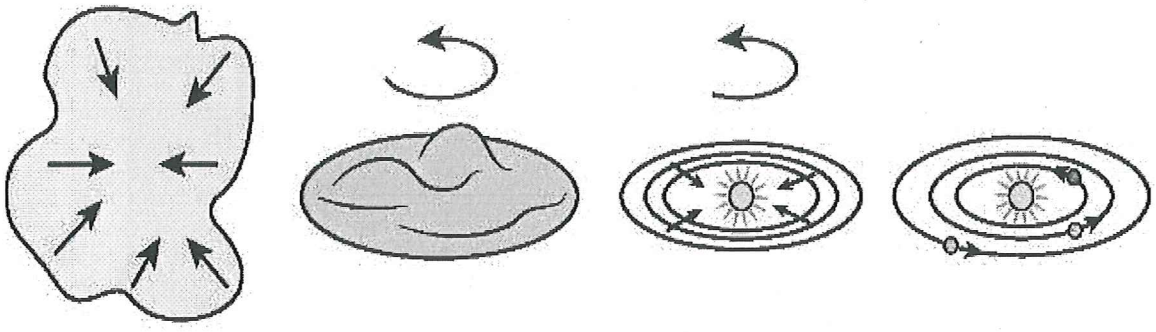
INST 2403 Activity

Formation of the Solar System

According to the *nebular hypothesis*, the solar system formed from a primordial gas and dust cloud. A schematic sketch of the process is as follows.



(a) (b) (c) (d)

1. Describe the different stages of the formation of the solar system.

a) Contracting gas cloud

b) Gas cloud starts rotating, flattens into a disk.

c) Most material ends up at the center, while planets form in orbits around central mass d) The final product, all planets rotate in the same sense around sun.

2. Which of the features of our solar system are explained by this theory? Name and explain at least three.

i) All planets rotate around the sun in the same sense due to the initial rotation of the gas cloud.

ii) The sun is by far the most massive object in the solar system.

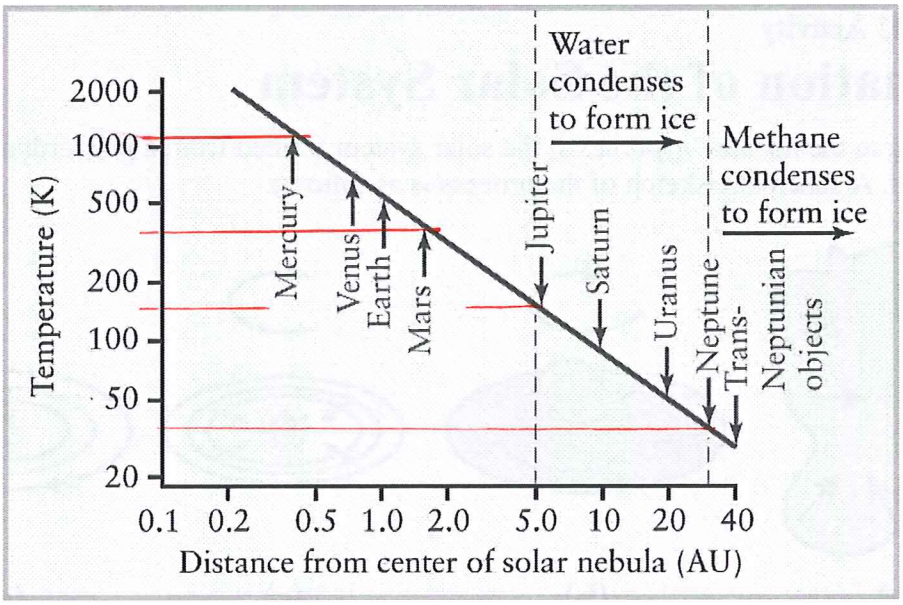
iii) The solar system is a disk, not a sphere due to the flattening caused by rotation

↓ b/c it is at the center, where most stuff naturally ends up going.

Assessing the content of the solar system, we found the following patterns:

a. The sun is 10 times bigger than the Jovian planets, which are 10 times bigger than the terrestrial planets
b. The sun and the Jovians have densities (mass per volume) that is only one third of the density of most of the terrestrial planets.

How can we explain these patterns? The crucial input can be gleaned from the fact that the Jovians are much farther from the sun. Indeed there is a large gap between the outmost terrestrial planet (Mars) and the innermost Jovian (Jupiter). To understand how this impacts the formation of planets, we look at the temperature distribution in the early solar system. Note that the temperatures at formation where much higher than they are today. Keep in mind that water freezes at 273K, and water boils at 373K.



3. What was the temperature range at the location of the terrestrial planets?

400 – 1200 K

4. What was the temperature range at the location of the Jovian planets?

40 – 150 K

At low temperatures light materials such as hydrogen and helium can condense to form large planets, but when temperatures are too hot (warmer than the freezing point of water), these substances are too volatile to stick together.

5. Develop a consistent theory as to how the formation location of a planet determines its size, mass and density.

Planets close to the sun must be made from "hardy" materials such as metals to be able to withstand the high temperatures. Also, these planets should be smaller than the gas planets, because the latter can "hold on" to much more (fluffy) material.

6. Does this theory save the appearances, i.e. does it explain the features and patterns of the solar system? Explain.

Yes, these properties of planets are exactly what we find realized in our solar system in the form of the two major groups of planets.