Chapter 1 The Earth and the Universe

Exploring the Universe

On a fine bright night when you look up at the sky, it seems to be studded with stars. Little do you realise that each of the stars is far bigger than the earth on which we live. Some of the larger ones have been estimated to be many millions of times the size of the earth. These stars are not scattered regularly in space: they occur in clusters, better described as *galaxies* or *nebulas*. Each galaxy may contain as many as 100 million stars. It is believed that the earth's own galaxy (the *Milky Way*) alone contains as many as 100,000 million stars.

The stars appear small to us even through a telescope because they are so far away. The light from the nearest star travelling at the speed of light (i.e. 186,000 miles per second) takes something like four years to reach us. A ray of light from the sun takes about eight minutes to reach the earth. Light takes only a second to reach us from the moon.

The Solar System

The solar system comprises the Sun and its nine planets (Fig. 1.) which are believed to have been developed from the condensation of gases and other lesser bodies. All the planets revolve round the Sun in *elliptical orbits*. Like the earth, they shine only by the reflected light of the sun. The Sun has a surface temperature of 6,000°C. (10,800°F.) and increases to 20 million°C. (36 million°F.) in the interior. All over its surface are fiery gases that leap up in whirls of glowing flames like a volcano in eruption. In size, the Sun is almost unimaginable. It is about 300,000 times as big as the earth!

Amongst the nine planets, Mercury is the smallest and closest to the sun, only 36 million miles away. It thus completes its orbit in a much shorter space of time than does Earth. A year in Mercury is only 88 days. Venus, twice the distance away from the sun, is the next closest planet. It is often considered as *'Earth's twin'* because of their close proximity in size, mass (weight) and density. But no other planet is in any way comparable to Earth which has life and all the living things we see around us. Like many other planets, the Earth has a natural *satellite*, the Moon, 238,900 miles away, that revolves eastward around the Earth once in every 27 days.

The fourth planet from the sun is Mars which has dark patches on its surface and is believed by most professional astronomers to be the next planet after Earth to have the possibility of some plant life. Much attention has been focused on Mars to explore the possibilities of extending man's influence to it. Next comes Jupiter, the largest planet in the solar system. Its surface is made up of many gases like hydrogen, helium, and methane. It is distinguished from other planets by its circular light and dark bands, and the twelve satellites that circle round it. As it is more than 485 million miles from the Sun, its surface is very cold, probably about -200°F. (-130°C.).

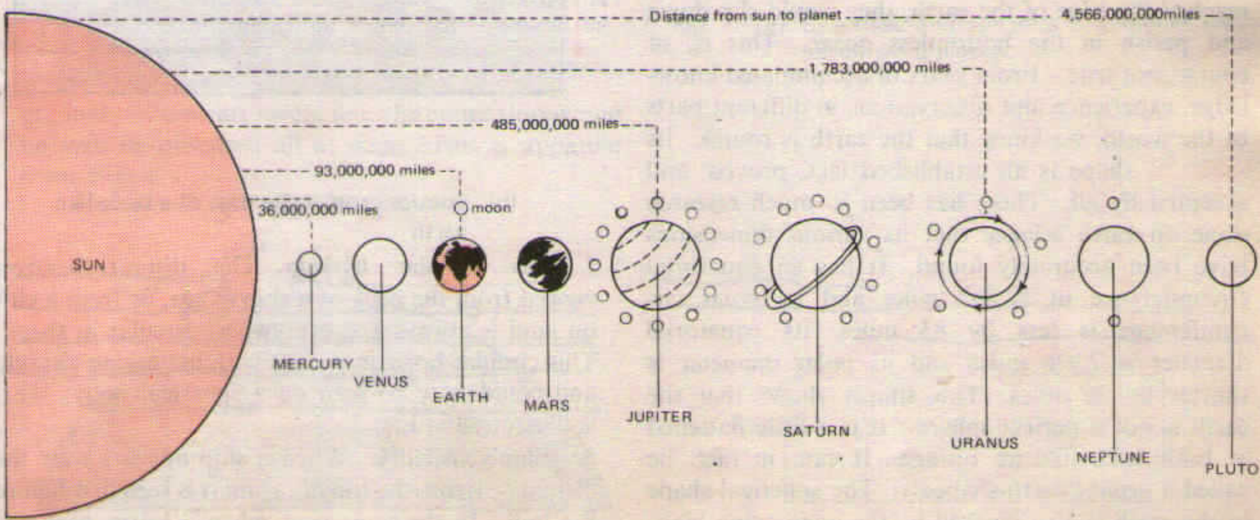


Fig. 1 The Solar System—the Sun and the nine Planets

Another unique planet is Saturn which has three rings and nine satellites around it. In size, it is the second largest after Jupiter. It is so far from the Sun that it takes 29½ years to complete its orbit. The seventh planet, Uranus, was not known to astronomers until the late eighteenth century when it was first seen as a faint bluish-green disc through a very powerful telescope. It is another giant planet, 50 times larger than Earth and 15 times as heavy. Unlike other planets, Uranus orbits around the sun in a clockwise direction from east to west with five satellites revolving round it.

