Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *The shape of things*.

1. Spheres, Potatoes and Dust.

The defines that both planets and dwarf planets must have sufficient mass for their self-gravity to overcome rigid body forces so that they assume a shape of hydrostatic equilibrium - that is, round.

This means a lot of objects in the Universe adopt a round shape if they have sufficient cumulative mass. On a smaller scale, there are also
have sufficient mass and self gravity to assume a round shape. These we generally call Potatoes which may have got part way towards conforming to a round shape but still have a way to go.

A key issue here is what we call the potato radius, or R_{pot}, which is the transition point from a Potato to a Sphere - and also represents the transition point from a small solar system body to a dwarf planet. Two key issues emerge when you try to determine what the correct value for the potato radius, R_{pot}, really is.

Firstly, a Sphere doesn't have to have so much self-gravity that it generates hydrostatic equilibrium at its surface. For example, on Earth you can have a mountain the size of Everest (which is nearly 9 kilometres high), but anything higher will begin to collapse back towards the surface maintaining its roughly spherical shape. So, there is an acceptable margin where a Sphere can still be considered a Sphere even if it does not demonstrate complete hydrostatic equilibrium.

The second key issue for determining the correct value of R_{pot}, is the yield strength of different materials - that is their resistance to gravitational collapse. In the context of the solar system, we can reliably predict that an icy Kuiper belt object is going to undergo gravitational collapse before a rocky asteroid belt object does.

On this basis, the research team Lineweaver and Norman concluded that R_{pot} for rocky objects is 300 kilometres radius, while R_{pot} for icy objects is only 200 kilometres radius, due to the weaker yield strength of ice, compared with rock.

Since Ceres is the only rocky asteroid with a radius that is greater than R_{pot} for rocky objects s 300 kilometres) we should not expect that any more dwarf planets will be identified in the asteroid belt. But if we use the 200 kilometre R_{pot} for icy bodies - that means there are a whole bunch of Kuiper belt objects out there that are ready to take on the dwarf planet title.

Lineweaver and Norman proposed that all naturally occurring objects adopt one of several basic shapes depending on their size, mass and dynamics. Very small and low mass objects can be considered Dust which is generally in loose, irregular shapes governed primarily by electromagnetic or Van der Waals forces. So from small to large, you start with Dust, next up are Potatoes and then Spheres.

2. Disks and Halos

Objects of the scale of molecular dust clouds are much too big to form Spheres and will instead collapse down into Disks because the sheer volume of accreting material means that much of it can only rotate in a holding pattern around and towards the centre of mass. Such objects may evolve into a spherical star, once that star has given up much of its angular momentum to its proto-planetary disk, but the initial disk structure does seem to be a mandatory step in the formation of objects at this scale.

At the galactic scale you may still find disk shapes, such as a spiral galaxy, but these large scale structures are too diffuse to undergo accretion and instead just loosely cluster, most often in Halo shapes   of which the central bulge of a spiral galaxy is one example. Other more obvious examples of Halos are globular clusters and elliptical galaxies.

3. The shape of pretty-much everything

At the galactic cluster and super-cluster scale, the role of dark matter and the expansion of the universe become significant factors. Very large scale views of the universe show visible matter clumps into a network of filaments separated by huge voids of empty space.

At this scale, the shape of things is a compromise between gravitational attraction and universal expansion. Early on in the life of the universe, all its contents was much closer together. As the universe expanded further, gravitational attraction between closely positioned objects made those objects clump together, while empty space expanded about them. The appearance of large scale filaments composed of loosely associated galactic clusters and super-clusters hints at the underlying scaffolding proposed to be made of dark matter.

This is what's called the cold dark matter theory, where dark matter is proposed to be the first type of matter to freeze out of the early, hot universe.

Only later on did visible matter began to freeze out, settling by gravitational attraction onto the invisible dark matter scaffolding, giving us the distribution of visible matter that we see today. This apparent non-homogeneity of the universe   where you have fairly concentrated areas of matter interspersed by huge gaps of empty space, has been proposed to challenge the current thinking around how the universe is shaped, particularly how it is expanding - along with all that thinking about dark energy   which you could probably tell was going to come up sometime.

4. Our Universe is shaped by some very big assumptions

The Einstein field equations, which include the expansion term Lambda, are based on a fundamental assumption that the universe is homogenous and isotropic. Now arguably it is, since it does seem to have an approximately equal distribution of matter filaments and empty voids, everywhere you look. But cosmologists continue to debate about whether this gross level of lumpiness confounds the ability of Einstein
going on.

In the great voids, general relativity predicts that clocks should run relatively faster and distance scales should be relatively bigger than they are in matter-dominated regions where space-time is more tightly curved.

If the universe is truly homogenous these different effects should just even out in the final analysis. But if it's non-homogenous, you have to start asking whether what you think you're observing is just a measurement artefact. And here, you also need to consider the time dimension since, even if the universe is fairly homogenous now, if the overall homogeneity has changed significantly over the universe's history then distant objects are really behaving in response to different conditions compared with the objects that are closer to us.

requires us to question the assumption that localised non-homogeneities even out at a cosmic scale. This is a question worth asking and re-asking as more data comes in. The cosmological models we have been running with for almost a century now are based on a bucket load of assumed universal constants. If those constants are not really constant over either space or time, then it's back to the drawing board with our current models.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where the whole universe can be extrapolated from potatoes. No ads, no profit, just good science. Bye.