Students' Learning Outcomes

After completing this chapter, the students will be able to:

- Explain the big bang theory of the origin of the universe.
- Evaluate the evidence that supports scientific theories of the origin of the universe.
- Describe a star using properties such as brightness and colour.
- Identify bodies in space that emit and reflect light.
- Suggest safety methods to use when observing the sun.
- Define the terms star, galaxy, milky way and the black holes.
- Explain the types of galaxies.
- Explain the birth and death of our sun.
- Identify major constellations visible at night in the sky.
- Describe the formation of black holes.
- Explain the working of a telescope.

Animation 12.2: Galaxy on milky way
Source & Credit: bathsheba

In a clear night we see thousands of stars and other heavenly bodies twinkling in the sky. In this chapter we shall learn about stars, constellations, galaxies and other astronomical bodies.

12.1: What's Beyond Our Solar System

We know that our solar system is a part of the universe. The universe is immensely vast. According to space scientists the universe is **expanding** and there are more than **200,000,000,000 billion stars** in the universe. Many questions may arise in our mind as to what is the universe? and how did it begin? Let us try to find the answers to these questions about the universe. The universe is all of space and everything in it. Most of the universe is empty space. Our solar system is an extremely small part of the universe. Many theories are given to explain the origin of the universe. These theories are results of human efforts in understanding the nature and origin of the universe.

12.1.1: The Big Bang Theory

According to Islam and other Ibrahimic religions, universe was created by Allah (Almighty). According to the Holy Quran, Allah (Almighty) said and the universe(كُنْ)was created (فَيَكُوْنُ) . Scientists have been presenting different theories of creation of the universe from time to time. One of these theories is "The Big Bang Theory". According to this theory:

