THE HONG KONG JOCKEY CLUB SERIES
香港賽馬會呈獻系列

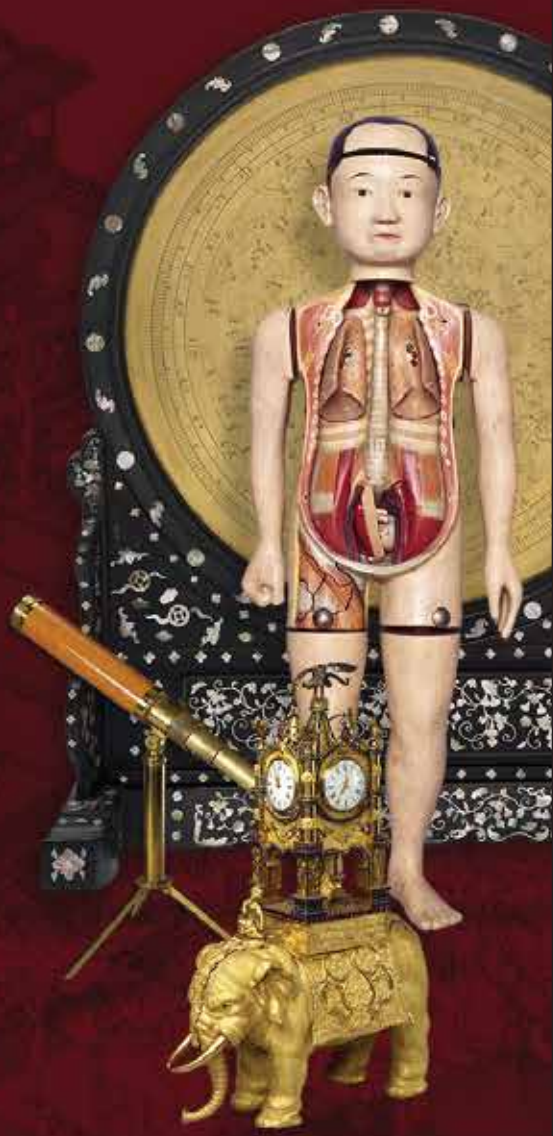
香港科學館 · 專題展覽 HONG KONG SCIENCE MUSEUM · SPECIAL EXHIBITION

清宮科技展

西洋奇器

Western Scientific Instruments of the Qing Court

26.6 – 23.9.2015



TEACHERS' GUIDE

聯合主辦 Jointly presented by
康樂及文化事務署 Leisure and Cultural Services Department
故宮博物院 THE PALACE MUSEUM

聯合籌劃 Jointly organised by
香港科學館 HONG KONG SCIENCE MUSEUM
故宮博物院 THE PALACE MUSEUM

獨家贊助 Solely sponsored by
130th 同心 同步 同進 RIDING HIGH TOGETHER

Introduction

China has a rich cultural heritage, and Chinese science and technology contributed significantly to global civilisations in historical times. In the process of science and technological development in various historical eras, China had made exchanges with western countries in varying degrees. During the late Ming and Qing Dynasties, European missionaries travelled vast distances to come to China to spread the Christian faith. While devoting much effort to learn the Chinese culture, they introduce a large number of Western scientific apparatuses to China. It was the time that scientific and cultural exchanges between China and the West reached the greatest heights.

The “Western Scientific Instruments of the Qing Court” Exhibition is one that merges science and history. About 120 exhibits presented in this exhibition are selected from the Western science and technology collection of the Palace Museum. These exhibits cover eight main themes: paintings, astronomy, mathematics, measurement, medicine, weapons, articles for daily use, clocks and watches. Many of these historic relics are being exhibited in Hong Kong for the first time. Some of the highlights in this exhibition are the gilt-silver armillary sphere; All nations coming to the court to present tributes by court painter under the imperial edict of Emperor Qianlong, to show off the power and might of the Qing Empire; an iron gun used by Emperor Kangxi; a clock with a barometer and a thermometer; a hand-cranked mutoscope; a British-made bicycle once used by China’s last Emperor Puyi; many exquisite clocks and watches, as well as science publications in the Qing Dynasty. These historic treasures of immense scientific value are a testimony to scientific and cultural exchanges between China and the West. Moreover, through these historic relics, the audience may reflect upon the causes for Chinese science and technology to lag behind the West during the Qing Dynasty. Hence, they may gain an insight into the importance of science and technology to the advancement of our society.

