

*“You and I are flesh and
blood, but we are also
stardust.”*

-Bio AP text book

Six elements are the major constituents of living tissue.....

And they account for 95% of the biosphere.....

C, H, O, N, P, S

-Zone of Life on Earth
-Global Sum of all ecosystems

-Biotic/Abiotic (i.e. – the living/non living)
components of a system....

Chemistry 101

- Atomic Number: number of protons

Hydrogen has 1 proton; Carbon has 6 protons

- Atomic Weight: average mass of atoms of an element, calculated using the relative abundance of isotopes in a naturally occurring element.

Carbon = 12.001; Nitrogen = 14.007

- Isotope: Atoms with the same number of protons but different number of neutrons.

Carbon-12 = 6 protons + 6 neutrons

Carbon-14 = 6 protons + 8 neutrons

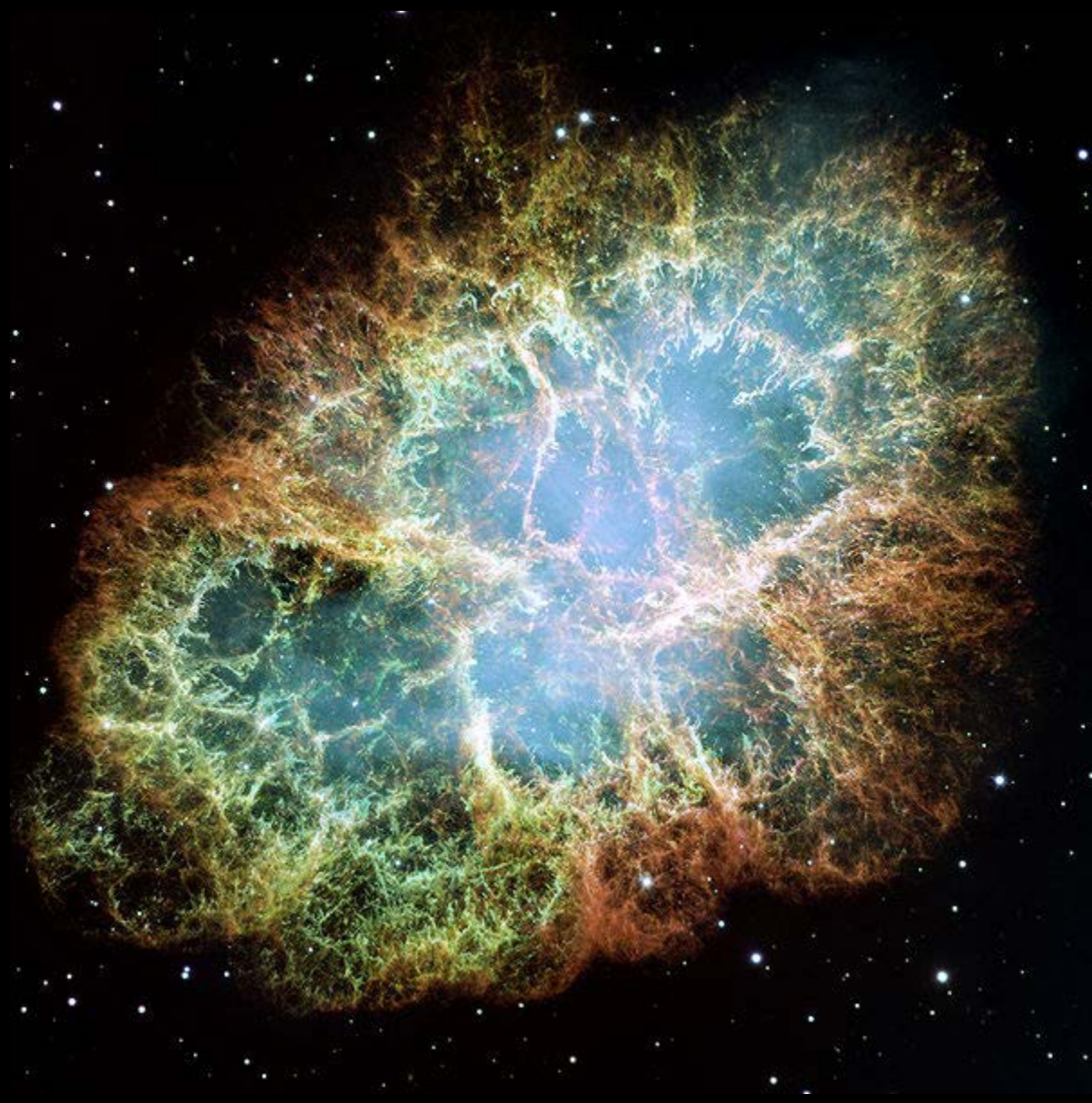
Periodic Table of Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18						
1 H Hydrogen 1.00794	Atomic # Symbd Name Atomic Mass																2 He Helium 4.002602						
C Solid		Metals										Nonmetals											
Hg Liquid		Alkali metals		Alkaline earth metals		Lanthanoids			Transition metals		Poor metals		Other nonmetals		Noble gases								
H Gas																							
Rf Unknown																							
3 Li Lithium 6.941	4 Be Beryllium 9.012182																	6 B Boron 10.811	7 C Carbon 12.011	8 N Nitrogen 14.007	9 O Oxygen 15.9994	10 F Fluorine 18.9984032	11 Ne Neon 20.1797
11 Na Sodium 22.98976928	12 Mg Magnesium 24.3050																	13 Al Aluminium 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.887	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798						
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (97.9072)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293						
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71		72 Hf Hafnium 178.49	73 Ta Tantalum 180.94738	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.221	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209.9824)	85 At Astatine (208.9871)	86 Rn Radon (222.0175)					
87 Fr Francium (223)	88 Ra Radium (226)	89-103		104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Cu Ununbium (285)	113 Cu Ununtrium (284)	114 Cu Ununquadium (289)	115 Cu Ununpentium (288)	116 Cu Ununhexium (289)	117 Cu Ununseptium (289)	118 Cu Ununoctium (294)					

