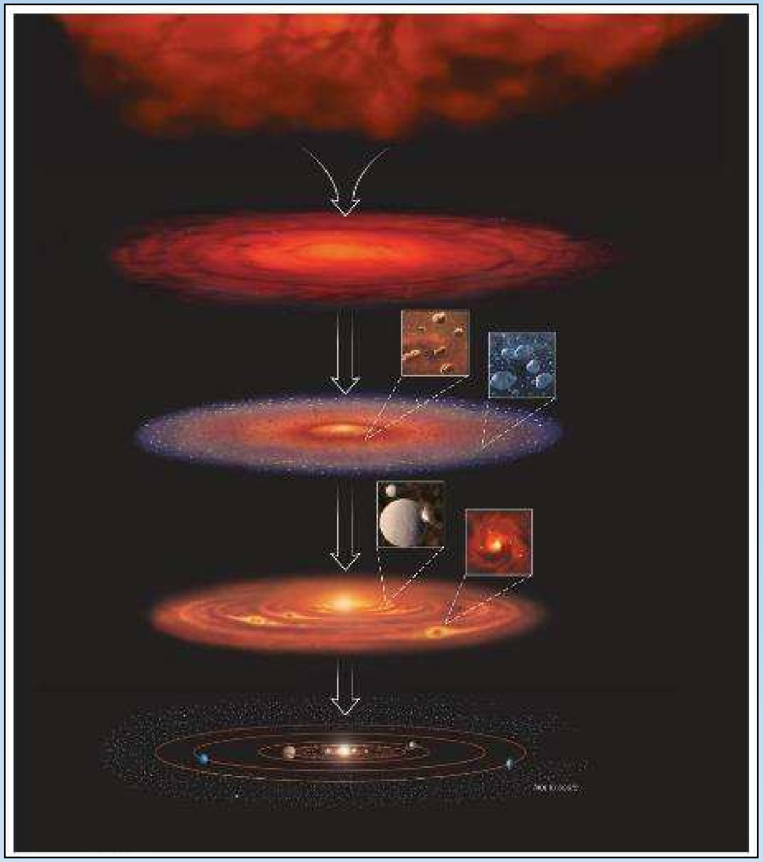
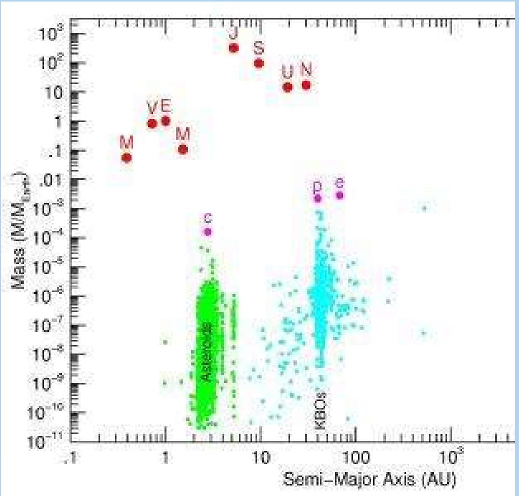
Bell Ringer

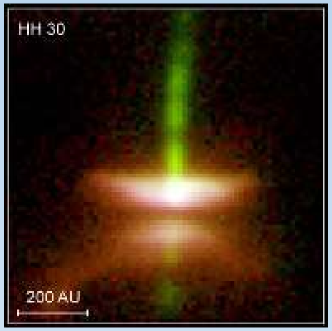
1. What is the order of the planets?
2. What objects can be considered to be part of our star system?
3. What do stars form from?

PRESENTATIONS

UNIT 2 – SOLAR SYSTEM
Overview of the Solar System





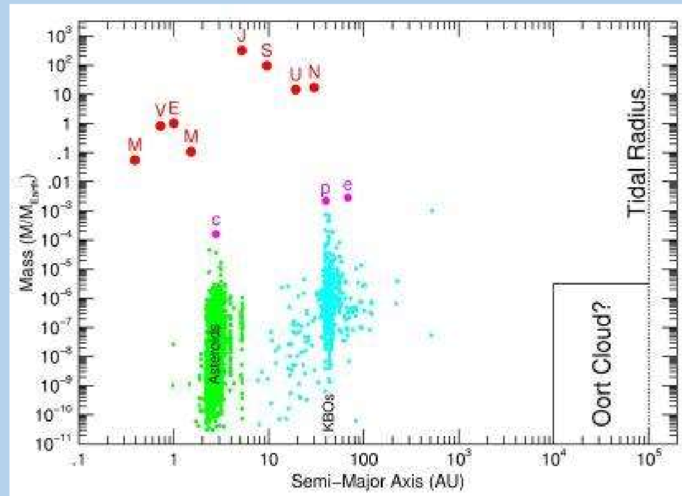


Key Points for Today

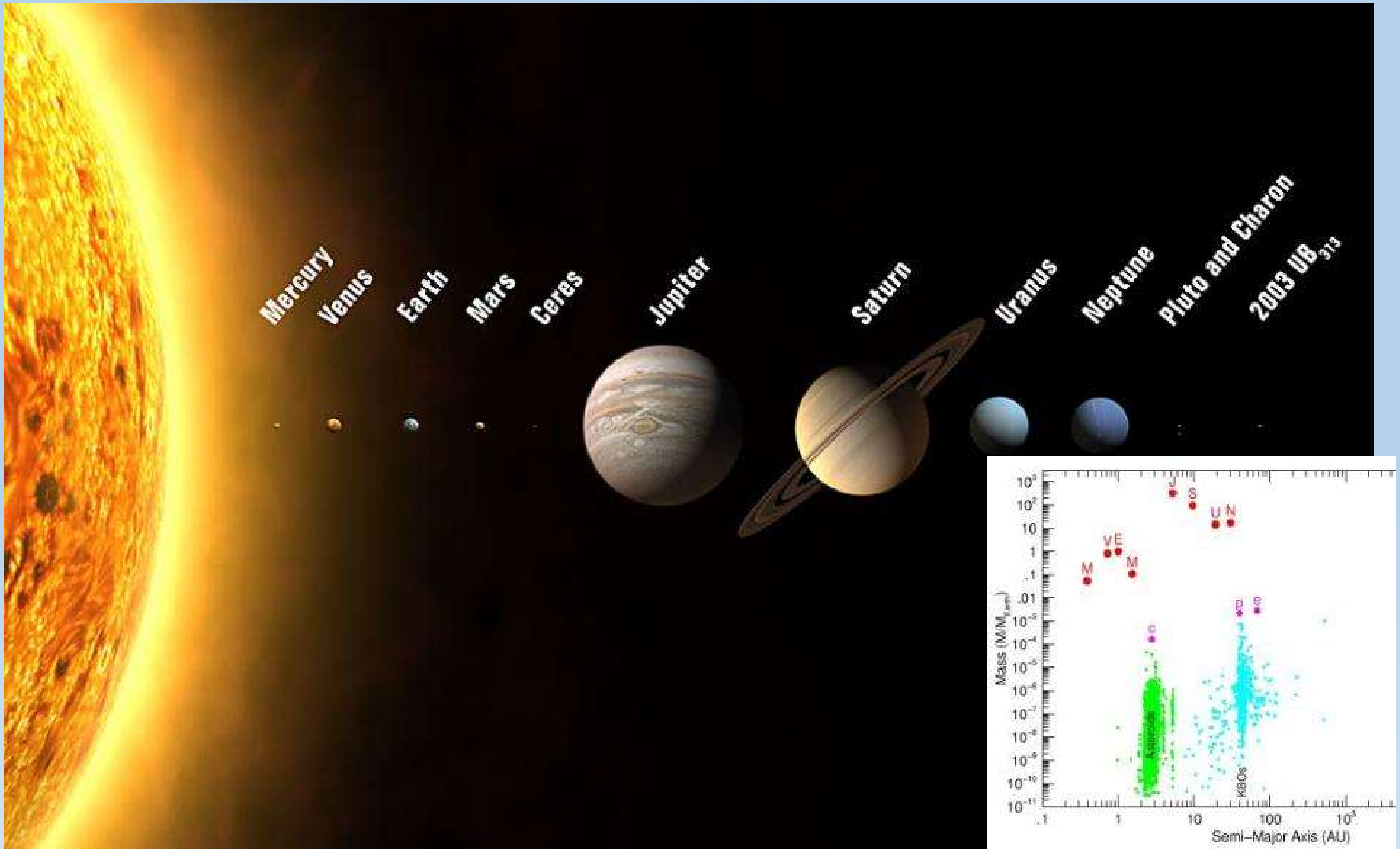
1. Four categories that the Solar System is broken up into.
2. Properties of the two main groups of planets.
3. Our current theory as to how the Solar System formed.
4. There’s a reason outer planets are bigger than inner planets.