The two outermost planets in the solar system, Neptune and Pluto are just visible with telescopes. Their discoveries were the result of mathematical calculations on their irregular gravitational effects on neighbouring planetary bodies. Neptune closely resembles Uranus, except that it has only two known satellites and is probably much colder. Pluto is smaller than Earth. As the orbits of the planets are not circular but elliptical, the distance of Pluto from the Sun during *perihelion* (i.e. when it is closest to the Sun) is 2,766 million miles, and at *aphelion* (i.e. when it is farthest from the Sun) is 4,566 million miles. A year in Pluto is no less than 247 years on earth! Due to their very recent discovery and their extreme remoteness from the earth, very little is so far known about these last two planets.

The Shape of the Earth

In the olden days, sailors feared to venture far into the distant ocean because they thought the earth was as flat as a table. They thought that when they reached the edge of the earth, they would slip down and perish in the bottomless ocean. This is, of course, not true. From years of accumulated knowledge, experience and observations in different parts of the world, we know that the earth is round. Its spherical shape is an established fact, proved, and accepted by all. There has been so much research done on earth science that its various dimensions have been accurately found. It has an equatorial circumference of 24,897 miles and its polar circumference is less by 83 miles. Its equatorial diameter is 7,926 miles and its polar diameter is shorter by 26 miles. This simply shows that the earth is not a perfect sphere. It is a little flattened at both ends like an orange. It can, in fact, be called a *geoid* ('earth-shaped'). The spherical shape of the earth is also masked by the intervening highlands and oceans on its surface.

Evidence of the Earth's Sphericity

There are many ways to prove that the earth is spherical. The following are some of them.

1. Circum-navigation of the earth. The first voyage around the world by Ferdinand Magellan and his crew, from 1519 to 1522 proved beyond doubt that the earth is spherical. No traveller going round the world by land or sea has ever encountered an abrupt edge, over which he would fall. Modern air routes and ocean navigation are based on the assumption that the earth is round (Fig. 2).

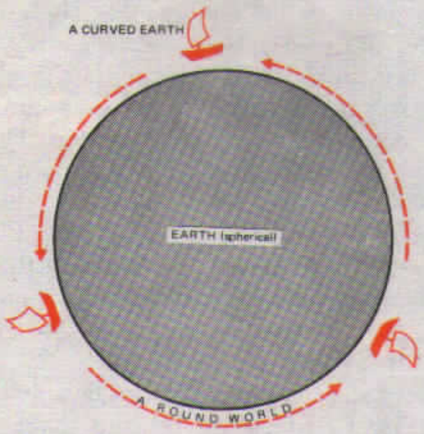


Fig. 2 (a) Circumnavigation of the earth

(b) Abrupt drop at the edge of a table-like earth

2. The circular horizon. The distant horizon viewed from the deck of a ship at sea, or from a cliff on land is always and everywhere circular in shape. This circular horizon widens with increasing altitude and could only be seen on a spherical body. This is illustrated in Fig. 3.

3. Ship's visibility. When a ship appears over the distant horizon, the top of the mast is seen first before the hull. In the same way, when it leaves harbour, its disappearance over the curved surface is equally

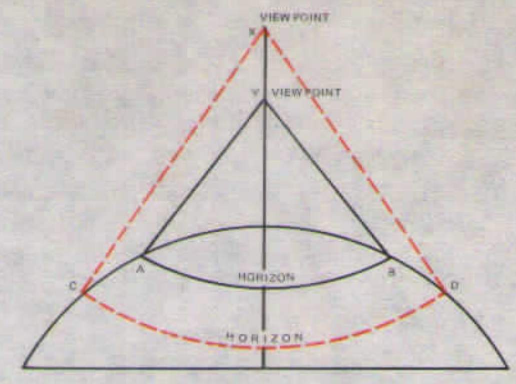
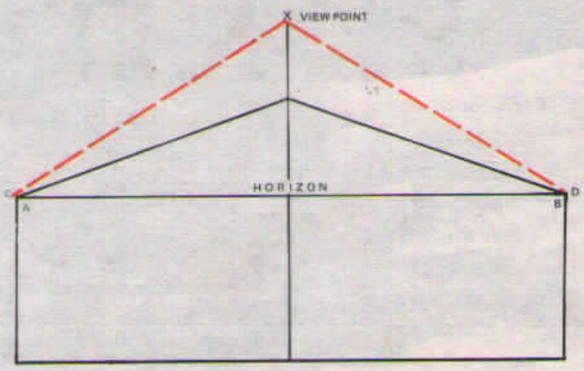


Fig. 3 (a) Increasing altitude widens the circular horizon. Viewed from Y the horizon would be AB but from a higher viewpoint (X) a wider horizon (C, D) would be seen



(b) Visible horizon remains the same regardless of altitude. If the earth were flat the horizon seen from either Y or X would be the same

gradual. If the earth were flat, the entire ship would be seen or obscured all at once. This is apparent from Fig. 4.

