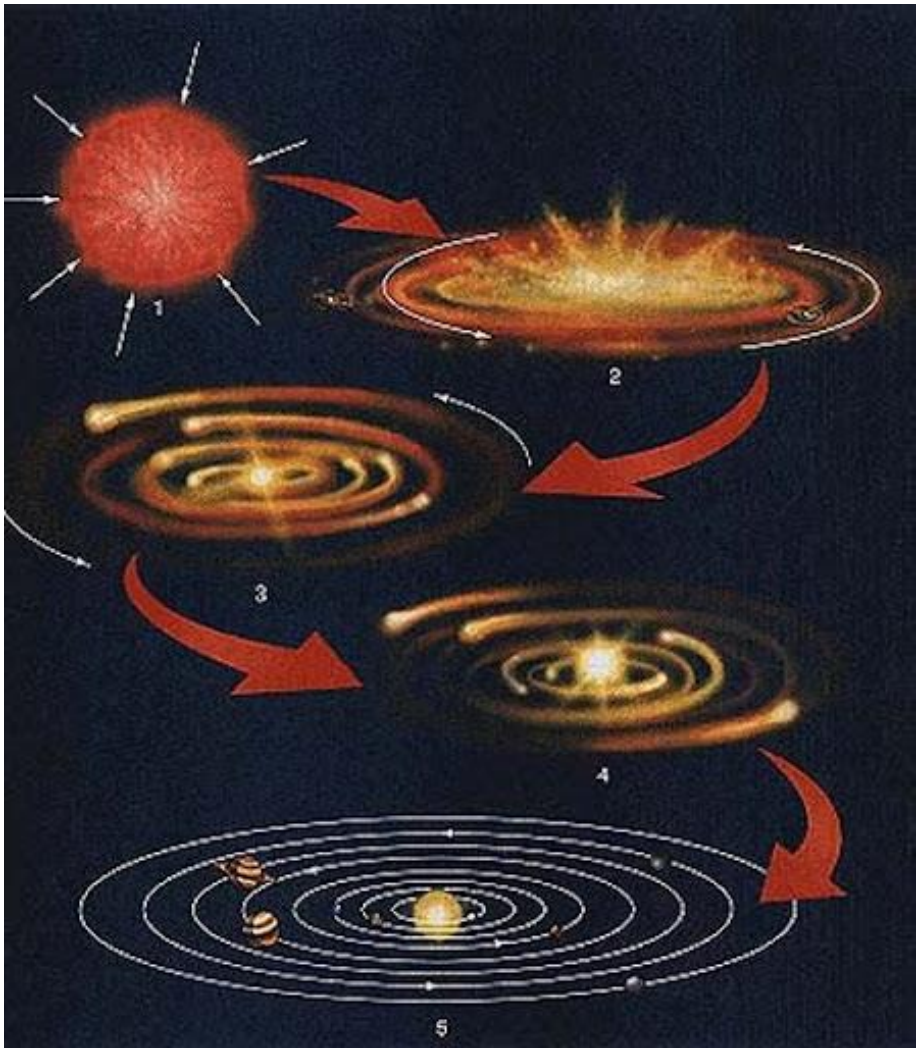
Lesson 15

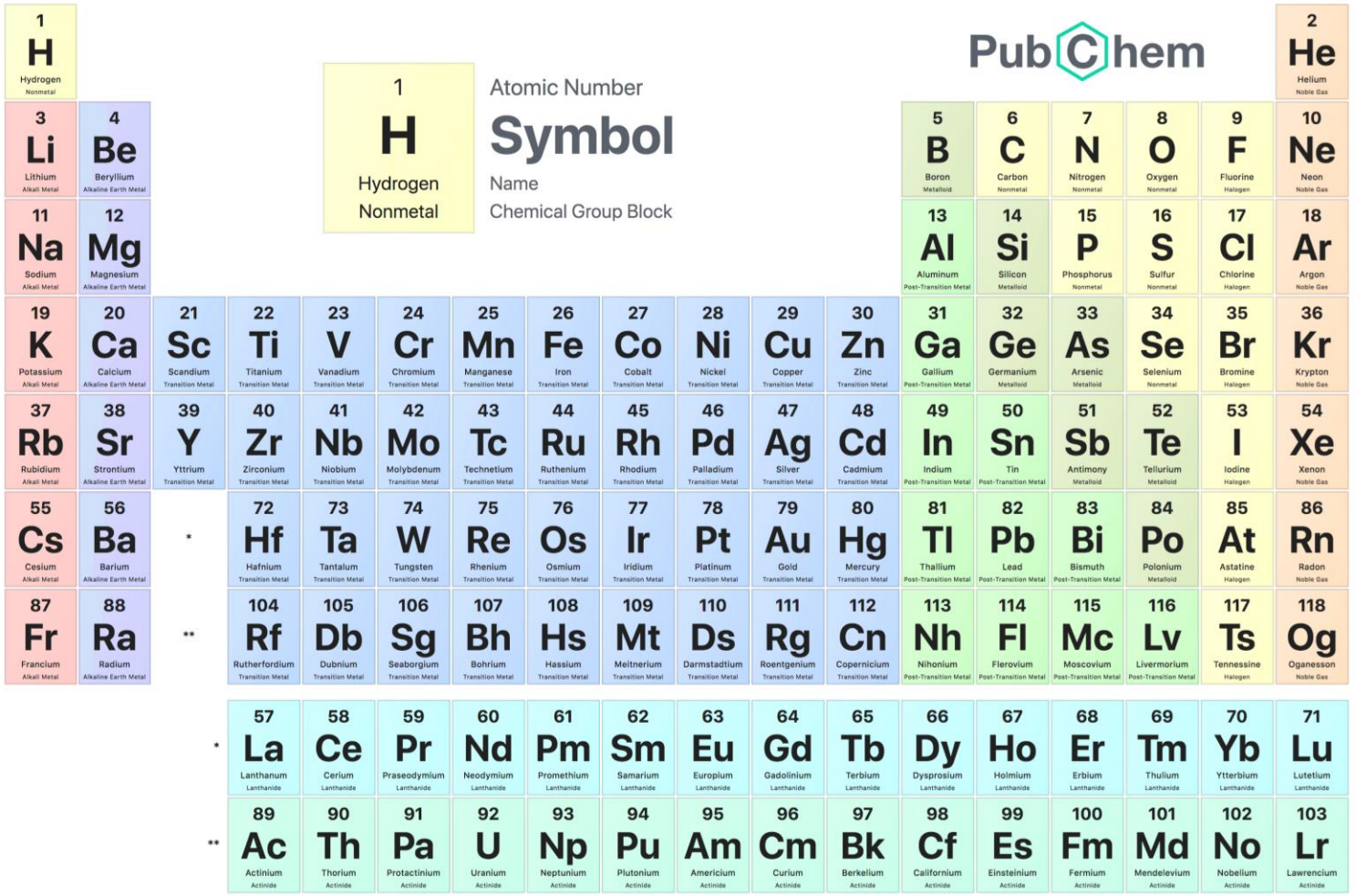
Formation of the Solar System
The Nebular Theory