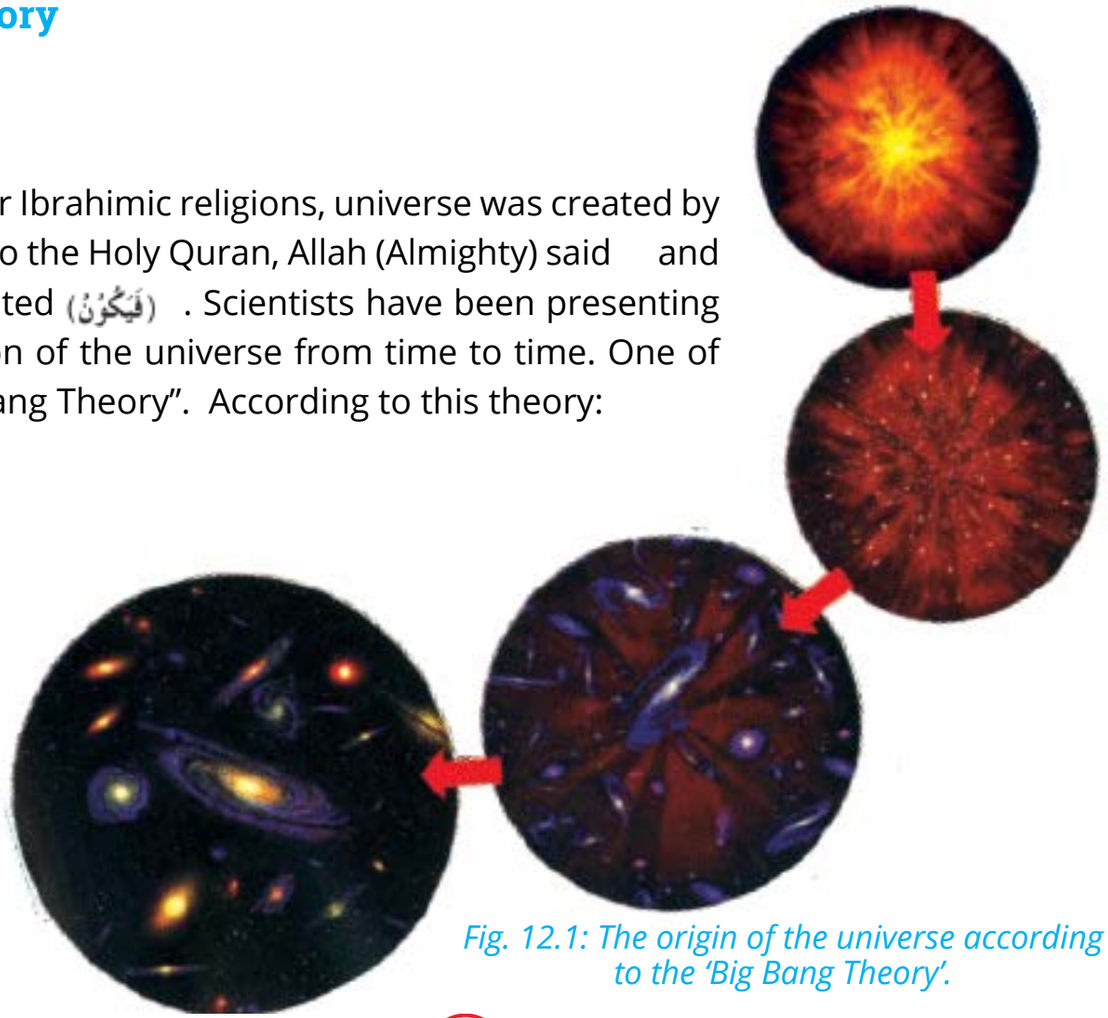


Fig. 12.1: The origin of the universe according to the 'Big Bang Theory'.

About 10 to 20 billion years ago, the universe was packed into one giant fireball. Then a tremendous explosion started the expansion of the universe. This extraordinary explosion is known as the **Big Bang**. This explosion hurled matter and energy in all directions (Fig.12.1). After the Big Bang, the universe assumed the form of huge clouds of extremely hot, expanding and contracting gases. With the passage of time, the matter cooled: the force of gravity pulled together the particles of matter to form stars and galaxies

The Big Bang theory was first proposed in 1927 by a priest, George Lamaitre of Belgium. This theory was supported by the discoveries of Edwin Hubble and Nobel Prize-winning scientists Arno Penzias and Robert Wilson (Fig. 12.2).

1. Edwin Hubble found experimental evidence to support The Big Bang Theory. He found that distant galaxies in every direction are going away from us with a very high speed. This observation is acceptable if the universe began in a huge explosion.
2. The Big Bang Theory also predicts the existence of cosmic background radiation (the glow left over from the explosion itself).

This radiation was discovered in 1964 by Arno Penzias and Robert Wilson. They later won the Nobel Prize for this discovery. Although the Big Bang Theory is widely accepted, it probably will never be proved. It cannot answer many questions about the occurrence of the Big Bang.

Tidbits

The study of the Sun, Moon, stars and other objects in space is astronomy. An astronomer studies the space objects.

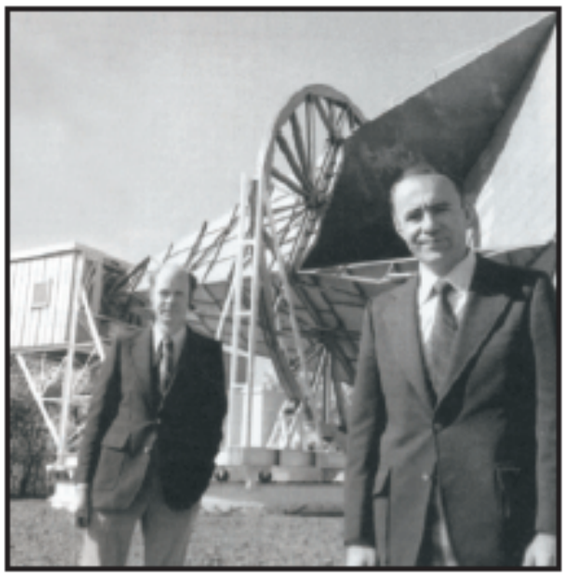
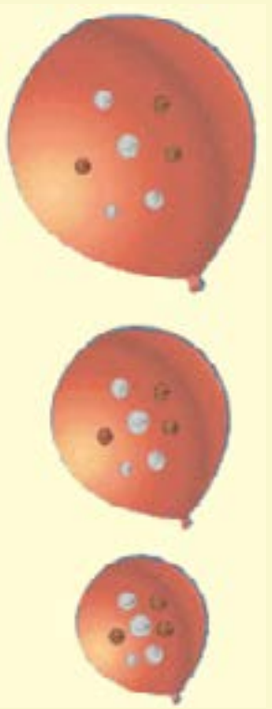


Fig. 12.2: Robert Wilson (left) and Arno Penzias (right) discovered cosmic background radiation in 1964.

