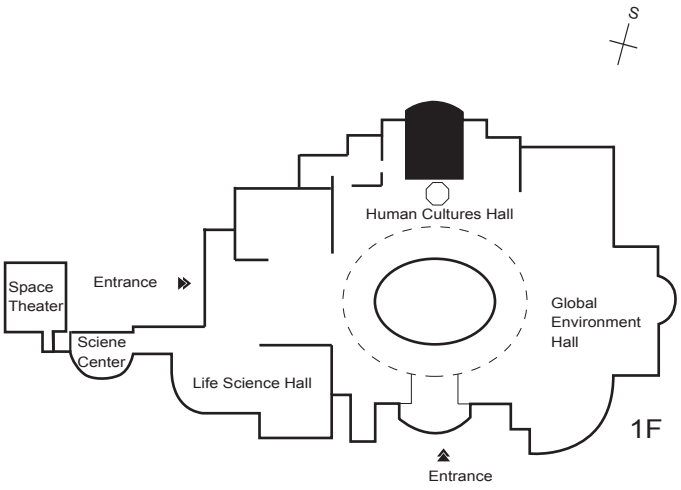
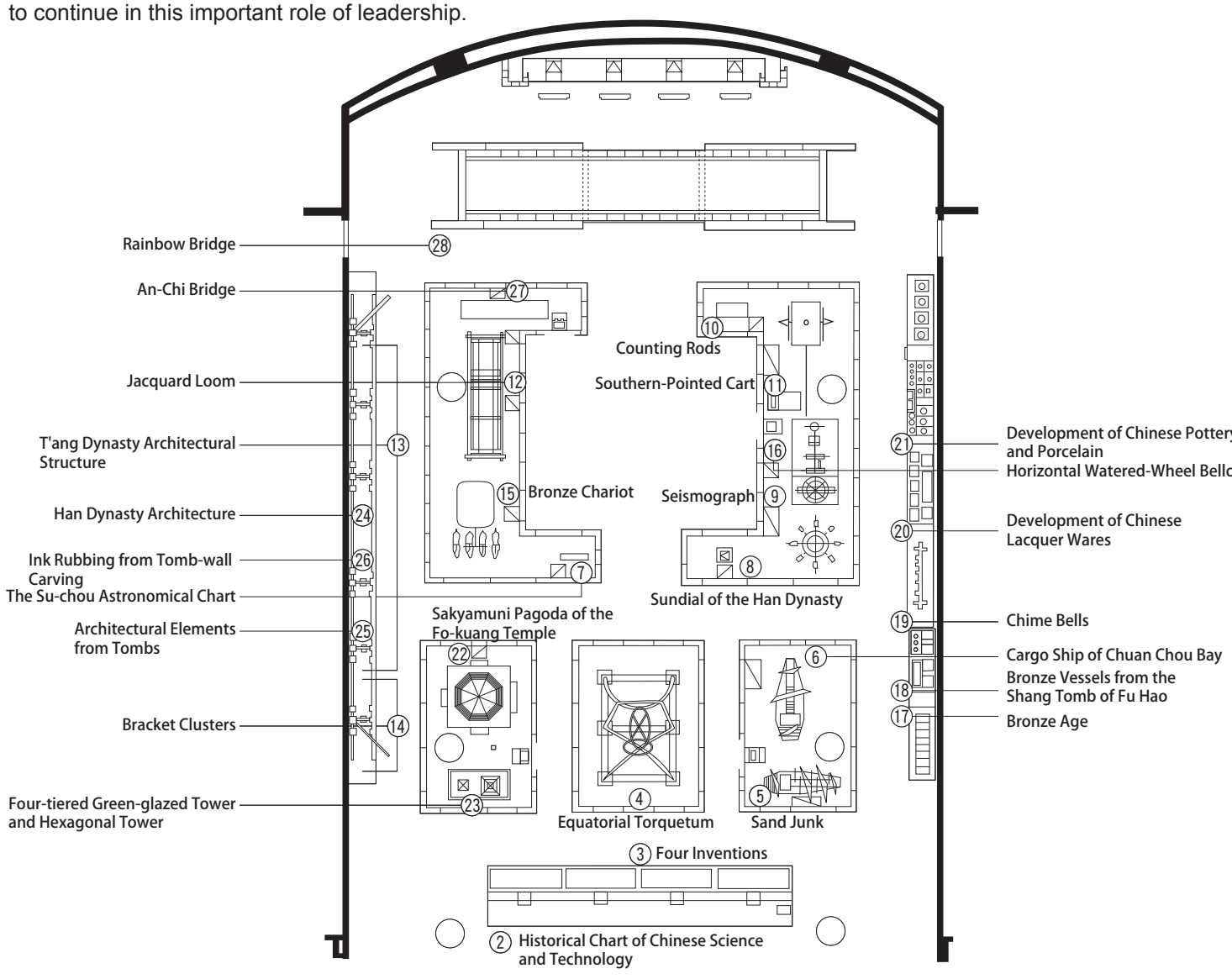
This gallery covers a wide range of exhibits which represent China's most significant achievements in the fields of science and technology. Many of these achievements are closely tied to the ordinary activities of daily life because, as the saying goes, "necessity is the mother of invention."

When this gallery was designed, there were two main purposes. First, to supplement the science education of Taiwan's school system because many of the topics presented here are not currently covered in the curriculum. Second, to encourage in visitors the spirit of creativity and invention by introducing them to the wisdom of traditional Chinese people in meeting the challenges of their own, earlier time. Also, as you move through this gallery, from exhibit to exhibit, We hope you will consider one of the important puzzles, or unanswered questions, about Chinese culture-that is, why did a civilization that for centuries led the world in science and invention cease to continue in this important role of leadership.