The modern theory of how the solar system formed is called the **Nebular Theory**. It is sometimes referred as the **Condensation/Accretion Theory**.



The solar system began to form around **4.5-4.6 billion years ago**. The Sun formed first, followed by the planets.

Important: The solar system (the Sun, the planets, and other bodies) has every natural element: **From element 1 Hydrogen to element 92 Uranium.**



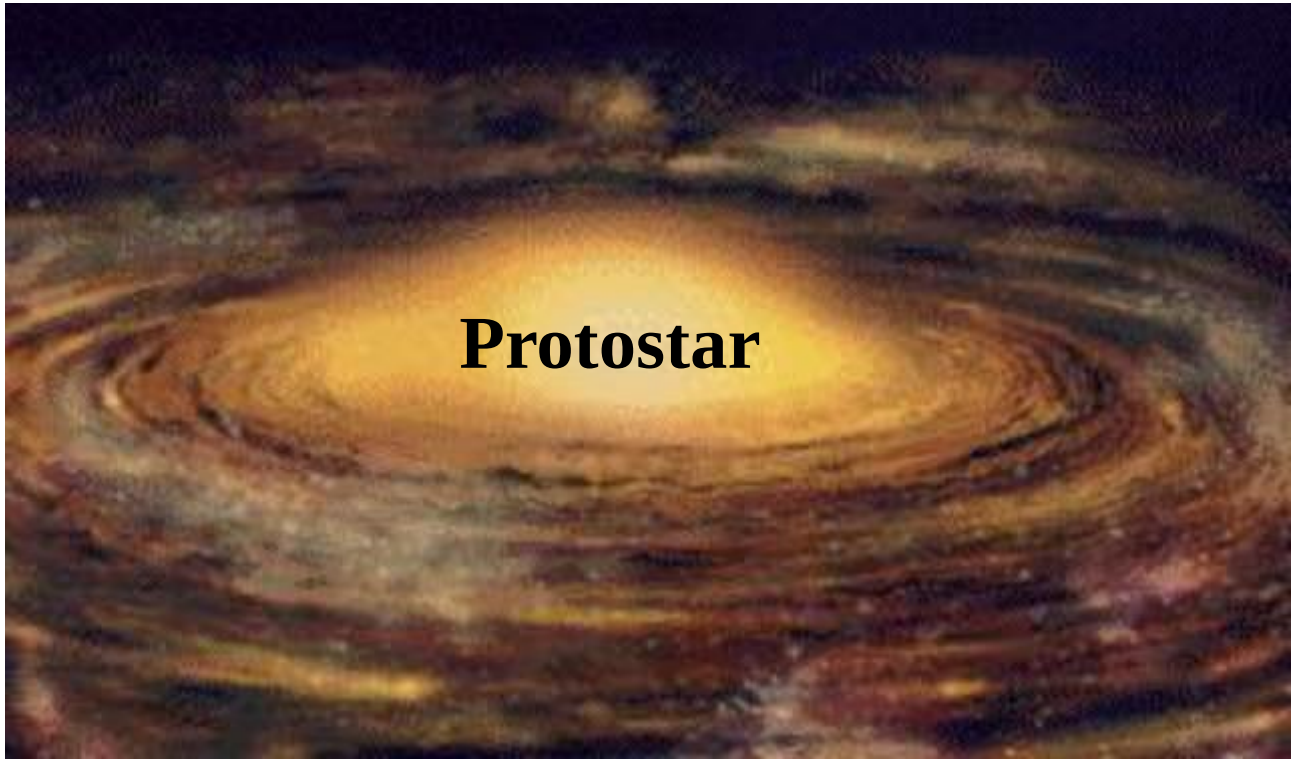
The presence of all elements (lightest to the heaviest natural metals) indicates that there was a past supergiant star located where our solar system is now present. That supergiant star went **supernova** (exploded) 4.6-5 billion years ago creating a very large **nebula**.

