



◀ The first mechanical clock used a water wheel to create sounds every quarter hour.

Chinese Discoveries and Inventions

18.1 Introduction

In Chapter 17, you learned about economic changes in China during the Song dynasty. In this chapter, you will explore **discoveries** and **inventions** made by the Chinese between about 200 and 1400 C.E. Many of these advances came during the Tang and Song dynasties.

Over the centuries, Chinese scholars and scientists studied engineering, mathematics, science, and medicine, among other subjects. Their studies led to impressive scientific and technological progress that was often far ahead of European advances.

To understand the importance of one Chinese invention, imagine that you are a trader in the 10th century. You are far out at sea on a Chinese junk loaded with goods you are bringing to Korea. Without any landmarks to guide you, how do you know which direction you're headed? Normally you might steer by the sun or the stars. But what if clouds cover the sky? Can you still figure out which way to travel?

In the past, you might have been lost. But thanks to the magnetic compass, you can find your way. Your compass is a magnetized needle that aligns itself with the Earth's magnetic poles so that one end points north and the other south. By the Song dynasty, the Chinese were using this type of compass to help them navigate on long voyages. People still use the same kind of device today.

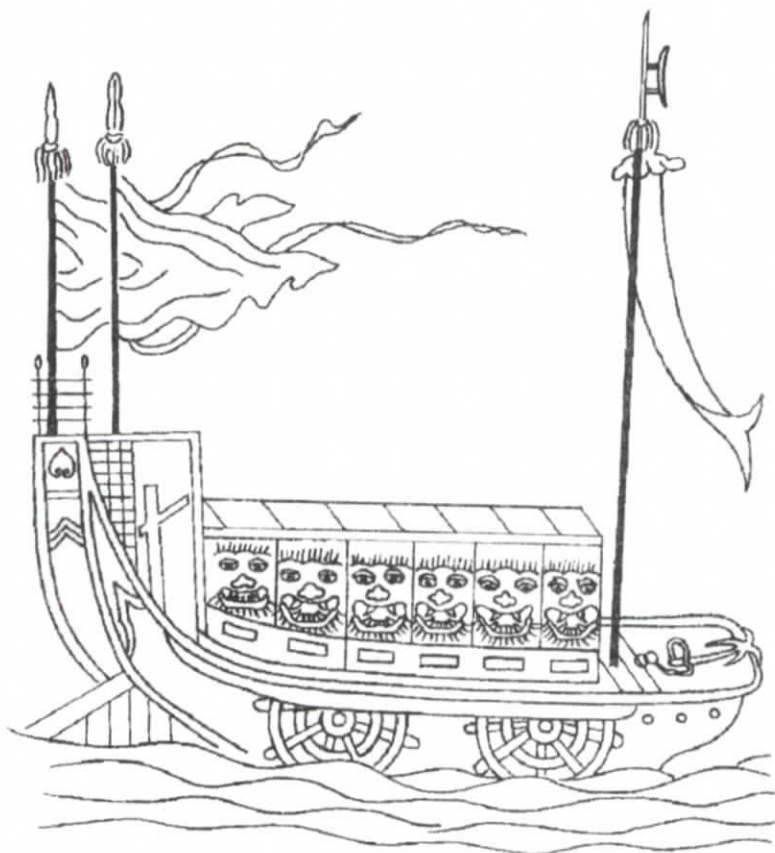
Like the compass, other Chinese inventions and discoveries allowed people to do things they had never done before. In this chapter, you will learn about Chinese advances in **exploration** and **travel**, **industry**, **military technology**, **everyday objects**, and **disease prevention**. As you'll see, the influence of many Chinese ideas reached far beyond China.



Use this illustration of a scroll as a graphic organizer to help you remember the Chinese discoveries and inventions you learn about.

18.2 Exploration and Travel

Several Chinese inventions made exploration and travel safer and faster. Some innovations benefited traders and other voyagers who ventured out to sea. Others improved travel on rivers, lakes, canals, and bridges inside China.