Activity 12.1 **Model of an Expanding Universe**

1. Cut out small circles from sticky labels. The circles will be the galaxies in your model.
2. Slowly blow up a balloon. Stop as soon as the balloon appears round. Hold the end of the balloon to keep the air from escaping.
3. Have a classmate place the galaxies at various positions on the balloon. The balloon now represents the universe and its galaxies.
4. Blow up the balloon until it is completely inflated. As you do, observe what happens to the galaxies.



Things to think

i. Do the galaxies get any bigger as the universe expands?

ii. What relationship can you find between the speed of the galaxies moving apart and their initial distances from one another?

12.2: Stars, Galaxies, Milky Way and Star Distances

On a clear night we can see a cloudy band that stretches North to South across the sky. In fact we are seeing part of our own galaxy, the Milky Way. There are countless stars in our galaxy. We cannot see our galaxy as a whole, but scientists can see many other galaxies in the sky.

12.2.1: Stars

We see many twinkling lights in the night sky. Some of these lights come from objects in space called stars. The Sun is also a star. Beyond the solar system, billions and billions of stars are present in space. Every star is a ball of glowing gases which emits energy in the form of heat and light. Astronomers say that our Sun is a medium-sized star. Some stars are much larger and some are smaller than our Sun.

Colours of Stars

We know that stars emit heat and light in different amounts, so stars have different temperatures. The colour of a star is related to its temperature (Fig.12.3). The coolest stars have about 2800^{o}C

temperature at their surfaces and appear red. The hottest stars have 28000°C or higher temperatures and look blue. The stars with in-between temperatures have orange, yellow and white colours. The Sun is a yellow star. It has a temperature of 5,500 to 6000°C at its surface. Stars that are a little colder than the Sun look orange. Stars that are a little hotter than the Sun appear white. See the table 12.1.

Fig. 12.3: Blue stars are hotter than red stars.

Table 12.1: Colour and Temperature of Some Stars

Name of Star	Color	Temperature
Betelgeuse	red	2,800°C
Arcturus	orange	4,100°C
Sun	yellow	6,000°C
Polaris	yellow	5,800°C
Vega	white	9,700°C
Algol	blue	11,700°C
Beta	blue	28,000°C

Extend Your Thinking

When viewed from the Earth, a red star and a blue star appear to be equally bright. What could you infer about these two stars?

Do You Know?

There are many stars in the universe whose light does not reach us. They are invisible to us.

Brightness of Stars

The brightness of a star depends on two factors:

1. Distance of the star from the Earth
2. Amount of energy the star emits

Imagine that you are looking at two stars that are exactly the same distance from the Earth. The star which emits greater amount of energy will seem brighter than the other.

Now imagine two stars that emit equal amount of energy. One is near to the Earth and other is very far away from the Earth. Which star will look brighter? The near one or the farther one?

Fig 12.4: We can estimate how far away each street light is by looking at its apparent brightness. Does this work with stars?

12.2.2: Star Distances

The stars are very far away from us. They are also at great distances from each other. Distances between stars are so great that these cannot be measured in kilometres. Instead, we use light-years to express the distance in the universe.

A **light-year** is a measure of distance that light covers in one year with a speed of 300,000 kilometres per second. It seems that a light-year is a very long distance. The Sun is our closest star in our galaxy. The next closest star Proxima Centauri is 4.2 light-years away from us. We can also say that light of this star will take 4.2 years to reach the Earth.