A **nebula** is a large interstellar cloud of gas, dust, and chunks of metal and rock. The nebula contained the remains of the exploded supergiant star. The nebula's material is the material that will make up the Sun, the planets, and all matter in the solar system.

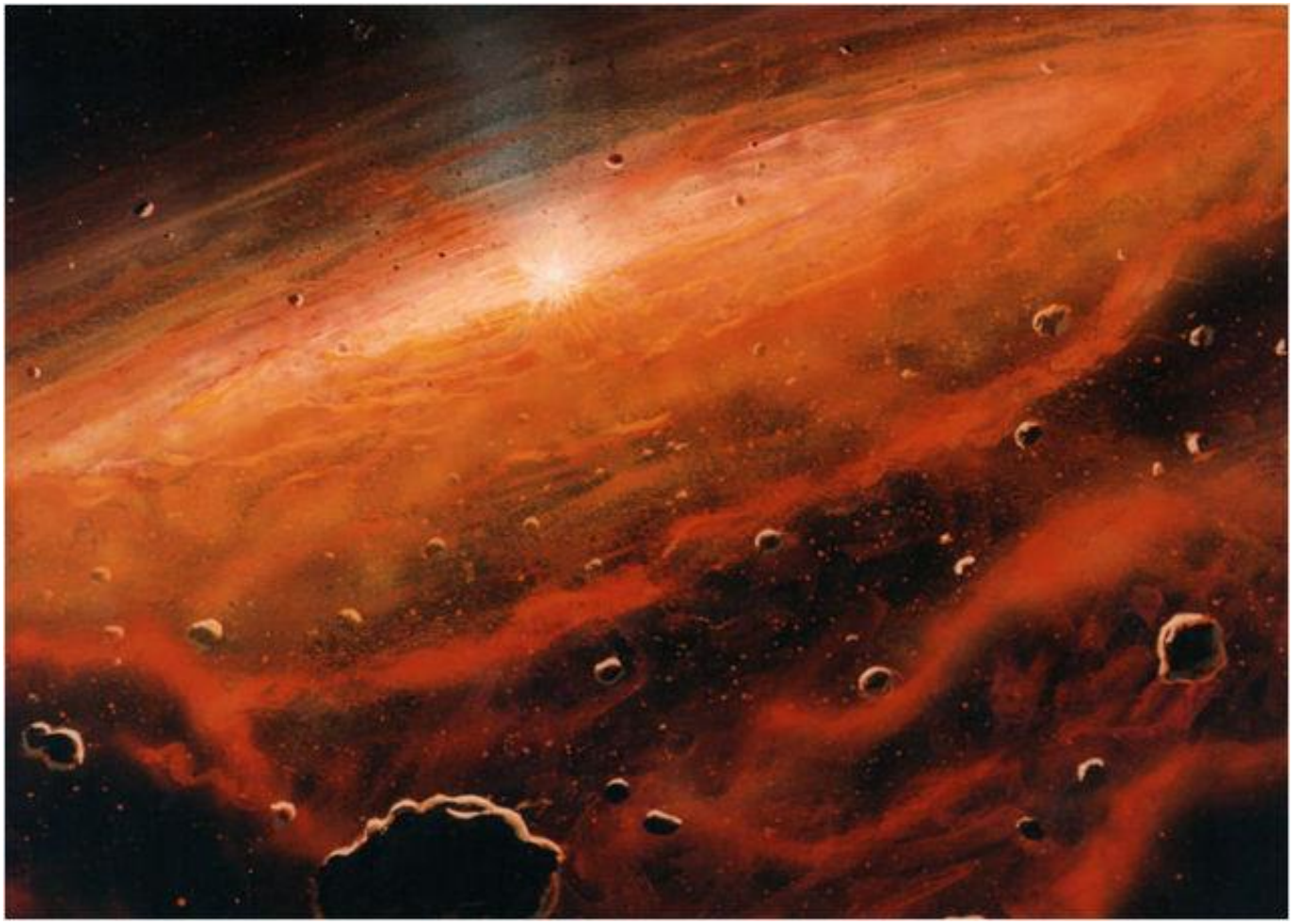
Around 4.6 billion years ago, the **nebula was disturbed by a shockwave** from another supernova. This caused the gas, dust, and chunks of rock and metal to collect by gravity into a dense central region that will become the solar system.

As the nebula collapsed inward under the force of gravity, the dust, gases, and chunks of rock became organized into a swirling flattened disk. This is called the **protoplanetary disk**.

Most of the nebula's material collected in the center of the protoplanetary disk. This bulging center was the **protostar** or protosun. It was the forming Sun/star.

