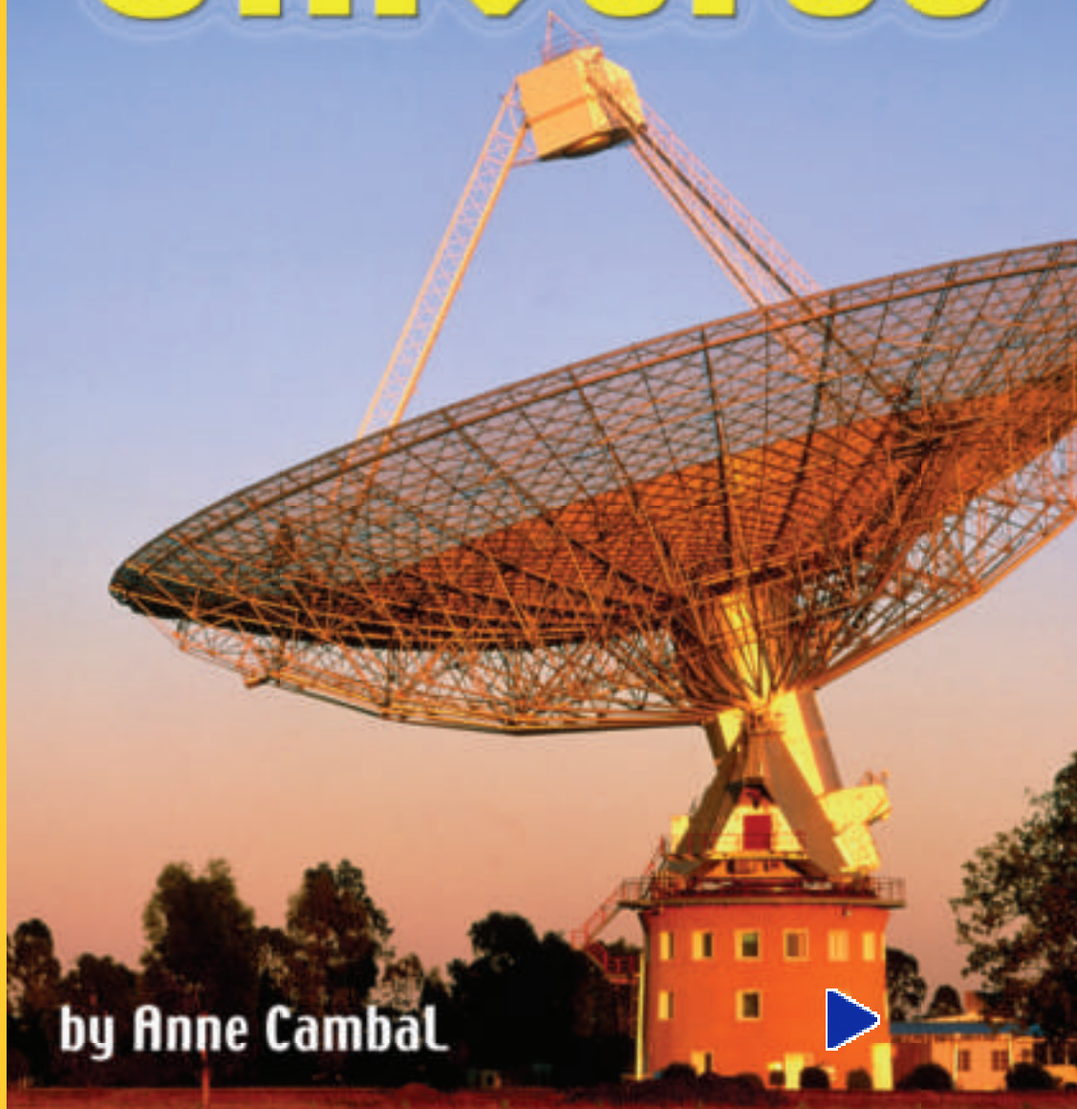
Science

Science

Space and Technology

Exploring the Universe



by Anne Cambal

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Summarize	• Labels • Captions • Diagrams • Glossary	Stars and Galaxies

