3

Motions of the Earth

Since ancient times we have been interested in the heavenly bodies in the sky. We have observed their movements across the sky. But in the past, it was thought that the other heavenly bodies including the Sun circled the Earth. It was only in the 16th century that Nicolaus Copernicus made it known that the Earth was not stationary.

When we look out from a moving train we find that all objects — trees, houses, relief features, stations — seem to go past us while we are stationary. But actually it is we, inside the train, who are moving, not the objects outside. Similarly, the Earth and, along with it, everything on it including us is in motion.

The Earth may seem to be still beneath our feet but it is actually moving. It is spinning around its own axis as well as circling around the sun along an **elliptical orbit**. These two **motions of the Earth** in space are known as **rotation** and **revolution respectively**.

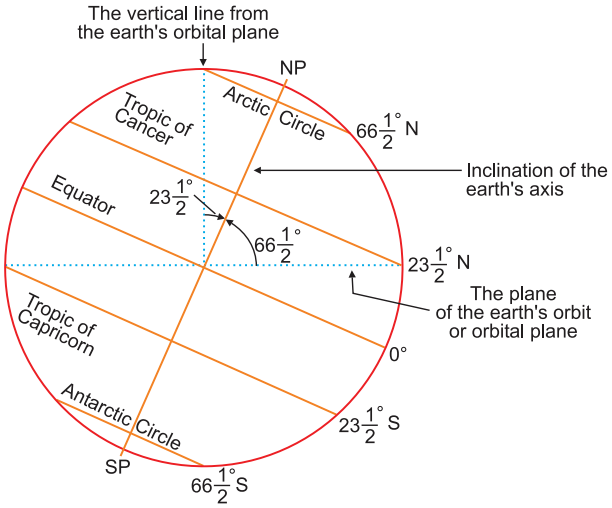

Fig. 3.1 : The inclination of the Earth

ROTATION

The daily **spinning movement** of the Earth from west to east on its own axis is termed as **rotation**. The imaginary line, axis of the Earth, is tilted at an angle of 23½° to the vertical plane. It makes an angle of 66½° to the orbit or path of Earth's revolution around the sun known as **orbital plane**. This tilt of the Earth remains fixed even when it revolves round the sun. This is called the **inclination of the Earth's axis**. The northern tip of the axis is called the North Pole while the southern point is called the South Pole.

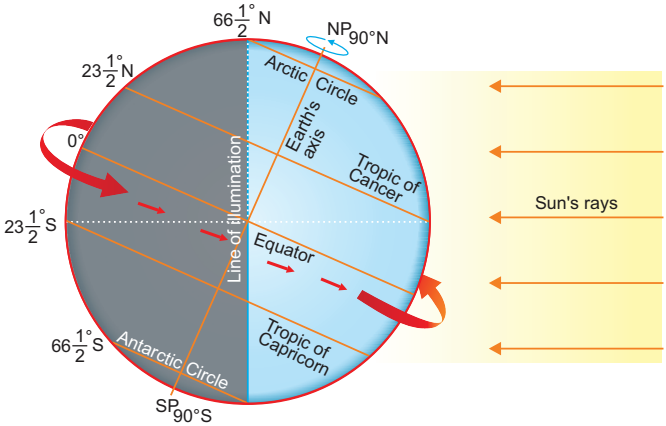

Fig. 3.2 : Day and Night and the Circle of Illumination

EFFECTS OF ROTATION

If you wake up early in the morning, you will notice that the darkness of the night gradually fades away with the break of the dawn. Gradually, the sun rises in the east and lights up the Earth for the entire day. In the evening the sun sets in the west and night approaches after dusk. In truth, however, it is the Earth that changes its position and not the sun.