Paddlewheel boats were easily maneuvered, which made them effective warships.

By the Song dynasty, the Chinese were using magnetic compasses for navigation at sea. Compasses made long sea voyages possible because sailors could figure out directions even without a landmark or a point in the sky to steer by. The compass remains an important navigational tool today.

The Chinese also made sea travel safer by improving boat construction. By the second century C.E., they discovered how to build ships with watertight compartments. Builders divided the ships into sections and sealed each section with caulk, a sealant that keeps out water. If there was a leak, it would be isolated in one compartment. The other compartments would stay dry, keeping the ship afloat. Modern shipbuilders still use this technique.

Improving Travel on Rivers, Lakes, Canals, and Bridges Within China, people often traveled by boat on rivers or across lakes. An invention called the *paddlewheel boat* speeded up this type of travel.

Improving Travel by Sea

The Chinese developed the first compass as early as the third century B.C.E. The first Chinese compasses were pieces of a magnetic mineral called *lodestone*. The Earth itself is like a giant magnet with north and south poles. Because lodestone is magnetic, it is influenced by Earth's magnetic poles. If you put a piece of lodestone on wood and float it in a bowl of water, the lodestone will turn until it points in a north-south direction.

The Chinese eventually replaced the lodestone with a steel needle. They had learned that rubbing a needle with lodestone made the needle magnetic. A needle used as a compass gave a more accurate reading than a piece of lodestone.

Have you ever paddled a canoe or other small boat? As you push your paddle through the water, the boat moves forward. In the fifth century, the Chinese adapted this idea by arranging a series of paddles in a wheel. As the paddlewheel turned, the paddles moved continuously through the water, causing the boat to move forward.

Paddlewheel boats allowed the Chinese to travel much faster on rivers and lakes. We still use this type of boat for pleasure trips today.

Another innovation, the **canal lock**, was invented in the 10th century, during the Song dynasty. As you've learned, the Chinese used canals extensively. As the surrounding land sloped up, parts of canals were at different levels. Before canal locks were invented, the Chinese had to drag their boats up stone ramps to reach water at a higher level. Sometimes the boats would be seriously damaged.

Canal locks solved this problem. When a boat entered the lock, a gate was lowered to hold in water. The water was then allowed to rise until it reached the level of the water up ahead. Then the boat floated on. To go "downhill," water was let out of the lock until it fell to the level of the water down below.

The invention of locks made canal travel much easier. Locks could raise boats as much as 100 feet above sea level. They are used today on rivers and canals around the world, including the famous Panama Canal.

