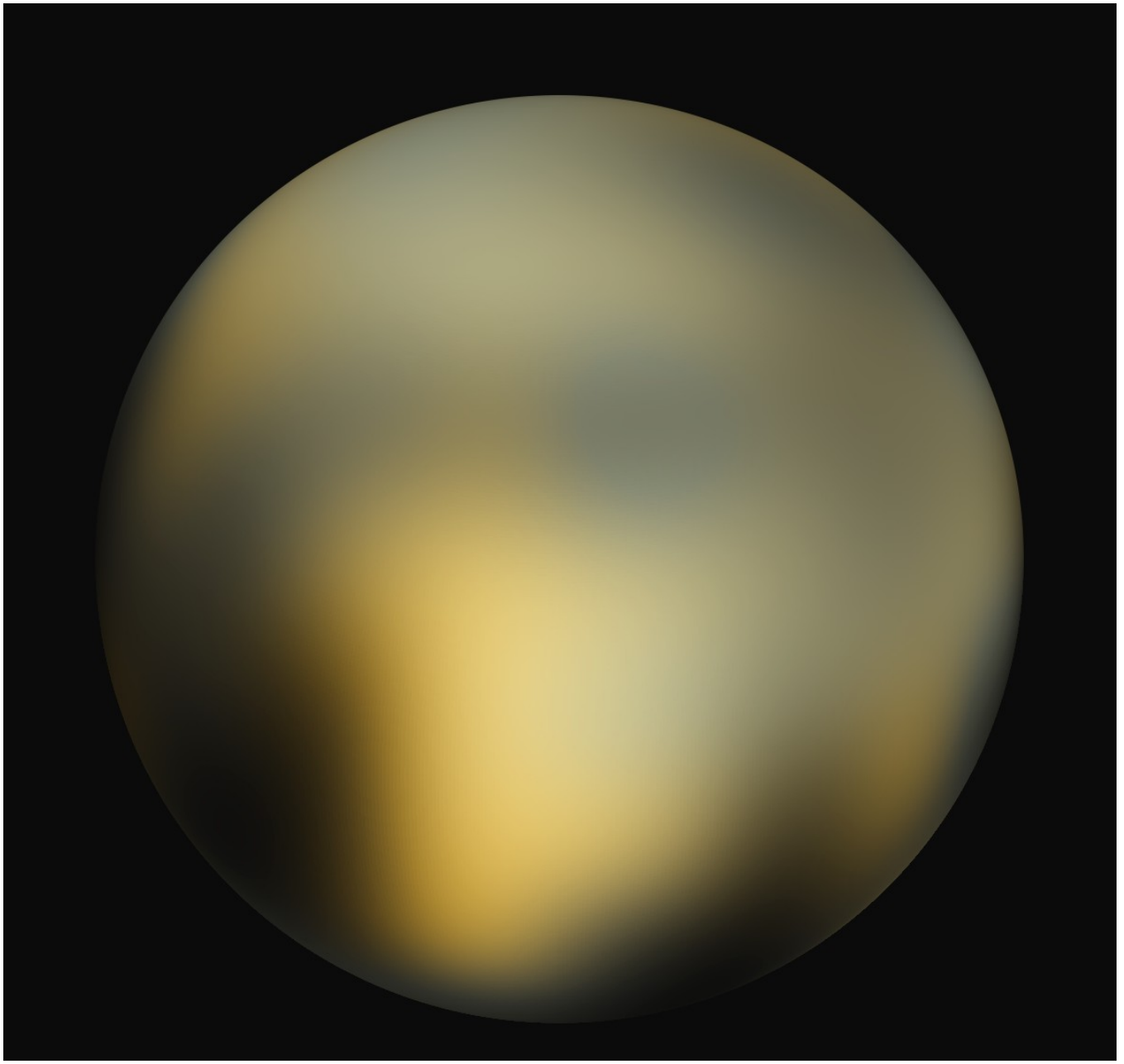


Credit: NASA

Pluto and the Dwarfs

Glenn Holliday
for Rappahannock Astronomy Club
December 2011

Beginning the Search for Pluto

I noticed the discovery of Pluto, and its later reclassification as a dwarf planet, resembled other things that happened in astronomy a short time earlier.

So I took a small small step back to begin the story of the discovery and later adventures of Pluto.

The Beginning of the Discovery of Pluto

Credit: NASA

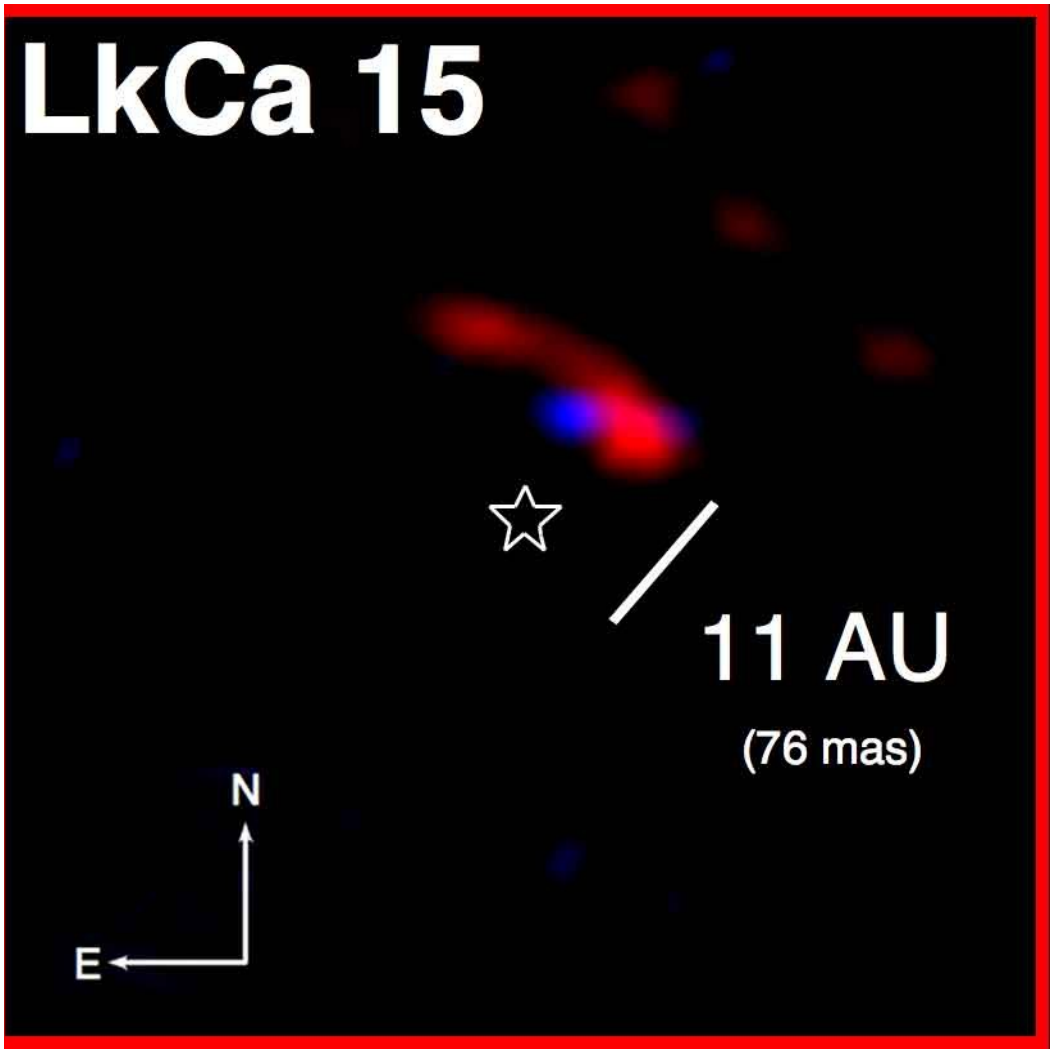
Our primal molecular cloud produced a protosolar disk, which produced a star.

Planets tend to form after a new star

Credit: NASA

The protosolar disk was now a protoplanetary disk.
Lots of raw material for planets, denser close to star.

Protoplanetary disk makes many solid bodies



Credit: Keck Observatory

Many of them tiny, a few of them pretty big.

First direct image of a protoplanet (blue) sweeping up material (red) from its surrounding protoplanetary disk. Released October 19 2011 by Keck Observatory.
Star icon marks where the telescope blocked the light from the young star in this system. LkCa 15 is near tau Tauri.

A few years later, on one of the big objects

Credit: Wikimedia Commons

People started to figure out what the rest of the objects were.

Early astronomical observations?

37,000 years old (Old Stone Age).

Credit: Science Museum of Brussels

Generally accepted as the oldest evidence of counting. Its 29 lines may be the days of a lunar month.

Credit: Musée des Antiquités Nationales at St-Germain-en-Laye

25,000 years old (Old Stone Age).

It may record the phases of the Moon.

Both may have non-astronomical interpretations.

Understanding that astronomical events recur

Credit: Wikimedia Commons

5,000 years old (New Stone Age)

People could predict where the Sun would fall on significant dates.

Understanding that stars and planets differ

Credit: British Museum

4000 years old (Bronze Age).

Babylonian astronomers recorded sightings of Venus on this tablet. They recognized that the stars and planets moved at different speeds.

An important milestone in the discovery of Pluto.

How did Babylonian observations help us discover Pluto?