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Vocabulary

black hole
constellation
galaxy
light-year
nebula
supernova

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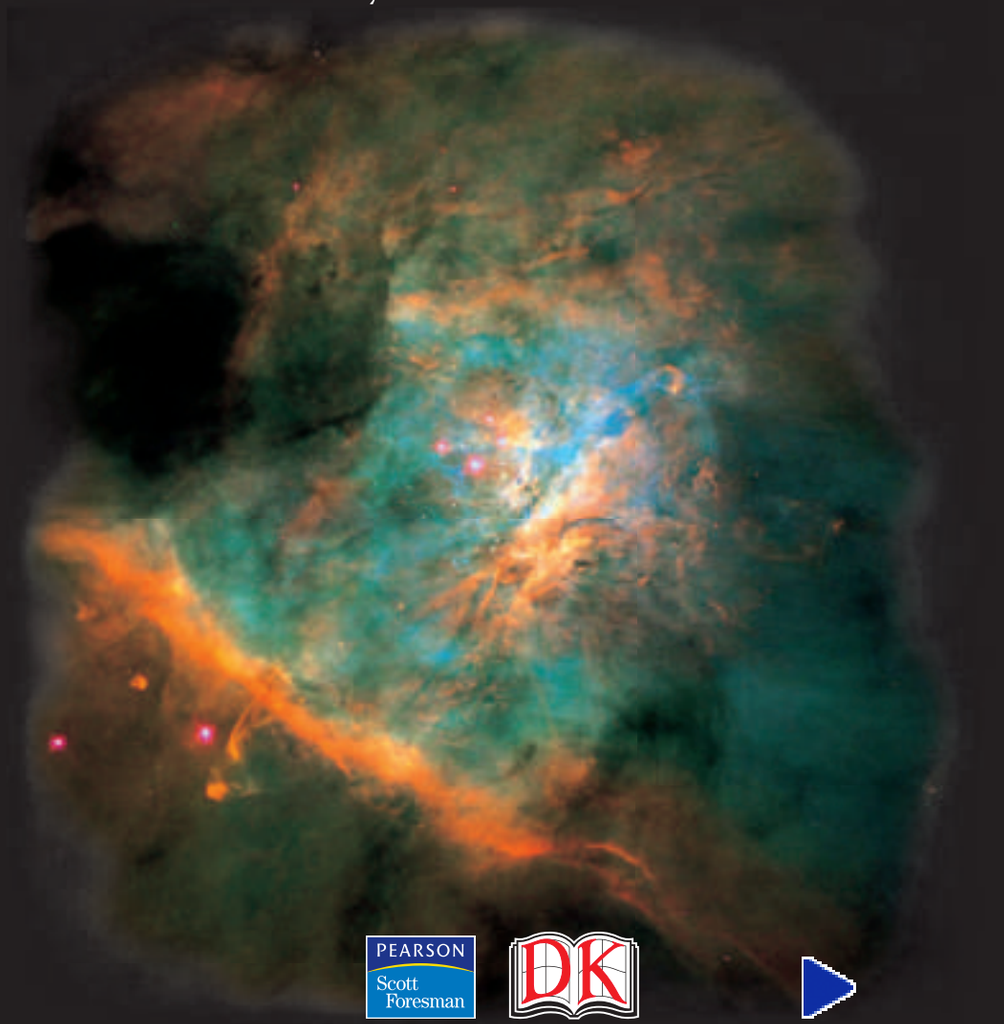

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The History of Astronomy

Patterns in the Sky

It's a cold, rainy day at the end of winter. You are tired of this weather, and you want to know when it will be warm enough to go swimming. How will you find out when the seasons will change? You will probably look at a calendar. But what would you do if there were no calendars?

People solved this problem thousands of years ago by observing the night sky. Ancient people needed to know when the seasons would change so they would know when to plant their crops. They noticed that the Sun, the Moon, and the stars moved in regular patterns. The patterns were visible at the same time each year. Calendars were made based on these patterns.

Eclipses

When ancient people saw something in the sky that did not fit into the normal patterns, they often became alarmed. For example, today we know that an eclipse is a rare but normal event. A solar eclipse happens when the Moon blocks our view of the Sun. A lunar eclipse happens when Earth casts a shadow on the Moon. Long ago, people did not understand eclipses. They thought these events meant that something very bad was going to happen.

But some ancient leaders learned that eclipses follow patterns. By observing the movements of the Sun and the Moon, they learned the patterns. They learned to predict when an eclipse was going to happen. People who could predict eclipses seemed very powerful.

Astronomy Everywhere

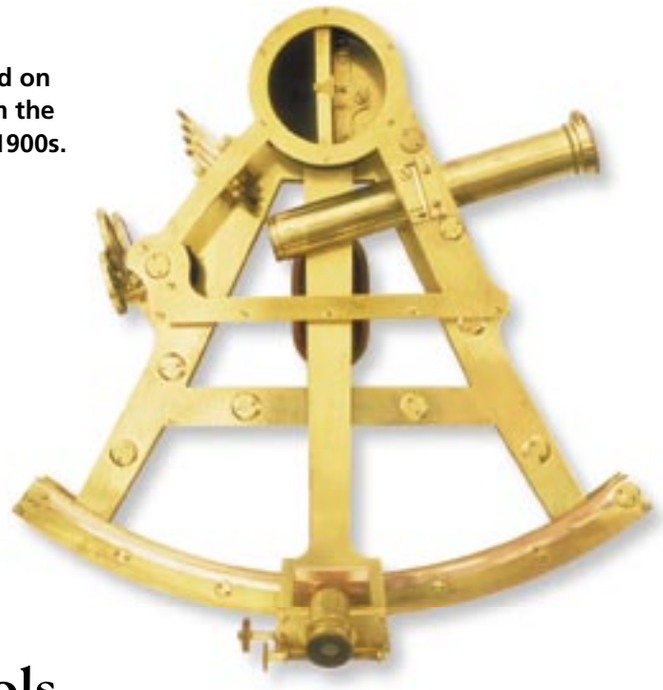
Ancient people from all over the world observed the stars. We know this because many of them built buildings and other structures to help them keep track of the patterns in the sky.

Long ago, people in North America built huge stone circles on the ground. These circles, called medicine wheels, were designed to show the positions of the Sun and other stars at certain times of the year. Some of the circles are more than two thousand years old. One of the most famous medicine wheels is located on top of Medicine Mountain near Sheridan, Wyoming.

This medicine wheel marks the positions of stars in the sky.

Memorizing star groups as characters from stories helped sailors navigate across the sea.

The native people of some islands in the southern Pacific Ocean used the stars to navigate, or find their way, at sea. On land they made large, complicated maps that showed where the stars would appear in the sky. Sailors could not take these large maps to sea but instead used them as a learning tool to recognize the stars they would see. They would memorize patterns of stars. When they went to sea, they would use small maps to remind them of what they had memorized.



Navigators relied on the sextant from the 1700s until the 1900s.