A CURVED EARTH

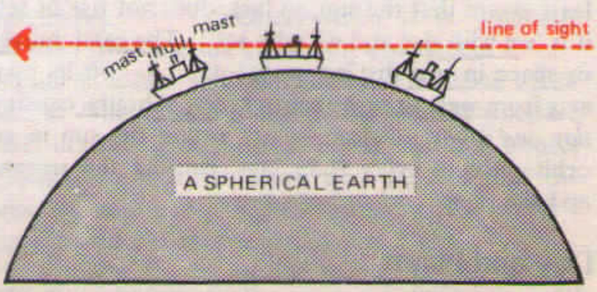


Fig. 4 (a) The mast of a ship is seen before the hull on curved horizon

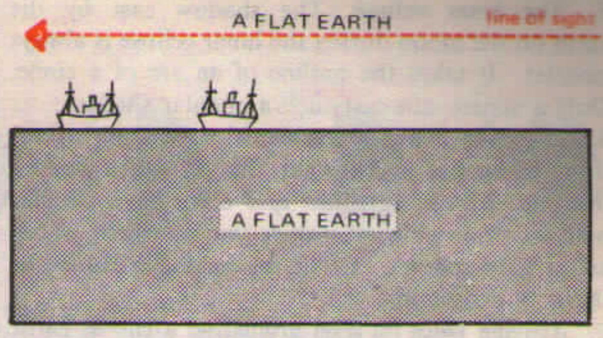


Fig. 4 (b) A flat earth, the entire ship is seen at once on a flat surface

4. Sunrise and sunset. The sun rises and sets at different times in different places. As the earth rotates from west to east, places in the east see the sun earlier than those in the west. If the earth were flat, the whole world would have sunrise and sunset at the same time. But we know this is not so. Fig. 5 illustrates this.

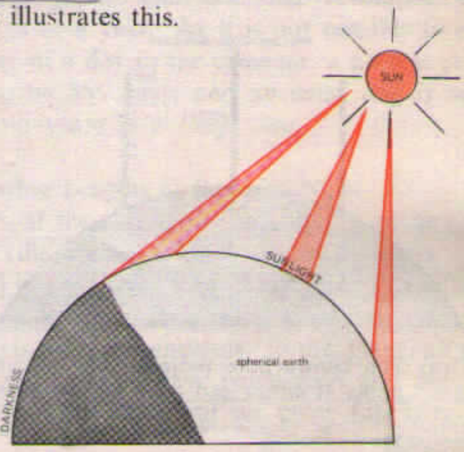
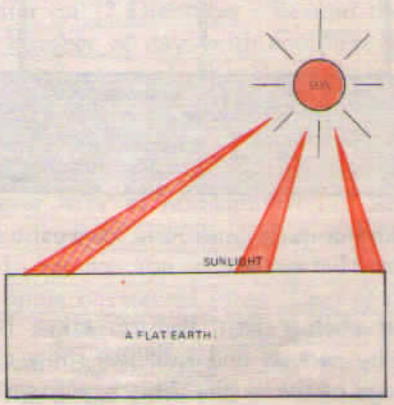


Fig. 5 (a) Sun rises and sun sets at different times for different places



(b) The whole world will have sun rise or sun set at the same time

5. The lunar eclipse. The shadow cast by the earth on the moon during the lunar eclipse is always circular. It takes the outline of an arc of a circle. Only a sphere can cast such a circular shadow.

6. Planetary bodies are spherical. All observations from telescopes reveal that the planetary bodies, the Sun, Moon, satellites and stars have circular outlines from whichever angle you see them. They are strictly spheres. Earth, by analogy, cannot be the only exception.

7. Driving poles on level ground on a curved earth. Engineers when driving poles of equal length at regular intervals on the ground have found that they do not give a perfect horizontal level. The centre pole normally projects slightly above the poles at either end because of the curvature of the earth, as illustrated in Fig. 6. Surveyors and field engineers therefore have to make certain corrections for this inevitable curvature, i.e. 8 inches to the mile.

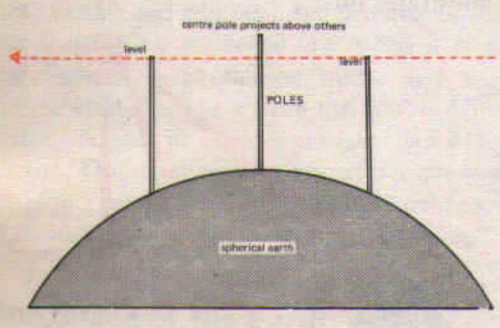
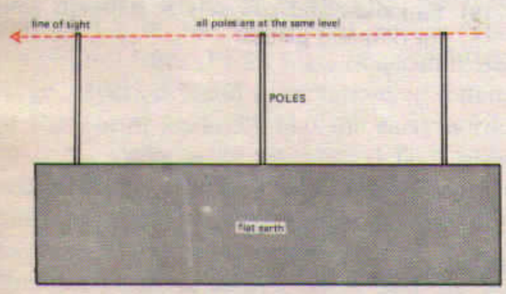


Fig. 6 (a) The centre pole projects well above the poles at either end on a curved surface



(b) All the three poles have identical heights on a flat surface

8. Aerial photographs. Pictures taken from high altitudes by rockets and satellites show clearly the curved edge of the earth. This is perhaps the most convincing and the most up-to-date proof of the earth's sphericity.

The Earth's Movement

Man is always conscious of the *'apparent movement of the sun'* and little realizes that the earth on which he stands is constantly in motion. When the sun disappears, he says that the sun sets and when it emerges, he says that the sun rises. He is not the least aware that the sun, in fact, does not rise or set, it is 'we who rise and we who set'! The earth moves in space in two distinct ways: it *rotates* on its own axis from west to east once in every 24 hours, causing *day and night*; it also *revolves* round the sun in an orbit once in every $365\frac{1}{4}$ days, causing the *seasons* and the *year*.