Beginning to apply a scientific method

We already have

- Records of observations
- Ability to predict events in the sky

Here we see for the first time

- Separating observations into different categories

Scientific Method

1. Make a hypothesis that predicts a result
2. Perform an experiment
3. Gather data from the experiment
4. Decide if the data agrees with the prediction

What to hypothesize about?

Need another scientific method:

Equally important, but less taught

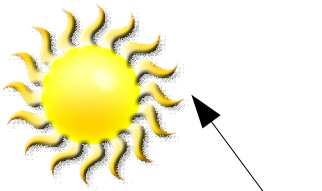
1. Observe a lot of events
2. Record your data
3. Try to make sense of your pile of data

Now you can make a hypothesis about some pattern you think you see in your data.

Categorization

A valuable strategy in science:

- Notice characteristics
- Put things that share a characteristic together to make a category
- One of these things is not like the others



bright

in sky

bright

in sky

bright

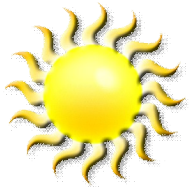
on ground

on ground

dim

Categorization is a Multiple Choice Game

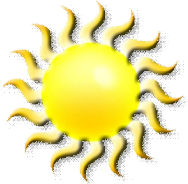
One way to categorize these things



Bright things

Dim things

Another way to categorize the same things




Astronomical objects


Terrestial objects

"Why do we care about classifying Pluto as a planet or as a minor planet, or as anything else for that matter? Why do we do classifications at all in astronomy, or in any other science for that matter? The reasons we do the classifications is to try to find patterns that will help us understand how things work or how they came to be." - Michael A'Hearn

Ancient Greek categorization

2500 years ago (Bronze Age)

Category and its characteristics	Members of this category
Stars •Shine brightly •In the sky •Fixed relationship to each other •Yearly cycle to return to same position	Sirius Arcturus many more
Planets •Shine more brightly than stars •In the sky •Move with respect to the stars and to each other •Have cycles of varying lengths	Helios Selene Stilbon Phosphoros Hesperus Pyroeis Phaethon Phainon (8 planets! Or 9?)
Earth •Does not shine •Not in the sky •Does not move	Gaia

Credit: attr. Plato, *Epinomis*

Scientists Demote a Planet!

Greeks recognizes that Phosphoros and Hesperus (morning and evening appearances of Venus) are really the same planet.

- Reduces the number of planets by one
- Paramenides? Or Pythagoras?

A precedence for Pluto?

Plato's Challenge:

The movements of the planets are chaotic. They should not be. Invent a theory that shows they are really smooth and regular, and explains why they only appear to be chaotic.

Solved by Eudoxus:

Theory of orbits.

Plato included Eudoxus's theory in his later writings.

Another important milestone in the discovery of Pluto.

Slight Delay in Discovery of Pluto

Ancient astronomy had some successes

Predicting significant annual events

- The Nile is about to flood.

Heliocentrism

- Proposed in Greece by Aristarchus, did not catch on.
- Proposed in India around 500.

Better orbital geometry

- Proposed in Arabia around 800.

Better categories

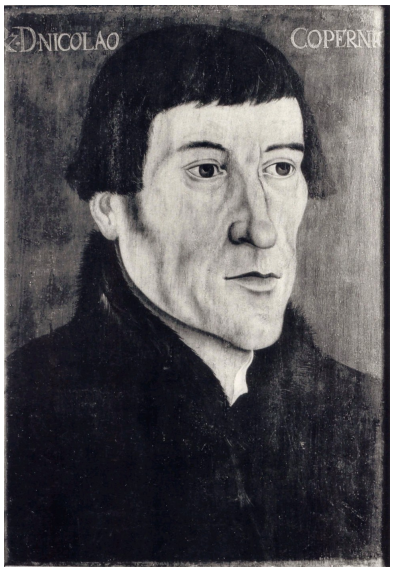
- Anaxagoras proposed the Sun is a star, and was condemned to death (then pardoned by Pericles).

But in general, astronomy in Europe used a Bronze Age model of the universe for the next 2,000 years.

Moving the Sun and Earth

1543: Copernicus: category “planet” means it orbits the Sun

Category and its characteristics	Members of this category
Stars •Shine brightly •In the sky •Fixed relationship to each other •Yearly cycle to return to same position	Sirius Arcturus many more
Planets •Shine more brightly than stars •In the sky •Move with respect to the Sun •Have orbits of varying lengths	Mercury Venus Earth Mars Jupiter Saturn
Sun •Shines more brightly than anything else •In the sky •Does not move	Sun
Moon •Shines more brightly than stars or planets •In the sky •Moves with respect to Earth	Moon



Credit: Wikimedia Commons

Scientists Demote more Planets!

The ancients categorized the Sun and Moon as planets.
Copernicus' new categories demotes both.

Evidence for Copernicus' categorization

1609 Galileo's direct observations (published in 1632)

Category and its characteristics	Members of this category
Stars •Shine brightly •In the sky •Fixed relationship to each other •Yearly cycle to return to same position	Sirius Arcturus many more
Planets •Shine more brightly than stars •In the sky •Move with respect to the Sun •Have orbits of varying lengths	Mercury Venus Earth Mars Jupiter Saturn
Sun •Shines more brightly than anything else •In the sky •Does not move	Sun
Moons •Shine •In the sky •Move with respect to a planet	Moon Io Europa Ganymede Callisto

Credit: Wikimedia Commons

Getting closer to finding Pluto

Galileo:

- There are things out there we don't know are there
- Nothing is unique – likely to have companions in a category
  - Our Moon is not a singleton – other planets have moons
- Phases of Venus: direct physical evidence that it orbits around something other than the Earth

1572 supernova

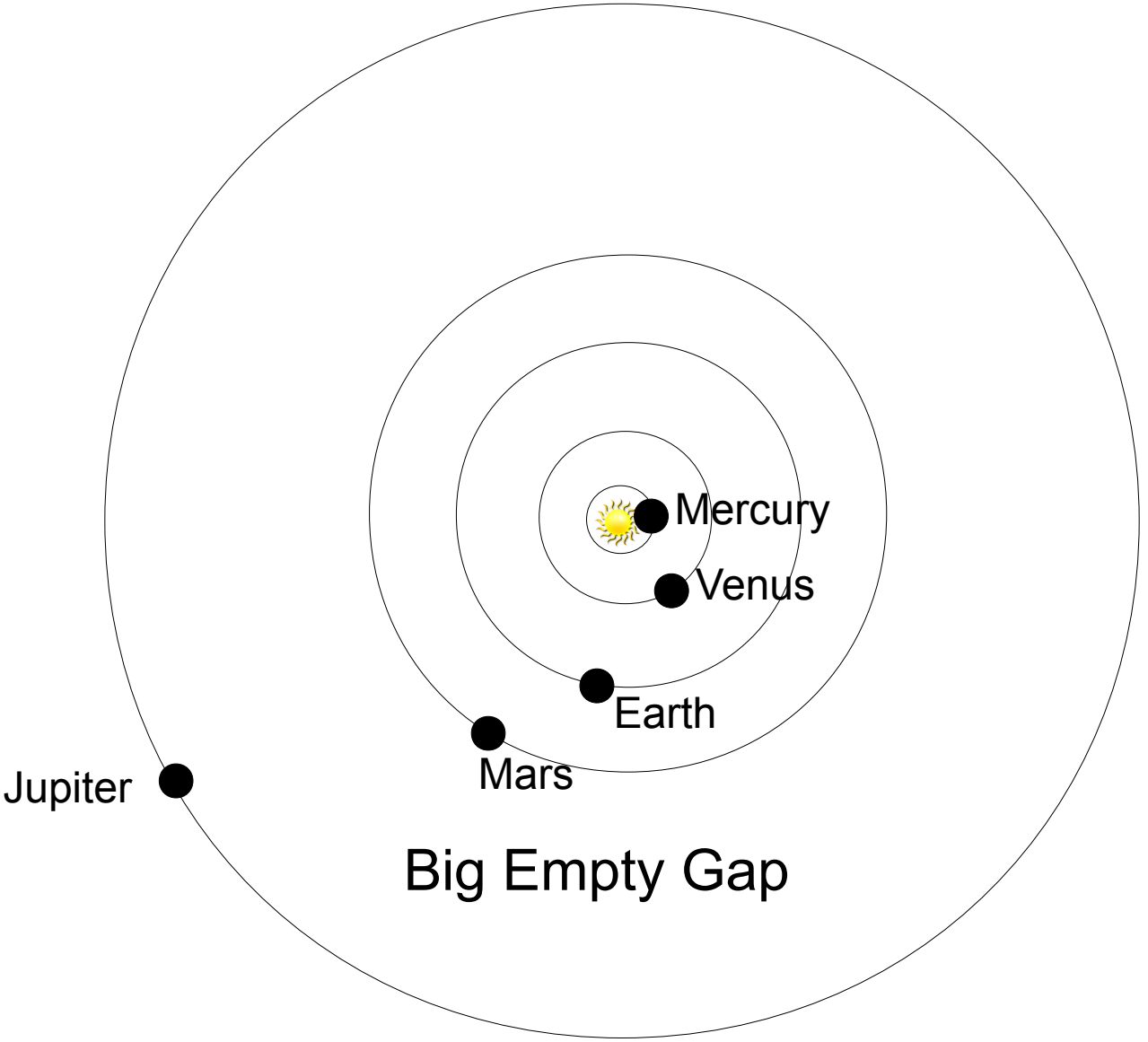
- Direct physical evidence that the sphere of fixed stars is not unchanging
- Helped dismantle the old theory, support the new

Categories pretty good, but theory not yet complete

- Copernicus still had troubles with epicycles
  - Others recognized Copernicus did not have the full solution
  - Kepler solved them
- Bruno: Our Sun is not unique
  - The sun is like the other stars
  - Was burned at the stake for it

Titus's Prediction

Enough data to make the theory of orbits more specific.