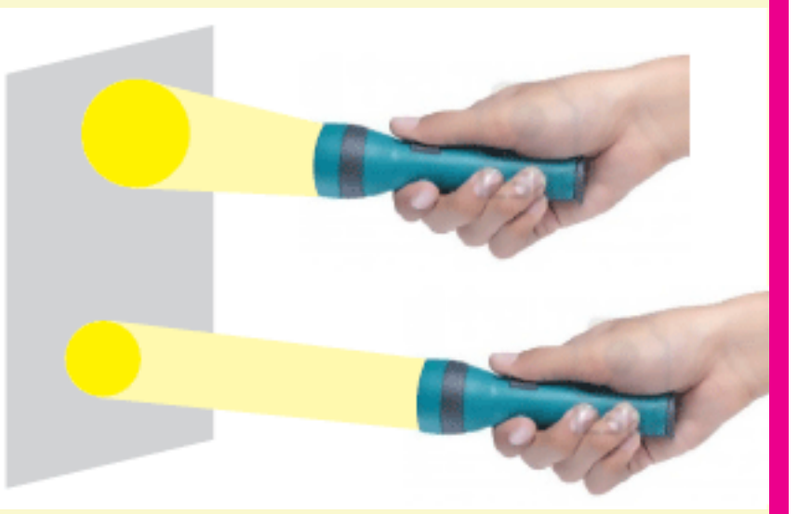
Extend Your Thinking

Why is the light-year a useful unit for measuring distance to stars as compared to the kilometres?

Activity 12.2 — Star Light, Star Bright

You will need:

- 2 flashlights of the same size
- transparent tape
- a white chart
- a meter rod
- measuring tape



Procedure

1. Label one flashlight A and another flashlight B.
2. Attach a large sheet of white paper to a wall at about shoulder height. Make the room dark.
3. Ask one student to stand at least 1 metre away from the white chart. Ask thisstudent to shine flashlight A on the paper.
4. Ask the second student to stand at least two metre away from the white chart. Ask this student to shine flashlight B on the same chart, to the right of the light from flashlight A.
5. Ask a third student to use a metre rod to measure the diameters of the central spots of light from flashlight A and flashlight B.
6. Measure the distances of flashlights A and B from the wall with measuring tape.
7. Record your information in your science note book.

Things to think

i. Which circle is brighter and which is dimmer?

ii. What can you conclude from this activity about the apparent brightness of stars at different distances from the Earth.

12.2.3: Galaxies

We have learnt that after the Big Bang the universe assumed the form of huge clouds. These clouds of gases and dust formed stars. A **galaxy** is a very large group of stars, nebulae, gases, dust and planets. A galaxy may contain billions of stars. Astronomers have used special instruments to identify about one billion galaxies. Our solar system is the part of the **Milky Way** galaxy. There are many types of galaxies in the universe. Scientists classify galaxies in three main types on the basis of shape

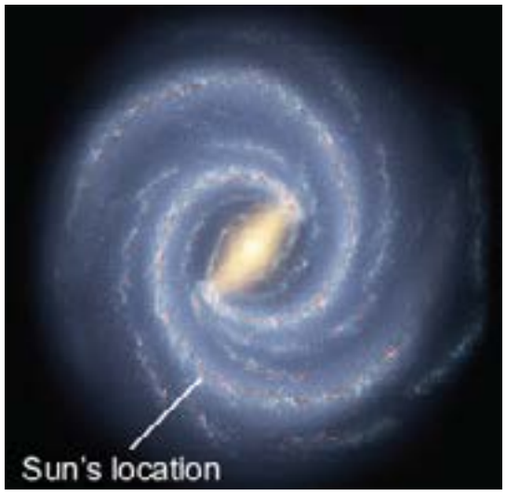


Fig. 12.5 :Milky Way is a spiral galaxy.

Spiral Galaxies

A galaxy that has a flat disklike shape with a bulge in the centre is called a spiral galaxy. Spiral galaxies may have a few or many spiral orcurved arms. A large amount of dust and gases is present in these galaxies. The Milky Way and Andromeda are spiral galaxies. The Milky Way galaxy contains 100 to 200 billion stars. The Sun is about 30,000 light-years away from its centre. The Milky Way galaxy is moving with a speed of 2200,000 kilometres per hour in space.

Tidbits Andromeda is about 2,250,000 light-years away from the Milky Way galaxy. It is our neighbouring galaxy.

Elliptical Galaxies

These are oval shaped galaxies (Fig.12.6). These galaxies do not rotate as spiral galaxies around their axis. An elliptical galaxy contains less amounts of dust and gases as compared to a spiral galaxy. Trillions of stars may be present in an elliptical galaxy. New stars cannot form in most elliptical galaxies. Most of them contain only old stars.

Fig. 12.6: An Elliptical Galaxy

Fig. 12.6: An Elliptical Galaxy

Irregular Galaxies

These galaxies have no definite shape (Fig.12.7). The stars in an irregular galaxy do not appear to be grouped in any set shape. These galaxies have many shapes and sizes. The Clouds of Magellan, is an irregular galaxy. It is a very small galaxy near the Milky Way. These galaxies are not very common.