Categorizing the Solar System

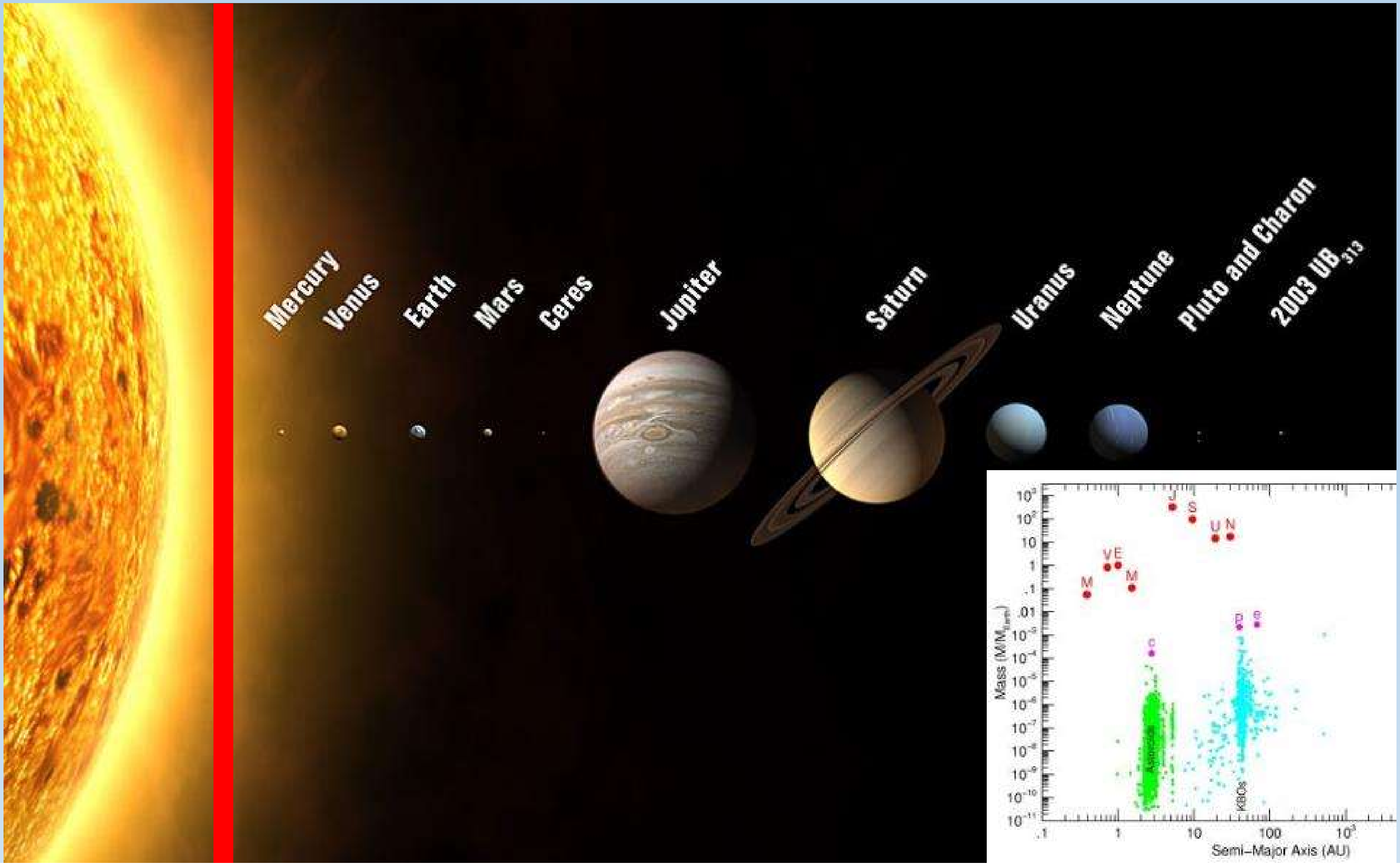
- Planets
  - Terrestrial
  - Jovian
    - Gas Giants/Ice Giants
- Dwarf Planets
- Planetesimals:
  - Asteroids
  - Comets
  - Kuiper Belt Objects (KBOs)



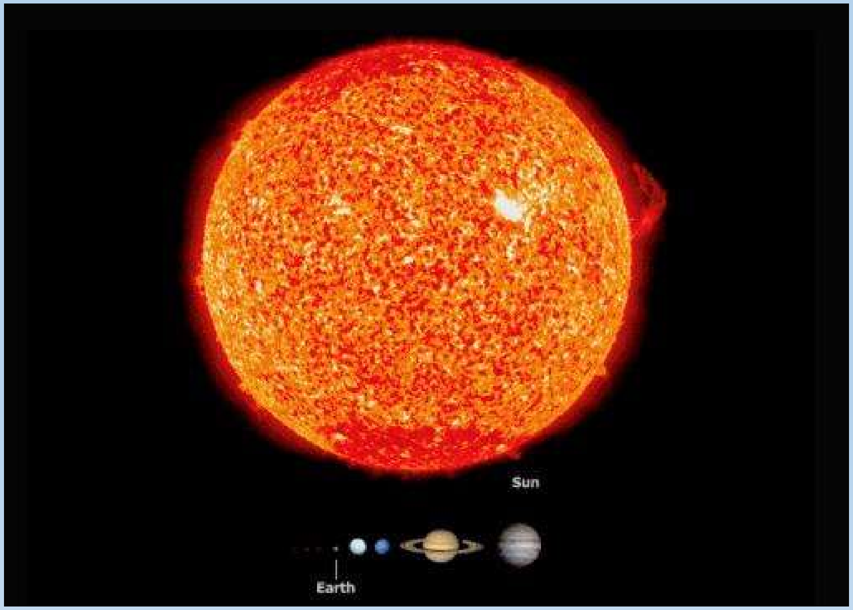
Some of the Major objects in our Solar System



Where would you draw lines to classify the different objects?