Day and Night

When the earth *rotates* on its own axis, only one portion of the earth's surface comes into the rays of

The earth viewed from the moon. The picture was taken on the Apollo 8 mission of 1968 which prepared the way for the moon landing
Camera Press

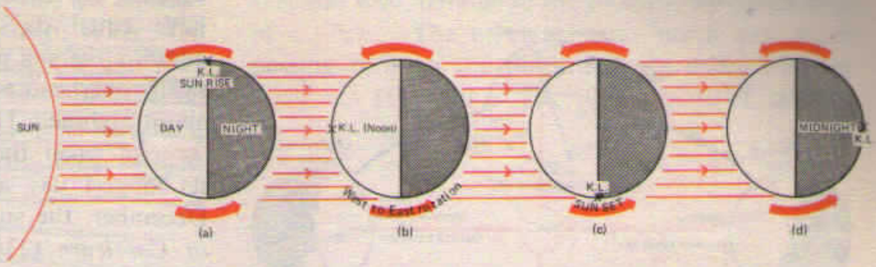


Fig. 7 (a) Kuala Lumpur emerges from darkness into daylight at sun rise when the earth rotates into the sun's rays
(b) The sun is directly overhead at Kuala Lumpur or midday
(c) Kuala Lumpur passes from daylight into darkness at sunset when the earth rotates away from the sun
(d) Kuala Lumpur is directly away from the sun at mid-night

the sun and experiences daylight. The other portion which is away from the sun's rays will be in darkness. As the earth rotates from west to east, every part of the earth's surface will be brought under the sun at some time or other. A part of the earth's surface that emerges from darkness into the sun's rays experiences sunrise. Later, when it is gradually obscured from the sun's beams it experiences sunset. The sun is, in fact, stationary and it is the earth which rotates. The illusion is exactly the same as when we travel in a fast-moving train. The trees and houses around us appear to move and we feel that the train is stationary. Fig. 7 explains the earth's rotation and the causes of day and night.

The Earth's Revolution

When the earth *revolves* round the sun, it spins on an elliptical orbit at a speed of 18.5 miles per second or 66,600 m.p.h. One complete revolution takes 365¼ days or a year. As it is not possible to show a quarter of a day in the calendar, a normal year is taken to be 365 days, and an extra day is added every four years as a *Leap Year*.

1. Varying Lengths of Day and Night

The axis of the earth is *inclined* to the plane of the ecliptic (the plane in which the earth orbits round the sun) at an angle of 66½°, giving rise to different seasons and varying lengths of day and night (Fig. 8). If the axis were perpendicular to this plane, all parts of the globe would have equal days and nights at all times of the year, but we know this is not so. In the northern hemisphere in winter (December) as we go *northwards*, the hours of darkness steadily increase. At the Arctic Circle (66½°N.), the sun never 'rises' and there is darkness for the whole day in mid-winter on 22 December. Beyond the Arctic Circle the number of days with complete darkness increases, until we reach the North Pole (90°N.) when half the year will have darkness. In the summer (June) conditions are exactly reversed. Daylight increases as we go polewards. At the Arctic Circle, the sun never 'sets' at mid-summer (21 June) and there is a complete 24-hour period of continuous daylight. In summer the region north of the Arctic Circle is popularly referred to as *'Land of the Midnight Sun'*. At the North Pole, there will be six months of continuous daylight. Fig. 8(a) illustrates the revolution of the earth and its inclination to the plane of the ecliptic which cause the variation in the length of day and night at different times of the year.

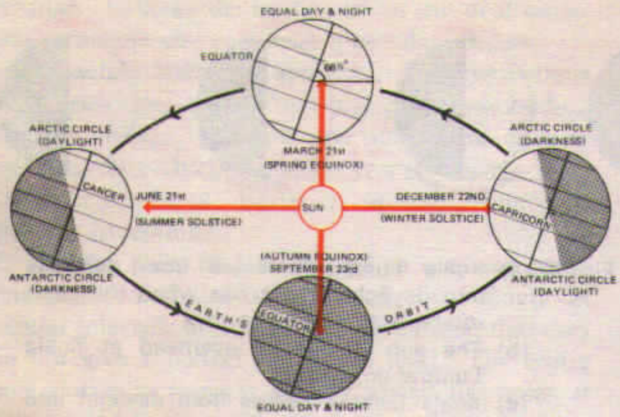


Fig. 8 (a) The revolution of the earth and its effects on seasons and the variations of lengths of day and night

(b) A simplified diagram showing the annual movement of the sun and the causes of the seasons

In the southern hemisphere, the same process takes place, except that the *conditions are reversed*. When it is summer in the northern hemisphere, the southern continents will experience winter. Mid-summer at the North Pole will be mid-winter at the South Pole.

2. The Altitude of the Midday Sun

In the course of a year, the earth's revolution round the sun with its axis inclined at 66½° to the plane of the ecliptic changes the apparent altitude of the midday sun. The sun is *vertically overhead at the equator* on two days each year. These are usually 21 March and 21 September though the date changes because a year is not exactly 365 days. These two days are termed *equinoxes* meaning 'equal nights' because on these two days all parts of the world have equal days and nights. After the March equinox the sun appears to move north and is vertically overhead at the *Tropic of Cancer* (23½°N.) on about 21 June. This is known as the *June or summer solstice*, when the northern hemisphere will have its longest day and shortest night. By about 22 December, the sun will be overhead at the *Tropic of Capricorn* (23½°S.). This is the *winter solstice* when the southern hemisphere will have its longest day and shortest night. The Tropics thus mark the limits of the overhead sun, for beyond these, the sun is *never overhead* at any time of the year. Such regions are marked by distinct seasonal changes—spring, summer, autumn and winter. Beyond the Arctic Circle (66½°N.) and the Antarctic Circle (66½°S.) where darkness lasts for 6 months and daylight is continuous for the remaining half of the year, it is always cold; for even during the short summer the sun is never high in the sky. Within the tropics, as the midday sun varies very little from its vertical position at noon daily, the four seasons are almost indistinguishable. Days and nights are almost equal all the year round Fig. 8(b).