Star Tools

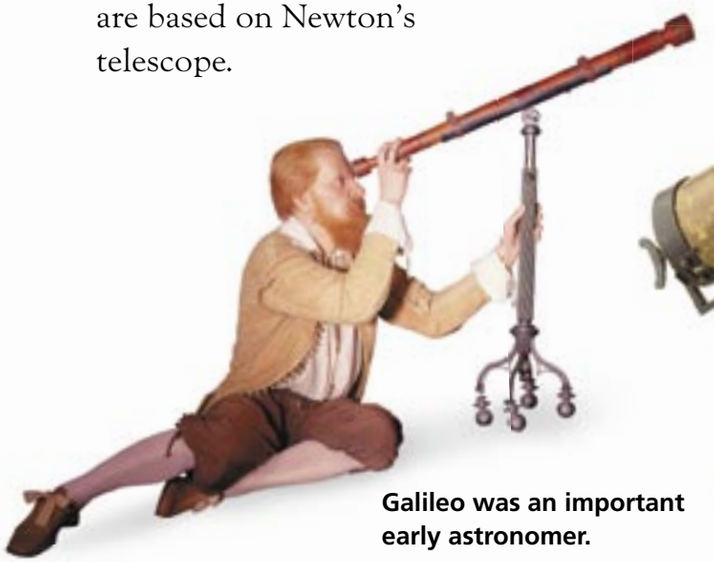
As time went on, people invented more advanced and convenient tools for observing the sky. The astrolabe came into use in Europe and the Middle East during the Middle Ages. It was a disc-shaped tool with a few moving parts. Astrolabes were used to measure the angle between the horizon and a star or the Sun. Sailors at sea could use this information to find out where they were and what time it was.

In the 1700s an instrument called a sextant replaced the astrolabe. A sextant works like an astrolabe, but it is easier to use. It has a metal frame that is shaped like a slice of pie. There are mirrors, a moving arm, and a small telescope attached to this frame. Using a sextant, sailors at sea can find our how far north or south they are on Earth. With the help of an accurate clock, they can also find out how far east or west they are. Sextants are accurate to within a few hundred meters.

The First Telescopes

When we think of watching the stars, one of the first things that comes to mind is the telescope. But in the history of astronomy, the telescope is a rather new invention. The first telescope was built in the early 1600s. It was invented to make it easier to see faraway objects on Earth. The famous Italian scientist Galileo Galilei was the first person to use a telescope to study the stars and planets. He is most famous for discovering that Earth revolves around the Sun. In Galileo's time, people believed that everything in the sky revolved around Earth. It would be many years before Galileo's discovery was accepted by most people.

Sir Isaac Newton was an English scientist who invented an improved telescope. Newton's telescope used mirrors instead of lenses. This reflecting telescope allowed astronomers to see objects that were farther away and to see things in sharper detail. Many telescopes used today are based on Newton's telescope.



Galileo was an important early astronomer.

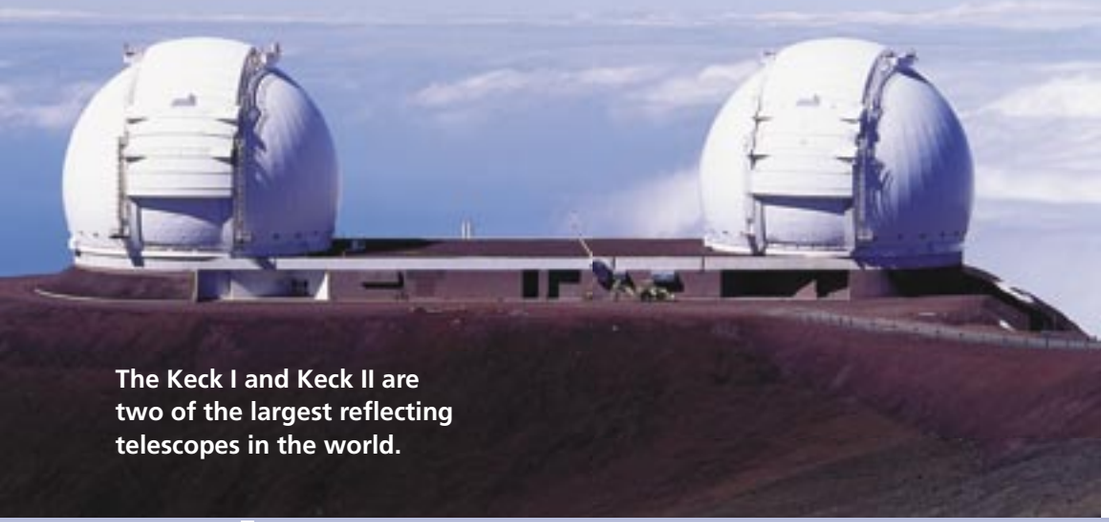
Newton's reflecting telescope

Modern Telescopes

Telescopes work by collecting lots of light and focusing it. Bigger telescopes collect more light and therefore produce brighter images. Telescopes have gotten bigger and bigger since they were invented. Newton's telescope had a mirror about five centimeters across. The largest modern reflecting telescopes, the Keck I and Keck II, have mirrors ten meters across!

Most objects in space produce types of electromagnetic radiation that humans cannot see. These include radio waves, infrared waves, ultraviolet waves, X rays, and gamma rays. Modern telescopes such as the Kecks can detect these types of radiation. They give astronomers much more information about the universe than Galileo and Newton had.

Images of space can look fuzzy because their light must pass through Earth's atmosphere. To solve this problem, the Hubble telescope has been launched into space. Because it is outside the atmosphere, it can take very clear pictures of the stars.



The Keck I and Keck II are two of the largest reflecting telescopes in the world.