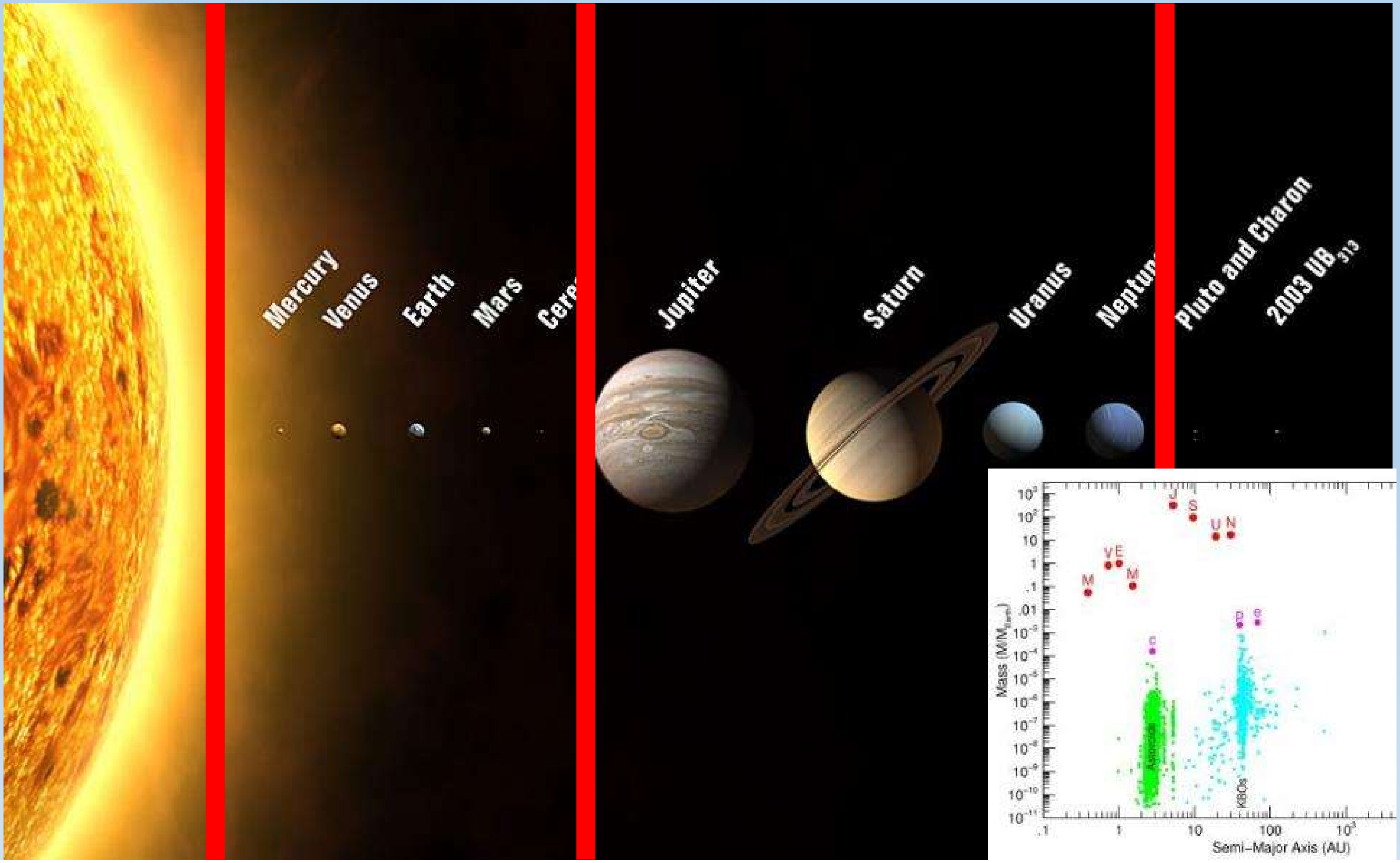


The Sun is the Largest Object in the Solar System

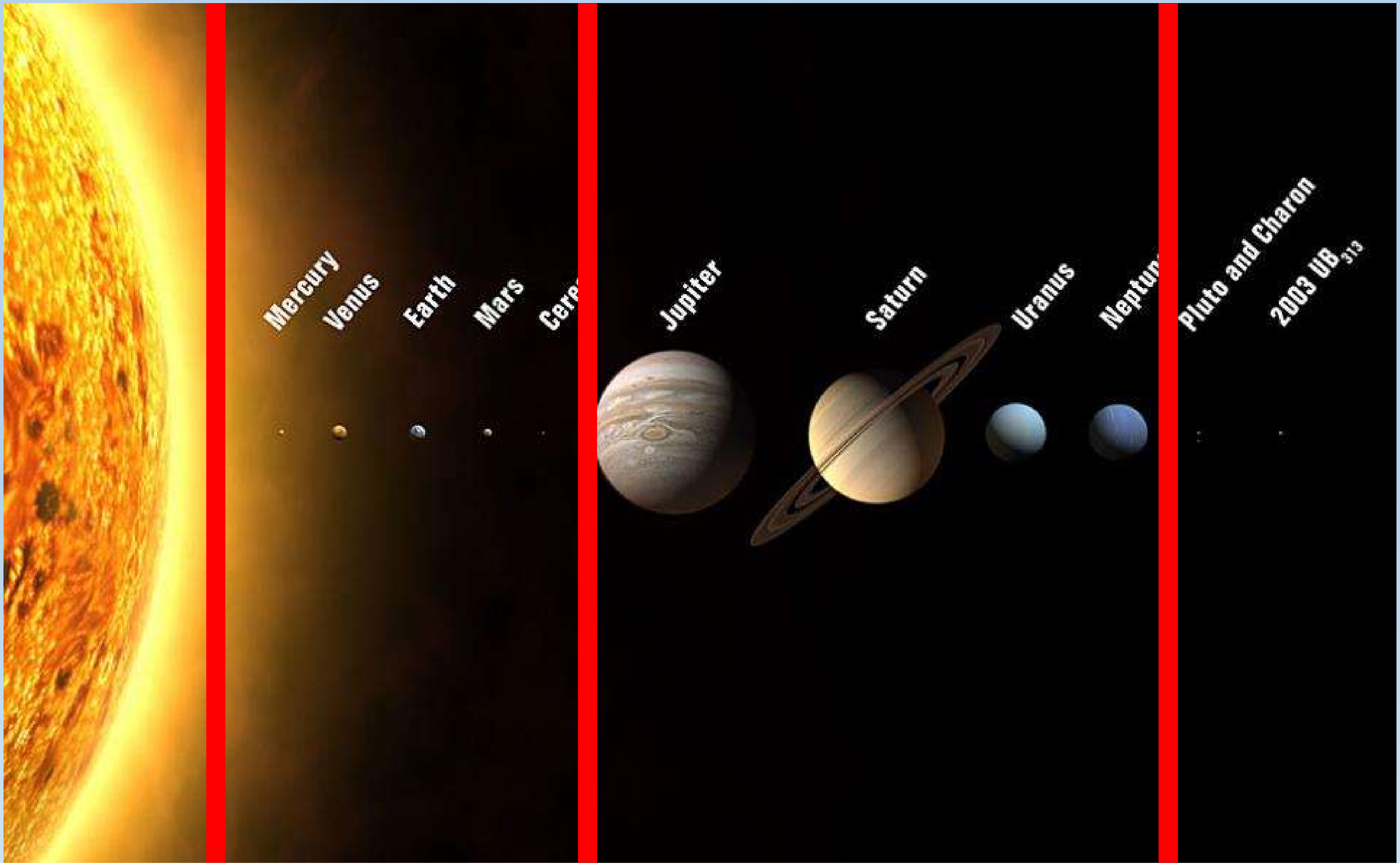


- The Sun contains more than 99.85% of the total mass of the solar system
  - Remaining mass is in a flat disk, with Jupiter being the next most massive object
- If you took *all* the other material in the solar system, it would not fill up the volume of the Sun
- Define the Solar System as containing every object whose motion is determined by the gravitational influence of the Sun