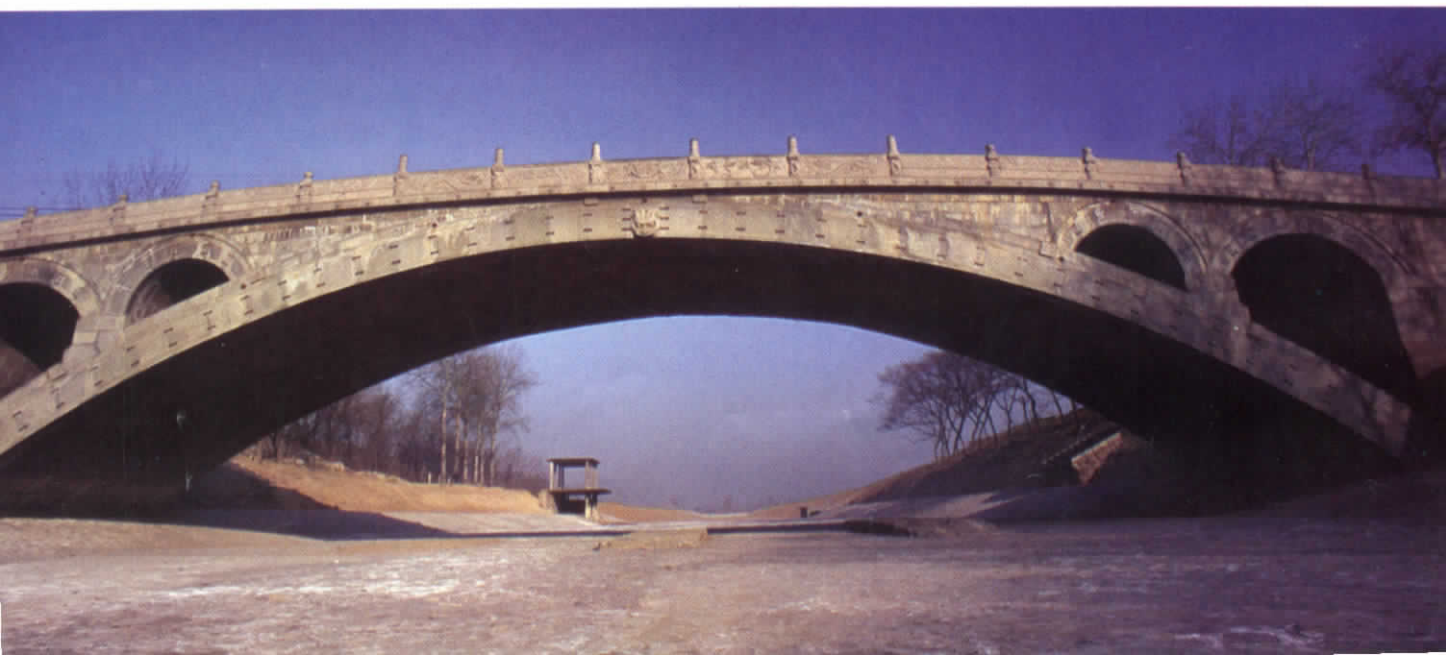
The Chinese also found ways to improve bridges. For example, in 610 C.E., a Chinese engineer invented a new type of arched bridge. In Europe, Roman-designed bridges rested on arches that were half-circles. The new Chinese bridge used arches that were a smaller part, or segment, of a circle. This made the bridges broader and flatter than semicircular arches. Called a **segmental arch bridge**, the new bridge took less material to build, and it was stronger as well.

The segmental arch bridge is one of China's most prized technological achievements. Today bridges with this design stretch over expressways around the world.

canal lock a gated chamber in a canal used to raise or lower the water level

segmental arch bridge a bridge supported by arches that are shallow segments (parts) of a circle

The Great Stone Bridge spanning the river Chiao Shui was the world's first segmental arch bridge. It has a span of 123 feet.



movable type individual characters made of wood or metal that can be arranged to create a job for printing and then used over again

The scene on the woodblock below (center) was carved with the engraving tools shown. It was then covered with ink, and paper was pressed onto it to create the print at the bottom. Notice that the printed scene is a mirror image of the carved scene on the woodblock.



18.3 Industry

Some of the advances made by the Chinese led to new industries. In this section, you'll learn about China's paper, printing, porcelain, and steel industries.

Paper The Chinese invented the art of papermaking by the second century C.E. The earliest Chinese paper was probably made out of the bark of the mulberry tree. Later, rags were used.

Papermaking became an important industry in China. For more than 500 years, the Chinese were the only people in the world who knew the secret of making paper. From China, knowledge of papermaking traveled to Japan and across Central Asia. Europeans probably first learned about this art after 1100. Considering how important paper is for recording and transmitting information, it's hard to think of an invention that touches our daily lives more today.

Printing The invention of paper made another key development possible—printing. In about the seventh century, the Chinese invented a technique called *woodblock printing*. The printer first drew characters (symbols) on paper. He then glued the paper to a wooden block. When the glue was dry, the printer carved out the wood around the characters, leaving the characters raised on the wood.

To print from the block, the printer covered the characters with black ink. Then he spread paper over the block and smoothed the paper with a brush. Some artists still use block printing today to create fine art prints.

