacement by a phonetic system.

The invention of block printing during the T'ang dynasty had an enormously stimulating effect on literature, and the T'ang period is regarded as the golden age of Chinese lyric poetry. A collection of T'ang poetry, compiled in the 18th century, contains 48,900 poems by more than 2,000 poets.

1.7 Islamic civilization and printing

Some Islamic contributions to civilization

In the 5th century A.D., there was a split in the Christian church of Byzantium;and the Nestorian church, separated from the official Byzantine church. The Nestorians were bitterly persecuted by the Byzantines, and therefore they migrated, first to Mesopotamia, and later to south-west Persia. (Some Nestorians migrated as far as China.)

During the early part of the middle ages, the Nestorian capital at Gondisapur was a great center of intellectual activity. The works of Plato, Aristotle, Hippocrates, Euclid, Archimedes, Ptolemy, Hero and Galen were translated into Syriac by Nestorian scholars, who had brought these books with them from Byzantium.

Among the most distinguished of the Nestorian translators were the members of a family called Bukht-Yishu (meaning "Jesus hath delivered"), which produced seven generations of outstanding scholars. Members of this family were fluent not only in Greek and Syriac, but also in Arabic and Persian.

In the 7th century A.D., the Islamic religion suddenly emerged as a conquering and proselytizing force. Inspired by the teachings of Mohammad (570 A.D. - 632 A.D.), the Arabs and their converts rapidly conquered western Asia, northern Africa, and Spain. During the initial stages of the conquest, the Islamic religion inspired a fanaticism in its followers which was often hostile to learning. However, this initial fanaticism quickly changed to an appreciation of the ancient cultures of the conquered territories; and during the middle ages, the Islamic world reached a very high level of culture and civilization.

Thus, while the century from 750 to 850 was primarily a period of translation from Greek to Syriac, the century from 850 to 950 was a period of translation from Syriac to Arabic. It was during this latter century that Yuhanna Ibn Masawiah (a member of the Bukht-Yishu family, and medical advisor to Caliph Harun al-Rashid) produced many important translations into Arabic.

The skill of the physicians of the Bukht-Yishu family convinced the Caliphs of the value of Greek learning; and in this way the family played an extremely important role in the preservation of the western cultural heritage. Caliph al-Mamun, the son of Harun al-Rashid, established at Baghdad a library and a school for translation, and soon Baghdad replaced Gondisapur as a center of learning.

The English word "chemistry" is derived from the Arabic words *"al-chimia"*, which mean "the changing". The earliest alchemical writer in Arabic was Jabir (760-815), a friend of Harun al-Rashid. Much of his writing deals with the occult, but mixed with this is a certain amount of real chemical knowledge. For example, in his *Book of Properties*, Jabir gives the following recipe for making what we now call lead hydroxycarbonate (white lead), which is used in painting and pottery glazes: "Take a pound of litharge, powder it well and heat it gently with four pounds of vinegar until the latter is reduced to half its original volume. The take a pound of soda and heat it with four pounds of fresh water until the volume of the latter is halved. Filter the two solutions until they are quite clear, and then gradually add the solution of soda to that of the litharge. A white substance is formed, which settles to the bottom. Pour off the supernatant water, and leave the residue to dry. It will become a salt as white as snow."

Another important alchemical writer was Rahzes (c. 860 - c. 950). He was born in the ancient city of Ray, near Teheran, and his name means "the man from Ray". Rahzes studied medicine in Baghdad, and he became chief physician at the hospital there. He wrote the first accurate descriptions of smallpox and measles, and his medical writings include methods for setting broken bones with casts made from plaster of Paris. Rahzes was the first person to classify substances into vegetable, animal and mineral. The word *"al-kali"*, which appears in his writings, means "the calcined" in Arabic. It is the source of our word "alkali", as well as of the symbol K for potassium.

The greatest physician of the middle ages, Avicenna, (Abu-Ali al Hussein Ibn Abdullah Ibn Sina, 980-1037), was also a Persian, like Rahzes. More than a hundred books are at-

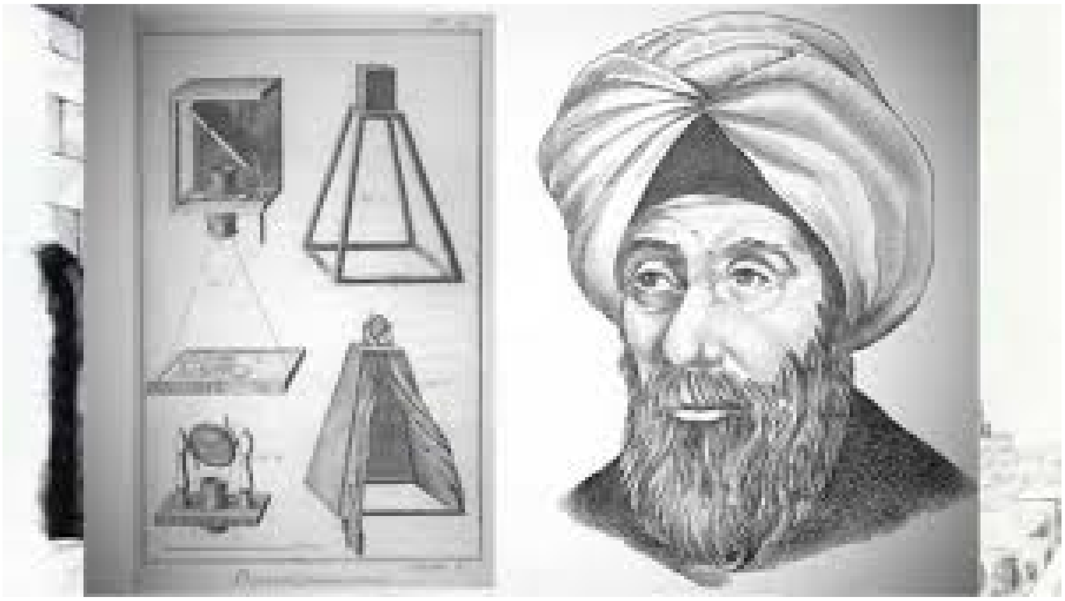

Figure 1.15: **Al-Hazen invented the camera-obscura during the years 1012-1021. It was a forerunner of the modern camera.**

tributed to him. They were translated into Latin in the 12th century, and they were among the most important medical books used in Europe until the time of Harvey. Avicenna also wrote on alchemy, and he is important for having denied the possibility of transmutation of elements.

In mathematics, one of the most outstanding Arabic writers was al-Khwarizmi (c. 780 - c. 850). The title of his book, *Ilm al-jabr wa'd muqabalah*, is the source of the English word "algebra". In Arabic *al-jabr* means "the equating". Al-Khwarizmi's name has also become an English word, "algorism", the old word for arithmetic. Al-Khwarizmi drew from both Greek and Hindu sources, and through his writings the decimal system and the use of zero were transmitted to the west.

One of the outstanding Arabic physicists was al-Hazen (965-1038). He made the mistake of claiming to be able to construct a machine which could regulate the flooding of the Nile. This claim won him a position in the service of the Egyptian Caliph, al-Hakim. However, as al-Hazen observed Caliph al-Hakim in action, he began to realize that if he did not construct his machine immediately, he was likely to pay with his life! This led al-Hazen to the rather desperate measure of pretending to be insane, a ruse which he kept up for many years. Meanwhile he did excellent work in optics, and in this field he went far beyond anything done by the Greeks.

Al-Hazen studied the reflection of light by the atmosphere, an effect which makes the stars appear displaced from their true positions when they are near the horizon; and he calculated the height of the atmospheric layer above the earth to be about ten miles. He also studied the rainbow, the halo, and the reflection of light from spherical and parabolic mirrors. In his book, *On the Burning Sphere*, he shows a deep understanding of the properties of convex lenses. Al-Hazen also used a dark room with a pin-hole opening to study the image of the sun during an eclipses. This is the first mention of the *camera obscura*, and it is perhaps correct to attribute the invention of the *camera obscura* to al-Hazen.

Another Islamic philosopher who had great influence on western thought was Averröes, who lived in Spain from 1126 to 1198. His writings took the form of thoughtful commentaries on the works of Aristotle. He shocked both his Moslem and his Christian readers by maintaining that the world was not created at a definite instant, but that it instead evolved over a long period of time, and is still evolving.

Like Aristotle, Averröes seems to have been groping towards the ideas of evolution which were later developed in geology by Steno, Hutton and Lyell and in biology by Darwin and Wallace. Much of the scholastic philosophy which developed at the University of Paris during the 13th century was aimed at refuting the doctrines of Averröes; but nevertheless, his ideas survived and helped to shape the modern picture of the world.

Muslims in Egypt and probably elsewhere were using printing to mass-produce texts as early as the 10th century. Dozens of examples of their output are preserved in museums and libraries, but have, until recently, been overlooked and neglected by scholars. This phenomenon is yet another example of the 1000-year missing history of science and technology.

It is, however, true that Muslims did not use printing to produce books, nor extended texts in any form, until the 18th century. This challenge was taken up by Europeans from the 15th century onwards, and it would not have been possible there, without the availability of another gift from the Muslims, paper, which had earlier reached Europe from the Muslim world, via Spain and Italy.

Figure 1.16: **A handwritten Islamic manuscript: Qazwini, 'Ajaib al-makhluqat, MS probably from Mosul, ca.1305. British Library.**

1.8 Gutenberg

Johannes Gensfleisch zur Laden zum Gutenberg (c.1400-1468) was born in the German city of Mainz. He was the youngest son of an upper-class merchant, Friele Gensfleisch zur Laden, whose long-established family traced its roots back to the 13th century.

Johannes Gutenberg was educated as a goldsmith and blacksmith, and may also have attended the University of Erfurt. In 1440, while he was living in Strassburg. he is said to have perfected and unveiled his system of printing with movable type.

By 1448, he was back in Mainz, where he took a loan from his brother-on-law to meet the expenses of setting up a printing press.In 1450, the press was in operation, and Gutenberg took a further loan, 800 guilders, from the moneylender Johann Fust. Peter Schöffer, who became Fust's son-in-law also joined the enterprise, and is believed to have designed the type faces.

Among the many technical innovations introduced by Gutenberg are the invention of a process for mass-producing movable type; the use of oil-based ink for printing books; adjustable molds; mechanical movable type; and the use of a wooden printing press similar to the agricultural screw presses of the period. The alloy which he used was a mixture of lead, tin, and antimony that melted at a relatively low temperature for faster and more economical casting, cast well, and created a durable type. The combination of all these elements made the mass production of books both practical and economically feasible.

Gutenberg's greatest artistic achievement was his printed Bible, but this project also cost so much that it left him with debts of more than 20,000 guilders. A court order gave Fust control of the Bible printing project, and half of the printed Bibles.

Although he had suffered bankruptcy, the aging Gutenberg's greatness was acknowledged in 1465. He was given the title "Hofmann" (Gentleman of the Court) and awarded a yearly stipend, as well as 2,180 liters of grain and 2,000 liters of wine tax-free. He died in 1468, having enjoyed this official recognition for only three years.

Printing quickly affected both religion and science in Europe. By 1517, when Martin Luther posted his Ninety-Five Theses on the door of All Saint's Church in Wittenburg, many cities has printing presses. The theses were quickly reprinted and translated, and they spread throughout Europe. This initiated a pamphlet war, in which both sides used printing to spread their views. The impact of Luther's German translation of the Bible was greatly increased by the fact that inexpensive printed copies were widely available.

Science was similarly revolutionized. Nicolaus Copernicus (1473-1543) had a far greater impact on the history of science than his near contemporary Leonardo da Vinci (1452-1519) because of printing. Leonardo's thousands of pages of notes and his innovations in virtually all the fields of human knowledge have only recently become available in printed form. By contrast, the publication Copernicus' great book, *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres) initiated a sequence of discoveries by Tycho Brahe, Galileo, Johannes Kepler and Isaac Newton, discoveries upon which the modern world is built.

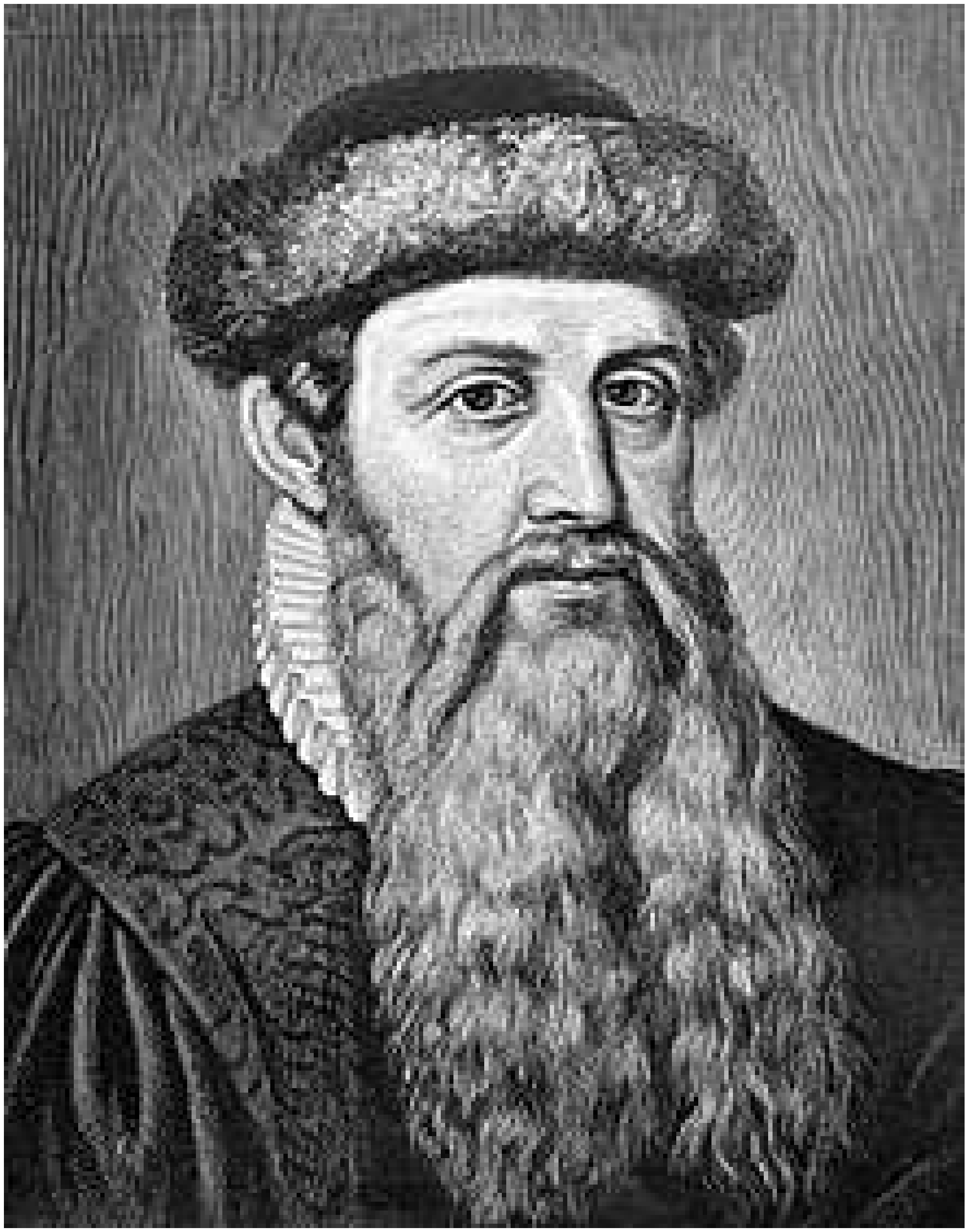

Figure 1.17: **Gutenberg is credited with introducing printing with movable type into Europe, with many improvements of technique. His inventions were a turning point in European history, and ushered in the modern era, the Reformation, the Age of Reason and the Industrial Revolution.**

Figure 1.18: **Gutenberg's printing press**

Figure 1.19: **Gutenberg's bible**

Suggestions for further reading

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Chapter 2

SOME LIBRARIES OF THE ANCIENT WORLD

2.1 The Library of Ashurbanipal and other ancient libraries

According to Wikipedia,

> "Over 30,000 clay tablets from the Library of Ashurbanipal have been discovered at Nineveh, providing modern scholars with a fantastic wealth of Mesopotamian literary, religious and administrative work. Among the findings were the Enuma Elish, also known as the Epic of Creation, which depicts a traditional Babylonian view of creation, the Epic of Gilgamesh, a large selection of omen texts including Enuma Anu Enlil which contained omens dealing with the moon, its visibility, eclipses, and conjunction with planets and fixed stars, the sun, its corona, spots, and eclipses, the weather, namely lightning, thunder, and clouds, and the planets and their visibility, appearance, and stations, and astronomic/astrological texts, as well as standard lists used by scribes and scholars such as word lists, bilingual vocabularies, lists of signs and synonyms, and lists of medical diagnoses...
>
> "According to legend, mythical philosopher Laozi was the keeper of books in the earliest library in China, which belonged to the Imperial Zhou dynasty. Also, evidence of catalogs found in some destroyed ancient libraries illustrates the presence of librarians.
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> "Persia at the time of the Achaemenid Empire (550-330 BC) was home to some outstanding libraries that were serving two main functions: keeping the records of administrative documents (e.g., transactions, governmental orders, and budget allocation within and between the Satrapies and the central ruling State)and collection of resources on different sets of principles e.g. medical science, astronomy, history, geometry and philosophy.

2.2 The Great Library at Alexandria

How much influence did Aristotle have on his pupil, Alexander of Macedon? We know that in 327 B.C. Alexander, (who was showing symptoms of megalomania), executed Aristotle's nephew, Callisthenes; so Aristotle's influence cannot have been very complete. On the other hand, we can think of Alexander driving his reluctant army beyond the Caspian Sea to Parthia, beyond Parthia to Bactria, beyond Bactria to the great wall of the Himalayas, and from there south to the Indus, where he turned back only because of the rebellion of his homesick officers. This attempt to reach the uttermost limits of the world seems to have been motivated as much by a lust for knowledge as by a lust for power.

Alexander was not a Greek, but nevertheless he regarded himself as an apostle of Greek culture. As the Athenian orator, Isocrates, remarked, "The word 'Greek' is not so much a term of birth as of mentality, and is applied to a common culture rather than to a common descent."

Although he was cruel and wildly temperamental, Alexander could also display an almost hypnotic charm, and this charm was a large factor in his success. He tried to please the people of the countries through which he passed by adopting some of their customs. He married two barbarian princesses, and, to the dismay of his Macedonian officers, he also adopted the crown and robes of a Persian monarch.

Wherever Alexander went, he founded Greek-style cities, many of which were named Alexandria. In Babylon, In 323 B.C., after a drunken orgy, Alexander caught a fever and died at the age of 33. His loosely-constructed empire immediately fell to pieces. The three largest pieces were seized by three of his generals. The Persian Empire went to Seleucis, and became known as the Seleucid Empire. Antigonius became king of Macedon and protector of the Greek city-states. A third general, Ptolemy, took Egypt.

Although Alexander's dream of a politically united world collapsed immediately after his death, his tour through almost the entire known world had the effect of blending the ancient cultures of Greece, Persia, India and Egypt, and producing a world culture. The era associated with this culture is usually called the Hellenistic Era (323 B.C. - 146 B.C.). Although the Hellenistic culture was a mixture of all the great cultures of the ancient world, it had a decidedly Greek flavor, and during this period the language of educated people throughout the known world was Greek.

Nowhere was the cosmopolitan character of the Hellenistic Era more apparent than at Alexandria in Egypt. No city in history has ever boasted a greater variety of people. Ideally located at the crossroads of world trading routes, Alexandria became the capital of the world - not the political capital, but the cultural and intellectual capital.

Miletus in its prime had a population of 25,000; Athens in the age of Pericles had about 100,000 people; but Alexandria was the first city in history to reach a population of over a million!

Strangers arriving in Alexandria were impressed by the marvels of the city - machines which sprinkled holy water automatically when a five-drachma coin was inserted, water-driven organs, guns powered by compressed air, and even moving statues, powered by water or steam!

For scholars, the chief marvels of Alexandria were the great library and the Museum established by Ptolemy I. Credit for making Alexandria the intellectual capital of the world must go to Ptolemy I and his successors (all of whom were named Ptolemy except the last of the line, the famous queen, Cleopatra). Realizing the importance of the schools which had been founded by Pythagoras, Plato and Aristotle, Ptolemy I established a school at Alexandria. This school was called the Museum, because it was dedicated to the muses.

Near to the Museum, Ptolemy built a great library for the preservation of important manuscripts. The collection of manuscripts which Aristotle had built up at the Lyceum in Athens became the nucleus of this great library. The library at Alexandria was open to the general public, and at its height it was said to contain 750,000 volumes. Besides preserving important manuscripts, the library became a center for copying and distributing books.

The material which the Alexandrian scribes used for making books was papyrus, which was relatively inexpensive. The Ptolemys were anxious that Egypt should keep its near-monopoly on book production, and they refused to permit the export of papyrus. Pergamum, a rival Hellenistic city in Asia Minor, also boasted a library, second in size only to the great library at Alexandria. The scribes at Pergamum, unable to obtain papyrus from Egypt, tried to improve the preparation of the skins traditionally used for writing in Asia. The resulting material was called *membranum pergamentum*, and in English, this name has become “parchment”.

Figure 2.1: **An image of Alexander.**

Figure 2.2: **Alexander on horseback.**

Figure 2.3: **Another image of Alexander.**

Figure 2.4: **Alexander's empire was very large, but it fell apart quickly after his early death..**

Figure 2.5: **A bust of Ptolemy II, who established the Great Library of Alexandria as a working institution.**

2.3 Euclid is called to the Museum

One of the first scholars to be called to the newly-established Museum was Euclid. He was born in 325 B.C. and was probably educated at Plato's Academy in Athens. While in Alexandria, Euclid wrote the most successful text-book of all time, the *Elements of Geometry*. The theorems in this splendid book were not, for the most part, originated by Euclid. They were the work of many generations of classical Greek geometers. Euclid's contribution was to take the theorems of the classical period and to arrange them in an order which is so logical and elegant that it almost defies improvement. One of Euclid's great merits is that he reduces the number of axioms to a minimum, and he does not conceal the dubiousness of certain axioms.

Euclid's axiom concerning parallel lines has an interesting history: This axiom states that "Through a given point not on a given line, one and only one line can be drawn parallel to a given line". At first, mathematicians doubted that it was necessary to have such an axiom. They suspected that it could be proved by means of Euclid's other more simple axioms. After much thought, however, they decided that the axiom is indeed one of the necessary foundations of classical geometry. They then began to wonder whether there could be another kind of geometry where the postulate concerning parallels is discarded. These ideas were developed in the 18th and 19th centuries by Lobachevsky, Bolyai, Gauss and Riemann, and in the 20th century by Levi-Civita. In 1915, the mathematical theory of non-Euclidean geometry finally became the basis for Einstein's general theory of relativity.

Figure 2.6: **Euclid, detail from "The School of Athens", a painting by Raphael. It is not proven that this is Euclid. Some references point this person out as Archimedes.**

2.4 Eratosthenes

Eratosthenes (276 B.C. - 196 B.C.), the director of the library at Alexandria, was probably the most cultured man of the Hellenistic Era. His interests and abilities were universal. He was an excellent historian, in fact the first historian who ever attempted to set up an accurate chronology of events. He was also a literary critic, and he wrote a treatise on Greek comedy. He made many contributions to mathematics, including a study of prime numbers and a method for generating primes called the "sieve of Eratosthenes".

As a geographer, Eratosthenes made a map of the world which, at that time, was the most accurate that had ever been made. The positions of various places on Eratosthenes' map were calculated from astronomical observations. The latitude was calculated by measuring the angle of the polar star above the horizon, while the longitude probably was calculated from the apparent local time of lunar eclipses.

