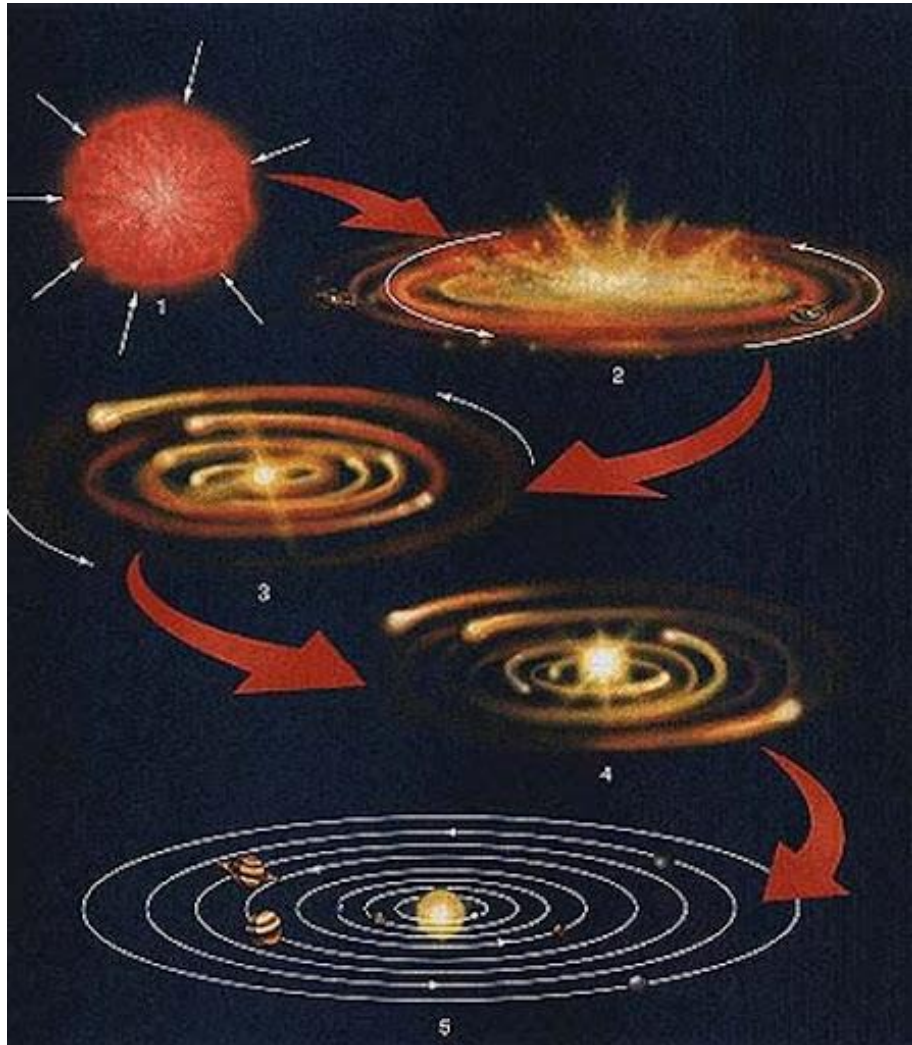


Lesson 15

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.**

PubChem

1 H Hydrogen Nonmetal																	2 He Helium Noble Gas	
3 Li Lithium Alkali Metal	4 Be Beryllium Alkaline Earth Metal																	10 Ne Neon Noble Gas
11 Na Sodium Alkali Metal	12 Mg Magnesium Alkaline Earth Metal																	18 Ar Argon Noble Gas
19 K Potassium Alkali Metal	20 Ca Calcium Alkaline Earth Metal	21 Sc Scandium Transition Metal	22 Ti Titanium Transition Metal	23 V Vanadium Transition Metal	24 Cr Chromium Transition Metal	25 Mn Manganese Transition Metal	26 Fe Iron Transition Metal	27 Co Cobalt Transition Metal	28 Ni Nickel Transition Metal	29 Cu Copper Transition Metal	30 Zn Zinc Transition Metal	31 Ga Gallium Post-Transition Metal	32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogen	36 Kr Krypton Noble Gas	
37 Rb Rubidium Alkali Metal	38 Sr Strontium Alkaline Earth Metal	39 Y Yttrium Transition Metal	40 Zr Zirconium Transition Metal	41 Nb Niobium Transition Metal	42 Mo Molybdenum Transition Metal	43 Tc Technetium Transition Metal	44 Ru Ruthenium Transition Metal	45 Rh Rhodium Transition Metal	46 Pd Palladium Transition Metal	47 Ag Silver Transition Metal	48 Cd Cadmium Transition Metal	49 In Indium Post-Transition Metal	50 Sn Tin Post-Transition Metal	51 Sb Antimony Metalloid	52 Te Tellurium Metalloid	53 I Iodine Halogen	54 Xe Xenon Noble Gas	
55 Cs Cesium Alkali Metal	56 Ba Barium Alkaline Earth Metal	*	72 Hf Hafnium Transition Metal	73 Ta Tantalum Transition Metal	74 W Tungsten Transition Metal	75 Re Rhenium Transition Metal	76 Os Osmium Transition Metal	77 Ir Iridium Transition Metal	78 Pt Platinum Transition Metal	79 Au Gold Transition Metal	80 Hg Mercury Transition Metal	81 Tl Thallium Post-Transition Metal	82 Pb Lead Post-Transition Metal	83 Bi Bismuth Post-Transition Metal	84 Po Polonium Metalloid	85 At Astatine Halogen	86 Rn Radon Noble Gas	