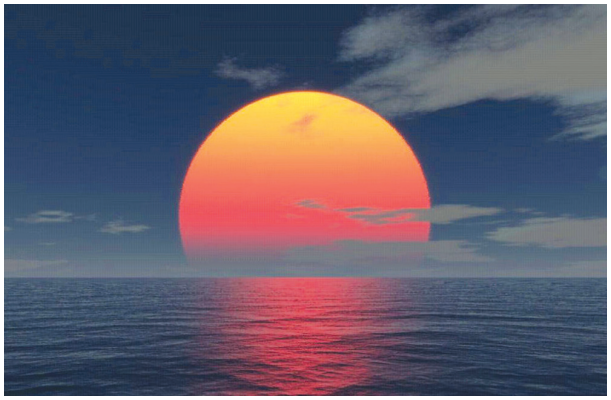

Fig. 3.3 : In the morning, the Sun looks as though it is rising, as your part of the Earth gradually turns to face it.

Fig. 3.4 : In the evening, the Sun seems to sink down in the sky, as your part of the Earth turns away from it.

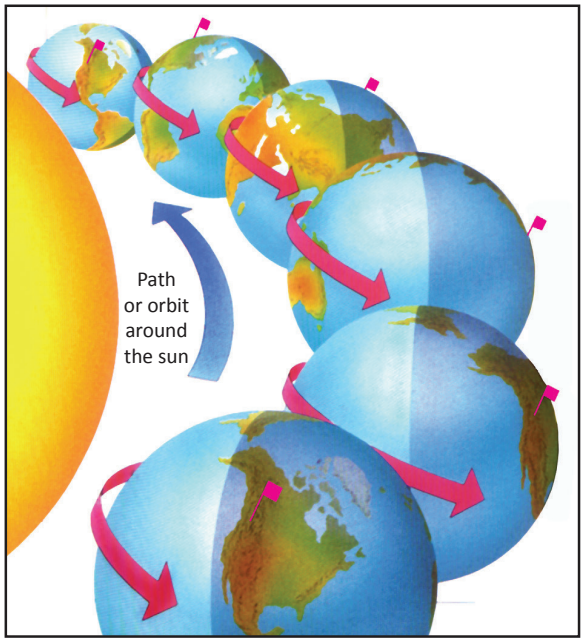

Fig. 3.5 : Change from day to night at one place (marked by the flag) as the Earth spins.

This important *phenomenon of day and night* is an outcome of the spherical shape of the Earth and its rotation around its axis.

Did you know?

The Earth takes 23 hours, 56 minutes, 6 seconds, *i.e.*, approximately 24 hours, to complete one rotation. This is termed as the Earth day.

The portion of the Earth that faces the sun receives the sun's rays and experiences day while the other half, which is on the other side, away from the sun, experiences darkness or night. The imaginary line that separates the lighted portion of the Earth (day) from the dark one (night) is termed as the **circle of illumination**.

In between day and night is a period of diffused light termed as dawn and dusk or twilight. When the sun has not yet appeared on the horizon, but there is faint light in the surroundings at daybreak, it is termed as dawn. The sun's rays are slanting at this period. Noon is the period of maximum heat as the sun rays are vertical at this time of the day. After the sun sets in the evening, there is a period of faint light before total darkness of night. This is termed as twilight or dusk.

Effects of different speeds of rotation

The Earth rotates at a speed of 1600 km per hour at the equator, 1200 km per hour at 45°N and 45°S, and the speed further decreases at the poles. This difference in speed causes the bulging of the Earth at the equator and flattening at the poles. It also affects the circulation of ocean currents and general circulation of the atmosphere. It causes deflection of ocean currents and wind.

As the Earth rotates from west to east, the sun, the moon and other stars seem to move from east to west. The concept of sunrise and sunset also gives us a sense of direction based on the position of sun as viewed from Earth. The sun rays are vertical at noon and slanting in the morning and evening. You can understand this by observing your shadow during the daytime.

What would happen if the Earth stops rotating?

