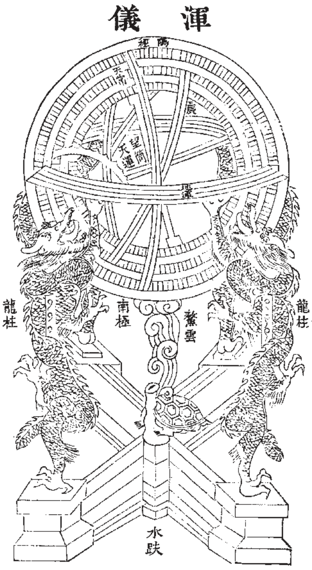
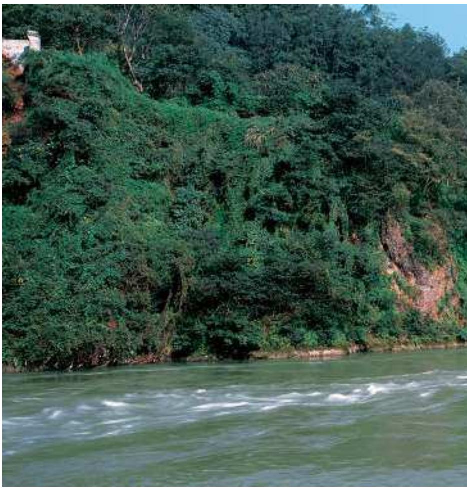
Foreword

China has attracted the attention of the world with its high-speed economic growth. As the country expands its global influence, people have become more interested in this ancient nation. They are eager to learn about its history, which might perhaps provide a clue to the driving force behind its current rapid economic growth. The Western world used to know little about China's past, except perhaps for the four major inventions: compass, gunpowder, paper, and printing. In fact, China led the world throughout much of the history of human civilization with its ancient science and technology, and until the middle of the nineteenth century its economy was the largest in the world. The development of science and technology in ancient China was based on the observation and study of the human body and of the world, including the heavens and the earth, leading to the concept of "integration of nature and man." These achievements nourished Chinese culture and civilization, and contributed greatly to human society. The inventions and discoveries of ancient China are rich and numerous.

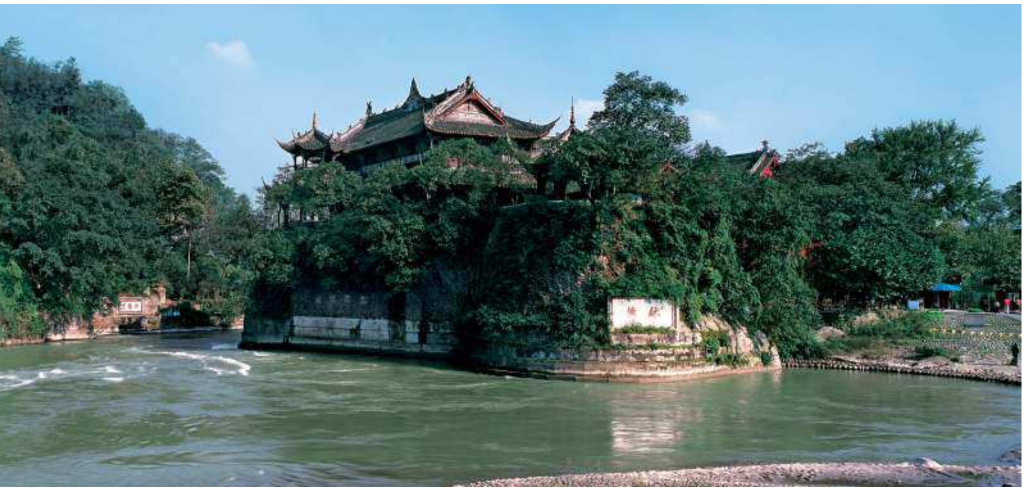


The *hun yi* (armillary sphere), one of the major astronomical instruments in ancient China. This sketch of the *hun yi* is by Su Song of the Song Dynasty.