87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth Metal	**	104 Rf Rutherfordium Transition Metal	105 Db Dubnium Transition Metal	106 Sg Seaborgium Transition Metal	107 Bh Bohrium Transition Metal	108 Hs Hassium Transition Metal	109 Mt Meitnerium Transition Metal	110 Ds Darmstadtium Transition Metal	111 Rg Roentgenium Transition Metal	112 Cn Copernicium Transition Metal	113 Nh Nihonium Post-Transition Metal	114 Fl Flerovium Post-Transition Metal	115 Mc Moscovium Post-Transition Metal	116 Lv Livermorium Post-Transition Metal	117 Ts Tennessine Halogen	118 Og Oganesson Noble Gas	
		*	57 La Lanthanum Lanthanide	58 Ce Cerium Lanthanide	59 Pr Praseodymium Lanthanide	60 Nd Neodymium Lanthanide	61 Pm Promethium Lanthanide	62 Sm Samarium Lanthanide	63 Eu Europium Lanthanide	64 Gd Gadolinium Lanthanide	65 Tb Terbium Lanthanide	66 Dy Dysprosium Lanthanide	67 Ho Holmium Lanthanide	68 Er Erbium Lanthanide	69 Tm Thulium Lanthanide	70 Yb Ytterbium Lanthanide	71 Lu Lutetium Lanthanide	
		**	89 Ac Actinium Actinide	90 Th Thorium Actinide	91 Pa Protactinium Actinide	92 U Uranium Actinide	93 Np Neptunium Actinide	94 Pu Plutonium Actinide	95 Am Americium Actinide	96 Cm Curium Actinide	97 Bk Berkelium Actinide	98 Cf Californium Actinide	99 Es Einsteinium Actinide	100 Fm Fermium Actinide	101 Md Mendelevium Actinide	102 No Nobelium Actinide	103 Lr Lawrencium Actinide	

1
H
Hydrogen
Nonmetal

Atomic Number

Symbol

Name

Chemical Group Block

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.