① Water-Powered Armillary Sphere and Celestial Globe Tower

This large tower has three levels, each one dedicated to a specific scientific function. Here on the bottom level you can see a clock…above, visible from the second floor, is a celestial globe… and at the top, also evident from the second floor is a large sphere for astronomical observation. This is a reconstruction of the Northern Sung Dynasty tower designed by the ancient scientist Su Sung during The 11th century. It was made from the writings and drawings recorded in his important work, The Major Rules of the New Observatory.

The images of birds carved on the side panels are perhaps water fowl, referring to the theme of water. The clock itself consists of five tiers, each one related to a different aspect of time. On the top tier, the figure of a man in the opening shakes a bell on the odd-numbered hours; another man strikes a gong on the even-numbered hours; and a third man marks every 15-minute period by hitting the drum in his hand. On the next level, a different man presents himself every hour holding a plaque that indicates the current hour. On the third tier a man comes to e opening every 15 minutes, holding a numbered sign that refers to the appropriate 15-minute interval.

On the fourth layer, a man strikes a gong 38 times throughout the night, beginning at dusk and continuing till dawn. And finally, with each strike of the gong, a figure appears on the bottom level with a sign indicating the nighttime hour.

①-1 How the Water-clock Works

To see how this water-clock works, step around to the left side where you'll find a window showing the clock's interior.

Through this window, you can see a large wheel with small white containers on the end of each arm. These containers are fed one at a time on the other side of the wheel by large buckets of water which flows at a constant, steady rate. As soon as one container is full, the wheel rotates lust far enough to allow another one to move into place, under the flow of the water. This regular, intermittent motion is the heart of the water clock’s mechanism and is widely accepted as the direct ancestor of modern Western clocks. As you can see on the second floor, this same water-powered motion drives the movement of the celestial globe and the sphere for astronomical observation.

①-2 Su Sung

Su Sung was one of the most accomplished of all Chinese scientists. He lived during the northern Sung Dynasty, in the 11th century A.D., and at the age of 33 was assigned to the imperial capitol of Kaifeng to catalogue books and manuscripts in the emperor's collection.

He was a skilled bureaucrat and eventually led a team of scientists and engineers in constructing the original tower on which this present model is based.

He also wrote a 21-volume catalogue on Chinese medicinal herbs. This comprehensive series provided the most updated information of the time on over 1,000 kinds of herbs, and continued to be read as late as the Ming dynasty, a few hundred years after his death.

①-3 The Book on the Major Rules of the New Observatory

If you step to the front of this model, there on the text panel you will find a drawing of the original tower, taken from the The Book on the Major Rules of the New Observatory by Su Sung.

From the data in this book, it is possible to glean a variety of details about the original tower, such as its size, descriptions of its components, and the building process. It also indicates that Su Sung and his colleagues made use of simple, commonplace tools such as the waterwheel in building this complex tower.

Over the centuries, many scientists have attempted to reconstruct the original observatory tower using Su Sung’s book. The model that you see here is the most successful effort to date. In fact, this is the world's first and only true-to-scale model, complete with all the functions of the original observatory.

② Historical Chart of Chinese Science and Technology

This timeline shows the major scientific achievements in traditional China from the Neolithic Period around 8,000 B.C. up through the Ch'ing, the last dynasty which was overthrown in 1911 A.D. During these almost 10,000 years China passed through periods of both unity and discord, under many different leaders and dynasties. However, her spirit of discovery and invention never lagged. Many of the objects on exhibit in the gallery ahead are illustrated on this timeline, indicating the period with which they are associated. Spend a few minutes here, if you like, to orient yourself before entering the gallery.

③ Four Inventions

This exhibit covers the Four Great Inventions of China. As shown from left to right, they are the compass, paper-making, printing, and gunpowder. Together, these four inventions comprise China's greatest contribution to world science and technology.

③-1 Invention of Compass

The discovery of the compass dates back to the 3rd century B.C. Historic records indicate that people at this time knew that the metal magnetite could be used to indicate direction. In fact, one book even describes how magnets were taken along for excavating jade in the remote mountains in case someone became lost.

Every compass contains two different types of magnetic poles–one pointing towards the north called the north pole, and another pointing towards the south called the south pole. Because the Earth has its own magnetic field, the needle of a compass will point towards the corresponding magnetic poles of the Earth.

The compass here, in the shape of a small ladle, is a model of the earliest type used in China, and is called "South Governor." This is because only when the long handle points in a southern direction, as you see it here, does the ladle stop moving on the smooth brass surface. This orientation was very deliberate because the south was traditionally thought to be the most direction and was associated with the notion of "heaven" and "up."

③-2 Invention of Paper

Prior to the invention of paper, events and activities were recorded on tortoise shells, animal bones, stones, metals, timbers, and bamboo. By the 2nd century B.C., we know, from archaeological evidence, that paper had been invented and was made using barks, hemp ends, rags and fishing nets as the raw materials. As you can see in the illustration, these materials were soaked, cut, cleaned, and then pounded into pulps. Afterwards, the pulp was shaped into delicate sheets of fiber using straw mats, and finally dried. Even today paper is produced by a somewhat similar process.

③-3 Invention of Printing

In the 2nd century, before the Han Dynasty, books and pamphlets were carved on stone which involved both hard work and many mistakes. In the eastern Han, it became common to dab ink on stone tablets, and then to place paper on top of the carved stone, creating what we call an "ink rubbing." This method was used to copy large numbers of words and may well be the origin of Chinese printing.

After the Han Dynasty, stone tablets were replaced by wood plates on which characters or figures were more easily carved, but the process of engraving each individual plate was still very time-consuming. Then in the 11th century A.D., this process was perfected by Pi Shen with the invention of movable type such as the example here on exhibit.

First each character was carved from clay. Then it was fired and arranged in the desired order on a metal plate. Next, ink was applied to the plates and they were printed, allowing many words to be recorded in a single printing. At the end, the individual characters could be moved around and reassembled to create yet another plate of words. Though this process was a great breakthrough at the time, it was not widely practiced until 300 years later, and the older method of printing with carved wooden plates continued to be used up until the Ming Dynasty.