As an astronomer, Eratosthenes made an extremely accurate measurement of the angle between the axis of the earth and the plane of the sun's apparent motion; and he also prepared a map of the sky which included the positions of 675 stars.

Eratosthenes' greatest achievement however, was an astonishingly precise measurement of the radius of the earth. The value which he gave for the radius was within 50 miles of what we now consider to be the correct value! To make this remarkable measurement, Eratosthenes of course assumed that the earth is spherical, and he also assumed that the sun is so far away from the earth that rays of light from the sun, falling on the earth,

Figure 2.7: **A map of the known world by Eratosthenes, surrounded by spheres on which moved the sun, moon and stars.**

are almost parallel. He knew that directly south of Alexandria there was a city called Seyne, where at noon on a midsummer day, the sun stands straight overhead. Given these facts, all he had to do to find the radius of the earth was to measure the distance between Alexandria and Seyne. Then, at noon on a midsummer day, he measured the angle which the sun makes with the vertical at Alexandria. From these two values, he calculated the circumference of the earth to be a little over 25,000 miles. This was so much larger than the size of the known world that Eratosthenes concluded (correctly) that most of the earth's surface must be covered with water; and he stated that "If it were not for the vast extent of the Atlantic, one might sail from Spain to India along the same parallel."

2.5 Preservation of the ancient Greek libraries

After the burning of the great library at Alexandria and the destruction of Hellenistic civilization, most of the books of the classical Greek and Hellenistic philosophers were lost. However, a few of these books survived and were translated from Greek, first into Syriac, then into Arabic and finally from Arabic into Latin. By this roundabout route, fragments from the wreck of the classical Greek and Hellenistic civilizations drifted back into the consciousness of the West.

The Roman empire was ended in the 5th century A.D. by attacks of barbaric Germanic tribes from northern Europe. However, by that time, the Roman empire had split into two halves. The eastern half, with its capital at Byzantium (Constantinople), survived until 1453, when the last emperor was killed vainly defending the walls of his city against the Turks.

The Byzantine empire included many Syriac-speaking subjects; and in fact, beginning in the 3rd century A.D., Syriac replaced Greek as the major language of western Asia. In the 5th century A.D., there was a split in the Christian church of Byzantium; and the Nestorian church, separated from the official Byzantine church. The Nestorians were bitterly persecuted by the Byzantines, and therefore they migrated, first to Mesopotamia, and later to south-west Persia. (Some Nestorians migrated as far as China.)

During the early part of the middle ages, the Nestorian capital at Gondisapur was a great center of intellectual activity. The works of Plato, Aristotle, Hippocrates, Euclid, Archimedes, Ptolemy, Hero and Galen were translated into Syriac by Nestorian scholars, who had brought these books with them from Byzantium.

Among the most distinguished of the Nestorian translators were the members of a family called Bukht-Yishu (meaning "Jesus hath delivered"), which produced seven generations of outstanding scholars. Members of this family were fluent not only in Greek and Syriac, but also in Arabic and Persian.

In the 7th century A.D., the Islamic religion suddenly emerged as a conquering and proselytizing force. Inspired by the teachings of Mohammad (570 A.D. - 632 A.D.), the Arabs and their converts rapidly conquered western Asia, northern Africa, and Spain. During the initial stages of the conquest, the Islamic religion inspired a fanaticism in its followers which was often hostile to learning. However, this initial fanaticism quickly changed to an appreciation of the ancient cultures of the conquered territories; and during the middle ages, the Islamic world reached a very high level of culture and civilization.

Thus, while the century from 750 to 850 was primarily a period of translation from Greek to Syriac, the century from 850 to 950 was a period of translation from Syriac to Arabic. It was during this latter century that Yuhanna Ibn Masawiah (a member of the Bukht-Yishu family, and medical advisor to Caliph Harun al-Rashid) produced many important translations into Arabic.

The skill of the physicians of the Bukht-Yishu family convinced the Caliphs of the value of Greek learning; and in this way the family played an extremely important role in the preservation of the western cultural heritage. Caliph al-Mamun, the son of Harun al-Rashid, established at Baghdad a library and a school for translation, and soon Baghdad replaced Gondisapur as a center of learning.

The English word "chemistry" is derived from the Arabic words "al-chimia", which mean "the changing". The earliest alchemical writer in Arabic was Jabir (760-815), a friend of Harun al-Rashid. Much of his writing deals with the occult, but mixed with this is a certain amount of real chemical knowledge. For example, in his Book of Properties, Jabir gives a recipe for making what we now call lead hydroxycarbonate (white lead), which is used in painting and pottery glazes:

Another important alchemical writer was Rahzes (c. 860 - c. 950). He was born in the ancient city of Ray, near Teheran, and his name means “the man from Ray”. Rhazes studied medicine in Baghdad, and he became chief physician at the hospital there. He wrote the first accurate descriptions of smallpox and measles, and his medical writings include methods for setting broken bones with casts made from plaster of Paris. Rahzes was the first person to classify substances into vegetable, animal and mineral. The word “al-kali”, which appears in his writings, means “the calcined” in Arabic. It is the source of our word “alkali”, as well as of the symbol K for potassium.

The greatest physician of the middle ages, Avicinna, (Abu-Ali al Hussain Ibn Abdullah Ibn Sina, 980-1037), was also a Persian, like Rahzes. More than a hundred books are attributed to him. They were translated into Latin in the 12th century, and they were among the most important medical books used in Europe until the time of Harvey. Avicinina also wrote on alchemy, and he is important for having denied the possibility of transmutation of elements.

In mathematics, one of the most outstanding Arabic writers was al-Khwarizmi (c. 780 - c. 850). The title of his book, Ilm al-jabr wa'd muqabalah, is the source of the English word “algebra”. In Arabic al-jabr means “the equating”. Al-Khwarizmi's name has also become an English word, “algorism”, the old word for arithmetic. Al-Khwarizmi drew from both Greek and Hindu sources, and through his writings the decimal system and the use of zero were transmitted to the west.

One of the outstanding Arabic physicists was al-Hazen (965-1038). He did excellent work in optics, and in this field he went far beyond anything done by the Greeks. Al-Hazen studied the reflection of light by the atmosphere, an effect which makes the stars appear displaced from their true positions when they are near the horizon; and he calculated the height of the atmospheric layer above the earth to be about ten miles. He also studied the rainbow, the halo, and the reflection of light from spherical and parabolic mirrors. In his book, On the Burning Sphere, he shows a deep understanding of the properties of convex lenses. Al-Hazen also used a dark room with a pin-hole opening to study the image of the sun during an eclipes. This is the first mention of the camera obscura, and it is perhaps correct to attribute the invention of the camera obscura to al-Hazen.

Another Islamic philosopher who had great influence on western thought was Averroes, who lived in Spain from 1126 to 1198. His writings took the form of thoughtful commentaries on the works of Aristotle. He shocked both his Moslem and his Christian readers by maintaining that the world was not created at a definite instant, but that it instead evolved over a long period of time, and is still evolving.

In the 12th century, parts of Spain, including the city of Toledo, were reconquered by the Christians. Toledo had been an Islamic cultural center, and many Moslem scholars, together with their manuscripts, remained in the city when it passed into the hands of the Christians. Thus Toledo became a center for the exchange of ideas between east and west; and it was in this city that many of the books of the classical Greek and Hellenistic philosophers were translated from Arabic into Latin.

It is interesting and inspiring to visit Toledo. A tourist there can see ample evidence of a period of tolerance and enlightenment, when members of the three Abrahamic religions, Christianity, Judaism and Islam , lived side by side in harmony and mutual respect, exchanging important ideas which were to destined to become the foundations of our modern civilization. One can also see cathedrals, mosques and synagogues, in each of which craftsmen from all three faiths worked cooperatively to produce beautiful monuments to human solidarity.

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Chapter 3

THE ENLIGHTENMENT

3.1 Ideals of the Enlightenment

Political philosophy of the Enlightenment

The 16th, 17th and 18th centuries have been called the "Age of Discovery", and the "Age of Reason", but they might equally well be called the "Age of Observation". On every side, new worlds were opening up to the human mind. The great voyages of discovery had revealed new continents, whose peoples demonstrated alternative ways of life. The telescopic exploration of the heavens revealed enormous depths of space, containing myriads of previously unknown stars; and explorations with the microscope revealed a new and marvelously intricate world of the infinitesimally small.

In the science of this period, the emphasis was on careful observation. This same emphasis on observation can be seen in the Dutch and English painters of the period. The great Dutch masters, such as Jan Vermeer (1632-1675), Frans Hals (1580-1666), Pieter de Hooch (1629-1678) and Rembrandt van Rijn (1606-1669), achieved a careful realism in their paintings and drawings which was the artistic counterpart of the observations of the pioneers of microscopy, Anton van Leeuwenhoek and Robert Hooke. These artists were supported by the patronage of the middle class, which had become prominent and powerful both in England and in the Netherlands because of the extensive world trade in which these two nations were engaged.

Members of the commercial middle class needed a clear and realistic view of the world in order to succeed with their enterprises. (An aristocrat of the period, on the other hand, might have been more comfortable with a somewhat romanticized and out-of-focus vision, which would allow him to overlook the suffering and injustice upon which his privileges were based.) The rise of the commercial middle class, with its virtues of industriousness, common sense and realism, went hand in hand with the rise of experimental science, which required the same virtues for its success.

In England, the House of Commons (which reflected the interests of the middle class), had achieved political power, and had demonstrated (in the Puritan Rebellion of 1640 and the Glorious Revolution of 1688) that Parliament could execute or depose any monarch who tried to rule without its consent. In France, however, the situation was very different.

After passing through a period of disorder and civil war, the French tried to achieve order and stability by making their monarchy more absolute. The movement towards absolute monarchy in France culminated in the long reign of Louis XIV, who became king in 1643 and who ruled until he died in 1715.

The historical scene which we have just sketched was the background against which the news of Newton's scientific triumph was received. The news was received by a Europe which was tired of religious wars; and in France, it was received by a middle class which was searching for an ideology in its struggle against the *ancien régime*.

To the intellectuals of the 18th century, the orderly Newtonian cosmos, with its planets circling the sun in obedience to natural law, became an imaginative symbol representing rationality. In their search for a society more in accordance with human nature, 18th century Europeans were greatly encouraged by the triumphs of science. Reason had shown itself to be an adequate guide in natural philosophy. Could not reason and natural law also be made the basis of moral and political philosophy? In attempting to carry out this program, the philosophers of the Enlightenment laid the foundations of psychology, anthropology, social science, political science and economics.

One of the earliest and most influential of these philosophers was John Locke (1632-1705), a contemporary and friend of Newton. In his *Second Treatise on Government*, published in 1690, John Locke's aim was to refute the doctrine that kings rule by divine right, and to replace that doctrine by an alternative theory of government, derived by reason from the laws of nature. According to Locke's theory, men originally lived together without formal government:

"Men living together according to reason," he wrote, "without a common superior on earth with authority to judge between them, is properly the state of nature... A state also of equality, wherein all the power and jurisdiction is reciprocal, no one having more than another; there being nothing more evident than that creatures of the same species, promiscuously born to all the same advantages of nature and the use of the same facilities, should also be equal amongst one another without subordination or subjection..."

"But though this be a state of liberty, yet it is not a state of licence... The state of nature has a law to govern it, which obliges every one; and reason, which is that law, teaches all mankind who will but consult it, that being equal and independent, no one ought to harm another in his life, health, liberty or possessions."

In Locke's view, a government is set up by means of a social contract. The government is given its powers by the consent of the citizens in return for the services which it renders to them, such as the protection of their lives and property. If a government fails to render these services, or if it becomes tyrannical, then the contract has been broken, and the citizens must set up a new government.

Locke's influence on 18th century thought was very great. His influence can be seen, for example, in the wording of the American Declaration of Independence. In England, Locke's political philosophy was accepted by almost everyone. In fact, he was only codifying ideas which were already in wide circulation and justifying a revolution which had already

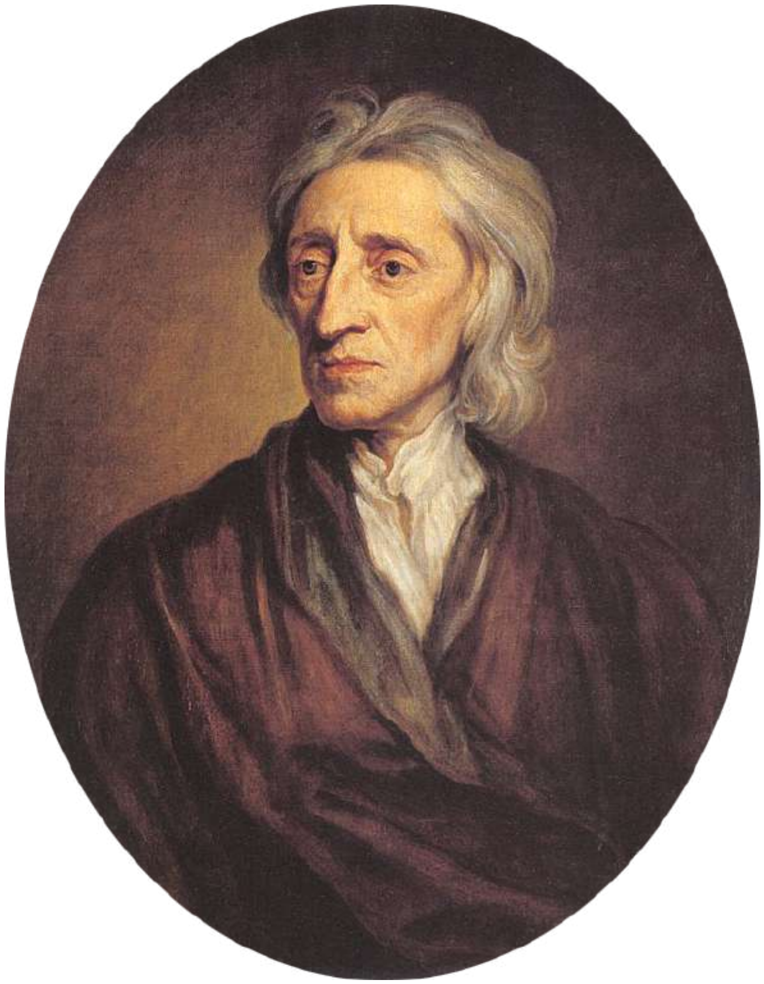


Figure 3.1: **John Locke (1632-1705): "Men living together according to reason, without a common superior on earth with authority to judge between them, is properly the state of nature... A state also of equality, wherein all the power and jurisdiction is reciprocal, no one having more than another; there being nothing more evident than that creatures of the same species, promiscuously born to all the same advantages of nature and the use of the same facilities, should also be equal amongst one another without subordination or subjugation..."**

occurred. In France, on the other hand, Locke's writings had a revolutionary impact.

Credit for bringing the ideas of both Newton and Locke to France, and making them fashionable, belongs to Francois Marie Arouet (1694-1778), better known as "Voltaire". Besides persuading his mistress, Madame de Chatelet, to translate Newton's *Principia* into French, Voltaire wrote an extremely readable commentary on the book; and as a result, Newton's ideas became highly fashionable among French intellectuals. Voltaire lived with Madame du Chatelet until she died, producing the books which established him as the leading writer of Europe, a prophet of the Age of Reason, and an enemy of injustice, feudalism and superstition.

The Enlightenment in France is considered to have begun with Voltaire's return from England in 1729; and it reached its high point with the publication of of the *Encyclopedia* between 1751 and 1780. Many authors contributed to the *Encyclopedia*, which was an enormous work, designed to sum up the state of human knowledge.

Turgot and Montesquieu wrote on politics and history; Rousseau wrote on music, and Buffon on natural history; Quesnay contributed articles on agriculture, while the Baron d'Holbach discussed chemistry. Other articles were contributed by Condorcet, Voltaire and d'Alembert. The whole enterprise was directed and inspired by the passionate faith of Denis Diderot (1713-1784). The men who took part in this movement called themselves *"philosophes"*. Their creed was a faith in reason, and an optimistic belief in the perfectibility of human nature and society by means of education, political reforms, and the scientific method.

The *philosophes* of the Enlightenment visualized history as a long progression towards the discovery of the scientific method. Once discovered, this method could never be lost; and it would lead inevitably (they believed) to both the material and moral improvement of society. The *philosophes* believed that science, reason, and education, together with the principles of political liberty and equality, would inevitably lead humanity forward to a new era of happiness. These ideas were the faith of the Enlightenment; they influenced the French and American revolutions; and they are still the basis of liberal political belief.

3.2 Voltaire and Rousseau

Voltaire (1694-1778)

Francois-Marie Arouet, who later changed his name to Voltaire, was born in Paris. His father was a lawyer and a minor treasury official, while his mother's family was on the lowest rank if the French nobility. He was educated by Jesuits at Collège Louis-le-Grande, where he learned Latin theology and rhetoric. He later became fluent in Italian, Spanish and English.

Despite his father's efforts to make him study law, the young Voltaire was determined to become a writer. He eventually became the author of more than 2,000 books and pamphlets and more than 20,000 letters. His works include many forms of writing, including plays, poems, novels, essays and historical and scientific works. His writings advocated civil liberties, and he used his satirical and witty style of writing to criticize intolerance, religious dogma and absolute monarchy. Because of the intolerance and censorship of his day, he was frequently in trouble and sometimes imprisoned. Nevertheless, his works were very popular, and he eventually became extremely rich, partly through clever investment of money gained through part ownership of a lottery.

During a period of forced exile in England, Voltaire mixed with the English aristocracy, meeting Alexander Pope, John Gay, Jonathan Swift, Lady Mary Wortley Montagu, Sarah, Duchess of Marlborough, and many other members of the nobility and royalty. He admired the English system of constitutional monarchy, which he considered to be far superior to the absolutism then prevailing in France. In 1733, he published a book entitled *Letters concerning the English Nation*, in London. When French translation was published in 1734, Voltaire was again in deep trouble. In order to avoid arrest, he stayed in the country château belonging to Émilie du Châtelet and her husband, the Marquis du Châtelet.

As a result, Madame du Châtelet became his mistress and the relationship lasted for 16 years. Her tolerant husband, the Marquis, who shared their intellectual and scientific interests, often lived together with them. Voltaire paid for improvements to the château, and together, the Marquis and Voltaire collected more than 21,000 books, and enormous number for that time. Madame du Châtelet translated Isaac Newton's great book, *Principia Mathematica*, into French, and her translation was destined to be the standard one until modern times. Meanwhile, Voltaire wrote a French explanation of the ideas of the *Principia*, which made these ideas accessible to a wide public in France. Together, the Marquis, his wife and Voltaire also performed many scientific experiments, for example experiments designed to study the nature of fire.

Voltaire's vast literary output is available today in approximately 200 volumes, published by the University of Oxford, where the Voltaire Foundation is now established as a research department.

Rousseau (1712-1778)

In 1754 Rousseau wrote: "The first man who, having fenced in a piece of land, said 'This is mine', and found people naïve enough to believe him, that man was the true founder of civil society. From how many crimes, wars, and murders, from how many horrors and misfortunes might not any one have saved mankind, by pulling up the stakes, or filling up the ditch, and crying to his fellows: Beware of listening to this impostor; you are undone if you once forget that the fruits of the earth belong to us all, and the earth itself to nobody."

Later, he began his influential book *The Social Contract*, published in 1752, with the dramatic words: "Man is born free, and everywhere he is in chains. Those who think themselves the masters of others are indeed greater slaves than they." Rousseau concludes Chapter 3 of this book with the words: "Let us then admit that force does not create right, and that we are obliged to obey only legitimate powers". In other words, the ability to coerce is not a legitimate power, and there is no rightful duty to submit to it. A state has no right to enslave a conquered people.

Figure 3.2: **Voltaire used his satirical and witty style of writing to criticize intolerance, religious dogma and absolute monarchy. He wrote more than 2,000 books and pamphlets and more than 20,000 letters. His writings made a significant contribution to the Enlightenment, and paved the way for revolutions both in France and America.**

Figure 3.3: **The frontpiece of Voltaire's book popularizing Newton's ideas for French readers. Madame du Châtelet appears as a muse, reflecting Newton's thoughts down to Voltaire.**

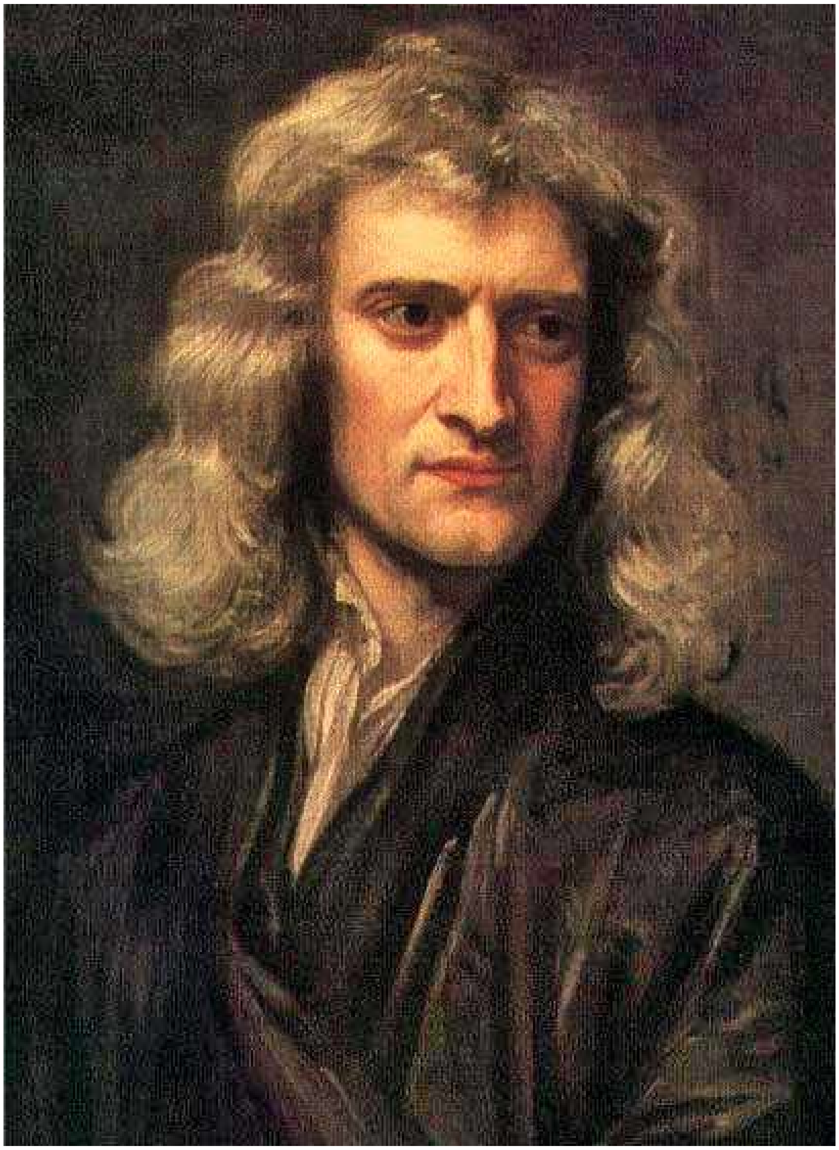


Figure 3.4: **The work of Sir Isaac Newton (1642-1726) illustrates a key aspect of human cultural evolution: Because of the introduction of printing in Europe, Newton was able to build on the work of his predecessors, Copernicus, Brahe, Galileo and Kepler. He could never have achieved his great synthesis alone. During the Enlightenment, Newton became a symbol of rationality and reason. Alexander Pope wrote: "Nature, and nature's laws, lay hid in night. God said 'Let Newton be', and all was light!"**

