# 4

# Motions of the Earth

You know that the earth has two kinds of motions—rotation and revolution. The earth revolves around the sun in a fixed path, or orbit. The orbit of the earth can be thought of to be lying on an imaginary surface, or plane, called its orbital plane. The earth also rotates, or spins, around its axis. The axis is the imaginary line joining the North Pole and the South Pole through the centre of the earth. This axis makes an angle of $23\frac{1}{2}°$ with the perpendicular to the plane of the earth's orbit. In other words, the earth's axis makes an angle of $66\frac{1}{2}°$ with the orbital plane. This means that the earth is always inclined to one side while it revolves around the sun. This tilt of the earth's axis is called the *inclination of the earth's axis.*

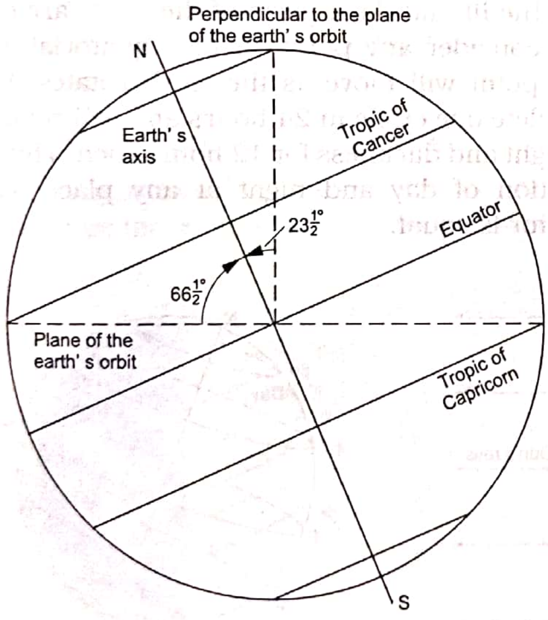


**Fig. 4.1** The inclination of the earth's axis and the plane of the earth's orbit

## *Rotation*

**Day and night** You know that the earth takes 24 hours to complete one rotation, and that it moves from west to east. Rotation causes days and nights to follow each other in a regular pattern, which is repeated every 24 hours.

Let us see how this happens. Look at Figure 4.2. You will see that the half of the earth which faces the sun is lighted. So in this half it will be day. The other half is in darkness, and it will be night in this half. The circle which divides the earth into a lit half and a dark half is called the *circle of illumination.* As the earth moves from west to east, the dark half gradually faces the sun, while the lit half turns away from it. This is how day follows night. Can you guess what would have happened if the earth did not rotate?

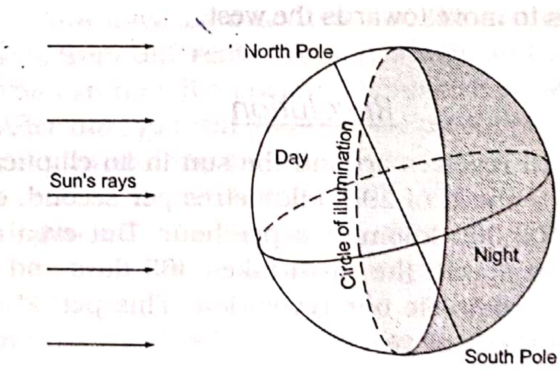


**Fig. 4.2** Day and night on the earth

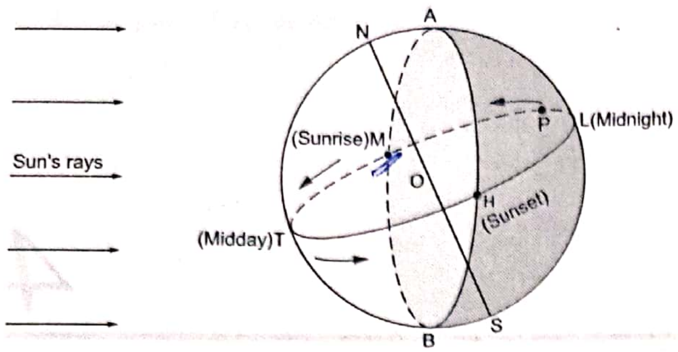


**Fig. 4.3** Changes in the position of a place from sunrise to midnight

**Apparent motion of the sun** You have learnt how the sun appears to move from east to west because the earth rotates from west to east. Now look at Figure 4.3.

