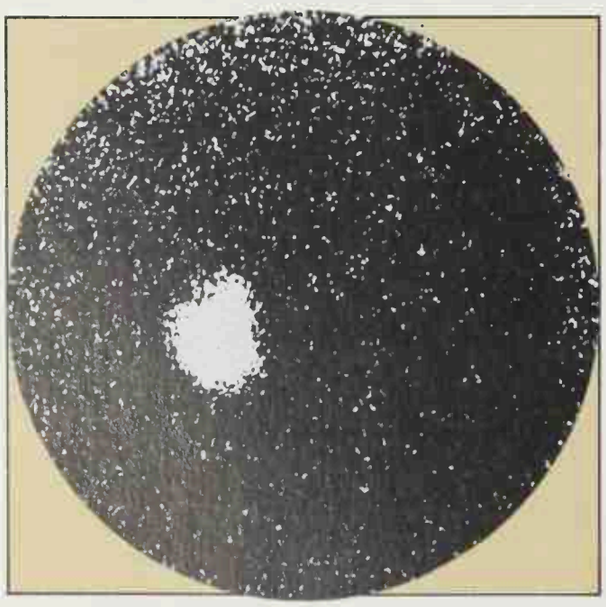
Pluto

The four inner planets have many common characteristics, as do the four gas giants, but Pluto, the outermost planet of the Solar System, seems to have little resemblance to any of them. Its mean distance from the Sun is so great (39·4 au) that it is very difficult to study and the few details which we have are given in Table 5·19. It has not been possible to determine the diameter directly, although from occultation results in 1965 it could not exceed 6 800 km. Indirectly it may be estimated from observations that the planet is covered in methane frost. Such a surface layer would have an albedo of 40–60 per cent, which, from the known brightness, leads to a diameter of 3 300–2 800 km, if it is completely frost-covered.

In the past, only very rough estimates of the density and mass have been possible. Despite the fact that Pluto was discovered in 1930 close to the predicted position calculated from the assumption that an unknown planet was perturbing Uranus, these calculations now seem to have been erroneous, and Pluto apparently has little effect on Uranus and Neptune. With the discovery in 1978 that it was accompanied by a large satellite, since named Charon, the situation has become much clearer. The total mass of the whole planet/satellite system now seems to be only about one-fifth of that of the Moon alone, and the Pluto:Earth mass ratio is certainly lower than 1:400. The diameter of Pluto appears to be close to 3 000 km, while Charon could be as large as 1 400 km, and probably orbits at a distance of approximately 20 000 km. The density of both bodies is very low, probably of the order of 1 000–2 000 kg per m^3, and it is almost certain that both are composed nearly exclusively of volatile materials. Charon is not fully resolved, being so close to Pluto (photographs merely appearing elongated) but its period seems to be 6·39 days, probably synchronized with Pluto's own rotational period which had been inferred from a variation in brightness. A longer-term change in the planet's magnitude almost certainly related to the position in its orbit suggested that the inclination of the axis was greater than 50°. Charon has a highly inclined orbit, and could well be orbiting in the plane of the planet's equator.

Table 5·19 **Pluto**

equatorial diameter (km)	3 300–2 800?
sidereal period of axial rotation	?
inclination to orbit	50°?
density (kg per m^3)	2 000?
mass (Earth = 1)	0·0025?
surface gravity (Earth = 1)	?
escape velocity (km per s)	?
albedo	0·40–0·60?
mean Sun-Pluto distance	39·4 au



A photograph showing the combined images of Pluto and its satellite which orbits from north (top) to south. The orbital plane is highly inclined to the plane of the sky. If the satellite has an albedo similar to Pluto's, it may have a diameter as great as 1 200 km and be the largest satellite in the Solar System relative to its primary.

Although it had been long suspected that Pluto had no atmosphere, and that the surface temperature would lead to any gases being permanently frozen, there is now some evidence that gaseous methane does exist. Uncertainties arise because the mass of the planet is poorly established, and hence the surface gravity and surface pressure are unknown. It is quite possible that Pluto only has a gaseous atmosphere when it is close to perihelion, and that at other times it is frozen out on to the surface. With certain assumptions it can be shown that with a surface temperature of 60 K a gaseous atmosphere of methane could just exist.

Orbit

The planet's orbital inclination and eccentricity are far greater than those of any other planet, including Mercury, and for part of its orbit the distance from the Sun is less than that of Neptune. In order to explain both Triton's highly inclined retrograde orbit and Pluto's unusual characteristics, it has been suggested that Pluto was once a satellite of Neptune. Tidal interaction between the two satellites could have placed Triton in its present orbit and caused Pluto to escape from Neptune's gravitational field. However, objections to this theory are that the two orbits do not intersect, that the closest approach Pluto makes to Neptune today is still a distance of several astronomical units, and that the circularity of Triton's orbit remains difficult to explain.

This small wanderer seems to have practically nothing in common with the rest of the planets and, indeed, with the discovery of object 1977 UB (Chiron), which will be discussed with the minor planets, it has been pointed out that it and Pluto have many similarities to certain minor planets and comets.

With confirmation that Pluto is of low mass, the problem of the motions of Uranus and Neptune remains unresolved. There seems to be a good chance that there is some body, as yet undiscovered, with sufficient mass to cause the observed perturbations. The suggestions as to what this could be are: another planet, a dark stellar companion to the solar System, and inevitably, a black hole! A planet would have to be quite large and massive, and even if it were in a highly inclined orbit would have been unlikely to escape detection. The most probable candidate body is another star, perhaps a 'black dwarf'. Discovering such a body, which could be located at quite a distance from the Sun, is likely to be very difficult,