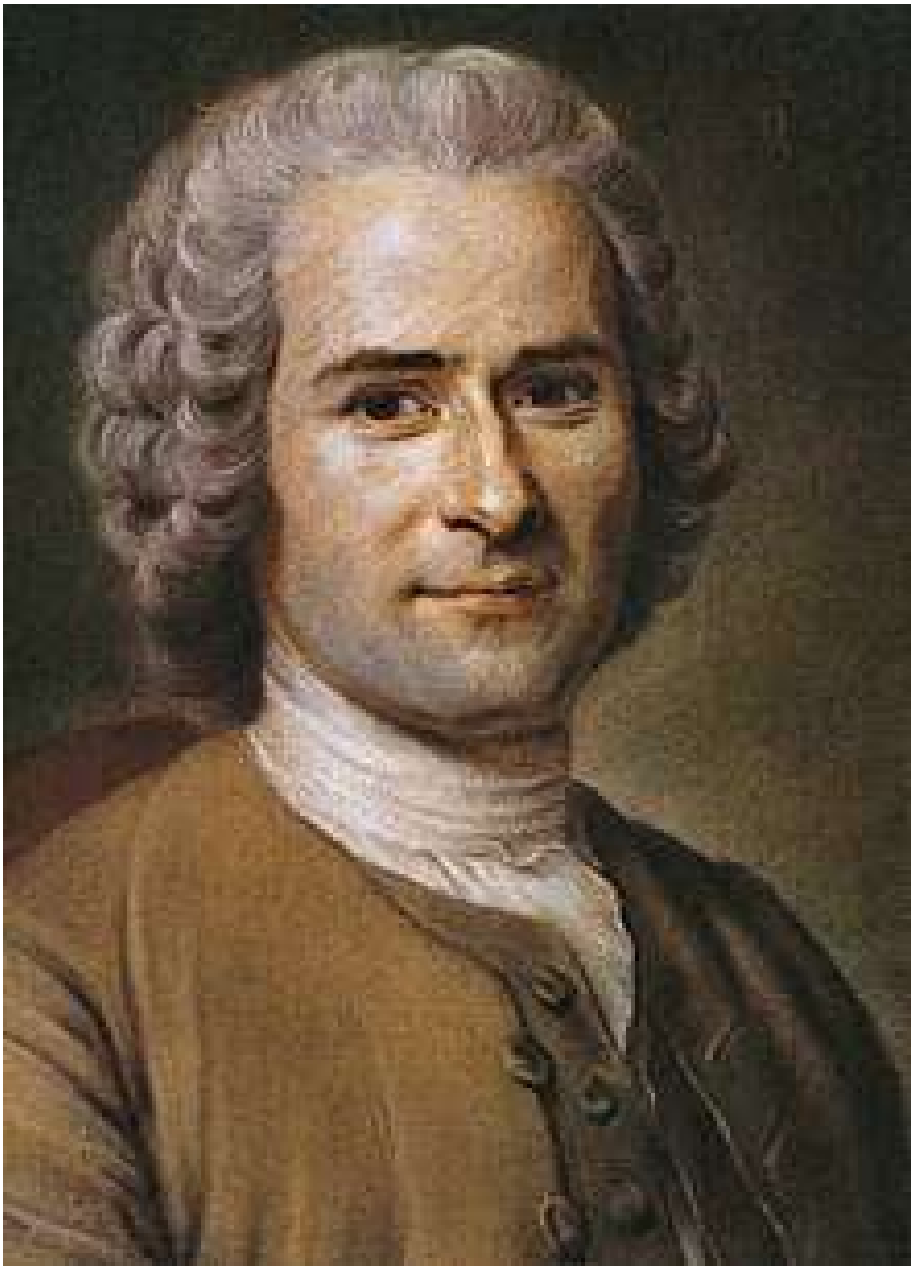
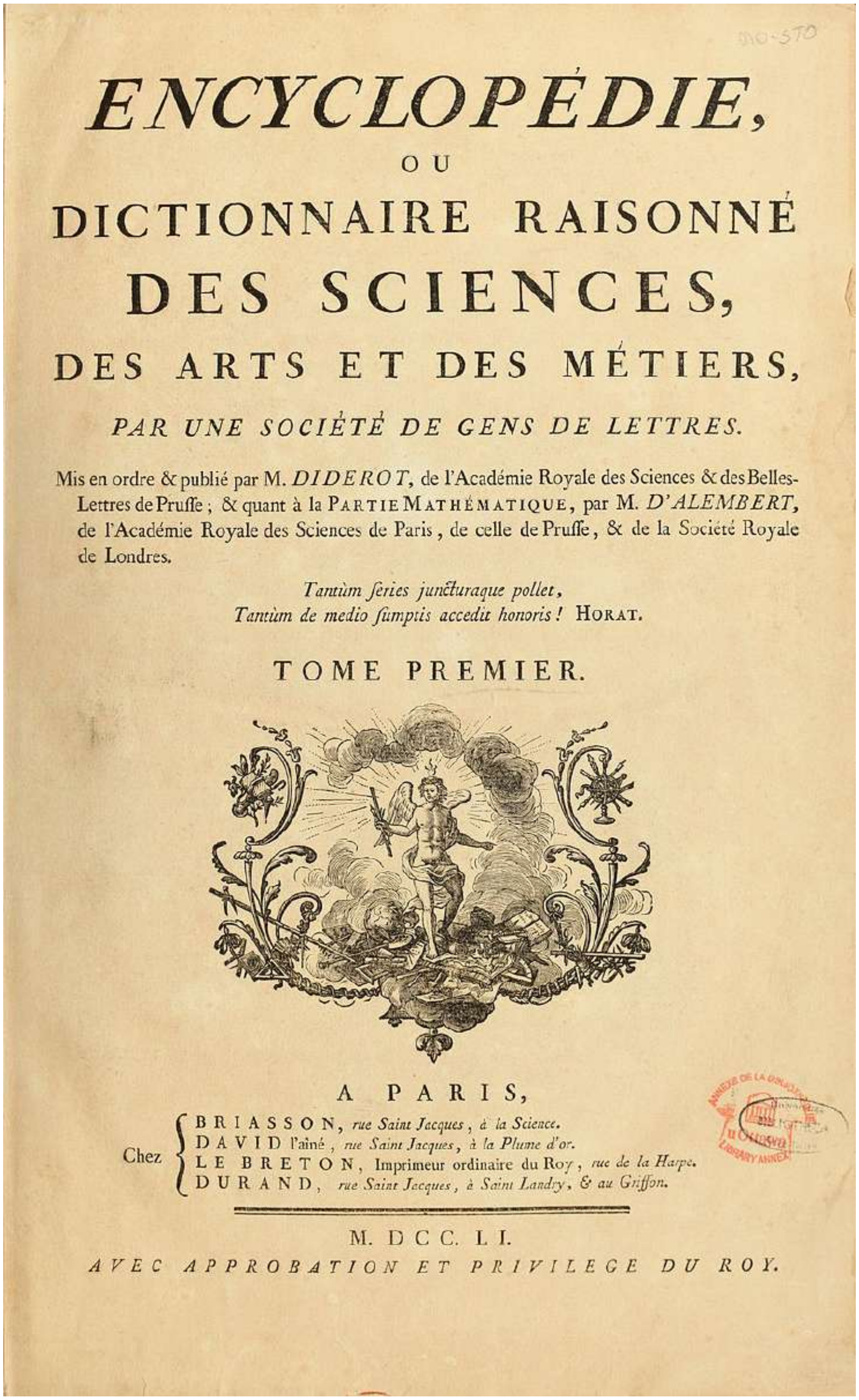


Figure 3.5: **Unlike Voltaire, Rousseau was not an advocate of science, but instead believed in the importance of emotions. He believed that civilization has corrupted humans rather than making them better. Rousseau was a pioneer of the romantic movement. His book, *The Social Contract*, remains influential today.**

These ideas, and those of John Locke, were reaffirmed in 1776 by the American Declaration of Independence: "We hold these truths to be self-evident: That all men are created equal. That they are endowed by their Creator with certain inaliable rights, and the among these are the rights to life, liberty and the pursuit of happiness; and that to pursue these rights, governments are instituted among men, deriving their just powers from the consent of the governed."

Today, in an era of government tyranny and subversion of democracy, we need to remember that the just powers of any government are not derived from the government's ability to use of force, but exclusively from the consent of the governed.

Figure 3.6: **Denis Diderot.**



ENCYCLOPÉDIE,
OU
DICTIONNAIRE RAISONNÉ
DES SCIENCES,
DES ARTS ET DES MÉTIERS,
PAR UNE SOCIÉTÉ DE GENS DE LETTRES.

Mis en ordre & publié par M. *DIDEROT*, de l'Académie Royale des Sciences & des Belles-Lettres de Pruſſe ; & quant à la PARTIE MATHÉMATIQUE, par M. *D'ALEMBERT*, de l'Académie Royale des Sciences de Paris, de celle de Pruſſe, & de la Société Royale de Londres.

Tantùm ſeries juncturaque pollet,
Tantùm de medio ſumptis accedit honoris ! HORAT.

TOME PREMIER.

A PARIS,

Chez
BRIASSON, *rue Saint Jacques, à la Science.*
DAVID l'aîné, *rue Saint Jacques, à la Plume d'or.*
LE BRETON, Imprimeur ordinaire du Roy, *rue de la Harpe.*
DURAND, *rue Saint Jacques, à Saint Landry, & au Griffon.*

M. DCC. LI.
AVEC APPROBATION ET PRIVILEGE DU ROY.

Figure 3.7: **Title page of the *Encyclopédie.***

Figure 3.8: ***Un diner de philosophes* painted by Jean Huber. Denis Diderot is the second from the right (seated).**

Figure 3.9: **Jean le Rond d'Alembert (1717-1783).**

Figure 3.10: **Portrait of Jean Le Rond d'Alembert, 1777, by Catherine Lusurier.**

Figure 3.11: **The printer and publisher Joseph Johnson (1738-1809).**

The printer and publisher Joseph Johnson

As an example of the influence of printing on the liberation of ideas, we can consider the circle of important authors that formed around the English printer and publisher Joseph Johnson (1738-1809). His weekly dinners for authors were famous. Among the many great thinkers. artists, scientists, writers and religious dissenters who attended these dinners, or whose works he published, were William Cowper, Erasmus Darwin, William Blake, Henry Fuselli, Mary Wollstonecraft, William Godwin, Thomas Robert Malthus, Thomas Paine, Pricilla Wakefield, Gilbert Wakefield. Benjamin Franklin, Richard Price and Joseph Priestly.

Throughout her career, the pioneering feminist writer Mary Wollstonecraft was aided by Johnson. As she wrote to her sister, she had decided to become the first of a new genus: a professional female writer. Having learned French and German, she translated Necker's *Of the Importance of Religious Opinions* and Saltzman's *Elements of Morality for the Use of Children*. Mary was helped in her new career by the liberal publisher, Joseph Johnson, who was also the publisher of Thomas Paine and William Godwin. Mary met these already famous authors at Johnson's dinner parties, and conversations with them helped to expand her knowledge and ambitions. Joseph Johnson was a very brave man. By publishing the works of radical authors, he was risking arrest by England's repressive government. In her letters, Mary described Johnson as "a father and brother".

At Johnson's parties Mary met, for the second time, the famous novelist and philosopher William Godwin. This time, they both formed a higher opinion of each other than at their first meeting. A passionate love affair developed between them, and when Mary became pregnant, they were married. Tragically, Mary Wollstonecraft died in childbirth. Her daughter Mary would later become the wife of Godwin's admirer, the poet Percy Bysshe Shelley, and Mary Shelly created the enduring masterpiece *Frankenstein*.

Figure 3.12: **Mary Wollstonecraft in a painting by John Opie. She called Joseph Johnson “my father and brother”.**

Figure 3.13: **The famous scientist and dissenter, Joseph Priestly, in a portrait by Henry Fuselli, commissioned by Joseph Johnson. Priestly and Fuselli were among Johnson's closest friends.**

3.3 The Enlightenment in Germany

Johann Wolfgang von Goethe

Johann Wolfgang von Goethe (born in 1749) achieved international fame at the age of 25 with his novel, *The sorrows of young Werther*.

In 1775, after studying law, Goethe was invited the court of Karl August, the Duke of Saxe-Weimar-Eisenach. At that time, the Duke was 18 years old, and Goethe was 26. Goethe remained in Weimar for the rest of his life.

Goethe soon became an indispensable aid to the young Duke, and his chief advisor. Wikipedia states that

"During his first ten years in Weimar, Goethe became a member of the Duke's privy council, sat on the war and highway commissions, oversaw the reopening of silver mines in nearby Ilmenau, and implemented a series of administrative reforms at the University of Jena. He also contributed to the planning of Weimar's botanical park and the rebuilding of its Ducal Palace,,,

"Goethe, aside from official duties, was also a friend and confidant to the Duke, and participated in the activities of the court. For Goethe, his first ten years at Weimar could well be described as a garnering of a degree and range of experience which perhaps could be achieved in no other way. In 1779, Goethe took on the War Commission of the Grand Duchy of Saxe-Weimar, in addition to the Mines and Highways commissions. In 1782, when the chancellor of the Duchy's Exchequer left his office, Goethe agreed to act in his place for two and a half years; this post virtually made him prime minister and the principal representative of the Duchy. Goethe was ennobled in 1782 (this being indicated by the 'von' in his name)".

Scientific work

Goethe was greatly interested in that natural sciences, and his writings include works on the theory of colors, and on biological topics such as metamorphosis and homologies. He discovered a bone, present in many mammals, including humans, now called "Goethe's bone". Goethe was also interested in geology, and he had the largest collection of minerals in Europe. By the time of his death, he had collected 17,800 rock samples.

Travels in Italy

During the years 1786-1788, Goethe traveled in Italy and Sicily. Regarding Sicily, he wrote, "To have seen Italy without having seen Sicily is to not have seen Italy at all, for Sicily is the clue to everything." Here he discovered Greek architecture's simplicity compared with Roman architecture, and he became enthusiastic about the Greek style.

Goethe later published an account of his travels in Italy as a nonfiction book. However, the book has nothing to say about the last year of his travels, and little is known about this last year except that he spent most of it in Venice.

Faust

Towards the end of his life, Goethe published Part One of his verse-drama *Faust*. Part Two was published after his death. Today *Faust* is regarded as one of the greatest works of German literature.

Friedrich Schiller

Schiller's early life and education

Friedrich Schiller was born on 10 November 1759, in Marbach, Württemberg, Germany. He was the only son of a military doctor, who was often away from home during the Seven Years War. Friedrich Schiller's early education was not good, but he was taught Latin and Greek by the local priest.

In 1766, Schiller's father took up a post in the service of the Duke of Würtenberg. The Duke noticed signs of promise in Friedrich Schiller, and he placed the boy in an elite military academy which had been founded by himself. As a result of this improved education, Schiller later studied medicine.

Die Räuber

While still a student, Schiller wrote the play *Die Räuber*. The play dramatizes the conflict between two brothers from the nobility. Their elder brother leads a group of rebellious students to form a Robin Hood-like bans in the Bohemian forest, robing the rich, and giving to the poor. Meanwhile, th younger brother busies himself in trying to take control of the large family fortune.

When performed. *Die Räuber* caused a sensation because of its forcefully written liberal and even revolutionary ideas. The play made Schiller instantly famous.

Ode to Joy

In our own time, Schiller's lasting fame is due to his poem, *An die Freude* (Ode to Joy) (1785) which became the basis for the last movement of Beethoven's ninth symphony. Beethoven's immortal music and Schiller's words combine to give us an anthem for all of humanity. All men and women are brothers and sisters, not just some, **All!**

Figure 3.14: **Goethe in 1775.**

Figure 3.15: **Goethe, age 38, painted by Angelica Kauffman 1787.**

Figure 3.16: **Ulrike von Levetzow.**

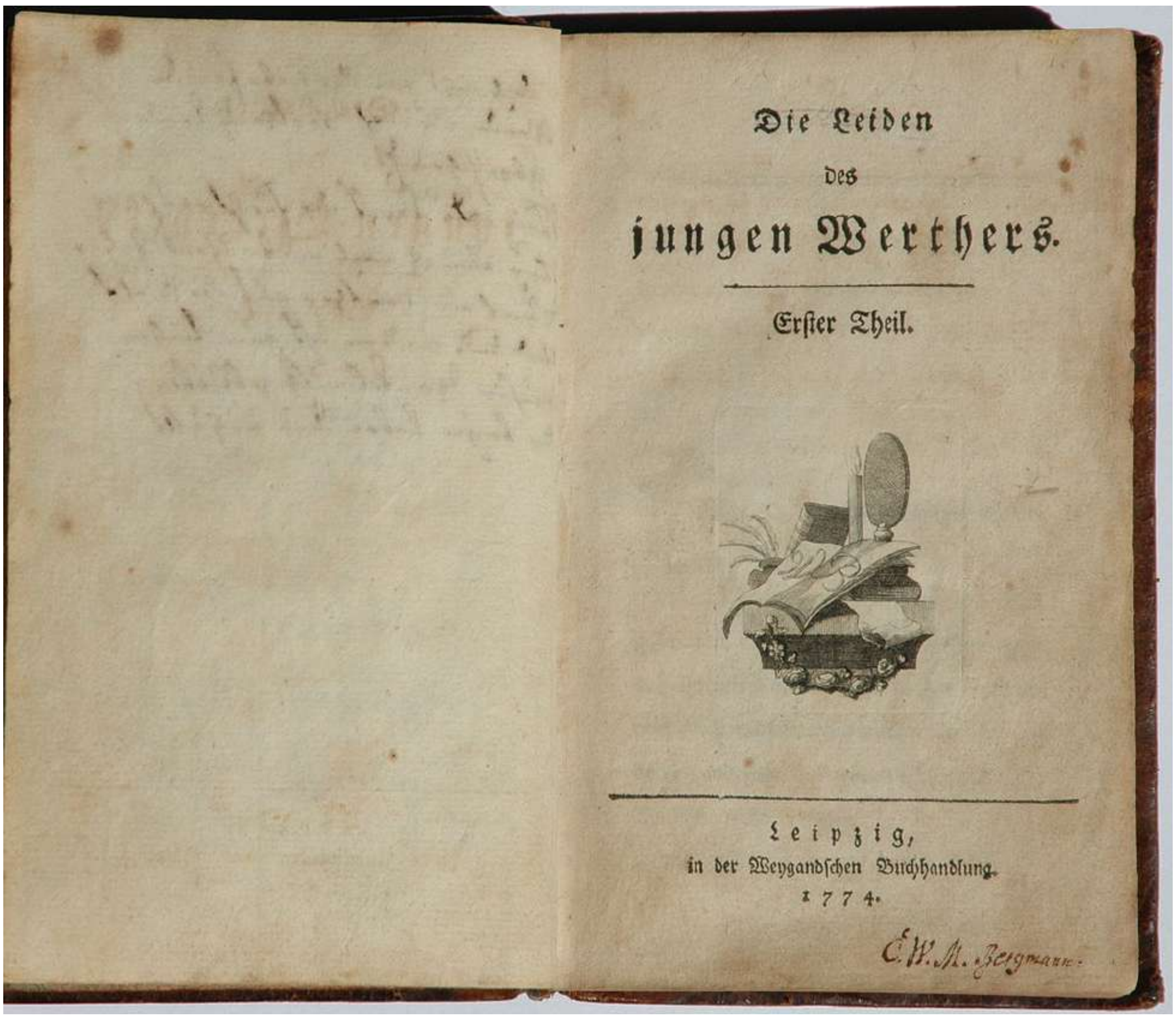


Figure 3.17: **First edition of *The Sorrows of Young Werther.***

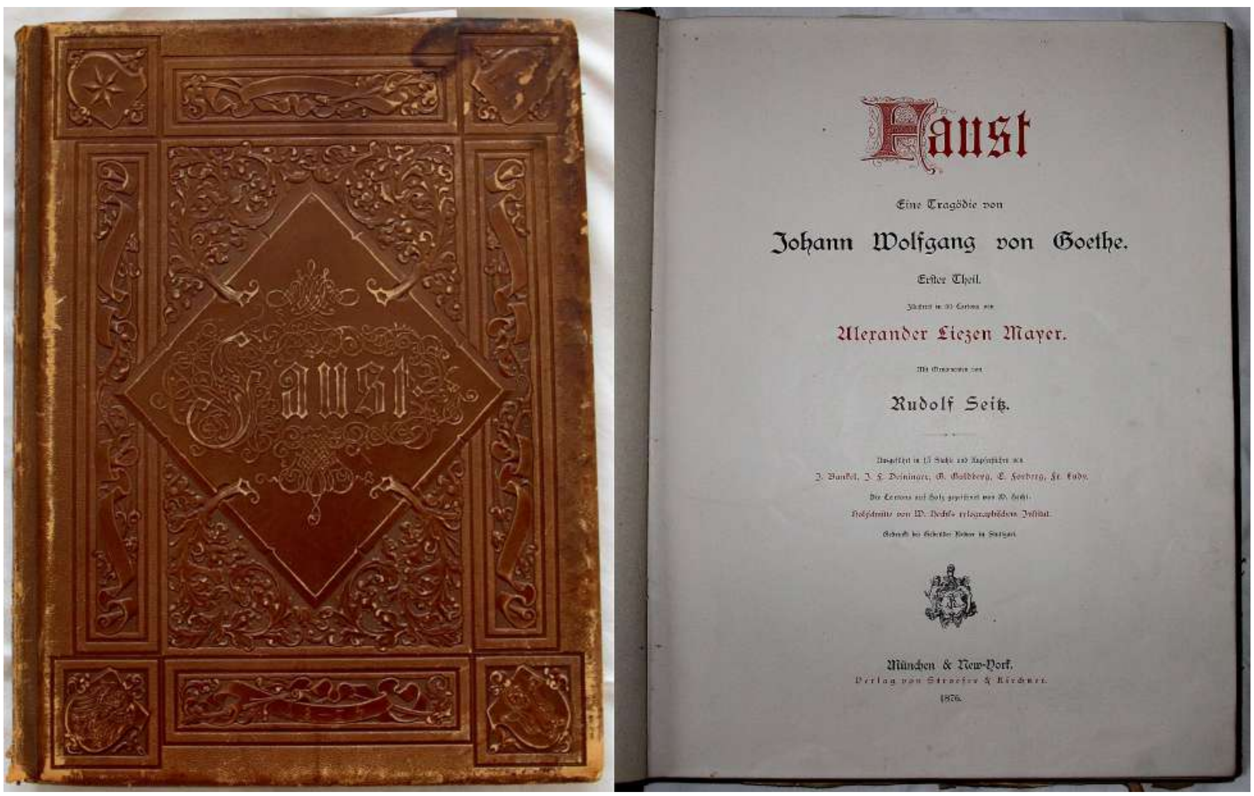


Figure 3.18: ***Faust*, by Goethe, decorated by Rudolf Seitz.**

Figure 3.19: **Goethe-Schiller Monument, Weimar.**

Figure 3.20: **Goethe in the Roman Campagna (1786) by Tischbein.**

Figure 3.21: **Schiller, Alexander and Wilhelm von Humboldt, and Goethe in Jena, 1797.**

Schiller's literary work

Plays

- Die Räuber (The Robbers), 1781
- Fiesco (Die Verschwörung des Fiesco zu Genua), 1783
- Kabale und Liebe (Intrigue and Love), 1784
- Don Karlos, Infant von Spanien (Don Carlos), 1787
- Wallenstein, 1800
- Maria Stuart (Mary Stuart), 1800
- Die Jungfrau von Orleans (The Maid of Orleans), 1801
- Turandot, Prinzessin von China, 1801
- Die Braut von Messina (The Bride of Messina), 1803
- Wilhelm Tell (William Tell), 1804
- Demetrius (unfinished at his death)

Histories

- Geschichte des Abfalls der vereinigten Niederlande von der spanischen Regierung or The Revolt of the Netherlands
- Geschichte des dreissigjährigen Kriegs or A History of the Thirty Years' War
- Über Völkerwanderung, Kreuzzüge und Mittelalter or On the Barbarian Invasions, Crusaders and Middle Ages

Translations

- Euripides, Iphigenia in Aulis
- William Shakespeare, Macbeth
- Jean Racine, Phèdre
- Carlo Gozzi, Turandot, 1801

Prose

- Der Geisterseher or The Ghost-Seer (unfinished novel) (started in 1786 and published periodically. Published as book in 1789)
- Über die ästhetische Erziehung des Menschen in einer Reihe von Briefen (On the Aesthetic Education of Man in a Series of Letters), 1794
- Der Verbrecher aus verlorener Ehre (Dishonoured Irreclaimable), 1786

Poems

- An die Freude (Ode to Joy) (1785) became the basis for the fourth movement of Beethoven's ninth symphony
- Der Taucher (The Diver; set to music by Schubert)
- Die Kraniche des Ibykus (The Cranes of Ibykus)
- Der Ring des Polykrates (Polycrates' Ring)
- Die Bürgschaft (The Hostage; set to music by Schubert)
- Das Lied von der Glocke (Song of the Bell)
- Das verschleierte Bild zu Sais (The Veiled Statue at Sais)
- Der Handschuh (The Glove)
- Nänie (set to music by Brahms)

Figure 3.22: **Portrait of Schiller by Ludovike Simanowiz (1794).**

Figure 3.23: **Portrait of Friedrich Schiller by Gerhard von Kügelgen.**

Figure 3.24: **French-occupied German stamp depicting Schiller.**

3.4 The United States Constitution and Bill of Rights

The history of the Federal Constitution of the United States is an interesting one. It was preceded by the Articles of Confederation, which were written by the Second Continental Congress between 1776 and 1777, but it soon became clear that Confederation was too weak a form of union for a collection of states.