Credit: Wikimedia Commons

1766: Titus: There's another planet in that gap.

1772: Bode repeats the prediction and provides the math.

New Planet Encourages Search for More

Credit: National Portrait Gallery, London

1781: Herschel discovers Uranus

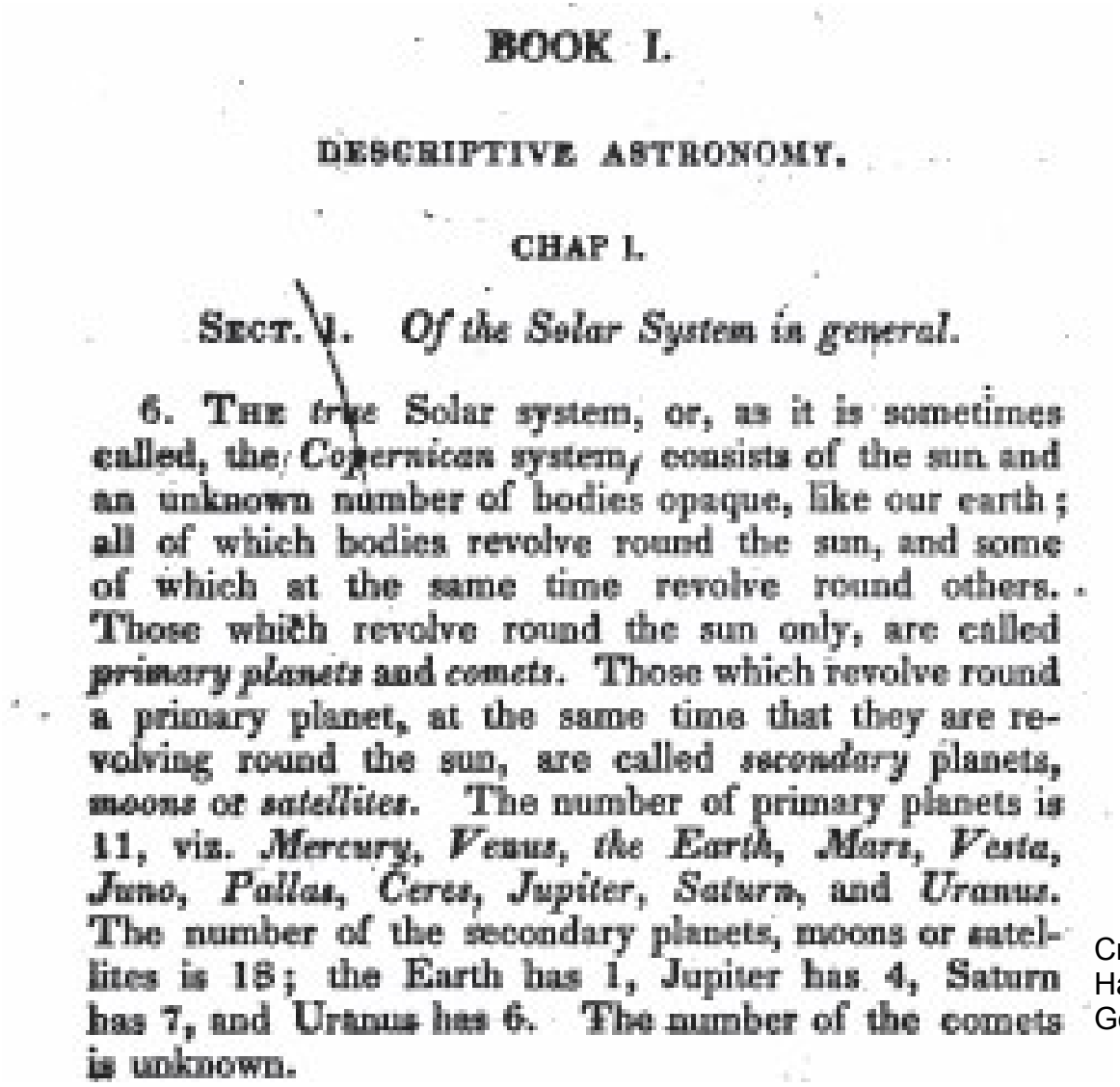
- First discovery of a planet beyond the traditional 5 of ancient times.
- Greeks and others observed and recorded Uranus as a star.
- Fits Titus's rule for planetary distances.

Bode urges search for Titus's predicted planet between Mars and Jupiter.

Rapid Discovery of Planets

1801: Piazzi discovers Ceres

Soon followed by the discoveries (by others) of Pallas, Juno, and Vesta.



BOOK I.

DESCRIPTIVE ASTRONOMY.

CHAP I.

SECT. I. *Of the Solar System in general.*

6. THE *true* Solar system, or, as it is sometimes called, the *Copernican system*, consists of the sun and an unknown number of bodies opaque, like our earth; all of which bodies revolve round the sun, and some of which at the same time revolve round others. Those which revolve round the sun only, are called *primary planets* and *comets*. Those which revolve round a primary planet, at the same time that they are revolving round the sun, are called *secondary* planets, *moons* or *satellites*. The number of primary planets is 11, viz. *Mercury*, *Venus*, *the Earth*, *Mars*, *Vesta*, *Juno*, *Pallas*, *Ceres*, *Jupiter*, *Saturn*, and *Uranus*. The number of the secondary planets, moons or satellites is 18; the Earth has 1, Jupiter has 4, Saturn has 7, and Uranus has 6. The number of the comets is unknown.

Credit: *Elements of Astronomy*, Harvard University Library via Google Books

More Planets Demoted

1851: Beginning of discoveries of many more bodies between Mars and Jupiter.

Neptune clearly shares more characteristics with the classical planets than do Ceres and company.

The 8 large planets are clearly a different category than the small bodies found between Mars and Jupiter.

Herschel had suggested the name asteroid for the new bodies based on current technology; this became popular.

The names of asteroids drop off the lists of planets in astronomy books.

1896: Greenwich Royal Observatory *Astronomical results from observations* lists 16 planets.

1905: Greenwich Royal Observatory has dropped the asteroids from the list of planets.

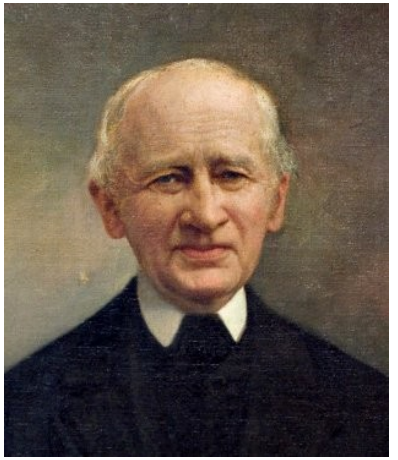
There is no international body to suggest or enforce this.

Prediction of Position of a New Planet

1821: Bouvard finds unexpected irregularities in the orbit of Uranus, predicts the cause is the gravity of a planet beyond Uranus.

Adams and Le Verrier ("the man who discovered a planet with the point of his pen") calculate and predict the position of the new planet.

1846: Galle finds Neptune at the predicted position.



Credit:Astrophysical Institute Potsdam

Another milestone in the discovery of Pluto.

Using the theory of gravity to predict a missing planet

- Predicted not only its orbital distance, but also its position in its orbit

Late 19th Century Categories

Category and its characteristics	Members of this category
Stars • Shine brightly • Fixed relationship to each other • Yearly cycle to return to same position	Sun Sirius Arcturus many more
Planets • Move with respect to the Sun • Have orbits of varying lengths • Significant mass • Disk visible in telescopic observation	Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune
Moons • Shine brightly • Move with respect to a planet	Moon Io Europa Ganymede Callisto many more
Asteroids • Move with respect to the Sun • Have orbits of varying lengths • Show no disk with current telescopes	Ceres Pallas Juno Vesta many more

(Finally!)

Pluto Predicted And Found

1905: Lowell: The orbit of Uranus suggests the influence of gravity of something else in addition to Neptune.

1916: Lowell dies, disappointed he has not found his expected “Planet X”.

1919: Pickering updates predictions of location of Pluto.

1930: Tombaugh discovers Pluto in new photographs.

Tombaugh announces his discovery in February, recommends the name Pluto in May.

The next year, Disney names Mickey's dog Pluto.

