Structure of the Solar System
The Effect of Temperature On Different Materials

In order to understand why the solar system is organized in the way we have observed, you will use this simulator to explore how temperature affects the behavior of various materials. You will be able to change between materials by clicking one of the circles under atoms and molecules at the top right corner as seen below. You can also control the temperature of the system the material is contained in by adjusting the knob at the bottom of the screen. Finally, you can observe the temperature in degrees Kelvin next to the thermometer at the top of the screen.

Hypothesis: What do you think explains the pattern of planet density?

Particle models of materials in solid, liquid, and gas state
Using the States of Matter simulator, investigate the behavior of the atoms or molecules materials are made of as they change between solid, liquid, and gas state.

Material	Drawing and written description of particle movement in solid state	Drawing and written description of particle movement in liquid state	Drawing and written description of particle movement in gas state
Argon			
Oxygen			
Water			

Analysis

1. What patterns do you see in your observations of the different materials when they exist in different states? (in solids? In liquids? gases?)

2. What differences do you see when comparing the solid state of each material to other materials? Does this relate to what you observed/learned during the first explore?

Part 2: What might explain the structure of the solar system?

Materials in the Solar Nebula

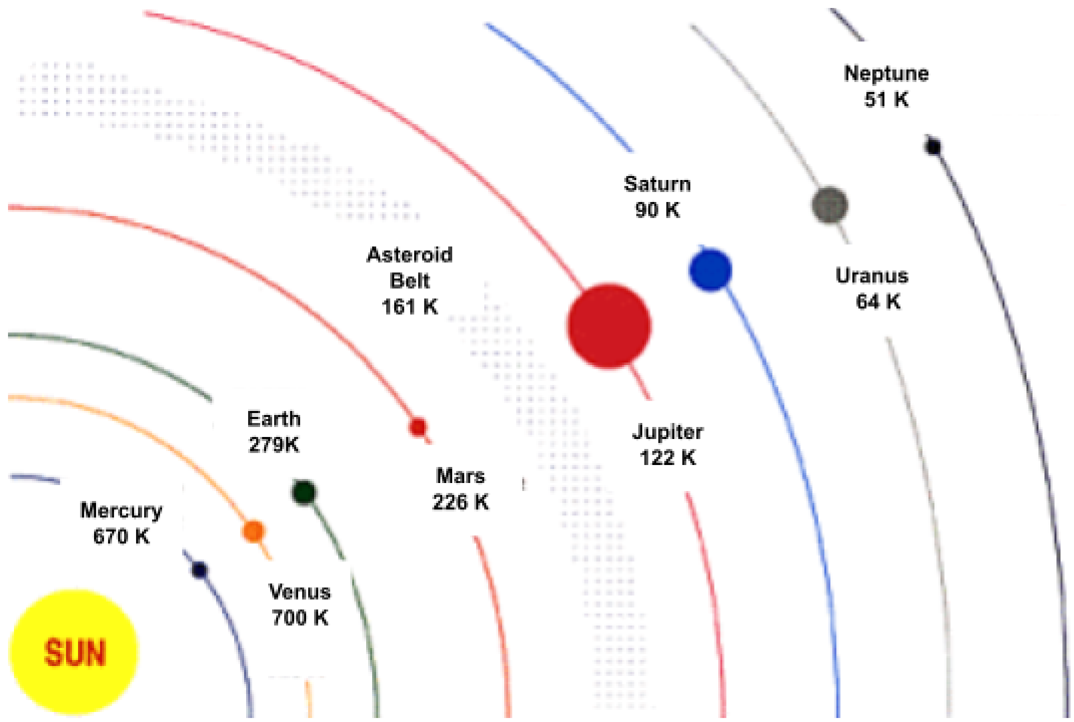
Below is a summary of the four types of materials that existed in the solar nebula. The ranges given for typical condensation temperature are the ranges at which each material begins to condense into solid form, but keep in mind, they can exist in a solid state at temperatures below their respective condensation temperature range.