③-4 Invention of Gunpowder

Gunpowder was discovered accidentally in the 7th century by a Taoist chemist in search of an elixir of immortality. It is composed of the three powders on exhibit, sulfur, nitrate, and charcoal-all materials that were frequently used by ancient alchemists.

Like fireworks today, gunpowder was originally intended for special celebrations. However, as early as the 9th century, grenades of gunpowder were being used on the battlefield.

④ Equatorial Torquetum

The equatorial torquetum was developed by Kuo Shou-ching in the 13th century, during the Yuan Dynasty. The name means "simplified observational instrument" because it is a streamlined version of an earlier, more complicated astronomical tool called an armillary sphere. Both the simplified instrument and its predecessor were used to observe and determine the location of celestial bodies and were important instruments in creating charts of the sky. The simplified version made charting the heavens a faster, more accurate process Also, because it had fewer large rings than the earlier instrument, it was much less cumbersome to manipulate.

Upstairs, on the second floor, you can see this instrument's predecessor, the armillary sphere, and

can compare it to this later, more advanced version.

④-1 Other Scientific Achievements by Kuo Shou-ching

Kuo Shou-ching is one of the greatest astronomers and engineers in ancient China. He was born in 1231 A.D. and even as a child showed the ability to tackle and solve scientific problems. At the beginning of the Yuan Dynasty, he was placed in charge of re-doing the imperial calendar, and in the process, developed the equatorial torquetum to replace older, obsolete instruments. His other scientific achievements include the invention of instruments for observing solar and lunar eclipses and improved methods for irrigation and canal construction. He was also the first Chinese scientist to use the concept of sea level in measuring altitude.

④-2 Comparison of Ancient Chinese and Western Approaches to Astronomy

Whereas astronomers in the West emphasize hypothetical thought in pursuing their science, in ancient China much greater emphasis was placed upon recording of data and observation. This was because the traditional Chinese believed that events in the human sphere were directly related to activities in the celestial sphere, and that we can understand and predict our own fates by studying the cosmos. For example, it was believed that the emperor received the mandate of heaven as proof of his legitimacy and his right to rule, and that the order and regular patterns of the universe-with the earth at the center, surrounded by its satellites-was a model for strong, stable government. Similarly, the relationships within a family, between husband and wife and parent and child, were ideally patterned after the cosmic model.

This emphasis upon observing the workings of the universe resulted in the recording of sunspots by the Chinese as early as 28 B.C., and the first record of Halley's Comet appears in a Chinese book dated 613 B.C., some 600 years before European sources mention it.

⑤ Sand Junk

The sand boat, also known as a junk, can be traced back at least three thousand years to the Yin or Chou Dynasties. The relatively flat bottom of the boat, along with the wide distribution of its weight, explains its ability to navigate through very shallow, sandy waters. Also, the boat's width, with its square body and stern, is an important factor in its stability, allowing it to support many sails, though in this model there are only two. The paddles on either side are used for steering, as well as for stabilizing the junk. And at the stern, near the small pavilion, is a so-called "stern post rudder" which was a Chinese development eventually adopted throughout Europe. This rudder was a very efficient steering system and allowed the Chinese, from a very early date, to launch ships of great size and surprising maneuverability.

The openings on the side of this model reveal another Chinese innovation in ship-building. As you can see, there are several partitions, or bulkheads, which divide the bottom of the boat into a series of compartments. These bulkheads helped to prevent leakage and also to protect the bottom from damage. Marco Polo noted this breakthrough towards the end of the 13th century, but bulkheads were not adopted by Western shipbuilders until five centuries later.

Sand boats were used for many purposes, and the model shown here is a warship from the Ming Dynasty. On the stern is an image of the sun rising above clouds, as well as five flags representing the points of the earth, with their corresponding colors. Along the sides of the warship are symbols of yin/yang together with flags representing the mountains and waters of the earth to suggest that the vessel carries all the vital forces of the universe into battle.

⑥ Cargo Ship of Chuan Chou Bay

This model of a 13th-century cargo ship is based upon the finds of an excavation in 1974 at Chuan Chou Bay, in the southeastern province of Fukien. The model is 1/10th the size of the original ship and was built from three types of wood-fir, pine, and camphor.

As you can see, the sails are horizontal panels woven from bamboo matting. Bamboo was the material of choice for masts and sails in all types of ships because it is light in weight, strong, and yet flexible. In fact, these sails can be lowered or raised like the Venetian blinds we now use on windows. Such a design made it very easy to manipulate the sails, and enabled sailors to respond quickly to changing weather conditions.

⑦ The Su-chou Astronomical Chart

This amazing astronomical chart, carved in stone, is a replica of one of the earliest known star charts in the world. The original was made in 1247, during the southern Sung Dynasty.

At the top is a celestial map divided into 28 segments known as "lunar mansions". The lunar mansions were considered temporary resting places for key stars, including the sun, planets and, most importantly, the moon, as they traveled across the sky. Some people have even compared these resting places to inns where weary travelers stop overnight during the course of their journey. This system of 28 mansions was a way of locating key stars in the sky, and of tracking their movements.

The inner-most circle on the diagram represents the North Pole,….and inside this circle is a large oval, marking the North Star. Symbolically, the North Star was associated with the emperor and his place in the center of the capital, at the heart of the universe. Surrounding it are the stars and constellations equated with the emperor's court and his highest officials, arranged in rank from the center outward.

Below the map is a text which provides a concise explanation of Chinese astrological knowledge of the time. For example, there is a calendar based on a year of 365 1/4 days, and a note that moonlight is, in fact, a reflection of the light of the sun. Also recorded here is the belief that day and night are created by the movement of the sky from right to left, because it was believed China stood at the center of the universe and the heavens rotated around her.