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

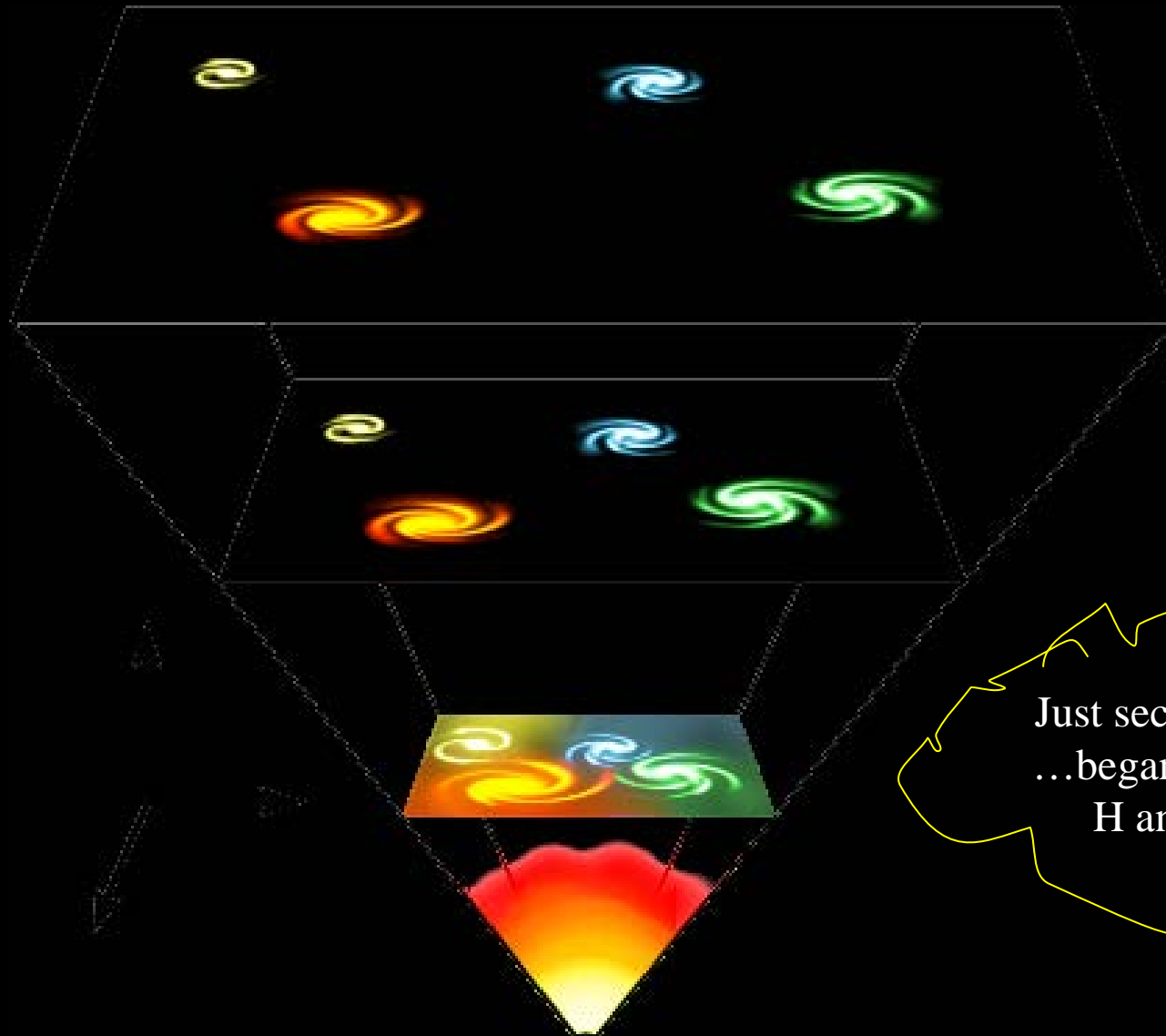
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57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.967
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)



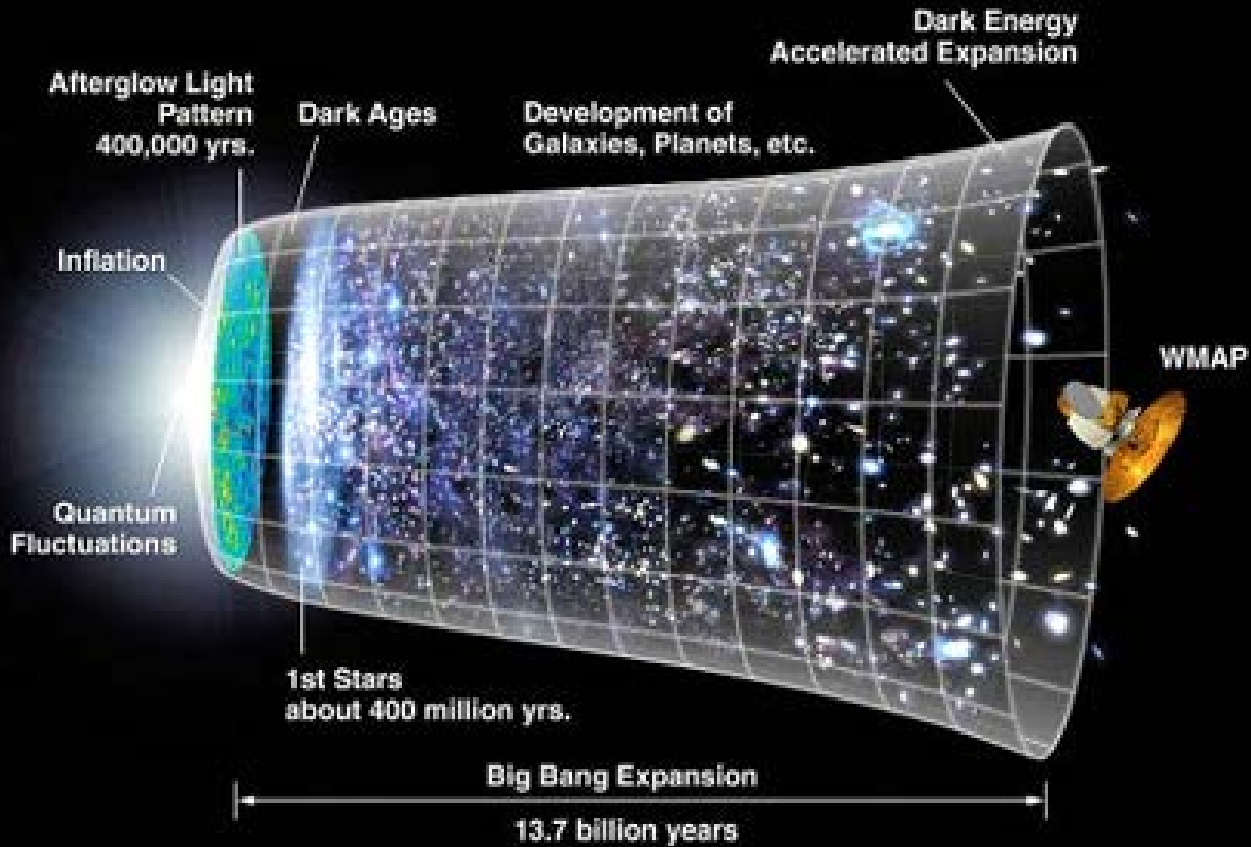
NASA's Hubble Space Telescope of the Crab Nebula

~ 13.7 billion years ago (bya)



Just seconds old
...began to form
H and He

Big Bang Nucleosynthesis.... 100-300 seconds.....



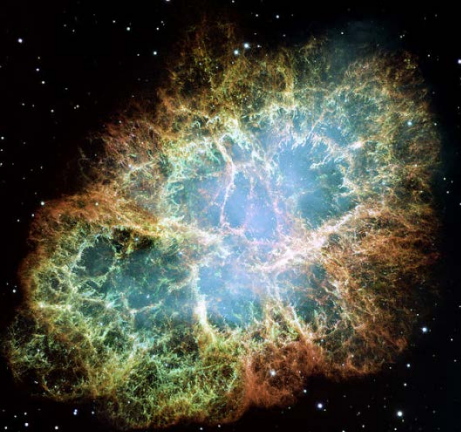
It's speeding up....



One BILLION years later.....

Stars Formed.... And with them – other,
heavier elements.....

This is called **Stellar Nucleosynthesis**.....



Temperature and Pressure



So how many stars are there....



Milky Way... we think – 200-400 billion.....

