

A VISIT TO THE ASTEROIDS

Harvest festival

A robotic probe examines some leftovers from the construction of the solar system

FOLLOWING Pluto's demotion from that hallowed status in 2006, a generation of schoolchildren has grown up learning that the solar system has eight planets. But it came close to having nine. The asteroid belt, a ring of spacegoing rubble between the orbits of Mars and Jupiter, is the remains of a planet that failed to form during the solar system's creation 4.5 billion years ago.

The largest of these remnants is called Ceres. By planetary standards Ceres, named after the Roman goddess of agriculture, is tiny, but by asteroidal ones it is a whopper. Its 974km diameter is roughly the length of the island of Great Britain. Its mass (about 1% the mass of Earth's Moon) is enough for its gravity to make it approximately spherical. And that means Ceres is also the smallest of the solar system's five officially recognised "dwarf planets", the freshly created category into which Pluto was moved. (The other three — Haumea, Eris and Makemake — are all, like Pluto, out beyond the orbit of Neptune.)

On March 6, assuming everything goes according to plan, Ceres will become the first of those dwarf planets to be orbited by a space probe. After an eight-year journey, including a 14-month stopover at Vesta, the second-biggest object in the asteroid belt, an American spacecraft called *Dawn* will begin a series of descending loops that will eventually bring it to within 375km

of Ceres's surface.

Studying rubble — even big chunks of it — sounds less romantic than missions to the "proper" planets. But the asteroids are of great interest to astronomers, for they offer a way to test their ideas of how the solar system came to be. Astronomers know, from computer modelling and from watching it happen elsewhere, that the sun and its planets condensed out of a giant rotating disc of dust and gas. The planets formed by agglomeration, with dust grains combining to form pebbles, pebbles uniting into boulders, boulders into "planetesimals", and so on. That process was disrupted in what is now the asteroid belt by the gravitational influence of Jupiter, the solar system's largest planet.

SPACE ARCHAEOLOGY

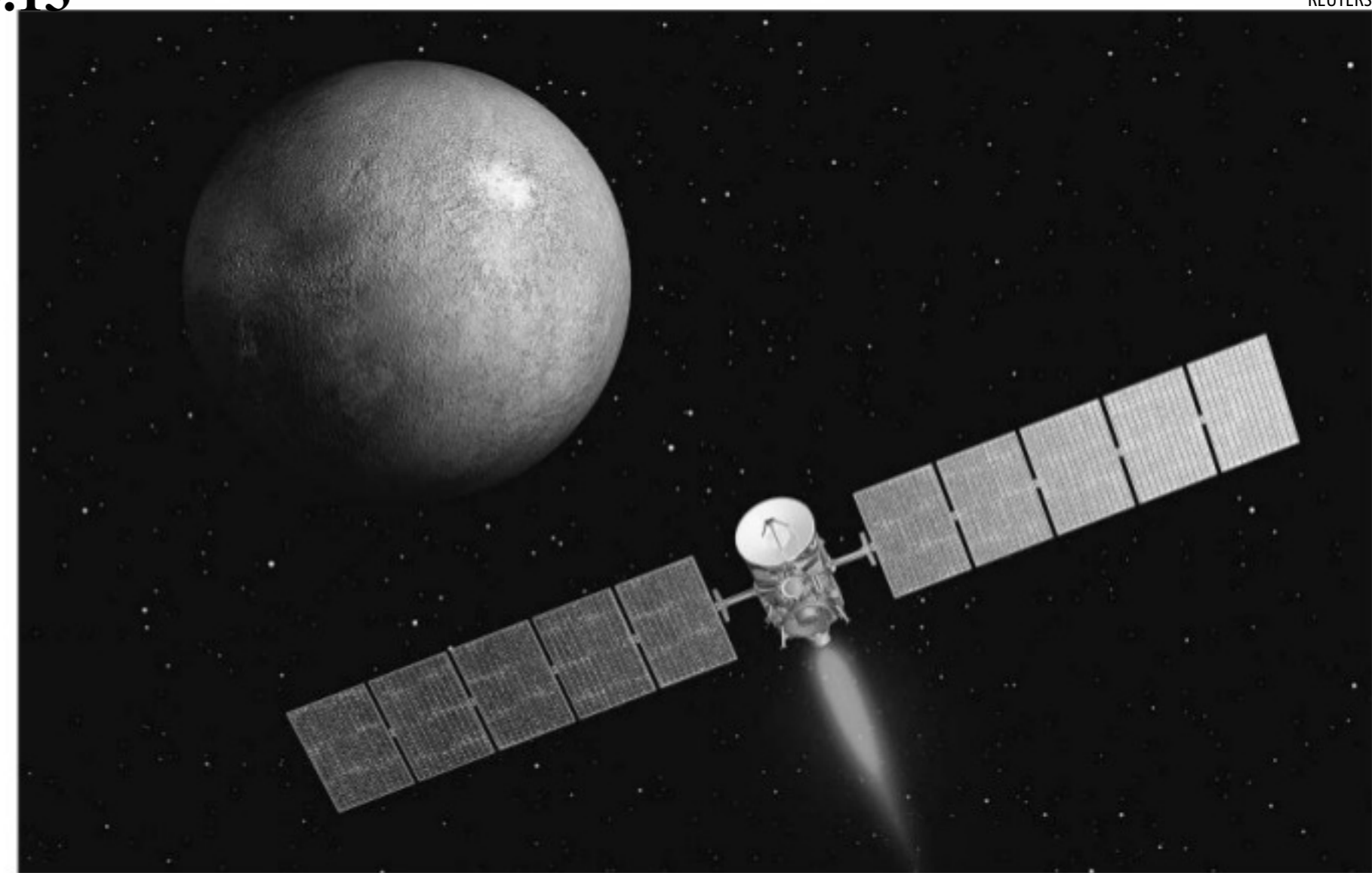
THESE are not merely lumps of homogenous rock. Ceres is noticeably different from Vesta. Both are big enough to be "differentiated", with cores made of dense materials such as nickel and iron and surfaces made from lighter constituents. Vesta's core is overlain by a rocky mantle. Its surface is covered with ancient lava, implying that the entire asteroid was once molten. And it seems to be as dry as a bone. Ceres, by contrast, has a smoother surface and an icy mantle. Indeed, a quarter of its mass may be water in one form or another. One of the questions that

