“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……

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

C, H, O, N, P, S

-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.

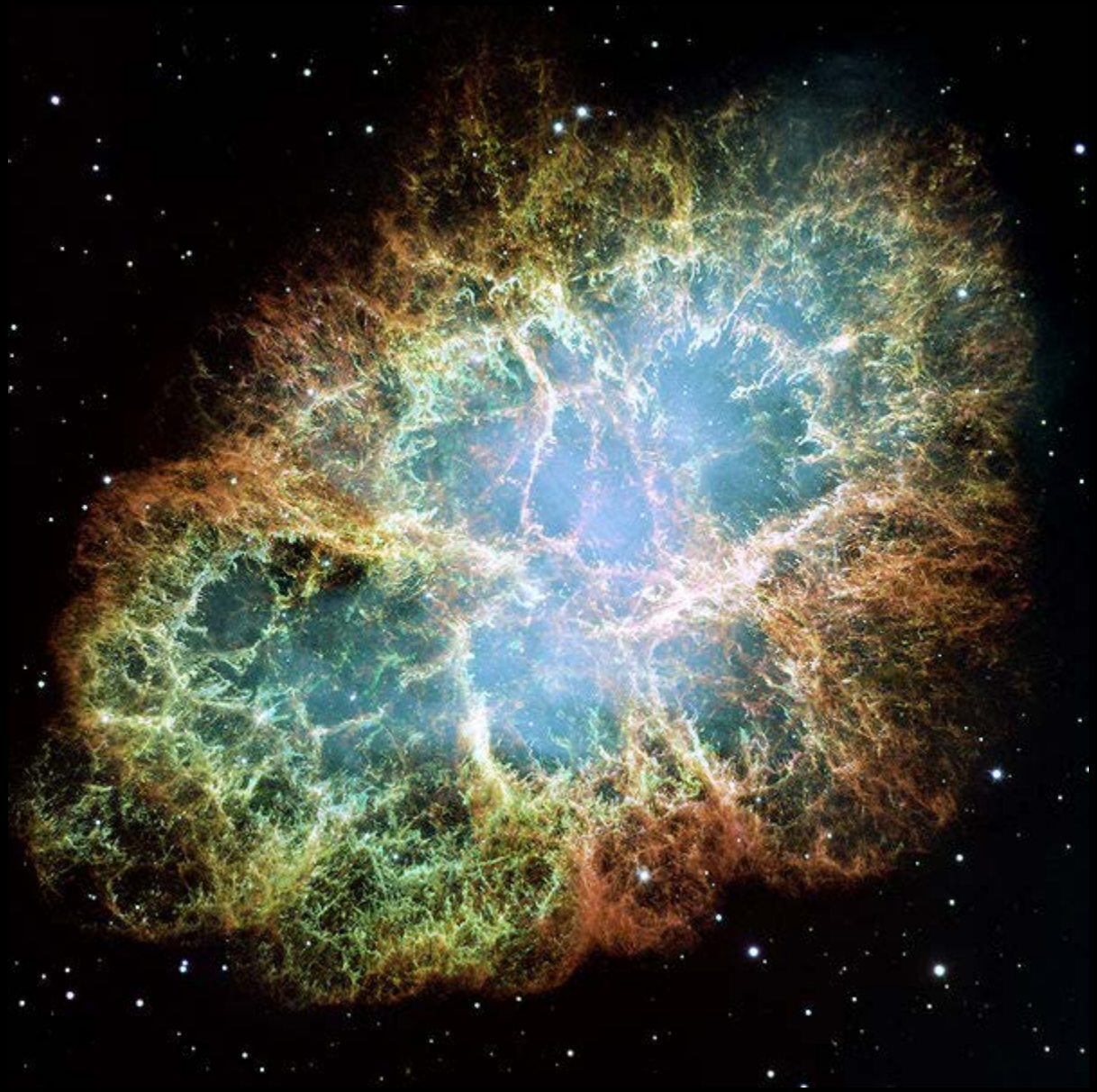
  Carbon = 12.001; Nitrogen = 14.007