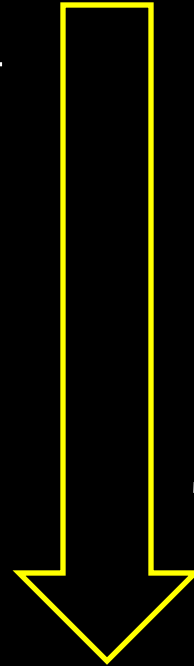
But there might be 3000 galaxies (in just a pin hole view of space)

The Nebular Hypothesis



Emanuel Swedenborg

1734



Today

**Solar Nebular Disk Model
(SNDM) or Solar Nebular
Model**

Formation of a Solar System

A nebula (a large, diffuse gas cloud of gas and dust) contracts under gravity. As it contracts, the nebula heats, flattens, and spins faster, becoming a spinning disk of dust and gas.

Star will be born in center.

Planets will form in disk.

Heavier Elements Drawn to Center by Gravity

Hydrogen and helium remain gaseous but other materials can condense into solid "seeds" for building planets.



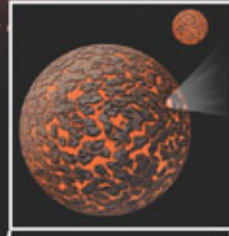
Warm temperatures allow only metal/rock "seeds" to condense in the inner solar system.



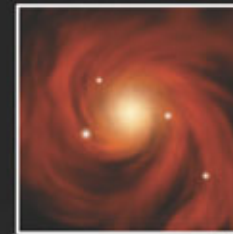
Cold temperatures allow "seeds" to contain abundant ice in outer solar system.

Formation of Protoplanets

Solid "seeds" collide and stick together. Larger ones attract others with their gravity, growing bigger still.

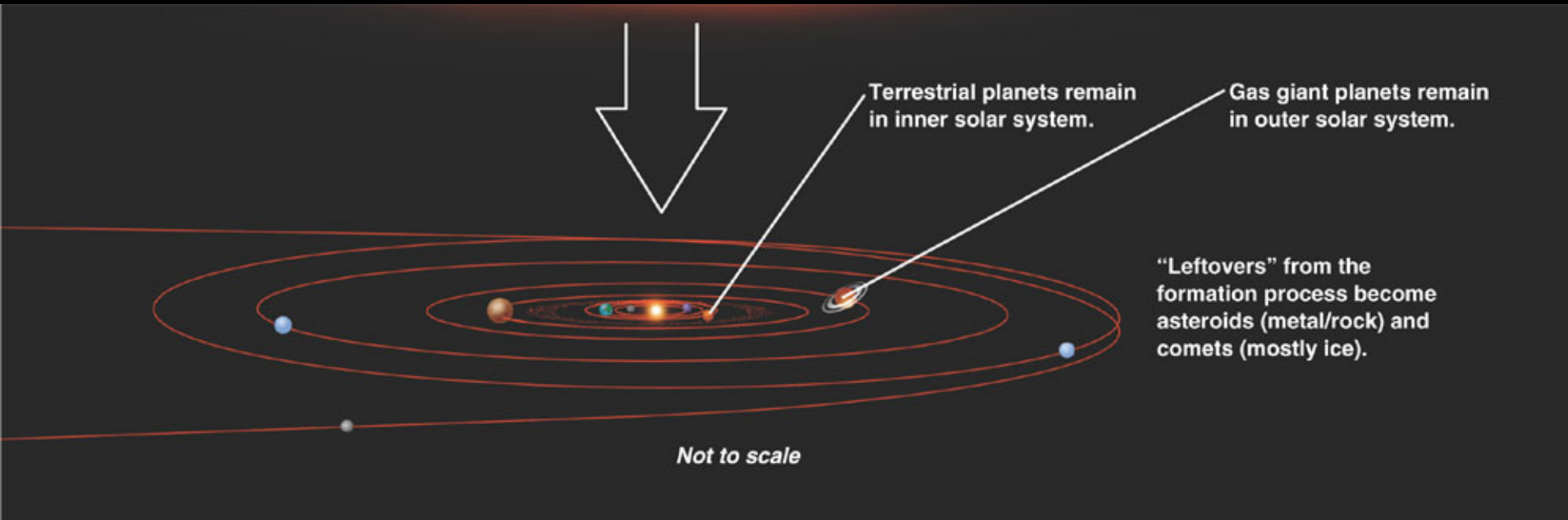


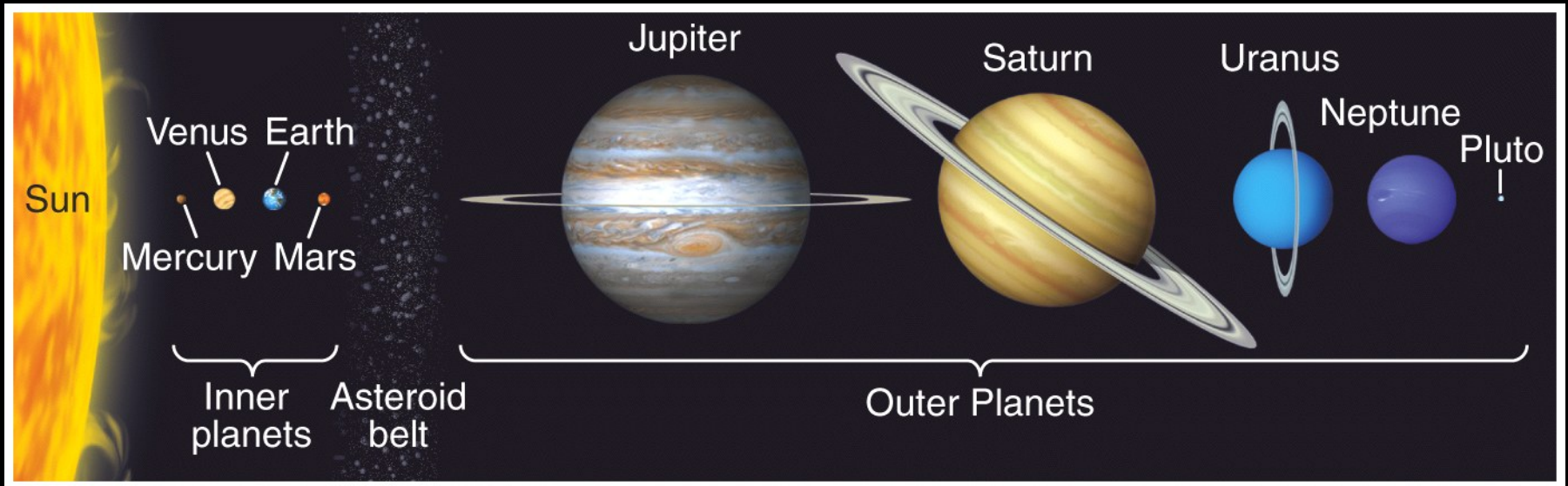
Terrestrial planets are built from metal and rock.



The seeds of gas giant planets grow large enough to attract hydrogen and helium gas, making them into giant, mostly gaseous planets; moons form in disks of dust and gas that surround the planets.

Our Solar System





Sun

Venus Earth
Mercury Mars

Inner planets

Asteroid belt

Jupiter

Saturn

Uranus

Neptune

Pluto !