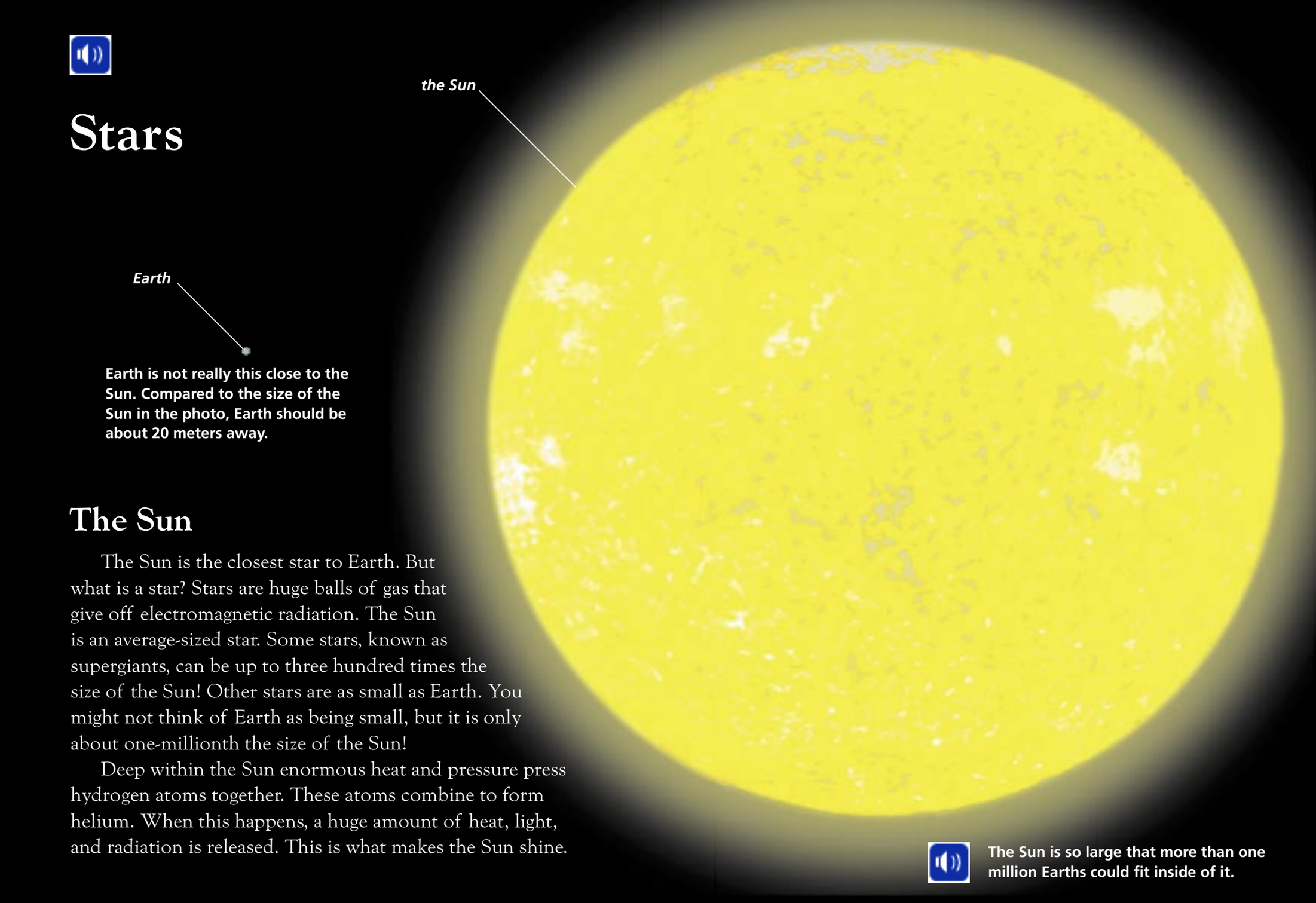
Parkes Radio Telescope in New South Wales, Australia

Radio Telescopes

Take a look at the huge instrument pictured above. It probably doesn't look much like a telescope to you. But it is! This is a radio telescope. Instead of mirrors or lenses, it has a large, bowl-shaped dish. It collects radio waves given off by objects far away in space.

Radio telescopes are located around the world. Some are huge single dishes, while others are networks of dishes. One famous radio telescope is the Arecibo in Puerto Rico. It's the world's largest single-dish radio telescope. In Australia there is a large network of radio telescopes called the Australia Telescope National Facility. Another network is called Atacama Large Millimeter Array. It is under construction in the Andes mountains in Chile. When finished, it will have sixty-four antennas.

Stars



Earth is not really this close to the Sun. Compared to the size of the Sun in the photo, Earth should be about 20 meters away.

The Sun

The Sun is the closest star to Earth. But what is a star? Stars are huge balls of gas that give off electromagnetic radiation. The Sun is an average-sized star. Some stars, known as supergiants, can be up to three hundred times the size of the Sun! Other stars are as small as Earth. You might not think of Earth as being small, but it is only about one-millionth the size of the Sun!

Deep within the Sun enormous heat and pressure press hydrogen atoms together. These atoms combine to form helium. When this happens, a huge amount of heat, light, and radiation is released. This is what makes the Sun shine.

The Sun is so large that more than one million Earths could fit inside of it.