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

Carbon-12 = 6 protons + 6 neutrons

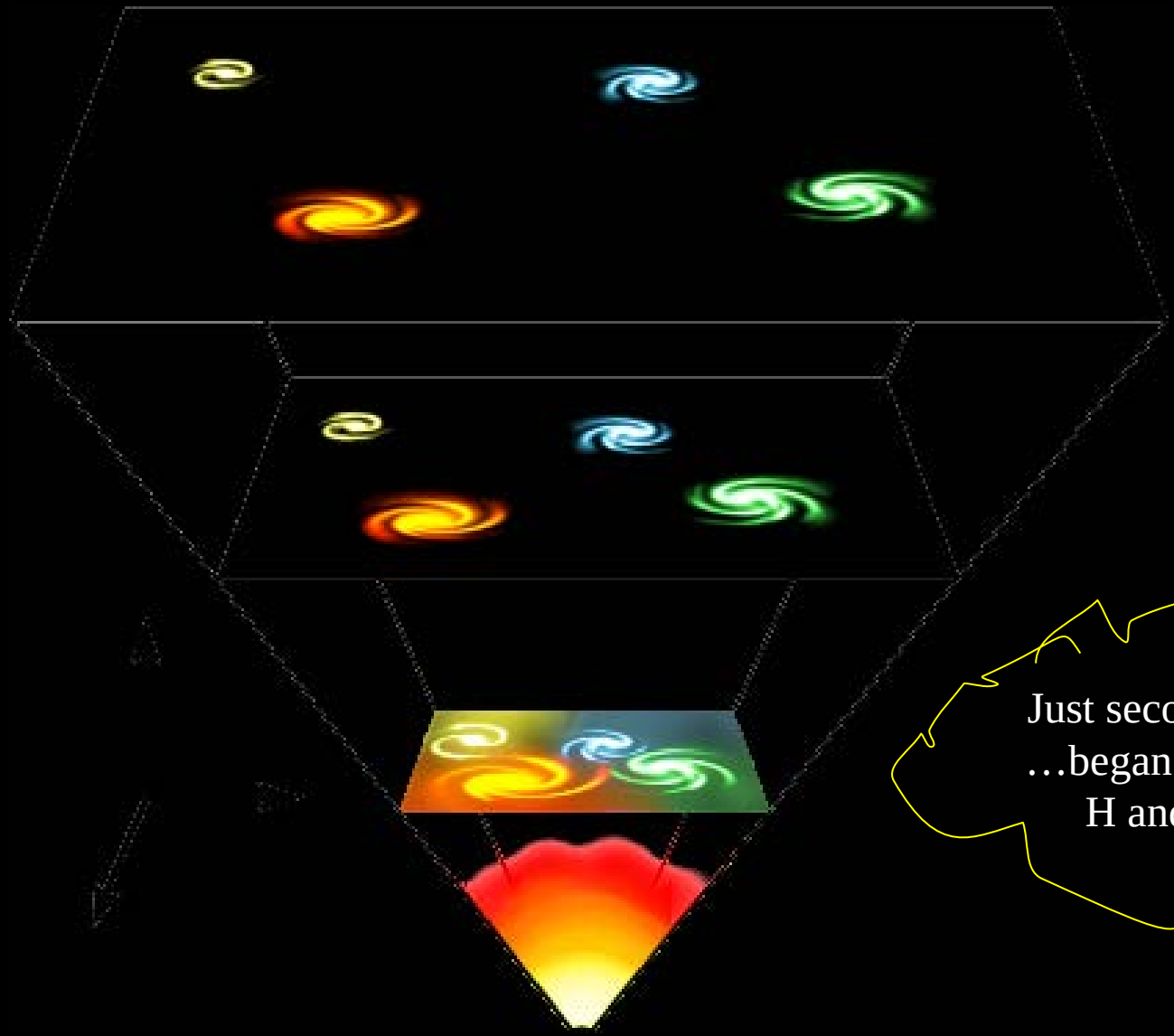
Carbon-14 = 6 protons + 8 neutrons

Periodic Table of Elements



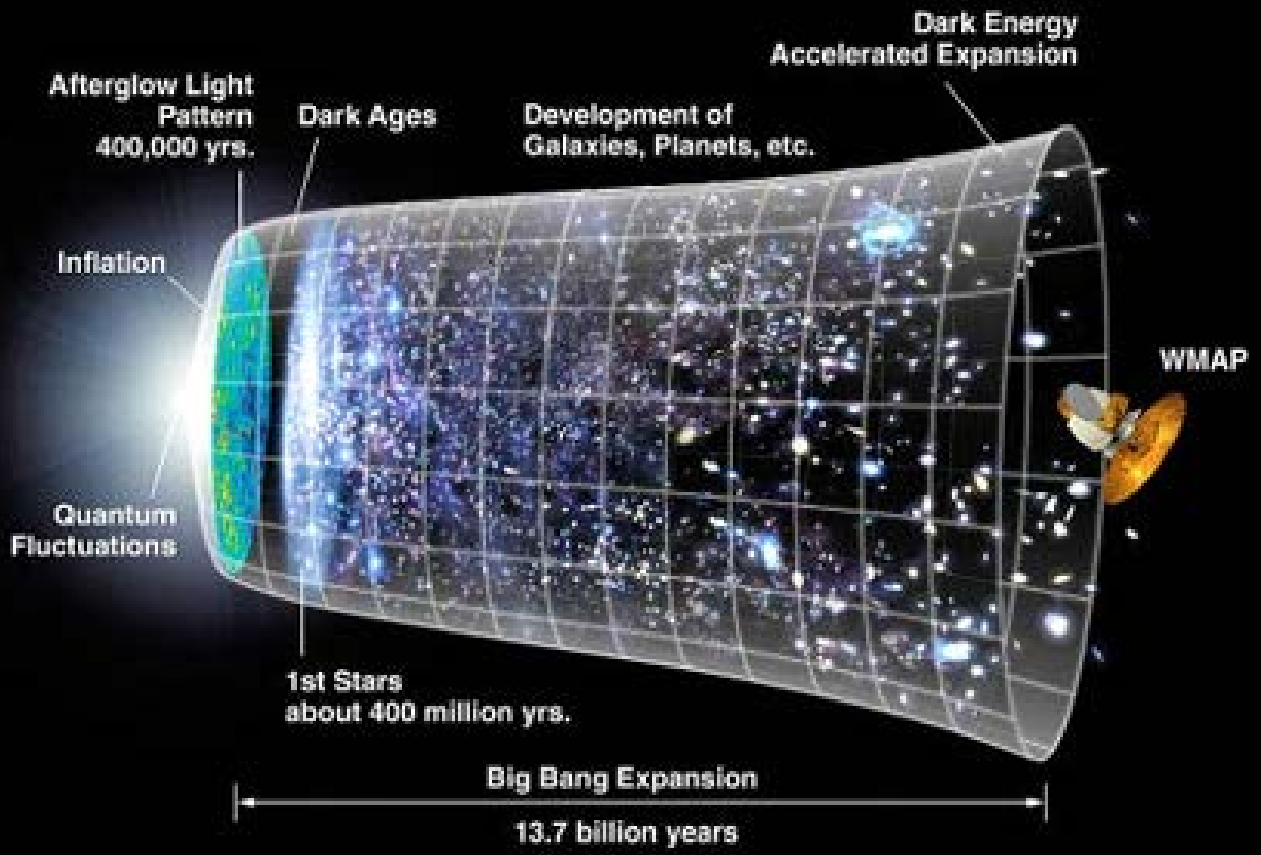
NASA's Hubble Space Telescope of the Crab Nebula

~ 13.7 billion years ago (bya)



Just seconds old
…began to form
H and He

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

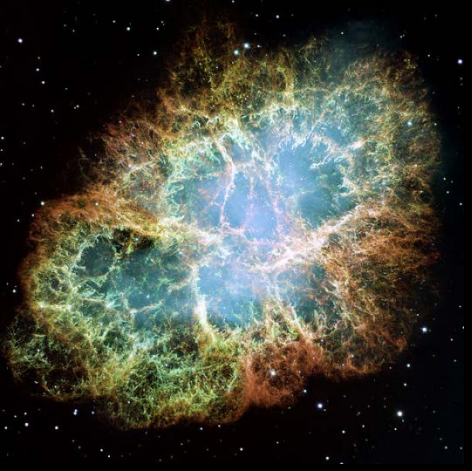


It’s speeding up….

One BILLION years later……..