Outer Planets

The Age of the Earth

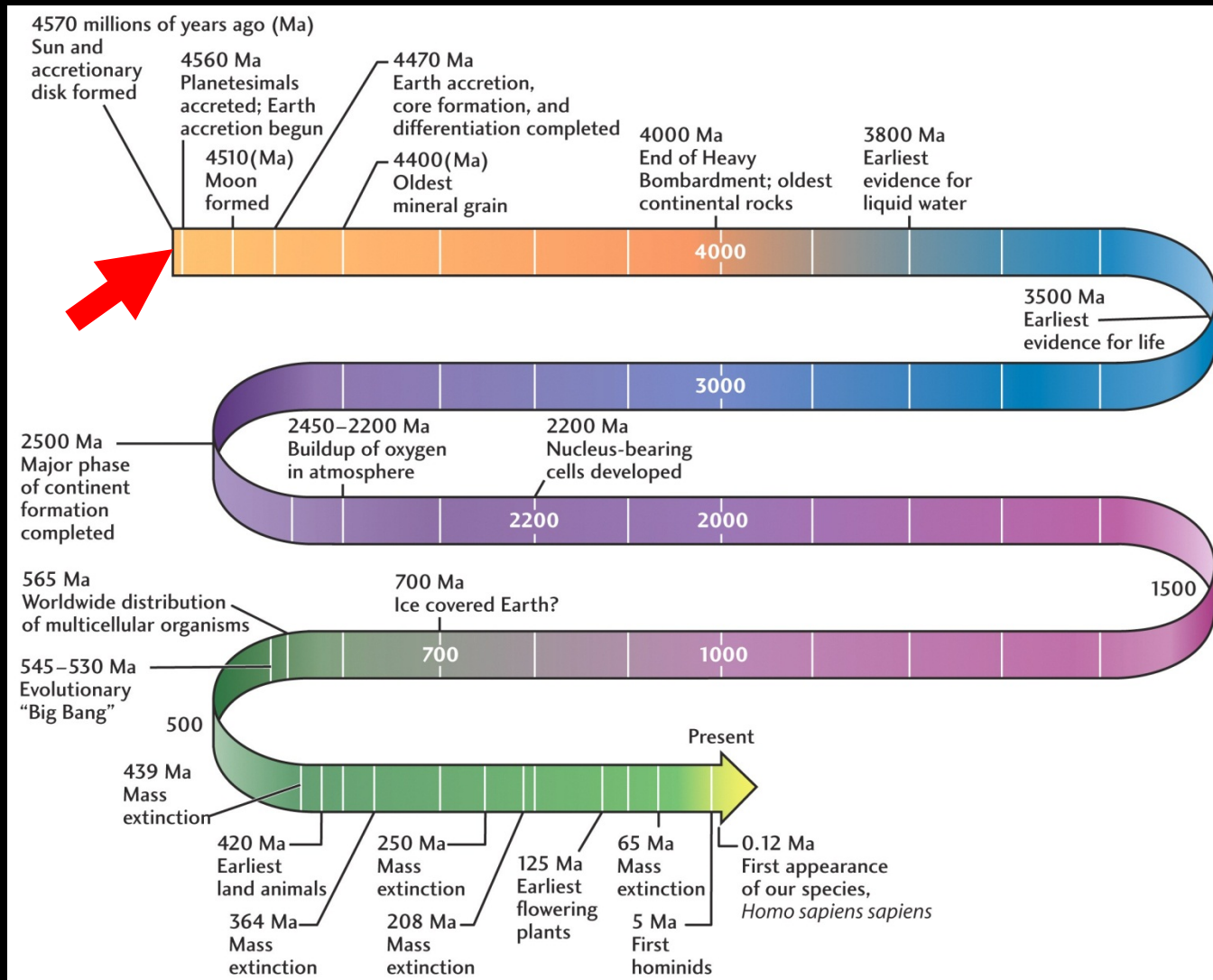
Earth is ~ 4,570,000,000 years old

Meteorites give us access to debris left over from the formation of the solar system

We can date meteorites using radioactive isotopes and their decay products

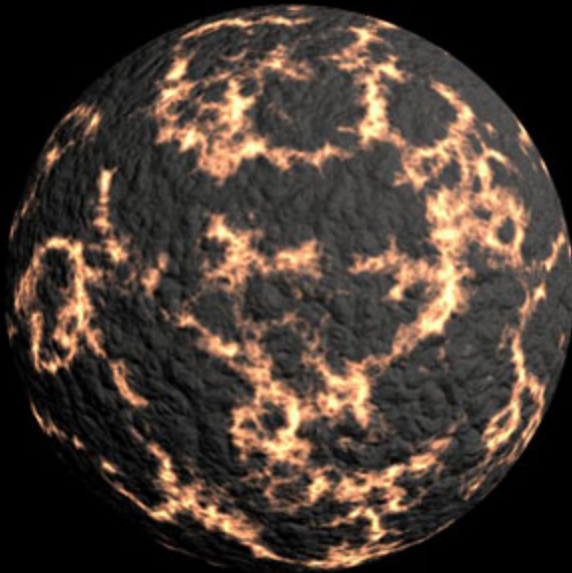


Geologic Time



The Early Earth Heats Up

3 major factors that caused heating and melting in the early Earth's interior:

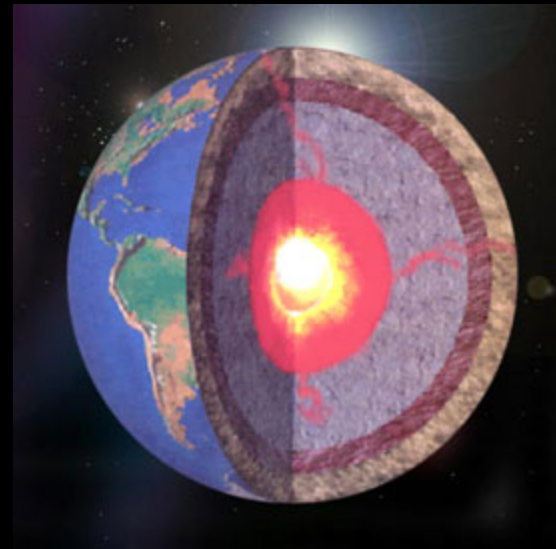


- 1. Collisions (Transfer of kinetic energy into heat)**
- 2. Compression**
- 3. Radioactivity of elements (e.g. uranium, potassium, or thorium)**

The Core

About 100 million years after initial accretion, temperatures at depths of 400 to 800 km below the Earth's surface reach the melting point of iron

During this time....the heavier elements, including the melted iron, began to sink down into the core of the Earth, while the lighter elements such as oxygen and silica floated up towards the surface



Density stratification

Crust forms

What is density ?