Life would not be possible on Earth if it stops rotating. The phenomenon of day and night would dissappear. Portion of the Earth facing the sun would experience continuous sunlight and warmth while the portion away from sunlight would experience night and low temperature for eternity. Thus, extremes of temperature would make Earth inhospitable and unsuitable to live.

REVOLUTION

The annual movement of the Earth around the sun along a fixed path is called revolution. The fixed elliptical path along which the Earth revolves is called its orbit. The Earth revolves along its obrit of approximately 965 million km length at a speed of 29.6 km per second. It takes 365 days 5 hours 48 minutes 46 seconds (approximately 365½th days) to complete one revolution. For the sake of convenience 365 days is taken as a single year. The extra quarter of a day adds up to make a whole day in a period of four years. Thus, we have a year with 366 days every four years. It is termed as a leap year. February 29 is the additional day added to compensate the difference of the common year (365¼). The year 2012 is a leap year. Can you say which was the first leap year of this century? When will you again experience a leap year?

Did you know?

The distance between the Sun and Earth is not constant throughout the year. This is because the orbit is shaped like an ellipse and is not circular. When the Earth is nearest to the sun, at a minimum distance of 147 million km, it is said to be at perihelion. It occurs on 3rd January every year. At aphelion the Earth is farthest away from the sun at a distance of 152 million km and it occurs on 4th July.

EFFECTS OF EARTH'S REVOLUTION

The revolution of the Earth along with its inclined axis determines the **primary distribution of the sun's energy** throughout the Earth. Its primary effect is the **occurrence of different seasons** throughout the Earth. The **varying lengths of day and night** throughout the Earth are a result of this.

PHENOMENON OF SEASONS

The entire year is divided into four seasons – spring, summer, autumn and winter. It is based

