Chapter

12 Beyond Earth

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Nubra is a beautiful region in Ladakh. An eleven-year old girl Yangdol and her twin brother Dorjay live in one of the villages of this region.



Nubra in Ladakh, India

They love their surroundings—the majestic mountain peaks, and the glaciers, but their favourite is the night sky when the entire sky is lit up with thousands of stars (Fig. 12.1). The weather in Nubra is almost cloudless. With almost no air or light pollution, the night sky is very clearly visible. Night after night, Yangdol and Dorjay observe the stars and experience an immense sense of awe.



Fig. 12.1: The beauty of night sky from a very dark location in Ladakh, India

Growing up, Yangdol and Dorjay have been hearing interesting stories about stars from their elders. They have heard how some particular stars in the clear skies helped the caravans passing through Nubra in finding direction in the ancient days. They wonder how far away and how big the stars are. They also enjoy trying to find some patterns among the stars that remind them of familiar objects. Have you ever looked at the stars in the night sky and tried to connect them with imaginary lines, just like dots and lines in a drawing?

Activity 12.1: Let us draw

- Fig. 12.2 shows bright stars in one part of the night sky.
- Look at it carefully and try to imagine a pattern formed by a group of stars.
- Draw lines to connect the stars and make the pattern.
- Think of an animal or an object that is similar to the pattern drawn by you. Write its name near your pattern.

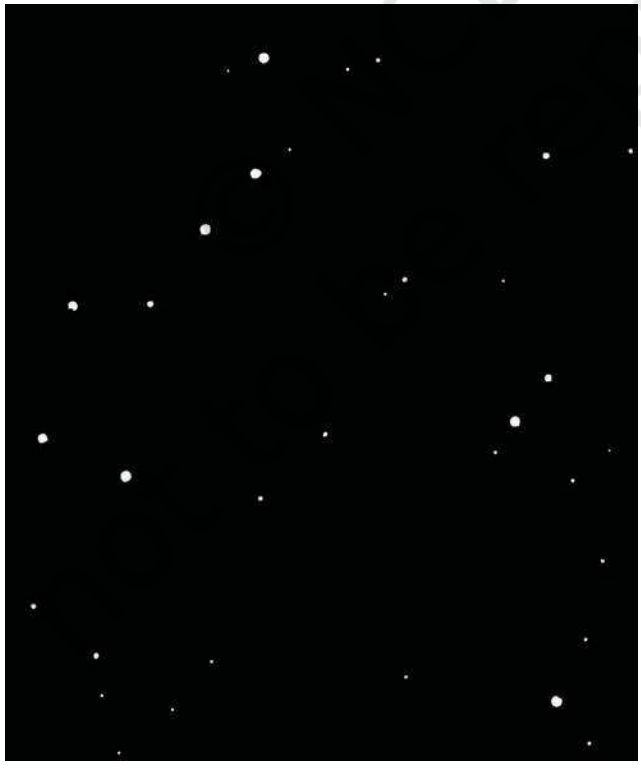


Fig. 12.2: A part of the night sky

- Repeat the above steps and make some more patterns.
- Now think of an interesting story about your patterns.

Compare your patterns with the patterns drawn by your friends. Are the patterns same or different? Narrate your story to others and listen to their stories. Do you notice that everyone's patterns, names and stories are different? Is it not fun?

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12.1 Stars and Constellations

At night, when we look up at the sky, we see many stars. Some stars are bright and others are dim. Stars shine with their own light.

Some groups of stars appear to form patterns which are like shapes of familiar things. Long ago, when watching stars in the night sky was a favourite pastime of our ancestors, they identified these star patterns with animals, things or characters in stories. Many cultures had names for patterns based on their own stories. These imaginary shapes helped them in recognising stars in the sky.



Recognising stars and their patterns was a useful skill for navigation in the olden times. Before the arrival of modern technology or even before the invention of the magnetic compass, it helped people, particularly sailors and travellers, in finding directions at sea or on land. It is still used in emergencies as a backup method.

In earlier times, groups of stars forming patterns were called constellations. Currently, the term constellation refers to defined regions of the sky that often include these patterns of stars. However, as the patterns of stars are often the most noticeable feature, the term constellation is still commonly used for these groups of stars.

More to know!

Since different cultures denoted the constellation boundaries in different ways, an internationally agreed set of constellation boundaries were defined by the International Astronomical Union (IAU) in the early twentieth century. 88 constellations were officially listed, thus, dividing the entire sky into 88 regions. These regions of sky are now defined as constellations.

Some constellations are shown in Fig. 12.3. The stars are joined by imaginary lines, drawn for easy identification. The constellation Orion is often represented as a hunter. There are three stars in the middle, which represent the belt of the hunter. Some people imagine that the hunter Orion, followed by his dog (constellation Canis Major), is battling a bull (constellation Taurus). Canis Major contains a star

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called Sirius, which is the brightest star in the night sky (Fig. 12.3).