Activity 12.3 Making a Model of a Spiral Galaxy

You will need

- paper plate
- paper chart
- coloured markers
- water
- straw
- glue stick
- glitters
- construction paper

Procedure

1. Using water-colour markers, draw colourful designs of stars, planets, moons, and comets on the back of the paper plate.
2. Use a straw to dribble a few drops of water on the paper plate. The water will make the colours run together in lovely ways. Let the colours dry.
3. When the colours are dry, cut the paper plate into spiral galaxy shape as shown in the figure.
4. Use a glue stick to add some blue glitter highlights to your galaxy.
5. Glue a piece of construction paper on the back of the plate to make a two-sided border.
6. Paste your spiral galaxy on the paper chart. Display your galaxy.

Animation12.3: Birth of Star 1. Source & Credit: enchantedlearning

12.2.4: Constellations

If we look at the sky in a night full of stars, we may see certain patterns of stars. These star patterns are constellations.

A **constellation** is a group of stars with a definite pattern or arrangement. Each constellation has a different pattern. Each constellation is found in a certain place in the sky.

Constellations were very important to people long ago. Those people used the night sky to tell time and seasons. Crop planting, festivals and other events were planned according to the movement of the stars in constellations.

People long ago named the star patterns they saw for objects, animals or famous people. People also made strange stories about constellations. We can observe many constellations in the night sky.

The **Big Dipper** is a famous constellation. There are seven visible stars in the Big Dipper. Four stars make the bowl of the Big Dipper while three stars form the handle. The two bright stars on the end of the Big Dipper's bowl point to the **Pole Star**. This star helps in finding directions (Fig.12.8).

Cassiopeia is a constellation that seems to move around the Pole Star all the year. Cassiopeia is on the opposite side of Pole Star from the Big Dipper and about the same distance away. The five brightest stars in Cassiopeia form the shape of capital letter M or W. People long ago thought this star pattern looked like a queen sitting on her throne (Fig.12.9).

Leo, the Lion is also a famous constellation seen in the months of March, April and May. Stars in this constellation are arranged in the shape of backward question mark and a triangle. We can also find this constellation with the help of two bright stars in the bowl of the Big Dipper. If we look North, these two stars indicate Pole Star. If we look South, these two stars point to Leo Constellation (Fig.12.10).

Fig.12.8: Big Dipper

Fig.12.9: Cassiopeia

Fig.12.10: Leo

Animation12.4: Birth of Star 2
Source & Credit: enchantedlearning

Activity 12.4 Constellation in a Can

You will need:

- a tin can
- constellation patterns
- a nail
- flashlight
- permanent marker
- scissors
- hammer

Procedure

1. Take a tin can. Open its one end.
2. Each student to select one of the constellation patterns. Use a black marker to trace inside the circle on the paper.
3. Put the paper on the close end of the can.
4. Using a nail and hammer, make holes on the close end of the can according to the constellation pattern.
5. Label the can with the name of the constellation using a permanent marker.
6. In a dark room, place your flashlight in the open end of the can and turn it on. The light will shine through the holes creating a constellation on the wall or ceiling.

You may rotate the can to have your constellation at different times of the night.

Things to think

i. How does turning the can affect the way the constellations appear ?

12.3: The Life of Stars

Science has told us that the universe is finite, with a beginning, a middle and a future. Stars have life cycles too. A star is also born, changes, and then dies. The life span of a star is measured in billions of years.

Animation12.5: Formation of black Hole
Source & Credit: media.giphy

Birth of a Star

We have studied that great clouds of gasses and dust are present in galaxies.

Each of these clouds is called a **nebula**. Stars are born in nebulae (singular nebula). A nebula collects more dust and gas during its travel through space (Fig. 12.11). The gas and dust particles are packed into a hot spinning ball of matter. Such a ball of hot matter is called a **protostar**. With the passage of time, a protostar becomes hot enough to produce great amount of energy. At this stage a protostar is called a **star**. A star like the Sun emits light and heat all the time.

Fig. 12.11: Scientists have observed proto-stars and young stars within the Horsehead nebula.

Extend Your Thinking
The matter that makes up a star today may have been part of another star that died billions of years ago. How is it possible?