⑦-1 The 28 Lunar Mansions

The 28 lunar mansions are the ancient Chinese system of organizing stars into constellations. They were formed by dividing the region of the sky near the celestial equator into 28 sections, and then identifying key stars within each section, watching exactly when they rose, reached their zenith in the sky, and then set. Following these movements was a way of determining the changing seasons and led to the development of the Chinese lunar calendar.

The 28 mansions were grouped into four celestial palaces and each palace was represented by a mythical creature. Together these creatures are believed to protect the four corners of the earth. The red phoenix is associated with the south and summer; the green dragon with the east and spring; the black tortoise with the north and winter; and the white tiger with the west and autumn.

⑧ Sundial of the Han Dynasty

This sundial is a replica of one from the Han Dynasty, that was excavated in Inner Mongolia in l897. The complete circle represents one day and consists of a hundred, equal intervals. In the center is a hole where a marker made of wood or bronze was placed. As the light of the sun struck the tilted surface of the dial, the marker's shadow was cast onto the circle, and the time of day could be read.

The bottom two-thirds of the circle has 69 small holes with numerals beside each one. Daylight hours could be read very precisely on this portion of the sundial by placing a stick in one of the small holes. When the shadow cast by this stick formed a straight line with the shadow of the marker in the center, the exact time of day was indicated by the number beside the outside stick.

In ancient times, the sundial was a scientific instrument as well as a common household item, used by all agrarian people. It played a function similar to that of clocks and calendars in modern society.

⑨ Seismograph

This is a model of one of the world's first working seismographs–an instrument for detecting earthquakes. The large covered jar contains an intricate set of levers, and on the outside surface are eight dragons. If you look at any of these dragons' mouths, you'll notice a small ball inside. When an earthquake occurs, the levers are set into motion, causing the mouth of the dragon that faces the direction of the earthquake to open and release the ball. The ball then falls into the wide-open mouth of the toad below, making a loud noise and signaling the earthquake. Therefore, not only does this seismograph indicate that earthquake is taking place, it also registers its general direction.

The original instrument was invented in the Eastern Han Dynasty during the 2nd century by the scientist Chang Heng. It was so precise that it was able to detect in 138 A.D. an earthquake which took place nearly 1,000 miles away, even though people living in the same city as the seismograph had not felt the tremors.

⑨-1 Chang Heng

Chang Heng was not only one of the most important scientists in China, but also an accomplished writer and artist. He lived during the Han Dynasty, between the first and second centuries A.D. and held the prestigious position of imperial astronomer. Among his findings are the discovery that moonlight is a reflection of sunlight, and that the universe is not, in fact, shaped like an upside down bowl, but is boundless and infinite. He also invented the world's first known

weather-vane. Eventually Chang Heng was exiled because he openly challenged the traditional belief, supported by the emperor himself, that human affairs were directly affected by cosmic activity.

⑩ Counting Rods

Counting rods were used by ancient Chinese for more than two thousand years. In 1954, forty-odd counting rods of the Warring States Period were found in Zuǒjiāgōngshān (左家公山) Chǔ Grave No.15 in Changsha, Hunan.

Counting rods are small bars, typically 3-14 cm long, used by mathematicians for calculation. They are placed either horizontally or vertically to represent any number and any fraction.

The written forms based on them are called rod numerals. They are a true positional numeral system with digits for 1-9 and later also for 0.

⑪ Southern-Pointed Cart

Although this large wooden vehicle is called a cart, it was actually used as a navigational tool in ancient China. Its origins are unknown, but it is certain that by the 3rd century such an instrument was already in existence.

If you look up at the long pole aimed at the ceiling, you will see the figure of a man with one arm raised, pointing straight ahead. Regardless of how the cart turns, this man always points in the direction of the south. The reason for this is that between the two back wheels, there is a series of gears which you can see if you step, now, around to the cart's rear. In the center at the top is a large circular gear which is connected to the tall pole. Next to it, on either side are two smaller gears. Whenever the cart turns, they cause the larger gear in the center to return to its original position. Therefore, the direction of the figure above remains constant, always pointing towards the south.

Some believe such a directional guide was used in battle to help orient the troops, or by the imperial entourage when the emperor was surveying his land.

⑪-1 Chinese Concept of Direction

In traditional China, the natural geography of the land affected the way people interpreted the directions of north, south, east and west. For example, the north was seen as less positive than the south because foreign invaders lived along the country's northern border, frequently attacking and representing a constant threat to be dealt with. Also, menacing winds came from the north, and Chinese houses were usually built with their backs to the north as protection against these winds. On the other hand, from the south came warm, moist breezes that brought the rainfall so important to China's agriculture and the climate of the south was sunnier and more hospitable. The Chinese welcomed these blessings from the south, facing their houses in that direction. Therefore, the south became associated with the notions of up, positive, and heaven, and was placed at the top of ancient maps, where the direction of north usually appears. This, of course, caused all the directions of traditional Chinese maps to be opposite from modern-day maps-north was on the bottom, west appeared at the right, and east at the left.

⑫ Jacquard Loom

This loom, known as a jacquard loom, **was** the type used to produce beautifully patterned textiles and brocades for the royal families of traditional China and is still used today by Chinese artisans. Beginning in the 13th century, during the Yuan Dynasty, Nanking was the center of this production and its many weaving factories turned out fabulous creations, such as the beautiful textile on exhibit here.

The jacquard was the most advanced loom of its time, famous for its ability to weave colorful and intricate designs. The weaver sat on the box in front of the loom, positioned here near the rear of the cart. He used the pedal on the floor to control the speed of the basic warp and weft weaving. The so-called jacquard was perched on the beams directly above the center of the loom. He was responsible for arranging and feeding lines of thread into the weaving process in such a way that a pattern was created. The two weavers worked from designs sketched on paper by the master craftsman, and careful co-ordination between the workers was exceedingly important. The result, as the textile here demonstrates, could be magnificent.

