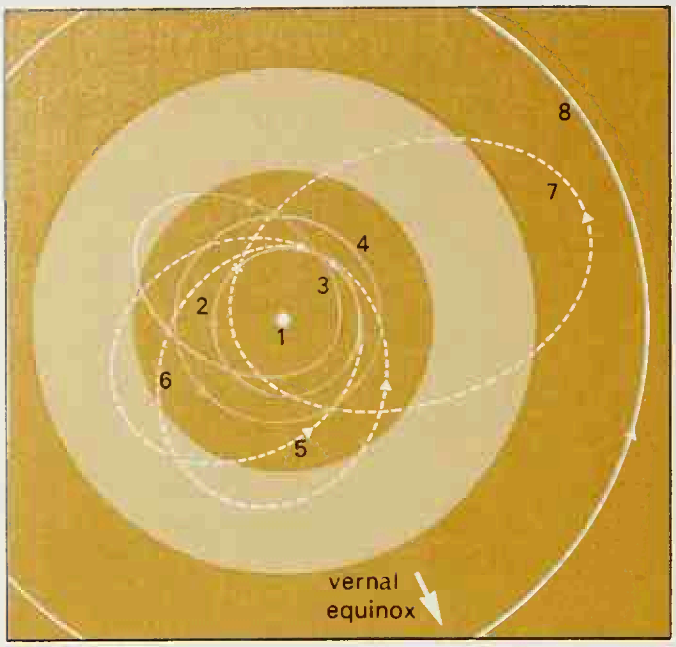

Fig. 5·22
The orbits of certain Apollo minor planets and three well-established meteorite bodies.

majority of fireballs do not result in meteorite falls, and observation of their break-up and slowing down in the atmosphere shows that they are fragile and probably of cometary origin.

Table 5·22 **Some terrestrial meteorite craters**

	diameter (km)
Manicougan (Quebec)	64
Richat (Mauretania)	50
Vredefort (South Africa)	40
Manson (Iowa)	31
Clearwater Lakes (Quebec)	26, 14
Ries Kessel (Germany)	23
Gosses Bluff (Australia)	19
Chassenon (France)	15
Ashanti (Ghana)	11
Lake Mien (Sweden)	6
Brent (Ontario)	4
Steinheim (Germany)	2·8
Meteor Crater (Arizona)	1·2
Wolf Creek (Australia)	0·8

Origin of the Solar System

The information which we now possess about the various bodies in the Solar System enables us to make reasonable assumptions about the way in which the System originated. Many different theories have been proposed in the past, but the one generally accepted today suggests that the Sun and planets were formed at about the same time from a concentration of gas and dust like that found in a galactic nebula or molecular cloud.

The processes of stellar formation, which have been discussed already (see p. 60), show that a protostar will form in the centre of the rotating primitive nebula of gas and dust. The major constituents of the protostar which formed the Sun and the nebula around it were hydrogen and helium, with the addition of a small amount (about 1·4 per cent) of the heavier chemical elements. The latter were themselves formed inside an earlier generation of stars and then dispersed as interstellar grains by supernova explosions (p. 63). The presence in meteorite samples of some products formed by very short-lived radio-active elements suggest that the Solar System originated about $4{\cdot}65 \times 10^9$ years ago, soon after a supernova exploded in the vicinity. Ices and the more volatile substances condensed on the surface of the grains; such particles accumulating into clumps with a maximum size of a few millimetres or centimetres. Within the primitive solar nebula, such clumps would rapidly settle towards the central plane, perhaps in as little as 100 years, so that the protostar would be surrounded by a disc of dust and gas. Objects have been observed elsewhere in space which show just such a structure, and where, it is believed, planetary systems are forming at the present time.

The actual mechanisms by which the planets condensed from the disc of particles are complex and somewhat uncertain. Because direct formation into large bodies could not occur, it seems likely that loose minor planet-sized bodies were produced. Collisions between clusters of such bodies would then result in the release of sufficient energy for more rigid objects to form, and by a repeated process planetary-sized bodies would develop. In the disc there would be a marked change of temperature outwards from the hot protostar, so that one would expect only the less volatile substances to be concentrated in the central regions. This accounts very satisfactorily for the differences in density of the inner planets; further out ices would not have been vaporized and, together with some denser materials, would collect together to form the cores of the giant planets. Moreover, these would be sufficiently large to capture a significant amount of hydrogen and helium from the nebula by gravitational attraction. In the cases of Jupiter and Saturn, subsidiary discs of gas and dust probably collected around the planets, eventually forming the satellite systems, by processes similar to those acting to produce the planets.

While the planets were forming, the central protostar continued to grow by collecting material until it eventually reached the point at which fusion of hydrogen began. At this time a considerable amount of material was lost because of an intense solar wind, this stream of atomic particles sweeping the Solar System clear of gas and dust, effectively putting an end to any more accumulation of material by the planetary bodies except by collision. Such mass loss is observed in T Tauri type variable stars (p. 60), which are young objects, just as the Sun would have been.

The energy acquired during collection of material is the main cause of the internal temperatures of Jupiter and Saturn, while the inner planets have been heated due to intense early bombardment by remaining interplanetary material and by RADIOACTIVE DECAY. Such heating caused the planets and the larger planetoids to separate into dense cores and lighter overlying layers.

The cratering produced by major impacts during an early period of bombardment can be seen on the Moon, Mercury and Mars, while as far as the Earth is concerned, it has been suggested that the impact of major planetoid-sized bodies broke up the original crust, producing a continental area and an ocean area.

Most of the larger-sized bodies had been swept up