George Mason, one of the drafters of the Federal Constitution, believed that "such a government was necessary as could directly operate on individuals, and would punish those only whose guilt required it", while another drafter, James Madison, wrote that the more he reflected on the use of force, the more he doubted "the practicality, the justice and the efficacy of it when applied to people collectively, and not individually."

Finally, Alexander Hamilton, in his Federalist Papers, discussed the Articles of Confederation with the following words: "To coerce the states is one of the maddest projects that was ever devised... Can any reasonable man be well disposed towards a government which makes war and carnage the only means of supporting itself, a government that can exist only by the sword? Every such war must involve the innocent with the guilty. The single consideration should be enough to dispose every peaceable citizen against such government... What is the cure for this great evil? Nothing, but to enable the... laws to operate on individuals, in the same manner as those of states do."

In other words, the essential difference between a confederation and a federation, both of them unions of states, is that a federation has the power to make and to enforce laws that act on individuals, rather than attempting to coerce states (in Hamilton's words, "one of the maddest projects that was ever devised.") The fact that a confederation of states was found to be far too weak a form of union is especially interesting because our present United Nations is a confederation. We are at present attempting to coerce states with sanctions that are "applied to people collectively and not individually."The International Criminal Court, which we will discuss below, is a development of enormous importance, because it acts on individuals, rather than attempting to coerce states.

There are many historical examples of successful federations; but in general, unions of states based on the principle of confederation have proved to be too weak. Probably our best hope for the future lies in gradually reforming and strengthening the United Nations, until it becomes a federation.

In the case of the Federal Constitution of the United States, there were Anti-Federalists who opposed its ratification because they feared that it would be too powerful. Therefore, on June 8, 1789, James Madison introduced in the House of Representatives a series of 39 amendments to the constitution, which would limit the government's power. Of these, only amendments 3 to12 were adopted, and these have become known collectively as the Bill of Rights.

Of the ten amendments that constitute the original Bill of Rights, we should take particular notice of the First, Fourth and Sixth, because they have been violated repeatedly and grossly by the present government of the United States.

The First Amendment requires that "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of

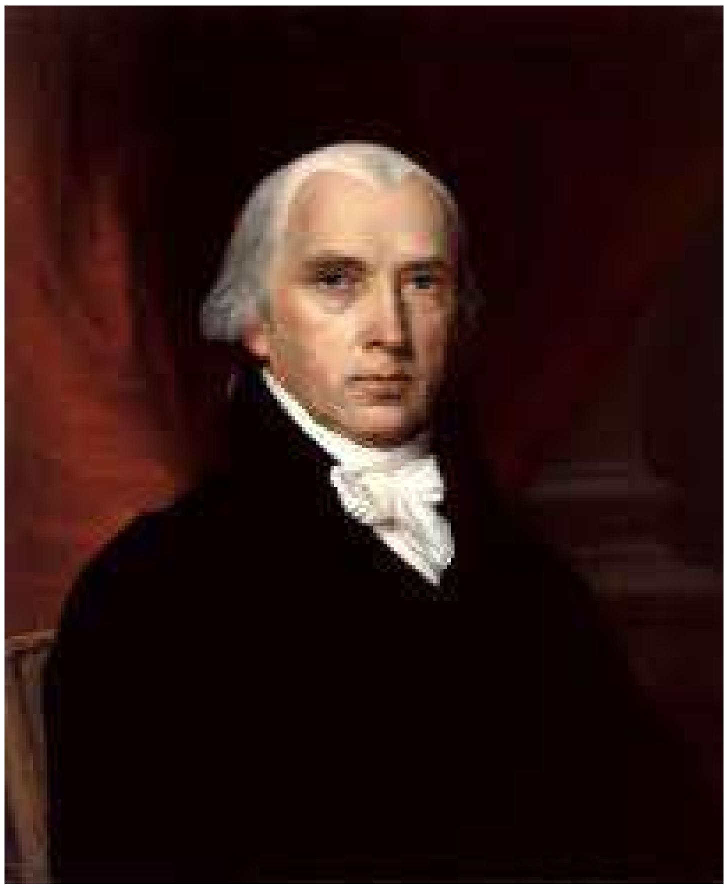


Figure 3.25: **James Madison, wrote that the more he reflected on the use of force, the more he doubted "the practicality, the justice and the efficacy of it when applied to people collectively, and not individually." He later introduced the Constitutional amendments that became the U.S. Bill of Rights.**

speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances." The right to freedom of speech and freedom of the press has been violated by the punishment of whistleblowers. The right to assemble peaceably has also been violated repeatedly and brutally by the present government's militarized police.

The Fourth Amendment states that "The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized."It is hardly necessary to elaborate on the U.S. Government's massive violations of the Fourth Amendment. Edward Snowden's testimony has revealed a huge secret industry carrying out illegal and unwarranted searches and seizures of private data, not only in the United States, but also throughout the world. This data can be used to gain power over citizens and leaders through blackmail. True democracy and dissent are thereby eliminated.

The Sixth Amendment requires that "In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the State and district wherein the crime shall have been committed, which district shall have been previously ascertained by law, and to be informed of the nature and cause of the accusation; to be confronted with the witnesses against him; to have compulsory process for obtaining witnesses in his favor, and to have the Assistance of Counsel for his defense."This constitutional amendment has also been grossly violated.

In the context of federal unions of states, the Tenth Amendment is also interesting. This amendment states that "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people."We mentioned above that historically, federations have been very successful. However, if we take the European Union as an example, it has had some problems connected with the principle of subsidiarity, according to which as few powers as possible should be decided centrally, and as many issues as possible should be decided locally. The European Union was originally designed as a free trade area, and because of its history commercial considerations have trumped environmental ones. The principle of subsidiarity has not been followed, and enlightened environmental laws of member states have been declared to be illegal by the EU because they conflicted with free trade. These are difficulties from which we can learn as we contemplate the conversion of the United Nations into a federation.

The United States Bill of Rights was influenced by John Locke and by the French philosophers of the Enlightenment. The French Declaration of the Rights of Man (August, 1789) was almost simultaneous with the U.S. Bill of Rights.

We can also see the influence of Enlightenment philosophy in the wording of the U.S. Declaration of independence (1776): "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.–That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed..."Another criticism that can be leveled against the present government of the United States is that its actions seem to have nothing whatever to do with the consent of the governed, not to mention the violations of the rights to life, liberty and the pursuit of happiness implicit in extrajudicial killings.

Here are a few things that Hamilton said:

Men give me credit for some genius. All the genius I have lies in this; when I have a subject in hand, I study it profoundly. Day and night it is before me. My mind becomes pervaded with it. Then the effort that I have made is what people are pleased to call the fruit of genius. It is the fruit of labor and thought.

Give all the power to the many, they will oppress the few. Give all the power to the few, they will oppress the many.

Those who stand for nothing fall for everything.

The art of reading is to skip judiciously.

There are seasons in every country when noise and impudence pass current for worth; and in popular commotions especially, the clamors of interested and factious men are often mistaken for patriotism.

Safety from external danger is the most powerful director of national conduct. Even the ardent love of liberty will, after a time, give way to its dictates. The violent destruction of life and property incident to war, the continual effort and alarm attendant on a state of continual danger, will compel nations the most attached to liberty to resort for repose and security to institutions which have a tendency to destroy their civil and political rights. To be more safe, they at length become willing to run the risk of being less free.

The sacred rights of mankind are not to be rummaged for among old parchments or musty records. They are written, as with a sunbeam, in the whole volume of human nature, by the Hand of Divinity itself, and can never be erased or obscured by mortal power.

Why has government been instituted at all? Because the passions of man will not conform to the dictates of reason and justice without constraint.

Hard words are very rarely useful. Real firmness is good for every thing. Strut is good for nothing.

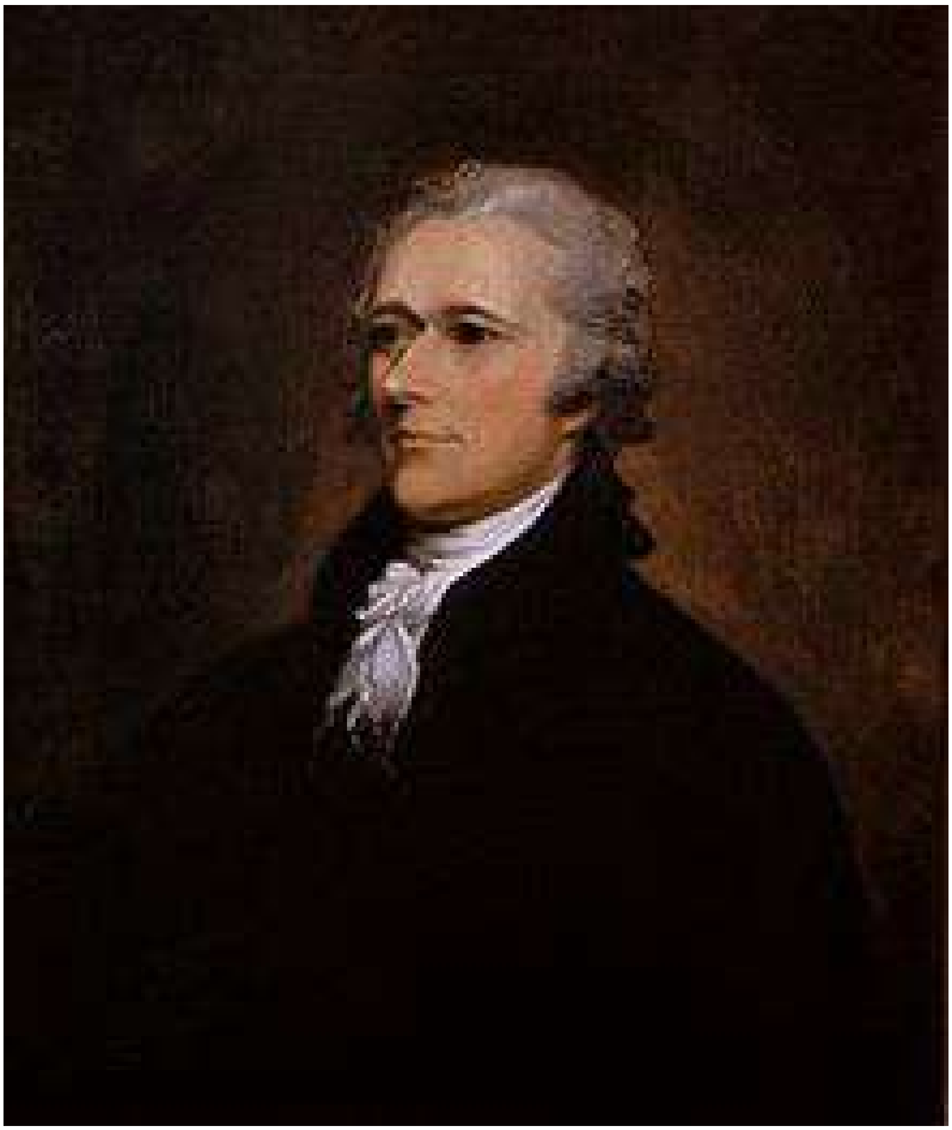


Figure 3.26: **Alexander Hamilton in a 1807 portrait by John Turnbull.**

I have thought it my duty to exhibit things as they are, not as they ought to be.

For in politics, as in religion, it is equally absurd to aim at making proselytes by fire and sword. Heresies in either can rarely be cured by persecution.

The republican principle demands that the deliberate sense of the community should govern the conduct of those to whom they intrust the management of their affairs; but it does not require an unqualified complaisance to every sudden breeze of passion or to every transient impulse which the people may receive from the arts of men, who flatter their prejudices to betray their interests.

Here, sir, the people govern; here they act by their immediate representatives.

Vigor of government is essential to the security of liberty.

It will be of little avail to the people, that the laws are made by men of their own choice, if the laws be so voluminous that they cannot be read, or so incoherent that they cannot be understood.

3.5 Thomas Paine

Early life

Thomas Paine was born in 1737 in Thetford, Norfolk, England. His father was a manufacturer of rope stays used on ships, and after attending grammar school, Paine was apprenticed to his father. Later, he held a variety of positions in England, including excise officer and school-teacher.

Paine also opened a tobacco shop, but it failed, and the resulting financial difficulties put Paine in danger of debtor's prison. He was saved from this fate by Benjamin Franklin, to whom he had been introduced by a fellow excise officer. Franklin suggested to Paine that he should emigrate to America, and he set sail in 1774.

Thomas Paine barely survived the voyage to America. The water on board had been polluted with typhoid fever, and when the ship arrived in Pennsylvania, Paine was so ill that he had to be carried ashore. Franklin's physician nursed the sick man back to health. Paine then became a citizen of Pennsylvania, and in 1775 he found work as editor of the *Pennsylvania Magazine*, a post which he filled with distinction.

Common sense, 1776

In Pennsylvania, Thomas Paine became an enthusiastic supporter American independence movement, and in 1776 he published an immensely successful pamphlet entitled *Common*

Sense. Ultimately half a million copies of this pamphlet were sold in the American colonies, whose population at that time was only 2.5 million. In proportion to the total population, Paine's pamphlet sold more copies than any printed work ever published in America, before or since.

Besides readers who owned copies of *Common Sense*, many others heard it read aloud in homes or taverns. The revolution against the English monarchy had already started, but Paine's pamphlet encouraged enlistment in George Washington's Continental Army and it supplied the the colonists with strong arguments for independence, Because of this, Paine is often called "the father of the American Revolution".

In his introduction to *Common Sense*, Paine wrote: "The cause of America is, to a great extent, the cause of all mankind. Many circumstances have, and will, arise, which are not local but universal, and through which principles all lovers of mankind are affected, and in the event of which their affections are interested. The laying of a country desolate with fire and sword, declaring war against the natural rights of all mankind, and extirpating the defenders thereof from the face of the earth, is the concern of every man to whom nature hath given the power of feeling; of which class, regardless of party censure, is the author."

In the main body of the pamphlet he opposed the idea that the English constitution is a good for America: "I know that it is difficult to get over long standing prejudices, yet if we suffer ourselves to examine the component parts of the English constitution, we shall find them to be the base remains of two ancient tyrannies, compounded with some new republican materials.
First: The remains of the monarchal tyranny in the person of the king.
Secondly: The remains of the aristocratical tyranny in the persons of the peers.
Thirdly: The new republican materials in the persons of the commons, on whose virtue depends the freedom of England."

"There is something exceedingly ridiculous in the composition of monarchy; it first excludes a man from the means of information, yet empowers him to act in cases where the highest judgement is required. The state of a king shuts him off from the world; yet the business of a king requires him to know it thoroughly; whereof the different parts, by opposing and destroying each other, prove the whole character to be absurd and useless."

"That the crown is the overbearing part of the English constitution, needs not be mentioned, and that it derives its whole consequence merely from being the giver of places and pensions is self-evident, whereof, although we have been wise enough to shut an lock a door against absolute monarchy, we at the same time have been foolish enough to put the crown in possession of the key."

The Rights of Man, (1791)

The Continental Congress sought financial help from France to support the revolutionary war against England. Thomas Paine was sent to France as one of two negotiators. He landed there in March 1781 and returned to America in August with 2.5 million livres in silver, as part of a "present" of 6 million and a loan of 10 million.

Paine returned to England in 1787 and he soon became involved a debate concerning the French Revolution. In 1790, the conservative writer Edmond Burke issued a pamphlet entitled *Reflections on the Revolution in France*. Burke's pamphlet was an argument for retaining traditional methods of government. Since they had evolved slowly and had been tested over long periods of time, Burke argued, traditional forms of government were more trustworthy than institutions that was newly invented.

Burke's pamphlet provoked a storm of refutations, and Thomas Paine joined the chorus with a pamphlet entitled *The Rights of Man*. He first offered this pamphlet to the liberal published Joseph Johnson. However, Johnson had been especially warned by government agents that if he printed anything by Paine, he would be speedily imprisoned. Paine himself was warned by William Blake that if he returned to his lodgings, he too would be imprisoned. Blake advised him to flee to France.

Before leaving for France, Paine entrusted *The Rights of Man* to another printer, J.S. Jordan, who risked arrest by publishing it. Nearly a million copies were sold! Details of the publication were handled by William Godwin, Thomas Brand Hollis and Thomas Holcroft, all of whom were close friends of Paine.

In England, Thomas Paine was tried *in absentia* for writing *The Rights of Man*, and he was convicted of seditious libel against the King. Of course he could not be arrested and hanged by the English government, because he was in France.

Despite not being able to speak French, Paine was elected to the French National Convention. However, France at that time was not a safe place, since rival revolutionary factions were fighting for control of the country. Paine was arrested in 1793 by Robespierre's party because he supported the rival Girondists After narrowly escaping execution, Paine was finally released from prison through the diplomatic efforts of the future American President, James Monroe. Thus Paine survived the critical days until the fall of Robespierre, after which he lived safely in France for a number of years.

In his 90,000-word book, *The Rights of Man*, Paine argued that human rights originate in Nature, thus, rights cannot be granted via political charter, because that implies that rights are legally revocable, hence, would be privileges:

"It is a perversion of terms", Paine wrote, "to say that a charter gives rights. It operates by a contrary effect - that of taking rights away. Rights are inherently in all the inhabitants; but charters, by annulling those rights, in the majority, leave the right, by exclusion, in the hands of a few... They... consequently are instruments of injustice ... The fact, therefore, must be that the individuals, themselves, each, in his own personal and sovereign right, entered into a contract with each other to produce a government: and this is the only mode in which governments have a right to arise, and the only principle on which they have a right to exist."

Thomas Paine argued that government's only purpose is safeguarding the individual's safety and inherent, inalienable rights; each societal institution that does not benefit the nation is illegitimate - especially monarchy and aristocracy.

Many of these ideas were already circulating during the Enlightenment period, for example in John Locke's *Second Treatise of Government*. Paine developed these ideas further, helped by conversations with Thomas Jefferson, who was also in Paris at that

Figure 3.27: **Thomas Paine in a portrait by Mathew Pratt (Wikipedia).**

time.

In the final part of *The Rights of Man*, Paine proposes that a reformed English Constitution should be drafted, along the lines of the American Constitution. He advocated the elimination of aristocratic titles, a budget without military allocations, lower taxes and subsidized education for the poor, and a progressively weighted and increased income tax for the wealthy.

The Impact of Thomas Paine's Ideas

Napoleon claimed that he slept with a copy of Paine's *The Rights of Man* under his pillow. Napoleon was once friendly with Paine, but when he assumed the title of Emperor, Paine denounced him as a charlatan.

Abraham Lincoln's writing style was very much influenced by Paine's. Roy Basler, the editor of Lincoln's papers, said: "Paine had a strong influence on Lincoln's style: No other writer of the eighteenth century, with the exception of Jefferson, parallels more closely the temper or gist of Lincoln's later thought. In style, Paine above all others affords the variety of eloquence which, chastened and adapted to Lincoln's own mood, is revealed in Lincoln's formal writings."

Thomas Edison wrote: "I have always regarded Paine as one of the greatest of all Americans. Never have we had a sounder intelligence in this republic ... It was my good fortune to encounter Thomas Paine's works in my boyhood ... it was, indeed, a revelation to me to read that great thinker's views on political and theological subjects. Paine educated me, then, about many matters of which I had never before thought. I remember, very vividly, the flash of enlightenment that shone from Paine's writings, and I recall thinking, at that time, 'What a pity these works are not today the schoolbooks for all children!' My interest in Paine was not satisfied by my first reading of his works. I went back to them time and again, just as I have done since my boyhood days."

The Uriguaian national hero Jose Gervasio Artigas became familiar with and embraced Paine's ideas. In turn, many of Artigas's writings drew directly from Paine's, including the Instructions of 1813, which Uruguayans consider to be one of their country's most important constitutional documents; it was one of the earliest writings to articulate a principled basis for an identity independent of Buenos Aires.

Interestingly, like his lifelong friend and mentor Benjamin Franklin, Thomas Paine was also an inventor. Single-span iron bridges designed by him have been constructed in many parts of the world, and he contributed to the improvement of the steam engine.

In 2002, Paine was voted number 34 of "100 Greatest Britons" in a public poll conducted by the BBC.

3.6 Thomas Jefferson

Jefferson's Education

Thomas Jefferson (1743-1826) was born in the British Colony of Virginia. His father, Peter Jefferson, who was a planter and surveyor, died when Thomas Jefferson was 14 years old, and Thomas inherited an estate of approximately 5000 acres.

At the age of 16, Jefferson entered the College of William and Mary in Williamsburg Virginia. His studies there included mathematics and philosophy. He became familiar with John Locke, Francis Bacon and Isaac Newton. Jefferson also improved his knowledge of languages and his skill in playing the violin. He graduated in two years and afterwards studied law. Jefferson was an avid reader, hand his personal library ultimately included 6,500 books.

When the British government passed the Intolerable Acts in 1774, Jefferson wrote a resolution calling for a day of fasting and prayer in protest, as well as a boycott of all British goods. He later expanded this into a larger publication with the title *A Summary View of the Rights of British America*.

Monticello

In 1768, Jefferson began construction his home, Monticello, on a hilltop overlooking his estate. It was a large mansion in the Paladian style, designed by Jefferson. He worked to improve it throughout most of his life. It is now a much-visited museum and national monument.

In 1772, Jefferson married his third cousin, the 23-year old widow Martha Wayles Skelton. The marriage was an extremely happy one, and they had six children. However, weakened by the birth of her last child, Martha died at the age of 33. Before her death she made her heartbroken husband promise never to marry again because she could not bear to think of her children being brought up by a stepmother. Through Martha, Jefferson inherited an additional estate of 11,000 acres, but he also inherited the debts of the estate, and this contributed to his financial worries. However, he was finally able to pay all of the debts.

Political service to Virginia and to the United States

At 33, Jefferson represented Virginia at the Continental Congress, where he was one of the youngest delegates. He was the main author of the *Declaration of Independence*. In writing it, he drew on his deep knowledge of Enlightenment thought, for example the writings of John Locke and Montaigne.

As a Virginia legislator, Jefferson drafted a law for religious freedom. He also served as Virginia's wartime governor (1779-1781).

In 1785, Jefferson became the United States' Minister to France. Later, from 1790 to 1793 he served as Secretary of State under President George Washington. He was America's second Vice President, under John Adams. Finally, from 1801 to 1809 he served as the third President of the United States.

A few things that Thomas Jefferson said

I tremble for my country when I reflect that God is just; that his justice cannot sleep forever.

