SCIENCE

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The Impact of Agriculture Hunting and gathering people obviously accumulated vast knowledge about nature, including the qualities and uses of plants and animals, which they passed along through oral tradition. They knew a lot about herbal medicines and sometimes a lot about poisons, and they surely accumulated some generalizations about weather and climate as well. With agriculture, however, needs for the study of nature changed somewhat, and somewhat greater specialization became possible. And writing enabled the more systematic recording and conveyance of knowledge. Early civilizations thus displayed great interest in astronomy, often coupled with astrological beliefs; in calculations of the seasons but also other measurements that depended on more formal mathematics; in medicine and biology. A few governments, particularly in China, provided some support for scientific research. Both Egypt and Mesopotamia contributed many findings that are relevant still: Sumerians developed a numbering system based on units of 60, still used in calculating time and circles; Egyptians divided the day into 24 hours, and advanced other forms of mathematics to the point that students from other regions, such as Greece, came to learn. Mayan scientists, in the early period of civilization in the Americas, advanced understanding of planetary motion, invented the concept of zero (which Indian mathematicians had done separately somewhat earlier). Scientists in several civilizations recognized that the earth moved around the sun.

The Classical Period The major civilizations all advanced science, but with somewhat differing emphases. While Confucian scholars were not terribly interested in science, other scholars pushed into new areas, with strong emphasis on practical findings: in astrology, in medicine, in physics. The Chinese introduced an accurate calendar by the 5th century BCE, and also discovered sunspots and introduced a kind of seismograph to measure earthquakes. Medical research emphasized anatomical knowledge and recommendations toward good health. Greek science had a practical side, including elaborate biology compilations about the qualities of plants. But there was more emphasis on more theoretical models and generalizations about the workings of nature. Considerable work went into calculating planetary motion, though it was a Hellenistic scientist who advanced the idea that the sun moved around the earth. Mathematics included important discoveries in geometry. Indian science also emphasized mathematics, including the first discovery of the concept of zero. Astronomers learned how to predict eclipses, while doctors introduced innoculations against smallpox and also pioneered in plastic surgery. Telescopes allowed discovery of seven planets, and a theory of gravity emerged as well. Training centers emerged, for example at the University of Nalanda. Collectively, these were important advances, while also setting some regional styles in science. Nowhere did science serve as the primary cultural focus – compared for example to religion or Confucian philosophy. Further, relatively little sharing occurred across regional lines. In Europe, finally, the fall of the Roman Empire actually reduced scientific capacity for many centuries, with much work long forgotten or poorly understood.

The Postclassical Period Arab science advanced strongly in this period, building on Greek and Hellenistic precedent. Arabs eagerly learned as well from India, from which they borrowed their numbering system. The government of the caliphate supported science, achievements emerged in medicine, mathematics (including the invention of algebra), and geography. Chinese science resumed, with new discoveries in chemistry and also the introduction of forensics in crime detection. West European science lagged, but the revival of trade by the 11th century spurred new interest in Arab science and also in recovering Greek and Hellenistic learning. By the end of the period Western scientists were introducing a few innovations of their own, for example in optics. Both in Europe and the Middle East debate occurred over the role of science and human reason against the primacy of faith, with some religious authorities urging that faith alone should suffice.

The Scientific Revolution Scientific work continued in all the major civilizations in the early modern centuries, but mainly along established lines. In the Middle East, the balance tipped somewhat toward greater reliance on religion and faith. In Europe, however, the challenge of recovering and building upon classical and Arab science continued, while discoveries in other parts of the world spurred interest in fields like botany. The Protestant-Catholic split ultimately also created new space for scientists to work partly independent of religion. A variety of discoveries began to emerge, along with better scientific instruments such as telescopes and microscopes. Scientists finally disposed of the idea that the sun moved around the earth, but also developed more basic laws of motion and gravity. Chemistry advanced, along with new knowledge of the human circulatory system. As important were increasing claims that science could continue to progress, that new knowledge was superior to inherited wisdom: nature

operated according to general principles that human observation and reason could uncover. Some scientists now attacked Catholic beliefs in miracles, and tensions with religious authorities surfaced at several points. Overall, however, what we now call a scientific revolution had occurred, with new knowledge combined with new definitions and claims about a larger scientific method. Many of the findings were widely popularized, affecting overall culture and promoting a greater belief in progress and new knowledge. Widespread social acceptance of older beliefs, in magic and witchcraft, began to decline. Most parts of western and central Europe were involved in this intellectual upheaval which began, for some, to put science ahead of religion as a source of truth for the first time.