3. Seasonal Changes and their Effects on Temperature

Summer is usually associated with much heat and brightness and winter with cold and darkness. Why should this be so? In *summer*, the sun is higher in the sky than in winter. When the sun is overhead its rays fall almost vertically on the earth, concentrating its heat on a small area; temperature therefore rises and summers are always warm. In *winter* the oblique rays of the sun, come through the atmosphere less directly and have much of their heat absorbed by atmospheric impurities and water vapour. The sun's rays fall faintly and spread over a great area. There is thus little heat, and temperatures remain low.

In addition, days are longer than nights in summer and more heat is received over the *longer daylight* duration. Nights are shorter and less heat is lost. There is a net gain in total heat received and temperature rises in summer. *Shorter days* and *longer nights* in winter account for the reverse effects.

Dawn and Twilight

The brief period between sunrise and full daylight is called dawn, and that between sunset and complete darkness is termed twilight. This is caused by the fact that during the periods of dawn and twilight the earth receives diffused or refracted light from the sun whilst it is still below the horizon. Since the sun rises and sets in a vertical path at the equator the period during which refracted light is received is short. But in temperate latitudes, the sun rises and sets in an oblique path and the period of refracted light is longer. It is much longer still at the poles, so that the winter darkness is really only twilight most of the time. (Fig. 9).

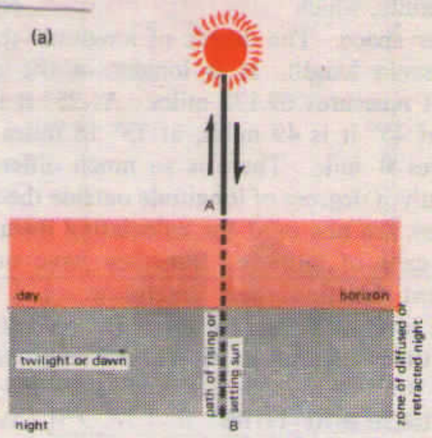
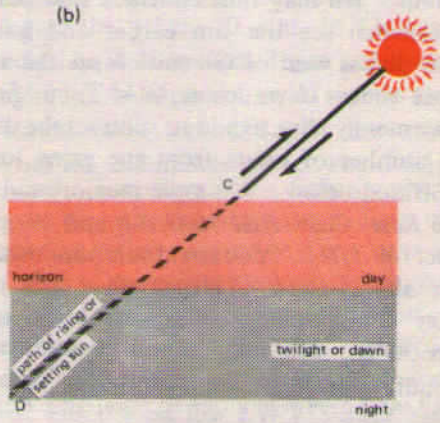


Fig. 9 Dawn and Twilight
(a) at the equator
(b) in temperate latitude



At the equator the sun rises and sets almost vertically so the time it takes to pass through the 'twilight zone' (A, B) will be shorter than for temperate latitudes where the sun rises and sets obliquely. Here the time taken to pass through the twilight zone (C, D) is longer

Mathematical Location of Places on the Globe

The earth's surface is so vast that unless a mathematical method can be used, it is impossible to locate any place on it. For this reason, imaginary lines have been drawn on the globe. One set running east and west, parallel to the equator, are called lines of latitude. The other set runs north and south passing through the poles and are called lines of longitude (Fig. 10). The intersection of latitude

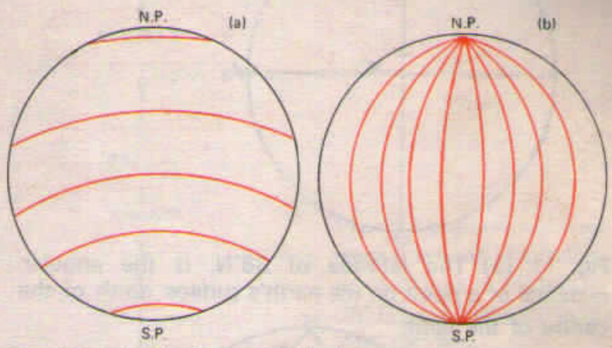


Fig. 10 (a) Parallels of latitude
(b) Meridians of longitude

and longitude pin-points any place on the earth's surface, (Fig. 11c.). For example Delhi is 28°37′ N. and 77°10′ E.; London is 51°30′ N. and 0°5′W, and Sydney is 33°55′S. and 151°12′E. We shall examine more closely how latitude and longitude are determined and the role they play in mathematical geography.

Latitude

Latitude is the angular distance of a point on the earth's surface, measured in degrees from the centre of the earth as shown in Fig. 10(a). It is parallel to a line, the *equator*, which lies midway between the poles. These lines are therefore called *parallels of latitude*, and on a globe are actually circles, becoming smaller polewards. The equator represents 0° and the North and South Poles are 90°N. and 90°S. Between these points lines of latitude are drawn at intervals of 1°. For precise location on a map, each degree is sub-divided into 60 minutes and each minute into 60 seconds. The most important lines of latitude are the equator, the Tropic of Cancer (23½°N.), the Tropic of Capricorn (23½°S.), the Arctic Circle (66½°N.) and the Antarctic Circle (66½°S.). As the earth is slightly flattened at the poles, the linear distance of a degree of latitude at the pole is a little longer than that at the equator. For example at the equator (0°) it is 68.704 miles, at 45° it is 69.054 miles and at the poles it is 69.407 miles. The average is taken as 69 miles. This is a useful figure and can be used for calculating distances to any place. Bombay is 18·55° N; it is therefore 18·55 × 69 or 1280 miles from the equator. With the aid of your atlas find the approximate distance of the following places from the equator: Singapore, Calcutta, Paris, New York, Buenos Aires, and Auckland.