Educate and inform the whole mass of the people... They are the only sure reliance for the preservation of our liberty.

We hold these truths to be self-evident: that all men are created equal; that they are endowed by their Creator with certain unalienable rights; that among these are life, liberty, and the pursuit of happiness.

Do you want to know who you are? Don't ask. Act! Action will delineate and define you.

I like the dreams of the future better than the history of the past.

I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them but to inform their discretion.

The care of human life and happiness, and not their destruction, is the first and only object of good government.

I never considered a difference of opinion in politics, in religion, in philosophy, as cause for withdrawing from a friend.

All, too, will bear in mind this sacred principle, that though the will of the majority is in all cases to prevail, that will to be rightful must be reasonable; that the minority possess their equal rights, which equal law must protect, and to violate would be oppression.

Our country is now taking so steady a course as to show by what road it will pass to destruction, to wit: by consolidation of power first, and then corruption, its necessary consequence.

Sometimes it is said that man cannot be trusted with the government of himself. Can he, then be trusted with the government of others? Or have we found

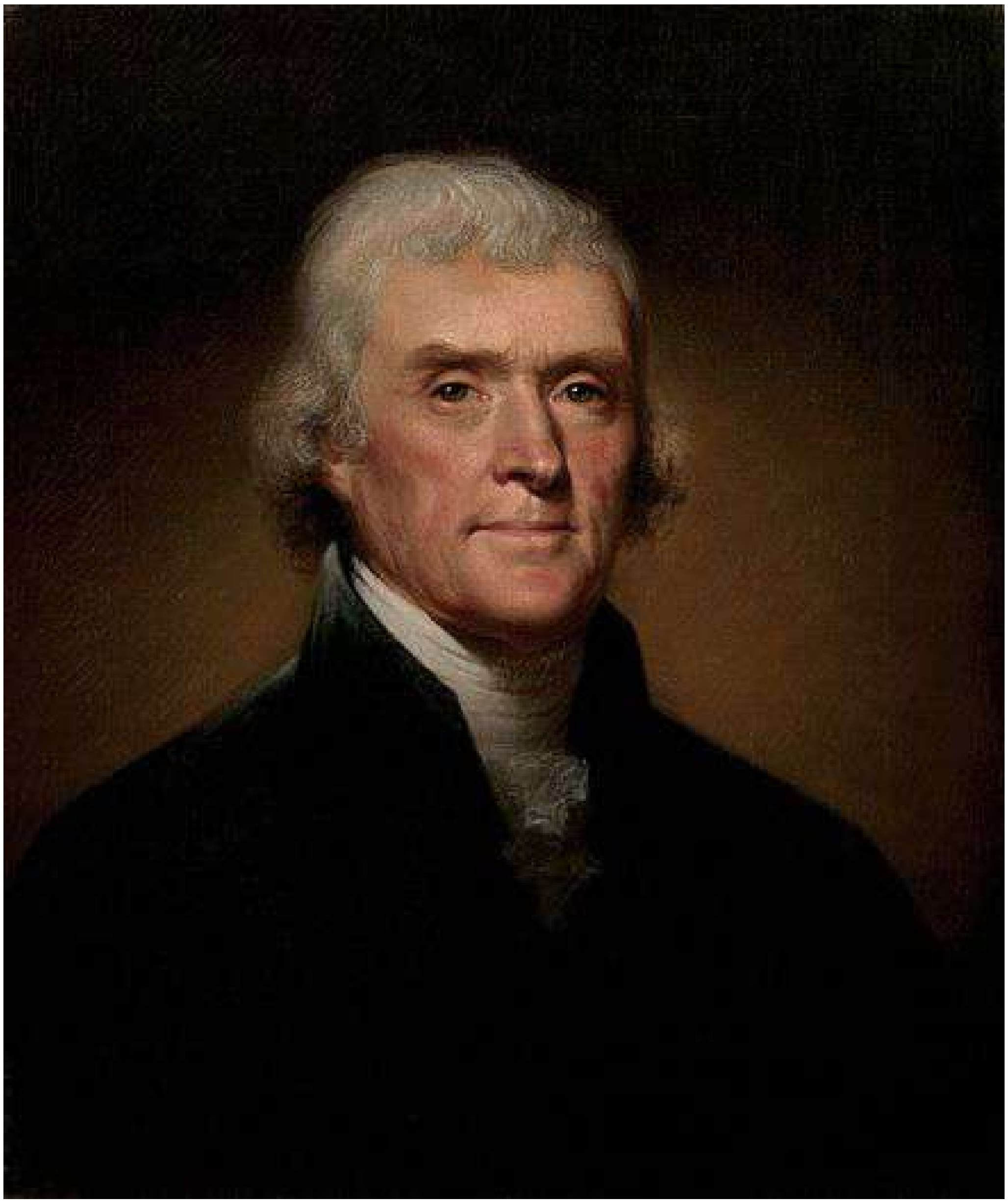


Figure 3.28: **Thomas Jefferson in a painting by R. Peale (Wikipedia).**

angels in the form of kings to govern him? Let history answer this question.

The world is indebted for all triumphs which have been gained by reason and humanity over error and oppression. Conquest is not in our principles. It is inconsistent with our government.

The spirit of this country is totally adverse to a large military force. I have seen enough of one war never to wish to see another.

I have sworn upon the altar of God, eternal hostility against every form of tyranny over the mind of man.

If there is one principle more deeply rooted in the mind of every American, it is that we should have nothing to do with conquest.

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed...

3.7 Benjamin Franklin

From humble origins to international fame

Benjamin Franklin (1705-1790) was born in Boston to a father with seventeen children. Because of his very large family Franklin's father, who was a candle and soap maker, could only afford to send him to school for two years. Franklin was largely self-educated through voracious reading.

After leaving school, Benjamin Franklin at first worked for his father, but soon he was apprenticed to his elder brother James, who was a printer, and who also had founded a newspaper. *The New England Courant*, the first truly independent newspaper in the America Colonies.

Young Ben was already full of ideas, and he strongly wished to contribute articles to James' newspaper, but his somewhat tyrannical elder brother forbad him to do so. To get around this prohibition, Ben secretly invented a fictitious middle-aged widow named Silence Dogood, and submitted many articles in her name. These articles proved to be extremely popular with readers of *The New England Courant*, but when James discovered the ruse, he was furious.

The result of the soured relationship between the two brothers was that Benjamin Franklin broke off the apprenticeship without James' permission and fled to another colony,

Figure 3.29: **A portrait of Benjamin Franklin by Joseph Duplessis, 1778.**

Figure 3.30: **Franklin's kite experiment, as visualized by the artist Benjamin West, who added some cherubs. Franklin's kite experiment led him to invent the lightning rod. His other inventions included bifocal glasses, the glass harmonica and the Franklin stove. In science, Franklin was an early supporter of the wave theory of light; and he made important contributions to demographics, the study of ocean currents and the theory of electricity. He discovered the principle of conservation of electrical charge and constructed a multiple plate capacitor.**

Figure 3.31: **Franklin (center) at work with his printing press, in a reproduction of a painting by Charles Mills.**

Figure 3.32: **A political cartoon by Benjamin Franklin urging the American colonies to unite.**

Figure 3.33: **A painting by John Turnbull showing the Committee of Five presenting the Declaration of Independence. Although illness made him unable to be present at the moment of presentation shown in the painting, Franklin made important contributions to the Declaration.**

Figure 3.34: **A painting showing Franklin as Ambassador to France, surrounded by French ladies, with whom he was very popular. When one of them rebuked him for not having come to see her, he replied, "Madam, I am waiting until the nights are longer".**

Pennsylvania. He arrived there at the age of 17, almost penniless, but he soon found work in the printing shops of the newly-founded city of Philadelphia.

Before long, Benjamin Franklin became a highly successful independent printer, writer and publisher. His publications, such as *The Pennsylvania Gazette*, *Poor Richard's Almanac*, *The Busy-Body*, *The General Magazine and Historical Chronicle for all the British Plantations in America*, and *Abraham's Sermon*, eventually made him a wealthy man.

The Wikipedia article about Franklin states that he was "...an American polymath and one of the Founding Fathers of the United States. Franklin was a leading author, printer, political theorist, politician, freemason, postmaster, scientist, inventor, humorist, civic activist, statesman, and diplomat. As a scientist, he was a major figure in the American Enlightenment and the history of physics for his discoveries and theories regarding electricity. As an inventor, he is known for the lightning rod, bifocals, and the Franklin stove, among other inventions. He founded many civic organizations, including the Library Company, Philadelphia's first fire department and the University of Pennsylvania.

"Franklin earned the title of 'The First American' for his early and indefatigable campaigning for colonial unity, initially as an author and spokesman in London for several colonies. As the first United States Ambassador to France, he exemplified the emerging American nation. Franklin was foundational in defining the American ethos as a marriage of the practical values of thrift, hard work, education, community spirit, self-governing institutions, and opposition to authoritarianism both political and religious, with the scientific and tolerant values of the Enlightenment."

Here are a few things that Benjamin Franklin said:

They who can give up essential liberty to obtain a little temporary safety deserve neither liberty nor safety.

Three may keep a secret, if two of them are dead.

Either write something worth reading or do something worth writing [about].

Tell me and I forget, teach me and I may remember, involve me and I learn.

He that can have patience can have what he will.

A Penny Saved is a Penny Earned.

You may delay, but time will not.

Many people die at twenty five and aren't buried until they are seventy five.

Never ruin an apology with an excuse.

We are all born ignorant, but one must work hard to remain stupid.

Justice will not be served until those who are unaffected are as outraged as those who are.

By failing to prepare, you are preparing to fail.

How many observe Christ's birthday! How few, His precepts!

Well done is better than well said.

Hide not your talents, they for use were made, What's a sundial in the shade?

Being ignorant is not so much a shame, as being unwilling to learn.

An investment in knowledge always pays the best interest

Lost Time is never found again.

It is the first responsibility of every citizen to question authority.

Instead of cursing the darkness, light a candle.

If all printers were determined not to print anything till they were sure it would offend nobody, there would be very little printed.

The Constitution only guarantees the American people the right to pursue happiness. You have to catch it yourself.

Be at war with your vices, at peace with your neighbors, and let every new year find you a better man.

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Chapter 4

UNIVERSAL EDUCATION

4.1 Universal education today

Today, there is some form of compulsory education in most countries. However, regional differences are still very great, as shown in the maps below.

The percentage of the global population without any schooling decreased from 36% in 1960 to 25% in 2000. In the developed countries, illiteracy rates and the number of children without schooling both were approximately halved between 1970 and 2000. However, illiteracy in the less developed countries exceeded that of the developed ones by a factor of ten in 1970. By 2000, this factor had increased to approximately 20.

As economies become more and more knowledge-based, high and higher educational levels of education are required. For many modern professions, students may be 30 years old before they complete their doctoral and post-doctoral educations. For this reason high educational levels are linked with lower fertility rates. Teenagers are biologically ready to have children, but in modern societies, they are not yet sufficiently educated to obtain well-paid work.

The Human Development Report

Since 1990, the Human Development Report has been published annually by the United Nations. It was launched jointly by the Pakistani economist Mahbub ul Haq and Indian Nobel laureate Amartya Sen. The purpose of the report has been to place people rather that material goods at the center of evaluations of economic progress. As Mahbub ul Haq put it, "People are the real wealth of a nation. The basic objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives. This may appear to be a simple truth. But it is often forgotten in the immediate concern with the accumulation of commodities and financial wealth."

Among the Human Development Index indicators used by the report is based on life expctancy, education and per-capita income. In 2010, the Human Development Report also introduced a Inequality Adjusted Human Development Index (IHDI).

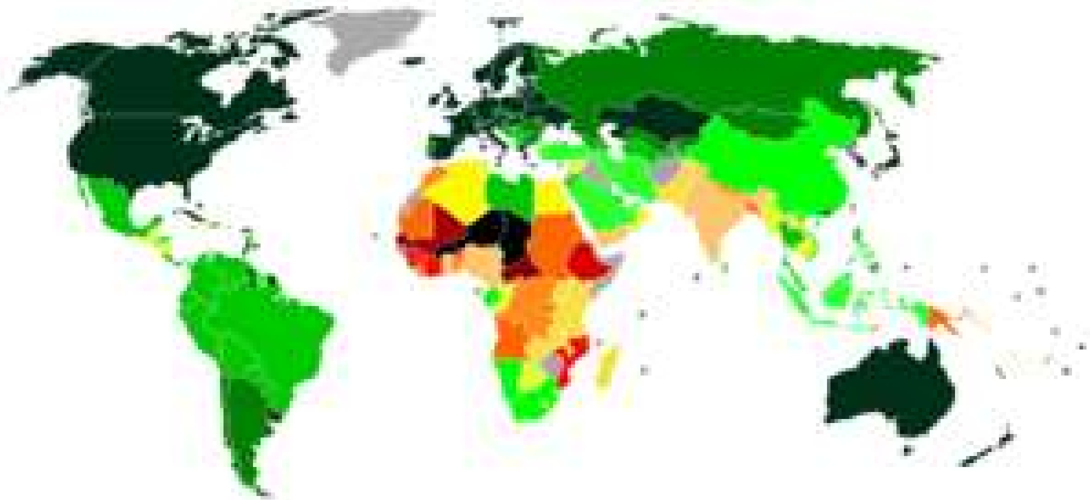

Figure 4.1: **A map showing global educational indices based on data from 2006 and 2007. Progressively darker shades of green indicate very high indices, while yellow, orange and red represent the low indices, red being the lowest.**

In a recent ranking of countries according to their Human Development Indices, the highest ranked countries were Norway, Australia, Switzerland, Germany, Denmark, Singapore, Netherlands, Ireland, Iceland, Canada, Hong Kong, United States, New Zealand, Sweden, Lichtenstein, United Kingdom, Japan, South Korea, Israel, Luxembourg, France, Belgium, Switzerland, Austria, Slovenia and Italy in that order.

The lowest ranked countries were Swaziland, Syria, Angola, Tanzania, Nigeria, Cameroon, Papua New Guinea, Zimbabwe, Solomon Islands, Mauritania, Madagascar, Rwanda, Comoros, Lethoso, Senegal, Haiti, Uganda, Sudan, Togo, Benin and Yemen, with Yemen having the lowest human development index of all the world's countries. In fact Yemen is currently experiencing a humanitarian crisis of huge proportions, and immediate international help is urgently needed.

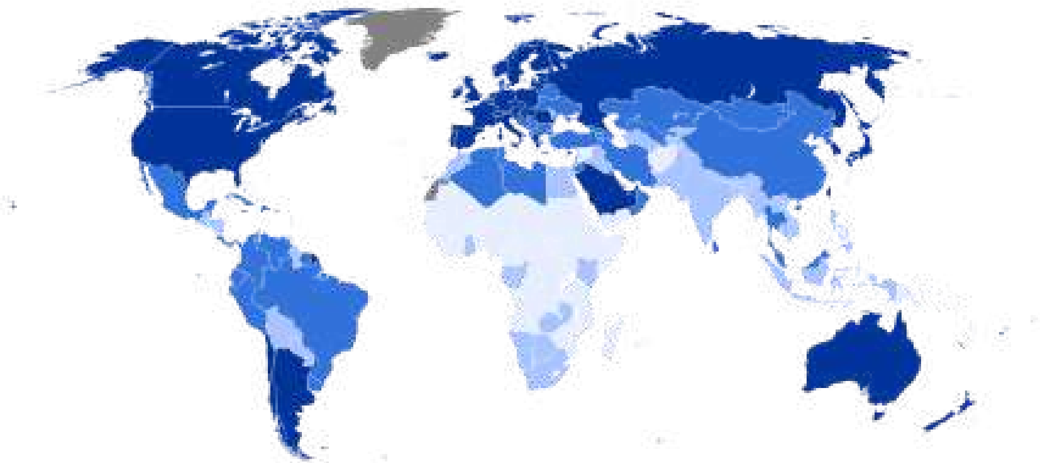

Figure 4.2: **A map showing the Human Development Index based on data from 2015 and 2016. The dark shades of blue indicate a very high index, while white indicates very low values. Grey indicates that data were not available.**

4.2 The importance of education for women

Maria Montessori and modern educational methods

Dr. Maria Montessori (1870-1952) was an Italian physician and educator who pioneered modern non-authoritarian methods of education. Her father was an official in the Italian Ministry of Finance, while her mother belonged to a family that greatly valued education. Encouraged by her mother, the young Maria first studied to become an engineer, at that time an unusual profession for a woman, and then changed to the even more unusual study of medicine.

After passing examinations in botany, zoology, experimental physics, histology, anatomy, and general and organic chemistry at the University of Rome, she was finally accepted as a medical student. Because she was a woman, Montessori encountered discrimination and opposition from both the students and staff of Rome's medical school. She was forced to perform anatomy dissections alone at night, because it was considered improper for a woman to view naked bodies in the company of men. Nevertheless, Maria Montessori graduated with distinction, having specialized in pediatrics and psychology during her last two years.

Dr. Montessori then became interested in the problem of educating retarded children. The experimental methods which she introduced were built on the natural tendencies of all children to explore their environments and to learn new skills. She gave her students the materials that they needed to be creative, and let them use these materials in their own spontaneous way. Her results were astonishingly successful, and most of her students, despite having been classified as retarded, were able to pass normal examinations. Encouraged by this success, Montessori tried the same methods on normal students. Again the results were remarkable. The normal children became super-good students. Her astonishingly good results made Maria Montessori internationally famous. She later studied anthropology and added this discipline to medicine, pediatrics and psychology as a background for her educational work.

Some quotations from Dr. Maria Montessori's many books

"And so we discovered that education is not something which the teacher does, but that it is a natural process which develops spontaneously in the human being. It is not acquired by listening to words, but in virtue of experiences in which the child acts on his environment. The teacher's task is not to talk, but to prepare and arrange a series of motives for cultural activity in a special environment made for the child" (from *The Absorbent Mind*).

"..the task of the educator lies in seeing that the child does not confound good with immobility, and evil with activity, as often happens in old-time discipline... A room in which all the children move about usefully, intelligently, and voluntarily, without committing any rough or rude act, would seem to me a classroom very well disciplined indeed." (from *The Montessori Method*)

"The instructions of the teacher consist then merely in a hint, a touch - enough to give a start to the child. The rest develops of itself." (from *Dr. Montessori's Own Handbook*)

"Today, however, those things which occupy us in the field of education are the interests of humanity at large and of civilization, and before such great forces we can recognize only one country - the entire world."(from *The Montessori Method*)

"How can we speak of Democracy or Freedom when from the very beginning of life we mould the child to undergo tyranny, to obey a dictator? How can we expect democracy when we have reared slaves? Real freedom begins at the beginning of life, not at the adult stage. These people who have been diminished in their powers, made short-sighted, devitalized by mental fatigue, whose bodies have become distorted, whose wills have been broken by elders who say: 'your will must disappear and mine prevail!' - how can we expect them, when school-life is finished, to accept and use the rights of freedom?" (from *Education for a New World*)

"Nowadays nobody's life is safe. An absurd war may be declared in which all men - young and old, women and children - are in mortal danger. Civilians are bombed and people have to take refuge in underground shelters just as primitive men took refuge in caves to defend themselves against wild beasts. The supply of food may be cut off and millions may die of famine and plague. Do we not see men in rags or even naked, freezing to death, families separated and torn apart, children abandoned and roaming about in wild hordes?

"This we see, not only among those vanquished in war, but everywhere. Humanity itself is vanquished and enslaved - but why enslaved? Because all men are slaves, the victors as

Figure 4.3: **Dr. Maria Montessori (1870-1952).**

well as the vanquished, insecure, frightened, suspicious and hostile, compelled to defend themselves by means of spying and brigandage, using and fostering immorality as a means of defense..."

"It may seem that we have drifted rather far from our original subject - Education. This digression, however, must open up the new road along which we now have to go. In the same way in which we help the patients in a hospital to recover their health and continue to live so we must now help humanity to save itself. We must be nurses in a hospital, as vast as the world itself." (from *The Formation of Man*).

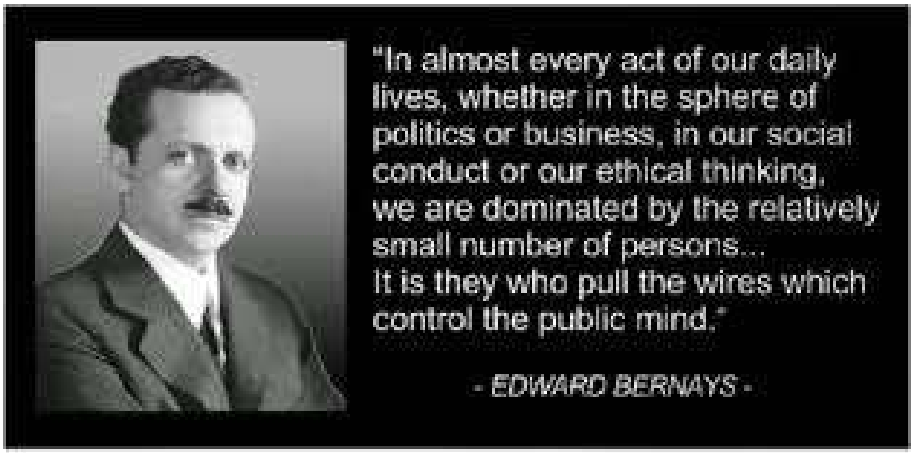

Figure 4.4: **Sigmund Freud's "double-nephew", Edward Bernays (1891-1995) is considered to be the father of modern propaganda methods. Among his best-known campaigns was a 1929 effort to promote female smoking by calling cigarettes "Torches of Freedom".**

The media as a battleground

Throughout history, art was commissioned by rulers to communicate, and exaggerate, their power, glory, absolute rightness etc, to the populace. The pyramids gave visual support to the power of the Pharaoh; portraits of rulers are a traditional form of propaganda supporting monarchies; and palaces were built as symbols of power.

Modern powerholders are also aware of the importance of propaganda. Thus the media are a battleground where reformers struggle for attention, but are defeated with great regularity by the wealth and power of the establishment. This is a tragedy because today there is an urgent need to make public opinion aware of the serious problems facing civilization, and the steps that are needed to solve these problems. The mass media could potentially be a great force for public education, but often their role is not only unhelpful - it is negative.

Suggestions for further reading

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Chapter 5

TWO CULTURES

5.1 C.P. Snow's *Two Cultures and the Scientific Revolution*

On the 7th of May, 1959, the scientist and novelist C.P. Snow presented the Rede Lecture at the Senate House of Cambridge University in England. Among the things that he said in the lecture are the following words:

"A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is the scientific equivalent of: Have you read a work of Shakespeare's? I now believe that if I had asked an even simpler question - such as, What do you mean by mass, or acceleration, which is the scientific equivalent of saying, Can you read? - not more than one in ten of the highly educated would have felt that I was speaking the same language. So the great edifice of modern physics goes up, and the majority of the cleverest people in the western world have about as much insight into it as their neolithic ancestors would have had."

Snow later expanded his lecture into a book.