⑬ T'ang Dynasty Architectural Structure

This large wooden piece, spanning almost the entire wall, is a reconstruction of a T'ang Dynasty architectural structure. It is what we call a "bracket system," used to support the massive, overhanging eaves that are typical of traditional Chinese architecture.

As you can see, above each column is a so-called "bracket cluster". It consists of several arms extending out from a central support, fitted

neatly together. The arms act as levers to balance and distribute the weight of the eaves that would have been above, thereby reinforcing the column directly below. The height of the bracket clusters in comparison to the length of the columns below them is a one to three ratio. This is typical of T'ang Dynasty architecture, and gives us an indication of the substantial weight supported by the cluster system.

The bracket cluster appeared as early as the Warring States Period of the 3rd century B.C., and over time became increasingly more elaborate. By the Ming Dynasty, brackets were multiplied to the point of forming a continuous ornamental cornice, and their major purpose was decorative rather than functional. In fact, in the Imperial Palace in Peking, the brackets form a frieze under the roof and the eaves are supported by jutting beams.

⑭ Bracket Clusters

These two wooden clusters are examples of brackets–an architectural feature found only in China. The cluster on the left dates to the 9th century A.D., or late T'ang Dynasty, while the one on the right is in the style of the Ch'ing Dynasty. Only the best wood was used for their construction, and various parts were fitted together snugly like the pieces of a puzzle, requiring no nails or adhesives.

⑭-1 Tang Dynasty Bracket Cluster

This bracket system is a model of one from the late T'ang Dynasty. As you can see, there are numerous wooden slats and joints fitted together, and each component plays a specific role in stabilizing the cluster and in supporting the eave. Extremely large bracket clusters were used during this period, and this model, in fact, is only 1/4 the size of the actual cluster.

⑭-2 Ch'ing Dynasty Bracket Cluster

This kind of bracket cluster was used in Ch'ing Dynasty architecture, between the 17th and 19th centuries. By then, decorative touches were commonly added to brackets, suggesting their more ornamental role at this time. On this example, you can see a cloud pattern carved on the bracket cluster, at the far right end. The size of this model is true to scale, reflecting the smaller dimensions of bracket clusters during the Ch'ing and, therefore, the decreasing importance of their function as supports for heavy overhanging eaves.

⑮ Bronze Chariot No. 2

This chariot is a reproduction of a burial object excavated in 1980 near Sian. The original was one of two bronze chariots found near the tomb of Ch'in Shi-huang, founder of the Ch'in Dynasty and the first emperor of China during the 3rd century B.C. The chariot was modeled on a vehicle used by Ch'in Shih-huang's army and was intended to serve as transportation for the imperial guard in the next world, just as it had in this life. As you can see, the figures of the horses and the imperial driver are amazingly life-like, and the original horses were decorated with elaborate gold and silver ornaments, befitting the position of the emperor. Also, the reins were constructed from intricate metal links which were exact models of their real-life counterparts. After reconstructing the entire chariot from 1,555 fragments, archaeologists were amazed to find these reins still in good working condition.

The intricate detail and fine workmanship of this chariot demonstrates the advanced state of bronze casting technology in the 3rd century B.C., and also the skill of the artisans who produced extraordinary works such as this.

If you move to the front of the chariot, you can see the devices used for preventing the horses from crowding one another. There is a yoke separating the two on the inside,...and the horses on the outside and their neighbors are kept in line by a spike just above their front legs. Notice, also, that the gold and silver studded harness on these outside horses runs around their chests, placing the stress of the chariot there instead of on their necks where Western horses were typically harnessed. Obviously, the chest was a stronger part of the body and horses harnessed in this manner were not in such danger of choking, especially when galloping along at a clipped pace.

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⑮-1 The Royal Tombs of Ancient China

In traditional China, emperors, members of the imperial court, and wealthy aristocrats began to prepare for the afterlife while they were still very much alive. Similar to Egypt's upper class, the Chinese built elaborate tombs and funeral complexes, many of them with satellite tombs surrounding the actual burial chamber. The tombs were often modeled on the imperial court or the palaces of the deceased, with many different rooms, servants quarters, and even stables for the horses. All the amenities of this world were placed inside, including bronze mirrors, jewelry, medicines, cosmetics and models of chariots,

horses, and attendants. In the case of Ch'in Shihuangti, the First Emperor of China, a terra cotta army of over 6,000 thousand soldiers was buried near his tomb to accompany the emperor to the next world, protecting him from attackers and enemies. Until the 7th century B.C., during the Chou Dynasty, it was common practice for soldiers, concubines, and even horses and dogs to be buried alive with the emperor, as his eternal attendants. However, this practice was abandoned with the practice of Confucianism in China, and models of clay or wood were placed in the royal tombs as stand-ins for the people themselves.

⑯ Horizontal Watered-Wheel Bellows

This exhibit is a model of the instrument used for melting metals in ancient China, as early as the 4th century B.C.. During the process of melting metals, or smelting, it was essential to maintain the furnace at a very high temperature, requiring a steady supply of air for the fire. The Chinese answer to such a demand was this watered-wheel bellows. It was built near a river or stream to guarantee a constant supply of running water to move the large horizontal wheel on the bottom front. Notice there is a pole which connects this wheel to that of a smaller wheel just above it. As the two wheels turn, they set the series of pistons behind them into motion. The small wheel, you can see, is linked to the first piston by a red-striped belt. The pistons then pump air into the cylindrical furnace at the far end.

The pistons were able to provide the furnace with a constant blast of air because they did two things at once: they drew in air through one valve, and simultaneously pumped air into the furnace through another valve. This unique feature was an invention in the field of mechanical engineering, and contributed enormously to the advanced state of metallurgy in China. In fact, this ingenious creation is also widely believed to be an early predecessor of the modem-day steam engine.