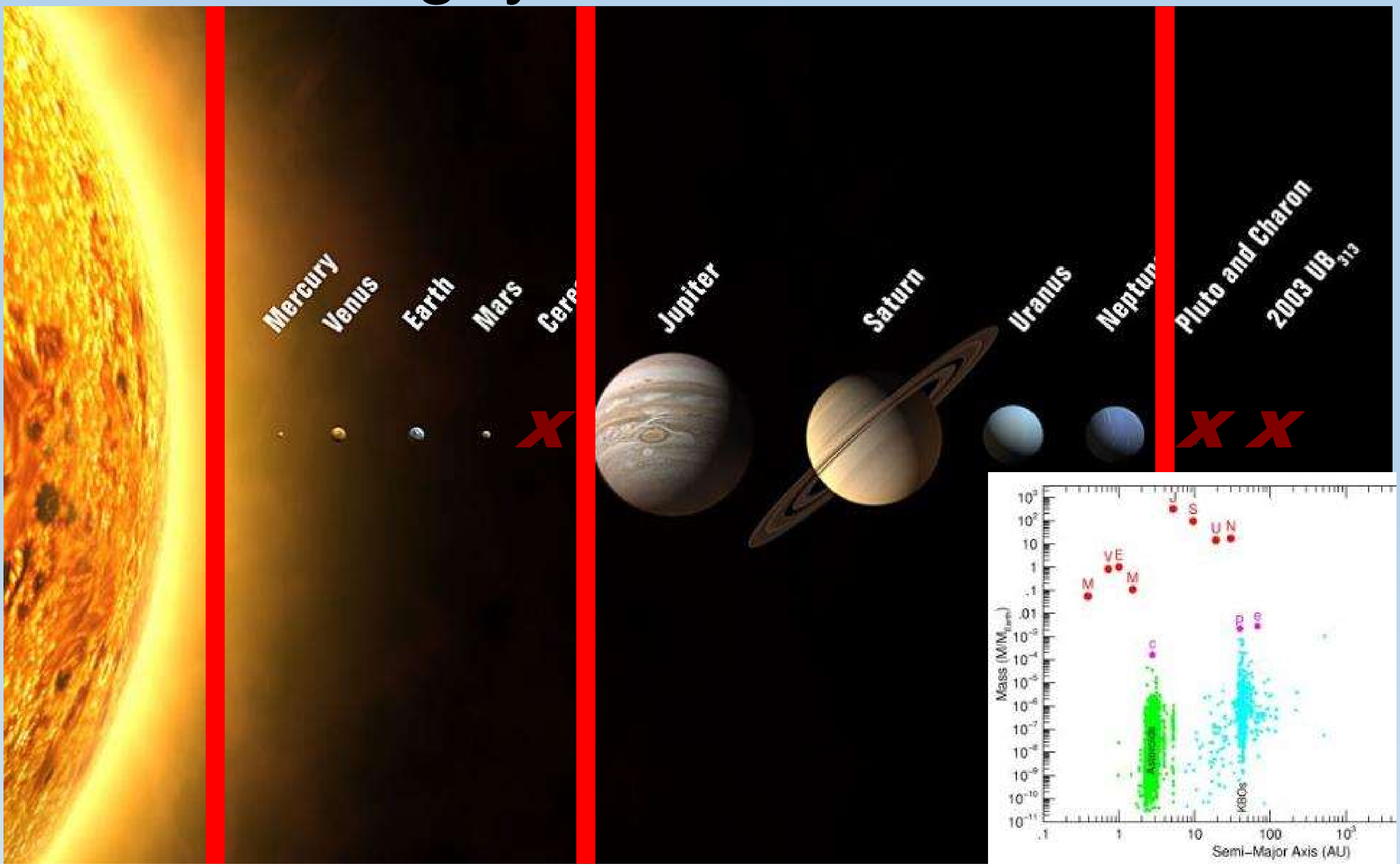
Where would you draw the next lines?



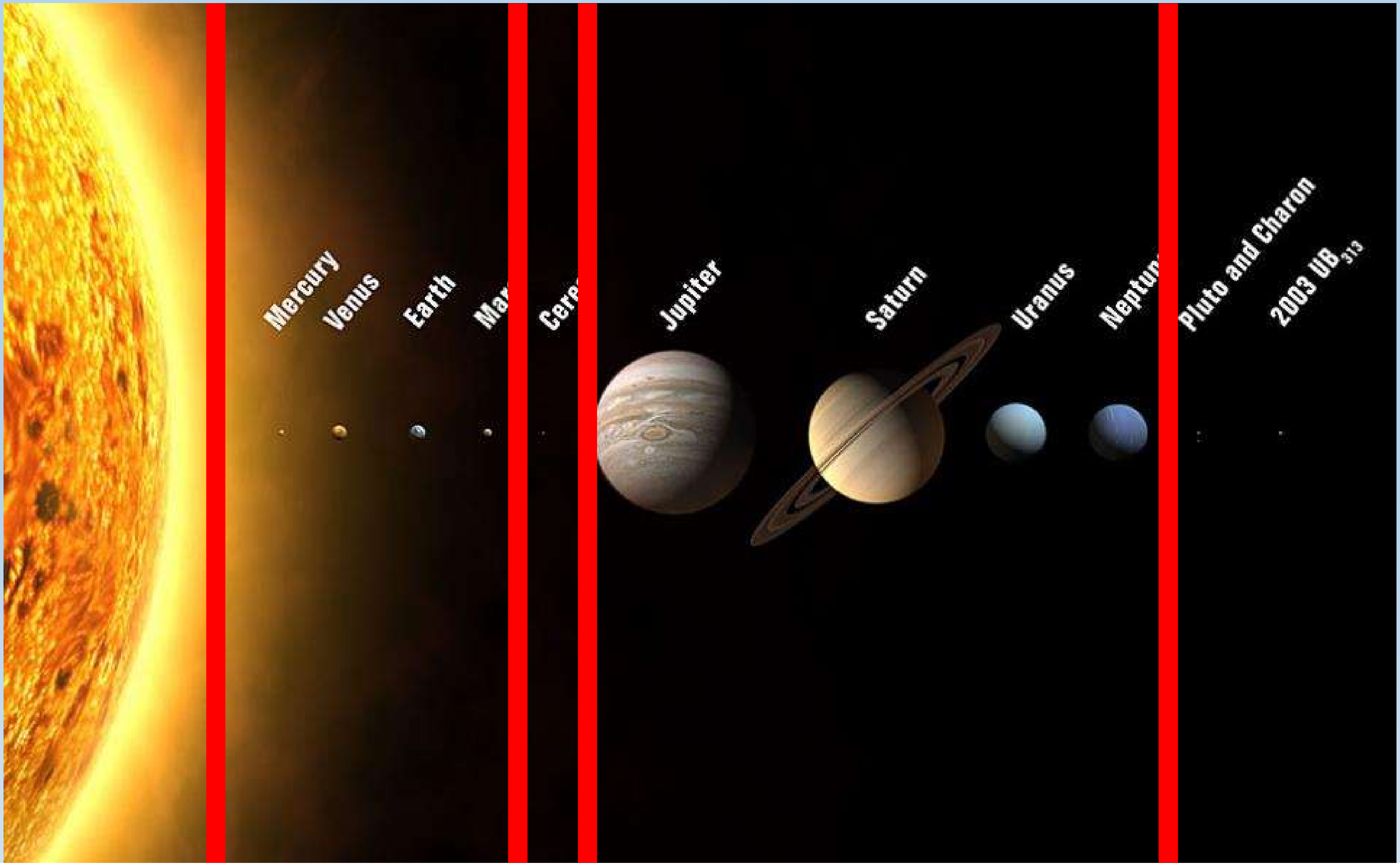
But do we call them all planets?