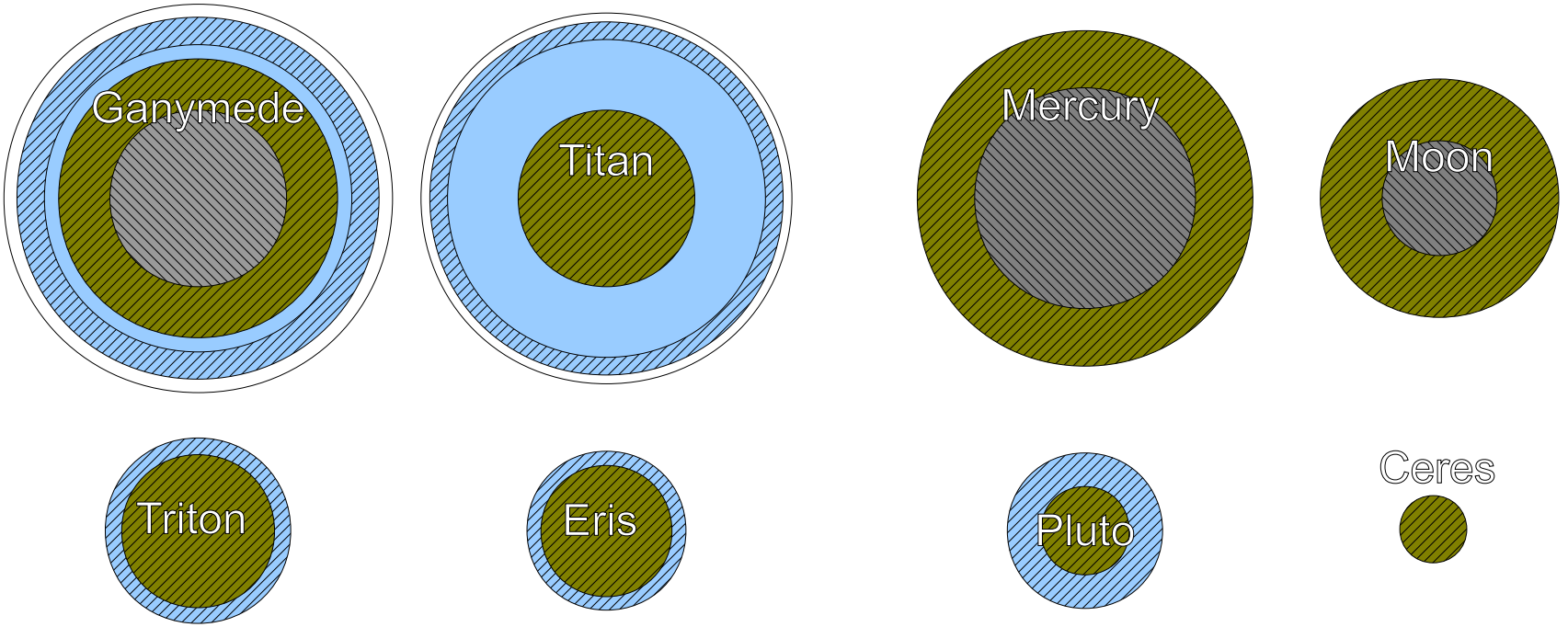
Credit: NASA

Credit: Disney

Later astronomers find Pluto in photographs Lowell's staff took before his death. Lowell looked at it, but did not recognize it.

Characteristics of Pluto

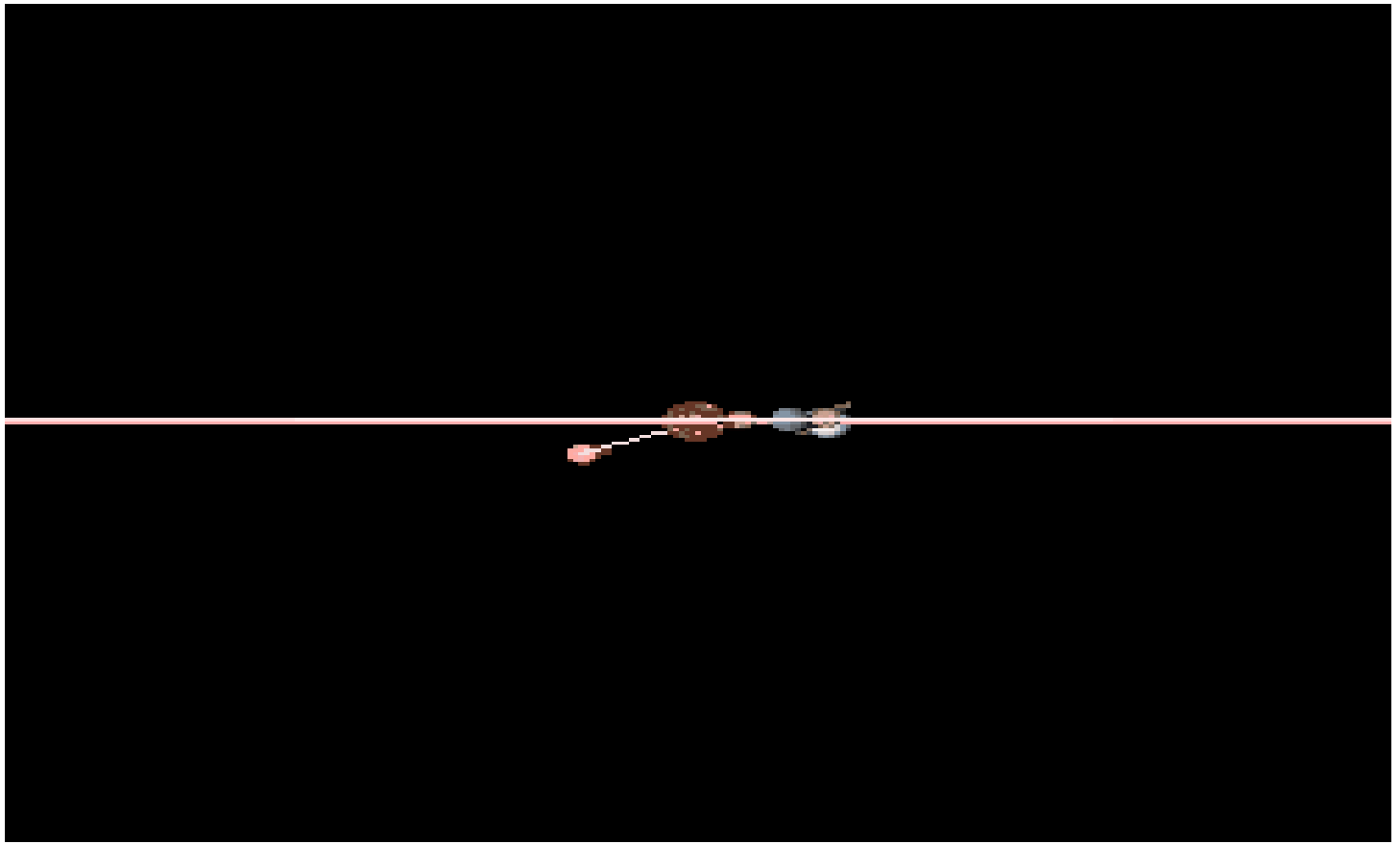
- ~2300 km diameter, but error margin is ~15%
- Smaller than 8 planets
- Smaller than 7 moons
- Bigger than all of the asteroids
- Bigger than most of the Kuiper Belt objects



- Rocky core, icy crust
- More similar to the other Kuiper Belt objects than to the 8 big planets, asteroids, comets, or other groups of objects