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

This is called Stellar Nucleosynthesis……



Temperature and Pressure

1. $^{4}He + {}^{4}He \rightarrow {}^{8}Be$

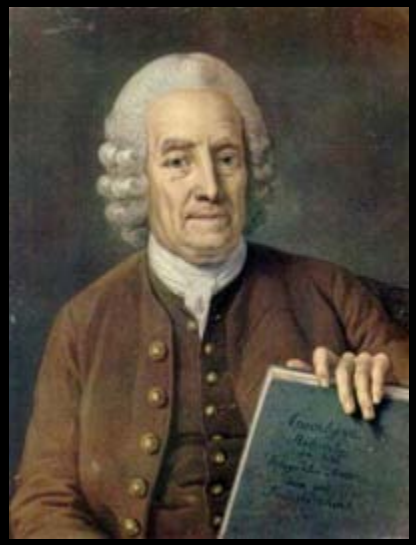
$\rightarrow {}^{8}Be + {}^{4}He \rightarrow {}^{12}C$

$^{12}C + {}^{4}He \rightarrow {}^{16}O$

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



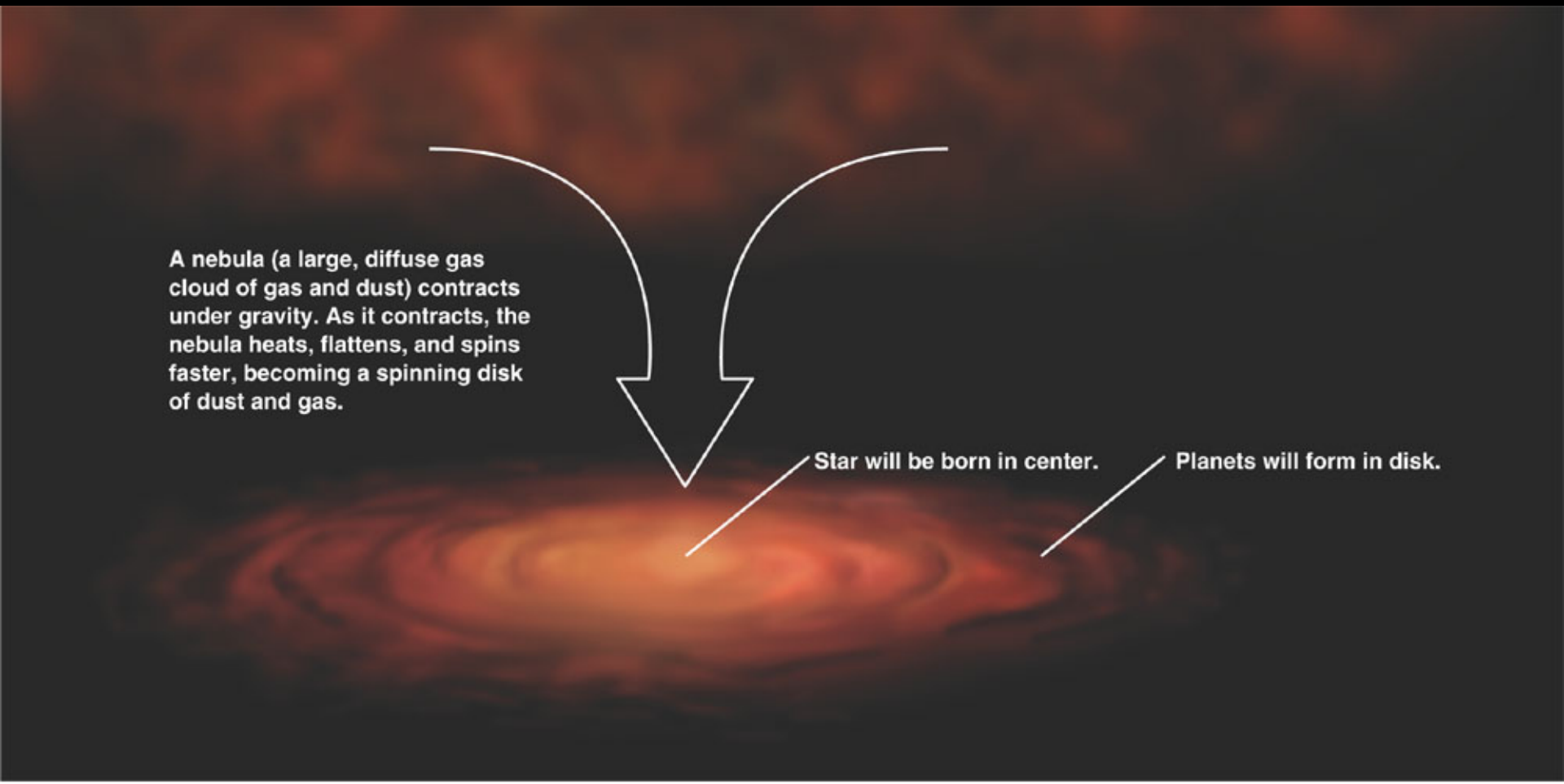
Emanuel Swedenborg

1734

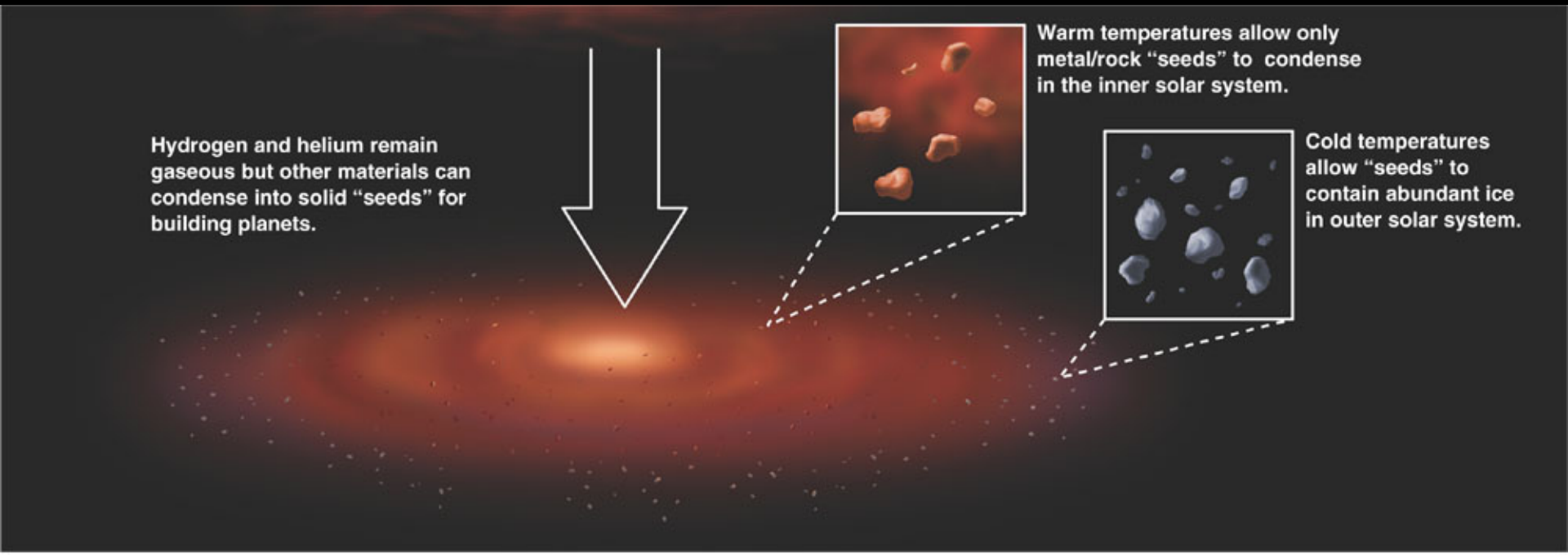