On this same platform is a smaller model of this bellows which you can operate by turning the wheels. You might want to take a look at it before moving onto the next exhibit.

⑰ Bronze Casting Technique

The technique of casting bronze in ancient China involved a series of steps. They are demonstrated in this exhibit, moving from right to left.

First, a solid model is made from clay. Next, in the second case, the model is encased in a thick layer of clay which is allowed to dry and is then cut into sections and pried off. This becomes the outer mold. In step #3, detailed decorations are carved onto the outer mold. And in step #4, inscriptions are added to the model-the piece in the center here. Afterward, in the following step, some of the model's surface is scraped off, making it slightly smaller than the mold. The differences in the sizes of these two will determine the thickness of the bronze vessel that is eventually created. In the next step #6, the pieces of the mold are fastened around the model and a hole is drilled in the top. Then, farther to the left, the sealed mold is fired at 600 degrees C before molten metal is poured through the hole, into the space between the two solid pieces of clay. Finally, in step #8, the mold and model are removed once the bronze is cool, and the surface of the bronze vessel is polished.

Chinese craftsmen preferred to cast their vessels in one pour, but sometimes the desired shape was too complicated to be achieved through a single casting. So, individual parts were added on to the main casting after it was completed.

⑰-1 Bronze Age

Around 1,500 B.C., a Bronze culture was developed on the plains of the Yellow River Valley, representing a major watershed in the development of Chinese civilization. Before, metal objects were made only of copper. But now, the addition of tin increased the metal's hardness and also made it quicker to melt and easier to control.

Despite its superior hardness, bronze was generally not used for common tools or agricultural implements in traditional China, but became almost a monopoly of the aristocracy. A Chinese king presented a loyal subject with bronze the way a Western ruler might hand out gold, and from the outset bronze was used to create majestic vessels that played central roles in state rituals and ancestor worship. We owe the preservation of these ancient vessels to the fact that they were buried, for they also took pride of place in the tombs of the royalty and upper class.

The Bronze Age officially ended between the 6th and the 5th centuries B.C., when cast iron began to be used in quantity. But iron never achieved the status of bronze and was used primarily for tools and weapons in which its superior strength could be exploited.

⑱ Bronze Vessels from the Shang Tomb of Fu Hao

The cases of this exhibit contain replicas of bronze vessels which all come from an extraordinary tomb, discovered intact in 1976 at Anyang, Honan Province. The tomb belonged to a woman named Fu Hao who lived during the 13th century B.C., and was a consort of king Wu Ting of the Shang dynasty. Fu Hao was a woman of some consequence who led military expeditions on behalf of the king and on other occasions presided in his name at state sacrifices. Though her grave was unpretentious in scale, it contained nearly 200 bronze ritual vessels-an extraordinary number for any tomb of the period.

The decorations on these pieces, as you can see, are cast in high relief, and explore a wide variety of treatments and textures, including images of coiled snakes, birds, elephants, rams, mythological creatures, geometric patterns, and swirling motifs. The effect is one of remarkable energy and somewhat bewildering exuberance.

⑲ Chime Bells

Chime bells play an important role in the rituals of ancient China. Cast in bronze, they produced a rich range of sound when struck. They were played hanging from a wooden rack, as shown here, by striking the curved edge of the bells. A single bell could produce two different notes, depending on whether the musician tapped it on center or the side of its edge. And in principle, the more curvaceous the bell's shape, the more it reverberated. When making a set of bronze chimes, artisans were faced with the challenge of producing a wide range of notes that harmonized but did not duplicate one another. During formal ceremonies, music from instruments like these accompanied chanting and dancing, adding to the festivity as well as the grandeur of the occasion.

⑳ Development of Chinese Lacquer Wares

Lacquer wares were widely used in China as early as the Shang Dynasty, five thousand years ago, and have served ornamental as well as functional purposes ever since. The sap from the lacquer tree was first used as a coating over objects made from wood, bronze, cloth, and even precious metals to protect them from water and heat. Then artists began adding various mineral pigments to the lacquer resin, creating vibrant colors and striking, decorative surfaces.

Up until the 2nd century A.D., at the end of the Han Dynasty, China's elite used lacquer wares as everyday objects. Decorations were almost always painted on the surface, as in the large tray here, holding several bowls and cups ... and in the chipped plates on either end of the first row.

During the 9th century **A.D.,** carved lacquers became popular and reached a peak in production a few hundred years later, by the Ming Dynasty. Both the large plate in the front row and the boxes in the back were made by first applying numerous layers of lacquer to their surfaces, and then carving the design into the lacquer. The manufacture of the best lacquer ware requires many hundreds of layers, each one drying before the next is added - a process that can sometimes take over ten years to complete.

㉑ Development of Chinese Pottery and Porcelain

In this exhibit you can see some of the major achievements in Chinese ceramics. For example, on the front row, at the right, are four jars, showing how the famous blue and white porcelain was painted with cobalt and glazed, before being fired at a very high temperature.

On the left side of the case, also at the bottom, are four plates which demonstrate the stages involved in producing a painted dish. First the dish was fired with a clear glaze at a high temperature; then decoration was painted on the surface; and finally the vessel was fired again at a lower temperature.

In the center of the front row, mounted on black velvet, is a shallow bowl from the Sung Dynasty-the time when China's ceramic production reached its peak. It's an extremely fine piece, especially valued for it beautiful translucent quality.

On the back row, at the far right, is a bowl from the T'ang Dynasty. It was a burial object, made in the san-tsai, or three colors, method-a technique for decorating pottery developed during the T'ang. Whites, greens, yellows, and sometimes blues were used together in lively combinations, reflecting the daring and cosmopolitan spirit of the times. But because the glaze used in the three-color method contained a toxic lead, it is clear that these items were produced exclusively for funerary purposes.