In order to enhance the education function and appeal of this exhibition, the Hong Kong Science Museum has designed a number of multimedia and interactive exhibits for the audience. We hope that through their hands-on experience, they would have an appreciation of the operation of these science apparatuses and their underlying scientific principles. Moreover, the museum has also developed a mobile phone app for this exhibition, providing exhibit information, games and audio tour guide service. The audience may also use this app to take photo with little Emperors. Please remember to download the app before coming to the exhibition to ensure you will have an enjoyable and fun-filled visit.

Jointly presented by Leisure and Cultural Services Department and the Palace Museum
Jointly organised by the Hong Kong Science Museum and the Palace Museum
Solely sponsored by The Hong Kong Jockey Club Charities Trust
Acknowledgement: Design and Cultural Studies Workshop

Curriculum Links

Primary School General Studies “Science and Technology in Everyday Life”, “National Identity and Chinese Culture” and “Global Understanding and the Information Era”

S4-S6 Combined Science Physics Part “Wave Motion”

S4-S6 Physics Compulsory Part “Force and Motion” and “Wave Motion”

S4-S6 Physics Elective Part “Astronomy and Space Science”

S4-S6 Chinese History Elective Part "宗教傳播與文化交流"

Information on Visits

Exhibition Period: 26.6.2015 – 23.9.2015

Venue: Special Exhibition Hall, Hong Kong Science Museum

Floor Plan

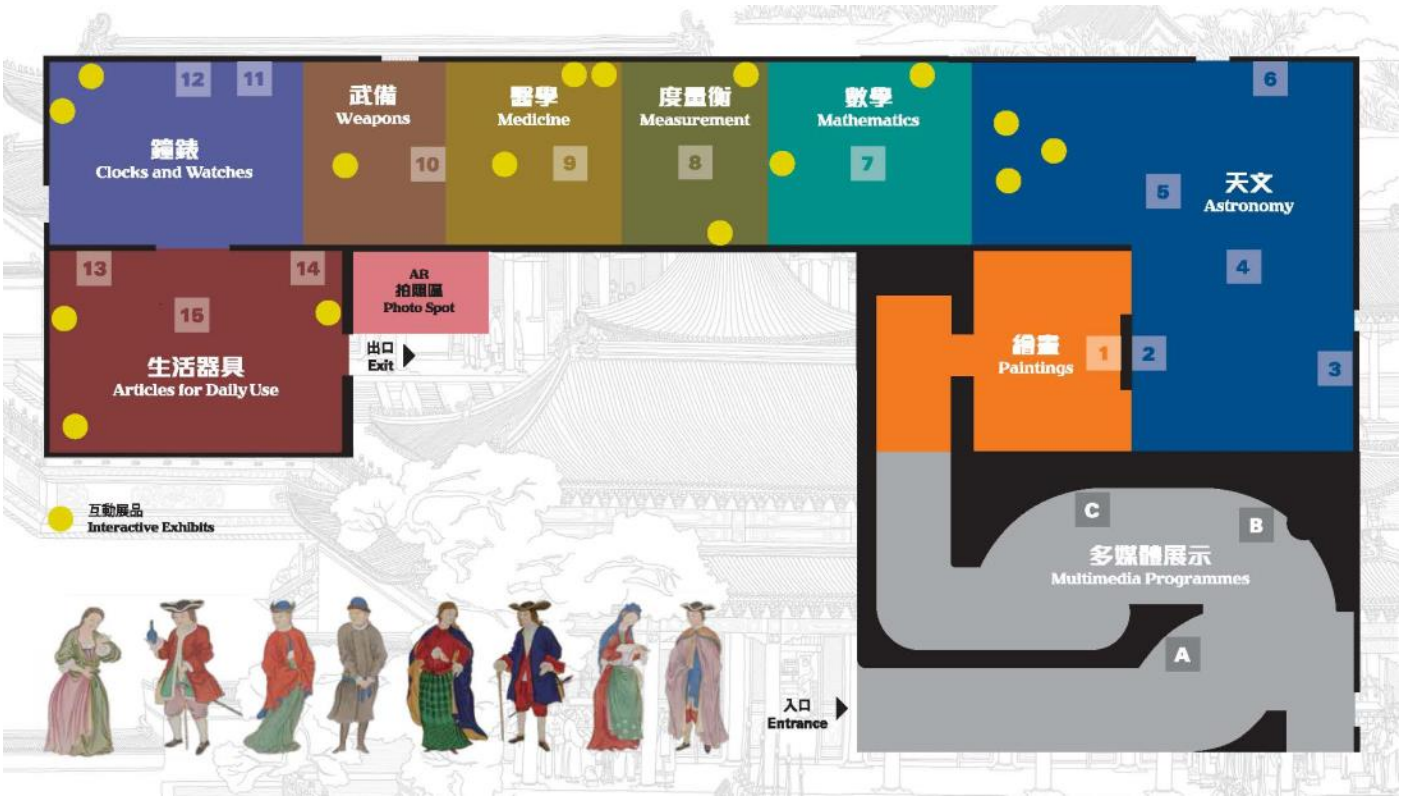


Exhibit Highlights

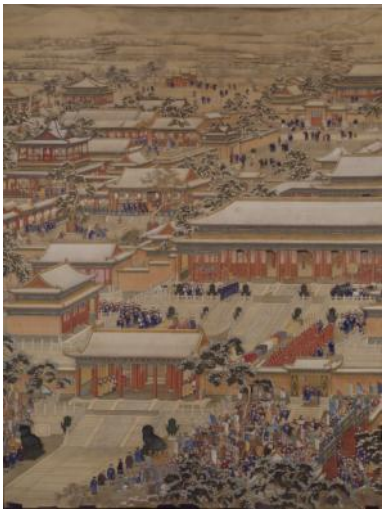
Painting

Pictorial scroll by Qing painter: Leisure activities of Yinzhen's Concubines