Death of a Star

The matter of a star is converting into energy. This radiant energy is released into space. Our star (the Sun) is dying (Fig. 12.12). Let us see, how.

Red Giant Stage

Our star (the Sun) has passed five billion years while emitting energy. After the next five billion years, the hydrogen in the core of the Sun may be used up. The Sun will start to collapse. Its core will become denser and hotter and the Sun will swell in size. It will become a **red giant**. The Sun will be a red giant for only about 500 million years.

Dwarf Stage

By and by the Sun in the form of red giant will cool and gravity will make it collapse inward. Our star will become a **white dwarf** at this stage. Eventually, the Sun will become a burn-out black chunk of very dense matter. It will not emit light any more. This last stage of a star's life is called a black dwarf.

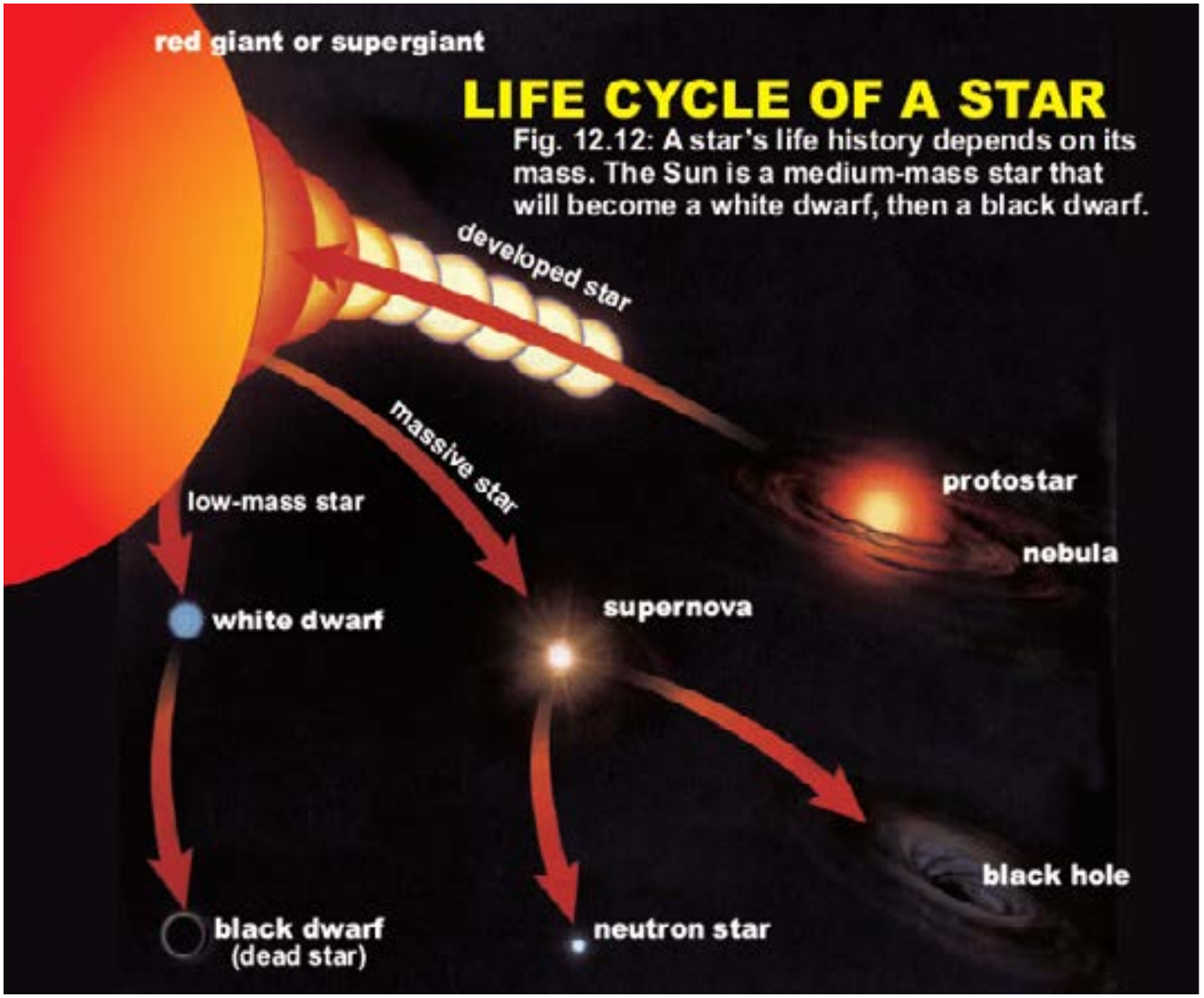


Fig. 12.12: A star's life history depends on its mass. The Sun is a medium-mass star that will become a white dwarf, then a black dwarf.