At the left, on the center and back rows, are six porcelain bowls which were produced in very different areas of China during the Sung Dynasty. Each one comes from a famous kiln of the period, and here you can compare for yourself the beauty and craftsmanship of these exquisite pieces.

㉑-1 How Porcelain Is Made

The art and technique of porcelain-making is one of China's most important contributions to the world. It is no coincidence that the English word "china" has come to mean porcelain because the Chinese began making porcelain wares about two thousand years ago.

Chinese porcelain consists essentially of two elements–a very fine white clay and the stone feldspar. It is the fine clay which distinguishes it from pottery and produces porcelain's unmatched hardness and translucency, allowing artisans to make thin and delicate objects with beautiful glazes. The best pieces of feldspar stone are reserved for the glaze which also contains lime, giving the porcelain its characteristic tinge of green or blue. In fact, in the Sung Dynasty, artisans worked to produce porcelains that imitated jade.

In ancient China it took several days to fire porcelain vessels in a kiln that was heated up to 1,200 degrees centigrade.

㉒ Sakyamuni Pagoda of the Fo-kuang Temple

This pagoda is a model of the largest and oldest existing wooden structure in China, located at the Fo Kuang Temple in the northwestern province of Shansi. It was built nearly a thousand years ago and is considered an architectural marvel, in part because it has stayed intact despite several major earthquakes

The octagonal shape reflects the tendency in Chinese architecture, beginning in the Tang Dynasty, to move away from mostly square buildings to those with more interesting, experimental shapes. As you can see, there are five tiers, each one with large eaves supported underneath by rows of decorative wooden brackets. These brackets represent more than 25 different designs, beautifully carved and serving an ornamental as well as a functional purpose. Under the eaves are walkways with balconies that wrap around the building and are a distinctive feature of the pagodas of this period. These create the appearance of a building consisting of five tiers, while in fact this structure has nine layers, or tiers, visible only on the interior.

㉒-1 History and Architecture of Pagodas

A pagoda is a hexagonal or octagonal building consisting of an uneven number of tiers-usually between three and nine. It combined the round form of the Buddhist stupa, or sacred structure, with the square of most traditional Chinese buildings to create a new architectural form.

The earliest pagodas were religious buildings and, in a sense, can be compared to Medieval churches in Europe. They stood in prime locations, and housed the shrine as well as the ashes of the deceased. But by the 13th century, pagodas had become more detached from religious concerns and most were built for purely scenic or memorial purposes. Many are found on hillsides, providing spectacular views, and were built to secure the good fortunes of the surrounding neighborhood.

Most pagodas were constructed of wood, which unfortunately has resulted in very few surviving structures. Almost all the ones that still stand today are made of bricks.

㉒-2 Buddhism

Buddhism was brought to China by an Indian monk in the year 2 B.C., becoming the first great foreign religion to mingle with indigenous Chinese beliefs. Though the Chinese were acquainted with all schools of Indian Buddhism, the Mahayana views, considered to be the most compassionate and tolerant, ultimately had the greatest appeal and popularity with the masses.

Buddhist teachings began with the truth that life is an endless cycle of births and deaths in a sorrowful world. This stream of existence and flux, known as the wheel of life and death, was based on the idea of rebirths, or reincarnations, which were determined by one's acts and deeds, or karma. The karma accumulated at each stage of existence played an essential role in the future of a being until one ultimately acquired the moral and mental discipline to achieve enlightenment or Nirvana. In Sanskrit, Nirvana can be translated as "extinction," and in Buddhism it came to mean an end to the painful chain of life, and a blissful oneness with the Ultimate Reality. In the popular mind, this indescribable Nirvana was equated with the idea of a heavenly repose, a point of view particularly encouraged by the Mahayana school.

㉓ Four-tiered Green-glazed Tower and Hexagonal Tower

These two ceramic green-glazed towers are burial objects from the Han Dynasty. Obviously the people who took them to their graves believed that towers would be just as important to life in the next world as in the world of the present. The taller one has human figures on every level, some of them looking out in the distance, while others guard the territory with bows and arrows. As you can see, flower motifs were popular as decorative

touches in architecture at this time, and birds, too, often adorned the rooftops of buildings, such as on the smaller tower here.

The small tower was a very unusual find because of its hexagonal shape. In fact, it is the only one of its kind to date. This is because most: towers during the Han had four sides, and so, of course, grave objects in the form of towers usually were four-sided as well.

㉓-1 Green-glaze Technique

During the Han Dynasty, tombs, even of the middle class, were stocked with clay models of everything the dead might need in the next life, from stoves and furniture to goat pens and pigsties. The demand on potters of the time grew so great that the carefully hand-painted burial objects of earlier years became impractical. Grave ceramics were now covered with a cheap, easily applied lead glaze fired at the relatively low temperature of between 700 to 800 degrees Celsius. This low-fire glaze allowed potters to work more quickly and to save money on fuel, leading to mass production of these green-glazed objects.

Even the ruling class saw the economic advantages of this glazing technique. Traditionally bronze was the most valuable material for burial goods in ancient China. But for some members of the elite class, bronze was too costly. As a result, the green-glaze technique provided an adequate alternative because it gave burial objects the appearance of being made of bronze.

Some people say that the Chinese learned about these lead glazes in their experiments to find elixirs of immortality. Ironically, the lead itself was toxic, and, therefore, the glaze could only be used on burial objects.

㉓-2 Burial Practices of the Han Dynasty

By the Han Dynasty, funerary vessels modeled of clay were mass produced in China, making them much more affordable and popular to people outside royal circles. This, to some extent, may explain why burials of the Han Dynasty were so much richer than in previous periods, chock full of ceramics, much to the delight of archaeologists and art historians alike. Another factor contributing to the extravagance of Han burials was the state's promotion of Confucianism, including the concept of filial piety, or respect for one's parents. Honoring one's parents in death as well as life was an important aspect of filial piety, and some people incorrectly took this to mean that the money spent on grave goods was a direct measure of one's devotion to the dead. Also, a decent burial was believed to be very helpful in assuring a happy, comfortable future for the descendants of the deceased.