Mass per unit volume

g/cm^3

Water: 1.00 g cm⁻³

Glass: 2.50

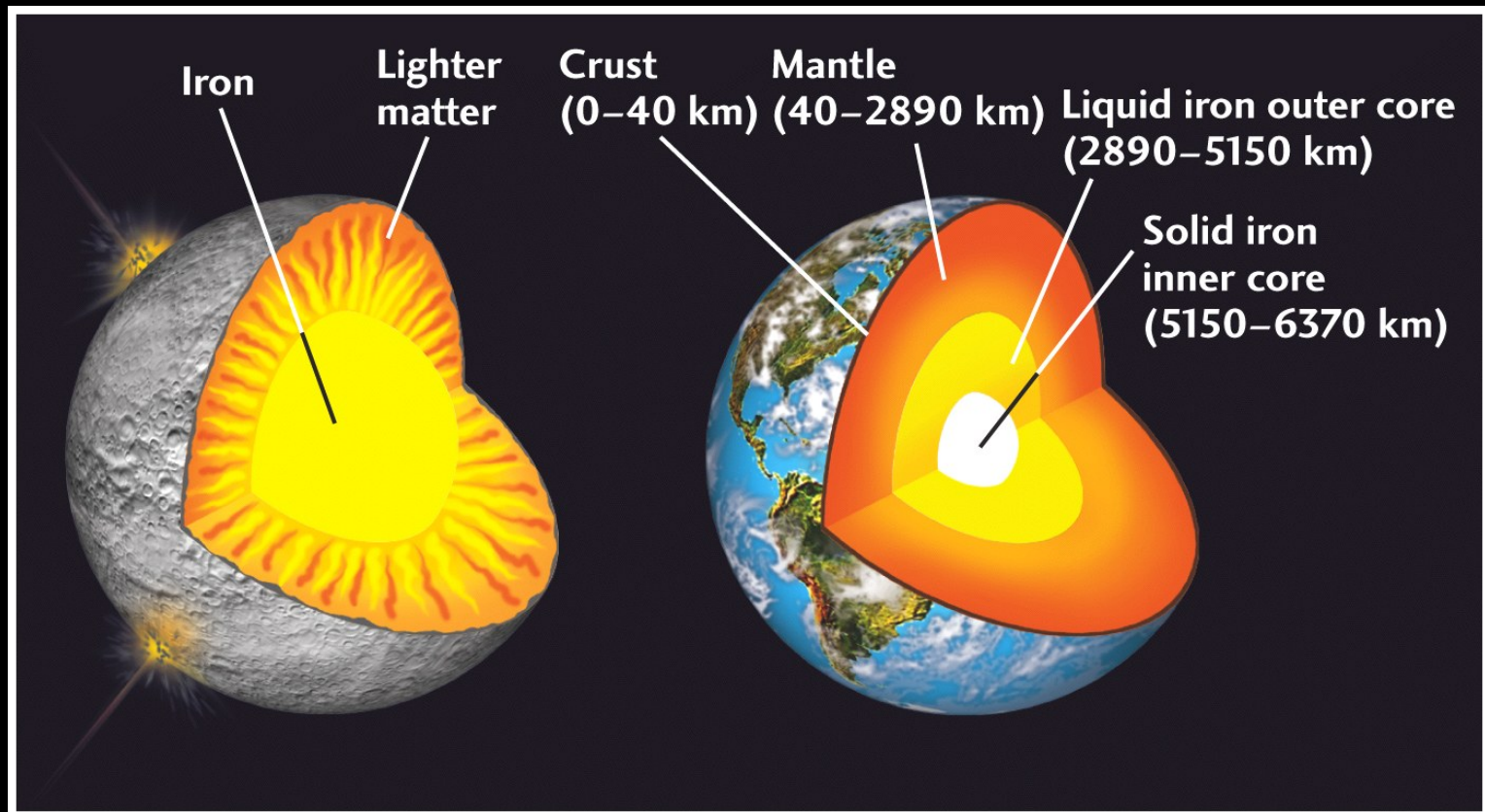
lead: 11.34

mercury: 13.54

gold: 19.30

Global Chemical Differentiation

Chemical separation was completed by about 4.3 billion years ago, and the Earth had developed an inner and outer core, a mantle and crust

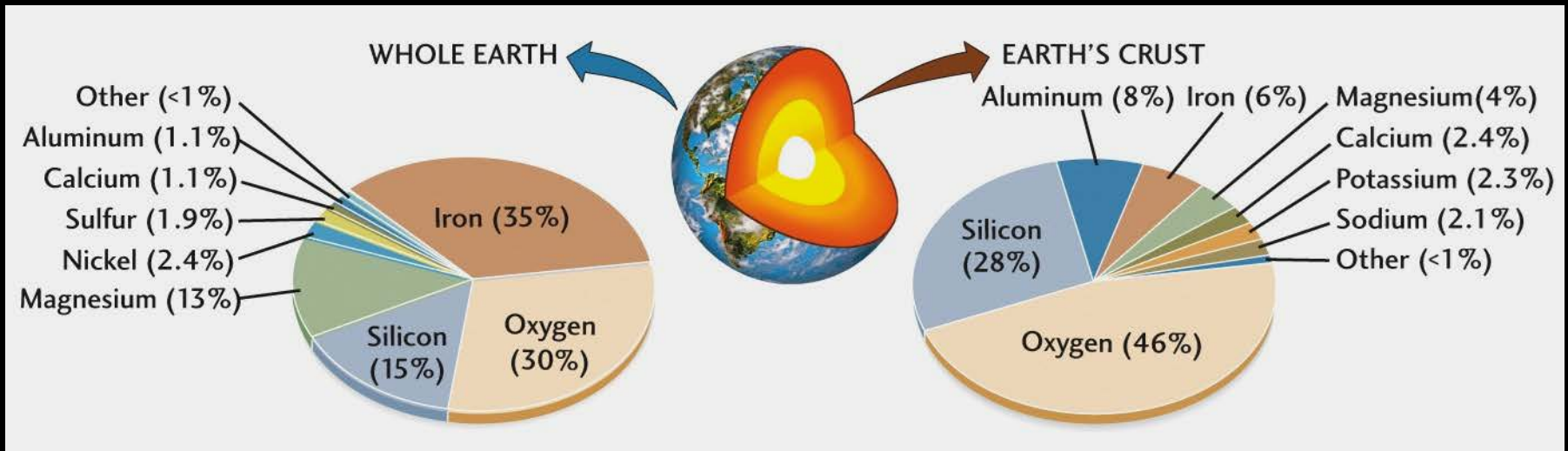


Chemical Composition of Earth

Each of the major layers has a distinctive chemical composition, with the crust being quite different from the Earth as a whole

Whole Earth:
 $\text{Fe} + \text{O} + \text{Si} + \text{Mg} = 93\%$

Crust:
 $\text{Si} + \text{O} + \text{Al} = 82\%$





PROTO-EARTH: 4.5 billion years agoThe sky above a still-forming proto-Earth is filled with the dust, rocks and gas that are shaping our solar system. A rising proto-sun illuminates the dust and rocks that gravity brings hurtling toward this new planet. The first comets, scattered by the gravity of the giant outer planets, appear in our sky.



EARLY EARTH: 4 to 4.5 billion years ago - Our recently formed moon rises in the night sky. Not in its final orbit yet, the moon is seen much larger in the sky than today's moon. Magma flow from mare volcanism can be seen on its surface. Three comets, or water-rich asteroids, begin their descent into Earth, delivering with them a supply of frozen water.