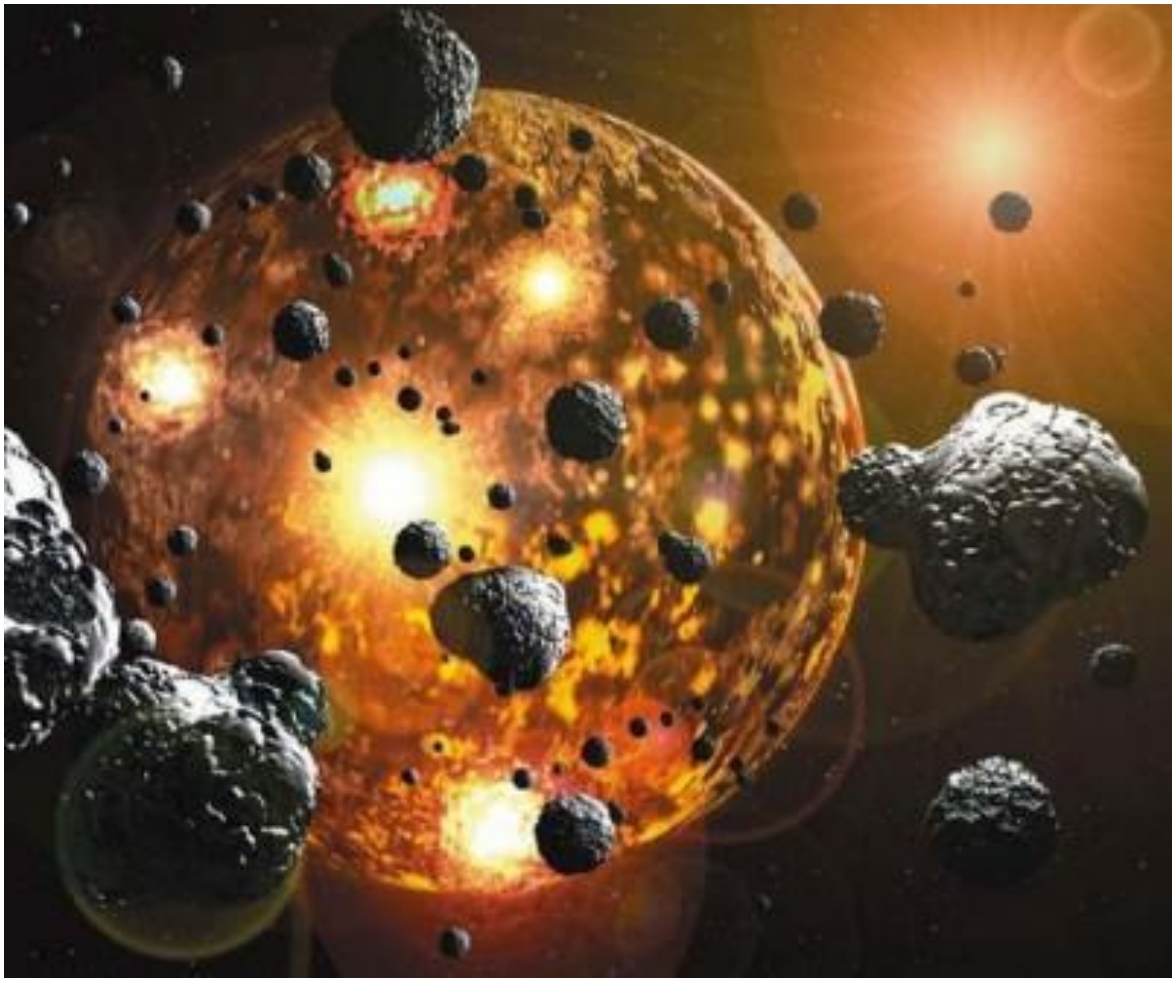


The protostar (or "pre-star") grew in size. Its large size and strong gravity pulled most of the mass of the nebula into the center of the protoplanetary disk.