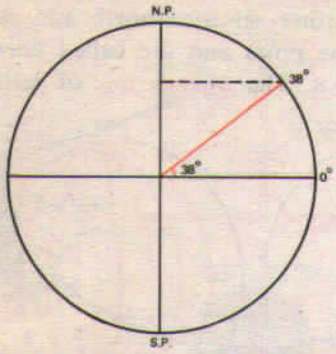
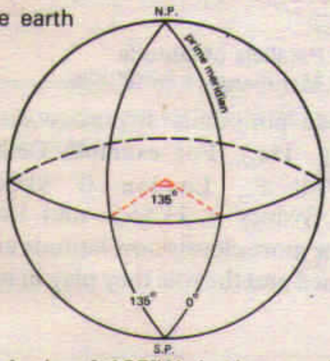
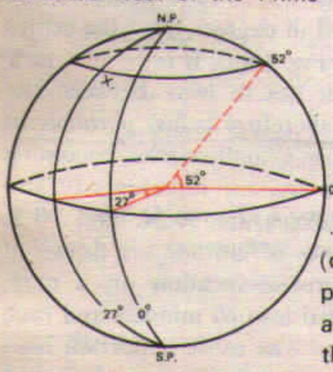


Fig. 11 (a) The latitude of 38°N. is the angular distance of a point on the earth's surface north of the centre of the earth



(b) The longitude of 135°W. is the angular distance west of the Prime Meridian



(c) The precise location of place X is latitude 52°N. and longitude 27°W. where they intersect

Longtitude

Longitude is an angular distance, measured in *degrees* along the equator east or west of the *Prime* (or First) *Meridian*, as indicated in Fig. 11(b). On the globe longitude is shown as a series of semi-circles that run from pole to pole passing through the equator. Such lines are also called meridians. Unlike the equator which is centrally placed between the poles, any meridian could have been taken to begin the numbering of longitude. It was finally decided in 1884, by international agreement, to choose as the zero meridian the one which passes through the Royal Astronomical Observatory at *Greenwich*, near London. This is the Prime Meridian (0°) from which all other meridians radiate eastwards and westwards up to 180°. Since the earth is *spherical* and has a circumference calculated at 25,000 miles, in linear distance each of the 360 degrees of longitude is 25,000÷360 or 69·1 miles. As the parallels of latitude become shorter polewards, so the meridians of longitude, which converge at the poles, enclose a narrower space. The degree of longitude therefore decreases in length. It is longest at the equator where it measures 69.172 miles. At 25° it is 62.73 miles, at 45° it is 49 miles, at 75° 18 miles and at the poles 0 mile. There is so much difference in the length of degrees of longitude outside the tropics, that they are not used for calculating distances as in the case of latitude. But they have one very important function, they determine local time in relation to G.M.T. or *Greenwich Mean Time*, which is sometimes referred to as World Time.

Longitude and Time

Local Time. Since the earth makes one complete revolution of 360° in one day or 24 hours, it passes through 15° *in one hour* or 1° in 4 minutes. The earth rotates from *west to east*, so every 15° we go *eastwards*, local time is advanced by 1 hour. Conversely, if we go *westwards*, local time is retarded by 1 hour. We may thus conclude that places east of Greenwich see the sun earlier and gain time, whereas places west of Greenwich see the sun later and lose time. If we know G.M.T., to find local time, we merely have to add or subtract the difference in the number of hours from the given longitude, as illustrated below. A simple memory aid for this will be *East–Gain–Add (E.G.A.)* and *West–Lose–Subtract (W.L.S.)*. You could coin your own rhymes for the abbreviations. Hence when it is noon, in London (Longitude 0°5W.), the local time for Madras (80°E.) will be 5 hours 20 minutes ahead of London or 5.20 p.m. But the local time for New York (74°W.) will be 4 hours 56 minutes behind London or 7.04 a.m. We can put it in another way, when Londoners are having lunch, Indians will have dinner and New Yorkers will have breakfast. (Fig. 12). This is difficult to believe, but it is true. The rotation of the earth round the sun means that at any point in time different places will experience a different time of day.

There are many ways of determining the longitude of a place. The simplest way is to compare the local time with G.M.T. by listening to B.B.C. radio.