From *Scientific America* (2/25/2008), by Lawrence M. Krauss and Robert J. Scherrer

Formation of the Moon

The Giant Impact Hypothesis –

~ 50 million years after the initial creation of Earth, a planet about the size of Mars collided with Earth

This idea was first proposed about 30 years ago, but it took calculations by modern high-speed computers to prove the feasibility

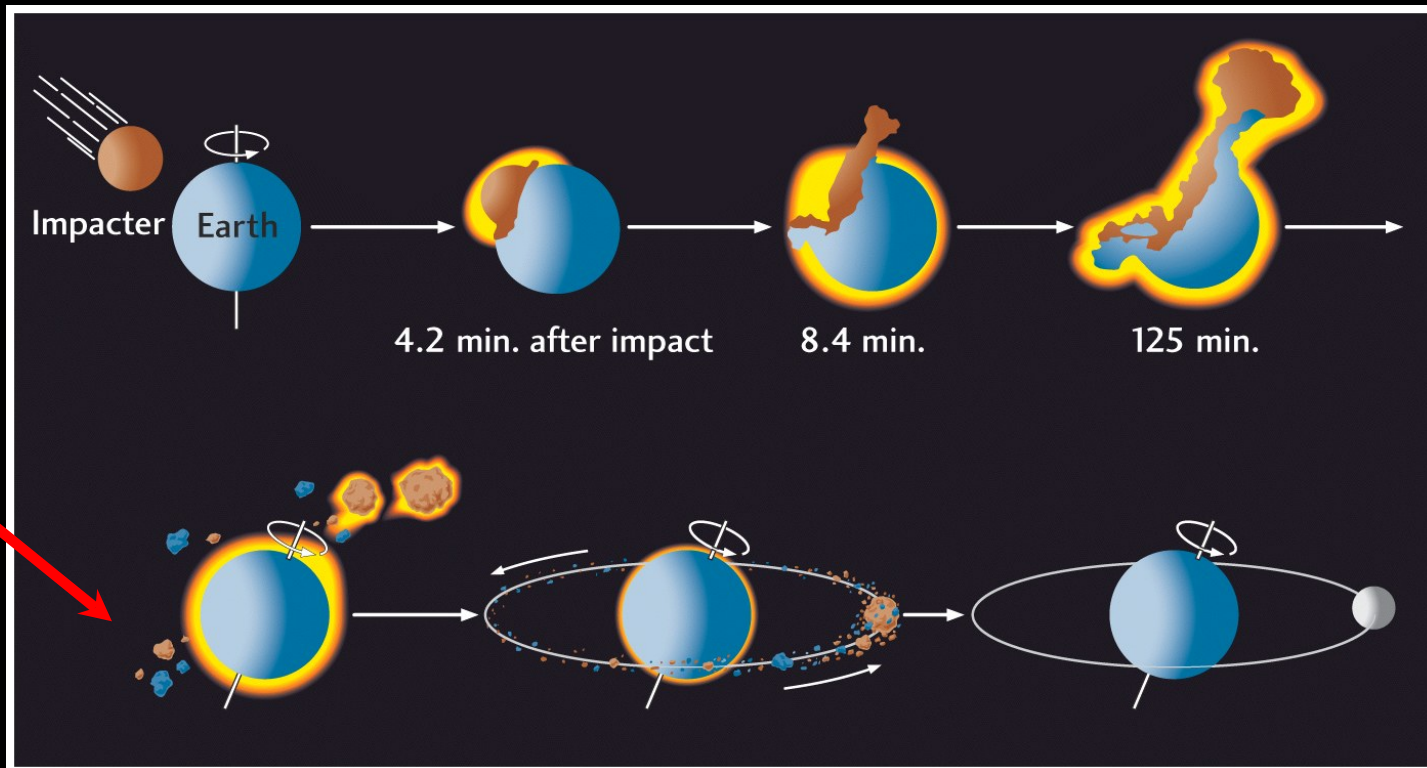


Formation of the Moon

- Evidence

- 1. moon rock is younger than other celestial bodies (~ 30-55 million years)
- 2. similar composition to earth
- 3. moon is less dense than earth and other planets.....

- So no iron core.



23.5°

Origin of Earth's atmosphere

- **Partial melting resulted in outgassing about 4 billion years ago**
 - **Similar to gases emitted from volcanoes**
 - **Mainly water vapor**
 - **Carbon dioxide, hydrogen**
 - **Other gases such as methane and ammonia**



An aerial photograph of the ocean, showing a vast expanse of blue water with white-capped waves. The horizon is visible in the upper third of the frame, with a bright, hazy glow from the sun or moon. The sky is a clear, deep blue.

Where did the Ocean come from ?

-two sources of water

-Outgassing

-Comets

Origin of Earth's oceans

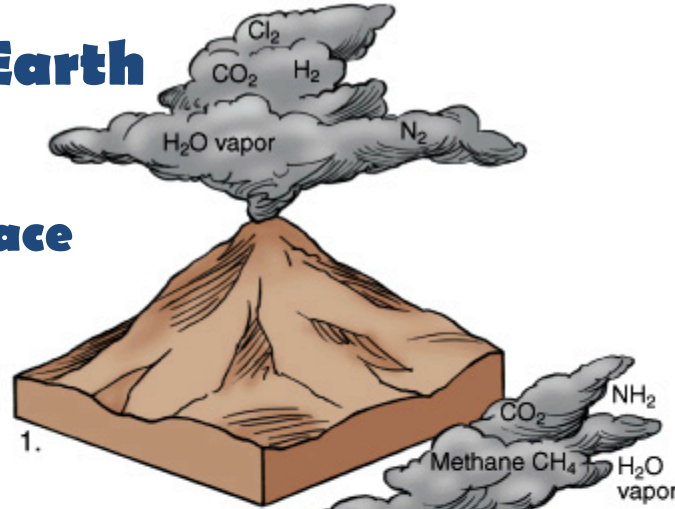
- **Water vapor released by outgassing**
- **Condensed as rain**
- **Accumulated in ocean basins**
- **About 4 billion years ago**

- *Ice Comets were (maybe) also important to adding water to the Earth system*

Formation of the Atmosphere and the Ocean

Early Solid Earth

Very Hot Surface

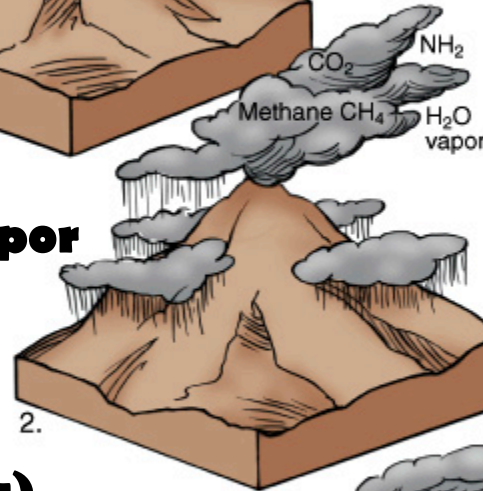


**Little or no
Atmosphere
And no Ocean**

**Outgassing
(Icy Comets)**

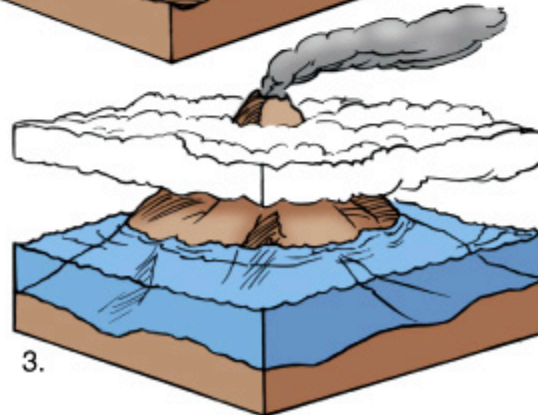
Condensing Water Vapor

Thick Clouds



Heavy Rain (~20 my)

**As Earth cooled
Oceans formed
4 bya**



PLANET WATER

- **70.8% OF EARTH IS COVERED BY WATER**
 - **97% in SW of oceans and seas**
 - **2% FW Lakes and rivers**
 - **1% snow and ice as glaciers**
 - **0.00057% - atmospheric water.**

Where did life on earth come from?