Staff of the Palace Museum discovered a set of twelve portraits of traditional Chinese ladies when they were collating collections in a warehouse in 1950s. Each colour painting on silk shows one lady. The set was originally mounted on the free-standing folding screens of the "willow trees study lodge" in the Yuan Ming Yuan Park. Emperor Yongzheng highly appreciated the pictures so he ordered to remove them from the folding screens and stored safely.

This is one of the pictures entitled Chibiao duiju "Sitting Beside Chrysanthemums and Holding a Pocket Watch". In this picture, a traditional Chinese lady holds an exquisite Western timepiece, a fashionable item, in her hand. A vase and some books are placed on the table. Inside the room, there is also a small black lacquer table decorated with golden decorative patterns and a Western astronomical instrument, the "Gilt-silver armillary sphere" was placed on it.

All nations coming to the court to present tributes



In order to promote the prosperity of the Qing Dynasty, Emperor Qianlong ordered the court painters to create several art pieces reflecting the envoys of foreign nations paying tribute to the Qing Court. The paintings show the envoys from the Qing's vassal states holding national treasures or native delicacies and gathered outside the Taihe Gate of the Forbidden City, all waiting to worship Emperor Qianlong. You can find the envoys of today's countries including Japan, United Kingdom, France and Russia. Interestingly, the painters might never have come across the actual scene and the painting might not entirely reflect scenario of the Qing Court as a certain amount of imagination was used to create it.