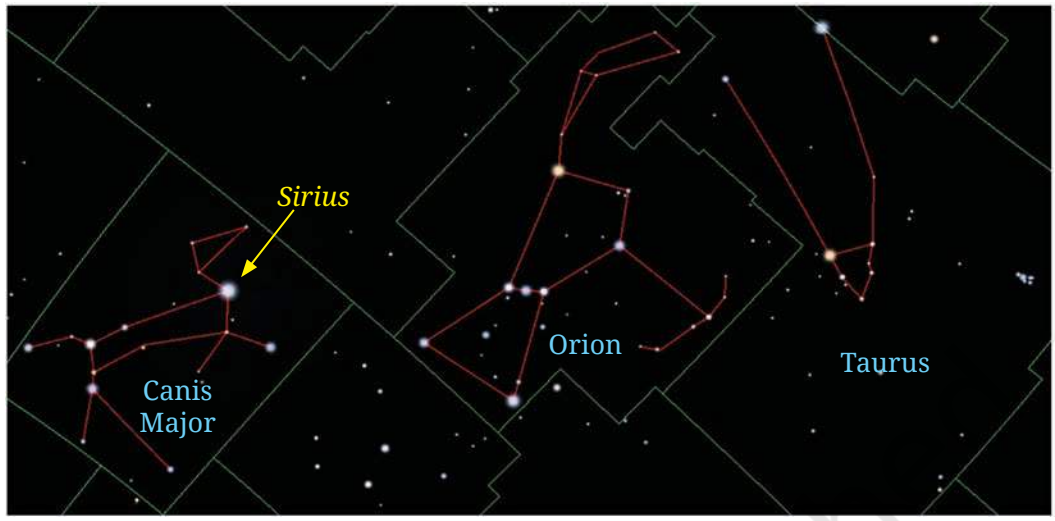
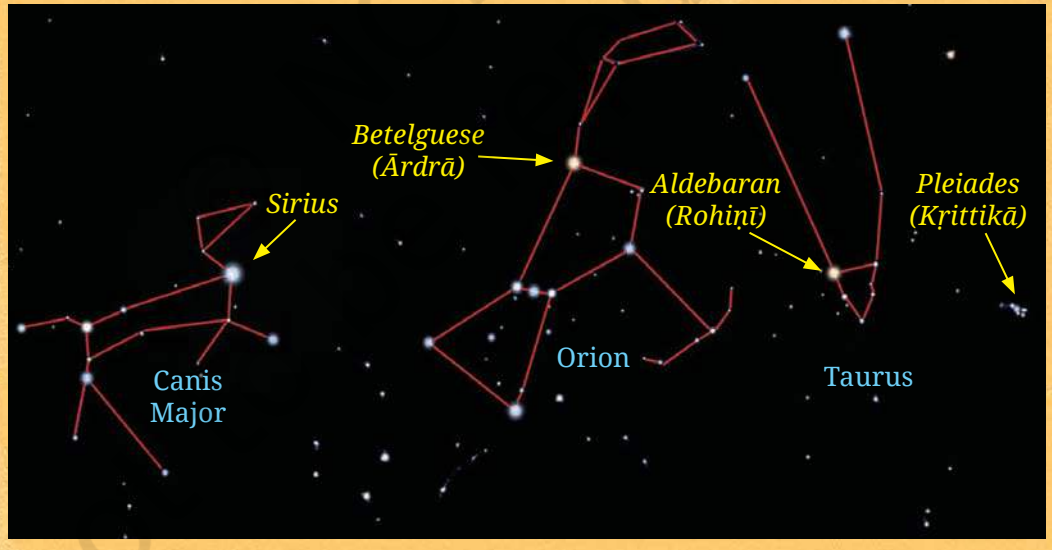


Fig. 12.3: Some constellations and stars

(The red lines indicate the patterns of stars while the green lines indicate the regions of the sky. The lines are not seen in the sky and have been drawn only for easy identification)



More to know!

In Indian astronomy, the term *nakṣhatra* is used to denote either a certain star or a group of stars, such as *Ārdrā* (a star called Betelgeuse in the Orion constellation) and *Kṛittikā* (a group of stars called Pleiades in the Taurus constellation). Aldebaran, a star in the constellation Taurus, is known as *Rohiṇī*.

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Two distinct patterns of stars, the Big Dipper and the Little Dipper, are shown in Fig. 12.4. The **Pole Star** or Polaris, which is part of the Little Dipper is also shown (Fig. 12.4).

The Pole Star appears nearly stationary in the North direction. This helps to locate the North direction in the Northern hemisphere.



Fig. 12.4: Big Dipper, Little Dipper and Pole Star (The lines are not seen in the sky and have been drawn only for easy identification)

More to know!

The Big Dipper lies in the constellation Ursa Major while the Little Dipper lies in the constellation Ursa Minor. In India, the Big Dipper is known as *Saptaṛiṣhi,* and the Pole Star is known as *Dhruva tārā.*

How can we identify some of these constellations in the night sky?



Do you know?

Apart from common regional stories associated with stars in the constellations, many forest dwelling communities or tribes of India also have their own stories about them. For example, the four stars in the Big Dipper that approximately form a rectangle, are viewed by tribes in Central India as the "grandmother's cot" with the three thieves (other three stars) stealing it. Fishermen along the Konkan coast imagine the four stars as a boat, with the last three stars as the neck of the boat.

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12.2 Night Sky Watching

If it is a clear cloudless night, a large number of stars may be visible in the sky. If you stay in a big city, you may find that the sky is rarely clear and only a few stars are seen in the night sky. This is due to light pollution, smoke and dust. The presence of excessive artificial light at night time is referred to as light pollution. In villages or areas where there is less light pollution, a larger number of stars can be seen. Also, your house may be surrounded by tall buildings and trees, which may block your view. The night sky is best viewed from open dark areas.

Do you know?

Light pollution is growing sharply globally. This is reducing our ability to enjoy and study objects in the night sky. Some dark sky reserves and parks have been established around the world. Light pollution in the reserves is controlled to preserve dark skies for research. There are organisations which are working to educate people about reducing light pollution.