Brightness, Color, and Temperature

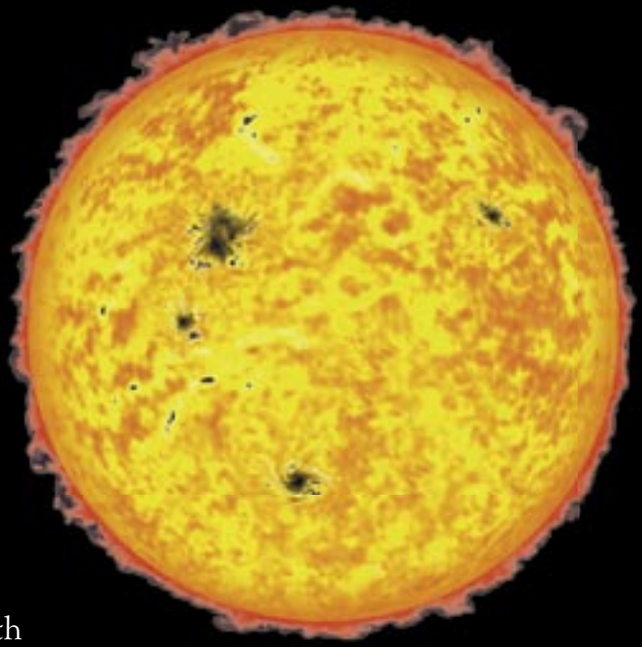
Only the Sun appears brighter than the star Sirius.

The Sun is the brightest object in space that we can see. In fact, it is so bright that during the day it is usually the only object in space that we can see. But being close to Earth is not the only thing that controls how bright an object appears. Sirius is the next-brightest star in the sky after the Sun. It is about nine light-years away from Earth. A **light-year** is the distance light travels in one year, or about nine trillion kilometers. The closest star to Earth other than the Sun is only about half as far away. But this star can't even be seen without a telescope! So what makes Sirius so much brighter?

Sirius looks brighter because it is very large and gives off a huge amount of energy. If you were to travel close to Sirius, you would find that it is twenty times brighter than the Sun. But because it is so far away, it doesn't look as bright as the Sun.

Stars come in different colors. These colors tell astronomers how hot each star is. There are red, orange, yellow, white, and blue-white stars. Red stars are the coolest. Yellow stars, such as the Sun, are hotter than red stars. The hottest stars, such as Sirius, are blue-white. Even though we talk about red stars as being "cool," they are still amazingly hot. At 2,250°C, they are hot enough to melt iron instantly!

Features of the Sun



Dark places on the Sun are called sunspots.

You may think of the Sun as a smooth ball of light, quietly glowing in the sky. But the Sun is actually very active. It is made up of several different layers. The photosphere is the Sun's surface layer. It gives off the light we see. The layer above the photosphere is called the chromosphere. The outermost layer is called the corona.

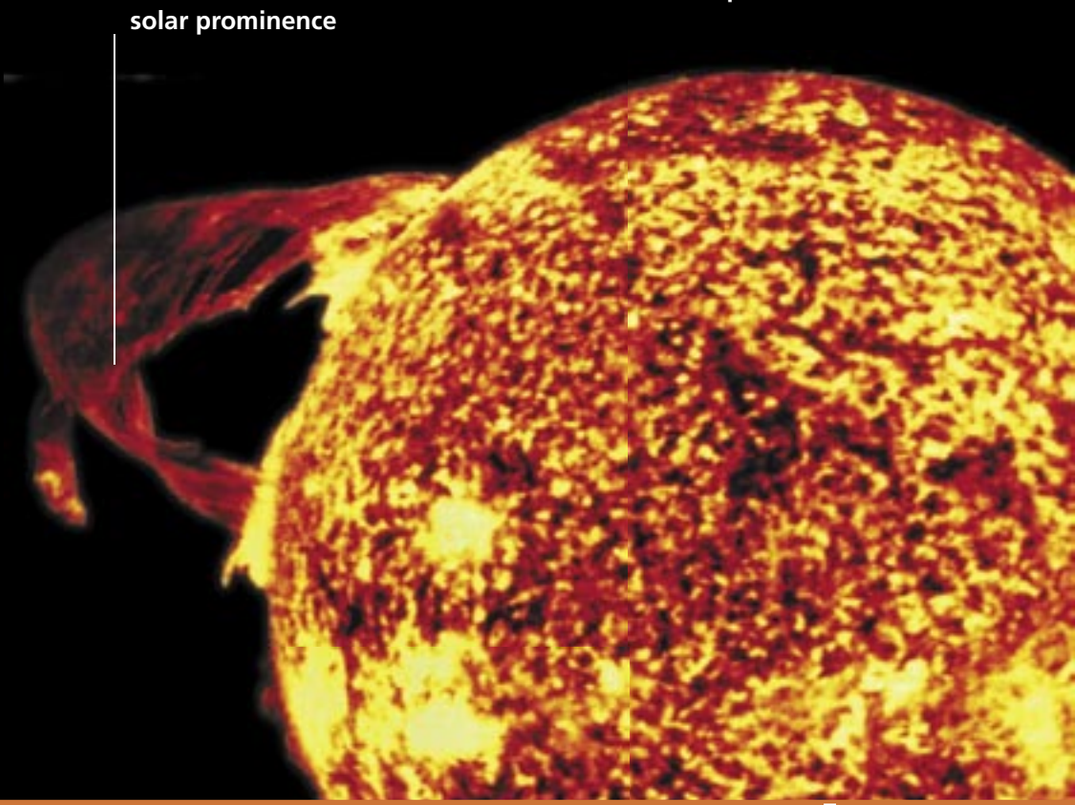
Scientists have discovered lots of activity on the Sun. Remember, you should never look directly at the Sun! Scientists must use special protective equipment when observing the Sun, to keep its rays from hurting their eyes. By using this equipment they have found dark spots on the photosphere, called sunspots. Galileo saw these spots moving across the surface and concluded that the Sun was rotating. Their movement shows us that the Sun rotates more slowly at its poles than at its equator. Sometimes there are more sunspots than at other times. The number of sunspots changes in cycles of about eleven years.