Maybe first – What is life?

- a) Homeostasis
- b) Organization
- c) Metabolism
- d) Responds to stimuli
- e) Adapts
- f) Reproduces
- g) Growth

Where did life on earth come from?

Maybe second– What is required for life?

a)Water – essential to all living things

b)The right temperature range

c)Renewing crust! (CHNOPS)

d)Atmosphere (why?)

e)Stable energy source

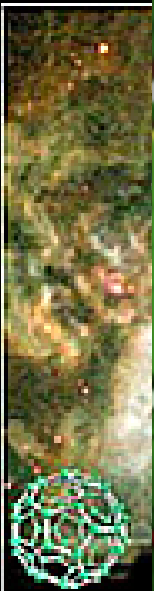
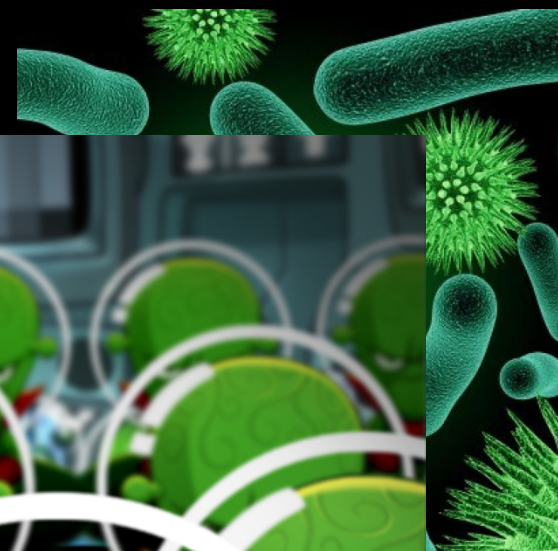
Ok – so where did life on earth come from?