Not all stars and constellations are visible from all places on Earth and on all nights in a year. For example, the Pole Star is not visible from the southern hemisphere of Earth. To identify a star or a constellation, you need to know how a particular constellation looks like and where to look for it in the night sky. To get familiar with the pattern of a constellation you may use images such as Fig. 12.3 and Fig. 12.4. To find out when and in which portion of the sky a star or a constellation will be visible from your location, you may take the help of sky mapping apps that can be downloaded on a mobile phone, or other online resources.

More to know!

Sky Map is a very handy app for identification of stars, constellations and planets from mobile phones. Stellarium is another such app. The computer version of Stellarium is free for download and has many features.

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Preparation for night sky watching

- Under the guidance of adults, identify a dark open area for night sky watching. This should be away from lights, tall buildings and trees.
- With the help of an app, choose the date and time based upon what you plan to identify in the night sky.
- Choose a night where neither the Moon nor the clouds are visible particularly for identifying the Pole Star which is not very bright.
- It may be useful to have access to a mobile app with a map of the sky, or print out images of the constellations you plan to view. You may also carry a magnetic compass to find directions and a notebook to note or draw your observations.
- On the particular day and time selected, go to the identified place with an adult, where the night sky watching is to be done.
- After reaching there, wait for about half an hour for your eyes to get adjusted to the darkness. This will help you to see the night sky better (Fig. 12.5).

Caution
Do not go to a dark open place at night time without adults accompanying you.



Fig. 12.5: Night sky watching

You may easily identify the Big Dipper and the Pole Star in the night sky.

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Activity 12.2: Let us try to locate

- Look for the Big Dipper during summer time in the early part of the night, say, around 9 p.m. View the sky towards the northern part of the sky and identify the Big Dipper.
- Once you identify the Big Dipper, try to locate the Pole Star. Look at the two stars present at the end of the Big Dipper's cup and imagine a straight line passing through these towards the north. At about five times the distance between these two stars, the imaginary line will lead to another star which is not very bright. This star is the Pole Star.

You may also locate the bright constellation Orion and the star Sirius in the night sky.

Activity 12.3: Let us try to identify

- In India, Orion is best viewed during the months of December to April after sunset. So, look for it during that period.



- Three bright stars in a short straight line are located around the middle of Orion (imagined to be the belt of a hunter). Identify these three stars first, as this is the easiest way to find Orion.
- Once you identify Orion, it is easy to locate the very bright star Sirius which is located close to Orion. Imagine a straight line passing through the three middle stars of Orion and look along this line towards the east. This will lead to Sirius.

12.3 Our Solar System

The Sun

The Sun is a star. It is the star closest to us. It is an extremely hot spherical ball of gases. The Sun gives out a huge amount of energy, and that is why it glows so brightly.

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The Sun produces heat and light, and is the main source of energy on the Earth (Fig. 12.6).

How big is the Sun? It is about 100 times bigger than the Earth in diameter. And still, it looks so small because it is very far from the Earth.

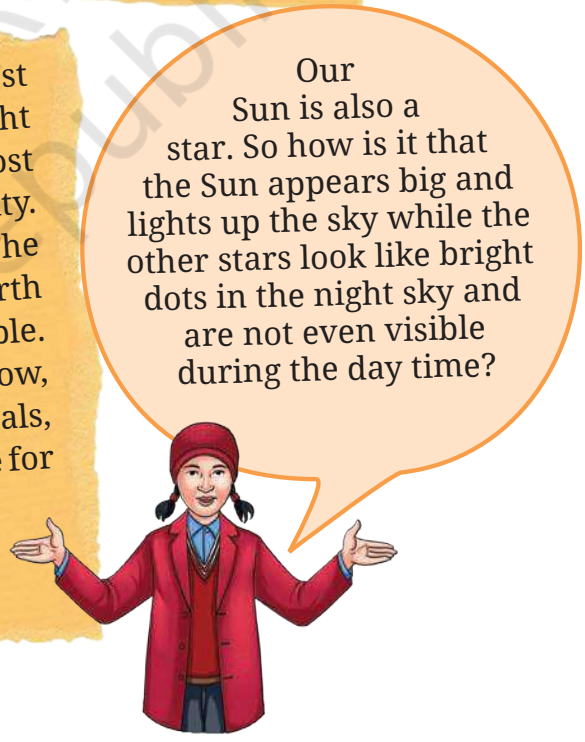


Fig. 12.6: The rising Sun

The distance of the Sun from the Earth is about 150 million km. A useful unit for expressing distances within the solar system is 'astronomical unit' (au) which is approximately the distance between the Sun and the Earth.

More to know!

The Sun, being the brightest object and the source of light and heat on Earth, was elevated in most ancient civilizations to the status of a deity. In India, the Sun is worshipped as *Sūrya*. The heat provided by the Sun keeps the Earth at a temperature that makes life possible. Sunlight is essential for plants to grow, which provide food and oxygen to animals, including humans. The Sun is responsible for climate, seasons, weather, water cycle, winds—all of which are important for sustaining life on the Earth.



However, the Sun is much closer to us than the other stars hence it appears much bigger than the stars. As the stars (other than the Sun) are much farther away, they appear like points, even though some of those stars are much bigger

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than our Sun. During daytime, due to the extreme brightness of the Sun, it is not possible to view other stars from Earth.

More to know!

The star nearest to us after the Sun is Proxima Centauri which lies at a distance of about 269000 au. This means that its distance is about 269000 times our distance to the Sun.



There are many more objects in the sky. Our Earth, along with some of these objects, and the Sun together form our Solar System (Fig. 12.7). Most of these objects move around the Sun. The movement of an object around the Sun is called **revolution**.