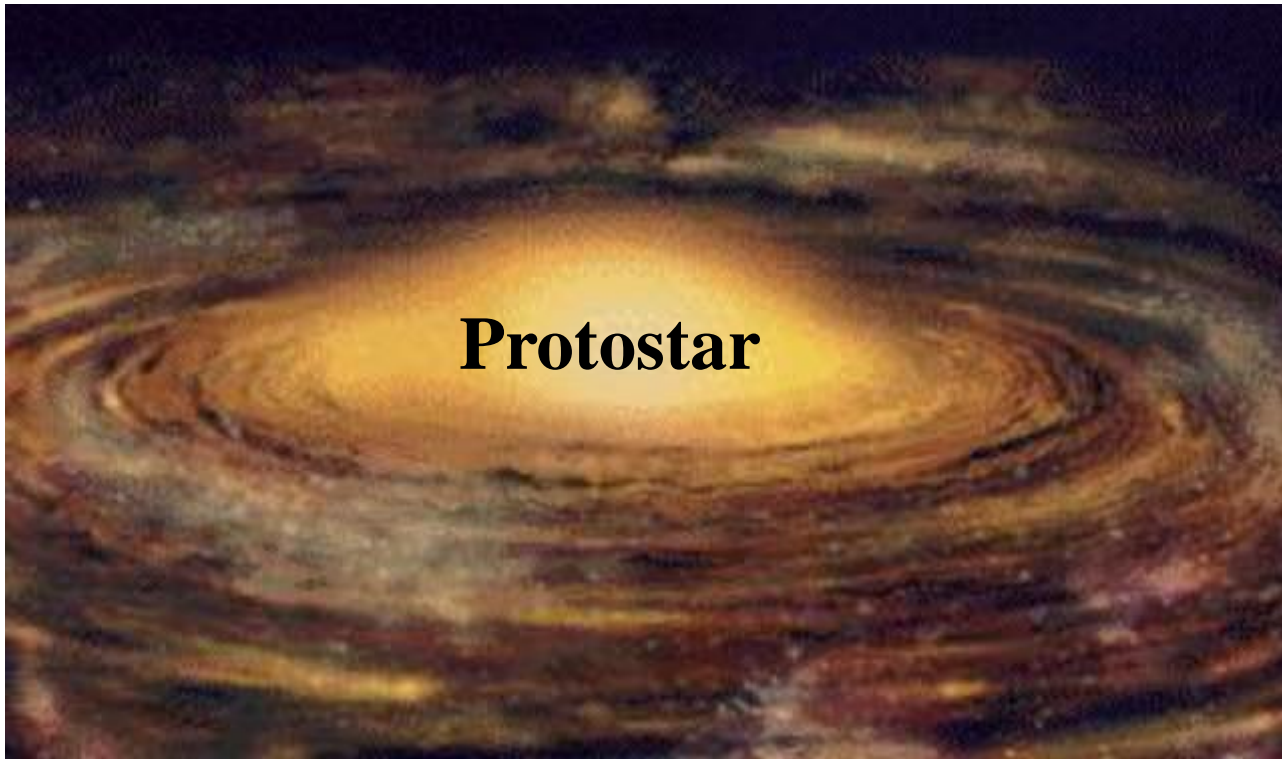
Around 4.6 billion years ago, the **nebula** was **disturbed by a shockwave** from another supernova. This caused the gas, dust, and chunks of rock and metal to collect by gravity into a dense central region that will become the solar system.



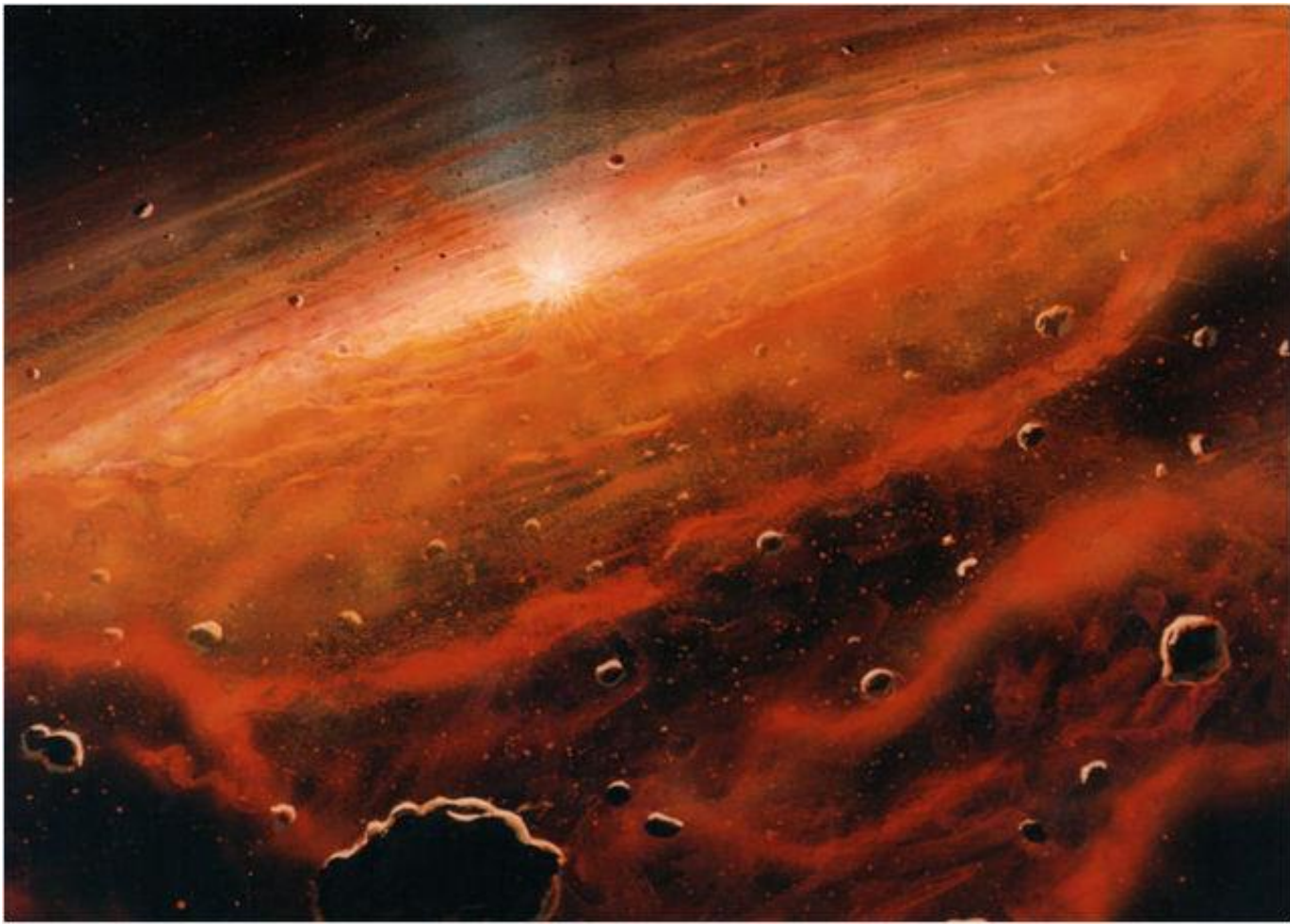
As the nebula collapsed inward under the force of gravity, the dust, gases, and chunks of rock became organized into a swirling flattened disk. This is called the **protoplanetary disk**.