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Dawn is seeking to answer is just how two such radically different bodies could form in the same region of the solar system.

One possibility is that they did not. Ceres looks similar in some ways to Pluto, its dwarf-planet colleague. Some astronomers therefore wonder whether it might not be a native of the asteroid belt. Instead, it may have formed further out, like Pluto, in the freezing cold beyond the orbit of Neptune, before being flung inward by the gyrations of the bigger planets.

That would fit with modern ideas of how solar systems develop. Old theories assumed that planets mostly stayed in the orbits in which they were born. But data from exoplanets — those which orbit stars other than the sun — drove a coach and horses through that idea. The galaxy seems to be full of planets in impossible places, most notably the so-called "hot Jupiters", gas giants that orbit very close to their parent stars.



NASA's *Dawn* spacecraft heads toward the dwarf planet Ceres in this undated artist's conception. Ceres, with its 974 km diameter, is the largest among the remnants of the solar system's asteroid belt.

The intense radiation they experience means that they could not have formed there, for their atmospheres would have evaporated as fast as they formed. That means they must have moved in from elsewhere.

Newer models of how planetary systems form can accommodate such restlessness. The most widely accepted ideas about the solar system's youth now hold that Jupiter and Saturn, the two biggest planets, experienced drastic changes of position early in the solar system's life. The gravitational disruption caused by such movements would have rearranged large chunks of the rest of the system along the way. If Ceres turns out not to be an asteroid after all, it could prove a useful empirical test of such theories.

There are other mysteries, too. *Dawn*'s approach has already given astronomers their best-ever pictures of Ceres's surface, which, although smoother than Vesta's, seems rougher and more weathered than they had assumed. The place may have a tenuous atmosphere. And it may, just possibly, have pockets of liquid water, kept so by dissolved salts or other natural antifreezes, buried within its icy mantle.

Such subsurface seas are a hot topic among alien-hunters. Water is essential for life on Earth and many believe that, because of its peculiar chemical properties, this will be true anywhere else that harbours living things. Looking for life in other watery parts of the solar system there-

fore makes sense, especially in places that also have the sorts of carbon-bearing chemicals which might plausibly pre-date the chemistry of life. Most of the focus is on Europa and Enceladus, moons of Jupiter and Saturn respectively, but Ceres may now join the list. It is a long shot. But long shots occasionally come off. And even if there were no evidence that Ceres had ever hosted life, it has all the ingredients needed to have hosted some interesting prebiotic chemistry, which would be the next-best thing. Earth's nearest dwarf planet could shed light not just on how the solar system got started, but how life did too. That would be a rich harvest indeed.