Formation of Black Holes (Life of a Massive Star)

Stars more than six times as massive as our Sun are called **massive stars**. A massive star has short lifespan than the Sun or other low-mass stars. Hydrogen in the core of a massive star is used up with a much fast speed. After only 50 to 100 million years, no hydrogen is left in the core of a massive star. At this time, the core collapses and the star becomes 1000 times greater than its original size. It is now called a **supergiant** (Fig.12.12).

With the passage of time the supergiant becomes so dense that it cannot bear the pressure of outer layers. The outer layers crash inward with a tremendous explosion, called **supernova**. At the time of supernova, the light of the star becomes much more than all other stars of the galaxy. Great shells of gases fly off the star. Only the tiny core of the star remains left. This core contains only neutrons, so it is called a **neutron star**. It is extremely dense. Some times after the supernova explosion the massive star becomes a black hole. **A black hole** is so dense that nothing can escape from it due to its very strong gravity. Even light cannot escape from a black hole and it is no more glowing. In fact the black hole is the last stage of the life cycle of a massive star.

Extend Your Thinking
Given that there are more low-mass stars than high-mass stars in the universe, do you think there are more dwarfs or more black holes? Explain.

12.4: Looking at Stars

People have looked at the stars for thousands of years. A **telescope** is a device that makes a far away object appear very close (Fig.12.13). Many more stars can be seen with the telescope than with the unaided eye. A simple telescope has two lenses. The **objective lens** collects light from a distant object and brings that light, or image, to a point or focus. An **eyepiece** lens takes the light from the objective lens and magnifies it.

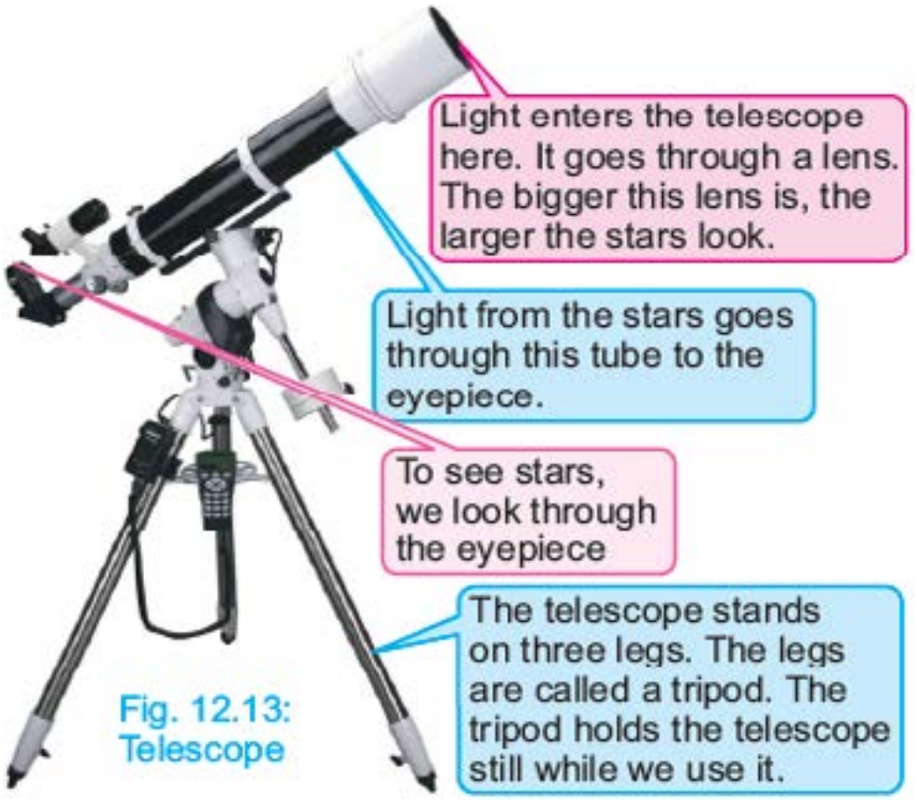


Fig. 12.13: Telescope

Activity 12.5 **How to make a Telescope**

You will need

.scotch tape .1 thin lens (objective) .1 thick lens (eyepiece)