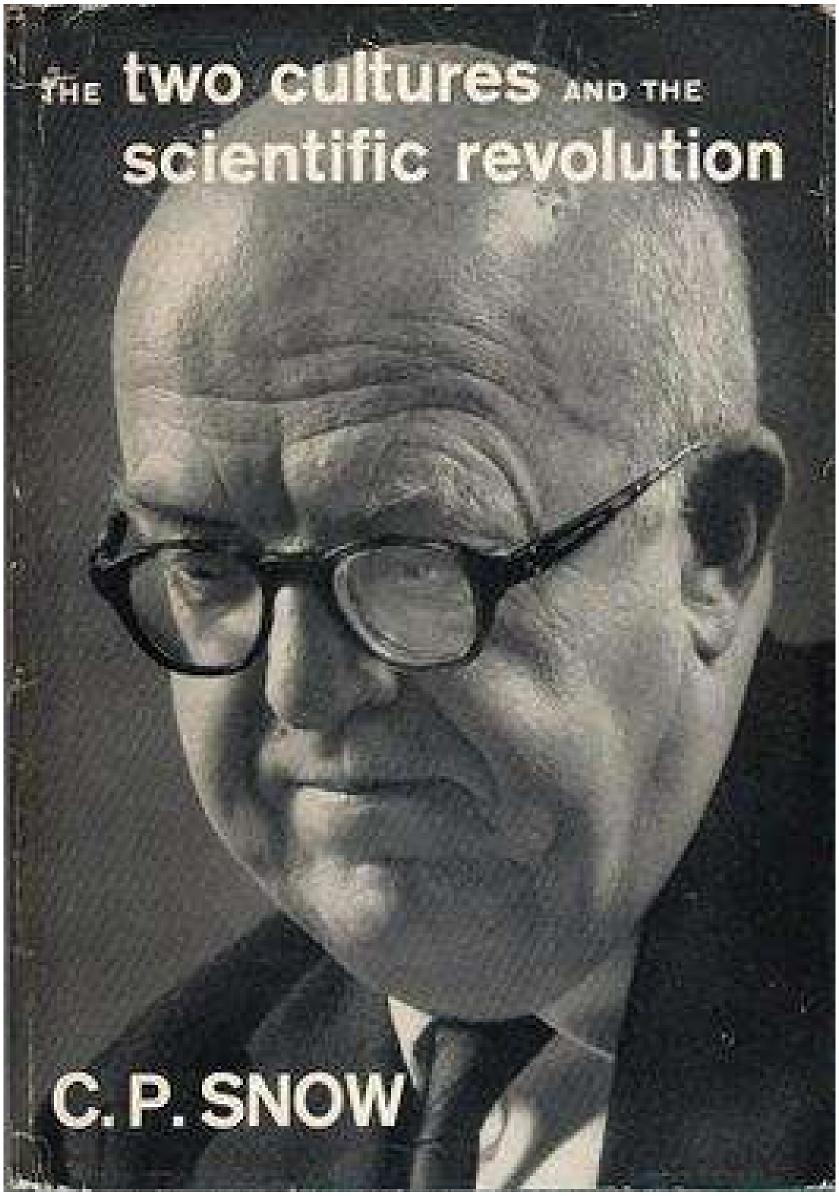

Figure 5.1: **C.P. Snow, speaking and writing in England, called attention to the split between the humanities and the culture of scientists. He pointed out the England's educational system greatly favored the humanities over the sciences, and thus left the country with few experts to deal with the challenge of modernization.**

5.2 The blindness of science

The great power of science is derived from an enormous concentration of attention and resources on the understanding of a tiny fragment of nature; but this concentration is at the same time a distortion of values. To be effective, a scientist must believe, at least temporarily, that the problem on which he or she is working is more important than anything else in the world, which is of course untrue. Thus a scientist, while seeing a fragment of reality better than anyone else, becomes blind to the larger whole. For example, when one looks into a microscope, one sees the tiny scene on the slide in tremendous detail, but that is all one sees. The remainder of the universe is blotted out by this concentration of attention.

The system of rewards and punishments in the training of scientists produces researchers who are highly competent when it comes to finding solutions to technical problems, but whose training has by no means encouraged them to think about the ethical or political consequences of their work. Scientists may, in fact, be tempted to escape from the intractable moral and political difficulties of the world by immersing themselves in their work. Enrico Fermi, (whose research as much as that of any other person made nuclear weapons possible), spoke of science as "soma" - the escapist drug of Aldous Huxley's Brave New World. Fermi perhaps used his scientific preoccupations as an escape from the worrying political problems of the 30's and 40's.

The education of a scientist often produces a person with a strong feeling of loyalty to a particular research discipline, but perhaps without sufficient concern for the way in which progress in that discipline is related to the general welfare of humankind. To remedy this lack, it would be very desirable if the education of scientists could include some discussion of ethics, as well as a review of the history of modern science and its impact on society.

The explosive growth of science-driven technology during the last two centuries has changed the world completely; and our social and political institutions have adjusted much too slowly to the change. The great problem of our times is to keep society from being shaken to pieces by the headlong progress of science, the problem of harmonizing our social and political institutions with technological change. Because of the great importance of this problem, it is perhaps legitimate to ask whether anyone today can be considered to be educated without having studied the impact of science on society. Should we not include this topic in the education of both scientists and non-scientists?

Science has given us great power over the forces of nature. If wisely used, this power will contribute greatly to human happiness; if wrongly used, it will result in misery. In the words of the Spanish writer, Ortega y Gasset, "We live at a time when man, lord of all things, is not lord of himself"; or as Arthur Koestler has remarked, "We can control the movements of a spaceship orbiting about a distant planet, but we cannot control the situation in Northern Ireland."

To remedy this situation, educational reforms are needed. Science and engineering students ought to have some knowledge of the history and social impact of science. They could be given a course on the history of scientific ideas; but in connection with modern historical developments, such as the industrial revolution, the global population explosion,

Figure 5.2: **Enormous concentration of attention on a small fragment of reality blinds the researcher to the larger whole. Looking through a microscope, he sees what is on the slide in great detail, but he sees nothing else.**

the development of nuclear weapons, genetic engineering, and information technology, some discussion of social impact could be introduced. One might hope to build up in science and engineering students an understanding of the way in which their work is related to the general welfare of humankind. These elements are needed in science education if rapid technological development is to be beneficial rather than disastrous.

Suggestions for further reading

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Chapter 6

WOMEN'S LITERACY

6.1 Malala Yousafzai

Malala Yousafzai was born in 1997 in the beautiful Swat Valley of Pakistan. Her father, Ziauddin Yousafzai is a poet, educational activist, and school owner. In 2008, he was contacted by a representative of the BBC's Urdu service and asked to recommend a girl from one of his schools to write a continuing blog about what life was like under the Taliban. When all of the girls whom Ziauddin asked were too frightened, he finally recommended his own daughter, Malala. Her blog was aired anonymously by the BBC Urdu service.

After the BBC diary ended, Malala Yousafzai and her father were approached by a New York Times reporter about filming a documentary. Wikipedia states that "Following the documentary, Yousafzai was interviewed on the national Pashto-language station AVT Khyber, the Urdu-language Daily Aaj, and Canada's Toronto Star. She made a second appearance on Capital Talk on 19 August 2009. Her BBC blogging identity was being revealed in articles by December 2009. She also began appearing on television to publicly advocate for female education. From 2009 to 2010 she was the chair of the District Child Assembly of the Khpal Kor Foundation through 2009 and 2010."

"In October 2011, Archbishop Desmond Tutu, a South African activist, nominated Yousafzai for the International Children's Peace Prize of the Dutch international children's advocacy group KidsRights Foundation. She was the first Pakistani girl to be nominated for the award. The announcement said, 'Malala dared to stand up for herself and other girls and used national and international media to let the world know girls should also have the right to go to school.' The award was won by Michaela Mycroft of South Africa.

"Her public profile rose even further when she was awarded Pakistan's first National Youth Peace Prize two months later in December. On 19 December 2011, Prime Minister Yousaf Raza Gillani awarded her the National Peace Award for Youth. At the proceedings in her honor, Yousafzai stated that she was not a member of any political party, but hoped to found a national party of her own to promote education. The prime minister directed the authorities to set up an IT campus in the Swat Degree College for Women at Yousafzai's request, and a secondary school was renamed in her honor. By 2012, Yousafzai was planning to organize the Malala Education Foundation, which would help poor girls go to school

“As Yousafzai became more recognized, the dangers facing her increased. Death threats against her were published in newspapers and slipped under her door. On Facebook, where she was an active user, she began to receive threats and fake profiles were created under her name. Eventually, a Taliban spokesman said they were ‘forced’ to act. In a meeting held in the summer of 2012, Taliban leaders unanimously agreed to kill her.

6.2 Malala shot by the Taliban

“On 9 October 2012, a Taliban gunman shot Yousafzai as she rode home on a bus after taking an exam in Pakistan’s Swat Valley. Yousafzai was 15 years old at the time. According to reports, a masked gunman shouted ”Which one of you is Malala? Speak up, otherwise I will shoot you all”, and, on upon her being identified, shot her. She was hit with one bullet, which went through her head, neck, and ended in her shoulder. Two other girls were also wounded in the shooting.”

Malala did not die, however. The shooting resulted in an enormous international wave of sympathy for her, and outrage at Taliban’s murder attempt. She became the world’s most famous teenager. She met Queen Elizabeth II and Barack Obama, and spoke at the Oxford Union. Harvard University and the Canadian Parliament. In 2014, she shared the Nobel Peace Prize with Kailash Satyarthi, a children’s rights activist from India. Here are some excerpts from her Nobel Address:

6.3 Excerpts from Malala’s Nobel Peace Prize Lecture

“We had a thirst for education, we had a thirst for education because our future was right there in that classroom. We would sit and learn and read together. We loved to wear neat and tidy school uniforms and we would sit there with big dreams in our eyes. We wanted to make our parents proud and prove that we could also excel in our studies and achieve those goals, which some people think only boys can.

“But things did not remain the same. When I was in Swat, which was a place of tourism and beauty, suddenly it changed into a place of terrorism. I was just ten when more than 400 schools were destroyed. Women were flogged. People were killed. And our beautiful dreams turned into nightmares.

“Education went from being a right to being a crime. Girls were stopped from going to school. When my world suddenly changed, my priorities changed too. I had two options. One was to remain silent and wait to be killed. And the second was to speak up and then be killed. I chose the second one. I decided to speak up.

"We could not just stand by and see those injustices of the terrorists denying our rights, ruthlessly killing people and misusing the name of Islam. We decided to raise our voice and tell them: Have you not learnt, have you not learnt that in the Holy Quran Allah says: if you kill one person it is as if you kill the whole humanity?

"...I tell my story, not because it is unique, but because it is not. It is the story of many girls. Today, I tell their stories too. I have brought with me some of my sisters from Pakistan, from Nigeria and from Syria, who share this story. My brave sisters Shazia and Kainat who were also shot that day on our school bus. But they have not stopped learning. And my brave sister Kainat Soomro who went through severe abuse and extreme violence, even her brother was killed, but she did not succumb.

"Also my sisters here, whom I have met during my Malala Fund campaign. My 16-year-old courageous sister, Mezon from Syria, who now lives in Jordan as refugee and goes from tent to tent encouraging girls and boys to learn. And my sister Amina, from the North of Nigeria, where Boko Haram threatens, and stops girls and even kidnaps girls, just for wanting to go to school.

"I am Malala. But I am also Shazia. I am Kainat. I am Kainat Soomro. I am Mezon. I am Amina. I am those 66 million girls who are deprived of education. And today I am not raising my voice, it is the voice of those 66 million girls.

"...Dear sisters and brothers, today, in half of the world, we see rapid progress and development. However, there are many countries where millions still suffer from the very old problems of war, poverty, and injustice.

"We still see conflicts in which innocent people lose their lives and children become orphans. We see many people becoming refugees in Syria, Gaza and Iraq. In Afghanistan, we see families being killed in suicide attacks and bomb blasts.

"Many children in Africa do not have access to education because of poverty. And as I said, we still see, we still see girls who have no freedom to go to school in the north of Nigeria.

"Many children in countries like Pakistan and India, as Kailash Satyarthi mentioned, many children, especially in India and Pakistan are deprived of their right to education because of social taboos, or they have been forced into child marriage or into child labor.

"...Dear sisters and brothers, dear fellow children, we must work - not wait. Not just the politicians and the world leaders, we all need to contribute. Me. You. We. It is our duty.

"Let us become the first generation to decide to be the last , let us become the first generation that decides to be the last that sees empty classrooms, lost childhoods, and wasted potentials. Let this be the last time that a girl or a boy spends their childhood in a factory. Let this be the last time that a girl is forced into early child marriage. Let this be the last time that a child loses life in war. Let this be the last time that we see a child out of school. Let this end with us. Let's begin this ending ... together ... today ... right here, right now. Let's begin this ending now."

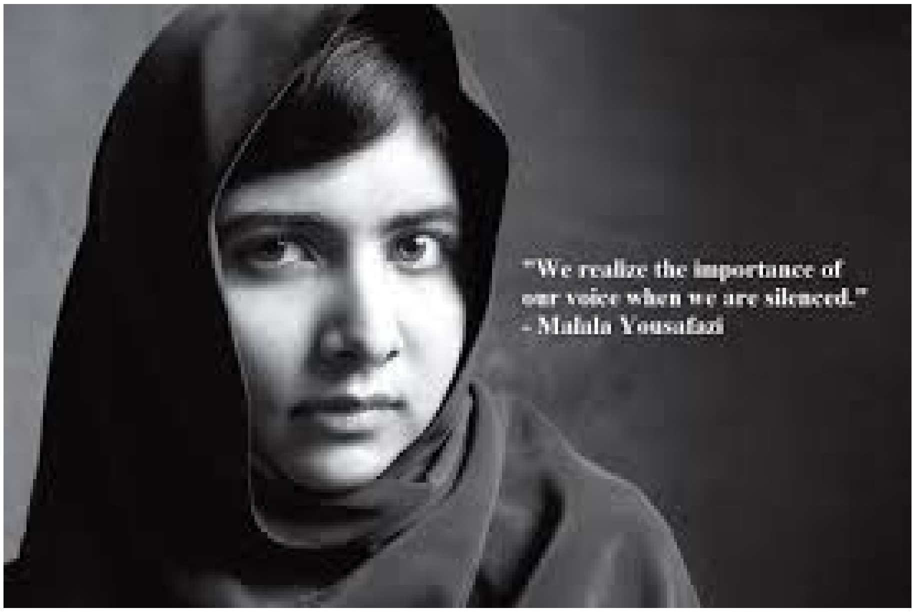

Figure 6.1: **Malala Yousafzai: "We realize the importance of our voice when we are silenced".**

Figure 6.2: **Women are the intellectual equals of men.**

Figure 6.3: **When he was Sweden's Prime Minister, Olof Palme declared that his administration's goal was that "neither in education, nor in opportunities for employment, nor in law, nor in social custom, should there be any difference whatever between men and women".**

Figure 6.4: **Experts agree that educational and legal equality for women are vitally important steps towards stabilizing, and ultimately reducing, global population. These reforms are also extremely important for their own sake, and for the sake of the uniquely life-oriented insights that women can give to the world.**


RIGHT
TO
EDUCATION


गणित


Educated Girls
Educated Society
Developed Nation
Strong Base School
Without Education
51% Of Population
the Country Cannot
Progress
Strong Base School

Suggestions for further reading

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Chapter 7

THE BATTLE AGAINST ILLITERACY

7.1 Illiteracy today

According to Wikipedia,

Many policy analysts consider literacy rates as a crucial measure of the value of a region's human capital. For example, literate people can be more easily trained than illiterate people, and generally have a higher socioeconomic status; thus they enjoy better health and employment prospects. The international community has come to consider literacy as a key facilitator and goal of development. In regard to the Sustainable Development Goals adopted by the UN in 2015, the UNESCO Institute for Lifelong Learning has declared the "central role of literacy in responding to sustainable development challenges such as health, social equality, economic empowerment and environmental sustainability".

Print illiteracy generally corresponds with less knowledge about modern hygiene and nutritional practices, an unawareness which can exacerbate a wide range of health issues. Within developing countries in particular, literacy rates also have implications for child mortality; in these contexts, children of literate mothers are 50% more likely to live past age 5 than children of illiterate mothers.[56] Public health research has thus increasingly concerned itself with the potential for literacy skills to allow women to more successfully access health care systems, and thereby facilitate gains in child health.

In 2013, the UNESCO Institute for Lifelong Learning published a set of case studies[79] on programs that successfully improved female literacy rates. The report features countries from a variety of regions and of differing income levels, reflecting the general global consensus on "the need to empower women through the acquisition of literacy skills." Part of the impetus for UNESCO's focus on literacy is a broader effort to respond to globalization and "the shift

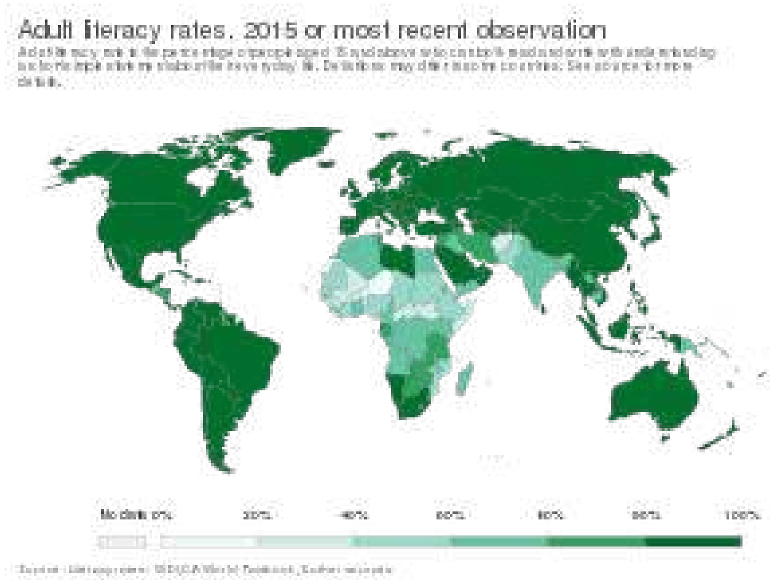

Figure 7.1: **Geographical distribution of adult literacy rates, 2015 or most recent observation. Sub-Saharan Africa, the region with the lowest overall literacy rates, also features the widest gender gap: just 52% of adult females are literate, and 68% among adult men. Similar gender disparity persists in two other regions, North Africa (86% adult male literacy, 70% adult female literacy) and South Asia (77% adult male literacy, 58% adult female literacy.)**

towards knowledge-based societies" that it has produced.[81] While globalization presents emerging challenges, it also provides new opportunities: many education and development specialists are hopeful that new ICTs will have the potential to expand literacy learning opportunities for children and adults, even those in countries that have historically struggled to improve literacy rates through more conventional means.

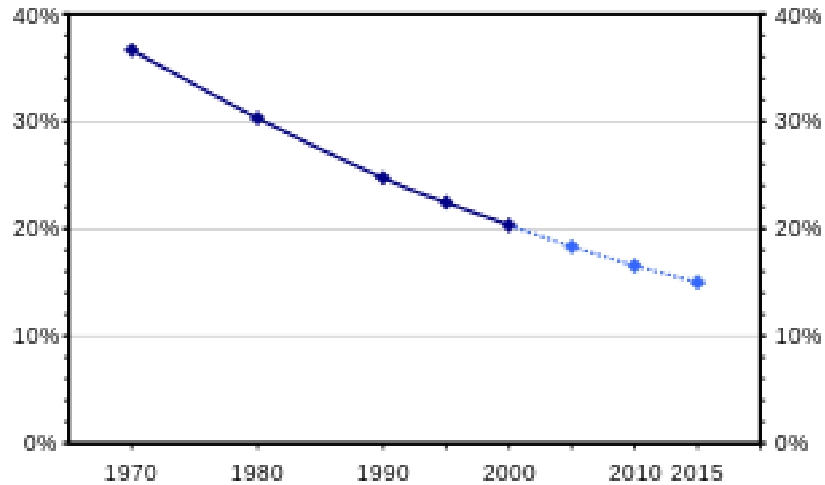

Figure 7.2: **World illiteracy has halved between 1970 and 2015, when measured as a percent of the total global population.**

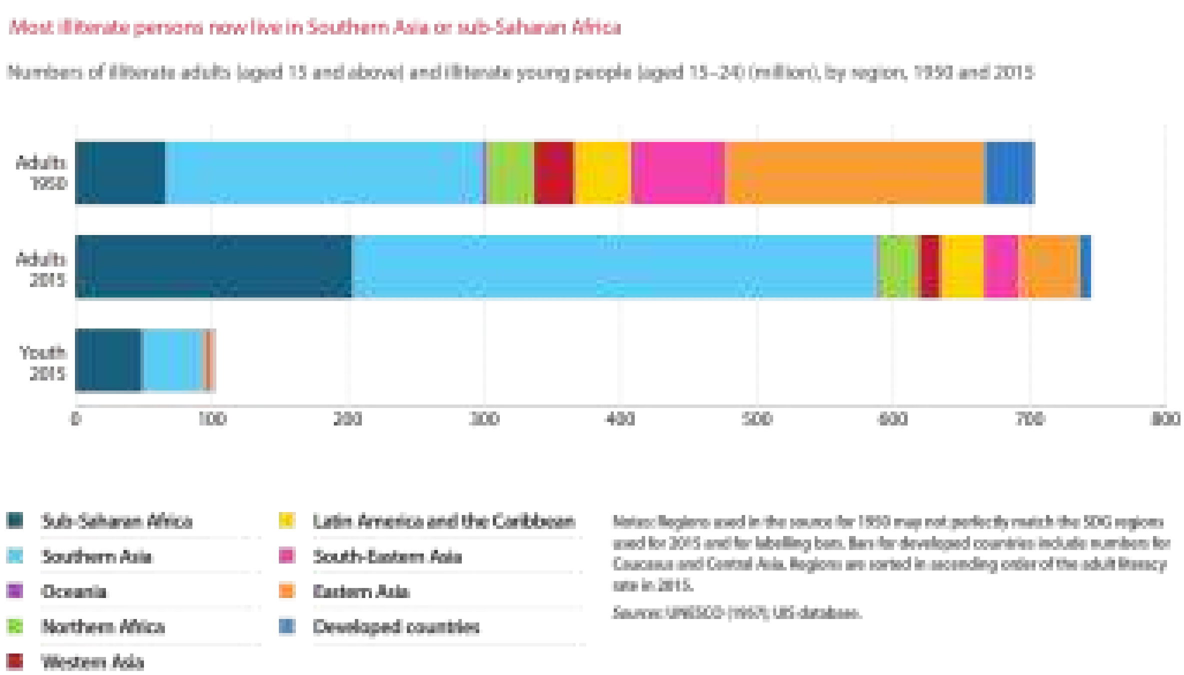

Figure 7.3: **Although the illiterate percentage of the world's population decreased between 1950 and 2015, the total number if illiterate people increased because of rapid population growth.**

7.2 UNESCO

Activities of UNESCO

UNESCO is a leader in the struggle against illiteracy. Here are some excerpts form the Wikipedia article on UNESCO:

UNESCO implements its activities through the five program areas: education, natural sciences, social and human sciences, culture, and communication and information.

- **Education: UNESCO supports research in comparative education; and provide expertise and fosters partnerships to strengthen national educational leadership and the capacity of countries to offer quality education for all. This includes the**
  - **UNESCO Chairs, an international network of 644 UNESCO Chairs, involving over 770 institutions in 126 countries.**
  - **Environmental Conservation Organization**
  - **Convention against Discrimination in Education adopted in 1960**
  - **Organization of the International Conference on Adult Education (CONFINTEA) in an interval of 12 years**
  - **Publication of the Education for All Global Monitoring Report**
  - **Publication of the Four Pillars of Learning seminal document**
  - **UNESCO ASPNet, an international network of 8,000 schools in 170 countries**
- **Designating projects and places of cultural and scientific significance, such as:**
  - **Global Geoparks Network**
  - **Biosphere reserves, through the Programme on Man and the Biosphere (MAB), since 1971**
  - **City of Literature; in 2007, the first city to be given this title was Edinburgh, the site of Scotland's first circulating library.[51] In 2008, Iowa City, Iowa became the City of Literature.**
  - **Endangered languages and linguistic diversity projects**
  - **Masterpieces of the Oral and Intangible Heritage of Humanity**
  - **Memory of the World International Register, since 1997**

Figure 7.4: **UNESCO's flag.**

– Water resources management, through the International Hydrological Programme (IHP), since 1965

– World Heritage Sites

– World Digital Library

- **Encouraging the "free flow of ideas by images and words" by:**

  – Promoting freedom of expression, including freedom of the press and freedom of information legislation, through the Division of Freedom of Expression and Media Development,[52] including the International Programme for the Development of Communication

  – Promoting the safety of journalists and combatting impunity for those who attack them, through coordination of the UN Plan of Action on the Safety of Journalists and the Issue of Impunity

  – Promoting universal access to and preservation of information and open solutions for sustainable development through the Knowledge Societies Division,[56] including the Memory of the World Programme[57] and Information for All Programme

  – Promoting pluralism, gender equality and cultural diversity in the media

  – Promoting Internet Universality and its principles, that the Internet should be (I) human Rights-based, (ii) Open, (iii) Accessible to all, and (iv) nurtured by Multi-stakeholder participation (summarized as the acronym R.O.A.M.)

