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What Is a Planet?

Is Pluto a planet? This question appears so simple—clearly the answer is either yes or no—yet the simplicity is misleading. Logically, we must know what a planet is and determine whether Pluto fits those criteria if we are to construct a well-reasoned answer.

The question *Is Pluto a planet?* has stirred the passions of professional astronomers since this enigmatic object was discovered in 1930. In order to understand why this question vexes the professionals, we will first follow the path of early intellectual discovery along which scientists came to recognize that the Earth is a planet. Then we will walk the historical path that led to the discovery of much of the solar system, including the planets Uranus and Neptune, the asteroid belt, and Pluto. Finally, we will focus our attention on important astrophysical discoveries since the discovery of Pluto that have culminated in widespread, popular confusion and impassioned professional debate over the status of Pluto.

At the end of the twentieth century, the debate over the answer to the question *Is Pluto a planet?* spilled into the public domain because several new discoveries—large objects in the Kuiper Belt in our solar system, giant planets orbiting other stars, possible planet-sized objects floating freely through space—all provide new and important ways to think about how to answer this question. We will look at these new discoveries, especially at their impact on how we think about planets and planetary systems, including, of course, how we think about our own solar system.

The question *Is Pluto a planet?* illustrates a difficult challenge common to all areas of research and thought: how do we draw the lines we use to categorize objects and ideas? Categorization is one of the first steps in learning: we organize information by similarities and differences. We know that mammals give birth to live young; yet, a platypus lays eggs and is a mammal. Despite its name, a koala bear is a marsupial, not a bear. So which similarities are most important and fundamentally determine membership in a group or class? Which differences are incidental? As is often said, the devil is in the details.

Astronomers like to joke that knowledge of one object—a bright point of light in the nighttime sky—defines a class of objects: stars. The discovery of a second bright point of light that is not identical to the first forces us to create two distinct classes of objects—for example, red stars and blue stars. In this example, the two stars share one important characteristic—they are both bright points of light in the sky—but differ in the apparently important characteristic of color. If we then discover a third object in the sky sharing the original characteristic—a bright point of light in the nighttime sky—but differing in the second characteristic—this third object is yellow—do we conclude that these three objects belong to three distinct categories of objects, with each group being represented by only one example? Or, might we realize that we have discovered three similar objects that differ only in the incidental quality of color? Which is more important, recognizing the similarities among the objects (they are all stars) or emphasizing the differences (colors) between them? At what point should we discard the categories we are using and start anew?

By defining finer and finer categories, we learn about the physical universe in which we live. We use our knowledge both to expand our understanding (Wow, three kinds of stars exist!) and to delimit what we do not understand (Why do stars have different colors?). The problem for us lies in how we define a group (for example, planets) when we know very little about the individual objects in the group and almost nothing about the processes that made or make

similar objects and have very few examples of objects that presumably are members of the group.

We cannot answer our question *Is Pluto a planet?* unless we are able to determine the qualities that define the boundaries of the category *planet*. Once we agree on how to define *planet*, we can ask whether a particular object, in this case Pluto, satisfies our criteria. Since we need to define *planet*, we could turn to a dictionary.

The *Oxford English Dictionary* (*OED*)[1] defines the modern word *planet* as deriving from the Old French *planete* out of the Latin *planeta*; in turn, the Latin is derived from the Greek word for wandering star, *planetos*, which in turn evolved from *planasthai*, the verb "to wander." Clearly, we need to understand what the ancient Greeks meant by their word, and the *OED* tells us, giving the *Old Astronomy* (i.e., archaic and no longer used) usage:

> A heavenly body distinguished from the fixed stars by having an apparent motion of its own among them; each planet, according to the Ptolemaic system, being carried round the Earth by the rotation of the particular sphere or orb in which it was placed. The seven planets, in the order of their accepted distance from the Earth, were the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn.

If you are reading carefully, you will have noticed that according to the ancient Greeks, *the Sun was a planet* but *the Earth was not*! Certainly, no person in the twenty-first century thinks of the Sun as a planet. We all were taught that the Sun is a star, not a planet.

So did the Sun change from a planet into a star? Of course not. Apparently, though, *our understanding* of what is meant by *planet* changed; hence, at the moment when our understanding changed, we reclassified the Sun as a star and the Earth as a planet and discarded the Old Astronomy usage.

Next, we find the *Modern Astronomy* definition:

> The name given to each of the heavenly bodies that revolve in approximately circular orbits round the Sun (*primary planets*), and to those that revolve round these (*secondary planets or satellites*). The primary planets comprise the *major planets*, of which nine are known,

> viz., in order of distance from the Sun, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto, and the *minor planets* or asteroids, the orbits of which lie between those of Mars and Jupiter.

Another *OED* definition, given in the *New Shorter OED*, is similar:

> Any of various rocky or gaseous bodies that revolve in elliptical orbits about the Sun and are visible by its reflective light, esp. each of the nine major planets (see below); any of various smaller bodies that revolve around these; a similar body revolving around another star.

The "see below" points to a list of *primary planets*, a definition of *minor planet* as an asteroid, and a definition of *secondary planet* as "a planet that orbits another planet, a satellite, a moon."

Whoa! The Moon revolves around the Earth; therefore, the Moon must be considered a *secondary planet*? Certainly, a secondary planet is some kind of planet just as a sweet potato is some kind of potato. Do we normally think of our Moon as a planet? No.

Mars has two potato-shaped moons, Phobos and Deimos, each no larger than a small city, both of which also match this definition. Are objects like Phobos and Deimos, with diameters of only a few miles, planets? No.

The Hubble Space Telescope most definitely is a satellite revolving around a primary planet, the Earth. Is the manufactured Hubble Space Telescope, which astronomers would consider to be a "rocky body," a *heavenly body*? If not, what if NASA hauled a ten-ton boulder into space and launched that boulder into a terrestrial orbit? The boulder is certainly a naturally made rocky body that would be in orbit around a primary planet. What meaningful difference would permit us to distinguish between these two orbiting objects, or would both qualify as *secondary planets*?

According to the latter two definitions, all of these objects might be planets, as are the asteroids in the asteroid belt, even the ones that are smaller than a house or car, since most of these objects revolve in approximately circular orbits around the Sun. However,

according to the Modern Astronomy definition, a Sun-orbiting asteroid whose orbit keeps it in between the orbits of Earth and Mars, rather than in between the orbits of Mars and Jupiter, would not be a planet. Similarly, an asteroid in a moderately elliptical orbit between Mars and Jupiter, traveling from an outermost distance just outside of Jupiter's orbit to an innermost distance just inside of Mars's orbit, also would be disqualified as a planet. The *New Shorter OED* definition would allow asteroids with more elliptical orbits and those outside the Mars and Jupiter boundaries to be secondary planets, but why are such objects considered planets at all?

When I read these definitions, I want to know: Who are these Old and Modern astronomers? Am I one? Surely, the Old astronomers were not to be trusted, as they included the Moon and Sun as planets. And what of these Modern astronomers whose definition appears to include objects big and small, natural and manufactured, but only if those objects are in nearly circular orbits and in preferred locations? If either of the modern definitions is correct, far more than nine planets orbit the Sun. In fact, there must be hundreds of thousands, perhaps even millions, of planets in our solar system. Clearly, the commonly accepted notion that nine planets orbit the Sun does not match the *OED* version of the universe.

I, for one, am very dissatisfied when I read the *OED* definitions. I hope you are similarly bothered. Because the dictionary definition of *planet* is essentially worthless, scientifically, we have to probe much deeper into astronomy in order to answer what initially appeared to be a simple question. That is what we will do in the rest of this book.