Planets

A planet is a large, nearly spherical object that revolves around the Sun. Our Earth is a planet as it revolves around the Sun as shown in Fig. 12.7. The Earth takes nearly one year to complete one revolution. Like the Earth, there are other planets that revolve around the Sun.

More to know!

While revolving around the Sun, the Earth is also rotating about its axis. For one full rotation, the Earth takes about 24 hours which is called a day. Like the Earth, other planets also rotate about their axes while revolving around the Sun. You will learn more about this in the next Grade.

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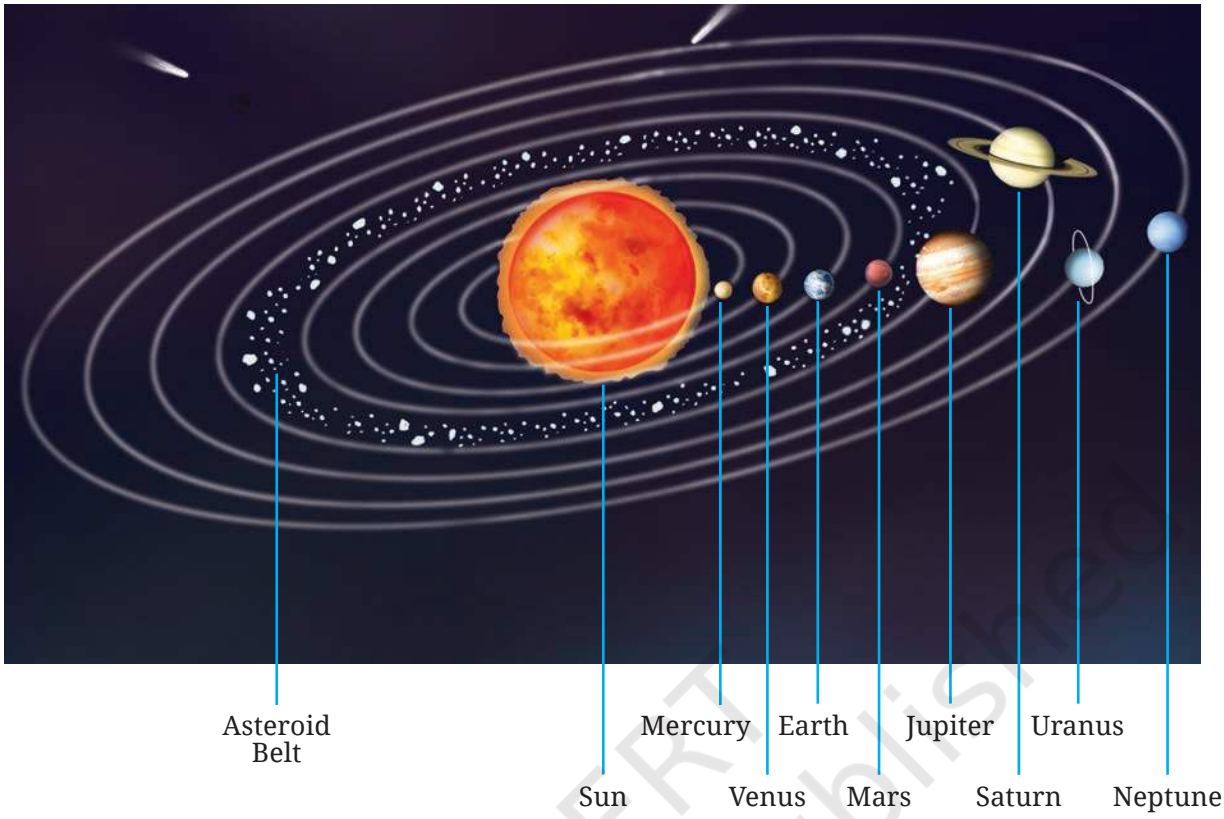


Fig. 12.7: An artist's representation of the Solar System

(To fit this figure within the page, the sizes and distances of various objects are not as per their actual sizes and distances in relation to each other, that is, the sizes and distances are not to scale in the figure)

The eight planets, in order of their increasing distance from the Sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune (Fig. 12.7).

The inner four planets nearest to the Sun—Mercury, Venus, Earth and Mars—are smaller in size. They have solid surfaces with rocks on them.

More to know!

From ancient times, various names have been used across India for the planets visible to the naked eye. For example, *Budha* (Mercury), *Śhukra* (Venus), *Pṛithvī* (Earth), *Mangala* (Mars), *Bṛihaspati* or *Guru* (Jupiter) and *Śhani* (Saturn).

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Venus is usually seen shining brightly at dawn and dusk, and is commonly called the Morning Star or the Evening Star, even though it is not a star. Mars is called the Red Planet because it appears red. This is because the soil on Mars is reddish in colour.

A large portion of the Earth's surface is covered with water and thus, it appears blue from the space. Due to this, the Earth is also called the Blue Planet.

The four outermost planets—Jupiter, Saturn, Uranus and Neptune—are much larger compared to the Earth, and are mostly made of gas and ice. These giant planets have large flat ring-like structures around them which are made of dust particles and rocky material.

Planets get most of their energy from the Sun. So, the farther they are, the colder they are in general. The presence of an atmosphere on a planet can trap heat which can significantly change the temperature of a planet. That is why Venus, for example, is hotter than Mercury, although it is farther from the Sun.

More to know!

There is another object called Pluto that lies farther than Neptune, and revolves around the Sun. It is smaller than the Earth's Moon. When it was discovered, it was called a planet of the Solar System. But later, when similar more small objects were discovered, the International Astronomical Union (IAU) in 2006 redefined the requirements of an object to be called a planet. As per this definition, these smaller objects, including Pluto, are now called dwarf planets.