The circle AMBHA divides the earth into two equal parts—one experiencing day and the other, night. Let us follow a place P on the equator while the earth rotates from west to east. As the place moves towards sunlight, it will reach a point, close to M, where it will get some diffused light. This part of the day, when the sun is not visible and yet there is some light, is called *dawn*. As P moves further east and comes to M, it receives the direct rays of the sun for the first time. This is the time of sunrise, when the sun appears to come into sight on the eastern horizon. When the place reaches the point T, the sun shines overhead. At this time it is noon, or midday, at the place. After midday, the place begins to turn away from the sun. At point H, the sun appears to go down on the western horizon. This is the time of sunset. However, the place receives diffused light even after the sun disappears from view. This time is called *dusk*. At point L, the place is farthest from sunlight. At this time it is midnight at that place. Thus, as the earth rotates from the west to the east, the sun first appears in the east and then appears to move towards the west.

## Revolution

The earth revolves around the sun in an elliptical orbit at a speed of 29.8 kilometres per second, or about 100,000 kilometres per hour. But even at this great speed, the earth takes 365 days and 6 hours to complete one revolution. This period of time is called one year.

**Leap year** Strictly speaking, one year is 365 days and six hours. But to make things simpler, we take one year to be 365 days. The extra six hours each year add up to 24 hours, or a day, in four years. Thus, every fourth year we add an extra day to a year. Such a year, which has 366 days, is called a *leap year*. In a leap year, the month of February has 29 days instead of 28.

You know that the earth's axis is inclined to the earth's orbital plane. So, it is always slightly tilted in the same direction as the earth revolves around the sun. This makes each hemisphere tilt towards the sun during half the year (six months), and away from it during the other half. Between 21 March and 23 September, the North Pole remains inclined towards the sun. Between 23 September and 21 March, the North Pole is tilted away, and the South Pole is tilted towards the sun. The earth's tilt and motion around the sun has the following consequences.

### 1. Unequal Days and Nights

You may have noticed that in some seasons, days are longer than nights, and in others nights are longer than days. Let us see why this happens.

**Northern Hemisphere tilted towards the sun** Look at Figure 4.4. It shows the situation during that half of the year when the Northern Hemisphere is tilted towards the sun and the Southern Hemisphere is tilted away from it. Measure the parts of the equatorial circle which fall in the lit and dark zones, using a piece of thread. You will see that both the lit and dark parts of the circle are equal. Now consider any point on the equatorial circle. This point will move as the earth rotates. It will complete one circle in 24 hours and will remain in sunlight and darkness for 12 hours each. Thus, the duration of day and night at any place on the equator is equal.

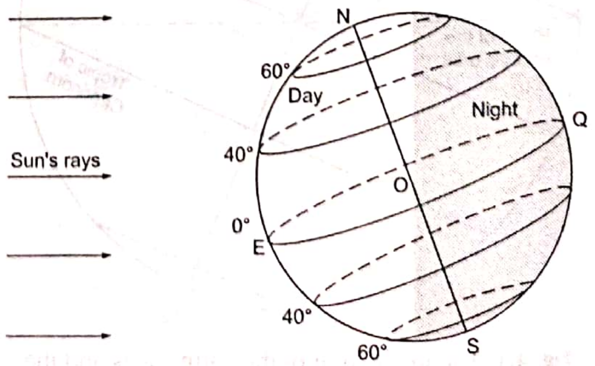


**Fig. 4.4** Northern Hemisphere inclined towards the sun (between 21 March and 23 September)

You can also verify by measuring as above that as we go north, the length of the lit part of a parallel is more than the dark part. It means that days become longer and nights shorter from the equator towards the North Pole during this half of the year. A small region, around the North Pole, falls only in the lighted part. In other words, this area around the North Pole has six months of daylight.