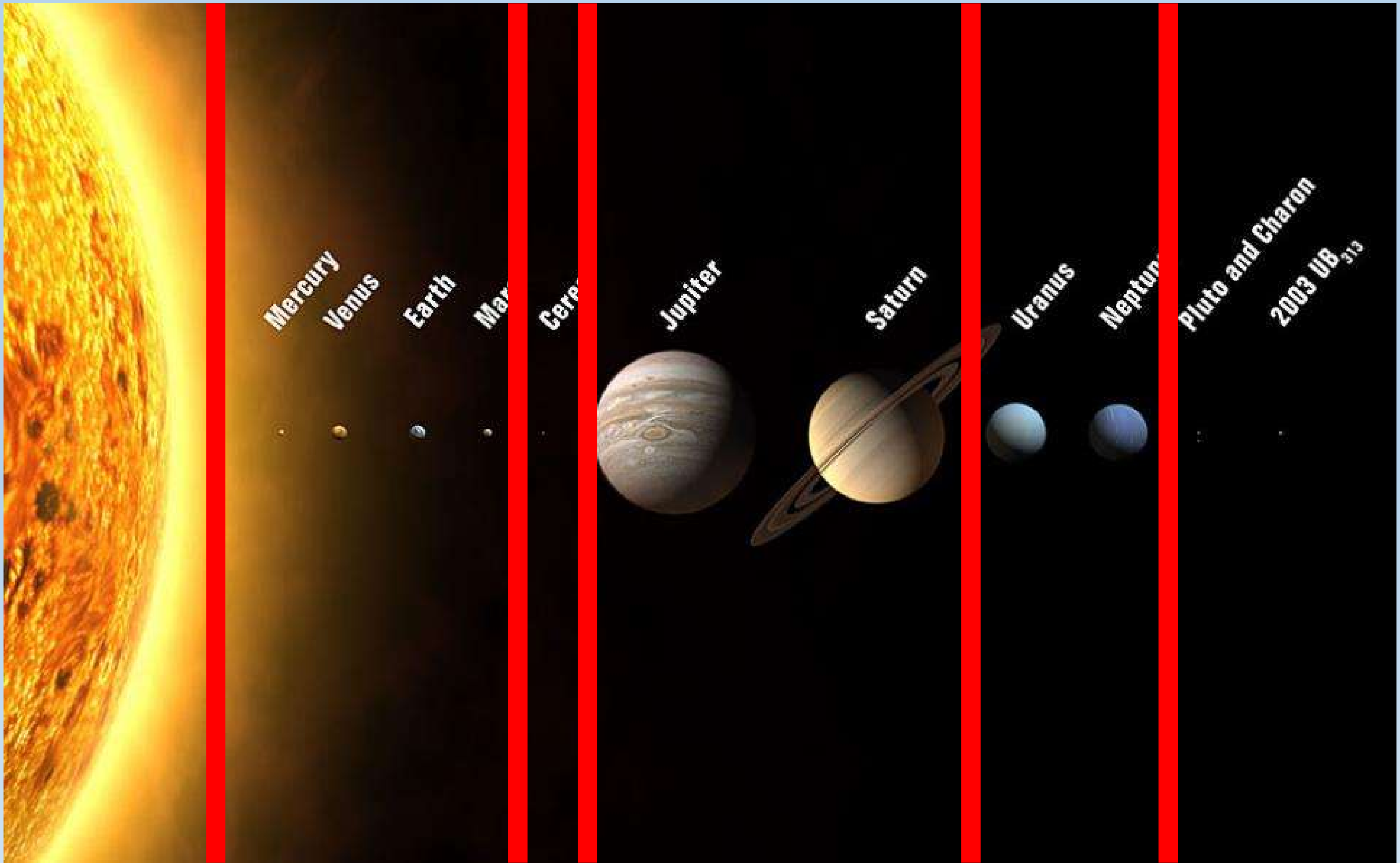
Terrestrial and Jovian Planets
- No little guys