Eruptions on the Sun

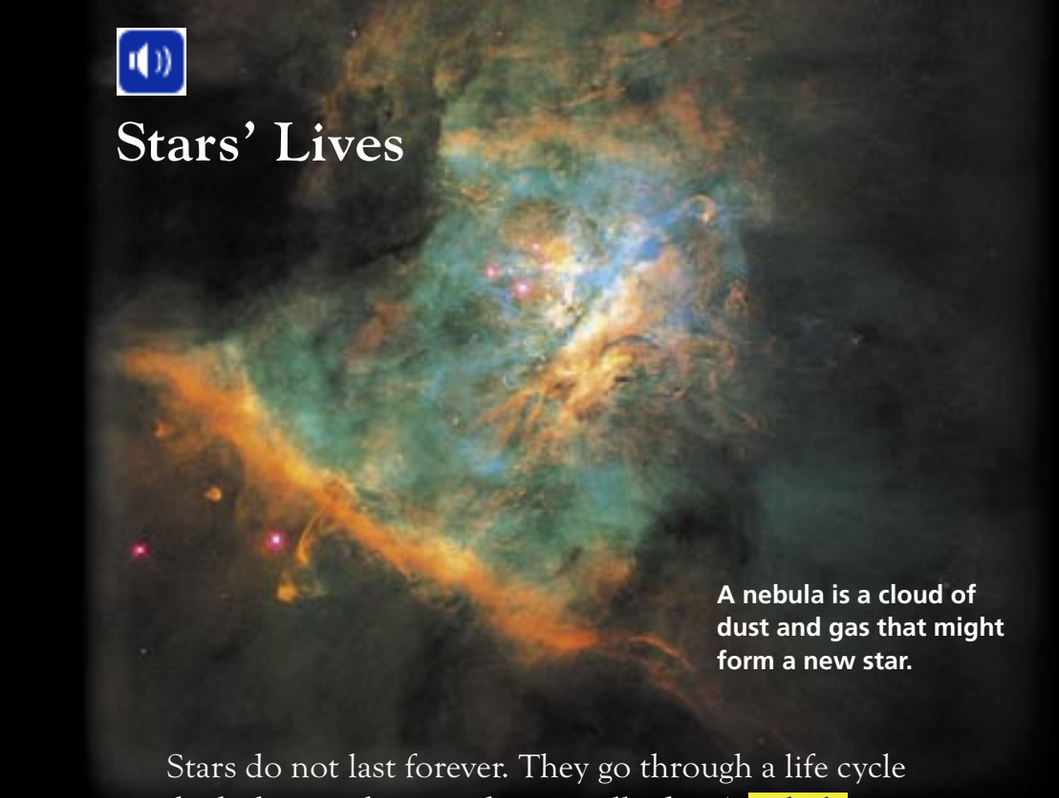
Fiery gases often leap off the Sun's surface in huge loops and fountains. These are called prominences. They may last for a few minutes or several months, and they may be more than a million kilometers high.

Sometimes a part of the Sun's chromosphere will erupt like a volcano. This is called a solar flare. Solar flares last from a few minutes to several hours, and they release huge amounts of energy. Protons, electrons, and electromagnetic waves from a solar flare may disturb radio signals and damage electrical systems on Earth.

Solar prominences may rise at a speed of one thousand kilometers per second.



Stars' Lives



A nebula is a cloud of dust and gas that might form a new star.

Stars do not last forever. They go through a life cycle in which they are born and eventually die. A **nebula** is a cloud of dust and gas in which new stars may form. This cloud rotates and churns. Gravity makes some particles move into a tight ball in the nebula's center. The particles move together with great force as gravity pulls them in. This raises the temperature within this ball of particles. If the temperature gets high enough, the gases change. Hydrogen converts to helium, releasing huge amounts of energy. Eventually, this ball of gas will become a star.

The life cycle of stars can be very long. The Sun, which is the star closest to Earth, is already about 4.6 billion years old! Scientists estimate that the Sun will shine for about another 7 billion years. As it ages it will use up all the hydrogen in its core. It will become thousands of times brighter than it is today. It will become so large that it will extend as far as the orbit of Mars.

Supernovas are much brighter than the stars from which they form.

When the Sun reaches this huge size, it will cool slightly and turn red. This type of star is known as a red giant. Since red giants have run out of hydrogen, they start using helium as fuel. When the helium runs out, the outer layers of the star simply float off into space. The core shrinks to a tiny fraction of the red giant's size. This type of small star is called a white dwarf. A white dwarf has no fuel, so it cannot produce any energy. It has only leftover heat from when it was a red giant. Over millions of years it will cool down and become a cold object called a black dwarf.

Very large stars do not become black dwarves. They shrink very rapidly, until they can shrink no further. They stop suddenly, causing a huge explosion called a **supernova.** A supernova can be billions of times brighter than the star ever was. All that is left is a ball of neutrons, about twenty kilometers across, called a neutron star.

If a very large star collapses, its gravity can cause it to keep shrinking until it becomes a black hole. A **black hole** is a point in space with so much gravity that nothing can escape being pulled into it, not even light.

spiral galaxy

Grouping Stars

elliptical galaxy

Galaxies

Earth and Sun are part of a large system of planets, dust, stars, and gas called a **galaxy.** Our galaxy is called the Milky Way. There are billions of galaxies in the universe, but only a few can be seen without a telescope. They appear as single points of light.

