

The Nebula's Temperature Continues To Change, and The Frost Line Forms

21. As time went by, the nebula's temperature continued to heat up

Why? Gravity continued to compress it.

22. What part of the nebula was the hottest? The center

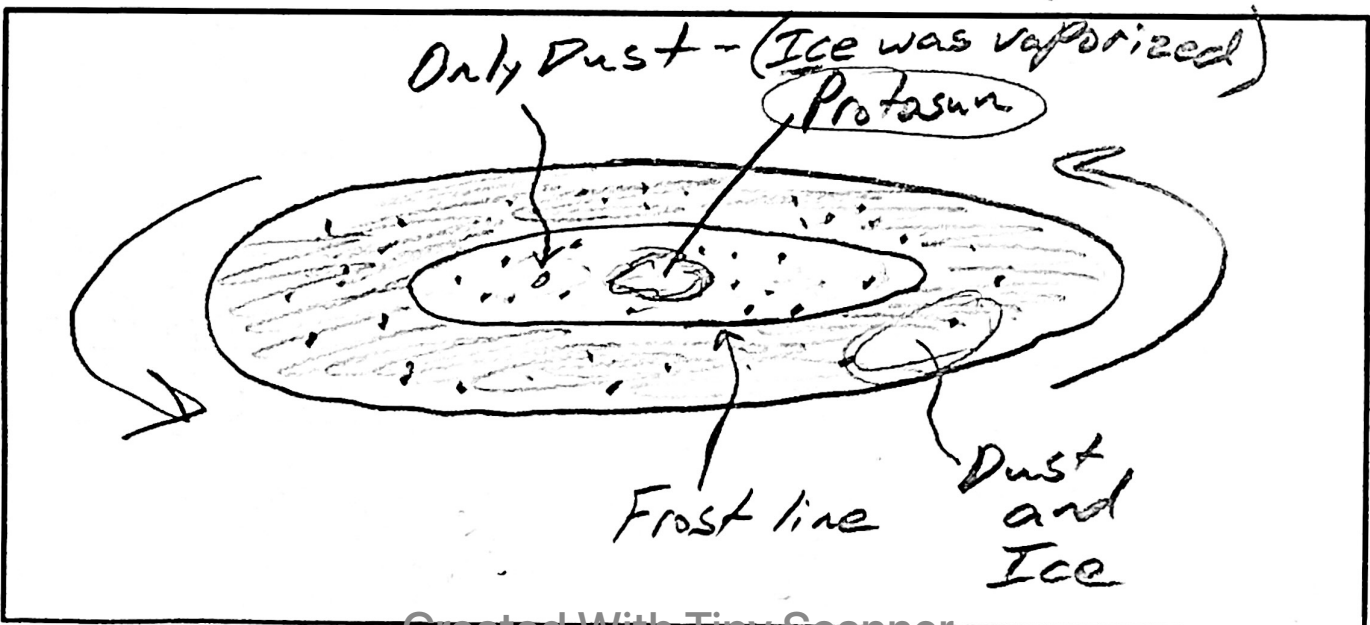
23. Why was this the hottest part of the nebula? The center has the most pressure (like the center of the Earth)

24. The hot center of the forming solar system was called the protosun

25. The nebula had been a rotating disk of ice ("frozen gas") and dust. As the center heated up, the ice (frozen gases) near the sun were melted and vaporized. This created a boundary called the frost line. Beyond the boundary the "frozen gases" survived as ice, but inside that boundary they were turned to gas.

Drawing #3: The Solar Nebula (Around 4.55 Billion years ago)

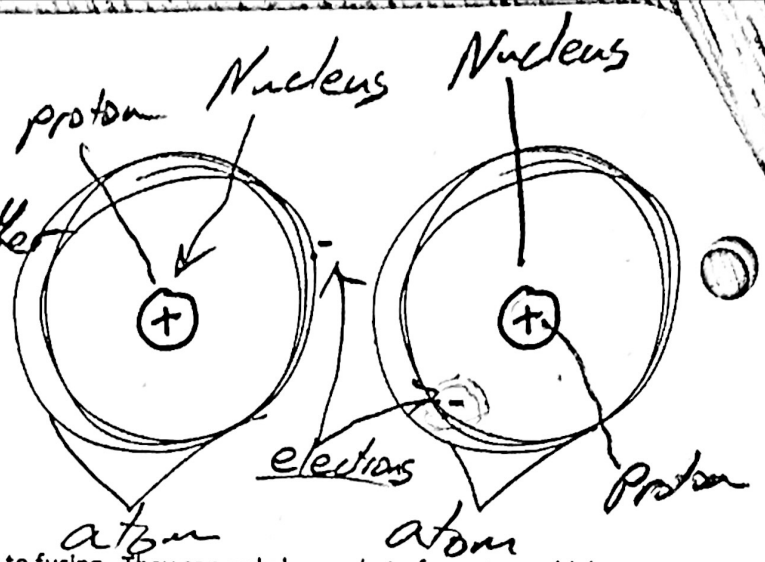
- The ice that was located near the center of the nebula melted and vaporized because The center was the hottest part