Astronomy

The Chinese people have always greatly valued the development of astronomy since antiquity. They relied upon making divinations using the heavenly signs to pursue good fortune and avoid bad luck, as well as compiling calendars and forecasting the change of seasons to help with agricultural activities. Ancient Chinese astronomers accomplished great achievements. Before the Ming Dynasty, astronomical observation instruments such as the gnomon, clepsydra, armillary sphere, simplied armilla and water-driven astronomical clock-tower were invented and used for making observations, resulting in a rich set of observational records. Unfortunately, astronomical observations in ancient China were totally subjugated to the power of the Emperor and clouded by superstition. Ancient Chinese did not pay special attention to explain astronomical events. Consequently, no significant breakthroughs were achieved in astronomy.

By the end of the Ming Dynasty, Johann Adam Schall von Bell and other European missionaries were appointed to official positions at the Bureau of Astronomy because of their profound knowledge of astronomy. This dealt a devastating blow to traditional Chinese astronomy. After the Manchurian army took over China, these European missionaries surrendered to the conquerors, and continued their work at the Bureau of Astronomy. Apart from Johann Adam Schall von Bell, there were also many other missionaries came to China. They carried with them astronomical instruments of many kinds from Europe, including the telescope and various instruments for astronomical measurement. The introduction of these new instruments and new knowledge facilitated the development of astronomy and the calendar system in China.

Gilt-copper armillary orrery with seven celestial bodies

This demonstrative instrument is considered as a combination of an armillary sphere and orrery. The armillary sphere demonstrates the concepts of the celestial sphere. Divided into three layers, the outermost layer has a horizontal ring and a meridian ring. The horizontal ring is inscribed with the zodiac and twelve months. The middle layer consists of the zodiac, four longitudinal rings, and five rings of latitude parallel to each other, including the Arctic Circle, the Tropic of Cancer, the Equator, the Tropic of Capricorn and the Antarctic Circle.

The innermost layer of this instrument is an orrery which was constructed according to the heliocentric theory proposed by the Polish astronomer Nicolaus Copernicus in 1543. The heliocentric theory states that our Earth is not the centre of the universe. Instead, the Earth and the other planets revolve around the Sun.

The orrery illustrates the motions of Mercury, Venus, Earth, Mars, Jupiter and Saturn revolving around the Sun.

Gilt-silver armillary sphere engraved with “Ferdinand Verbiest”

This instrument was built by Ferdinand Verbies of the Bureau of Astronomy, for Emperor Kangxi to learn astronomy. As a demonstrative apparatus, the armillary sphere presents concepts on the celestial sphere such as how the Sun and Moon circle around the Earth as well as solar and lunar eclipses. The outermost layer of the armillary sphere comprises a horizontal ring and a meridian ring. The horizontal ring is inscribed with quadrant scales representing four principal winds. The middle layer consists of the rings of the ecliptic and zodiac, lunar orbit, and celestial equator. All rings are graduated with angular scales. A globe is placed at the centre. Notations for the major continents are inscribed on the globe. Metal rings are inscribed with Manchu alphabets.

Gilt-copper star chart table plaques

From the outset, astronomical observation was always very important to the ancient Chinese. The ancient Chinese believed that the motions of astronomical objects were linked to the rise and fall of their country. A great effort was rendered to make accurate astronomical instruments and star maps in order to record sky phenomena. “Gilt-copper star chart table plaques” are beautifully crafted art pieces with decorated star maps of the north and south celestial spheres. Their frames are made of rosewood with lucky symbols such as bat and copper coin mounted on their circumference. The bottom of the frame features a curly grass pattern. This plague is the south celestial sphere.