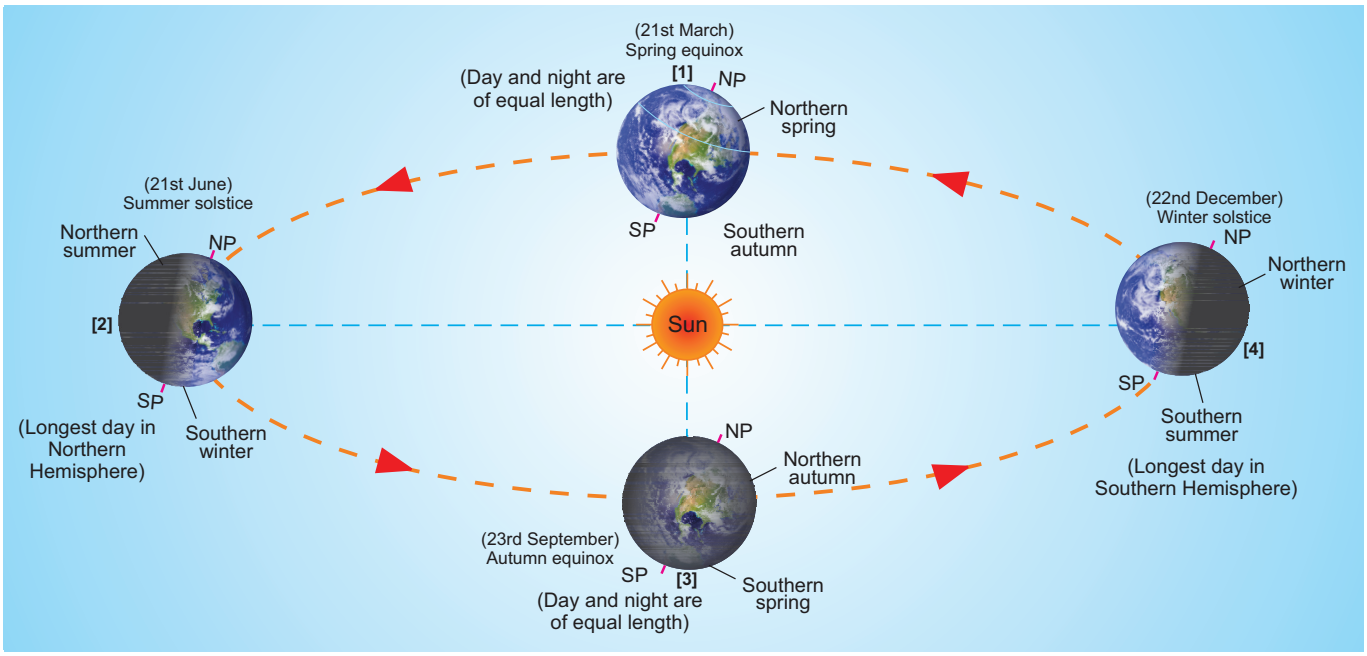

Fig. 3.6 : Revolution of the Earth and the phenomenon of seasons

on the tilt of the Earth's axis and revolution which positions the places nearest or farthest from the sun. It determines the intensity of sun's energy received by that place at a particular time of year and hence warm or cold weather.

Figure 3.6 shows the position of the Earth in its annual journey round the sun. The main reason why we experience seasons is because the Earth's rotational axis is not perpendicular to the orbital plane. Because of the axial tilt the angle of the sun rays hitting a point on the Earth's surface changes with time in a year.

Equinox

On **21st March** and **23rd September** the sun shines vertically overhead on the equator at midday (position 1 and 3 in Fig. 3.6). The day and night are of equal duration throughout the world. These two days are termed as '**equinoxes**' meaning 'equal nights'. **21st March** is termed as the **Spring** or **Vernal Equinox**. The Northern Hemisphere experiences spring at this time while the Southern Hemisphere experiences autumn.

On **23rd September**, termed as **Autumn Equinox**, the Northern Hemisphere experiences autumn while the Southern Hemisphere experiences spring. It is neither very hot nor very cold in any hemisphere.

Solstice

A solstice is the day, when the midday sun shines vertically overhead at one of the tropics i.e., Tropic of Cancer and Tropic of Capricorn, and the duration of the day is the longest in that hemisphere. Two solstice are: Summer solstice (Position 2) and Winter solstice (Position 4 in Fig. 3.6).

On 21st of June, the Tropic of Cancer (23½°N) receives the direct rays of the sun (Fig. 3.7). The Northern Hemisphere receives maximum warmth and sunlight and experiences summer season. Days are longer than nights during this period. Places in the Northern Hemisphere experience longest day and shortest night on 21st June.

The North Pole is tilted towards the sun and places beyond the Arctic Circle experience daylight for 24 hours for six months at the North Pole. Conditions are reversed in the Southern Hemisphere which experiences winter during this period.

On 22nd December, the Tropic of Capricorn (23½° S) receives the direct rays of the Sun (Fig. 3.7).

The Southern Hemisphere experiences summer with longer days and shorter nights. The South Pole is tilted towards the sun. Places beyond Antarctic Circle have continuous daylight for 24 hours on this day, while places beyond Arctic Circle in the Northern Hemisphere have 24 hours darkness on this day. The South Pole receives six months of daylight during this period while the North Pole has continuous darkness for six months. This date is termed as Winter Solstice with the Northern Hemisphere experiencing winter.