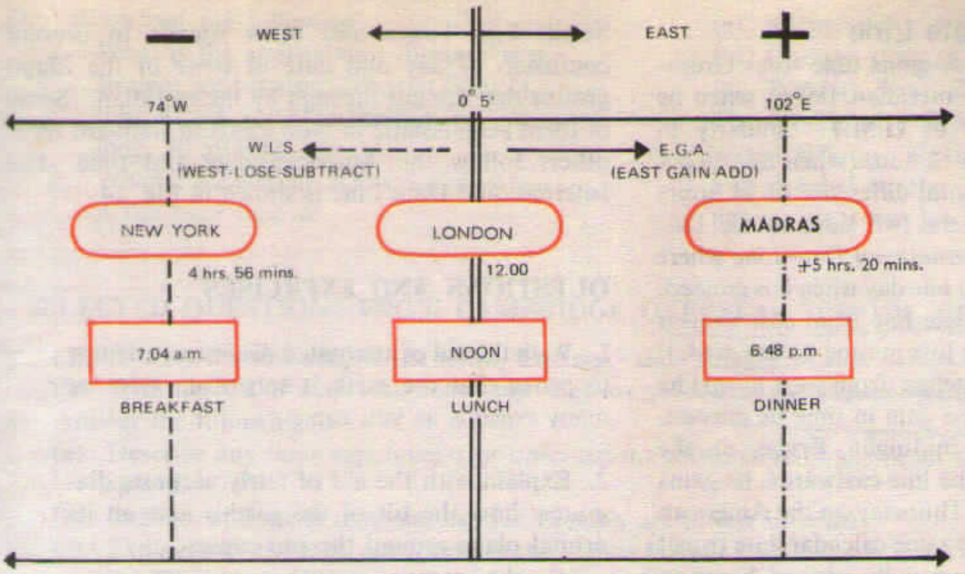


Fig. 12 Longitude and time — when it is noon in London, it is 5.20 p.m. in Madras (80° E.) and 7.04 a.m. in New York (74° W.).

For example: the captain of a ship in the midst of the ocean wants to find out in which longitude his ship lies. If G.M.T. is 8.00 a.m. and it is noon in the local region, it means that he is four hours ahead of Greenwich, and must be east of Greenwich. His longitude is 4 × 15° or 60°E.

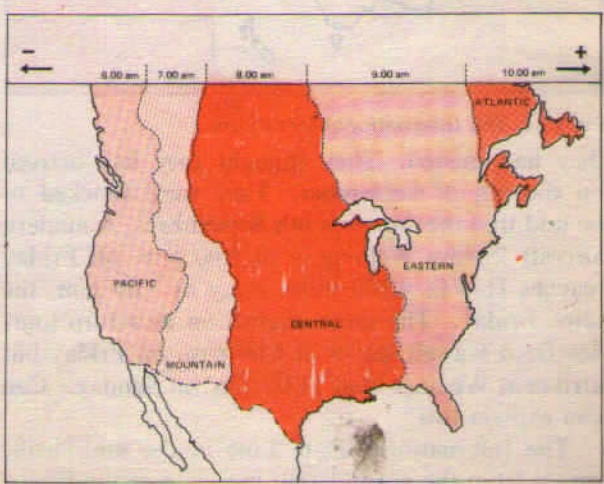
Standard Time and Time Zones

If each town were to keep the time of its own meridian, there would be much difference in local time between one town and the other. 10 a.m. in Georgetown, Penang would be 10.10 in Kota Bharu (a difference of $2\frac{1}{2}°$ in longitude). In larger countries such as Canada, U.S.A., China, India and U.S.S.R. the confusion arising from the differences alone would drive the people mad. Travellers going from one end of the country to the other would have to keep changing their watches if they wanted to keep their appointments. This is impracticable and very inconvenient.

To avoid all these difficulties, a system of standard time is observed by all countries. Most countries adopt their standard time from the central meridian of their countries. The Indian Government has accepted the meridian of 82·5° east for the standard time which is 5 hrs. 30 mins. ahead of Greenwich Mean Time. The whole world has in fact been divided into 24 Standard Time Zones, each of which differs from the next by 15° in longitude or one hour in time. Most countries adhere to this division but due to the peculiar shapes and locations of some countries, reasonable deviations from the Standard Time Zones cannot be avoided (Fig. 13).

Larger countries like U.S.A., Canada and U.S.S.R. which have a great east-west stretch have to adopt several time zones for practical purposes. U.S.S.R. the largest country, which extends through almost 165° of longitude is divided into eleven time zones. When it is 10.00 p.m. on a Monday night in Leningrad, it will be almost 7.00 a.m. the following Tuesday morning in Vladivostock. Travellers along the Trans-Siberian Railway have to adjust their watches almost a dozen times before they reach their destination. Both Canada and U.S.A. have five time zones—the Atlantic, Eastern, Central, Mountain and Pacific Time Zones. The difference between the local time of the Atlantic and Pacific coasts is nearly five hours (Fig. 13).

Fig. 13 The five time zones of North America



The International Date Line

A traveller going eastwards gains time from Greenwich until he reaches the meridian 180°E. when he will be 12 hours ahead of G.M.T. Similarly in going westwards, he loses 12 hours when he reaches 180°W. There is thus a total difference of 24 hours or a whole day between the two sides of the 180° meridian. This is the *International Date Line* where the date changes by exactly one day when it is crossed. A traveller crossing the date line from *east to west loses* a day (because of the loss in time he has made); and while crossing the dateline from *west to east* he gains a day (because of the gain in time he encountered). Thus when it is midnight, Friday on the Asiatic side, by crossing the line eastwards, he gains a day; it will be midnight Thursday on the American side, i.e. he experiences the same calendar date twice! When Magellan's ship eventually arrived home in Spain in 1522 after circumnavigating the world from the Atlantic Ocean to the Pacific Ocean and westwards across the International Date Line, the crew knew nothing about adding a day for the one