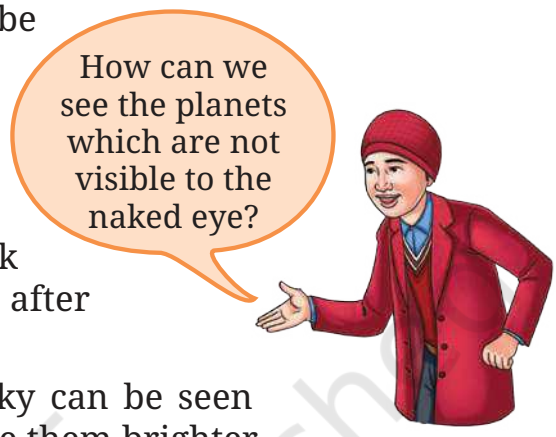
Among the planets, it is easiest to identify Venus which is very bright. After the Sun and the Moon, Venus is the brightest object in the sky. Mercury, Mars, Jupiter and Saturn can also be seen with the naked eye. They are

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so far away that they look like shining dots, just like stars. So how can we distinguish between planets and the stars? Unlike planets, the stars appear to twinkle a lot.

Activity 12.4: Let us try to identify

- With the help of an app, Venus can be located either at dawn or at dusk.
- When you are viewing at dawn, look for it near the Eastern direction before sunrise.
- When you are viewing at dusk, look for it near the Western direction after sunset.



While many of the objects in the sky can be seen with our naked eyes directly, we can see them brighter and larger using a pair of binoculars or an instrument called a telescope (Fig. 12.8). A telescope also helps us view many dim objects not visible by our naked eyes directly.

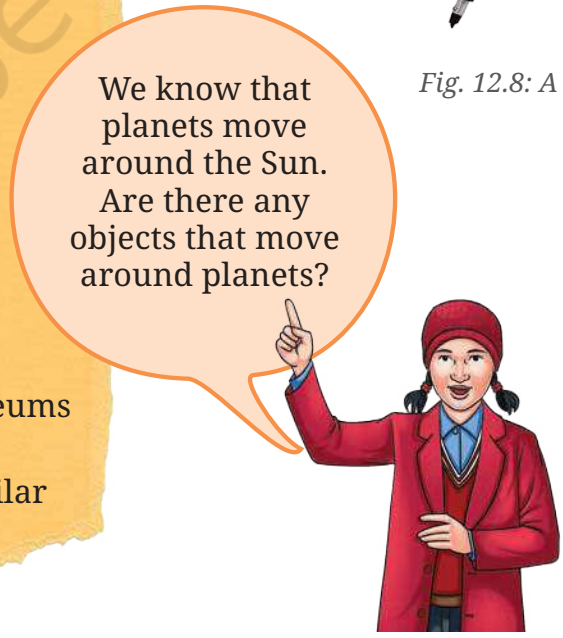
You may get an opportunity to view the sky through a telescope whenever a night sky watching event is organised in your region.



Fig. 12.8: A telescope

Do you know?

Many Higher Education Institutions conduct night sky watching activities for school students. There are many Amateur Astronomy Clubs all over the country which organise sky watching events periodically. Museums and Planetariums also organise similar events.



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Natural Satellites

Objects that move around planets are commonly called satellites. They are smaller in size than planets. Moons are natural satellites of planets. The Earth has one Moon, while Mars has two moons. Jupiter, Saturn, Uranus and Neptune have a large number of moons.

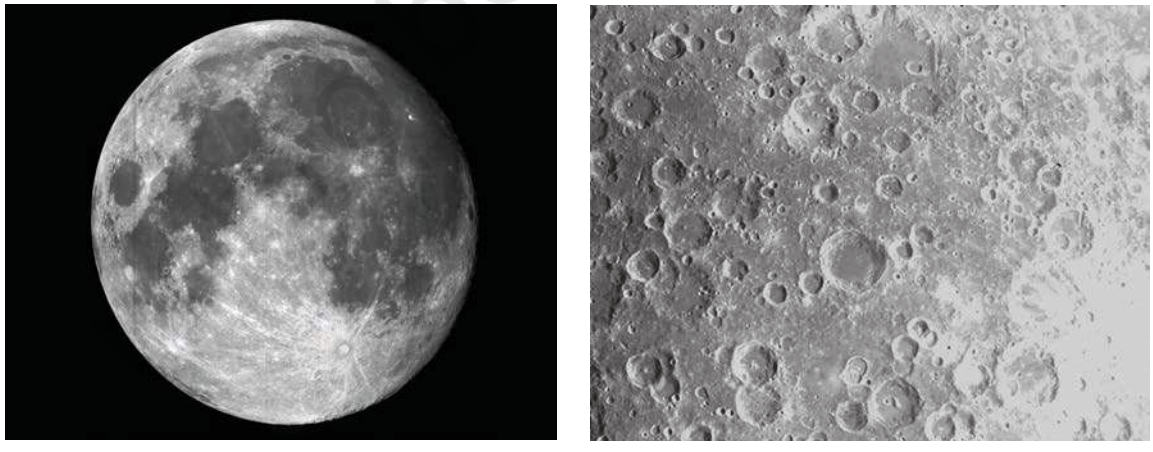
In general, any object that moves around a much larger object can also be called a satellite. For example, Earth can be considered a satellite of the Sun.

More to know!

The Moon is about 3,84,000 km away from the Earth.