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.

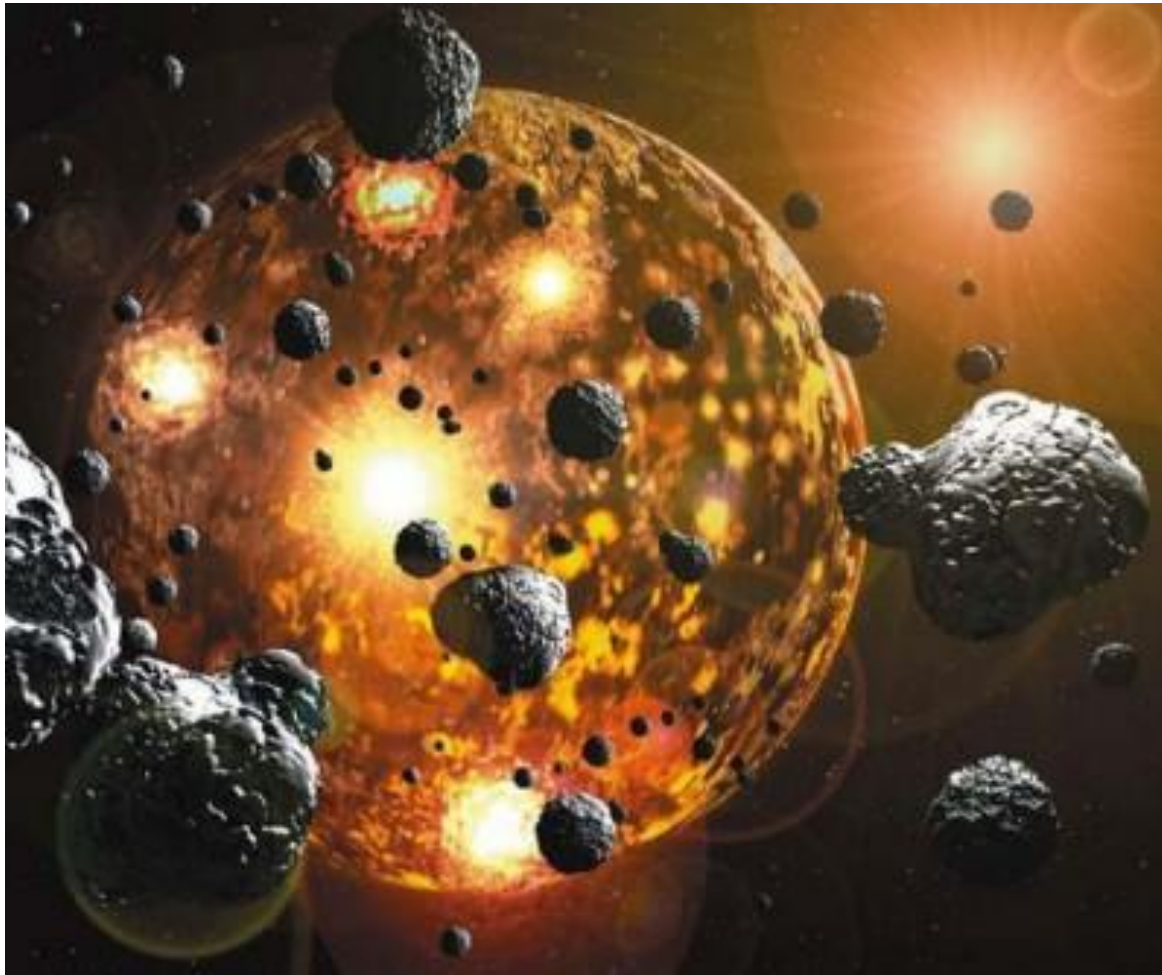


The protostar (or “pre-star”) grew in size. Its large size and strong gravity pulled most of the mass of the nebula into the center of the protoplanetary disk.