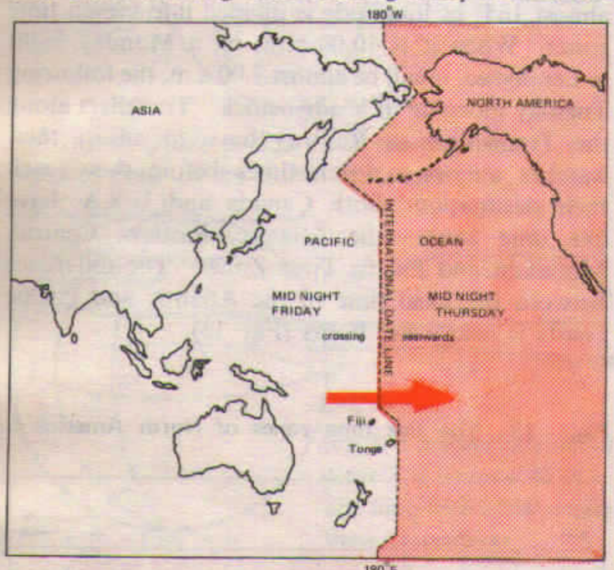


Fig. 14 The International Date Line

they had missed. They thought they had arrived on the 5th of September. They were shocked to be told that the date was 6th September. A modern aircraft leaving Wellington at 5.00 p.m. on Friday reaches Hawaii 4,100 miles away at 2.00 p.m. the same Friday. The same aircraft on its return journey from Hawaii leaves at 6.00 p.m. on Friday but arrives at We .ington at 11.00 a.m. on Sunday. Can you explain this?

The International Date Line in the mid-Pacific curves from the normal 180° meridian at the Bering Strait, Fiji, Tonga and other islands to prevent confusion of day and date in some of the island groups that are cut through by the meridian. Some of them keep Asiatic or New Zealand standard time, others follow the American date and time. The International Date Line is shown in Fig. 14.

QUESTIONS AND EXERCISES

1. With the aid of annotated diagrams, attempt to prove that the earth is spherical. Give as many reasons as you can.

2. Explain with the aid of fairly accurate diagrams, how the tilt of the earth's axis on its orbital plane around the sun causes:
   (a) the seasons
   (b) the variations in the length of day and night
   (c) the altitude of the midday sun to change at different times of the year.

3. Explain the differences between any *three* of the following:
   (a) perihelion and aphelion
   (b) parallels of latitude and meridians of longitude
   (c) the earth's rotation and the earth's revolution
   (d) solstice and equinox
   (e) Standard Time and Greenwich Mean Time

4. Explain any *three* of the following terms connected with the earth and its planetary relations:
   i. galaxy
   ii. Pime Meridian
   iii. elliptical orbit
   iv. International Date Line

5. *Either:* Give an explanatory account of the following.
   (a) Daylight increases as we go polewards in summer in the northern hemisphere.
   (b) The period of twilight in Britain is longer than in Malaysia.
   (c) A ship crossing the International Date Line at midnight on Wednesday eastwards finds that it is midnight, Tuesday, on the American side.

Or: Work out the following.

i. What is the approximate distance in a straight line between Cairo (lat. 30°0 N., long. 31°5'E.) and Durban (lat. 29°57'S., long. 30°59'E.)?

ii. When it is 2.00 p.m. in Greenwich, what is the local time of

(a) Sydney (long. 151°E.)

(b) Chicago (long. 87°30'W.)

(c) Bombay (long. 73°E.)

iii. The captain of a ship observed that it was local noon. He turned on the radio and listened to the 7.00 a.m. B.B.C. news. What was his longitude?

SELECTED QUESTIONS FROM CAMBRIDGE OVERSEAS SCHOOL CERTIFICATE PAPERS

1. (a) Explain the meaning of the terms 'Equinox' and 'Solstice'.
   (b) With the aid of diagrams, show how they are related to the movements of the earth. (1967)
2. Answer the following:
   (a) Describe any *three* experiments or observations which support the belief that the earth is roughly a sphere.
   (b) Explain why mean temperatures for London are lowest in winter.
   (c) Explain why the local clock time in the Samoa Islands (171°W.) was noon on 1st November when in the Fiji Islands (178°E.), it was 11.00 a.m. on 2nd November. (1966)
3. Explain the following:
   (a) Polar air routes follow great circles.
   (b) When it is noon at Cairo (30°E.), the local time in New York (75°W.) is 5.00 a.m.
   (c) On 21st March at noon, it was observed that the shadow cast by a wall 4 ft. 8 ins. high pointed northward and was 7 in. long. The observer was able to calculate his latitude to be about 7°N. (1965)
4. Select *two* of (a), (b), (c) and draw diagrams to illustrate your answers:
   (a) i. Calculate the longitude of the position of a ship whose navigation officer observes that Greenwich Mean Time is 14.16 hours when the local time is noon.
       ii. Explain the geographical facts which enable you to make the calculation.
   (b) Explain fully why 25th December in New Zealand may be one of the hottest days of the year.
   (c) Why must a traveller, when crossing North America from New York to the west coast, alter his watch at special places. (1964)
5. With the aid of annotated diagrams, explain the following:
   (a) The apparent daily movement of the sun and its changes during the year as observed
       i. at the Equator.
       ii. at a place 50°N.
   (b) The relationship between latitude and the angle of elevation of the noonday sun. (1963)
6. Explain the effect of:
   (a) Latitude on temperature.
   (b) Latitude on the length of day and night.
   (c) *Either:* Altitude on temperature.
       Or: Longitude on time. (1961)