Figure 7.5: **Biologist, author, and environmentalist Sir Julian Huxley, first Director.General of UNESCO. He cane from a famous family whose members included Darwin's friend and defender, Thomas Henry Huxley, the novelist Aldous Huxley and the Nobel-laureate physiologist Sir Andrew Huxley.**

  - Generating knowledge through publications such as World Trends in Freedom of Expression and Media Development,[60] the UNESCO Series on Internet Freedom, and the Media Development Indicators, as well as other indicator-based studies.

Other activities of UNESCO

- Promoting events, such as:
  - International Decade for the Promotion of a Culture of Peace and Non-Violence for the Children of the World: 2001-2010, proclaimed by the UN in 1998
  - World Press Freedom Day, 3 May each year, to promote freedom of expression and freedom of the press as a basic human right and as crucial components of any healthy, democratic and free society.
  - Crianca Esperanca in Brazil, in partnership with Rede Globo, to raise funds for community-based projects that foster social integration and violence prevention.
  - International Literacy Day
  - International Year for the Culture of Peace
  - Health Education for Behavior Change program in partnership with the Ministry of Education of Kenya which was financially supported by the Government of Azerbaijan to promote health education among 10-19-year-old young people who live in informal camp in Kibera, Nairobi. The project was carried out between September 2014 - December 2016.
- Founding and funding projects, such as:
  - Migration Museums Initiative: Promoting the establishment of museums for cultural dialogue with migrant populations.
  - UNESCO-CEPES, the European Centre for Higher Education: established in 1972 in Bucharest, Romania, as a de-centralized office to promote international co-operation in higher education in Europe as well as Canada, USA and Israel. Higher Education in Europe is its official journal.
  - Free Software Directory: since 1998 UNESCO and the Free Software Foundation have jointly funded this project cataloguing free software.
  - FRESH Focussing Resources on Effective School Health.
  - OANA, Organization of Asia-Pacific News Agencies

- **International Council of Science**
- **UNESCO Goodwill Ambassadors**
- **ASOMPS, Asian Symposium on Medicinal Plants and Spices, a series of scientific conferences held in Asia Botany 2000, a programme supporting taxonomy, and biological and cultural diversity of medicinal and ornamental plants, and their protection against environmental pollution**
- **The UNESCO Collection of Representative Works, translating works of world literature both to and from multiple languages, from 1948 to 2005**

  GoUNESCO, an umbrella of initiatives to make heritage fun supported by UNESCO, New Delhi Office

7.3 The 2000-2015 Education For All Report

Goal 1 - Early childhood care and education

Expanding and improving comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children

- Despite a drop in child mortality rates of nearly 50%, 6.3 million children under the age of 5 died in 2013 from causes that are mostly preventable.
- Progress in improving child nutrition has been considerable. Yet globally, one in four children are still short for their age - a sign of chronic deficiency in essential nutrients.
- In 2012, 184 million children were enrolled in pre-primary education worldwide, an increase of nearly two-thirds since 1999.

Goal 2 - Universal primary education

Ensuring that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to and complete free and compulsory primary education of good quality

- The primary school net enrolment ratio was 84% in 1999 and is estimated to reach 93% in 2015.
- Net enrolment ratios improved significantly, rising at least 20 percentage points from 1999 to 2012 in 17 countries, 11 of which were in sub-Saharan Africa.
- While some increases in enrolment ratios are evident, nearly 58 million children were out of school in 2012, and progress in reducing this number has stalled.

- Despite progress in access, dropout remains an issue: in 32 countries, mostly in sub-Saharan Africa, at least 20% of children enrolled are not expected to reach the last grade.

- By the 2015 deadline, one in six children in low and middle income countries - or almost 100 million - will not have completed primary school.

Goal 3 - Youth and adult skills

Ensuring that the learning needs of all young people and adults are met through equitable access to appropriate learning and life skills programmes

- Reflecting improved transition rates and higher retention rates, the lower secondary gross enrolment ratio increased from 71% in 1999 to 85% in 2012. Participation in lower secondary education has increased quickly since 1999. In Afghanistan, China, Ecuador, Mali and Morocco, the lower secondary gross enrolment ratio has increased by at least 25 percentage points.

- Inequality persists in the transition from primary to secondary school. For example, in the Philippines, just 69% of primary school graduates from the poorest families continued into lower secondary, compared with 94% from the richest households.

- A majority of the 94 low and middle income countries with information have legislated free lower secondary education since 1999. Of these, 66 have constitutional guarantees and 28 enacted other legal measures. As of 2015, only a few nations charge lower secondary school fees, including Botswana, Guinea, Papua New Guinea, South Africa and the United Republic of Tanzania.

Goal 4 - Adult literacy

Achieving a 50 per cent improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults

- There are about 781 million illiterate adults. The rate of illiteracy dropped slightly, from 18% in 2000 to an estimated 14% in 2015, which means the Dakar target of halving illiteracy was not achieved.

- Only 17 out of the 73 countries with a literacy rate below 95% in 2000 had halved their illiteracy rate by 2015.

- Progress has been made towards gender parity in literacy but is not sufficient. All 43 countries where fewer than 90 women for every 100 men were literate in 2000 have moved towards parity, but none of them will have reached it by 2015.

Goal 5 - Gender equality

Eliminating gender disparities in primary and secondary education by 2005, and achieving gender equality in education by 2015, with a focus on ensuring girls' full and equal access to and achievement in basic education of good quality.

- At the primary level, 69% of the countries with data are expected to have reached gender parity by 2015. Progress is slower in secondary education, with 48% projected to be at gender parity in 2015.
- Progress in tackling severe gender disparity has been made. Between 1999 and 2012, the number of countries with fewer than 90 girls enrolled in primary school for every 100 boys fell from 33 to 16.
- Amongst out-of-school children, girls are more likely than boys never to enrol in school (48% compared with 37%), while boys are more likely to leave school (26% compared with 20%). Once enrolled, girls are more likely to reach the upper grades.
- In sub-Saharan Africa, the poorest girls remain the most likely to never attend primary school. In Guinea and Niger in 2010, over 70% of the poorest girls had never attended primary school, compared with less than 20% of the richest boys.

Goal 6 - Quality of education

Improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills.

- Pupil/teacher ratios declined in 83% of the 146 countries with data at the primary education level. In one-third of the countries with data, however, less than 75% of primary school teachers are trained up to national standards.
- At the lower secondary education level, 87 of the 105 countries with data have a pupil/teacher ratio below 30:1.
- n 1990, 12 learning assessments were conducted according to national standards, but by 2013 the number had increased to 101.

7.4 Disparity between male and female literacy rates

According to a recent report[1],

[1] https://huebler.blogspot.com/2007/08/disparity-between-male-and-female.html

"In spite of the movement towards gender equality, large gaps remain. In four countries, the gap between male and female literacy among the adult population is greater than 30 percent: Yemen (male literacy rate 73.1 percent, female 34.7 percent, difference 38.4 percent), Central African Republic (male 64.8, female 33.5, difference 32.3), Afghanistan (male 43.1, female 12.6, difference 30.5), and Togo (male 68.7, female 38.5, difference 30.2). In 18 more countries, the male-female gap is between 20 and 30 percent. These countries are, in descending order of the size of the gap: Mozambique (difference male-female literacy rate 29.9 percent), Pakistan, Angola, Chad, Niger, Nepal, Ethiopia, Democratic Republic of the Congo, Morocco, India, Benin, Guinea, Egypt, Sierra Leone, Cote d'Ivoire, Senegal, Malawi, and Cambodia (difference 20.6 percent)."

Suggestions for further reading

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Chapter 8

SOME MODERN LIBRARIES

8.1 The library of Congress

The Library of Congress was founded in 1800. During the War of 1812 it was burned by the British, and its collection of books was destroyed. Thomas Jefferson then offered to sell to the Library his very large private collection of books, and after some debate, his offer was accepted.

Today, the library's collection of more than 173 million items includes more than 51 million cataloged books and other print materials in 470 languages; more than 75 million manuscripts; the largest rare book collection in North America; and the world's largest collection of legal materials, films, maps, sheet music and sound.

The Library of Congress is currently adding about two million items to its collection every year. Many of these items are acquired through copyright laws, which require two copies of any book or document to be copyrighted to be submitted to the Library of congress in two copies.

The library is currently undertaking a program of digitalization, whose aim is to make its materials available throughout the world on the internet.

Music at the Library of Congress.

Besides housing the vast collection of folk music contributed by Alan Lomax, the Library of Congress also has on microfilm music from all ages and all parts of the world. I remember that when I lived in Washington D.C., I sang in a choir whose director was interested in music from the School of Notre Dame, during the middle ages. Our choir director was able to obtain this music from the Library of Congress, where it had been preserved on microfilm, and we performed it. What an ancient and interesting sound this music from the Middle Ages had! Perhaps our performance was the first in almost a thousand years.

Figure 8.1: **One of the three building which house the Library of Congress. It is the largest library in the world. More than 470 languages are represented in the library's book collection.**

Figure 8.2: **A research center at the the Library of Congress.**

Figure 8.3: **Alan Lomax spent his life recording folk music from around the world for the Library of Congress.**

8.2 The British Library

Here is what the British Library has to say about itself:

"We are the national library of the United Kingdom and give access to the world's most comprehensive research collection. We provide information services to academic, business, research and scientific communities.

"Our collection of over 170 million items includes artefacts from every age of written civilization. We keep the nation's archive of printed and digital publications, adding around three million new items to our collection every year.

"We have many books, but we have so much more. Our London and Yorkshire sites have everything from newspapers to sound recordings, patents, prints and drawings, maps and manuscripts. Our inspiring exhibitions interpret these collections and bring their stories to the public."

Figure 8.4: **Until 1973, the British Library was a part of the British Museum, located in the building shown here.**

Figure 8.5: **The present location of the British Library.**

8.3 The Royal Library of Denmark

The Royal Library of Denmark, which is also the main library of the University of Copenhagen, was founded in 1648 by King Frederick III. It is among the largest libraries in the world, and is the largest in the Nordic countries.

The library holds nearly all known books printed in Denmark since 1482.

In addition to books, the Royal Library holds journals, newspapers, pamphlets and corporate publications, manuscripts and archives, maps, prints and photographs, music scores, documentation of folkways and popular traditions, four annual electronic copies of the Danish Internet by legal deposit.

As of 2017, there Royal Library had 36,975,069 physical units and 2,438,978 electronic titles.

Figure 8.6: **The old building which used to house the Royal Library of Denmark**

Figure 8.7: **The "Black Diamond", present home of Denmark's Royal Library**

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Chapter 9

EDUCATION AND THE INTERNET

9.1 The first computers

If civilization survives, historians in the distant future will undoubtedly regard the invention of computers as one of the most important steps in human cultural evolution - as important as the invention of writing or the invention of printing. The possibilities of artificial intelligence have barely begun to be explored, but already the impact of computers on society is enormous.

The first programmable universal computers were completed in the mid-1940's; but they had their roots in the much earlier ideas of Blaise Pascal (1623-1662), Gottfried Wilhelm Leibniz (1646-1716), Joseph Marie Jacquard (1752-1834) and Charles Babbage (1791-1871).

In 1642, the distinguished French mathematician and philosopher Blaise Pascal completed a working model of a machine for adding and subtracting. According to tradition, the idea for his "calculating box" came to Pascal when, as a young man of 17, he sat thinking of ways to help his father (who was a tax collector). In describing his machine, Pascal wrote: "I submit to the public a small machine of my own invention, by means of which you alone may, without any effort, perform all the operations of arithmetic, and may be relieved of the work which has often times fatigued your spirit when you have worked with the counters or with the pen."

Pascal's machine worked by means of toothed wheels. It was much improved by Leibniz, who constructed a mechanical calculator which, besides adding and subtracting, could also multiply and divide. His first machine was completed in 1671; and Leibniz' description of it, written in Latin, is preserved in the Royal Library at Hanover: "There are two parts of the machine, one designed for addition (and subtraction), and the other designed for multiplication (and division); and they should fit together. The adding (and subtracting) machine coincides completely with the calculating box of Pascal. Something, however, must be added for the sake of multiplication..."

Figure 9.1: **Blaise Pascal (1623-1662) was a French mathematician, physicist, writer, inventor and theologian. Pascal, a child prodigy, was educated by his father, who was a tax-collector. He invented his calculating box to make his father's work less tedious.**

Figure 9.2: **The German mathematician, philosopher and universal genius Gottfried Wilhelm von Leibniz (1646-1716) was a contemporary of Isaac Newton. He invented differential and integral calculus independently, just as Newton had done many years earlier. However, Newton had not published his work on calculus, and thus a bitter controversy over priority was precipitated. When his patron, the Elector of Hanover moved to England to become George I, Leibniz was left behind because the Elector feared that the controversy would alienate the English. Leibniz extended Pascal's calculating box so that it could perform multiplication and division. Calculators of his design were still being used in the 1960's.**

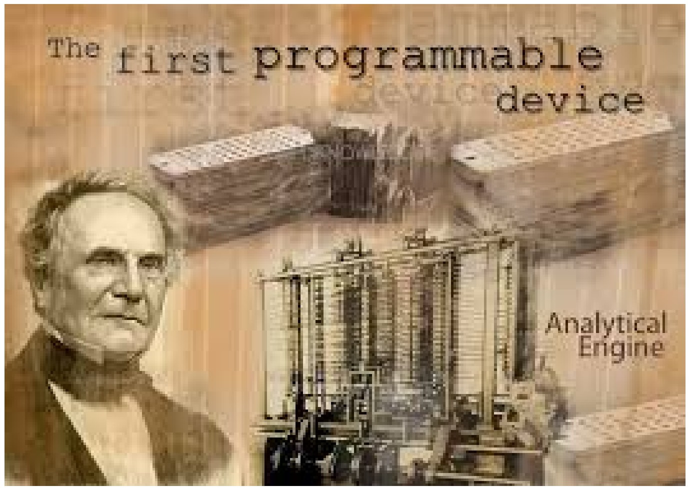

Figure 9.3: **Charles Babbage (1791-1871) and his analytical engine.**

“The wheels which represent the multiplicand are all of the same size, equal to that of the wheels of addition, and are also provided with ten teeth which, however, are movable so that at one time there should protrude 5, at another 6 teeth, etc., according to whether the multiplicand is to be represented five times or six times, etc.”

“For example, the multiplicand 365 consists of three digits, 3, 6, and 5. Hence the same number of wheels is to be used. On these wheels, the multiplicand will be set if from the right wheel there protrude 5 teeth, from the middle wheel 6, and from the left wheel 3.”

By 1810, calculating machines based on Leibniz’ design were being manufactured commercially; and mechanical calculators of a similar (if much improved) design could be found in laboratories and offices until the 1960’s. The idea of a programmable universal computer is due to the English mathematician, Charles Babbage, who was the Lucasian Professor of Mathematics at Cambridge University. (In the 17th century, Isaac Newton held this post, and in the 20th century, P.A.M. Dirac and Stephen Hawking also held it.)

In 1812, Babbage conceived the idea of constructing a machine which could automatically produce tables of functions, provided that the functions could be approximated by polynomials. He constructed a small machine, which was able to calculate tables of quadratic functions to eight decimal places, and in 1832 he demonstrated this machine to the Royal Society and to representatives of the British government.

The demonstration was so successful that Babbage secured financial support for the construction of a large machine which would tabulate sixth-order polynomials to twenty decimal places. The large machine was never completed, and twenty years later, after having spent seventeen thousand pounds on the project, the British government withdrew its support. The reason why Babbage’s large machine was never finished can be understood from the following account by Lord Moulton of a visit to the mathematician’s laboratory:

“One of the sad memories of my life is a visit to the celebrated mathematician and inventor, Mr. Babbage. He was far advanced in age, but his mind was still as vigorous as ever. He took me through his workrooms.”

"In the first room I saw the parts of the original Calculating Machine, which had been shown in an incomplete state many years before, and had even been put to some use. I asked him about its present form. 'I have not finished it, because in working at it, I came on the idea of my Analytical Machine, which would do all that it was capable of doing, and much more. Indeed, the idea was so much simpler that it would have taken more work to complete the Calculating Machine than to design and construct the other in its entirety; so I turned my attention to the Analytical Machine.'"

"After a few minutes talk, we went into the next workroom, where he showed me the working of the elements of the Analytical Machine. I asked if I could see it. 'I have never completed it,' he said, 'because I hit upon the idea of doing the same thing by a different and far more effective method, and this rendered it useless to proceed on the old lines.'"

"Then we went into a third room. There lay scattered bits of mechanism, but I saw no trace of any working machine. Very cautiously I approached the subject, and received the dreaded answer: 'It is not constructed yet, but I am working at it, and will take less time to construct it altogether than it would have taken to complete the Analytical Machine from the stage in which I left it.' I took leave of the old man with a heavy heart."

Babbage's first calculating machine was a special-purpose mechanical computer, designed to tabulate polynomial functions; and he abandoned this design because he had hit on the idea of a universal programmable computer. Several years earlier, the French inventor Joseph Marie Jacquard had constructed an automatic loom in which large wooden "punched cards" were used to control the warp threads. Inspired by Jacquard's invention, Babbage planned to use punched cards to program his universal computer. (Jacquard's looms could be programmed to weave extremely complex patterns: A portrait of the inventor, woven on one of his looms in Lyon, hung in Babbage's drawing room.)

One of Babbage's frequent visitors was Augusta Ada[1], Countess of Lovelace (1815-1852), the daughter of Lord and Lady Byron. She was a mathematician of considerable ability, and it is through her lucid descriptions that we know how Babbage's never-completed Analytical Machine was to have worked.

The next step towards modern computers was taken by Herman Hollerith, a statistician working for the United States Bureau of the Census. He invented electromechanical machines for reading and sorting data punched onto cards. Hollerith's machines were used to analyze the data from the 1890 United States Census. Because the Census Bureau was a very limited market, Hollerith branched out and began to manufacture similar machines for use in business and administration. His company was later bought out by Thomas J. Watson, who changed its name to International Business Machines.

In 1937, Howard Aiken, of Harvard University, became interested in combining Babbage's ideas with some of the techniques which had developed from Hollerith's punched card machines. He approached the International Business Machine Corporation, the largest manufacturer of punched card equipment, with a proposal for the construction of a large, automatic, programmable calculating machine.

Aiken's machine, the Automatic Sequence Controlled Calculator (ASCC), was com-

[1] The programming language ADA is named after her.

Figure 9.4: **Joseph Marie Jacquard (1752-1834) invented a loom which could be programed to produce any design by means of punched cards. News of his invention inspired Babbage to invent a universal programmable computing machine.**

Figure 9.5: **Jacquard's loom.**

Figure 9.6: **Lord Byron's daughter, Augusta Ada, Countess of Lovelace (1815-1852) was an accomplished mathematician and a frequent visitor to Babbage's workshop. It is through her lucid description of his ideas that we know how Babbage's universal calculating machine was to have worked. The programming language ADA is named after her.**

Figure 9.7: **The Automatic Sequence-Controlled Calculator ASCC can still be seen by visitors at Harvard's science building and cafeteria.**

pleted in 1944 and presented to Harvard University. Based on geared wheels, in the Pascal-Leibniz-Babbage tradition, ASCC had more than three quarters of a million parts and used 500 miles of wire. ASCC was unbelievably slow by modern standards - it took three-tenths of a second to perform an addition - but it was one of the first programmable general-purpose digital computers ever completed. It remained in continuous use, day and night, for fifteen years.

In the ASCC, binary numbers were represented by relays, which could be either on or off. The on position represented 1, while the off position represented 0, these being the only two digits required to represent numbers in the binary (base 2) system. Electromechanical calculators similar to ASCC were developed independently by Konrad Zuse in Germany and by George R. Stibitz at the Bell Telephone Laboratory.

9.2 Electronic digital computers

In 1937, the English mathematician A.M. Turing published an important article in the Proceedings of the London Mathematical Society in which envisioned a type of calculating machine consisting of a long row of cells (the "tape"), a reading and writing head, and a set of instructions specifying the way in which the head should move the tape and modify the state and "color" of the cells on the tape. According to a hypothesis which came to be known as the "Church-Turing hypothesis", the type of computer proposed by Turing was capable of performing every possible type of calculation. In other words, the Turing machine could function as a universal computer.

In 1943, a group of English engineers, inspired by the ideas of Alan Turing and those of the mathematician M.H.A. Newman, completed the electronic digital computer Colossus. Colossus was the first large-scale electronic computer. It was used to break the German Enigma code; and it thus affected the course of World War II.

In 1946, ENIAC (Electronic Numerical Integrator and Calculator) became operational. This general-purpose computer, designed by J.P. Eckert and J.W. Mauchley of the Uni-

Figure 9.8: **Alan Turing (1912-1954). He is considered to be the father of theoretical computer science. During World War II, Turing's work allowed the allies to crack the German's code. This appreciably shortened the length of the war in Europe, and saved many lives.**

versity of Pennsylvania, contained 18,000 vacuum tubes, one or another of which was often out of order. However, during the periods when all its vacuum tubes were working, an electronic computer like Colossus or ENIAC could shoot ahead of an electromechanical machine (such as ASCC) like a hare outdistancing a tortoise.

During the summer of 1946, a course on "The Theory and Techniques of Electronic Digital Computers" was given at the University of Pennsylvania. The ideas put forward in this course had been worked out by a group of mathematicians and engineers headed by J.P. Eckert, J.W. Mauchley and John von Neumann, and these ideas very much influenced all subsequent computer design.

Figure 9.9: **John von Neumann (1903-1957, right) with J. Robert Oppenheimer. In the background is an electronic digital computer.**

9.3 Cybernetics

The word "Cybernetics", was coined by the American mathematician Norbert Wiener (1894-1964) and his colleagues, who defined it as "the entire field of control and communication theory, whether in the machine or in the animal". Wiener derived the word from the Greek term for "steersman".

Norbert Wiener began life as a child prodigy: He entered Tufts University at the age of 11 and received his Ph.D. from Harvard at 19. He later became a professor of mathematics at the Massachusetts Institute of Technology. In 1940, with war on the horizon, Wiener sent a memorandum to Vannevar Bush, another MIT professor who had done pioneering work with analogue computers, and had afterwards become the chairman of the U.S. National Defense Research Committee. Wiener's memorandum urged the American government to support the design and construction of electronic digital computers, which would make use of binary numbers, vacuum tubes, and rapid memories. In such machines, the memorandum emphasized, no human intervention should be required except when data was to be read into or out of the machine.