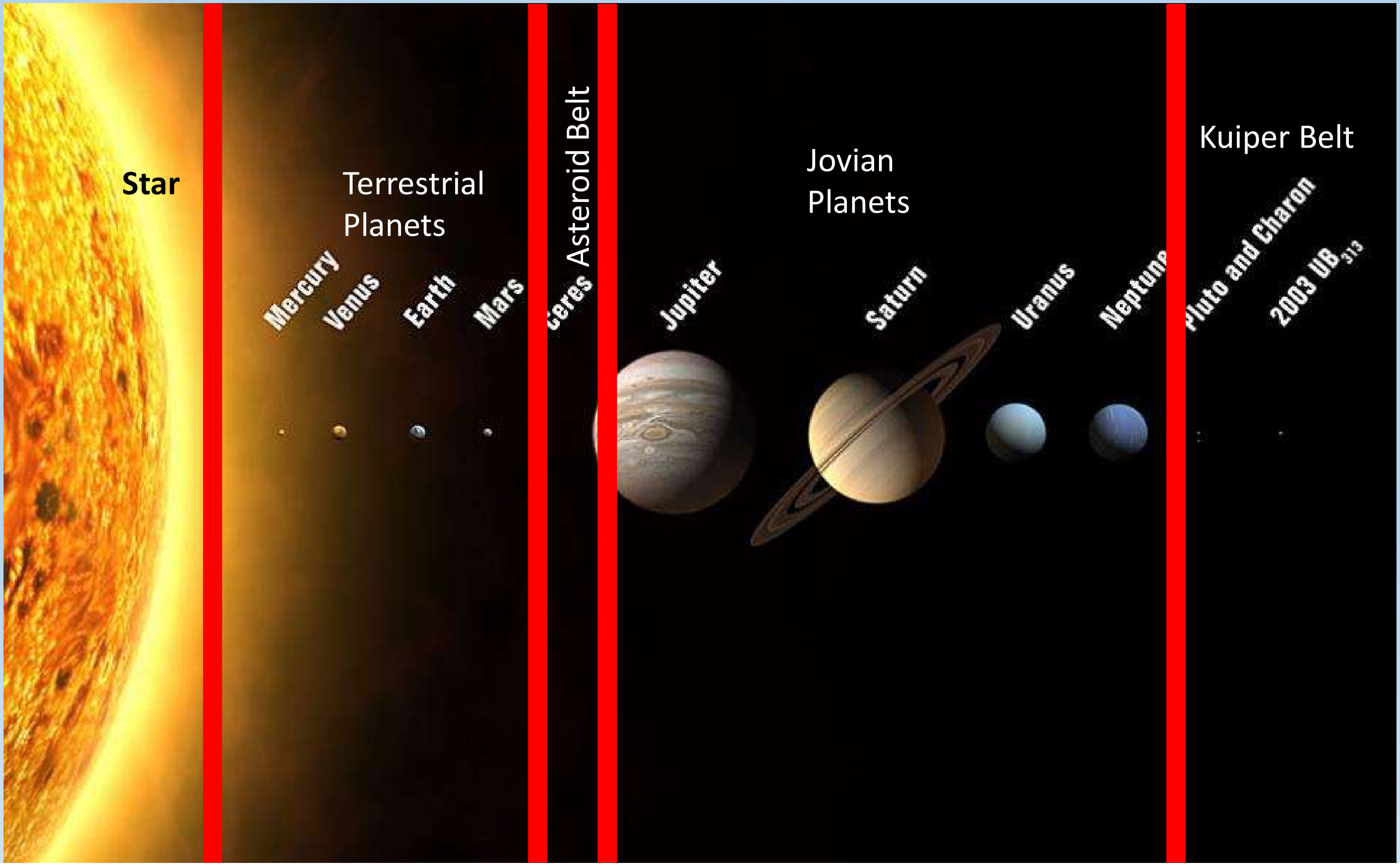
Final Break Down



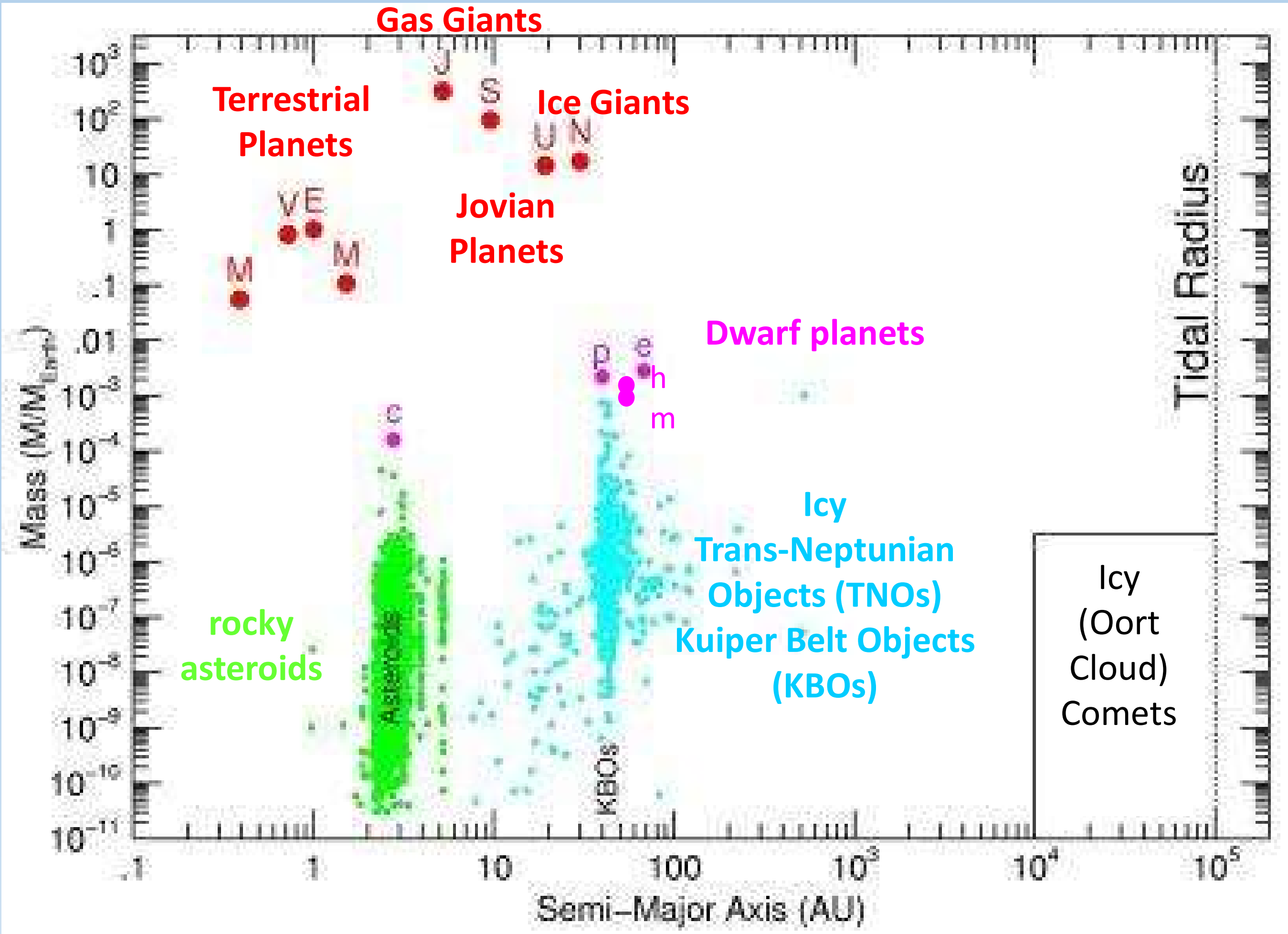
Could even take it one step further



Classification of all the nearest objects in the Solar System (sizes to scale)



Categorizing the Solar System



Let’s investigate planetary properties:

- Object Radius
- Orbital Period (Time it takes to go around the Sun)
- Density
- Rotational Period (Time it takes to spin around once – day length)
- Number of moons
- Distance from Sun

Terrestrial vs. Jovian

- Small
- High density = rocky/metallic
- Slow rotators
- Few/no moons and rings
- Distance from Sun < 2 AU
- Solid surface

- Large
- Low density = gaseous/icy
- Fast rotators
- Many moons and some large rings
- Distance from Sun > 5 AU
- No solid surface

(1 AU – Astronomical Unit = Distance between Earth and Sun)

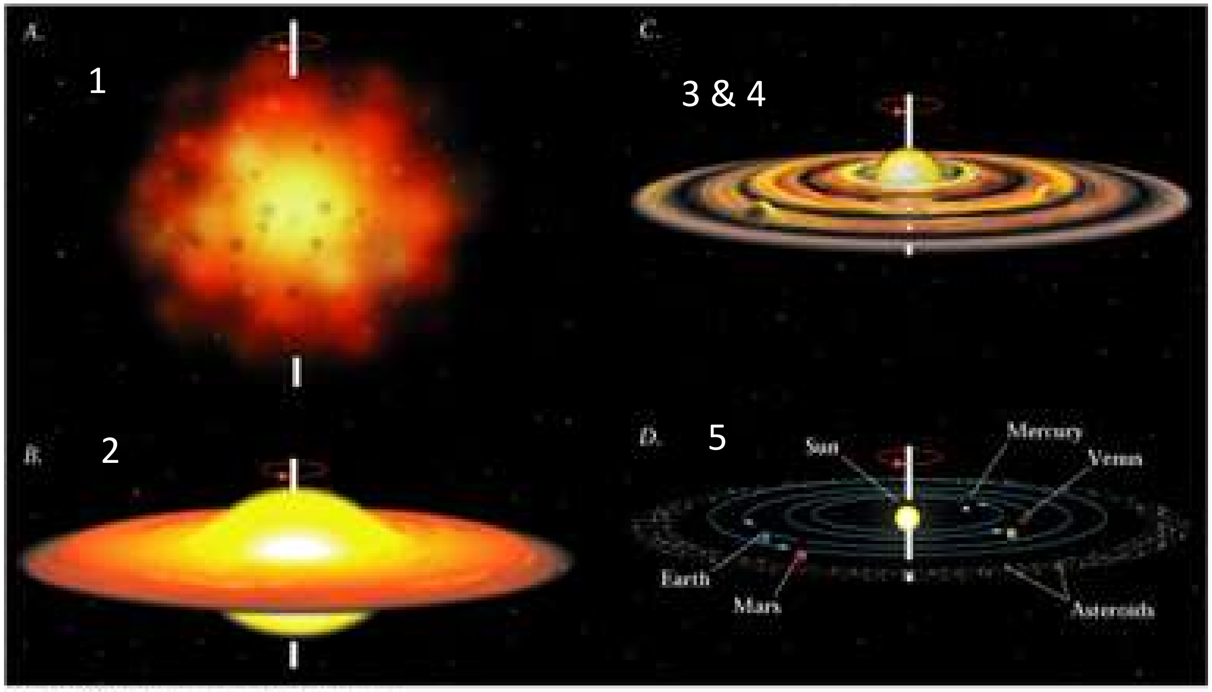
Formation and Evolution of Planetary Systems

- How do planets form?
  - Where does the raw material come from?
  - How is this raw material put together?
- How do planets evolve?
  - How do the interiors, surfaces, and atmospheres change with time?
- There is some overlap between the end of "formation" and the beginning of "evolution"
- Most of the information we have is: *what are planets like now*?

- Today, we're talking just about formation.