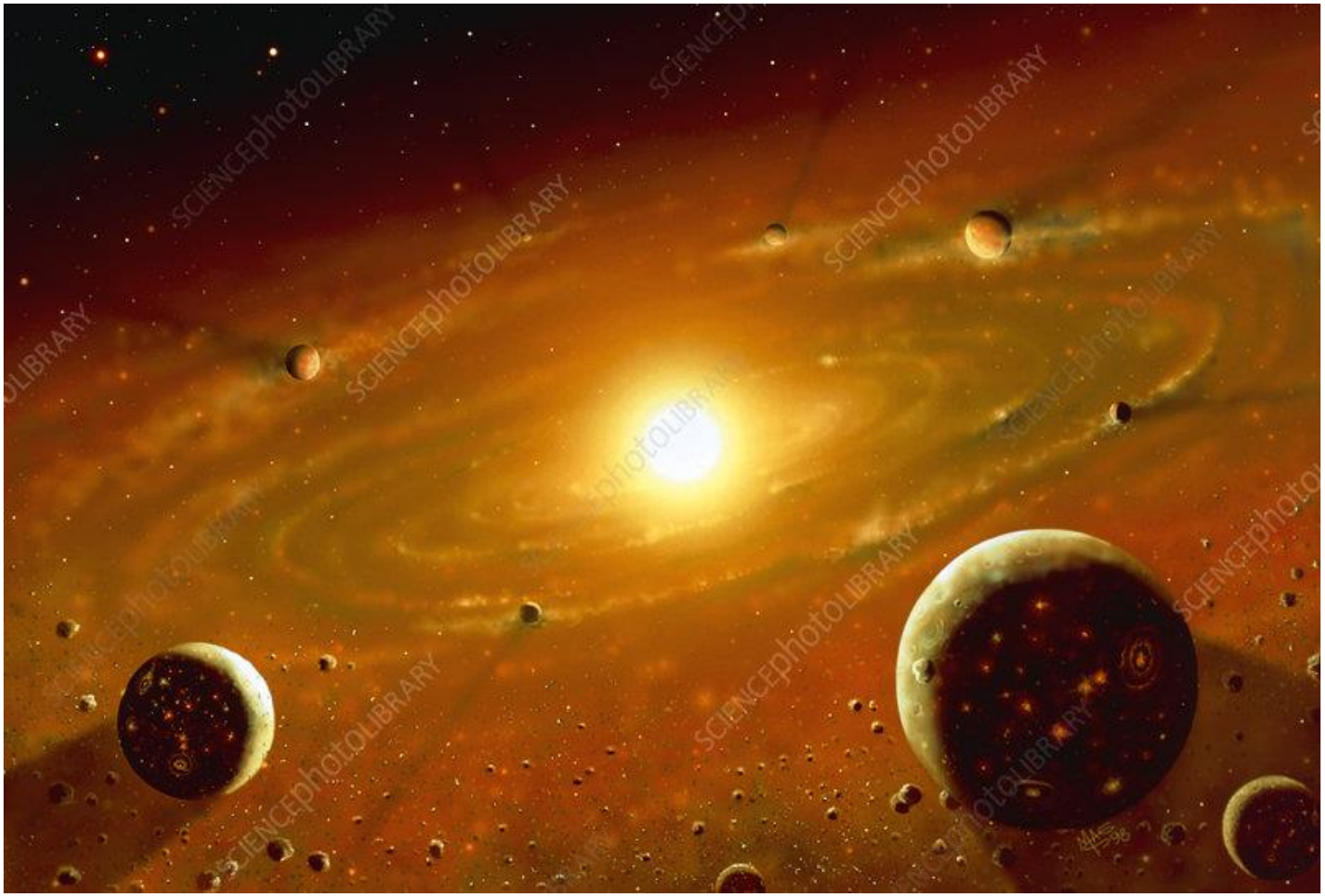


Outside of the forming star's region, millions of **planetesimals** formed and grew larger and larger as they collected more and more dust, gas, and asteroids from the cloud.

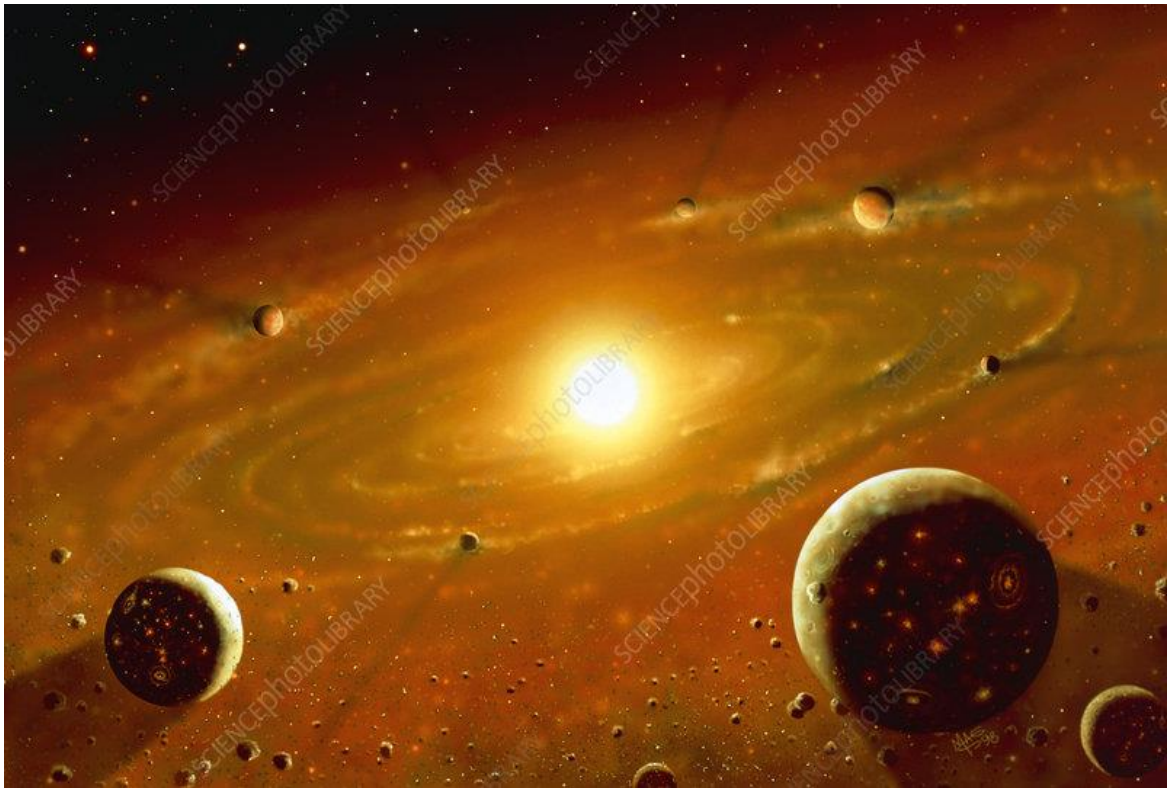
The planetesimals then collect together under gravity building larger and larger **protoplanets**. This process is called **accretion**. Accretion means to grow in size by accumulating more and more material.