Like Leo Szilard, John von Neumann, Claude Shannon and Erwin Schrödinger, Norbert Wiener was aware of the relation between information and entropy. In his 1948 book Cybernetics he wrote: "...we had to develop a statistical theory of the amount of information, in which the unit amount of information was that transmitted by a single decision between equally probable alternatives. This idea occurred at about the same time to several writers, among them the statistician R.A. Fisher, Dr. Shannon of Bell Telephone Laboratories, and the author. Fisher's motive in studying this subject is to be found in classical statistical theory; that of Shannon in the problem of coding information; and that of the author in the problem of noise and message in electrical filters... The notion of the amount of in-

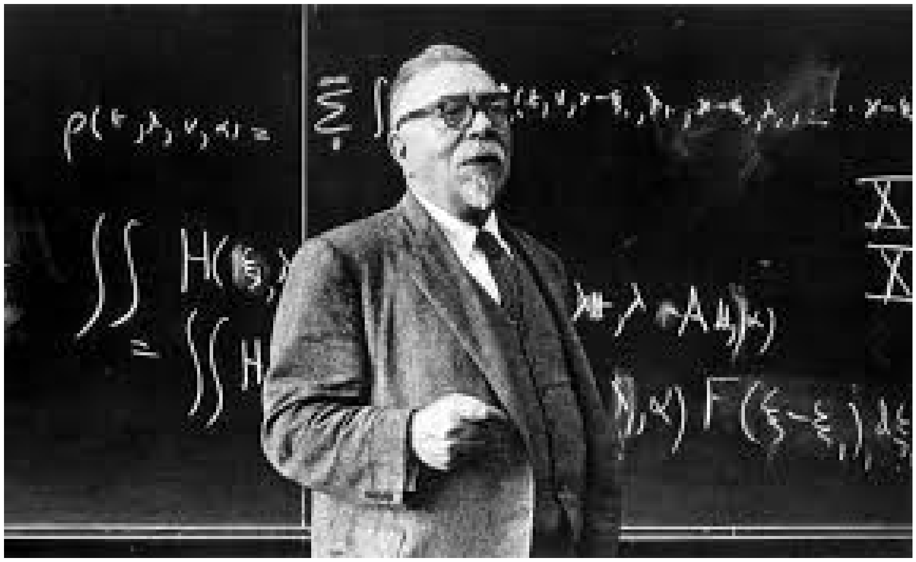

Figure 9.10: **MIT's Norbert Wiener (1894-1964) coined the word "Cybernetics", derived from a Greek word meaning "steersman". Wiener was one of the principle organizers of the Macy Conferences.**

formation attaches itself very naturally to a classical notion in statistical mechanics: that of entropy. Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other."

During World War II, Norbert Wiener developed automatic systems for control of anti-aircraft guns. His systems made use of feedback loops closely analogous to those with which animals coordinate their movements. In the early 1940's, he was invited to attend a series of monthly dinner parties organized by Arturo Rosenbluth, a professor of physiology at Harvard University. The purpose of these dinners was to promote discussions and collaborations between scientists belonging to different disciplines. The discussions which took place at these dinners made both Wiener and Rosenbluth aware of the relatedness of a set of problems that included homeostasis and feedback in biology, communication and control mechanisms in neurophysiology, social communication among animals (or humans), and control and communication involving machines.

Wiener and Rosenbluth therefore tried to bring together workers in the relevant fields to try to develop common terminology and methods. Among the many people whom they contacted were the anthropologists Gregory Bateson and Margaret Mead, Howard Aiken (the designer of the Automatic Sequence Controlled Calculator), and the mathematician John von Neumann. The Josiah Macy Jr. Foundation sponsored a series of ten yearly meetings, which continued until 1949 and which established cybernetics as a new research discipline. It united areas of mathematics, engineering, biology, and sociology which had previously been considered unrelated. Among the most important participants (in addition to Wiener, Rosenbluth, Bateson, Mead, and von Neumann) were Heinz von Foerster, Kurt

Figure 9.11: **Margaret Mead (1901-1978) and Gregory Bateson (1904-1980). They used the feedback loops studied by Wiener to explain many aspects of human behavior. Bateson is considered to be one of the main founders of the discipline Biosemiotics, which considers information to be the central feature of living organisms.**

Lewin, Warren McCulloch and Walter Pitts. The Macy conferences were small and informal, with an emphasis on discussion as opposed to the presentation of formal papers. A stenographic record of the last five conferences has been published, edited by von Foerster. Transcripts of the discussions give a vivid picture of the enthusiastic and creative atmosphere of the meetings. The participants at the Macy Conferences perceived Cybernetics as a much-needed bridge between the natural sciences and the humanities. Hence their enthusiasm. Wiener's feedback loops and von Neumann's theory of games were used by anthropologists Mead and Bateson to explain many aspects of human behavior.

9.4 Microelectronics

The problem of unreliable vacuum tubes was solved in 1948 by John Bardeen, William Shockley and Walter Brattain of the Bell Telephone Laboratories. Application of quantum theory to solids had led to an understanding of the electronic properties of crystals. Like atoms, crystals were found to have allowed and forbidden energy levels.

The allowed energy levels for an electron in a crystal were known to form bands; i.e., some energy ranges with a quasi-continuum of allowed states (allowed bands), and other energy ranges with none (forbidden bands). The lowest allowed bands were occupied by electrons, while higher bands were empty. The highest filled band was called the valence band, and the lowest empty band was called the conduction band.

According to quantum theory, whenever the valence band of a crystal is only partly filled, the crystal is a conductor of electricity; but if the valence band is completely rilled with electrons, the crystal is an electrical insulator. (A completely filled band is analogous to a room so packed with people that none of them can move.)

In addition to explaining conductors and insulators, quantum theory yielded an understanding of semiconductors - crystals where the valence band is completely filled with electrons, but where the energy gap between the conduction band and the valence band is relatively small. For example, crystals of the elements silicon and germanium are semiconductors. For such a crystal, thermal energy is sometimes enough to lift an electron from the valence band to the conduction band.

Bardeen, Shockley and Brattain found ways to control the conductivity of germanium crystals by injecting electrons into the conduction band, or alternatively by removing electrons from the valence band. They could do this by forming junctions between crystals "doped" with appropriate impurities, and by injecting electrons with a special electrode. The semi-conducting crystals whose conductivity was controlled in this way could be used as electronic valves, in place of vacuum tubes.

By the 1960's, replacement of vacuum tubes by transistors in electronic computers had led not only to an enormous increase in reliability and a great reduction in cost, but also to an enormous increase in speed. It was found that the limiting factor in computer speed was the time needed for an electrical signal to propagate from one part of the central processing unit to another. Since electrical impulses propagate with the speed of light, this time is extremely small; but nevertheless, it is the limiting factor in the speed of electronic computers.

In order to reduce the propagation time, computer designers tried to make the central processing units very small; and the result was the development of integrated circuits and microelectronics. (Another motive for miniaturization of electronics came from the requirements of space exploration.)

Integrated circuits were developed, in which single circuit elements were not manufactured separately, but instead the whole circuit was made at one time. An integrated circuit is a multilayer sandwich-like structure, with conducting, resisting and insulating layers interspersed with layers of germanium or silicon, "doped" with appropriate impurities. At the start of the manufacturing process, an engineer makes a large drawing of each layer. For example, the drawing of a conducting layer would contain pathways which fill the role played by wires in a conventional circuit, while the remainder of the layer would consist of areas destined to be etched away by acid.

The next step is to reduce the size of the drawing and to multiply it photographically. The pattern of the layer is thus repeated many times, like the design on a piece of wallpaper. The multiplied and reduced drawing is then focused through a reversed microscope onto the surface to be etched. Successive layers are built up by evaporating or depositing thin films of the appropriate substances onto the surface of a silicon or germanium wafer. If the layer being made is to be conducting, the surface might consist of an extremely thin layer of copper, covered with a photosensitive layer called a "photoresist". On those portions of the surface receiving light from the pattern, the photoresist becomes insoluble, while on those areas not receiving light, the photoresist can be washed away.

The surface is then etched with acid, which removes the copper from those areas not protected by photoresist. Each successive layer of a wafer is made in this way, and finally the wafer is cut into tiny "chips", each of which corresponds to one unit of the wallpaper-like pattern. Although the area of a chip may be much smaller than a square centimeter, the chip can contain an extremely complex circuit.

In 1965, only four years after the first integrated circuits had been produced, Dr. Gordon E. Moore, one of the founders of Intel, made a famous prediction which has come to be known as "Moore's Law". He predicted that the number of transistors per integrated circuit would double every two years, and that this trend would continue through 1975. In fact, the general trend predicted by Moore has continued for a much longer time. Although the number of transistors per unit area has not continued to double every two years, the logic density (bits per unit area) has done so, and thus a modified version of Moore's law still holds today. How much longer the trend can continue remains to be seen. Physical limits to miniaturization of transistors of the present type will soon be reached; but there is hope that further miniaturization can be achieved through "quantum dot" technology, molecular switches, and autoassembly, as will be discussed in Chapter 8.

A typical programmable minicomputer or "microprocessor", manufactured in the 1970's, could have 30,000 circuit elements, all of which were contained on a single chip. By 1989, more than a million transistors were being placed on a single chip; and by 2000, the number reached 42,000,000. As a result of miniaturization and parallelization, the speed of computers rose exponentially. In 1960, the fastest computers could perform a hundred thousand elementary operations in a second. By 1970, the fastest computers took less than a second to perform a million such operations. In 1987, a massively parallel computer, with 566 parallel processors, called GFll was designed to perform 11 billion floating-point operations per second (flops). By 2002 the fastest computer performed 40 at teraflops, making use of 5120 parallel CPU's.

Computer disk storage has also undergone a remarkable development. In 1987, the magnetic disk storage being produced could store 20 million bits of information per square inch; and even higher densities could be achieved by optical storage devices. Storage density has until followed a law similar to Moore's law.

In the 1970's and 1980's, computer networks were set up linking machines in various parts of the world. It became possible (for example) for a scientist in Europe to perform a calculation interactively on a computer in the United States just as though the distant machine were in the same room; and two or more computers could be linked for performing large calculations. It also became possible to exchange programs, data, letters and manuscripts very rapidly through the computer networks.

The exchange of large quantities of information through computer networks was made easier by the introduction of fiber optics cables. By 1986, 250,000 miles of such cables had been installed in the United States. If a ray of light, propagating in a medium with a large refractive index, strikes the surface of the medium at a grazing angle, then the ray undergoes total internal reflection. This phenomenon is utilized in fiber optics: A light signal can propagate through a long, hairlike glass fiber, following the bends of the fiber without losing intensity because of total internal reflection. However, before fiber optics could be used for information transmission over long distances, a technological breakthrough in glass manufacture was needed, since the clearest glass available in 1940 was opaque in lengths more than 10 m. Through studies of the microscopic properties of glasses, the problem of absorption was overcome. By 1987, devices were being manufactured commercially that were capable of transmitting information through fiber-optic cables at the rate of 1.7 billion bits per second.

9.5 The history of the Internet and World Wide Web

The history of the Internet began in 1961, when Leonard Kleinrock, a student at MIT, submitted a proposal for Ph.D. thesis entitled "Information Flow in Large Communication Nets". In his statement of the problem, Kleinrock wrote: "The nets under consideration consist of nodes, connected to each other by links. The nodes receive, sort, store, and transmit messages that enter and leave via the links. The links consist of one-way channels, with fixed capacities. Among the typical systems which fit this description are the Post Office System, telegraph systems, and satellite communication systems." Kleinrock's theoretical treatment of package switching systems anticipated the construction of computer networks which would function on a principle analogous to a post office rather than a telephone exchange: In a telephone system, there is a direct connection between the sender and receiver of information. But in a package switching system, there is no such connection - only the addresses of the sender and receiver on the package of information, which makes its way from node to node until it reaches its destination.

Further contributions to the concept of package switching systems and distributed communications networks were made by J.C.R. Licklider and W. Clark of MIT in 1962, and by Paul Baran of the RAND corporation in 1964. Licklider visualized what he called a "Galactic Network", a globally interconnected network of computers which would allow social interactions and interchange of data and software throughout the world. The distributed computer communication network proposed by Baran was motivated by the desire to have a communication system that could survive a nuclear war. The Cold War had also provoked the foundation (in 1957) of the Advanced Research Projects Agency (ARPA) by the U.S. government as a response to the successful Russian satellite "Sputnik".

In 1969, a 4-node network was tested by ARPA. It connected computers at the University of California divisions at Los Angeles and Santa Barbara with computers at the Stanford Research Institute and the University of Utah. Describing this event, Leonard Kleinrock said in an interview: "We set up a telephone connection between us and the guys at SRI. We typed the L and we asked on the phone 'Do you see the L?' 'Yes we see the L', came the response. We typed the 0 and we asked 'Do you see the 0?' 'Yes we see the O.' Then we typed the G and the system crashed." The ARPANET (with 40 nodes) performed much better in 1972 at the Washington Hilton Hotel where the participants at a Conference on Computer Communications were invited to test it.

Although the creators of ARPANET visualized it as being used for long- distance computations involving several computers, they soon discovered that social interactions over the Internet would become equally important if not more so. An electronic mail system was introduced in the early 1970's, and in 1976 Queen Elizabeth II of the United Kingdom became one of the increasing number of e-mail users.

In September, 1973, Robert F. Kahn and Vinton Cerf presented the basic ideas of the Internet at a meeting of the International Network Working Group at the University Sussex in Brighton, England. Among these principles was the rule that the networks to be connected should not be changed internally. Another rule was that if a packet did not arrive at its destination, it would be retransmitted from its original source. No information was to be retained by the gateways used to connect networks; and finally there was to be no global control of the Internet at the operations level.

Computer networks devoted to academic applications were introduced in the 1970's and 1980's, both in England, the United States and Japan. The Joint Academic Network (JANET) in the U.K. had its counterpart in the National Science Foundation's network (NSFNET) in America and Japan's JUNET (Japan Unix Network). Internet traffic is approximately doubling each year,[2] and it is about to overtake voice communication in the volume of information transferred.

In March, 2011, there were more than two billion Internet users in the world. In North America they amounted to 78.3 % of the total population, in Europe 58.3 % and worldwide, 30.2 %. Another index that can give us an impression of the rate of growth of digital data

[2] In the period 1995-1996, the rate of increase was even faster - a doubling every four months

Table 9.1: **Historical total world Internet traffic (after Cisco Visual Networking Index Forecast). 1 terrabyte =1,000,000,000,000 bytes**

year	terabytes per month
1990	1
1991	2
1992	4
1993	10
1994	20
1995	170
1996	1,800
1997	5,000
1998	11,000
1999	26,000
2000	75,000
2001	175,000
2002	358,000
2003	681,000
2004	1,267,000
2005	2,055,000
2006	3,339,000
2007	5,219,000
2008	7,639,000
2009	10,676,000
2010	14,984,000

generation and exchange is the "digital universe", which is defined to be the total volume of digital information that human information technology creates and duplicates in a year. In 2011 the digital universe reached 1.2 zettabytes, and it is projected to quadruple by 2015. A zettabyte is 10^{21} bytes, an almost unimaginable number, equivalent to the information contained in a thousand trillion books, enough books to make a pile that would stretch twenty billion kilometers.

9.6 Self-reinforcing information accumulation

Humans have been living on the earth for roughly two million years (more or less, depending on where one draws the line between our human and prehuman ancestors, Table 6.1). During almost all of this,time, our ancestors lived by hunting and food-gathering. They were not at all numerous, and did not stand out conspicuously from other animals. Then, suddenly, during the brief space of ten thousand years, our species exploded in numbers from a few million to seven billion (Figure 6.1), populating all parts of the earth, and even setting foot on the moon. This population explosion, which is still going on, has been the result of dramatic cultural changes. Genetically we are almost identical with our hunter-gatherer ancestors, who lived ten thousand years ago, but cultural evolution has changed our way of life beyond recognition.

Beginning with the development of speech, human cultural evolution began to accelerate. It started to move faster with the agricultural revolution, and faster still with the invention of writing and printing. Finally, modern science has accelerated the rate of social and cultural change to a completely unprecedented speed.

The growth of modern science is accelerating because knowledge feeds on itself. A new idea or a new development may lead to several other innovations, which can in turn start an avalanche of change. For example, the quantum theory of atomic structure led to the invention of transistors, which made high-speed digital computers possible. Computers have not only produced further developments in quantum theory; they have also revolutionized many other fields.

The self-reinforcing accumulation of knowledge - the information explosion - which characterizes modern human society is reflected not only in an explosively-growing global population, but also in the number of scientific articles published, which doubles roughly every ten years. Another example is Moore's law - the doubling of the information density of integrated circuits every two years. Yet another example is the explosive growth of Internet traffic shown in Table 7.1.

The Internet itself is the culmination of a trend towards increasing societal information exchange - the formation of a collective human consciousness. This collective consciousness preserves the observations of millions of eyes, the experiments of millions of hands, the thoughts of millions of brains; and it does not die when the individual dies.

9.7 The history of Wikipedia

Here is an excerpt from Wikipedia's article on the history of Wikipedia:

Wikipedia began with its first edit on 15 January 2001, two days after the domain was registered by Jimmy Wales and Larry Sanger. Its technological and conceptual underpinnings predate this; the earliest known proposal for an online encyclopedia was made by Rick Gates in 1993, and the concept of a free-as-in-freedom online encyclopedia (as distinct from mere open source) was proposed by Richard Stallman in December 2000.

Crucially, Stallman's concept specifically included the idea that no central organization should control editing. This characteristic greatly contrasted with contemporary digital encyclopedias such as Microsoft Encarta, Encyclopædia Britannica, and even Bomis's Nupedia, which was Wikipedia's direct prede-

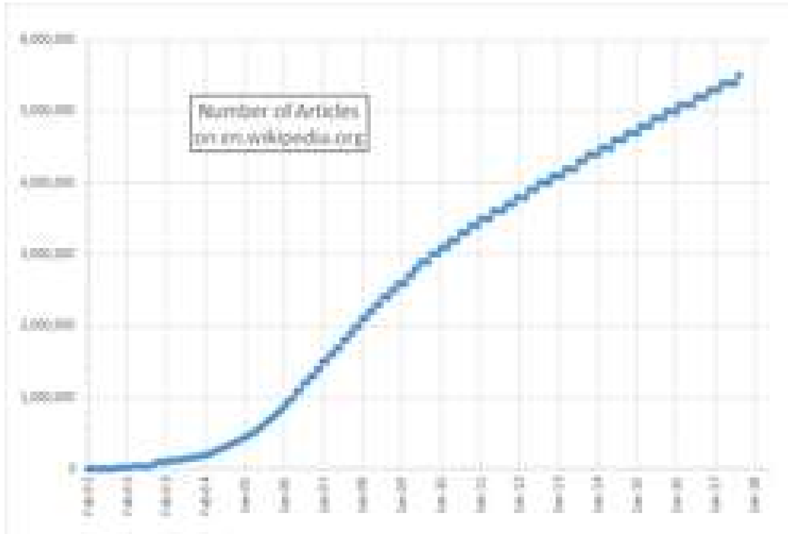

Figure 9.12: **The English edition of Wikipedia has grown to 6,074,878 articles, equivalent to over 2,600 print volumes of the Encyclopædia Britannica. Including all language editions, Wikipedia has over 53 million articles as of 2020, equivalent to nearly 20,000 print volumes.**

cessor. In 2001, the license for Nupedia was changed to GFDL, and Wales and Sanger launched Wikipedia using the concept and technology of a wiki pioneered in 1995 by Ward Cunningham. Initially, Wikipedia was intended to complement Nupedia, an online encyclopedia project edited solely by experts, by providing additional draft articles and ideas for it. In practice, Wikipedia quickly overtook Nupedia, becoming a global project in multiple languages and inspiring a wide range of other online reference projects.

According to Alexa Internet, as of December 2019, Wikipedia is the world's ninth most popular website in terms of global internet engagement. Wikipedia's worldwide monthly readership is approximately 495 million. Worldwide in September 2018, WMF Labs tallied 15.5 billion page views for the month. According to comScore, Wikipedia receives over 117 million monthly unique visitors from the United States alone.

Figure 9.13: **Jimmy Wales (born in 1966), cofounder of Wikipedia. He is seen here in 2019.**

9.8 The history of Google

Here is an excerpt from Wikipedia's article on the history of Google:

The Google company was officially launched in 1998 by Larry Page and Sergey Brin to market Google Search, which has become the most used web-based search engine. Larry Page and Sergey Brin, students at Stanford University in California, developed a search algorithm at first known as "BackRub" in 1996, with the help of Scott Hassan and Alan Steremberg. The search engine soon proved successful and the expanding company moved several times, finally settling at Mountain View in 2003. This marked a phase of rapid growth, with the company making its initial public offering in 2004 and quickly becoming one of the world's largest media companies. The company launched Google News in 2002, Gmail in 2004, Google Maps in 2005, Google Chrome in 2008, and the social network known as Google+ in 2011 (which was shut down in April 2019), in addition to many other products. In 2015, Google became the main subsidiary of the holding company Alphabet Inc.

The search engine went through a lot of updates in attempts to combat search engine optimization abuse, provide dynamic updating of results, and make the indexing system rapid and flexible. Search results started to be personalized in 2005, and later Google Suggest autocompletion was introduced. From 2007, Universal Search provided all types of content, not just text content, in search results.

Google has engaged in partnerships with NASA, AOL, Sun Microsystems, News Corporation, Sky UK, and others. The company set up a charitable offshoot, Google.org, in 2005. Google was involved in a 2019 legal dispute in the US over a court order to disclose URLs and search strings, and has been the subject of tax avoidance investigations in the UK.

The name Google is a misspelling of Googol, the number 1 followed by 100 zeros, which was picked to signify that the search engine was intended to provide large quantities of information.

Google has its origins in "BackRub", a research project that was begun in 1996 by Larry Page and Sergey Brin when they were both PhD students at Stanford University in Stanford, California. The project initially involved an unofficial "third founder", Scott Hassan, the lead programmer who wrote much of the code for the original Google Search engine, but he left before Google was officially founded as a company; Hassan went on to pursue a career in robotics and founded the company Willow Garage in 2006.

In the search of a dissertation theme, Page had been considering among other things exploring the mathematical properties of the World Wide Web, understanding its link structure as a huge graph. His supervisor, Terry Winograd, encouraged him to pick this idea (which Page later recalled as "the best advice I ever got") and Page focused on the problem of finding out which web

Figure 9.14: **Larry Page and Sergey Brin in 2003.**

pages link to a given page, based on the consideration that the number and nature of such backlinks was valuable information about that page (with the role of citations in academic publishing in mind). Page told his ideas to Hassan, who began writing the code to implement Page's ideas...

Convinced that the pages with the most links to them from other highly relevant Web pages must be the most relevant pages associated with the search, Page and Brin tested their thesis as part of their studies, and laid the foundation for their search engine. The first version of Google was released in August 1996 on the Stanford website. It used nearly half of Stanford's entire network bandwidth.

9.9 Bioinformation Technology

The merging of information technology and biotechnology

Information technology and biology are today the two most rapidly developing fields of science. Interestingly, these two fields seem to be merging, each gaining inspiration and help from the other. For example, computer scientists designing both hardware and software are gaining inspiration from physiological studies of the mechanism of the brain; and conversely, neurophysiologists are aided by insights from the field of artificial intelligence. Designers of integrated circuits wish to prolong the period of validity of Moore's law; but they are rapidly approaching physical barriers which will set limits to the miniaturization of conventional transistors and integrated circuits. They gain inspiration from biology, where the language of molecular complementarity and the principle of autoassembly seem to offer hope that molecular switches and self-assembled integrated circuits may one day be constructed.

Geneticists, molecular biologists, biochemists and crystallographers have now obtained so much information about the amino acid sequences and structures of proteins and about the nucleotide sequences in genomes that the full power of modern information technology is needed to store and to analyze this information. Computer scientists, for their part, turn to evolutionary genetics for new and radical methods of developing both software and hardware - genetic algorithms and simulated evolution.

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Chapter 10

LITERACY OF NATIONS

10.1 Some countries with low literacy rates

- Afghanistan 31.7%
- Niger 13.7%
- Nigeria 21.6%
- South Sudan 31.98%
- Mali 33.07%
- Chad 40.02%
- Guinea 30.47%
- Central African Republic 36.75%
- Somalia 37.8%
- Pakistan 56.44%
- India 72.23%
- Papua New Guinea, 63.43%
- Malawi 65.96%
- Mozambique 58.84%
- Madagascar 64.66%

10.2 Some countries with 100% Literacy

- Finland
- Liechtenstein
- Luxembourg
- North Korea
- Norway
- Uzbekistan

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