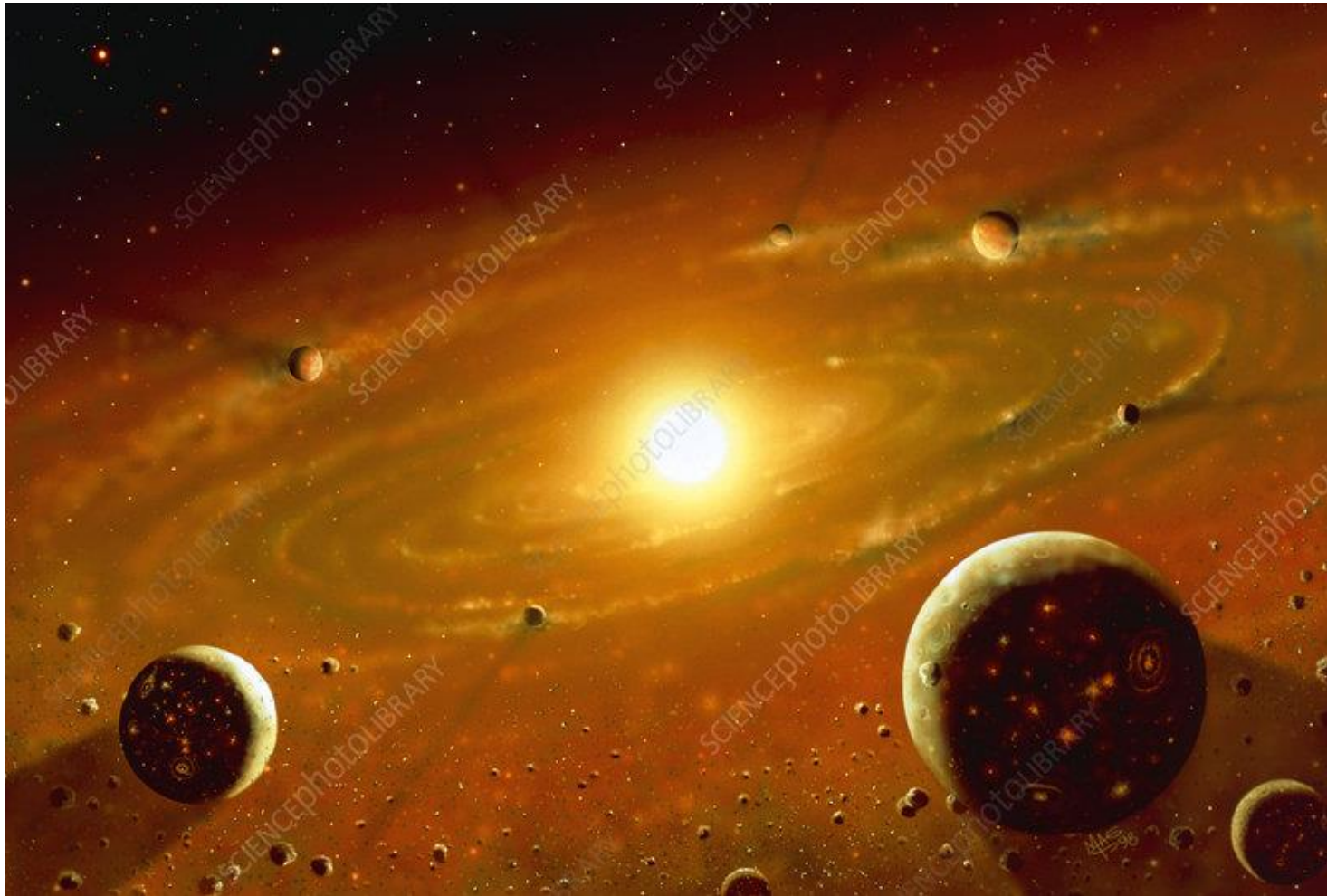


Outside of the forming star's region, millions of **planetesimals** formed and grew larger and larger as they collected more and more dust, gas, and asteroids from the cloud.