Hundreds or thousands of protoplanets could have formed throughout the protoplanetary disk. Many protoplanets developed in the same orbit around the protostar (Earth & Theia).



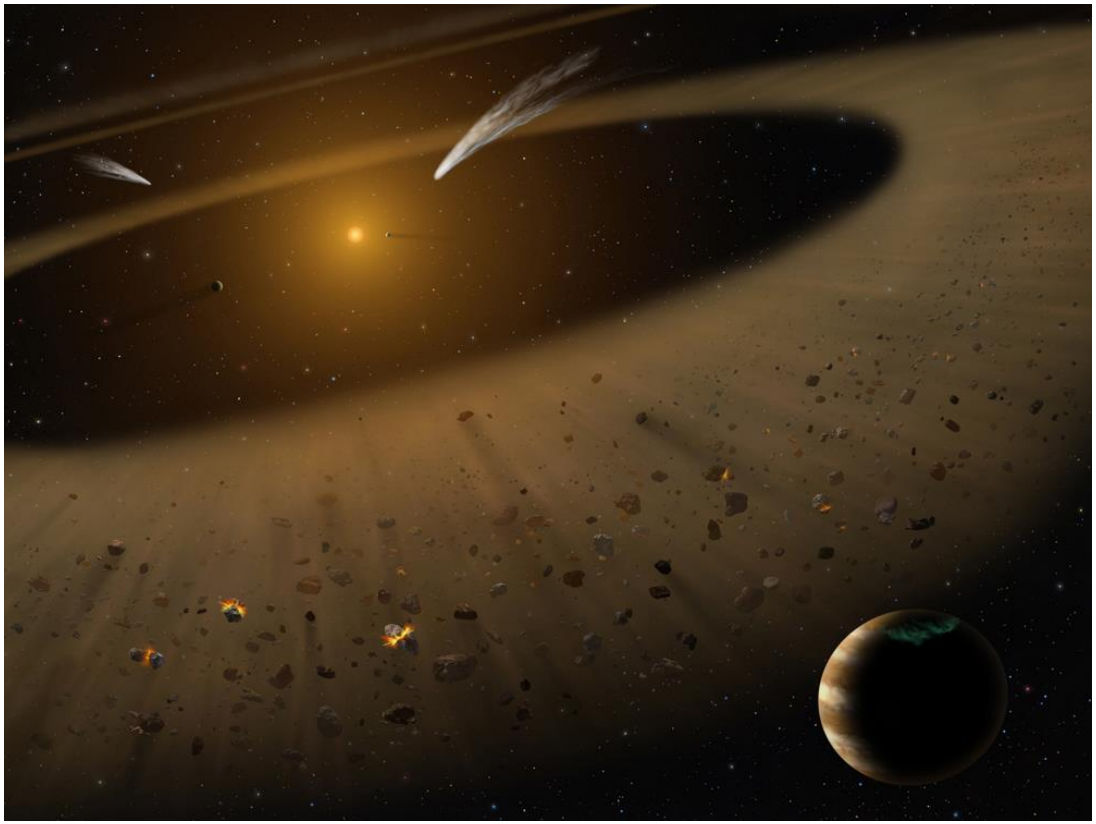
Over time smaller protoplanets collided with larger protoplanets, making fewer and fewer, but larger protoplanets.



Or the stronger gravitational pull of the larger protoplanets disrupted the orbits of smaller bodies, throwing the smaller bodies into the Sun or outward out of the solar system.

