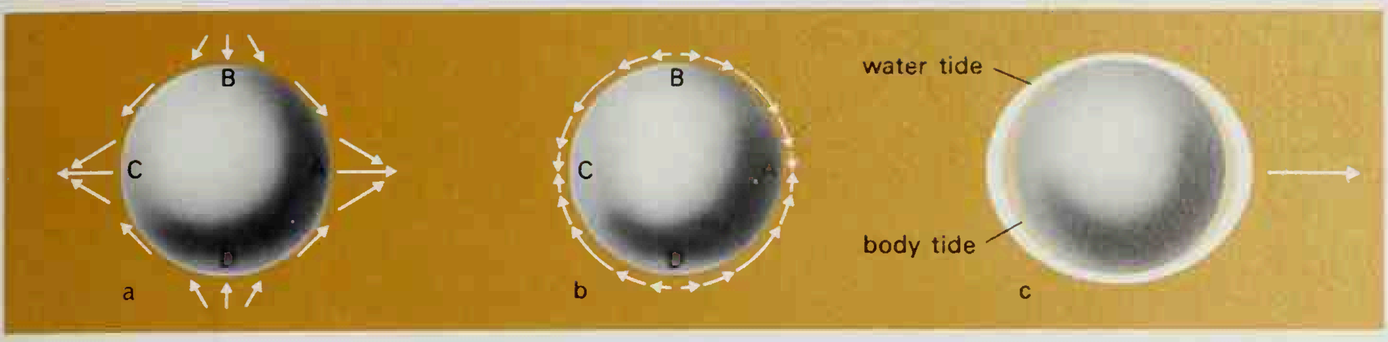

Fig. 5·5 left: The tidal forces produced on the Earth are shown in a. (Notice that these act inwards at B and D.) The forces acting around the Earth are the most important in raising the oceanic tides (b). Both the Earth's body and water tidal bulges are shown in c.

Table 5·3 **Typical ranges of albedo**

	(per cent)
clouds	44–80
land surfaces	8–40
water surfaces	4–>50
vegetation	9–25
snow and ice	up to 85

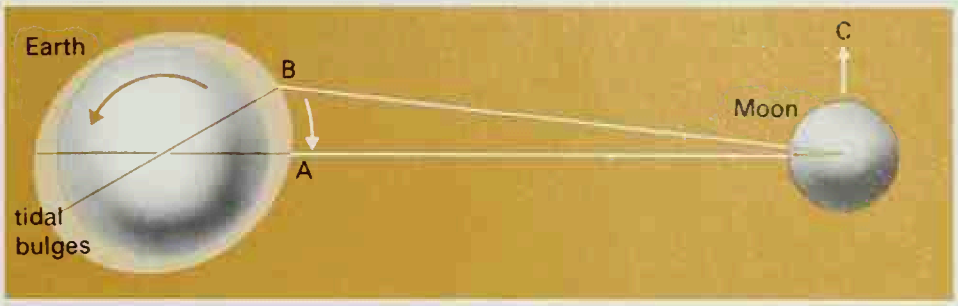

Fig. 5·6 above: Due to the effect of friction, the Earth's tidal bulges lie ahead of the Earth-Moon line. As a result, the Earth is retarded from B towards A, and the Moon accelerated towards C.

the centre of the Earth. Similar terms are used to describe the orbit of the Moon as for planetary or cometary orbits, with the closest and furthest points being known as perigee and apogee respectively. The motion of the Moon in its orbit is actually very complex. It has already been noted above that the synodic period (for example, from New Moon to New Moon) 29·53059 days, differs from the sidereal period of 27·32166 days, but due to various perturbations the orientation of the orbital plane in space and of the actual orbit on that plane change continually. Consequently the periods as measured from node to node (the **draconitic month**) and from (say) perigee to perigee (the **anomalistic month**) are 27·12222 days and 27·55455 days respectively. The first of these periods is of significance in calculating the occurrence of eclipses, as they may only occur when the Moon is very close to a node when the three bodies (Earth, Moon and Sun) are in line. The second is used in predicting tidal heights, as, naturally, the gravitational effect of the Moon is greatest when at perigee. There is even a fifth lunar period (the **tropical month**) measured from equinox to equinox, which differs slightly from the sidereal period, being 27·32158 days. (Similar considerations apply to the Earth to give tropical, sidereal and anomalistic years.)

The Moon always turns the same face towards the Earth, its sidereal periods of axial and orbital rotation being the same (said to be in a 1 : 1 **resonance**). However due to the inclination of the orbit, the varying speed along its path and the position of the observer on the Earth, **librations** in latitude and longitude occur. These mean that the Moon's visible face is not always precisely the same and that a total of about 59 per cent of the surface can in fact be seen from the Earth over a period of time.

The major effect which the Moon has upon the Earth is that of the tides. The actual explanation of the mechanisms involved is complex, but the combined effects of the motion of the Earth and Moon in their orbits about the centre of mass, the variation in the gravitational attraction of the Moon with distance, and the angle at which this is exerted, result in objects on the surface of the Earth being subjected to the forces shown in Fig. 5·5a. As far as the ocean tides are concerned, the vertical component of this force is less important than the horizontal (Fig. 5·5b), which effectively heaps the water up on opposite sides of the Earth (Fig. 5·5c).

The Sun also exerts tide-raising forces which are about 0·46 of those of the Moon, to give **spring tides** when the forces of Sun and Moon are aligned (close to Full and New Moon) and **neap tides** when acting at right-angles (near the Moon's 1st and 3rd quarter). There are numerous other effects such as the variation in the distance of the Moon from the Earth, of the Earth from the Sun, of the Moon's declination, as well as the shape and volume of the seas, which greatly complicate the task of actually predicting the times and heights of the tides at any place on Earth. It may be noted in passing that tides also occur within the bodies of the Earth and the Moon (the effects on the Moon will be mentioned later) and in the atmosphere, although in both cases the variations primarily have periods of a month.

Due to the effect of friction, both the body and water tidal bulges of the Earth lie ahead of the Earth-Moon line. As a result, the Moon is subjected to a small force which tends to accelerate it in its orbit, and the Earth's rotation is correspondingly slowed down (Fig. 5·6). As a consequence, the Moon's orbit is expanding and the Earth's day is becoming longer. This latter fact is confirmed by a study of certain fossil corals which have daily growth bands and where yearly variations can also be seen. These show that approximately 4×10^8 years ago, the 'day' was approximately 22 hours long. At that time the distance of the Moon was about 58 Earth radii, rather than the present 60. The effect will continue, until in the far distant future the Earth's axial period and the Moon's orbital period are equal at about 60 present Earth days.

Quite apart from this slowing effect by the Moon, the length of the Earth's day is also subject to slight, sudden irregularities which are caused by major earthquakes. These not only affect the rate of rotation, but also produce small alterations in the inclination of the axis of rotation.

Fig. 5·3 facing page, top: The structure of the Earth's atmosphere. The temperature rises very rapidly with height in the thermosphere. Ionization layers occur at about 60 km, 110 km and also 150 km (day) or 250 km (night).

Fig. 5·4 facing page, bottom: The Earth's magnetosphere is enveloped by the stream of particles forming the solar wind. Due to the inclination of the magnetic and rotational axes, the position of the magnetopause and the orientation of the field lines vary both daily and over a year.