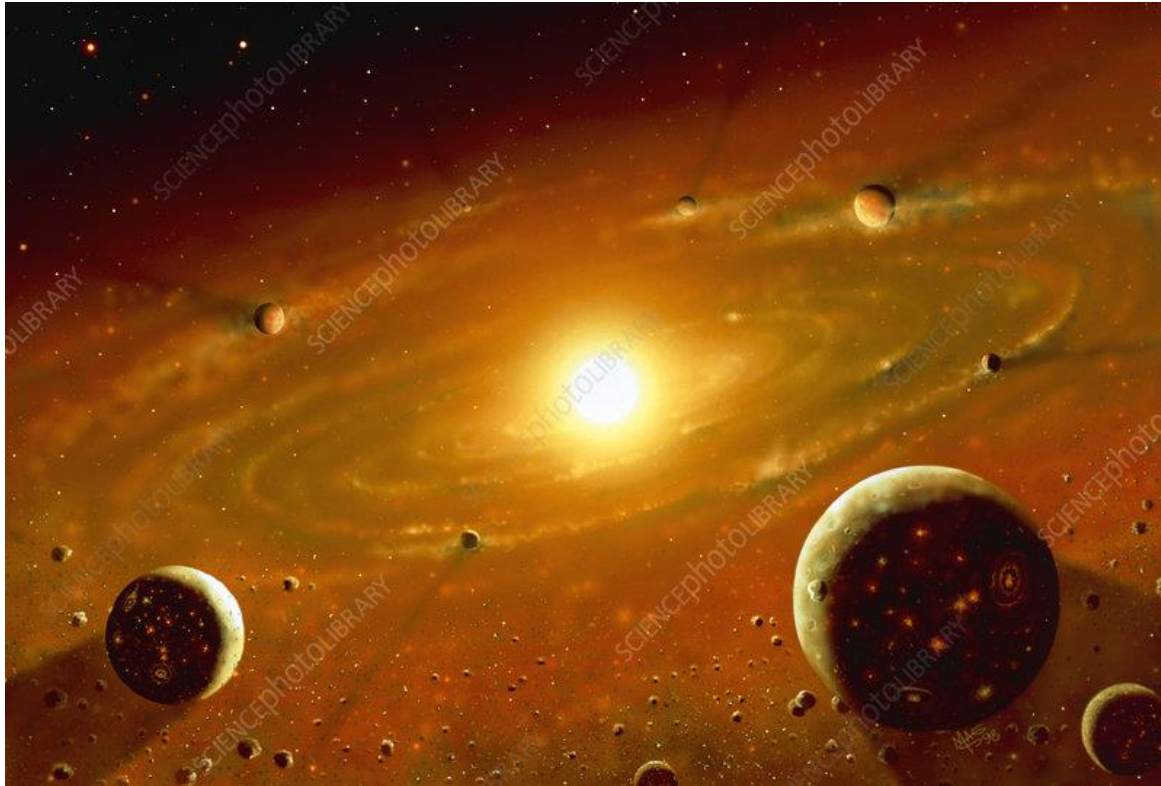
The planetesimals then collect together under gravity building larger and larger **protoplanets**. This process is called **accretion**. Accretion means to grow in size by accumulating more and more material.



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.