Characteristics of Pluto

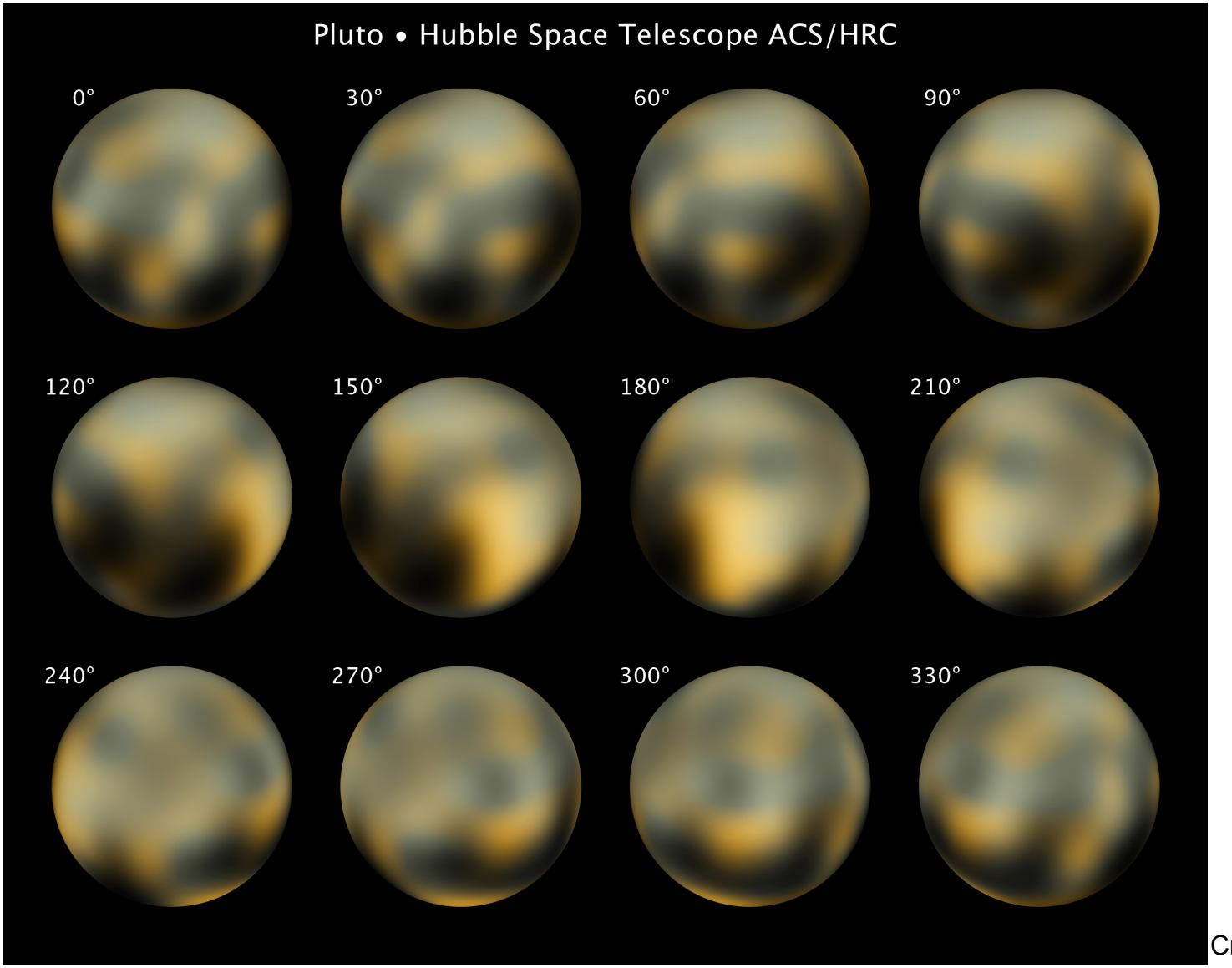
- Eccentric orbit



Credit: Wikimedia Commons

Characteristics of Pluto

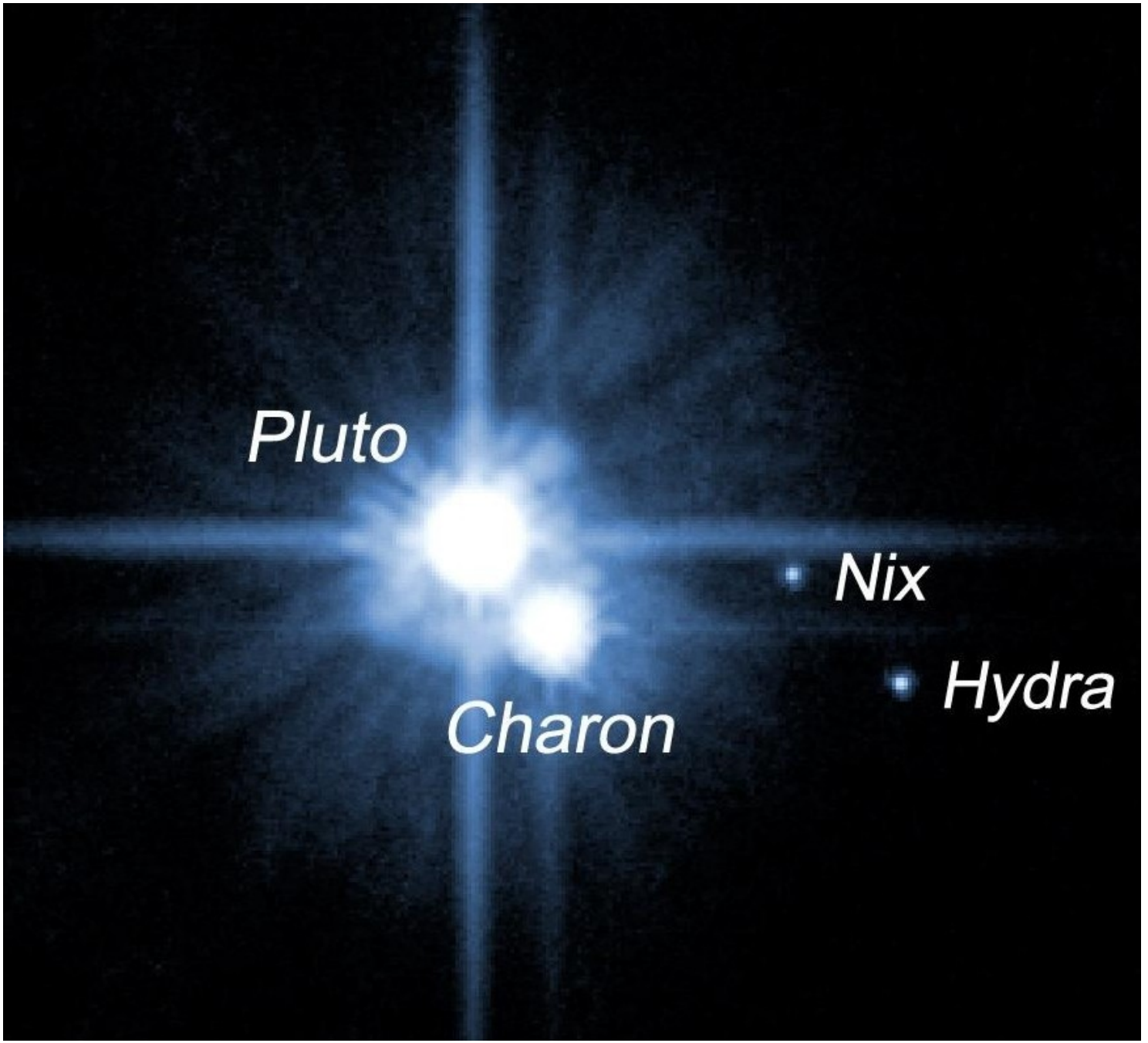
- Varying albedo



Credit: NASA

Characteristics of Pluto

•Double planet with its moon Charon



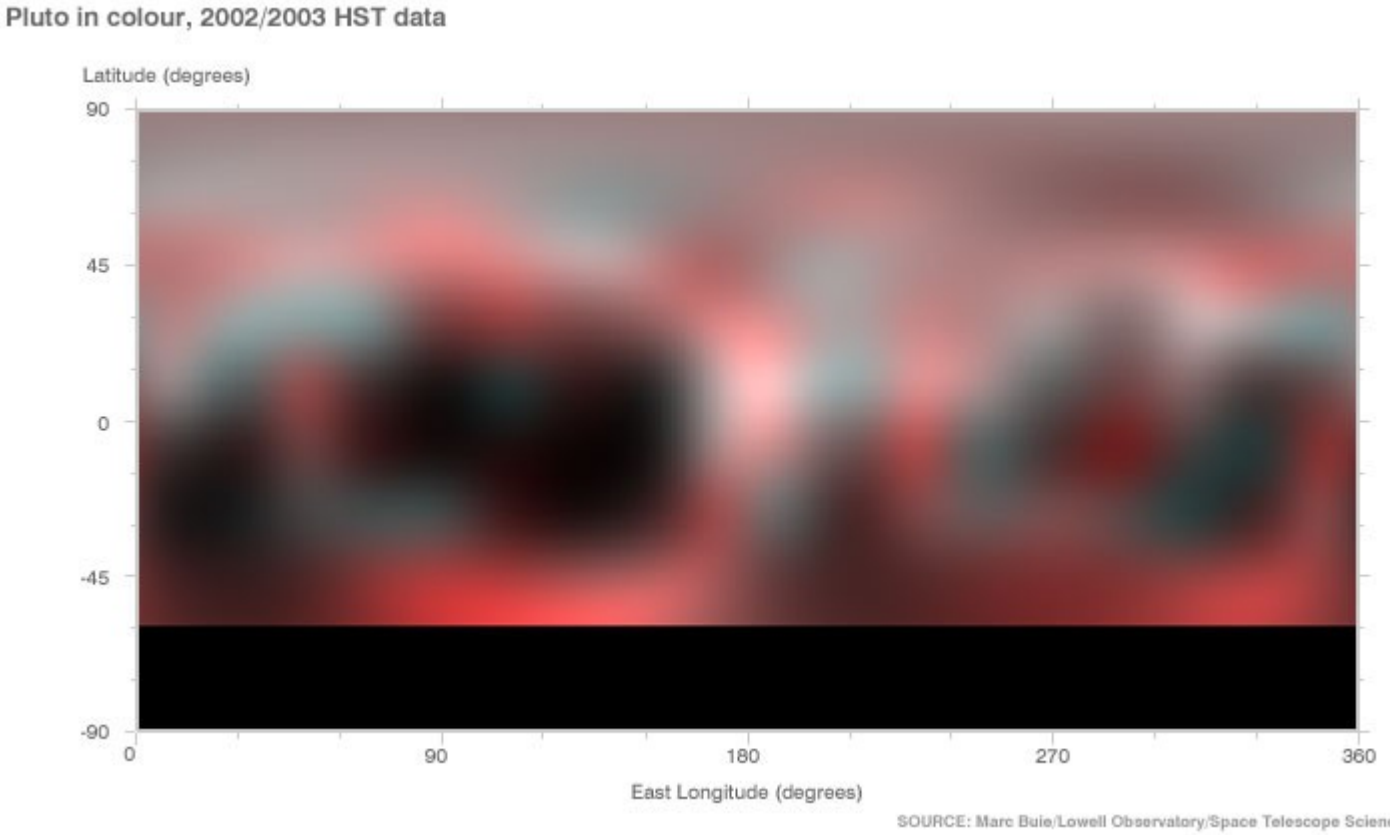
Charon is large enough that the center of mass of this system does not lie within Pluto. Pluto and its moons all orbit a barycenter that lies between Pluto and Charon.

Yet-unnamed moon P4 discovered July 2011.