From the earliest history of human civilization, China has been at the forefront of science and technology, a position achieved in relative isolation. In the Neolithic Period, animal husbandry, farming, construction, pottery, weaving, brewing, and medicine had all developed, albeit at an embryonic stage. The bronze culture of the Shang (1600–1046 BC) and Zhou (1046–771 BC) Dynasties opened a new chapter of civilization, paving the way for the development of the economy, culture, and science and technology. The Spring and Autumn (770–476 BC) and Warring States (475–221 BC) Periods were a significant time, full of creative enthusiasm, when ancient philosophers competed in exploration of truth. The most important discoveries and inventions in these periods were the production of iron and steel, basic to so many inventions and innovations, which led to a change from bronze culture to iron culture. There were rapid developments in farming, water conservation and handicrafts, and the appearance of the disciplines of astronomy, medicine, mathematics, and agronomy.

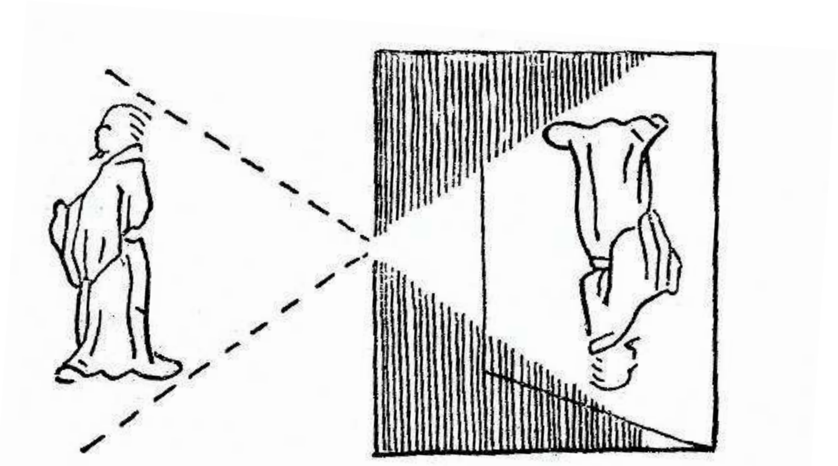
The achievements of the Spring and Autumn and Warring States Periods laid a solid foundation for the development of science and technology in ancient China. From then on, though with ups and downs, science and technology continued to advance in China. This was true in the Han (206 BC–220 AD) and Tang (618–907) Dynasties, which were strong and unified with vast territories; in the Wei, Jin, and Northern and Southern (220–589) Dynasties, when the country was temporarily divided; in the Song (960–1276) and Ming (1368–1644) Dynasties, which enjoyed relative stability and prosperity; and in the Yuan (1206–1368) and Qing (1644–1911) Dynasties. The Chinese made great advances



Baopingkou, the opening cut in the east bank of the Minjiang River, is an important part of the ancient Dujiangyan irrigation system.

Lu Ban, a legendary carpenter and inventor.

in the natural sciences as well as in art and literature, history, and philosophy, and invented and created many things necessary for use in daily life. In addition to building on earlier scientific achievements, the ancient Chinese made other discoveries and inventions, such as copper, iron, coal, petroleum, porcelain, silk and cotton cloth, wine and liquor, and Chinese medicine. They also made discoveries in the studies of mathematics, physics, chemistry, and astronomy. They manufactured wonderful machines and devices, created accurate calendars, built the Great Wall and the Grand Canal, as well as presenting the musical theory of "equal temperament." Mozi (c. 468–c. 376 BC), a great philosopher, thinker, and



The principle of the camera obscura—light passing through a pinhole in a box forms an inverted and reversed image of the subject on the back of the box.