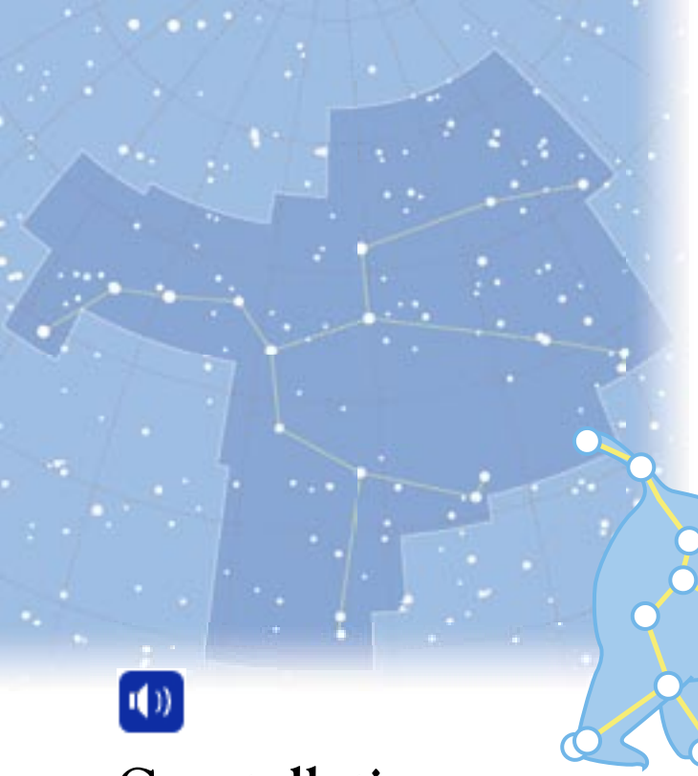
Astronomers have discovered that galaxies come in many shapes and sizes. Most are spiral galaxies, which look like pinwheels. They have thick middles and thin arms spreading out in all directions. Their stars rotate around the center of the galaxy. Some spiral galaxies may have black holes at their centers.

The Milky Way is a spiral galaxy. This is what it would look like from the side.

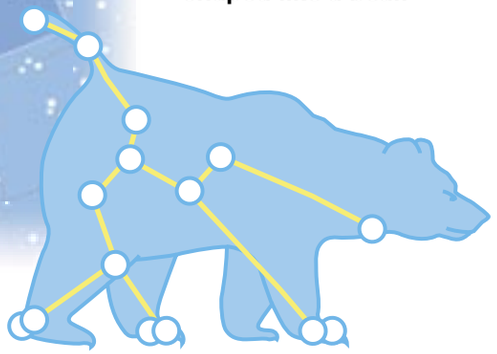
Another type of galaxy is an elliptical galaxy. These can be nearly round or oval-shaped. They might also have a shape similar to a football. Some elliptical galaxies are small, while others are very large. The largest known galaxies are elliptical.

Irregular galaxies have no real shape. They are probably young galaxies in which stars are still forming.

irregular galaxy



The constellation Ursa Major is shaped like a bear.



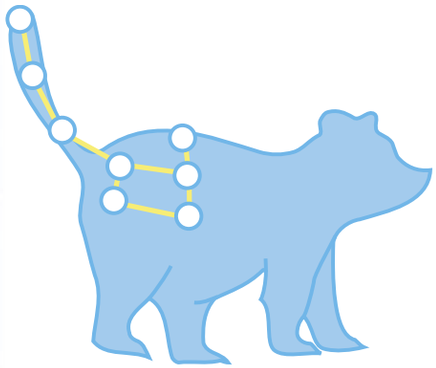
The flag of Australia features the Crux constellation.

Crux

Constellations

Have you ever seen a giant bear in the night sky? Ancient stargazers saw a pattern of stars in the sky that reminded them of a bear. They named this pattern Ursa Major, or the Great Bear. Such patterns of stars are called constellations. Today scientists define a **constellation** as an area of the sky and all the stars found within that area. They divide the sky into eighty-eight constellations. These constellations all have names. Many of these names are the same as the names of the ancient star shapes, such as Ursa Major or Orion.

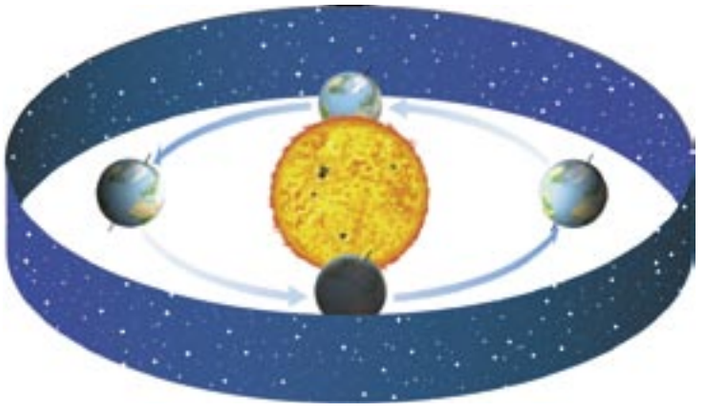
These constellations make finding stars in the night sky easier. Knowing a star's constellation is a bit like knowing what city a person lives in. It's a lot easier to think about the locations of eighty-eight large constellations than the locations of thousands of stars.



Ursa Minor

Not all constellations are visible everywhere on Earth. Crux is a constellation that is shaped like a cross. It is not visible in most places north of the equator. Crux is a very well-known constellation. It is pictured on the flags of several countries, including Australia.

Ursa Minor looks similar to Ursa Major. Its name means the Little Bear. This constellation is not visible in most places south of the equator.



