

Yongxiang Lu *Editor*

# A History of Chinese Science and Technology

Volume 3



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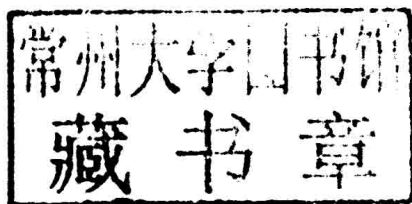


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# A History of Chinese Science and Technology



## Foreword

It has been in my mind for many years that the rich Chinese culture and civilisation should be communicated more extensively to the world. The ancient Chinese civilisation—one of the world's earliest civilisations flourished in the fertile basin of the Yellow River and the Yangtze River valleys in the Neolithic era. As a significant part of the Chinese civilisation, Chinese science and technology with a rich history plays a vital role in the development of Chinese social culture as well as the world's science, technology, culture and civilisation. This English version of *A History of Chinese Science and Technology* will be informative knowledge to help us further understand the evolution of Chinese science and technology over the past few centuries.

With the rise of China, she has become more important to the region and the world's economic and social development. China's stability and continuous evolution is fundamental to the attainment of global peace, and advancement and the progress of mankind. By comprehending the history of Chinese science and technology, we will be enlightened on how the Chinese society has evolved, how the advent of Chinese culture and civilisation has developed over the past few millennia and shaped the Chinese society with its unique culture today. These books—*A History of Chinese Science and Technology*—which contain copious information on wisdom in many aspects, personify the spirit of the unparalleled achievements of ancient China. They encompass a variety of subjects which include astronomy, mathematics, physics, agriculture, biology, medicine, four great inventions, and ceramic, textile, construction, mining, mechanical, water, transportation and military technologies.

The latest science and technology inventions, developments and innovations did not occur by chance and did not surface at one time. As the great scientist Sir Isaac Newton said: "If I have seen further, it is by standing on the shoulder of giants," all modern technologies and scientific discoveries were built on past achievements. I truly appreciate the evolution of science and technology cited in the books. A good example is the evolution of the navigation technology applied on board ships. As one of the four great inventions in the ancient China, the compass served as a historically significant navigation tool in the maritime and

shipping industry, which aided Zheng He and many seamen to travel across oceans to reach to their destinations. When I first started sailing in the 1950s, navigation in the open sea was conducted with laborious calculations based on the Sextant measurement of the altitudes of planets and stars, and the accuracy of the ship's position such as latitude, longitude, was measured in miles. Then the SatNav, a satellite navigating system, was invented, but soon, it was replaced by the superior Global Positioning System Navigation system in which accuracy is measured in metres. The newly developed technology has tremendously revolutionised position fixing at sea, resulting in convenient, effortless and seamless navigation, which reduces manning required on ships—a device that has become indispensable to mariners today. Throughout the books, we can understand why these inventions and developments are relevant to us and how they have transformed our lives and our work. Being deeply involved in the maritime industry for more than six decades, I realise that it is beneficial to stay abreast on trends and techniques and examine the evolving work-style and lifestyle preferences.

At present, many Chinese adopt the western culture and their advanced management methods, but as a Chinese, we should be aware of our history and culture, and understand our roots. With the world's focus shifting from the West to the East, it is imperative for us to learn more about Asia, including the Chinese culture. I believe these books can serve as a meaningful gift to the Chinese who are born, raised or educated overseas so that they can understand the profound contributions of Chinese science and technology to the world and promote them.

I cannot close this foreword without expressing my sincere appreciation to those who were instrumental in the planning, designing, writing, compiling and production of these books. Special thanks to the chief editor Prof. Yongxiang Lu, former President and member of Chinese Academy of Sciences (CAS); Dr. Baichun Zhang, Director of Institute for the History of Natural Sciences (IHNS) and Prof. Yuqun Liao, former Director of IHNS, for their immense efforts in producing the English version of these books so that they are accessible to everyone. I would also like to thank Shanghai Jiao Tong University Press for publishing these books. I am very happy to see this set of books being published successfully, and I am very honoured to be given the opportunity to play my part in promoting Chinese science and technology around the world.

Tan Sri Frank Tsao

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# Prelude

The grand mansion of modern science is constantly changing the course of civilization and the daily life of human beings, and influencing the mind of the human race with its infinite charisma. However, the emergence, development, and historical effects of science and technology remain the least understood part of the entire human civilization over a very long period of time. Since the mid-twentieth century, when the history of science became a relatively independent discipline, experts and scholars from the two fields of science and technology, and humanities gradually begin to cast their look on this emerging discipline that has been playing an important role in the process of human progress since ancient times and that is still exercising profound influence on contemporary society. Its profound significance is dual renaissance, just as George Sarton, the noted historian of science remarked in generalizing the outlines of the so-called new humanism: for humanity scholars, it is the revival of science; for scientists, it is the revival of humanities.