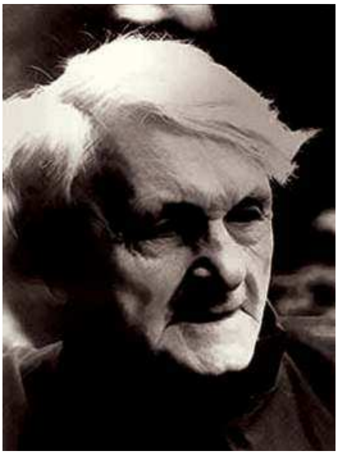
scientist of the Warring States Period, was the first to discover the principle of the *camera obscura*—light that passes through a pinhole in a box forms an inverted, reversed image of the subject on the back of the box. His discovery was made earlier than that of the Platonic School in Greece. Lu Ban (c. 507–c. 444 BC), a celebrated craftsman, established basic techniques for carpenters without the need for nails or glue. According to legend, Lu Ban once made a seemingly rough and unstable chair and dropped it down from a city wall. When the chair hit the ground, it became a rigid, perfect chair. This story suggests the advanced level of practical techniques in ancient China.

When we discuss inventions and discoveries in ancient China, we must mention the British historian of science Dr Joseph Needham (1900–1995), who firmly believed that China was the cradle of world inventions. In his multi-volume work *Science and Civilization in China*, this British scientist listed the major Chinese inventions and the related time lags between China and the West. These inventions include cast iron, gunpowder, papermaking, compass, movable type printing, porcelain, and the waterwheel. Needham argued that China had scored repeated "world's firsts," and that Francis Bacon (1561–1626) was correct in recognizing that the inventions of gunpowder, paper and printing, and the magnetic compass transformed the antique and medieval worlds into the modern age.

As the American scholar Robert G. Temple argued: "the 'modern world' in which we live is a unique synthesis of Chinese and Western ingredients. Possibly more than half of the basic inventions and discoveries upon which the 'modern world' rests come from China." Even Newton's first law of motion and William Harvey's discovery of blood circulation can be traced to Chinese sources; the Industrial Revolution was made possible in Europe by the preceding European Agricultural Revolution, which was brought about by the importation of Chinese inventions and agricultural techniques and their dissemination.

A foreign scholar, but a recognized authority on the history of science and technology in China, Needham devoted his life to the study of the history of Chinese science, technology, and medicine. Joseph Needham was at first a leading biochemist. He took his Chinese name Li Yuese after the ancient Chinese thinker Li Dan (Laozi) whom he admired greatly. In the mid-1930s, Chinese students at Cambridge awakened Needham's interest in China, and in 1939 he began to learn the Chinese language and to study Chinese history of science. During the War of Resistance against Japan (the second Sino-Japanese War), Needham went to China as Head of the British Scientific Mission and was later Scientific Counselor to the British Embassy at Chongqing, then the "acting-capital" of China. Under the auspices of the British Council, Needham established the Sino-British Science Cooperation Office (SBSCO), and met many Chinese scientists.

While supporting the Chinese resisting Japanese aggression, Needham also began a new phase in his study of the Chinese history of science. Needham had a deep love for the enterprising


Dr Joseph Needham.

spirit and great achievements of ancient Chinese scientists, and he devoted all his energy to his study. He read extensively in the Chinese classics, visited the cultural sites of various Chinese dynasties, and even rode on horseback to undertake field studies in northwest China. After the founding of New China in 1949, Needham visited China eight times, traveling widely, collecting large quantities of historical materials on Chinese history of science, and obtaining first-hand knowledge of China's political, economic, cultural, and scientific development. He was one of the founders of the Britain-China Friendship Association and served as its President in the 1950s. In 1954 he published the first volume of his monumental work *Science and Civilization in China*, with the help, among others, of Dr. Lu Gwei-djen, who awoke his interest in Chinese history. Needham was the only British scientist who had the honor of being both a Fellow of the Royal Society and a Fellow of the British Academy. He was also one of the first foreign academicians of the Chinese Academy of Sciences.

While admiring the brilliant achievements of science and technology in ancient China, Needham could not but wonder why modern China had a rather poor record in science and technology. This led to Needham's "Grand Question" or the "Needham Puzzle"—although it should be noted that Chinese scholars had also raised this question in 1915. The answers to this question are numerous and complex.