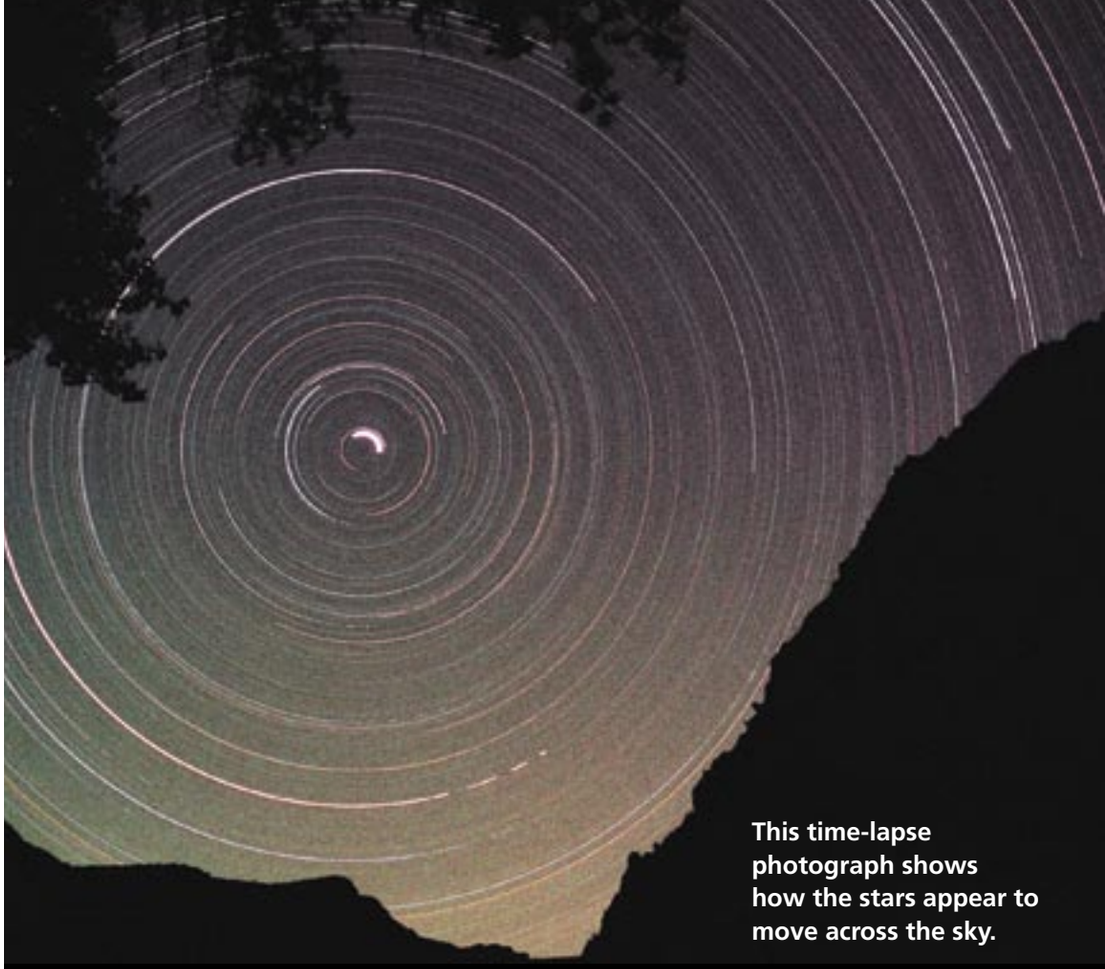
As Earth moves around its orbit, constellations come into and out of view.

Stars in Motion

If you have ever spent a few hours watching the stars, you might have noticed that they seem to move. You might take a look at the sky just after sunset and see the constellation Canis Major, or the Great Dog. If you take a look a few hours later, you'll notice that the dog has moved! Or has it? Actually, Canis Major has stayed in place. The movement you notice is the rotation of Earth. Just as the Sun seems to rise and set because of Earth's spin, the stars seem to move across the sky. The stars seem to move from east to west, just as the Sun does.

The constellation Orion looks like a hunter. Three bright stars form the hunter's belt, making it easy to spot. But if you look for Orion during the summer, you won't be able to find it at all. This is because of Earth's orbit around the Sun. When it is nighttime during the summer, our side of Earth is facing away from Orion, so the constellation cannot be seen.

Orion as seen through a specialized telescope



This time-lapse photograph shows how the stars appear to move across the sky.

Although the movement of the stars in the night sky is really caused by Earth's movement, the stars themselves also move. We don't notice the movement of the stars because they are so far away. But over hundreds of thousands of years, they move enough to change the patterns we see in the sky.

The night sky is a busy place. The Moon is spinning around Earth, just as Earth and planets are spinning around the Sun. The whole solar system is moving within our galaxy.

Glossary

black hole a point in space where gravity is so strong that nothing can escape it

constellation an area of the sky and all the stars seen in that area

galaxy a huge system of planets, stars, dust, and gas held together by gravity

light-year the distance light travels in one year, about nine trillion kilometers

nebula a cloud of gas and dust in which stars may form

supernova a huge explosion that occurs when a very large star collapses

What did you learn?

1. Why are modern telescopes built very large?

2. Some stars turn into black holes when they collapse, but others don't. Why is this?

3. What can astronomers learn from the color of a star?

4. **Writing** in Science Many constellations can only be seen during certain times of the year. Write to explain why this is. Include details from the book to support your answer.

5. **Summarize** Summarize how ancient leaders used eclipses to make themselves seem very powerful.