The Chinese Academy of Sciences established “The Research Committee for the History of Natural Sciences in China” back in 1954 and the “Research Office for the History of Natural Sciences in China” early in 1957, which gradually developed into an independent institute. Despite the fact that its scale is not large, the Institute for the History of Natural Sciences (IHNS) is characteristic and important too. This is because I have always upheld the view that science is the inexhaustible river for mankind to perceive the world, while technology is the indefatigable creation of sustainment and development modes for mankind. Investigation in the history of science is essentially study of the history created by the human race. It enables us to carry forward the cause pioneered by our predecessors and forge ahead into the future. And therefore, it is of important value and significance. In 2008, the IHNS undertook and completed the task of delivering lectures on the history of ancient Chinese science and technology for leading comrades. The series of lectures, including 44 individual lectures, began vertically with *Ancient Chinese Science and Technology in the Process of Human Civilizations* and horizontally with *Overview of Ancient Chinese Science and Technology*, and carried out deep discussion into “Several Issues in the History

of Science and the Needham Puzzle,” interspersed with the knowledge systems of Astronomy, Arithmetic, Agriculture and Medicine, “The Four Great Inventions,” as well as various technological areas closely related to clothing, food, shelter and transportation. For lecturers, IHNS enlisted the service of senior experts of lasting prestige from within and without the institute, as well as middle-aged scientific mainstays currently active in academic research. After the process of trial lecture, discussion, revision, etc., each lecture satisfied the requirements of rich in content, appropriate in exposition and argumentation, and reflective of the latest research level, and was therefore positively accepted and acclaimed by the leading comrades. After those lectures, the above mentioned experts and scholars meticulously collated their lecture notes and compiled them into a book, so that people from all walks of life may be able to share the academic findings.

China boasts a long history of civilization and eye-catching achievements in ancient science and technology, in which the author has harbored a keen interest. Learning them not only enriches cultural literacy but also has the significance of enabling learning from history. Review from the historical perspective of the regularity and evolutionary trend of science and technology, evolution in scientific and technological systems of different countries and the underlying causes, evolution of IPR system and situation of scientific and technological development in later-developing countries, means for nurturing scientific and technological competence of different countries, national objectives and scientific and technological planning and programs, the historical path for the creation and development of the National Innovation System, historical development of important contemporary cutting-edge disciplines, etc. Review will reveal the developmental regularity and trends on the basis of tracing the evolution path, and provide referential analyses for choosing the direction and path for the development of science and technology in China, and for the reform of the scientific and technological system. In addition, although there is already no geographic difference in the modern science and technology rising in the West, the interactions remain between science and technology and social, political, cultural, religious, etc. factors. Therefore, comparative research from the international perspective of development, dissemination and schools of science and technology is also one of the purports for learning and investigating the history of science. In addition, we should also be attentive to the fact that the development of modern science and technology is not only changing the material world, but also profoundly changing the spiritual world of the human race. Therefore, it is also of great significance to find a solution to the contradiction between fast-developing economy and relatively lagging cultural construction, promote the scientific culture development in China, carry forward the scientific spirit, advocate scientific methods, and accelerate the construction of innovative culture. In recent years, IHNS research staff has spearheaded interdisciplinary research in the cultural connotations of science and technology, the social environment of scientific activities, and the compatibility between scientific culture and humanistic culture. This would be beneficial for the process of pursuing independent scientific innovation and achieving coordinated and common development of science, technology, society, and culture. Firstly, the development of science and

technology will drive socio-economic and cultural development; second, economic and cultural environments will boost and ensure the development of scientific and technological innovation, and to realize mutual promotion, beneficial cycle, sustainable development, construction of an innovation system, and a harmonious society.

Last, the author wishes to extend his heartfelt thanks to Shanghai Jiao Tong University Press, which is dedicated to the cause of scientific history and cultural construction, for its investment of manpower and financial resources to make possible publication of this book with beautiful design and exquisite binding, and pictures complementing essays.

Yongxiang Lu

A stylized handwritten signature in black ink, likely representing the author's name in Chinese characters.



## About Tan Sri Frank Tsao



**Tan Sri Frank Tsao** Founder and Senior Chairman of the IMC Group, is a much respected and acclaimed veteran in the shipping industry.