The Moon

Earth's natural satellite, the Moon, takes about 27 days to complete one revolution around the Earth. It is our nearest neighbour in the space. Unlike on the Earth, there is hardly any atmosphere on the Moon. How big is the Moon as compared to the Earth? The Moon is about a quarter the size of the Earth in diameter. The Moon's surface shows circular bowl-like structures called craters (Fig. 12.9). Most of these craters have been formed due to the impact of asteroids or rocks from the space hitting the Moon's surface. Since there is no



(a) (b)

Fig. 12.9: The Moon
(a) Image taken by Cartosat, ISRO.
(b) Close-up image by cameras onboard Chandrayaan-3, ISRO.

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atmosphere, water or life on the Moon, these features stay on the Moon's surface for a very long time.

Although the Moon is very far, humans have sent spacecrafts to explore and understand more about the Moon. India has also launched three Chandrayaan missions to study the Moon, and a further mission is being planned.

Do you know?

To improve our understanding of the Moon, India's first mission to the Moon, Chandrayaan-1, was launched in 2008 and the second mission, Chandrayaan-2, in 2019. The third mission, Chandrayaan-3, was launched in July 2023 and its Vikram lander carrying the Pragyan rover successfully soft-landed on the Moon on 23 August 2023. With this mission, India became the first country in the world to achieve a landing near the little explored Moon's south pole. To mark this success, the Government of India declared 23 August to be celebrated as 'National Space Day' in India. A fourth mission, Chandrayaan-4, is being planned which aims to bring back soil and rock samples from the Moon.

Asteroids

The Sun and the planets are nearly spherical in shape. There are many small objects in the Solar System which are rocky and irregular in shape. These are called asteroids. Many of these asteroids revolve around the Sun in paths that lie between those of Mars and Jupiter. This region is called the asteroid belt (Fig. 12.7). Occasionally, some asteroids pass very close to the Earth.

More to know!

The sizes of asteroids are from 10 m to about 500 km.

Comets

Sometimes we have visitors from the outer regions of the Solar System! These objects with long tails are called comets (Fig. 12.10). They are made up of dust, gases, rocks and ice. As a comet approaches close to the Sun, the frozen material in it starts evaporating. This evaporating

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material forms the tail of the comet. Comets appear dim as they move away from the Sun and then, it is not possible to see them with the naked eye.



Fig. 12.10: A Comet

Many comets have been found that revolve around the Sun. These comets approach close to the Sun periodically. However, there are a few comets that escape and move out of the Solar System. Few other comets get broken up, or fall into the Sun or other planets when they approach them.

We have learnt about the objects which form the Solar System. Which are these objects? **The Sun, eight planets, their moons, and many smaller objects including asteroids, and comets, together form the Solar System**.

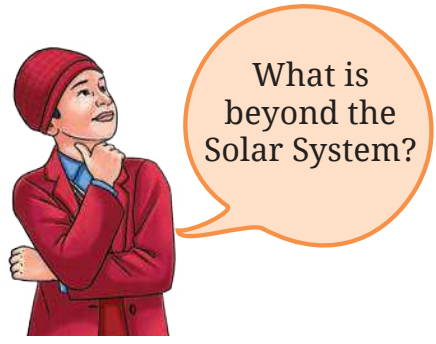
The Sun—our star—is the largest and the heaviest object in the Solar System. The Sun produces almost all the energy in the Solar System. All other objects in our Solar System shine due to the sunlight that they reflect from their surfaces.

One famous comet is the Halley's Comet which appears every 76 years. Its last appearance was in 1986.

More to know!

In Sanskrit and a few other Indian languages, a comet is called *Dhūmaketu*. Various tribes in India also call it *Pucchya-Taro* (star with a tail) or *Zendya-Taro* (star like a flag).

In many cultures, comets have been feared and it was earlier believed that comets bring bad luck. However, thanks to scientists, we now know that these are just icy-rocky visitors making a trip close to the Sun!



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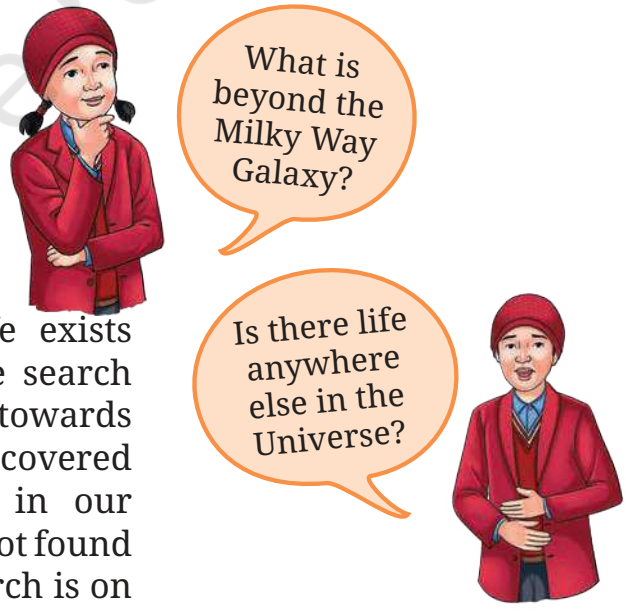
12.4 The Milky Way Galaxy

In the moonless night sky, viewed from dark locations away from city lights, one can see an extended faint band of light from near north to south across the sky (Fig. 12.11). This is our home galaxy called the Milky Way Galaxy or *Ākāśha Gangā*. A galaxy has millions to billions of stars. Our Solar System is part of the Milky Way Galaxy.



Fig. 12.11: Milky Way Galaxy as seen from a very dark location in Ladakh, India

12.5 The Universe



There are many galaxies in the outer space beyond the Milky Way Galaxy. Scientists study them to understand the stars, galaxies and the Universe.