By the 8th century, there was an entire woodblock printing industry in China. Printers turned out religious and other works on scrolls. In the 10th century, the Chinese started printing modern-style books with pages.

In the 11th century, during the Song dynasty, the Chinese invented **movable type**. Movable type consists of separate blocks for each character. Printers made their type by carving characters out of clay and baking them. To print, they selected the characters they needed and placed them in an iron frame in the order they would appear on the page. When the printing job was done, the type could be removed from the frame and used again.

With the invention of movable type, printers no longer had to create a new set of woodblocks for each item they printed. This dramatically

lowered the cost of printing. By making written materials more widely available, advances in printing helped spread learning throughout China.

Europe first developed movable type in the 1400s. Until recently, all newspapers, books, and magazines were printed using movable type.

Porcelain A famous Chinese invention is the type of fine pottery called **porcelain**. Some historians think the first porcelain was made as early as the first century C.E.

Porcelain is made by combining clay with the rocks quartz and feldspar. The mixture is baked in a kiln, or oven, at very high temperatures. The resulting pottery is white, hard, and waterproof. Light can pass through it, which makes it look quite delicate and beautiful.

By the 10th century, the Chinese were making porcelain of great beauty. Craftspeople learned how to paint pictures on porcelain pieces. They also made colored glazes to decorate their porcelain.

Porcelain making became a major industry in China. Hundreds of thousands of people worked to **mass-produce** dishes, bowls, and vases. Some washed the clay. Others applied the glaze or operated the kiln.

Chinese porcelain became a prized item for trade. The Europeans did not learn how to make fine porcelain until the 18th century.

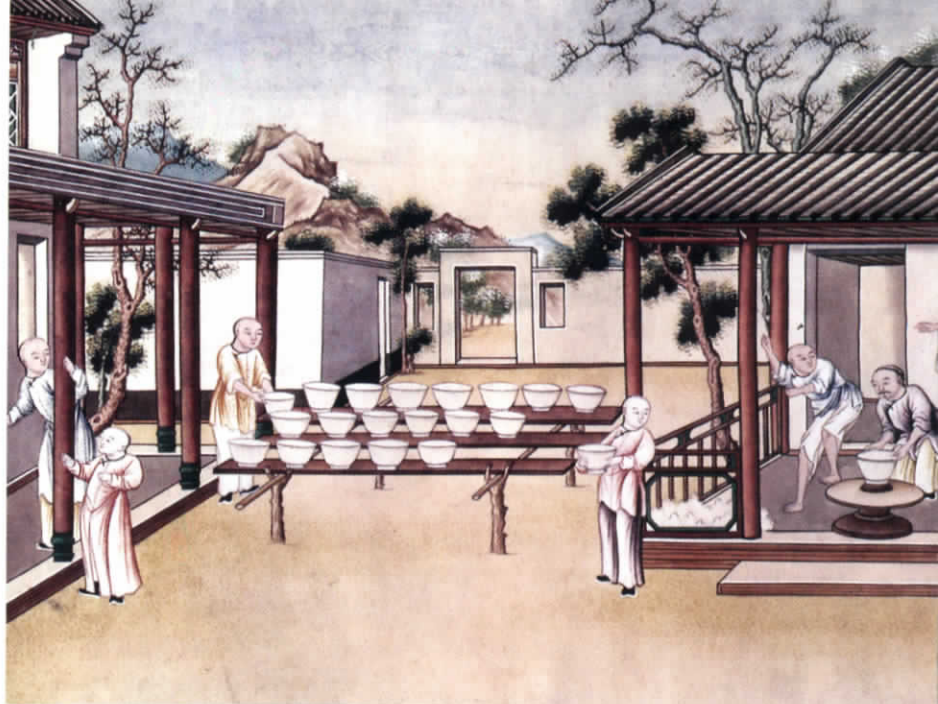
Many people think that medieval Chinese porcelain is the finest in the world. People today still refer to fine dinnerware as “china.”