Black lacquered rectangular compass

The compass is an indispensable surveying tool for Fung Shui master when determining sources and directions. This compass is made of wood and consists of an inner and an outer dial and a “pool of heaven”. The inner dial is circular in shape and is the major component of the compass. Various scales are engraved on the inner dial so that the master could make Fung Shui recommendations based on the theories of I Ching and Lo Shu Square, and stellar movements. The outer box is rectangular in shape. It has golden inscriptions of the 24 solar terms. The “pool of heaven” is the centre of the dial, where the compass is placed. It is because the notch in the centre of the dial acts as the pool on which the compass needle floats when filled with water.

Mathematics

In ancient times, the Chinese tied knots in string for counting and recording, clearly showing the fact that mathematics was closely linked to daily human activities. The earliest development of Chinese mathematics began from ancient times to the late Western Han Dynasty. With the emergence and wide use of the counting rod and the decimal system, a basic mathematical system became complete by the time of the Qin Dynasty and early Han Dynasty. The nine chapters on arithmetic, written in the early years of the Eastern Han Dynasty, is a classic work of ancient Chinese mathematics. It covers the foundations of arithmetic still used today, including algebra and geometry, etc. This book not only established the development model for Chinese mathematics, but also had an influence in other countries such as India, Arabia and Europe, and contributed to the development of mathematics throughout the rest of the world.

By the time of Ming Dynasty, the abacus had been invented in China and became the major calculation tool. However, the development of mathematics slowed down at the same time. In contrast, Western mathematics was achieving a number of breakthroughs. The remarkable achievements of that era included the invention of the world's earliest calculating machines and the emergence of calculus. Emperor Kangxi of the Qing Dynasty had a penchant for studying science. He appointed European missionaries as his personal tutors, who produced numerous Western mathematical instruments for him and guided him in his study of mathematics. These European missionaries even joined forces with Chinese scholars to translate various books on Western mathematics, hence ushering in the admirable era of East-West interaction and exchanges in mathematical research.

Mechanical calculator

Don't think that calculator is a modern instrument. In 1642, French scientist Blaise Pascal invented the world's first mechanical calculator. The device was later introduced by missionaries to Emperor Kangxi, and he liked it very much. Later, the Qing Court started making mechanical calculators.

This "Mechanical calculator" has ten discs on the surface to indicate ten digits. The base of each disc is equipped with a set of gears to carry out addition and subtraction. The modern computer applies similar principles to perform calculations, so this mechanical calculator can be accounted as the forerunner to modern calculators and computers.

To learn more, you may like to visit the interactive game "Pascal's mechanical calculator".

Measurement

Measurement, including measuring the length, volume and weight of an object, is crucial to the daily activities in human societies. From book keeping and sales of goods to the collection of taxes on land and technological inventions, high-precision measuring instruments have always been important. As early as the 1st Century AD, great strides were already being made in the formal study of the system of weights and measures. At that time, the scholar Liu Xin developed a complete system of weights and measures. This work was later incorporated into the *Han shu - Lu li zhi*, making it a classic in terms of Chinese metrology – the formal study of measurement.

In the Qing Dynasty, measurement standards varied in different areas across the country, resulting in confusion and inequality. During the reigns of Emperor Kangxi and Emperor Qianlong, new instruments and techniques for measurement were introduced by European missionaries. New weights and measuring instruments were also produced locally to standardise measurement throughout the whole country. This greatly eliminated inconsistencies and improved efficiency in China.

Balance

A balance is a simple instrument to weigh objects. To measure the weight of an object, the object is put on one side and standard weights are put on the other side. When equilibrium, the object's weight is equal to the total weight of the standard weights. In China, simple balances already came into use as early as the Chunqiu period.

This balance was used by the Qing Court. The outer portion includes a one-sided wooden frame used to stabilise the beam and trays on both sides. A set of standard weights is also included. Based on the heaviness of these weights, this balance was likely used to weigh heavier items.

If you want to use the balance and learn the science of the Qing Court, you can try out the interactive game "Beam balance".