We do not know yet if life exists elsewhere in the Universe. The search for life has been directed mostly towards exoplanets—the planets discovered revolving around other stars in our galaxy. Till now, scientists have not found any evidence of life but this search is on and continuing.

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Keywords

Asteroid
Comet
Constellation
Milky Way Galaxy
Moon
Planet
Revolution
Satellite
Solar System
Stars
Sun

Draw
Explore
Identify
Observe

Summary

Key Points

- The sky is divided into regions called constellations, which include groups of stars that appear to form patterns.
- The Pole Star appears nearly stationary in the North direction. This helps in locating the North direction in the Northern hemisphere.
- The Sun is a star which produces heat and light.
- A planet is a large, nearly spherical object that revolves around the Sun.

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- The eight planets, in order of their increasing distance from the Sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
- The Earth revolves around the Sun in nearly one year.
- Objects that move around planets are commonly called satellites.
- The Moon is Earth's natural satellite.
- The Moon revolves around the Earth in nearly 27 days.
- The Sun, eight planets, their moons, and many smaller objects including asteroids and comets, together form the Solar System.
- Our Solar System is part of the Milky Way Galaxy.

Let us enhance our learning

1. Match the column:

Column I	Column II
(i) Satellite of Earth	(a) Orion
(ii) Red planet	(b) Venus
(iii) Constellation	(c) Mars
(iv) Planet which is commonly called an evening star	(d) Moon

2. (i) Solve the following riddle.

My first alphabet is in MAN but not in CAN
My second alphabet is in ACE and also in FAN
My third alphabet is in RAT and not in CAT
My fourth alphabet is in SUN but not in FUN
I am a planet that moves around the Sun.

(ii) Make two similar riddles by yourself.

3. Which of the following is not a member of our Solar System?

(i) Sirius (ii) Comets
(iii) Asteroids (iv) Pluto

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4. Which of the following is not a planet of the Sun?

(i) Jupiter (ii) Pluto
(iii) Neptune (iv) Saturn

5. Which is the brighter star, the Pole Star or Sirius?

6. An artist's representation of the Solar System is given in Fig. 12.12. Is the order of the planets correct? If not, write the correct order in the boxes in the figure.

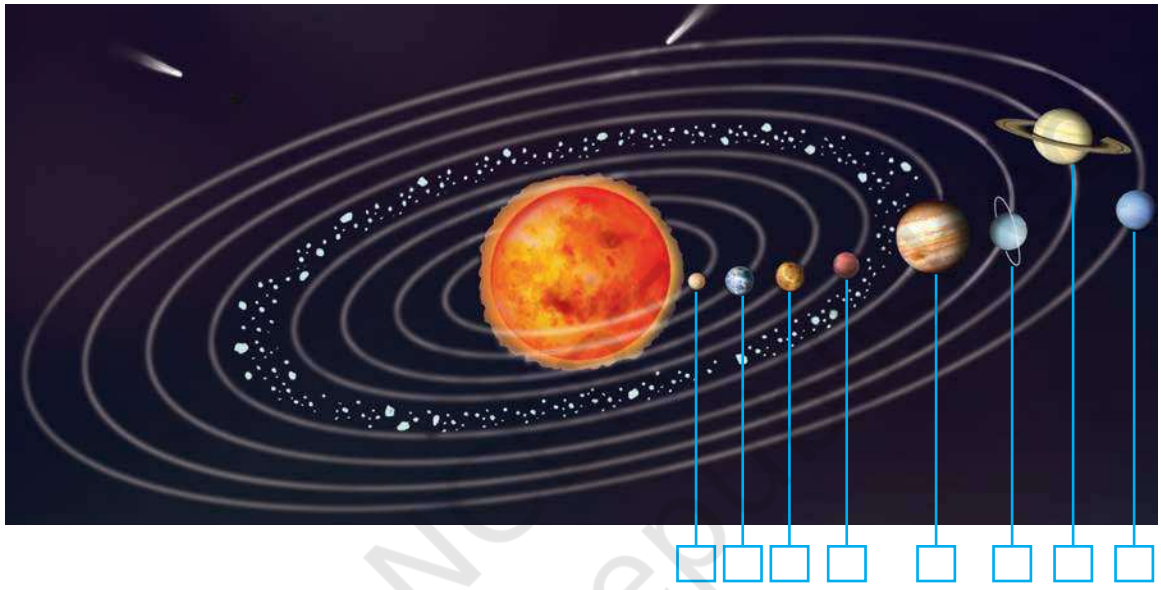


Fig. 12.12

7. A portion of night sky with stars is shown in Fig. 12.13. Look carefully and identify the groups of stars that form the patterns—the Big Dipper and the Little Dipper. Draw lines to connect the stars for these patterns and label them. Also, identify and label the Pole Star. You may refer to Fig. 12.4 for help.

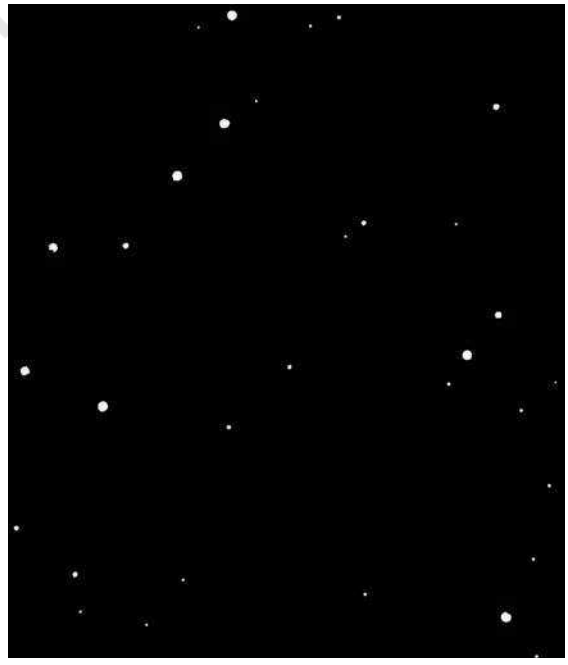


Fig. 12.13

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8. A portion of the night sky is shown in Fig. 12.14. Draw lines to connect the stars for Orion and label the star Sirius. You may refer to Fig. 12.3.