In the Southern Hemisphere, the situation is just the opposite. As one moves from the equator to the South Pole, days become shorter and nights longer during this half of the year. The area around the South Pole is in darkness. In other words, places near the South Pole have six months of darkness.

**Southern Hemisphere tilted towards the sun** Now look at Figure 4.5. It shows the earth during the six months when the Southern Hemisphere is inclined towards the sun. As before, you can verify that places on the equator have days and nights of equal duration. So we see that the inclination of the earth's axis does not affect the duration of days and nights on the equator. Thus, *places on the equator always have days and nights of equal duration.*

During this half of the year, places in the Northern Hemisphere have longer nights and shorter days. Places near the North Pole have only darkness and no light. In the Southern Hemisphere the days will be longer and the nights shorter. The area around the South Pole has daylight and no darkness for this half of the year.

*Thus we see that days and nights are unequal because the earth's axis is tilted.*

## 2. Change in Amount of Heat Received

The portion of the earth which is tilted towards the sun receives more direct rays of the sun. The other

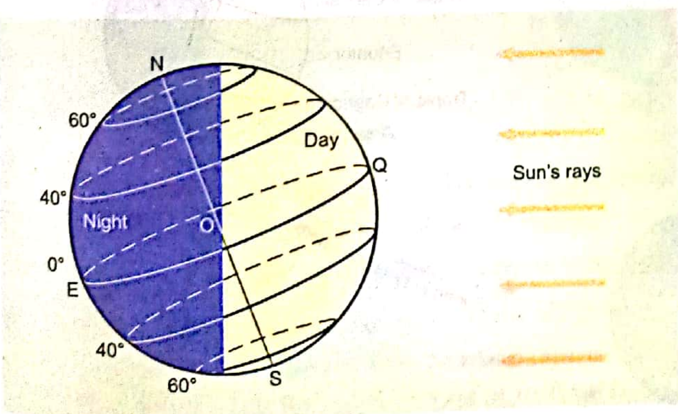


**Fig. 4.5** Southern Hemisphere inclined towards the sun (between 23 September and 21 March)

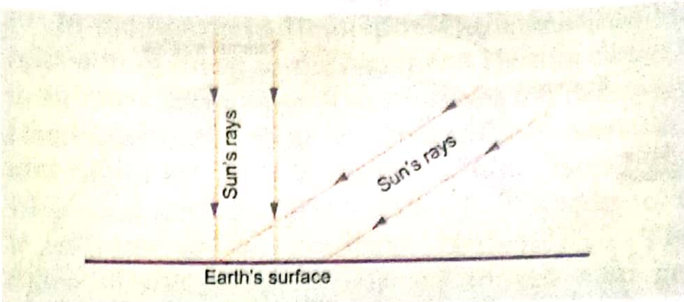


**Fig. 4.6** Vertical and slanting rays

portion receives more slanting rays. The inclination of the sun's rays at a given place keeps changing throughout the year. The amount of heat that any place receives depends on the inclination of the sun's rays. The amount of heat is greater when the rays are vertical. This is mainly because the vertical rays of the sun get concentrated on a smaller area, whereas the slanted rays get spread over a wider area (Figure 4.6). Thus, the vertical rays cause more heating.

In the morning, when the sun's rays are slanting, it is cooler. But as the day advances, the sun's rays gradually become more direct. You must have noticed that midday, or noon, is the hottest time of the day. After this the sun's rays gradually become slanting again. That is why the temperature starts falling as evening comes.