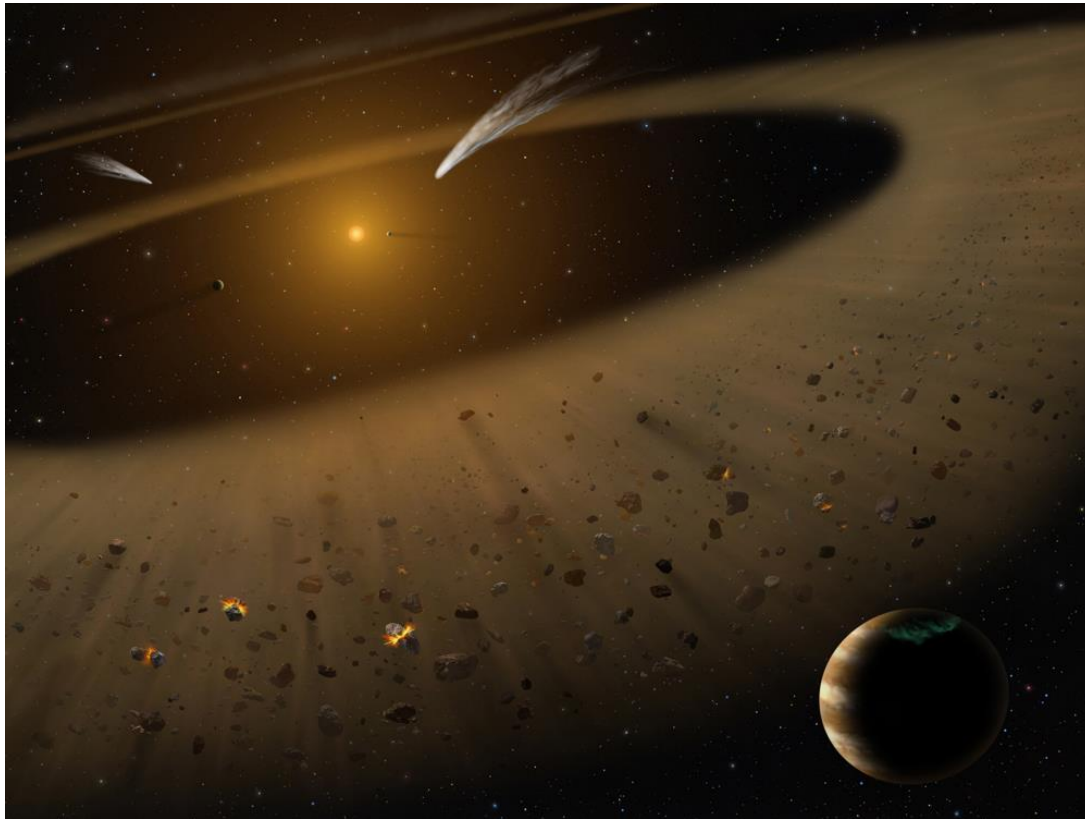


Or the stronger gravitational pull of the larger protoplanets disrupted the orbits of smaller bodies, throwing the smaller bodies into the Sun or outward out of the solar system.

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.

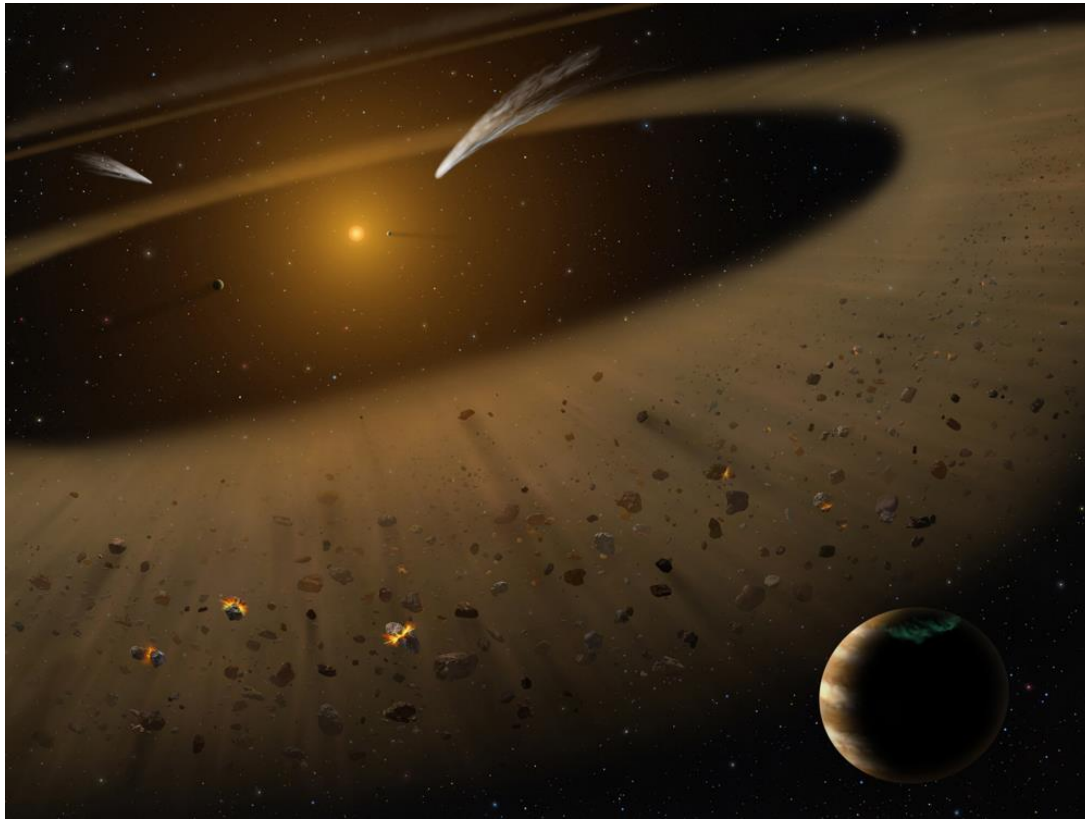


The solar wind pushed most of the gas and dust out of the inner solar system. If the inner planets (the terrestrial planets) had large dense atmospheres before the Sun's ignition, the solar wind blew those large atmospheres away to the outer solar system.