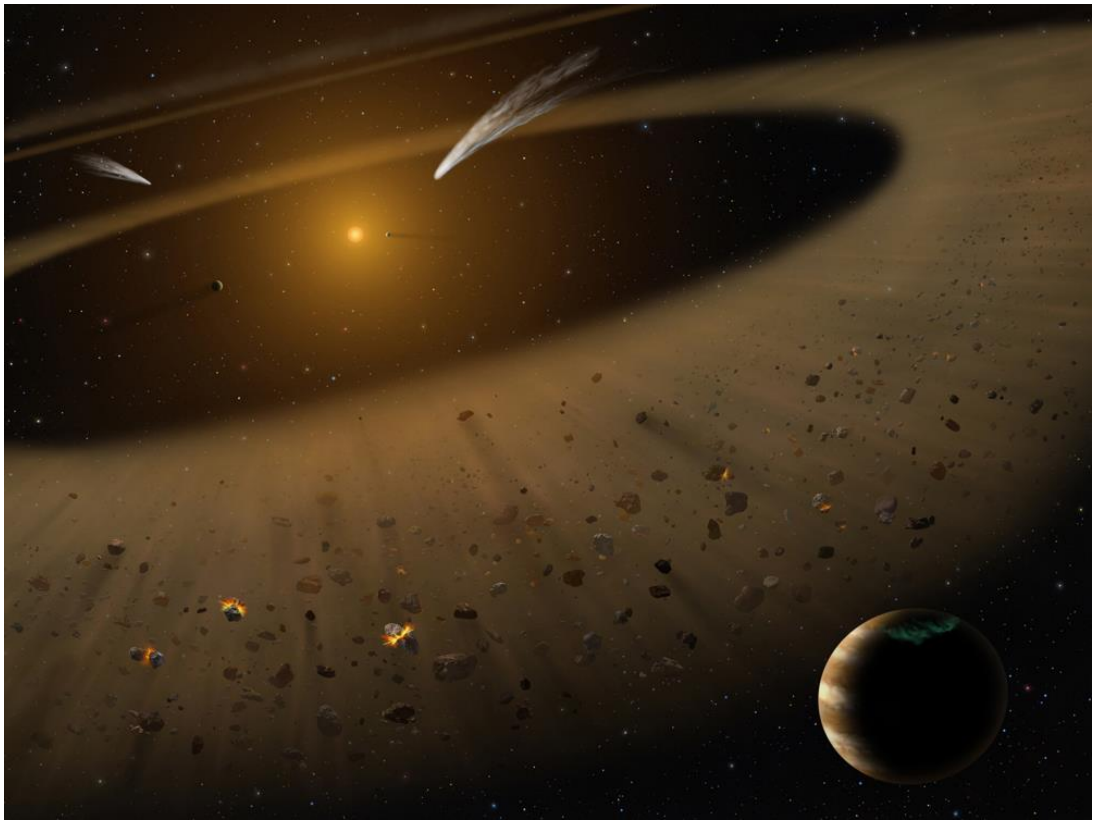
The sun achieved **ignition**. The Sun's mass grew large enough that the inward gravity force at the Sun's core started fusion of hydrogen to helium. The Sun violently burst out waves of heat, light, and solar wind across the forming solar system.

The solar wind pushed most of the gas and dust out of the inner solar system. If the inner planets (the terrestrial planets) had large dense atmospheres before the Sun's ignition, the solar wind blew those large atmospheres away to the outer solar system.