Global Impact The scientific revolution would stay centered in Europe for some time. Ottoman scholars were not widely interested, though there was some attention to European medicine. Chinese culture was not affected, and indeed cultural contacts with Western missionaries were attacked in the 18th century. But amateur scientists in North America followed European developments, without yet producing basic research. Under Peter the Great Russia established a scientific academy and began to promote education in mathematics and technology. Japan, by the later 18th century and through the remaining contacts with Dutch merchants, began to learn of Western science and allow translations of scientific and medical work. New regional divisions began to open up, based on awareness of and reactions to Western science. In Europe itself, scientific discoveries continued and scientific methods were also applied to areas like economics, creating early versions of several social sciences: science was fundamental to the more general intellectual climate of the Enlightenment.

The Long 19th Century Science, and perhaps even more the larger beliefs in the importance of rational knowledge and progress, helped generate the industrial revolution. While many inventions came from the hands of artisans, based on practical experience alone, knowledge of the behavior of gasses contributed to the development of the steam engine, while chemistry was soon applied to industry and agriculture as well. Major scientific advances in Western Europe included the theory of evolution and germ theory. Beginning in Germany, universities became more systematically involved in basic research, as well as work in medicine and agriculture; and formal industrial research now moved beyond the discoveries of individual innovators. The global scope of science expanded, and regional differentiations were redefined. Japanese reformers realized that Confucianism must be modified to include emphasis on science and on new knowledge. Russian researchers now introduced some basic discoveries, including the operation of the conditioned reflex and a variety of work in advanced mathematics. North America, though still largely an importer of scientific and medical research, began to expand its capacity. And global conferences now helped coordinate data in areas such as medicine, meteorology, and statistics – an important development in its own right. At the same time, however, many scientific discoveries raised new controversies with some religions. Darwinian biology seemed to attack the creation beliefs both of Christians and of Muslims, and this caused particularly bitter debate.

The Contemporary Period Science continued to advance, now on an increasingly global basis. Important debates continued, with some religious groups still attacking some aspects of science. Key scientific discoveries now became so complex and specialized that only experts could follow them. Innovations in physics, such as the theory of relativity, formed one example; new discoveries in genetics were another. New gaps opened, as a result, between ordinary popular understandings and the more advanced scientific levels, and this could generate some new suspicions about scientists even aside from religious disputes. Investment in scientific research and education expanded, nevertheless, literally in every region of the world, on the assumption that this would lead to economic advance, medical improvements, greater knowledge. Regional differences reflected gaps in the levels of funding that could be afforded, more than cultural divisions. Communist regimes pushed science for the most part, though China pulled back briefly during the Cultural Revolution. Greater attention to science was a key part of Kemal Ataturk's reforms in Turkey. Scientific research centers increasingly recruited students and experts literally around the world, while computer technology facilitated collaborations across borders as well, while also greatly increasing speed and capacity in scientific calculations. By the 21st century it was estimated that new knowledge was now expanding by about 3% a year, an unprecedented pace.

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Science in World History. By James Trefil (Routledge, 2011).

The Scientific Revolution and the Origins of Modern Science. By John Henry (Palgrave MacMillan, 2008).

Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950. By Helen Tilley (University of Chicago Press, 2011).

Discussion

1. What were the main scientific emphases in early civilizations like Mesopotamia?

2. Compare the scientific emphases of China, India and the Mediterranean in the classical period? How did Arab science compare in turn?

3. What kinds of scientific exchanges occurred before the Scientific Revolution?

4. What were the key innovations of the Scientific Revolution? What wider social and cultural impact did it have?

5. What was the relationship between colonization and science? What types of scientific inquiries were performed within colonies? How did scientific views impact views on colonial subjects?

6. How has science changed in China during the contemporary period? What impact has the globalization of science had on China?

7. Compare key regional reactions and contributions to modern science in the 19th and 20th centuries.