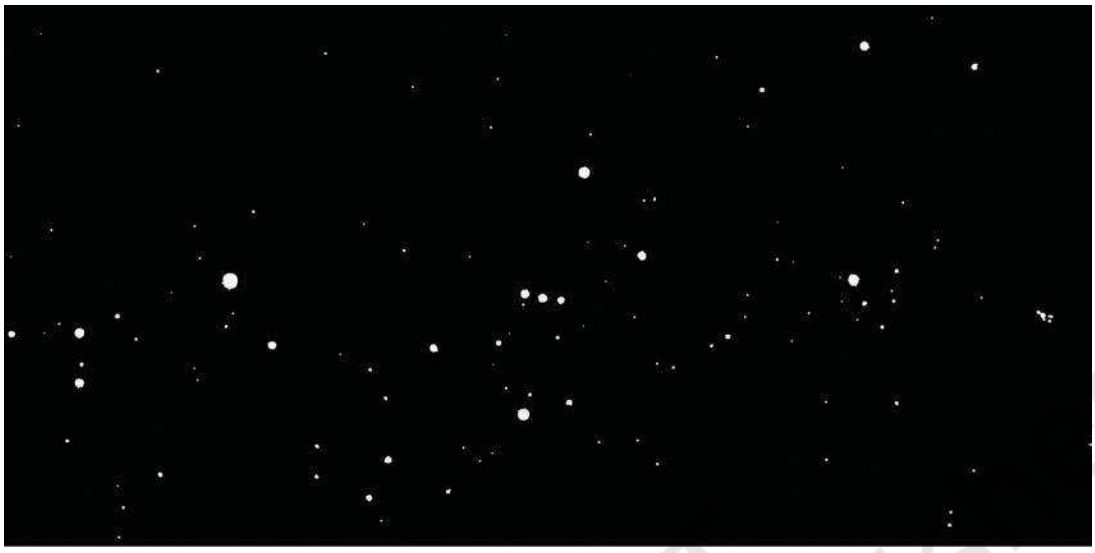


Fig. 12.14

9. From Earth, you can see stars fading away at dawn and appearing at dusk. During the day we do not see the stars. Explain why.

10. During a clear night, try to observe the Big Dipper 3–4 times at an interval of 2 to 3 hours. Also try to locate the Pole Star each time. Does the Big Dipper appear to move? Draw a rough sketch to illustrate this, mentioning the time in each case.

11. Think about the night sky and write a poem or a story on it.

Learning further

- Try to find out the names of planets in your local language. Also, find out the stories associated with stars and constellations in your region. Present these stories in a pictorial form.
- If there is a planetarium or a science museum nearby, then you can visit it, especially if a night sky observation session is scheduled by them. You will get to see the Moon, the planets and the stars through a telescope. If you visit the planetarium during daytime, you can also see their models, pictures and sky shows.

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Fig. 12.15: Embroidery of constellations

- Find out if the increasing light pollution is causing problems for humans, wildlife and the environment. Write an action that you would take at the personal level to control light pollution.
- Find out the weather conditions due to which the Indian Institute of Astrophysics (IIA) found Hanle, Ladakh a suitable place to set up an observatory.
- If you enjoy doing embroidery, try to embroider on a dark coloured cloth the constellations that you have seen (Fig. 12.15). Otherwise, you may use your creativity and depict constellations in multiple other ways using various art and craft ideas.



More to know!

Indian Astronomical Observatory, Hanle, is situated atop the highest peak of Digpa-ratsa-Ri mountain range in Hanle. This peak has been renamed Mount Saraswati.

It has several telescopes. One of them is called the Himalayan Chandra Telescope, which has been named after the Nobel Prize winning scientist Subrahmanyan Chandrasekhar. It is an observatory at one of the highest locations in the world.

The area surrounding this observatory was notified as the Hanle Dark Sky Reserve (HDSR) in December 2022. The reserve is open to the public throughout the year. Local people have been provided with small telescopes and are trained to be Astronomy Ambassadors for visitors by the Indian Institute of Astrophysics. It is expected to promote astro-tourism in the region.



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It is not the end, my friend!

This might be the last page of this book, but it is certainly not the end of our 'Curiosity'. The title of this book not only drives our journey through the amazing world of science, but also defines what it means to be human. As a species, we are curious. We want to find out more about the world we live in and worlds beyond. By now, you have perhaps read a little bit about the world of plants and animals, done some fun activities, learnt about how we measure, wondered about the stars that shine in the night sky, and so on. But remember, this is just the beginning. Science is a never-ending adventure, with new discoveries coming up all the time. And as you progress through the Middle Stage, the things you come across will help you find out even more about the world around you. The key lies in that curiosity you have nurtured throughout this journey. Keep observing the world around you, keep asking questions, and do not be afraid to experiment. Remember, even the most groundbreaking discoveries often begin with a simple "Why?". There are countless questions waiting to be answered, and countless answers waiting to be questioned. You, my young scientist, can find them out. So, go forth and explore! And see you again in the next Grade for more adventures in science!



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Notes

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