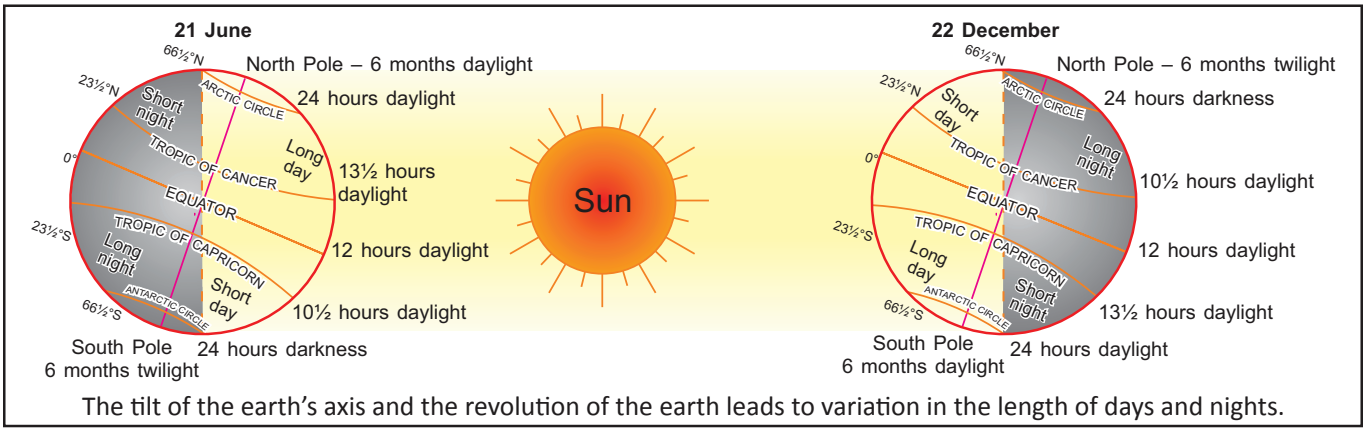

Fig. 3.7 : Position of the earth on 21 June and 22 December

ACTIVITY-1

Take a table lamp and a ball to represent the globe. On the ball, paste a small map of India and mark on it the city where you live and label it A.

Darken the room. Switch on the table light. Place the ball in front of the light at a distance of one foot. The map should be facing the opposite side. It would be in darkness that is night. Slowly rotate the ball from west to east. The point A gradually receives diffused light that is sunrise, then when it faces the lamp it has daytime. On rotating it further, the point passes from light to faint light as in twilight after sunset. Our country is in Eastern Hemisphere. If you mark a point B exactly on the opposite side of point A on the ball, it would represnt Western Hemisphere. You will see that when point A has day, point B will experience night and vice-versa.

ACTIVITY-2

If you can arrange for a rotating globe and a small revolving stool, you can perform the experiment with further accuracy. You can also demonstrate the change of seasons.

Place the table lamp on a small stool or table of the same height as the revolving stool. Draw an elliptical orbit round the stool with a chalk. Place the globe on the revolving stool. Move it along the orbit round the lighted lamp (representing the sun) in the dark room from east (Winter Solstice) to north (Equinox) to west (Summer Solstice) to south (Equinox) to east (Winter Solstice) to complete one revolution. Observe how the intensity of the light from the table light falling on the globe changes as you revolve the globe. You can now view how seasons change from summer with more heat and light to winter with less warmth.

INTERESTING FACTS

Places (like North Cape in Norway and Alaska) north of the Arctic Circle are called 'Land of the Midnight Sun', because at the Arctic Circle the sun never 'sets' on the Summer Solstice or 21st June. There is a complete 24 hours period of continuous daylight. At the North Pole the sun does not set for six months. However, only slanting rays of the sun reach these areas. Therefore, even in summer with continuous daylight, these areas remain cold.

To sum up, we can say that the rotation and revolution of the Earth along with the inclined axis are responsible for the phenomenon of day and night and changes of seasons. These are the major factors in determining the variety of life forms on Earth.

FIND OUT

In which season does Australia celebrate Christmas and New Year?

Points to Remember

- The daily spinning movement of the Earth from west to east on its own axis is termed as rotation.
- The Earth rotates at a speed of 1600 km per hour at the equator, 1200 km per hour at 45ºN and 45ºS, and the speed further decreases at the poles.
- 21st March is termed as the Spring or Vernal Equinox.
- On 23rd September, termed as Autumn Equinox, the Northern Hemisphere experiences autumn while the Southern Hemisphere experiences spring.