26. The Sun's energy comes from nuclear fusion.

a. Define "fuse." *Come together to form one object*

b. Hydrogen atoms are very simple. On the figure to the right, label the atoms, protons, electrons, and the nucleus (center) of each atom.



c. Nuclei (plural of nucleus) are very resistant to fusing. They can only be made to fuse at very high temperatures.

- o Why do the nuclei of hydrogen atoms resist fusing?

They are both positive, so they repel each other.

- o How can very high temperatures make nuclei fuse?

When atoms move fast enough, they can collide with enough force to overcome the repulsion.

d. The Sun was born when the protosun became so hot that hydrogen atoms moved

fast enough to hit one another and fuse. Once this

process began, it heated up the protosun even more, so the

nuclear fusion happened even faster. This was the birth of the Sun.

e. In the Sun, what is the main element that fuses, and what gets created when it fuses?

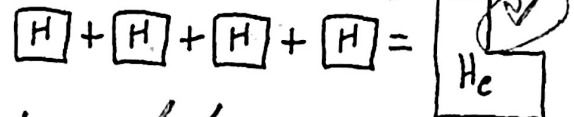
Hydrogen

Helium

27. Why does fusion of Hydrogen into Helium produce so much energy?

a. Explain how this graphic explains the production of energy by nuclear fusion. [FYI, the diagram is exaggerated.]

When hydrogen fuses mass gets "lost" and turned to energy



b. Use Einstein's famous formula to explain how to calculate the energy that gets produced when Hydrogen fuses into helium.

mass lost during fusion

$$E = mc^2$$

↑ Energy Produced

c = speed of light (a big number!!)

Initial Clumping To Form Planets

28. In the earliest stages (when the planets were just tiny clumps of dust and ice), what force caused the dust and ice in the solar system to clump together?

Static Electricity

29. You can demonstrate this force by rubbing a balloon on your hair. When you do that, the balloon takes

electrons from your hair. This gives the balloon a negative charge and

gives your hair a positive charge. The balloon sticks to your hair because

opposite charges attract. In the nebula, dust particles had opposite

charges because, when they bumped into one another, some particles gained

electrons (making them negative), while the other particles lost electrons (making them positive).

[Electrical charges can also repel one another, and that is why it is so difficult to cause to positive hydrogen nuclei to fuse with one another.]

Continued Growth and Orbiting of Planets

30. Once the planets reached a sized that was about 1/2 mile across, their

gravity was strong enough to quickly pull in other clumps.

31. Inside the frost line, the planets that formed were rocky, because

there was no gas. The frozen gas was melted and vaporized

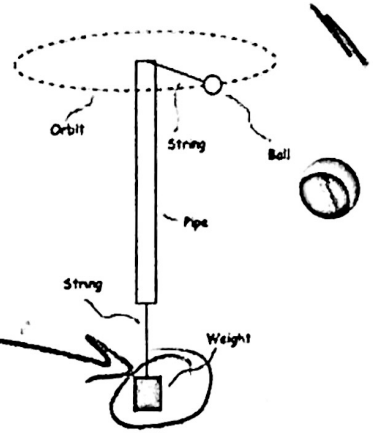
32. Beyond the frost line, the planets that formed were gas giants, because

ice containing hydrogen and helium survived and clumped together around the dust.

33.

Today we have a solar system of planets that orbit the sun in relatively stable orbits. In a stable orbit, two opposing tendencies are in balance.

- The model on the right is similar to our solar system. If the pipe is swirled at just the right speed, the ball and weight will maintain their positions, as shown.



Force of Gravity

- What keeps the ball from flying out into the room?

Weight of this object

- What keeps the ball from being pulled into the pipe?

Momentum

- In our Solar system...

- What prevents the planets from flying away from the Sun?

Gravity

- What prevents the planets from being pulled into the Sun?

Momentum

Drawing #4: 4.5 Billion Years Ago To The Present

- Planets clumped together, first due to the force of static electricity and later due to the force of gravity.
- The inner planets are Rocky because they formed inside the frost line, where only rock and metal survived (ice was vaporized).
- The outer planets are gas giants because they formed outside the frost line, where frozen hydrogen & helium survived.
- Planets are held in stable orbits by gravity, which keeps them from flying away from the sun and Momentum, which keeps them from falling into the Sun.