Born in Shanghai in 1925 and a graduate of St John's University, Tan Sri Frank Tsao founded the International Maritime Carriers Ltd (IMC) in Hong Kong in 1966. Under his leadership, IMC has established a strong foothold and developed a good brand name for its strengths in the international shipping and logistic arena. Besides shipping, he also diversified into other businesses that serve the basic human needs such as cement, textiles, vegetable oils, palm oil crushing mills and plantations, pharmaceuticals, and real estate developments in different parts of the world. With these as the foundation, IMC has developed into a diversified group with interests in the strategic business areas of industries (maritime and industrial solutions), lifestyle/real estate (Octave), investments, learning, and wellness (East West Group) with staff strength of over 8,000 employees in 13 countries working towards fulfilling its mission "to serve human well-being and create wealth at the same time".

Throughout his long and illustrious career, Mr Tsao has played a pivotal role in shaping the growth of the maritime industry and promoting maritime education and research in Asia. In Malaysia, he partnered the Malaysian Government in 1968 to help establish its first national shipping line—the Malaysian International Shipping Corporation Bhd and draft the first maritime law in Malaysia. In 1973, His Majesty, the Yang di-Pertuan Agong (the Bahasa Malaysia term for "King") of Malaysia conferred upon Mr Tsao the title of "Tan Sri" in recognition of his great contributions to the country.

In Singapore, Tan Sri Tsao provided valuable feedback to the Maritime and Port Authority of Singapore (MPA) on the conceptualisation of Singapore's Approved International Shipping Enterprise Scheme, which has successfully attracted over 100 international shipping groups since 1991. He was also instrumental in the

setting up of the permanent secretariat of the Asian Shipowners' Forum (ASF) in Singapore in 2007. He drove the establishment of the NUS Centre for Maritime Studies at the National University of Singapore, and oversees the Centre's advancement through serving as its Chairman since its inception in 2005. In 2008, Tan Sri Frank Tsao was conferred the Singapore's Honorary Citizen Award by the Singapore Government for his outstanding contributions to the country's growth and development.

In China, Tan Sri Frank Tsao supports the advancement of maritime education and training through scholarships and bursaries in many universities including Dalian Maritime University, Dalian University of Technology, Hong Kong Polytechnic University, Qingdao Ocean Shipping Mariner's College, Shanghai Jiaotong University, Shanghai Maritime University, Shanghai Tongji University, Tsinghua University and Zhejiang International Maritime College. He also provides the financial resources for the academics and the maritime community and has sponsored the set-up of the IMC-Frank Tsao Maritime Library and Research & Development Centre in the Hong Kong Polytechnic University.

Currently, Tan Sri Frank Tsao is the Chairman of Suntec Investment Pte Ltd, Vice Chairman of the Singapore-Zhejiang Economic and Trade Council (SZETC) and Member of Hong Kong Maritime Industry Council. Previous positions that he held include Chairman of Suntec Singapore International Convention and Exhibition Centre (1995–2009), Chairman of Hong Kong Shipowners Association (2003–2005), advisor to the Economic Development Board (EDB) (1991–1993). In addition, Tan Sri Tsao and his family have also set up the non-profit Tsao Foundation devoted to promoting successful ageing.

For his efforts, Tan Sri Tsao has earned numerous accolades, including: Lifetime Achievement Award from Seatrade Asia in 2008; Silver Bauhinia Star from the Hong Kong SAR Government and Honorary Citizen from the Dalian Government in 2006 apart from being the first Asian recipient of the CMA Commodore Award from the Connecticut Maritime Association of the US in 2002 and the Personality of the Year by Lloyd's List Maritime Asia in 1999.

The publication of this series of books has received support from Tan Sri Frank Tsao and IMC Group.

# Abstract

Consisting of three volumes, i.e., Volume 1, Volume 2, and Volume 3, this series are the result of collation and consolidation of lecture notes by the Institute for the History of Natural Sciences (IHNS) on the history of ancient natural science for leading comrades. The series of lectures, including 44 individual lectures, began vertically with *Ancient Chinese Science and Technology in the Process of Human Civilizations* and horizontally with *Overview of Ancient Chinese Science and Technology*, and carried out deep discussion into “Several Issues in the History of Science and the Needham Puzzle,” interspersed with the knowledge systems of Astronomy, Arithmetic, Agriculture, and Medicine, “The Four Great Inventions,” as well as various technological areas closely related to clothing, food, shelter, and transportation. Mostly delivered by well-known experts of various expertises from IHNS, Chinese Academy of Science, the 44 lectures also involve noted scholars of relevant fields from other units.

The series are rich in content, systematic and comprehensive, with objective argumentation, and extensive citation, and appropriate for people from all walks of life, especially teachers and students of history of science, philosophy of science, and other relevant disciplines.



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