Different ideas..... But 3 main ones

1. Panspermia

2. Frozen Ocean Theory

3. Hydrothermal Vents

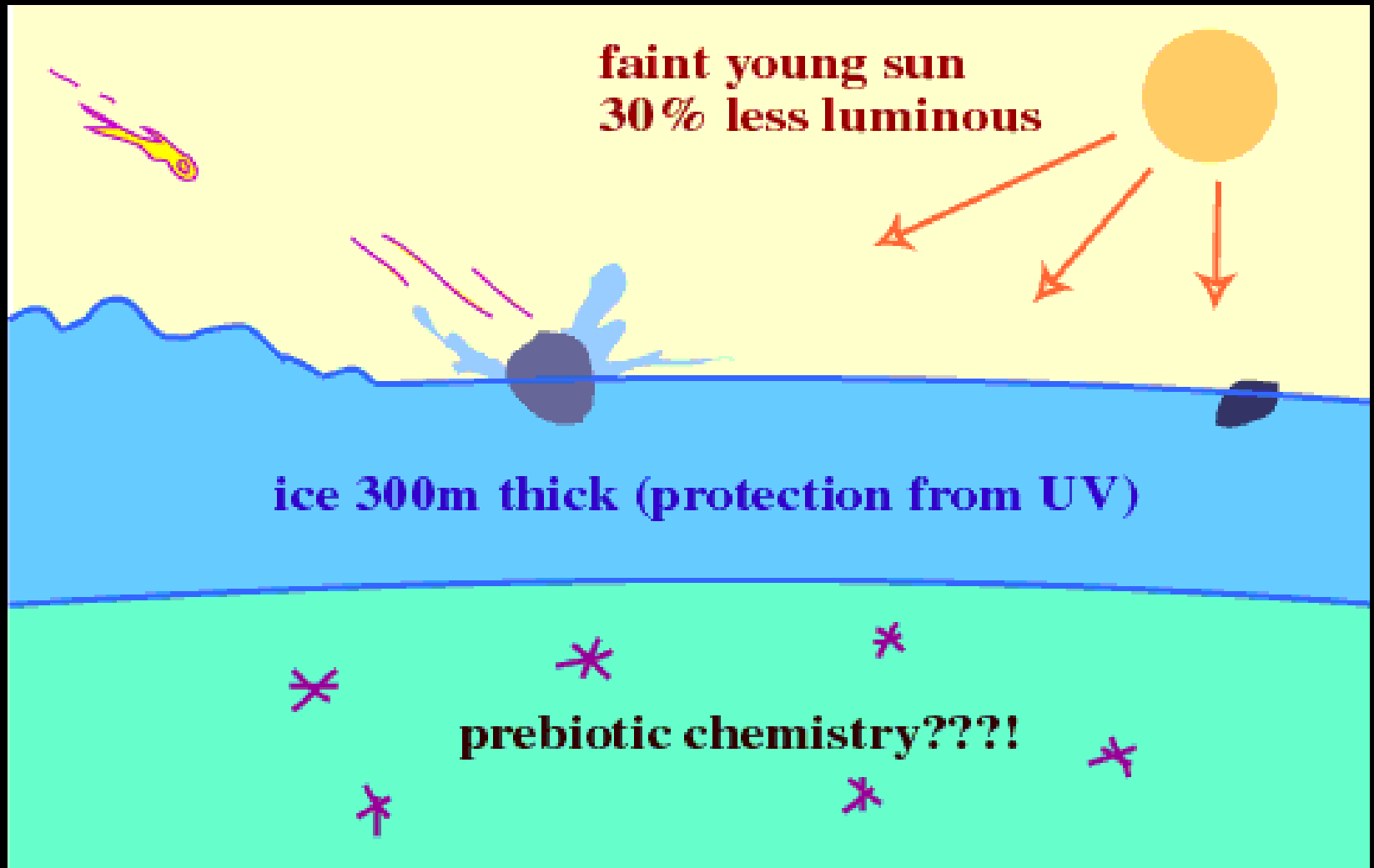


FULLERE

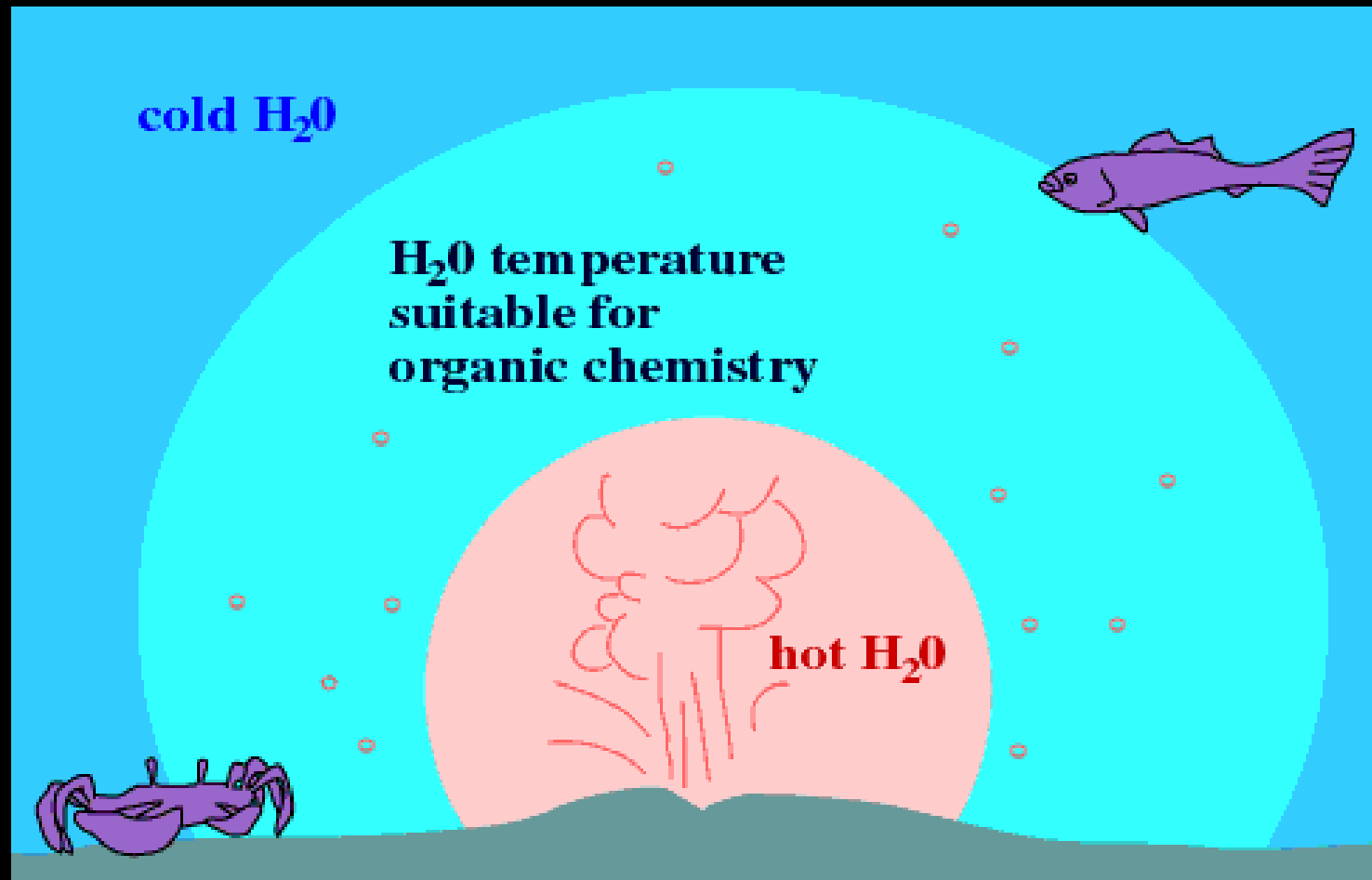
R.R. Infante '99

ACETYLENE

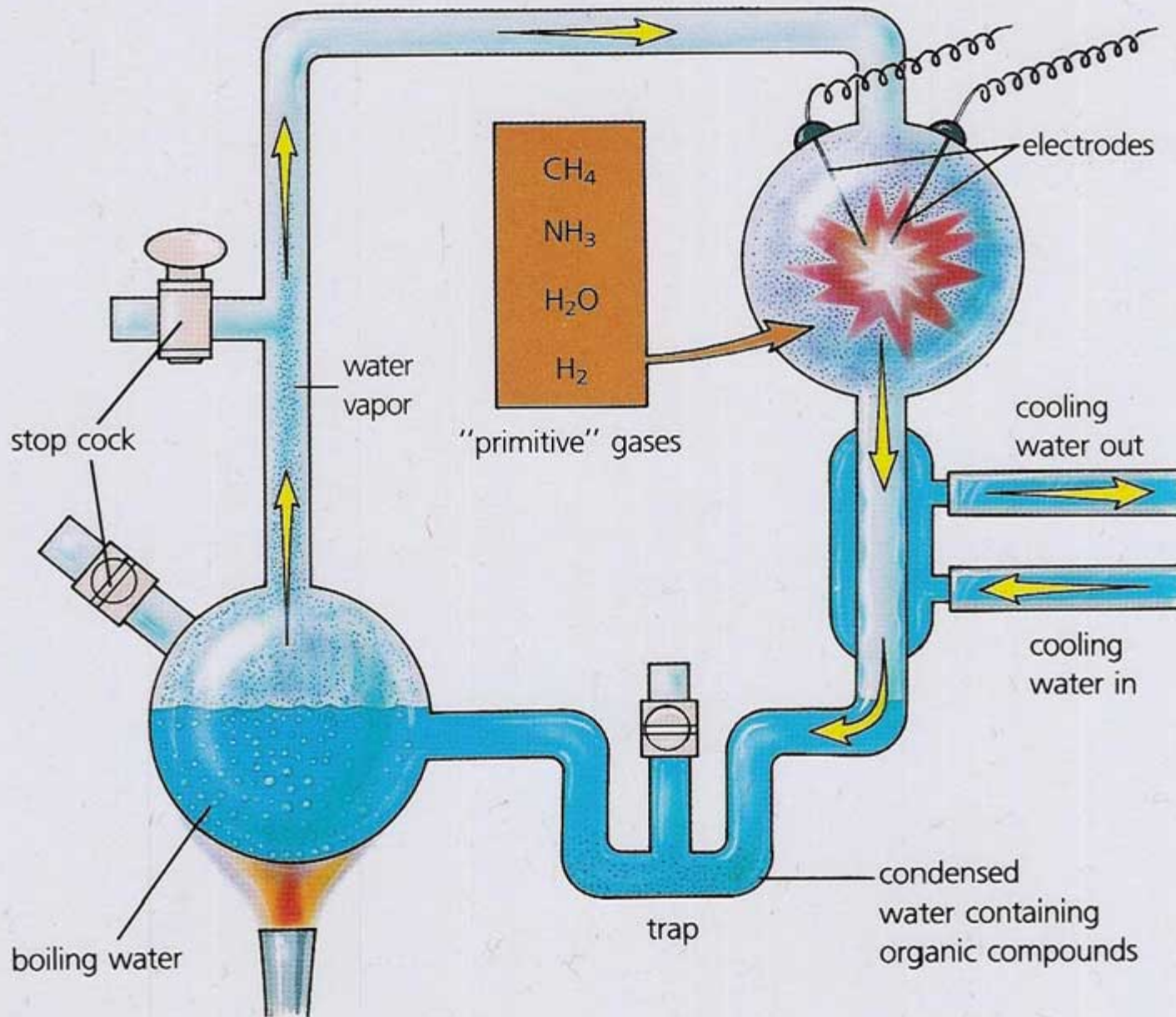
Frozen Ocean Theory



Hydrothermal Vents



18. Stanley Miller's Experiment



QUIZ

- Name 3 of the six critical elements needed for life?