Credit: NASA

Characteristics of Pluto

- Only has an atmosphere in summer
- Atmosphere freezes and covers the planet surface as ice in winter



Credit: NASA

Red is methane ice
Dark is water ice
Grey is nitrogen ice
Bright highlights may be carbon monoxide ice

Pluto Prediction Preposterous

1989: New measurements of Neptune's mass by Voyager account for all of the gravitational influence on Uranus.

Lowell was a victim of GIGO: there was no problem with Uranus's orbit that needed a new planet to explain it. Tombaugh was lucky.

New Horizons spacecraft

Credit: NASA

On the way to Pluto since 2006

Flyby expected 2015

- Carrying Clyde Tombaugh's ashes past Pluto
- Visible light imaging
- Telescope
- Infrared spectrometer
- Ultraviolet atmosphere imager
- Solar wind particle spectrometer
- Dust counter
  - Built by students
  - Named for Venetia Burney, the student who named Pluto

Ice Hunters project: you can help find additional targets after New Horizons passes Pluto

Pluto is not a singleton

Remember all that stuff from our protoplanetary disk?

Credit: NASA

It doesn't cut off sharply at Neptune. It continues out for a long way farther.

The major planets used up most of in the inner solar system.
Pluto did not use up very much of what was left.
The leftovers are not dense enough to build big planets, but there's enough for a lot of little objects in the outer solar system.

1931: Leonard predicts Pluto is “the first in a series of ultra-Neptunian bodies”.

Sagan's Proposal

1980: In the TV series *Cosmos*, astronomer Carl Sagan suggests how alien astronomers might categorize our solar system:

Category and its characteristics	Members of this category
Stars •Fuse	Sun
Planets •Don't fuse •Big enough to notice	Jupiter Saturn Uranus Neptune
Rubble	Everything else

Credit:Carl Sagan,*Cosmos: A Personal Journey*

Asimov's Proposal

1987: Suggestion by science fiction author Isaac Asimov:
If there are a lot of things like Pluto, then we haven't just discovered a planet, we've discovered a category.

Category and its characteristics	Members of this category
Stars •Fuse	Sun
Major Planets •At least as massive as Mercury	Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune
MesoPlanets •Between the masses of Ceres and Mercury	Pluto many more not yet discovered
Minor Planets •No more massive than Ceres	Ceres Pallas Juno Vesta many more

Credit: Isaac Asimov, *The Incredible Shrinking Planet*

Some Astronomers Stop Treating Pluto as a Planet

1992: Jewitt and Luu begin to discover more Kuiper Belt objects

2000: Hayden Planetarium, New York, under Neil Tyson, opens new solar system display that groups

Stars	Sun	
Terrestial Planets • Rocky	Mercury Earth	Venus Mars
Gas Giants • Primarily gas	Jupiter Uranus	Saturn Neptune
Asteroid Belt	Ceres	many more
Kuiper Belt	Pluto	many more
Oort Cloud	Comets	

Credit: American Museum of Natural History

“We saw no value in counting planets - or counting anything … planet counting … impedes the inquiry of a vastly richer landscape of science drawn from all that populates our cosmic environment.” - Neil Tyson

The 10th Planet

2005: Brown discovers Eris.

Credit: NASA

Credit: NASA

- Named for the Greek goddess of discord.
- Because this planet caused a lot of it.
- First known Kuiper Belt object as big as Pluto.

If Pluto is a planet, so is Eris.

If Eris is not a planet, neither is Pluto.

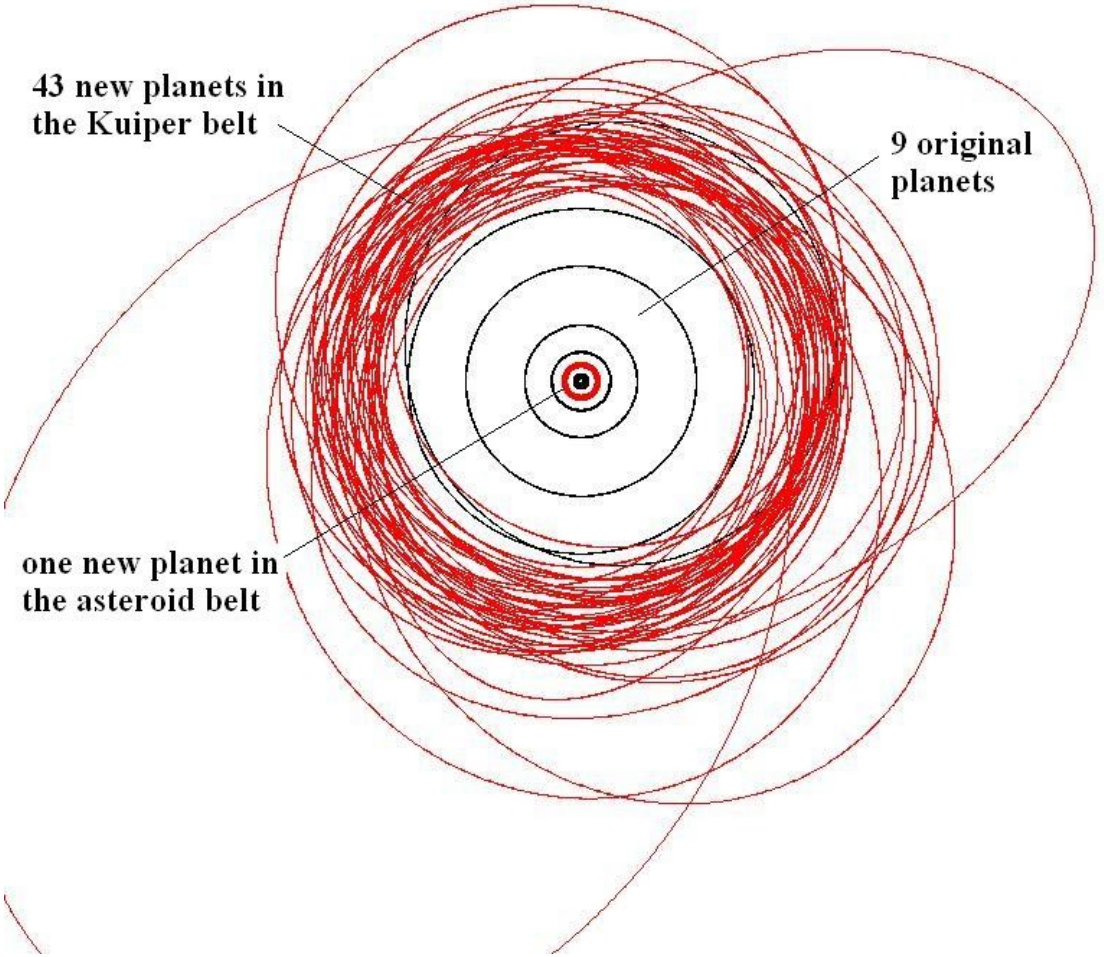
The Problem with Planethood for Pluto

Credit: NASA

Hundreds or thousands of objects have characteristics that fit the category of planet as well as Pluto does.

Many applicants – how many positions?

IAU considered a definition that would have kept Pluto a planet. It also included all of these objects already known at that time:

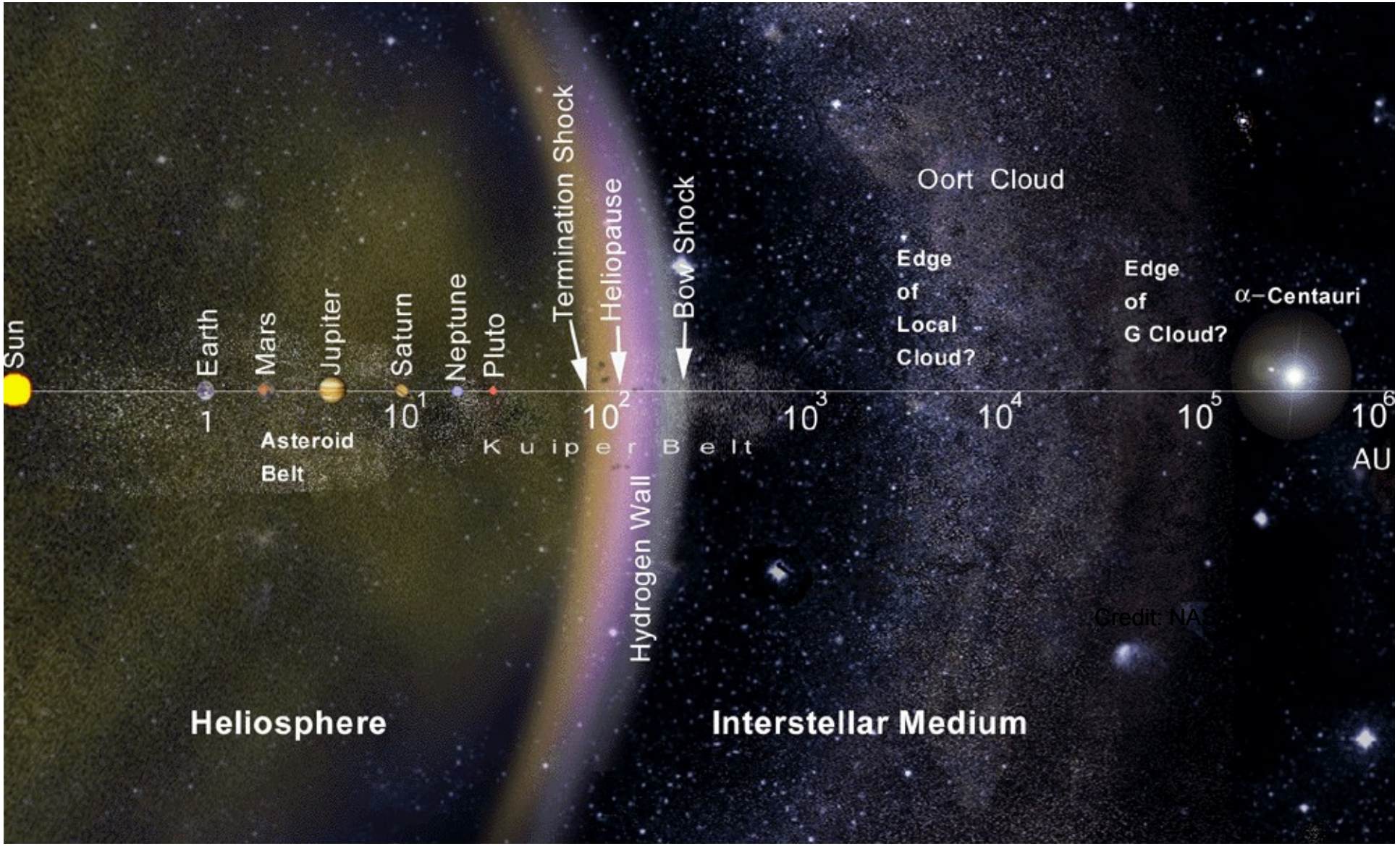


Credit: Mike Brown

Everybody expects this number to keep growing with new discoveries.

Lots of room for many exotic objects

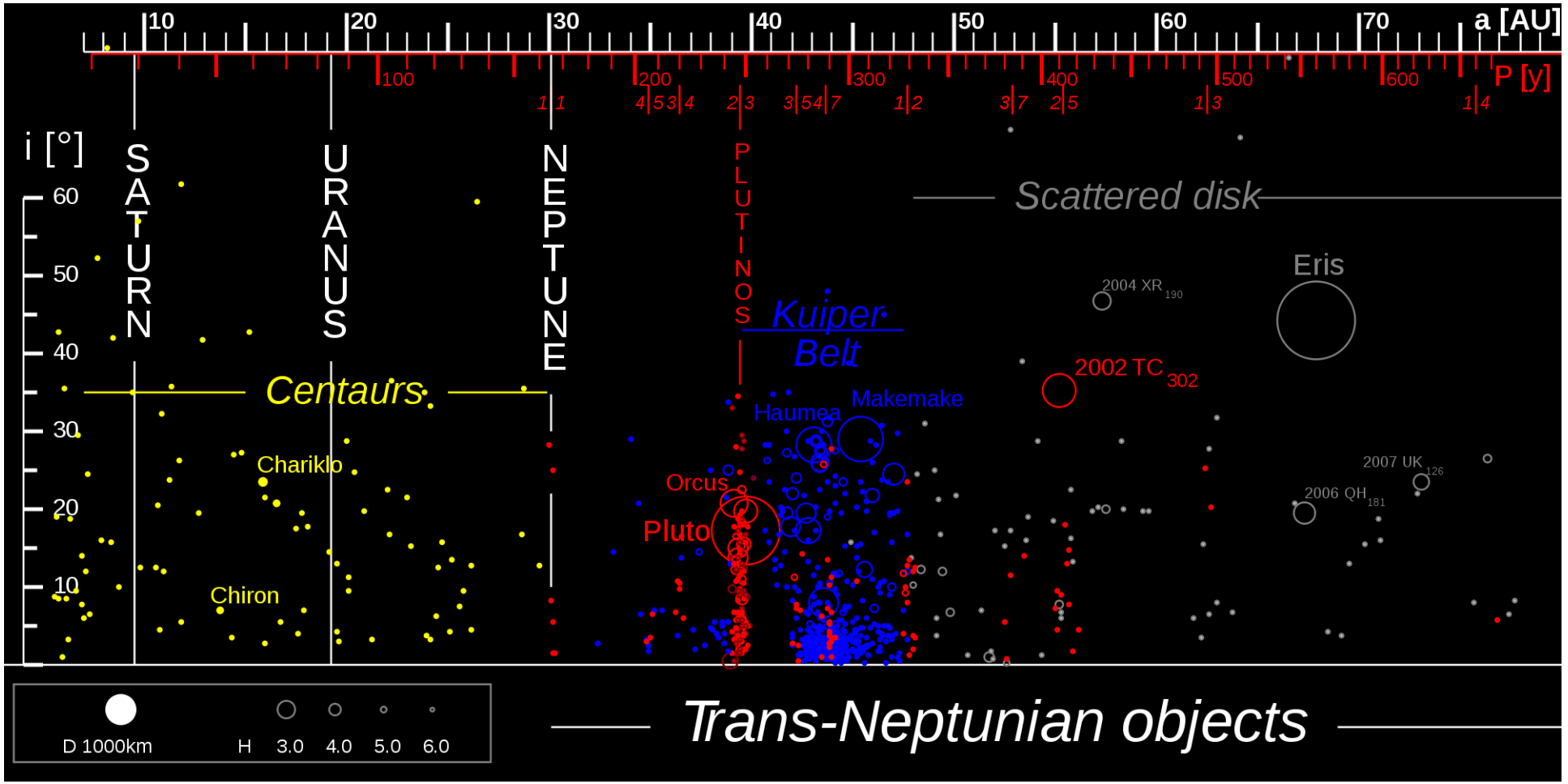
How many of them are planets?
Astronomers estimate 10 the size of Pluto,
low probability of 1 the size of Earth or larger.



Credit: NASA

Already a complicated group of categories

There are groups of small objects at several positions in the Solar System.
Which are planets, which are not?



Credit: Wikimedia Commons

Showdown at the IAU Corral

2006: Meeting of International Astronomical Union

The scientific question: What is a planet?

The question people cared about: Is Pluto still a planet?

The underlying question: Does it feel right to have hundreds of planets?

The philosophical question: What does “planet” mean to people?

The linguistic answer: People use “planet” to mean one of the names they've always heard was a planet.

The intuitive answer: Planets are big, important bodies in the solar system.

The data: The Kuiper Belt objects share more characteristics with each other than they do with the traditional 8 planets.

Does the traditional category still work?

The Argument For Planethood

“Did we limit the number of stars for memorization convenience when Galileo turned his telescope to the sky and found there weren't any more a countable number of them? … our solar system does not have nine or 10 planets as we long thought it had, but more like 900.”

- Alan Stern

The Argument Against Planethood

“To me, it made no sense to pull one or even a few objects out of the swarm and call them something other than part of the swarm.”

- Mike Brown

The Last Definition Standing

IAU considered several competing definitions.

Finally voted for this definition of a planet:

(a)Is in orbit around the Sun,

(Excludes exoplanets!)

(b)Has sufficient mass … so that it assumes a (nearly round) shape,

(Excludes little objects.)

(c)Has cleared the neighbourhood around its orbit.

(Excludes objects found in swarms like the Asteroid Belt and Kuiper Belt. A characteristic of its behavior, or dynamics, rather than a characteristic of the body.)

Complaints about the new definition

Mostly focus on the third part, “Has cleared the neighbourhood around its orbit.”

All planets, including Earth and even Jupiter, have some smaller objects remaining in their orbits.

- This is sensitive to how you define “cleared the neighbourhood.” The mass remaining in Earth's orbit is very small in proportion to the mass of Earth. The mass remaning in Pluto's orbit is large in proportion to the mass of Pluto.

If Earth migrated to Pluto's orbit, it would no longer be a planet (because unable to clear its orbit).

Was the definition necessary?

Did IAU solve a scientific problem or a bureaucratic problem?

- The name of Eris needed to be approved by a different subcommittee if it were a planet than if it were something else.

Do we need a definition or a concept?

"... scientists work by concepts rather than definitions." - Mike Brown

"... nature abhors a definition. Try to lock something into too small a box and I guarantee nature will find an exception." - Phil Plait

2006 IAU categories

Category and its characteristics	Members of this category
Stars • Fuse • Orbit galactic center (with some exceptions)	Sun Sirius Arcturus many more
Planets • Orbit the Sun • Enough mass to be round • Enough mass to clear their orbits	Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune
Dwarf Planets • Orbit the Sun • Enough mass to be round • Not enough mass to clear their orbits	Ceres Pluto Eris many more
Moons • Orbit a planet	Moon Io Europa Ganymede Callisto many more
Asteroids • Orbit the Sun • Not enough mass to be a dwarf planet	Pallas Juno Vesta many more

… and a zoo of other categories

What has changed?

“I personally don't care one way of the other. Pluto just goes on the way it is, regardless of what you call it.” - Jane Luu

“... neither Pluto nor anything else in the outer Solar System cares in the slightest what anybody on Earth labels it.” - Robert Staehle

“Pluto is not a planet not because it fails to meet the … criteria laid out by the IAU... the critera were written to … explain the concept that Pluto is not a planet.” - Mike Brown

What changed:

- What characteristics identify the category “planet”
- A way of thinking about the data.
- A model of the solar system.

If you find that unsatisfying, then you may prefer this new mnemonic for the 8 planets of the Solar System:

Mean Very Evil Men Just Shortened Up Nature - Mike Brown

Using the definition

“... decisions and recommendations are not enforceable by any national or international law; rather they establish conventions that are meant to help our understanding” - IAU

A normal event in science

- IAU for the first time defined a familiar concept.