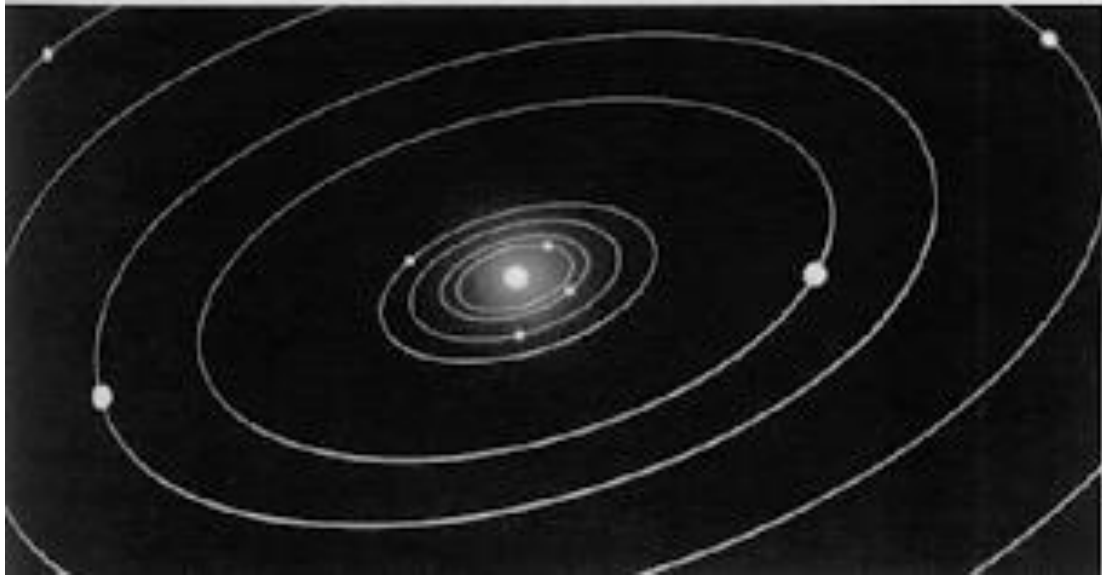
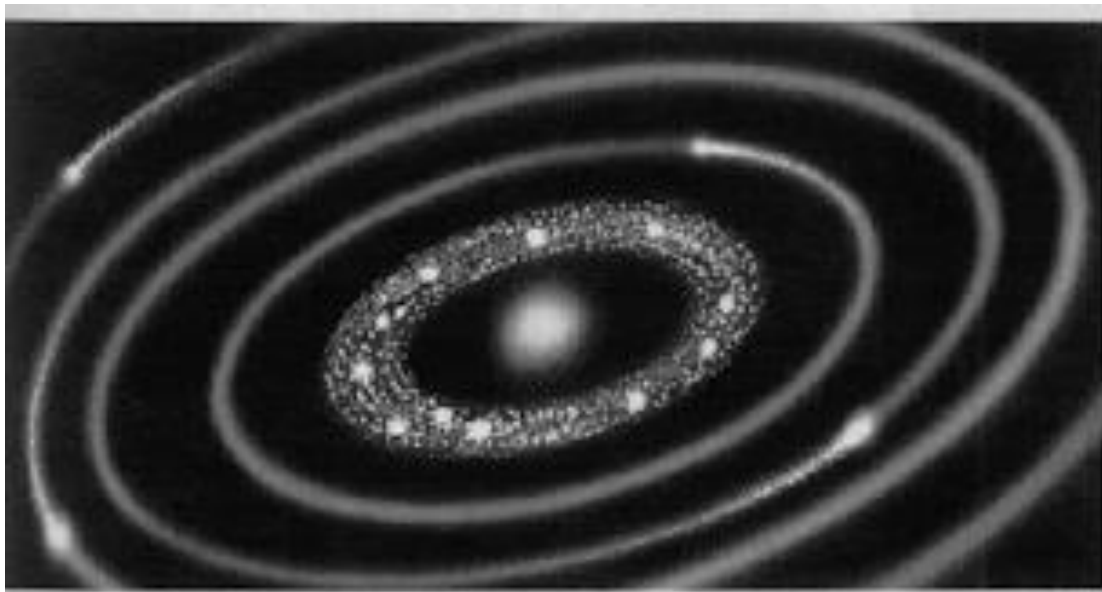


Only the small rocky and metal spheres of the terrestrial planets were left behind in their orbits.

The gravity of the larger planets of the outer solar system (Jovian planets) caused them to collect the most of the gases and dust blown 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.