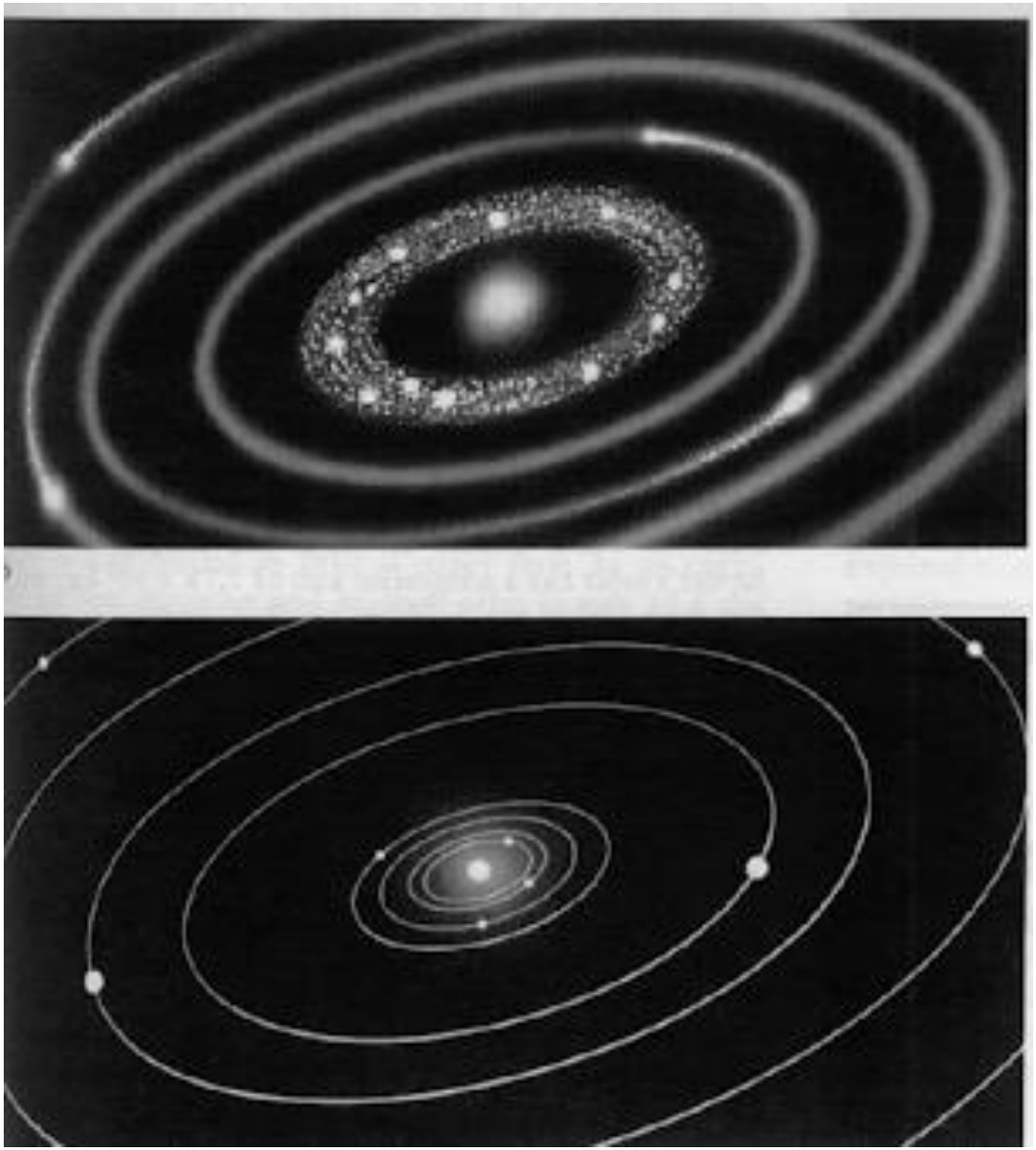


Only the small rocky and metal spheres of the terrestrial planets were left behind in their orbits.

The gravity of the larger planets of the outer solar system (Jovian planets) caused them collected the most of the gases and dust blow out of the inner solar system by the solar wind.



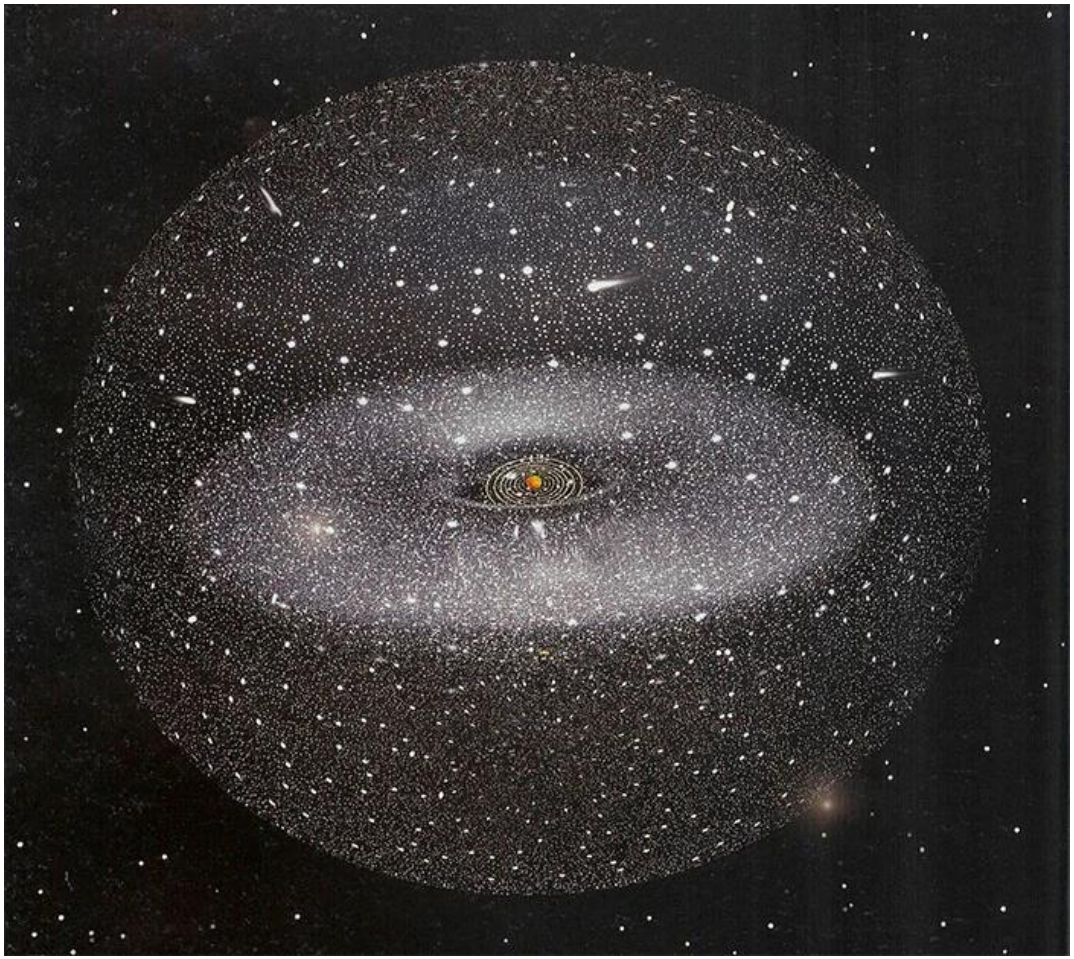
Jupiter and Saturn grew to enormous sizes with huge atmospheres by sweeping up the gases and dust pushed out by the solar wind.



The Sun stabilized. The rate of fusion stabilized.

The remaining planets that survived the protoplanetary collisions **swept their orbits clean** of all remaining dust, gases, and asteroids. By 4.5 billion years ago, the solar system resembled the modern solar system.

The **Oort cloud** is the most primordial of the nebular material. The ice, dust, and comets represent the original contents of the nebula that never formed any part of the protoplanetary disk or solar system.



The **Kuiper Belt** is made of the lighter compounds (gases and ices) that were blown out of the main areas of solar system by the solar wind.

The **Main Asteroid Belt** is made of the asteroids and planetesimals (leftover material) that did not form into a cohesive inner solar system planet or were not swept clear by a forming planet 4.5-4.6 billion years ago.