Glossary

ROTATION : The daily spinning movement of the Earth from west to east on its own axis is termed as rotation.

REVOLUTION : The annual movement of the Earth around the sun along a fixed path is called revolution.

DAWN	:	Period of diffused light before sunrise.
ORBIT	:	The fixed imaginary elliptical path along which the Earth revolves.
CIRCLE OF ILLUMINATION	:	The imaginary line that separates the lighted portion of the Earth (day) from the dark one (night) during each Earth day.
EARTHDAY	:	The period of the earth's rotation is called the Earthday.
SOLSTICE	:	One of the two moments in a year when the sun's rays fall vertically on the Tropic of Cancer and Capricorn.
EQUINOX	:	One of the two moments in a year when the sun appears overlead at the equator. On the day of equinox, the day and night are of equal length.
ORBITAL PLANE	:	The plane formed by the orbit is known as the orbital plane.

TIME TO LEARN

A. Multiple Choice Questions (MCQs)

1. The annual movement of the Earth round the sun

(a) Rotation (b) Revolution (c) Orbit (d) Inclination

2. Direct rays of the sun fall on the Tropic of Cancer on

(a) 21st March (b) 21st June (c) 23rd September (d) 22nd December

3. The phenomenon of change of seasons is caused due to

(a) Rotation (b) Revolution

(c) Movement of the sun (d) Spherical shape of the Earth

4. A leap year has

(a) 365 days (b) 365¼th days (c) 366 days (d) 366 days 6 hours

5. Which of the following is called Land of the Midnight Sun?

(a) North Cape in Norway (b) Tokyo in Japan

(c) Sydney in Australia (d) Nagaland in India

6. On which of the following days, the day and night are of equal duration throughout the world?

(a) 21st March and 23rd September (b) 28th March and 21st September

(c) 23rd March and 21st September (d) 21st June and 22nd December

7. The Tropic of Capricorn receives the direct rays of the Sun on

(a) 21st June (b) 22nd December (c) 21st March (d) 23rd September

B. Mention True or False

1. The equator experiences six months of daylight during summer.

2. On Summer Solstice the rays of the sun fall vertically on the Tropic of Cancer.

3. February in a leap year has 29 days.

4. Direct rays of the sun fall on the equator on 21st March.

5. The speed of the Earth's revolution along its orbit is 29.6 km per second.

6. The speed of the Earth's rotation at equator is approximately 1600 km per hour.

C. Very short answer type questions

1. Name the two motions of the earth.

2. Which motion of the earth causes the phenomenon of day and night?

3. What is the direction of rotation of the earth?
4. What is the exact time taken by the earth to complete one revolution?
5. When do the Summer and Winter Solstice occur?

D. Short answer type questions

1. Explain the meaning of the 'angle of inclination'. Why is it important?
2. What are the main effects of the Earth's rotation?
3. Give the main effects of the Earth's revolution.
4. What is meant by 'leap year'?
5. Why do the poles experience six-months day and six-months night?
6. What would happen if the Earth stops rotating? **[HOTS]**

E. Long answer type questions

1. Differentiate between the Summer and Winter Solstice.
2. Why does the Southern Hemisphere experiences Winter and Summer Solstice in different times than that of the Northern Hemisphere? **[HOTS]**
3. How does the phenomenon of seasons occur?
4. Differentiate between
   (a) Rotation and Revolution
   (b) Summer and Winter Solstice.

F. Activity

- Perform an experiment to demonstrate the phenomenon of day and night.

G. Trip/ Excursion

- Go on a trip to a seaside or a hill station with your parents. A class excursion will be more enjoyable. Take photographs of sunrise and sunset. Calculate the total duration of day and night. Link it with the date of the year and the season. Draw conclusions and share them with your friends.

LIFE SKILLS

Suppose you and your family want to visit Australia around 22nd December for about 10 days. Make a checklist of things that you have to pack for the trip.