Individual scientists will continue to use the definitions most useful for their own needs.

“... my opinions on the planet definition question have nothing to do with the 'status of Pluto' ...I don't really consider the issue that interesting but it comes up in every public talk I give” - Marc Buie

Barrie's prediction: This has all happened before, and it will all happen again.

Credit: J. M. Barrie, *Peter Pan*

When it happens again...

Do we use “planet” as a concept or a definition?

What categories are most useful for us?
What characteristics interest us?

- Planetary characteristics:
  - mass
  - roundness
  - atmosphere
  - moons
- Dynamic characteristics:
  - how it moves
  - what it moves around
  - whether it clears its orbit

Credit: Larry Lebofsky

Almost no planet will have all of the planet characteristics.
We may be more interested in different characteristics at different times.

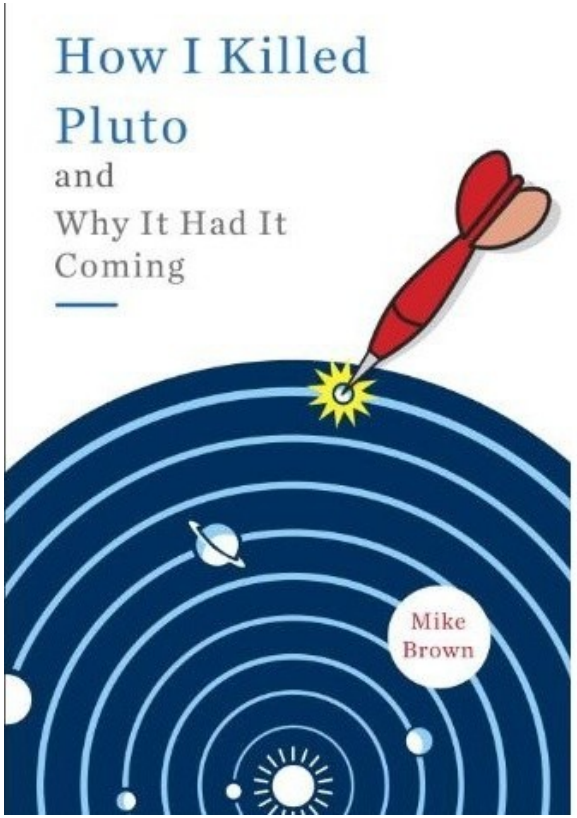
We may find different models more appropriate for different needs.

Another possible categorization of planets

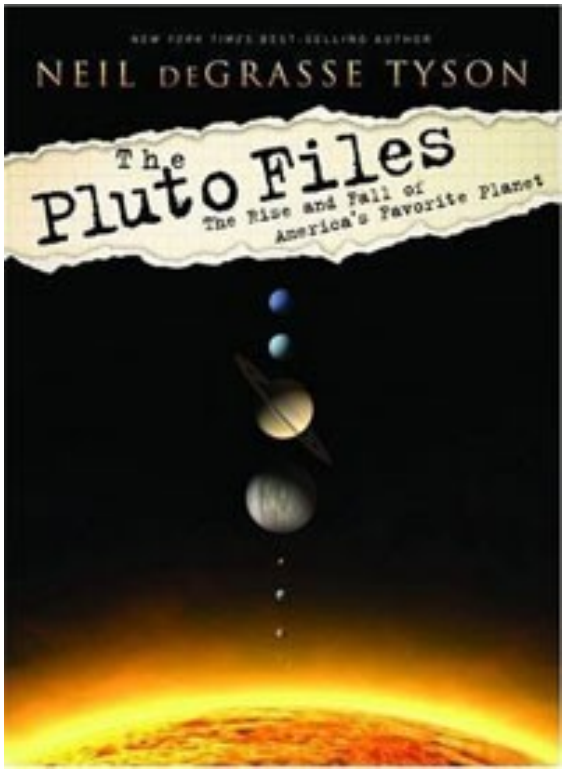
Category and its characteristics	Members of this category
Terrestial Planets • Rocky	Mercury Venus Earth Mars
Gas Giants • Primarily gas	Jupiter Saturn Uranus Neptune
Dwarf Planets • Enough mass to be round • Significantly less mass than other planets	Ceres Eris Pluto many more
Planetary Moons • Complex geology • Atmosphere • Oceans • Orbit a planet	Titan Ganymede? others?

Credit: Larry Lebofsky

… and astronomers became celebrities for a moment



Credit: Mike Brown



Credit: Neil DeGrasse Tyson

Bibliography

Asimov, Isaac. "The Incredible Shrinking Planet". *The Magazine of Fantasy & Science Fiction*, March 1987.

Barrie, J. M. *Peter Pan and Wendy*. London: Hodder & Stoughton, 1911.

Brown, Mike. *How I Killed Pluto and Why It Had It Coming*. New York: Spiegel & Grau, 2010.

Buie, Marc. "My response to 2006 IAU Resolutions 5a and 6a". Southwest Research Institute. Retrieved November 22, 2011, from: http://www.boulder.swri.edu/~buie/pluto/iauresponse.html

Christie, W. H. M. (Astronomer Royal). *Results of the Astronomical Observations Made At The Royal Observatory, Greenwich in the year 1895*. London: Darling & Son, 1897.

Hilton, James L. "When did the asteroids become minor planets?" United States Naval Observatory. Retrieved October 19, 2011, from: http://aa.usno.navy.mil/faq/docs/minorplanets.php

Lebofsky, Larry (Lunar and Planetary Laboratory, University of Arizona). Personal email, October 7, 2011.

Lewis, George Cornewall. *An historical Survey of the astronomy of the ancients*. London: Parker, Son, and Bourn, 1862.

Marschack, Alexander. *The Roots of Civilization*. New York: McGraw-Hill, 1972.

Plait, Phil. "How to Settle, Once and For All, The Whole "What is a Planet" Debate". *Discover*, December 2010.

Sagan, Carl. *Cosmos: A Personal Journey*. Los Angeles: KCET, 1980.

Strous, Lewis (National Solar Observatory). "Who discovered that the Sun was a star?". Stanford Solar Center. Retrieved October 19, 2011, from: http://solar-center.stanford.edu/FAQ/Qsunasstar.html

Tyson, Neil deGrasse. "Pluto is not a planet." The Planetary Society, 1999. Retrieved November 16 2011, from: http://planetary.org/explore/topics/topten/tyson_pluto_is_not.html

---. *The Pluto Files*. New York: W. W. Norton, 2009.

Wall, Mike. "Fighting for Pluto's Planet Title: Q & A With Planetary Scientist Alan Stern". SPACE.com, 2010. Retrieved October 19, 2011, from: http://www.space.com/9594-fighting-pluto-planet-title-planetary-scientist-alan-stern.html

Wilkins, John Hubbard. *Elements of Astronomy*. Boston: Cummings, Hilliard & Co., 1825.

"An Old Mathematical Object". The State University of New York at Buffalo. Retrieved October 19, 2011, from: http://www.math.buffalo.edu/mad/Ancient-Africa/ishango.html.

"Cave Paintings and Sculptures". Don's Maps. Retrieved October 19, 2011 from: http://www.donsmaps.com/cavepaintings.html.

"Enuma Anu Enlil text". British Museum. Retrieved October 19, 2011, from: http://www.mesopotamia.co.uk/astronomer/explore/enuma.html

"Pluto and the Developing Landscape of Our Solar System". International Astronomical Union. Retrieved October 19, 2011, from: http://www.iau.org/public/pluto/

"Alexis Bouvard". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Alexis_Bouvard

"Ceres (dwarf planet)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Ceres_%28dwarf_planet%29

"Clyde Tombaugh". Wikipedia. Retrieved October 19, 2011 from: http://en.wikipedia.org/wiki/Clyde_Tombaugh

"Eris (dwarf planet)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Eris_%28dwarf_planet%29

"Formation and evolution of the Solar System". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Solar_system_formation

"Galileo Galilei". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Galileo_Galilei

"Ganymede (moon)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Ganymede_%28moon%29

"Gerard Kuiper". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Gerard_Kuiper

"Giordano Bruno". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Giordano_Bruno

"Giuseppe Piazzi". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Giuseppe_Piazzi

"Greek astronomy". Wikipedia. Retrieved October 19, 2011 from: http://en.wikipedia.org/wiki/Greek_astronomy

"Ishango bone". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Ishango_bone.

"Jan Oort". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Jan_Oort

"Johann Gottfried Galle". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Johann_Gottfried_Galle

"Johannes Kepler". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Johannes_Kepler

"John Couch Adams". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/John_Couch_Adams

"Kuiper belt". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Kuiper_belt

"Mercury (planet)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Mercury_%28planet%29

"Moon". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Moon

"New Horizons". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/New_Horizons

"Newgrange". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Newgrange

"Nicolaus Copernicus". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Copernicus

"Percival Lowell". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Percival_Lowell

"Pluto (Disney)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Pluto_%28Disney%29

"Pluto". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Pluto

"Titan (moon)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Titan_%28moon%29

"Titius–Bode law". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Titius%E2%80%93Bode_law

"Triton (moon)". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Triton_%28moon%29

"Urbain Le Verrier". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/Urbain_Le_Verrier

"William Herschel". Wikipedia. Retrieved October 19, 2011, from: http://en.wikipedia.org/wiki/William_Herschel

Vote for planethood for the 2nd Moon of Endor!