Steel The Chinese first made steel, a very useful metal, before 200 B.C.E. Steel is made from iron, but it is less brittle than iron and easier to bend into different shapes.

The earliest Chinese steel was made from cast iron. The Chinese were the first to learn how to make cast iron by melting and molding crude iron. Later they learned that blowing air onto molten (melted) cast iron causes a chemical reaction that creates steel.

In the fifth century, the Chinese learned to mix cast iron with wrought iron. Wrought iron is softer than cast iron. Combining these two forms of iron under high heat changes them into steel.

These discoveries eventually made it possible to produce large amounts of steel cheaply. In the 1800s, the mass production of steel was crucial to the European Industrial Revolution. Today, iron and steel making are among China’s most important industries.



The art of making porcelain was invented in China and became a major industry there.

porcelain a hard, white pottery; also called *china*

mass-produce to make similar items in quantity by using standardized designs and dividing labor among workers

gunpowder an explosive powder made of saltpeter and other materials

alchemy a combination of science, magic, and philosophy that was practiced in medieval times

catapult a slingshot-like war machine used for shooting rocks, shells, and other objects

18.4 Military Technology

During the Song and Mongol periods, the Chinese developed powerful weapons. The invention of **gunpowder** made these weapons possible.

The Chinese who first made gunpowder were alchemists, people who practiced a blend of science and magic known as **alchemy**. Alchemists experimented with mixtures of natural ingredients, trying to find a substance that might allow people to live forever. They also searched for a way to make gold out of cheaper metals.

Chinese alchemists experimented with a salty, white mineral called *saltpeter*. They may have believed that saltpeter could extend life.

Perhaps by accident, they discovered that it could be used to make an explosive powder. In 850 C.E., during the Tang dynasty, alchemists recorded a formula for gunpowder. They warned others to avoid it because it was dangerous.

In the 10th century, the Chinese made the first weapon that used gunpowder: the flamethrower. Early flamethrowers contained gunpowder mixed with oil. The Chinese used them to spray enemies with a stream of fire.

Between the 11th and 14th centuries, the Chinese created many other weapons using gunpowder. Artillery shells, for example, exploded after being hurled at enemies by a **catapult**. The sound of the exploding shells confused the enemy and terrified their horses. Small bombs called *grenades* were lit and thrown by hand.

In the 13th century, the Chinese used large bombs that were as explosive as modern bombs. Around the same time, they developed weapons much like today's rifles and cannons.

Travelers brought knowledge of gunpowder to Europe by the early 1300s. Gunpowder changed the way war was waged in Europe and around the world forever. Weapons like crossbows and spears gave way to guns and artillery.

Rocket technology was developed in China during the Song dynasty. Rockets used a black powder made of saltpeter, charcoal, and sulfur. At first rockets were used only in fireworks. Later the Chinese used them as weapons. They even made a two-stage rocket for their armies. The first stage propelled the rocket through the air. The second stage dropped arrows on the enemy.

By 1300, rockets had spread through much of Asia and into Europe. The rockets that we use to explore space today are based on principles discovered by the Chinese.



This model of a 14th-century bees' nest rocket launcher was re-created based on a medieval drawing and written descriptions.



18.5 Everyday Objects

Do you ever play games with a deck of cards? If so, you're using a Chinese invention. The Chinese invented a number of the everyday objects we take for granted today, including playing cards, paper money, and mechanical clocks. All these inventions came during the Tang dynasty.

Playing cards were invented in China in about the ninth century. Printers used woodblock printing to make the cards from thick paper. Famous artists drew the designs that appeared on the backs of the cards.

Europeans were introduced to playing cards by around 1300. Today, card games are played throughout the world.

Paper money was invented by the Chinese in the late eighth or early ninth century. Before that time, coins were the only form of currency.

Like playing cards, paper money was printed with wood blocks. By 1107, Song printers were using multiple wood blocks to print each bill. A single bill would have many colors. Paper money is the most common form of currency in the world today.