Solar Nebula Hypothesis

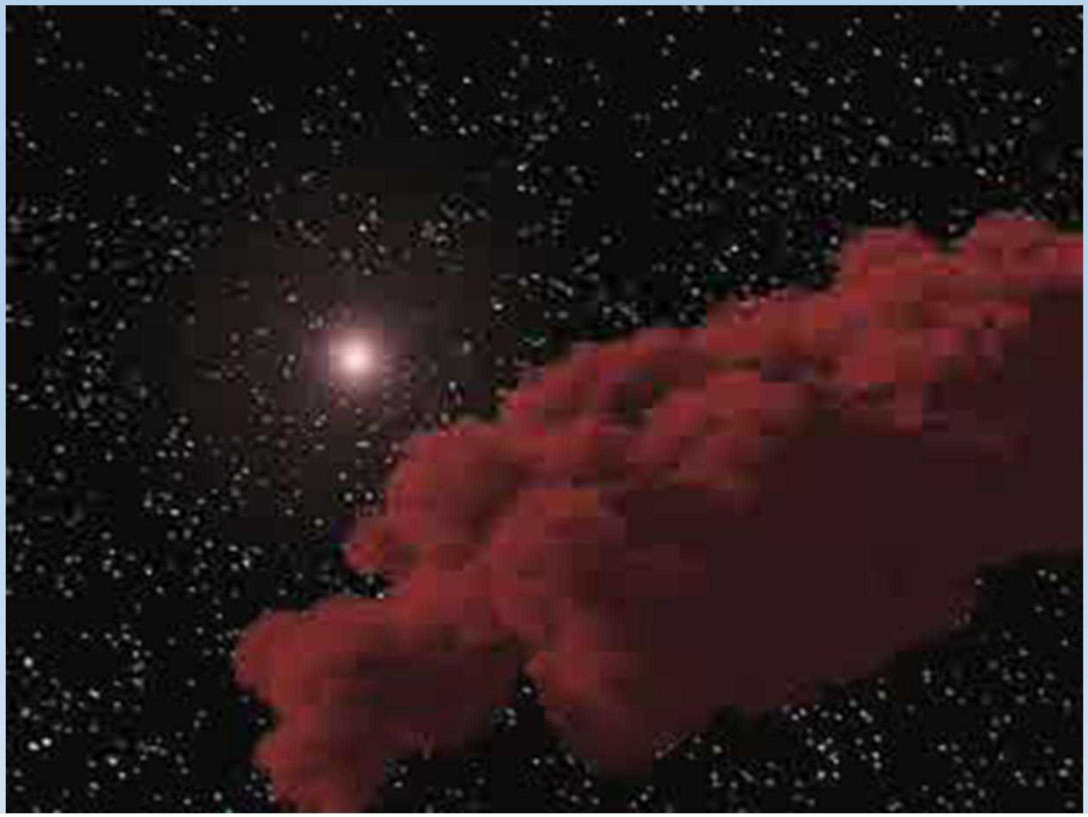
A step by step recipe for making the solar system



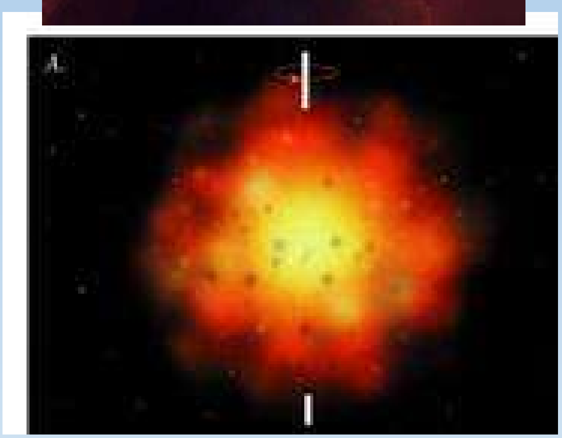
Evidence from Other Gas Clouds

- We can see stars forming in other interstellar gas clouds, lending support to the nebular theory.

1. First need some kind of instability to start the collapse of matter in a giant nebula.

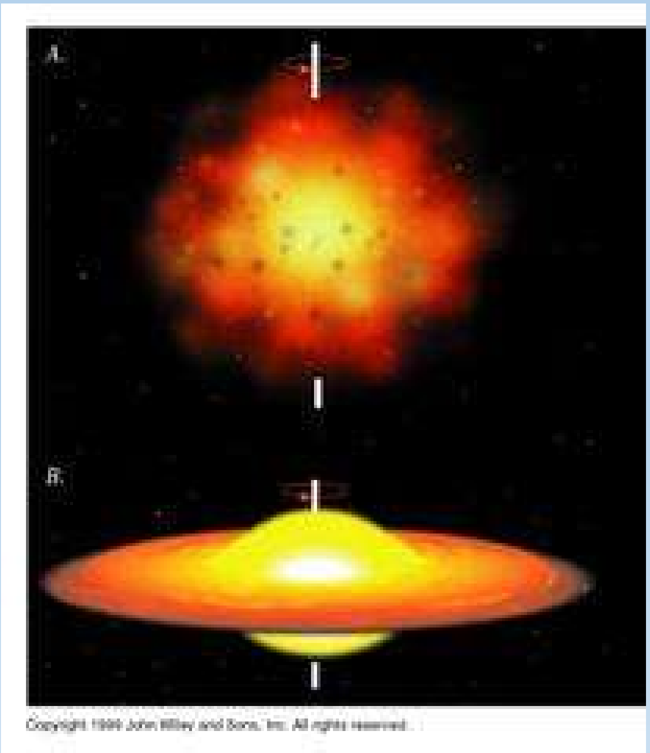


Gas and dust within the nebula begins to collapse



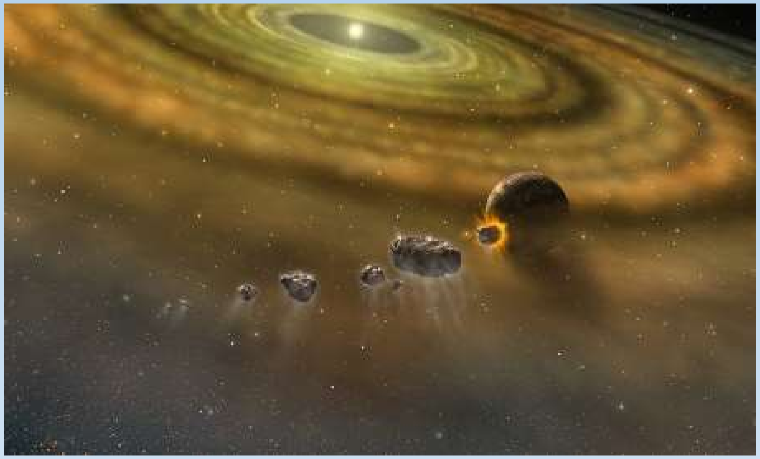
- Clump of gas and dust begins to collapse towards a central point due to its own self-gravity
  - As it falls, it gets faster and faster.
  - As it nears the center, collisions turn kinetic energy (motion) into heat (Like when you rub your hands together).
  - Center of the nebula begins to get very hot

2. <u>Protoplanetary Disk</u> develops and a <u>Protostar</u> forms



- Clump of gas and dust had some preferred direction of rotation before collapse, possibly very slow
  - As it gets smaller, it begins to speed up as well.

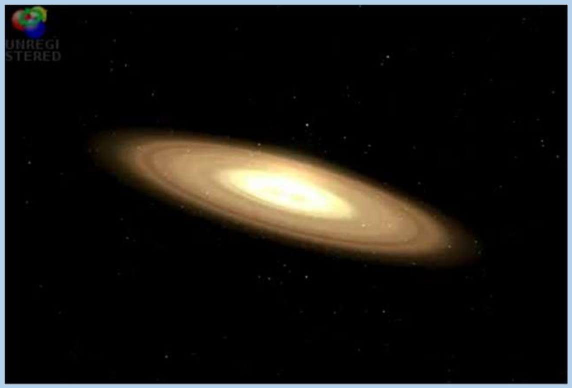
Step 3 – Planets form in the Disk through **<u>accretion</u>**



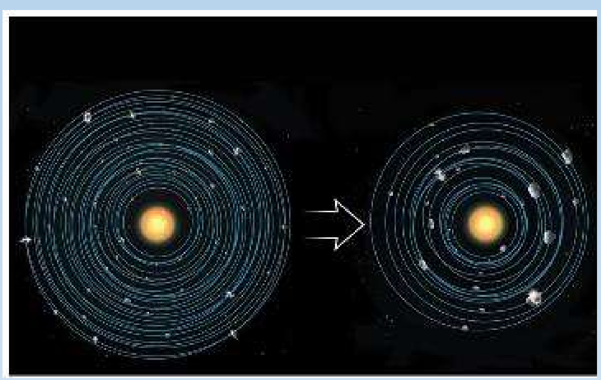
- Most of the material from the collapse falls into the protosun, but other material in the disk is moving so fast that it doesn't fall in right away.