For a long stretch of time Chinese bureaucracy had promoted and protected the productivity of science. But in the mid- to late Ming Dynasty, feudal rule was strengthened and the country was closed to the rest of the world. This hindered the development of science and technology severely. In the meantime, Europe was experiencing its Renaissance. For two to three hundred years thereafter, science and technology in China remained in a backward state, especially when the nation became yet more isolated under Emperor Yongzheng (r. 1723–1735) of the Qing Dynasty. Yet it was in this same period that the Industrial Revolution was taking place in Europe. As science and technology in Europe advanced at an ever-increasing pace, their counterparts in China were hindered by rapidly worsening political and economic conditions.

The closed-door policies of the Ming and Qing Dynasties undoubtedly stifled the development of science and technology in China. In the absence of exchange with the outside world there was no understanding of world science or import of ideas from abroad. In the meantime, the feudal, high-handed rule and repression of free thinking prevented enterprising exploration.

After the extraordinary advance of global science and technology in the mid-nineteenth century, China was subjected to aggression and suppression by imperialist powers, which in turn controlled its economy and extorted huge war reparations from the Qing government. The nation was depleted, its scientific and cultural undertakings rapidly declined, and its earlier glory was all but lost.

Science and technology in ancient China also suffered from another deficiency: lack of exchange and distribution of ideas, and an absence of governmental guidance and institutional protection. Scientific research was quite often the endeavor of an individual person, therefore it was not to meet the demands of society, and findings usually disappeared with the death of the scientist. For instance, twelve tone "equal temperament," developed by Zhu Zaiyu (1536–1611) of the Ming Dynasty, is a great achievement in music, but his findings were almost forgotten and there was no successor to carry on his research. Emperor Kangxi (r. 1661–1722) of

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the Qing Dynasty was a great mathematical enthusiast and made algebra calculations as a pastime, but that was only his personal hobby. The emperor never used his love of mathematics to promote and develop science and technology.

Ancient China had an extreme bias for arts and against science. Ancient Chinese learning included only literature, philosophy, history, and language. Science and technology, which were needed in production and daily life, were regarded as something trivial and vulgar. Intellectuals in ancient China had a very poor understanding of the natural sciences. Among those who had contributed to the development of science and technology in ancient China, there were very few who were funded and rewarded by the government, with the exception of a few imperial historians who made astronomical and calendar-related findings. Students of the whole nation devoted their efforts to the study of classics and stereotyped writings. All the schools were for the arts and there were hardly any institutions for the training of scientific personnel. Although the country had a large population and a large number of students, very few of them devoted themselves to natural sciences and technology. With the implementation of imperial examinations, by which government officials were chosen according to the quality of the essays they had written, the shortage of scientific personnel became still more acute.

In addition, the few Chinese who did study science quite often focused their efforts on questions related to philosophy and practical techniques rather than on issues of basic sciences such as physics, chemistry, and biology. They also had little interest and experience in purposeful scientific experiments. As European scientists experienced an explosive advance in science and technology in the past two or three centuries, their Chinese counterparts were left far behind.

A review of inventions and discoveries in ancient China should help people recognize the wisdom and creativity of the Chinese, as well as the internal dynamic behind China's rapid economic, cultural, scientific, and technological growth over the last thirty years. The years of reform and opening up to the rest of the world are but a second in Chinese history, and China's economy has expanded greatly. The gap between China and advanced Western countries has been reduced, and in some fields the country has moved to the forefront.

Deng Xiaoping, the chief architect of China's reform and opening up, said, "Science and technology constitute a primary productive force." The Chinese government has recognized the vital role of science and technology in promoting production, and regarded it as a basic state policy to utilize science for the development of the country. China has made substantial progress in long-term planning for the development of science and technology, building infrastructure facilities, training scientific personnel, and exchanging information. The nation is losing no time and is forging ahead to catch up with more advanced countries, and the future seems bright for the renewal of China, especially in the fields of science and technology.