## 3. Seasons

The four seasons common the world over are—summer, autumn, winter and spring. These seasons are caused by the tilt of the earth's axis and the earth's revolution around the sun. The seasons are marked by changes in temperature, and in the duration of days and nights. But places on the equator do not feel these changes, and have only hot weather throughout the year.

You must have noticed that the sun rises and sets from different points in winter and summer. You can note the position of sunrise in late June. After this, you will find that the position of sunrise goes on shifting on the horizon every day. In the Northern Hemisphere, it shifts towards the south (Figure 4.7). The semicircle in the figure represents the sky, which looks like a huge dome to us when we stand in an open field. At one particular moment in December, the sun seems to reach its southernmost point in the sky. After this, it begins its journey back northwards. At the extreme south and north positions of its journey, the sun seems to

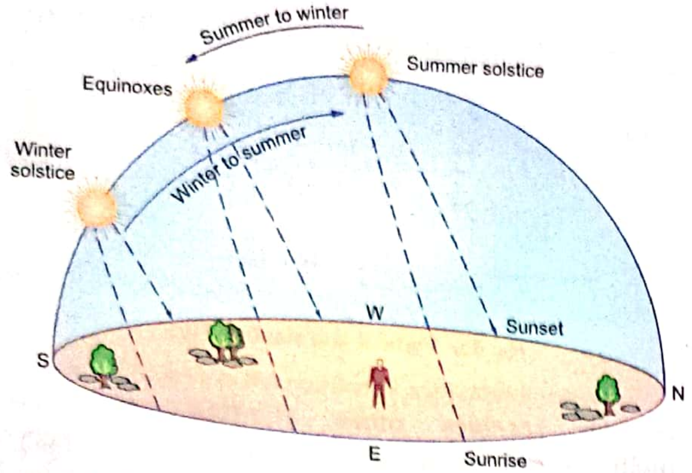


**Fig. 4.7** The sun appears to travel along different paths across the sky in different seasons.

stop before changing directions. The moment or position at which this happens is called *solstice*, which means "sun is still".

The sun's highest position (at noon) in the sky also varies. When a part of the earth is tilted towards the sun, the sun appears higher in the sky there than when it is tilted away from the sun.

Look at Figure 4.8. When the Northern Hemisphere is tilted towards the sun, the rays of the sun are close to vertical on this hemisphere, and the days are longer. This means that it receives more heat, and for a longer period of time. As a result, it is *summer* in this hemisphere. The sun also appears higher in the sky and more towards the north on the horizon. On 21 June, the sun reaches its highest and northernmost position in the sky at noon. This moment is called *summer solstice*. At the summer solstice, the sun's rays fall vertically on the tropic of Cancer. On the day of the summer solstice, the Northern Hemisphere has the longest day and shortest night.

When the Northern Hemisphere is tilted away from the sun, the rays of the sun are slanted on it, and the days are shorter. This means that it receives less heat, and for a shorter period of time. As a result, it is *winter* in this hemisphere. On 22 December, the sun reaches its lowest and southernmost position in the sky at noon. This moment is called *winter solstice*. At the winter solstice, the sun's rays fall vertically on the tropic of Capricorn. On the day of the winter solstice, the Northern Hemisphere has the shortest day and longest night.

Twice in a year (21 March and 23 September), the sun appears in the sky at a position midway