- Gives enough time for small solid grains within the disk to collide and stick together, or **<u>accrete</u>** to begin forming <u>planetesimals</u>

4. Planetesimals grow larger in size (~ 1 km) to become protoplanets

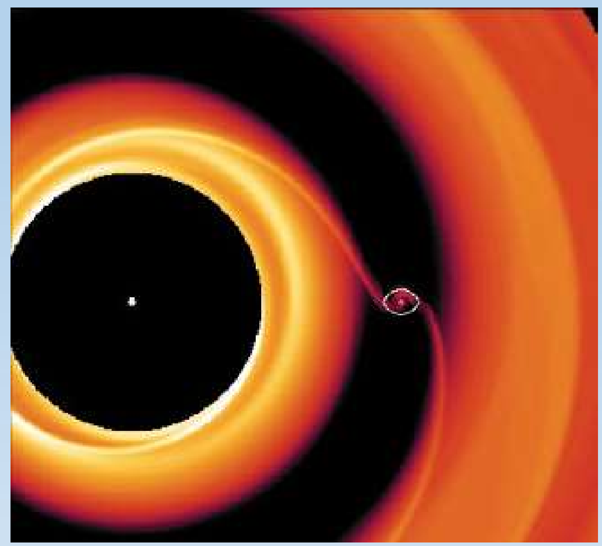


- The process of gradual accretion into larger and larger bodies is called the **core accretion hypothesis** of planet formation
- Planetesimals continue to grow by accretion until they become protoplanets.

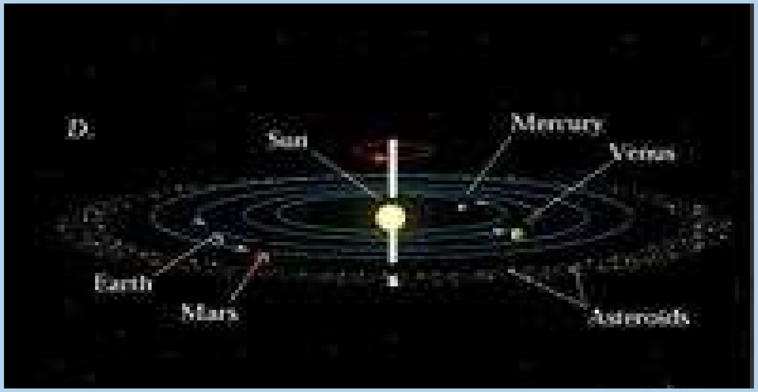


Late-Stage Accretion

- Once each protoplanet has swept up debris out of the area where its gravity dominates that of the Sun, accretion slows down drastically.
- Collisions now only occur because of crossing paths between these protoplanets, timescale of millions of yrs.
- These collisions are *big* and can change the physical properties of the planet (Earth is an example of this).



Step 5 – Protoplanets collide, some destroyed, left with planets

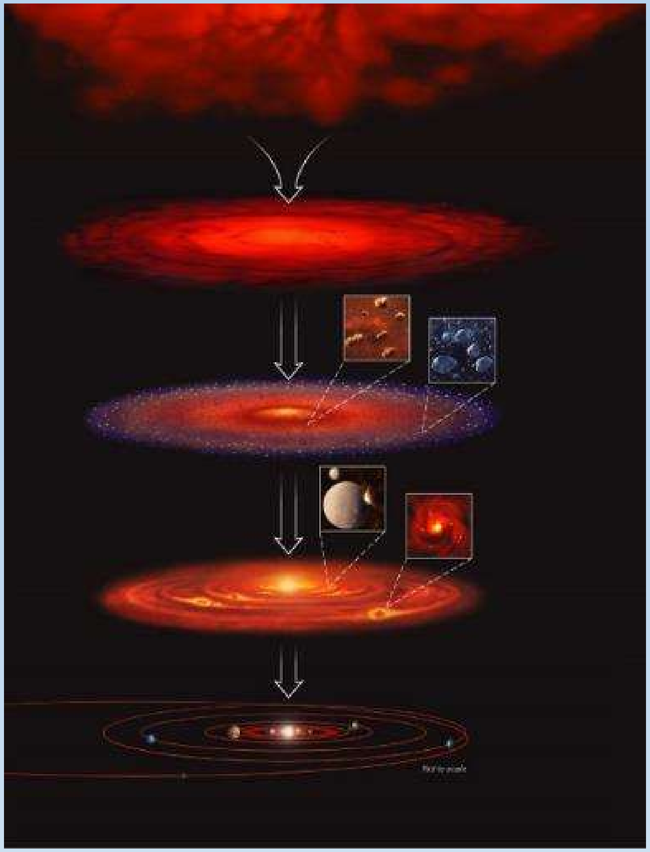


- Protoplanets will interact and collide with other protoplanets and nearby planetesimals until just one protoplanet is left dominating its orbit

- If a planet does not form, still possible to have small planetesimals and protoplanet sized objects today in the solar system
  - Asteroids, Kuiper Belt Objects

- In our solar system we were left with
  - 8 planets controlling their orbits
  - Leftover planetesimal and protoplanet debris in orbits without planets
    - Asteroid belt, kuiper belt, oort cloud
  - All planets orbiting in the same direction, in the same plane

Are we done?



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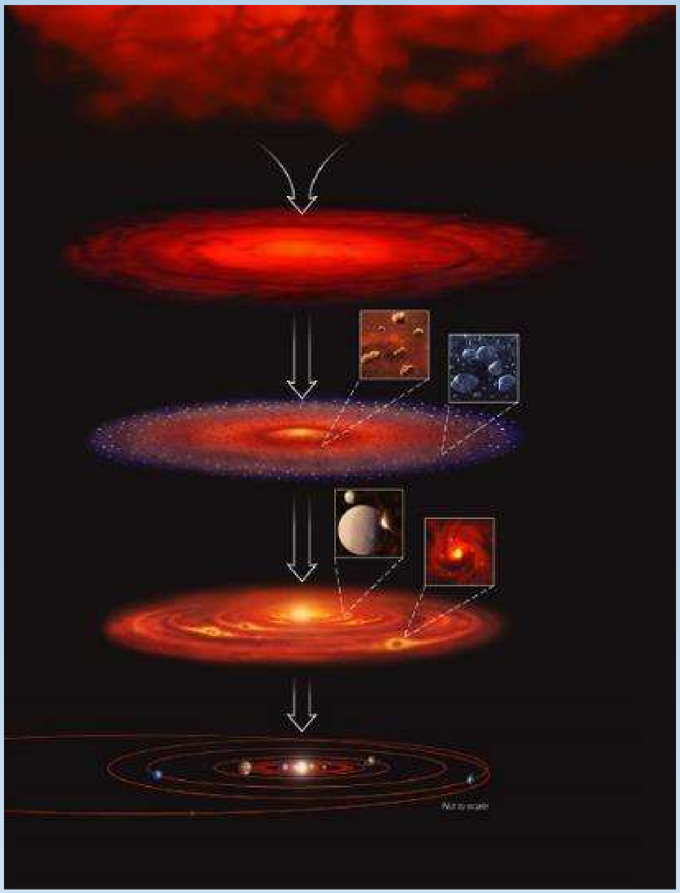
    - Asteroid belt, Kuiper belt, Oort cloud
  - All planets orbiting in the same direction, in the same plane
- <u>But why are outer planets larger</u>?

Difference in planet size and composition is due to the temperature in the disk:



Close to the Sun = HOT

- Only rocks and metals can form solids
- Not enough material to make big planets

Farther away = COLD

- Ices like water (H_2O), ammonia (NH_3), and methane (CH_4) can also form solids
- In addition still have metal and rocks to work with
- Much more solid material to make big planets!

- Bigger solid planets can attract more gas.

Moons are Similar

- Moons and rings form in a similar way in a disk around their planets
- Show some similar properties
  - Galilean moons (Biggest four around Jupiter) have rocky on the inside and icy on the outside

Group Project:
Research an planet in the Solar System

No smaller than 3. No larger than 6.