Medicine

Chinese medicine has an enriching legacy, having developed a sound system with an emphasis on the harmony of man with nature and underscoring the wholeness of the human body. This approach means that wherever there is a problem in the body, Chinese medicine adopts a holistic approach to restore the body's balance as the means of therapy. The earliest written work on Chinese medicine first appeared in the 1st Century BC during the Han Dynasty and it was about the knowledge of herbal remedies. Later on, Chinese medicine evolved into a complete system comprising observation, olfactory sensing, questioning and taking the pulse as the basis for diagnosis. Western medicine, meanwhile, came to focus on the cause of the disease itself yielding faster efficacy by administering medication according to these symptoms.

In the area of exchanges between East and West in medical science, inoculation was already available during the Qing Dynasty. This was introduced to England via Turkey and inspired the English doctor Edward Jenner to develop the smallpox vaccine. As far back as the 17th Century, the theory of anatomy was introduced into China by European missionaries. Emperor Kangxi ordered anatomy books to be translated into the Manchurian script. However, because such theory conflicted with traditional Chinese values, it was therefore kept within the walls of the Imperial Palace. Under the vigorous advocacy of Emperor Kangxi, Western medicine once flourished within the Imperial Palace. Despite this, due to the indifference to Western medicine by succeeding sovereigns after Emperor Kangxi, Western medicine did not become widely popular in China. Moreover, because very few missionaries in the wider community were also doctors by profession, and the majority of ordinary people thought there was too much of a difference between the theories and practices of Chinese and Western medicines, the development of Western medicine in China was further hampered. It was not until the Reign of Emperor Guangxu in the late-Qing Dynasty period that Western doctrines and technologies started to regain importance inside and outside the Imperial Palace, when Western medicine reappeared in the Qing Court.

Human anatomy model

In the 32nd year of Kangxi, Emperor Kangxi suffered from malaria. Chinese medicine was not effective for him. After taking the Western medicine “cinchona”, Kangxi recovered quickly. Afterwards, he showed a great interest in Western medical sciences, especially human anatomy. He ordered missionaries to translate Western anatomy and medical publications and import anatomy models for his study.

This one is a female anatomy model. The right half of the chest and thigh show muscle tissue and blood vessels. The arms and legs are detachable from this model and the skull and chest can also be opened. Brain tissue can also be taken out once the model’s skull is opened.

Weapons

Gunpowder is one of the four great inventions of China. Its main ingredients are saltpetre, brimstone and charcoal. The origin of gunpowder is closely attributed to alchemy. By the time of the Song and Yuan Dynasties, because of the constant series of wars and conflicts, breakthrough developments were made in the application of gunpowder along with the appearance of tube-shaped firearms and primitive forms of the cannon. Additionally, firearms were also introduced into Arabia via India, where the Arabs made improvements to the firearms which then flowed into Europe and later developed into various forms of guns and cannons, including the matchlock, flintlock, rifle, short musket, etc.

During the Ming and the Qing Dynasties, firearms were reintroduced into China from the West via Japan. By this time, significant progress had been made to firearm technology in terms of design and application. Guns remained under strict control during the Qing Dynasty. Except for the Imperial Palace, soldiers of the Firearms Battalion and members of the Imperial Guards, ordinary citizens were forbidden from possessing and having access to firearms. In the case of the Imperial Palace, except for the guns purveyed for the exclusive use of the Emperor imported from England or custom-made by the Workshops of the Qing Court, the other firearms used to equip the officers and soldiers were manufactured by the Ministry of Public Works or were produced locally after approval was granted. All of them were matchlock guns.

Iron gun used by Emperor Kangxi

Most of the weapons of the Qing Court were imported from the West, contributed by officials, or produced by the Court. This “Iron gun used by Emperor Kangxi” was manufactured by the Qing Imperial Manufactory under the direct supervision and guidance of Kangxi, and finally reserved for his own personal use. The barrel of this gun is made of iron while the barrel seat and stock are of wooden construction. The gun has both matchlock and flintlock firing mechanisms. The Emperor no longer used bows and arrows while hunting but used guns when guns were imported from the West.