.small-diameter cardboard tube . large-diameter cardboard tube

Procedure

1. Join the thin lens on one end of the small tube with the help of scotch tape.
2. Now join the thick lens on one end of the large tube with the help of scotch tape.
3. Slide the open end of the small tube into the large tube to make a telescope (see the picture).
4. Hold your telescope, and look at an object through one lens. Then turn the telescope around, and look through the other lens. Slide the small tube in and out of the large tube to focus the object.

Things to think

i.What did you observe as you looked through thin lens and thick lens?

ii. Using your observations, tell which lens you should look through to observe the stars.

12.4.1: Safety Tips for Observing the Sun

The Sun emits dangerous radiation. Viewing directly into the Sun can damage our eye sight. Make sure the safety of your eye before viewing the Sun.

1. A pinhole or small opening is used to view the image of the Sun on a screen placed a half metre or more beyond the opening.
2. Use two or three sheets of X-Rays film for viewing the Sun.
3. Remember! No filter is safe for use with any optical device, i.e. telescope, binoculars, etc.

Tidbits

Some people use special Mylar glasses to safely observe an eclipsed Sun.

Science, Technology and Society

Cities have many street lights and other lights from buildings and homes. Because of this, we may not see many stars. Light from street lights and advertising signs also make it difficult to see astronomical objects. Artificial light that makes it difficult to see the night sky clearly is known as **light pollution**. If light pollution increases, how will we see glittering stars and other astronomical objects?

Key Points

- According to scientists, the starting point of the universe was the Big Bang.
- According to the Big Bang Theory, once the universe was packed into one giant fireball. Then a tremendous explosion, the Big Bang scattered the matter of the universe into all directions.
- Stars are huge balls of glowing gases. Stars are very far away from us.
- The colour of a star is related to its temperature. Blue-coloured stars have higher temperatures than yellow and red-coloured stars.
- Stars emit energy in the form of light and heat. The stars which emit greater amount of energy look brighter than other stars.
- A galaxy is a large group of stars, nebulae, gases, dust and planets. Our solar system is the part of Milky Way galaxy.
- A black hole is the last stage in the life of a massive star. A black hole is so dense that nothing can escape from it.
- Scientists classify galaxies in three main types on the basis of shape. These are spiral galaxies, elliptical galaxies and irregular galaxies.
- A star (the Sun) starts its life as a protostar in a nebula. Then it changes to a star.
- After releasing its energy the star becomes a red giant and in the end a dwarf.
- A telescope is a device that is able to make a far away object appear very close.
- We can see many more stars in the night sky with the help of a telescope.
- The Sun emits dangerous radiation. We must observe safety measures before viewing the Sun.

Questions

1. Complete each of the following sentence by writing the correct term.

i. An oval-shaped galaxy is called _____

ii. A cluster of stars with a definite pattern _____

iii. A large group of stars, gas, and dust _____

iv. The last stage of a low-mass star's life _____

v. A device that is able to make far away objects appear close _____

3. Give short answers.

i. Are blue stars young or old? How can you tell?

ii. Name one observation that supports the Big Bang Theory.

iii. List in order, the four stages in the life cycle of a low-mass star.

iv. How do constellations differ from galaxies?

v. How do scientists think the universe began?

vi. What type of star ends its life cycle as a black hole?

vii. For how many years will the Sun be a red giant?

viii. On which factors does the brightness of a star depend?

ix. What is a light-year?

x. What galaxy our Sun belongs to?

4. Explain the Big Bang Theory of the origin of the universe.

5. Describe the life cycle of a low-mass star.

6. Describe the three main types of galaxies.

7. Write notes on:

i. Star Distances

ii. Safety methods to use when observing the Sun

End of Life

When our Sun will become a red giant, it may become so large that it will absorb Mercury and Venus planets. The Earth would become extremely hot. All life on the Earth would be wiped off.

For more information visit:

- http://www.ugcs.caltech.edu/~yukimoon/BigBang/BigBang.htm
- http://www.telescope.org/pparc/res8.html