	Examples	**Solid***	**Liquid***	**Gas***	**Density**
Hydrogen and Helium Gas	Hydrogen, Helium	Below 1K	1 K - 20 K	Above 20 K	0.1 -0.2 g/cm^3 (Gas state)
Hydrogen Compounds	Water (H_2O), Methane (CH_4), Ammonia (NH_3)	Below 90 K	90 K - 160 K	Above 160 K	0.5 -1 g/cm^3 (Solid state)
Rocks	Various minerals	Below 500 K	500 K - 1300 K	Above 1300 K	2.2-3.4 g/cm^3 (solid state)
Metals	Iron, Nickel, Aluminum	Below 1000 K	1000 K -1600 K	Above 1600 K	7.9-8.9 g/cm^3 (solid state)

* Temperatures are an approximation when multiple substances are present

Composition of Planets in the Solar System
Examine the typical temperature range at which each material condenses into a solid and compare those temperature ranges to the temperature where different planets in the solar system exist.

For each of the four material above, label on the diagram above where each material would be a solid, liquid, and a gas



1. What materials do you think the four planets closest to the Sun are composed of? **Be sure to explain your thinking by citing evidence and connecting it to your response.**

Claim	**Evidence**	**Reasoning** How does the evidence support your claim?

2. What materials do you think the four planets farthest from the Sun are composed of? **Be sure to explain your thinking by citing evidence and connecting it to your response.**

Claim	Evidence	**Reasoning** How does the evidence support your claim?

3. Were the densities of the four planets closest to the sun high or low? Does this match with the materials above you said the planets were composed of? **Be sure to explain your thinking by citing evidence and connecting it to your response.**

4. Were the densities of the four planets farthest from the sun high or low? Does this match with the materials above you said the planets were composed of? **Be sure to explain your thinking by citing evidence and connecting it to your response.**

Part 3: Atmospheres in the Solar System

What is the Earth's atmosphere?
The Earth's atmosphere is a thin layer of gasses that surrounds the Earth. It seals the planet and protects us from the vacuum of space. It protects us from electromagnetic radiation given off by the Sun and small objects flying through space such as meteoroids.

Atmospheres in the solar system
Here on Earth, we tend to take our atmosphere for granted, and not without reason. Our atmosphere has a lovely mix of 78% nitrogen and 21% oxygen with trace amounts of water vapor, carbon dioxide and other gaseous molecules. In short, our atmosphere is plentiful and life-sustaining. But what about the other planets of the Solar System? How do they stack up in terms of atmospheric composition? We know for a fact that they are not breathable by humans and cannot support life. But just what is the difference between these balls of rock and gas and our own?

Our next-door neighbor, Venus, has a thick carbon-dioxide atmosphere with no oxygen, but with sulfuric acid clouds. Mars also has an atmosphere that is primarily carbon-dioxide, but on Mars, the atmosphere is extremely thin, and prone to high winds. The giant jovian planets Jupiter, Saturn, Uranus, and Neptune have extremely thick atmospheres of hydrogen, helium, methane, and ammonia. In fact, the jovian planets are often called gaseous planets because they are largely composed of their very thick gaseous atmospheres.

Why all this diversity?
The presence of hydrogen and hydrogen-rich molecules in the atmospheres of the outer planets is easy to rationalize. Most of the universe is hydrogen. The only reason hydrogen and helium are rare in the inner solar system is that these light gasses were blown away in the early stages of the solar system via radiation pressure and the solar wind. Planets like Jupiter kept their hydrogen, and, since the hydrogen atom likes to combine with other atoms, you get things like methane, and ammonia.

Escape of an Atmosphere
The thickness of a planet's atmosphere depends on the planet's gravity and the temperature of the atmosphere. A planet with weaker gravity does not have as strong a hold on the molecules that make up its atmosphere as a planet with stronger gravity, so the gas molecules will be more likely to escape the planet's gravity.

If the atmosphere is cool enough, then the gas molecules will not be moving fast enough to escape the planet's gravity. But how strong is ``strong enough'' and how cool is ``cool enough'' to hold onto an atmosphere? To answer that you need to consider the following about a planet:

- its mass and how it affects its gravitational pull on gas molecules
- its temperature and how temperature and affects the energy of gas molecules which may allow them to escape gravity

Text adapted from the following source: http://www2.astro.psu.edu/users/rbc/a1/lec29n.html

How does this article support or conflict with your findings in Part 2? Write a paragraph using evidence and reasoning.