This gun is not easy to use. Try to learn the firing procedures and fire a gun from the interactive exhibit “Load the Musket”.

Clocks and Watches

Even far back in antiquity, the Chinese people already mastered the technique of using the sun's shadow cast onto the ground to measure time. The earliest recorded example of such a device dates back to the Sui Dynasty around 500 AD. In addition to the sundial invented during the Sui Dynasty, the bronze clepsydra was already being used to measure time during the period of the Western Han Dynasty. This device used drops of water in conjunction with a set of scale markings to indicate the passage of time. By the Song Dynasty, Su Song invented a water-driven celestial globe used to indicate time as well as chiming on the hour; furthermore, this device even incorporated an escapement system similar to the modern-day clock. Unfortunately, this invention did not evolve further, and it was the West that eventually thrived and achieved glory in the world of the timepiece.

Western timepieces first entered the Imperial Palace during the Reign of Emperor Wanli of the Ming Dynasty, when Matteo Ricci presented two sets of chiming clocks to Emperor Wanli. At the time, Emperor Wanli and his ministers were spellbound by these objects of exquisite novelty. Later on, the number of timepieces in the Qing Court grew. Most of the imported European timepieces were of English and French origin. They were used not only to indicate time, but also be crafted into buildings of different shapes, figures of men and animals, and would also be embellished with mechanical features that simulates water flowing effects, revolving flowers, animated figurines, etc. This gave these objects an eye-catching and magnificent appearance and made them the most fashionable gadgets in the Imperial Palace. Emperor Qianlong had a particular strong personal affinity for European timepieces, and he even ordered the Workshops of the Qing Court to acquire a whole series of beautifully crafted timepieces for the exclusive use of the Imperial Palace.

Metal clock with piston wheels, barometer and thermometer

Europe was the cradle of mechanical clocks and watches. Many works were masterpieces. This "Metal clock with piston wheels, barometer and thermometer" is made in France, is one of the collections of the Palace Museum. The design of this horology work is based on a typical French industrial theme.

The clock's two-hand dial is fixed onto a marble pedestal flanked by a piston-cylinder and a furnace on both sides into which a barometer and a thermometer are inlaid. Such special functions may have been added for marketing considerations. When the device is activated, a large wheel on top of the device rotates and drives the piston-cylinders, demonstrating the working principles of the steam engine.

To learn the internal structure of a clock, try out the interactive game '"Tik-tak" Escapement'.

Articles for Daily Use

The advent of the success of the industrial revolution in Europe resulted in a huge number of household items of all descriptions flooding the market. In the aftermath of the two Opium Wars, the Western powers smashed open the doors of the Manchurian Empire with their policy of gunboat diplomacy, resulting in a steady flow of Western merchandise into China. Meanwhile, a great variety of Western products and technology also entered the Imperial Palace in the late Qing Dynasty, adding colour and variety to court life.

Most of these new products were intended for recreation and entertainment. At the time, the reigning sovereign ruler adopted a rather passive stance on his dealings with the West, which was a far cry from the vision of the previous emperors who aimed to gain knowledge of the world outside China. For this reason, demand for these technology products by the Imperial Palace of the late Qing Dynasty mainly centred on daily essential amenities and entertainment, including health supplements, interior fixtures, transportation, entertainment apparatus, security firearms, etc. Among all these products, movie players, gramophones, cameras and bicycles were the royal family's favourites.

Rectangular wooden hand-cranked mutoscope

The first mutoscope was probably a lantern adorned with a revolving circle of paper horses, recorded during the time of the Han Dynasty. Such a lantern and the modern film player adopted the same theory of "Persistence of vision" of the human eye. This theory says that an afterimage is thought to persist for approximately 0.1 to 0.4 second after the image has disappeared. Observers thus interpret a sequence of fast-playing still pictures as a movie playing smoothly.