The Chinese developed the first mechanical clock in about the eighth century. The new clock was more accurate than earlier time-keeping devices such as sundials and hourglasses. The Chinese devised a wheel that made one complete turn every 24 hours. Dripping water made the wheel turn. Every quarter hour drums would beat, and every hour a bell would chime. The sounds let people know what time it was.

The Chinese improved the mechanical clock in 1092, during the Song dynasty. The new clock worked on the same principles as the first one, but it was much more complex and accurate.

Europeans first developed mechanical clocks in the late 1200s. As with Chinese clocks, a bell rang to indicate the hour. Later, dials and hands were added. Modern-day mechanical clocks are based on the same fundamental principles as early Chinese clocks.

Playing cards were invented in about the ninth century in China. A typical pack had 30 cards, and many different games were played with them.

Doctors and patients in China during the Middle Ages benefitted from new knowledge of medicine and treatment of diseases.



18.6 Disease Prevention

Chinese knowledge of medicine and disease prevention dates to ancient times. Before the first century C.E., the Chinese developed a way of fighting infectious diseases. (An infectious disease is one that can spread from person to person.) When someone died of an infectious disease, the Chinese burned a chemical that gave off a poisonous smoke. They believed that the smoke would destroy whatever was causing the disease.

Today we know that many diseases are caused by germs. We prevent the spread of disease by using disinfectants (substances such as bleach that kill germs). The poisonous smoke used by the Chinese was a type of disinfectant.

During the Song dynasty, the Chinese discovered another way to prevent the spread of disease. A Chinese monk recommended steaming the clothes of sick people. He believed that the steam would prevent others from becoming ill. The idea was sound, because hot temperatures kill many germs. Today we boil medical instruments to kill disease-causing germs.

Sometime around the 10th century, the Chinese discovered how to **inoculate** people against smallpox, a dreaded infectious disease. Inoculation is a way of stimulating a person's **immune system** to fight a particular disease. It works by exposing the person to a disease-carrying substance. To inoculate people against smallpox, Chinese physicians took a small part of a scab from an infected person and

inoculate to protect against disease by transmitting a disease-causing agent to a person, stimulating the body's defensive reactions

immune system the body's natural defense against disease

made it into a powder. Then they inserted the powder into the nose of the person they wanted to immunize (protect against the disease).

The Chinese knew that they had to take care when exposing people to smallpox. Sometimes the treatment itself caused people to become ill. To be as safe as possible, the Chinese took the infectious material from people who had already been inoculated.

Chinese knowledge about smallpox inoculation eventually led to the development of drugs called **vaccines**. We now have vaccines for many diseases, including smallpox and the flu.

vaccine a substance used to immunize people against a disease

We owe a debt to China for many of our modern advances. The invention of rockets, for instance, was the first step toward space exploration.

18.7 Chapter Summary

In this chapter, you learned about Chinese inventions and discoveries between about 200 and 1400 C.E. The influence of many of these advances spread far beyond China. Many Chinese inventions and discoveries continue to affect our lives today.

Several Chinese ideas improved travel and exploration. They include the compass, paddle-wheel boats, canal locks, and segmental arch bridges. Advances in papermaking and printing helped spread learning. Chinese porcelain became famous for its quality and beauty. The Chinese also discovered ways of making steel.

The Chinese revolutionized military technology. They discovered how to use gunpowder to make powerful weapons. They also developed the first rockets.

A number of Chinese inventions enriched people's everyday lives. Among them are playing cards, paper money, and mechanical clocks. The Chinese also made great strides in medicine and disease prevention. They developed the first disinfectants and discovered how to inoculate people against smallpox.

These scientific and technological advances were often far ahead of those made in Europe. Several, such as paper and gunpowder, eventually made their way to the western world. But the Chinese generally had little contact with other cultures. In the next chapter, you will learn more about the relationship between China and the outside world.