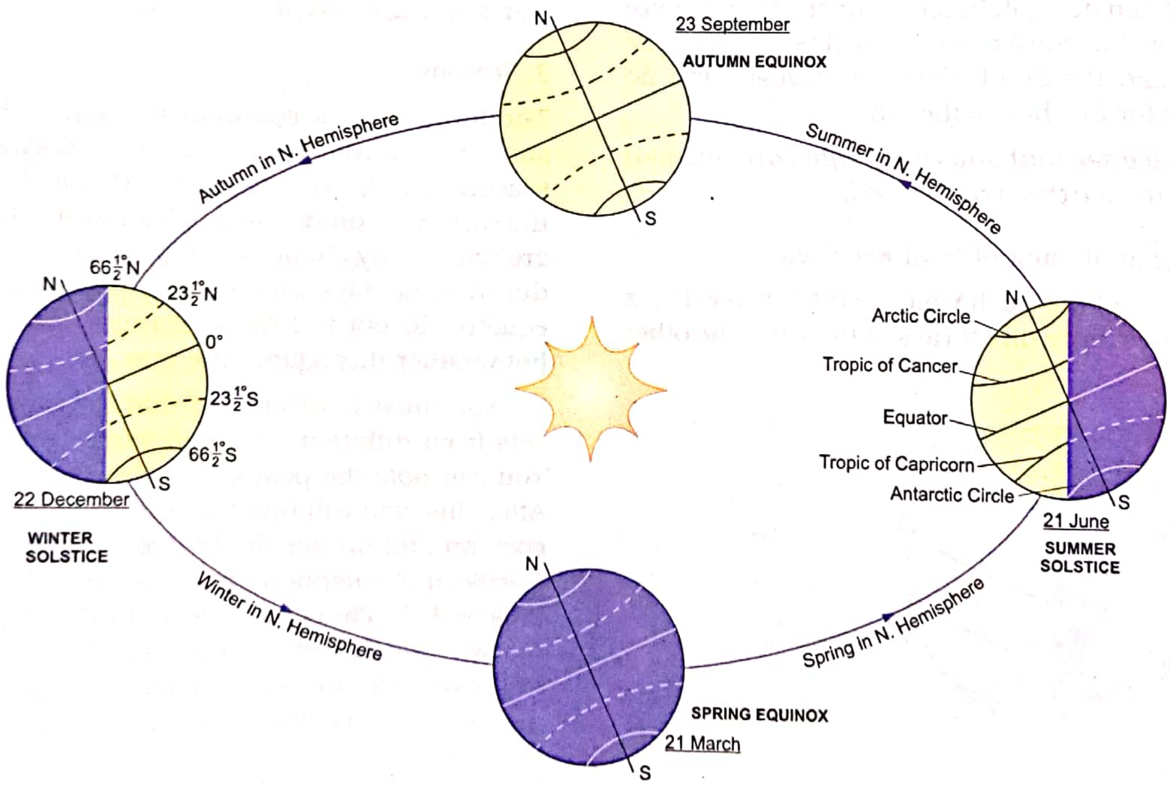


**Fig. 4.8** Revolution of the earth

between the solstice positions (Figure 4.7). Then the sun appears directly overhead at the equator at noon. These moments are called *equinoxes*. At an equinox the earth's axis is tilted neither towards the sun, nor away from it. *On the day of an equinox, the day and night are equal in length*. (Equinox means equal night.) In the Northern Hemisphere, the equinox on 21 March is called the *spring* or *vernal equinox*. The equinox on 23 September is called the *autumn equinox*.

In the Southern Hemisphere, the seasons are opposite to those in the Northern Hemisphere. It is summer there when it is winter in the Northern Hemisphere. So, when it is summer in Australia and South Africa, it is winter in India. Similarly, when it is spring in the Northern Hemisphere, it is autumn in the Southern Hemisphere. The dates of the solstices and equinoxes also get interchanged. For example, at the time of the summer solstice in the Northern Hemisphere, the Southern Hemisphere has its winter solstice.

## Things to Remember

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| *inclination of the earth's axis* | the angle of 66½° between the axis and the orbital plane of the earth |
| *circle of illumination* | the circle which divides the earth into a lit half and a dark half |
| *dawn* | the period of diffused light before sunrise |
| *dusk* | the period of diffused light after sunset |
| *solstice* | one of the two moments in a year when the sun's rays fall vertically on the tropic of Cancer or Capricorn |
| *equinox* | one of the two moments in a year when the sun appears overhead at the equator; on the day of an equinox, the day and night are of equal length |