This mutoscope is actually a "flipbook animation player". The flipbook is inserted into the device via a small door. Turning the metal handle sets the gears in motion to flip the book. Look inside the device to view the animation.

Gramophone

The gramophone was invented by Thomas Edison. The original design was made of a tinfoil sheet. Later, the gramophone was improved by using wax-coated zinc discs as the medium for playing back and recording. This method also allowed copies of recordings to be mass produced effectively from the master. The basic principle of the gramophone playback mechanism is that the needle on the pick-up head reads a series of grooves on the record. The vibration recorded by the needle is channelled into a thin diaphragm that vibrates, pushing air molecules and producing sound.

In the early 20th century, the new gramophone was imported into China. This item soon appeared in the Qing Court. This gramophone was once used in the Court. Consisting of the rotating machine, pick-up head and speaker, the gramophone plays music by turning the handle manually. Playing music on the gramophone became one of the pastimes of the members of the royal family in the late Qing Dynasty.

Bicycle manufactured by Birmingham Small Arms Company < England>

Everyone is familiar with the bicycle. It is good for daily use and recreation. The bicycle was imported into China around early 19th century. After appearing in the Qing Court, Emperor Puyi learnt to ride a bicycle in just a few days. Puyi was the only Emperor who rode a bicycle throughout history!

The frame of this bicycle is black and there is a bell installed on the right handlebar. On top of the bicycle frame, there is a brown leather seat with a leather tool bag hanging on the back. An oval logo where a triangle formed by three rifles is located at the front below the handlebar. In addition, the model number, manufacturer and other information are also marked on the bicycle.

In order to enhance the learning experience and consolidate knowledge acquired, teachers can carry out in-class or extra-curricular activities with students, and encourage students to research on the development of science and technology in Qing Dynasty (1636-1911, around one hundred to four hundred years ago), according to their levels and curriculum needs before or after the field visit.

Pre-visit Preparation

Kindergarten: Give students the idea of the articles for daily use by showing them modern household tools or their pictures such as measuring instruments, timer, thermometer or calculator. And let them know they will see the household tools used by people two hundred years ago during the visit.

Primary Schools: Ask the students to use the modern household tools to:

(1) Measure: (i) Length, area, volume, capacity and weight of objects;
(ii) Body temperature, temperature and humidity;
(2) Observe distant objects such as birds and stars;
(3) Identify directions;
(4) Read time;

Guide students to choose suitable tools as well as to manipulate them. Moreover, students are encouraged to search information from the Internet and discuss how the above measurements were performed in hundreds years ago.

Secondary Schools:

(1) Encourage students to search information regarding modern tools used for calculation, observation and measurement. Students may form groups and choose one of the above tools for in-depth research including its invention, development and contribution to human civilisation and discuss in the class.
(2) Encourage students to search the achievement in geography, zoology, anatomy, machinery and agriculture of Qing Dynasty.
(3) Guide students to discuss how Qing Dynasty leads to technology development falling behind the West.

Post-visit Extension Activities

Kindergartens: Teachers can guide students to look for the objects from the kindergarten which they have seen at the exhibition, such as clocks and watches, ruler and compass, and discuss about their uses.

Primary schools:

(1) Ask students to work in groups to choose their favourite exhibit and introduce it to class (including the name, appearance, functions, working principles of the exhibit and the reason of choosing it).
(2) Students can work in groups to do a presentation regarding the modern counterparts of one or more exhibits with their merits and defects listed.

Secondary Schools: Students work in groups to present the following topics:

(1) Choose an exhibit as an example to explain how technology makes human's life better.
(2) Explain how technology promotes the growth of society by summarising what they have learnt during the visit.
(3) Explore what factors affect the technology development and how they work.
(4) If you were the Education Minister in Qing Dynasty, how you would boost the education level of science?