㉓-3 The Significance of the Han Dynasty in Chinese History

The Han Dynasty was one of China's greatest periods and, in fact, later generations of Chinese proudly called themselves "the people of Han." It was founded in 202 B.C., and lasted for over 300 years. The key to its success was a blend of diverse schools of thought under powerful and energetic emperors. Confucianism and Legalism, philosophies that are poles apart, both played a role in government policies, and art and literature reflected a similar balance of Confucian and Taoist elements. The economy involved both state monopolies and private enterprise, and Han foreign relations were marked by aggressive expansion and appeasement. In fact, in the areas of government, foreign policy, the arts, and scholarship the Han set the style and pattern for most later dynasties, up to the 20th century. Interestingly enough, the Han existed around the same time as the Roman Empire, and the two civilizations were comparable in terms of their achievements and long-lasting influence on the history of the world.

㉔ Han Dynasty Architecture

These ceramic buildings are burial objects from the Han Dynasty. Such models were commonly placed in the tombs of wealthy individuals, and reveal something about their activities and daily lives, as well as about the architecture of the time. For example, the large painted structure in the center shows how a four-story house looked, complete with its occupants on the various levels, and a dog guarding the front door. On the roof, is a bird–a decorative motif that appeared often in Han Dynasty architecture.

In the case at the right are models of two other residential buildings from the Han. Both are typical of the architecture of southern China, and are early versions of the design known as the "courtyard house." This same design is preserved in architecture over the next several centuries, even as houses became more complex and expansive.

In the case at the far left is a small water tower with miniature human figures standing on the lookout. Scattered around them are various

domesticated animals, creating quite a lively scene. The reservoir below not only provided atmosphere and protection for the residents, but was also an immediate water source for putting out fires.

Architecturally, this tower illustrates one of the unique features of Chinese design. Under the eaves, extending out from the sides of the building, are a series of supports known as "bracket clusters." These can also be seen under the balcony, bearing the weight of the heavy structure overhead. The surface of this tower has a translucent color which demonstrates a magnificent execution of the green glaze so frequently used on burial objects of this era.

㉕ Architectural Elements from Tombs

Here we see some elements from tombs in the Han Dynasty – tiles and architectural details that come from the interiors. They reveal how people attempted to recreate in their burials the same pleasant surroundings and artistic touches of life in this world.

At the top are small round objects called end tiles, used as ornaments on the slanted roofs of Chinese houses. Beneath them, on the middle row, are three bricks that each depict a scene from daily life, showing the architecture, costumes, and activities of the period. The series of large bricks on the bottom row illustrate a great procession. On the last brick -- the one at the far right -- you can see a clear paw print. It was apparently made by a large dog which stepped onto the wet brick, leaving a most unexpected imprint on history.

㉖ Ink Rubbing from Tomb-wall Carving

Here we see an ink rubbing taken from a tomb of the Eastern Han Dynasty. The tomb belonged to a member of the land-owning gentry, and ink rubbing itself depicts the wealth and extravagant lifestyle of its occupant. As you can see in the picture, a grand feast is taking place.

The large house dominates the scene with its eaves providing cool shade for the five men seated in the center. As was customary during this era, they are sitting on mats placed on the ground. Laid out before them are trays of food and drinks, and for their entertainment, two minstrels are accompanying the dancers at the left. To the right, on the bottom, is a horse-drawn chariot and three attendants. Above them are more servants amidst the preparation of food. Food, of course, played a central role in all Chinese functions, just as it does today. You will find further evidence of this just to the right of the house, where a granary stands, suggesting the prosperity and abundance enjoyed by the gentry.

㉗ An-Chi Bridge

This model of a bridge represents one of ancient China's great landmarks–the structure popularly known as "Big Stone Bridge" at Chao Chou in Hebei province. Built during the Sui dynasty, at the end of the 6th century, it was the world's first large, modified arch bridge and is still standing today, over 1300 years later. The design is absolutely unique–a span of 123 feet in the form of a graceful crescent. It is more elongated than the normal arch bridge, making travel along the roadway at the top less difficult. And as you can see, the roadway is bordered by a handsome carved stone balustrade to beautify the crossing.

On each side of the bridge are two small cut-out arches, four altogether. The purpose of these is not only to lighten the weight of the bridge and to reduce the load on the main arch, but also to provide spillways for floodwater. This unique feature had a great influence in the field of bridge building and was later used in other structures throughout China.

This bridge was built at a time when immense public works were undertaken in China to improve communications of the empire. The engineer, Li Chun, was a master bridge builder, and this design was perfectly suited to conditions in northern China–a flat region where rivers often flooded and where people traveled heavily on both roads and waterways.

㉗-1 Chinese Bridge Building

Chinese bridges have a beauty of their own, as well as being of great importance in a country with many rivers and a vast system of artificial waterways. Besides rainbow and arch bridges, the Chinese also pioneered the design of the suspension bridge in the 3rd century B.C. At first the cables were made of bamboo, followed by iron chain-link suspension bridges in the 6th century. The use of iron chain links was adopted in European bridge building after the beginning of the 18th century, and it is possible that the techniques involved were learned from the Chinese.

㉘ Rainbow Bridge

Here we see a structure often called a "rainbow bridge"–that is, a bridge made of timber that spreads across the sky like a rainbow. The model for this exhibit was the most famous rainbow

bridge in traditional China. It was located just outside the capitol of the Northern Sung Dynasty, Kaifeng, and is depicted in a glorious scroll entitled "A City of Cathay." As you can see, the arch of the bridge has been formed by a network of wooden beams, criss-crossed vertically and horizontally. The fact that such an arched span was achieved in this way without the use a central pillar for support is among the finest Chinese achievements in the field of engineering.