Today

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

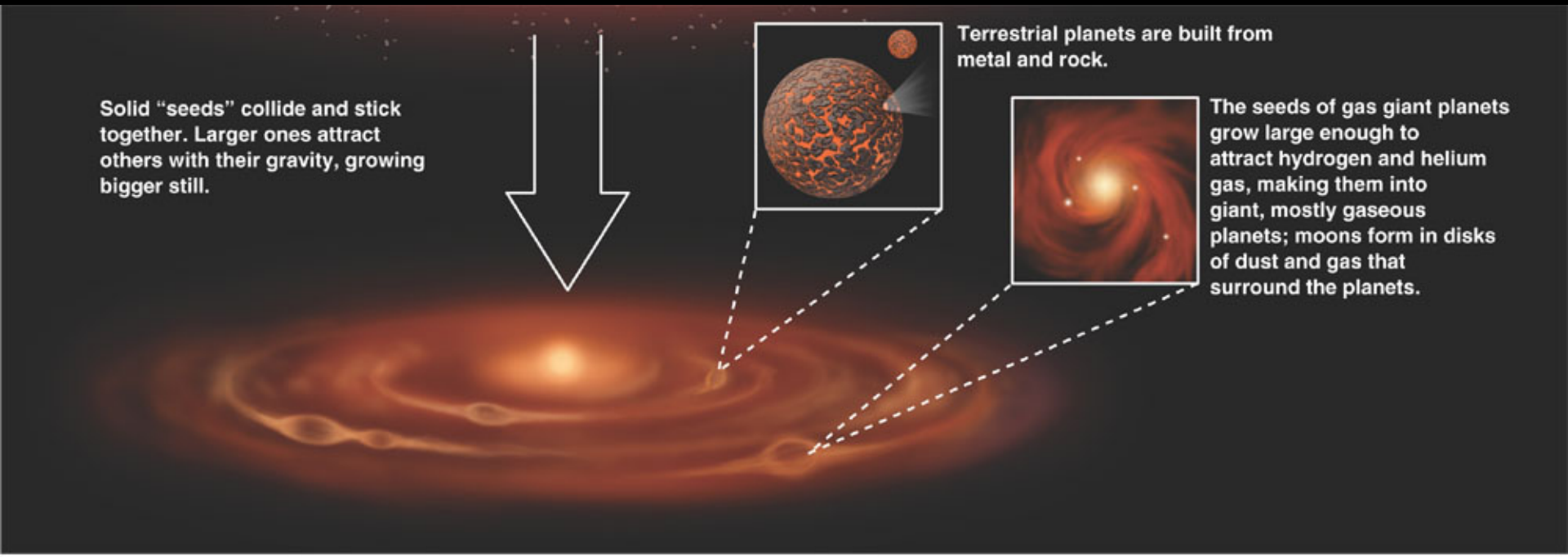
Formation of a Solar System



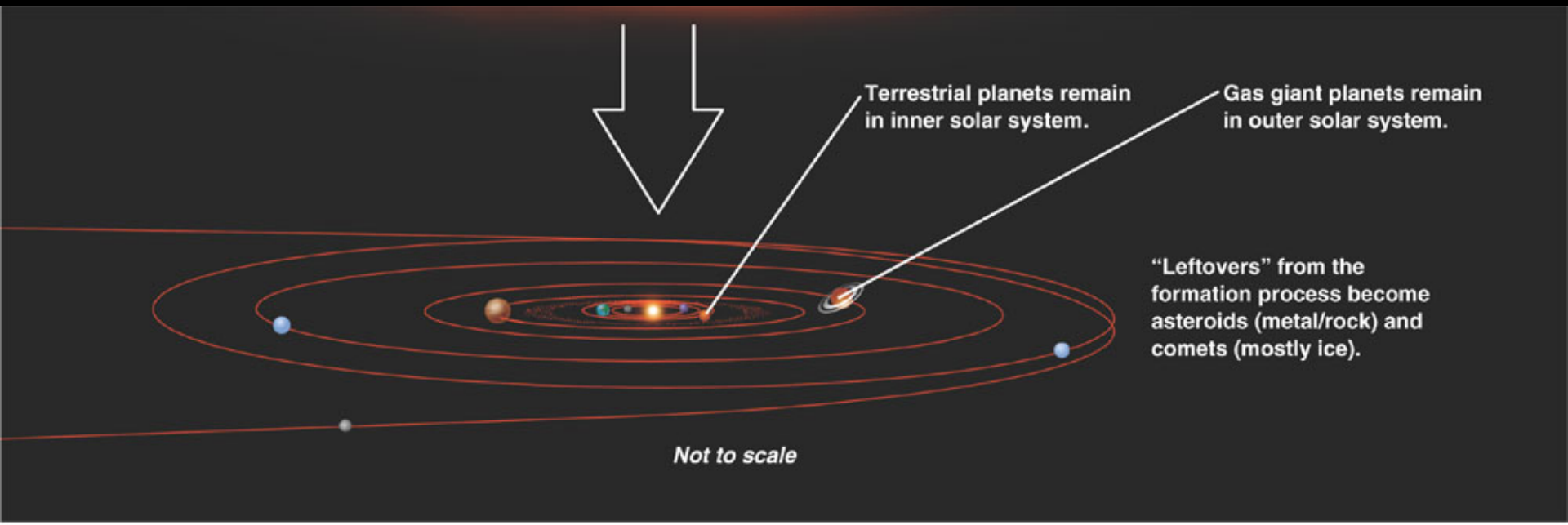
Heavier Elements Drawn to Center by Gravity

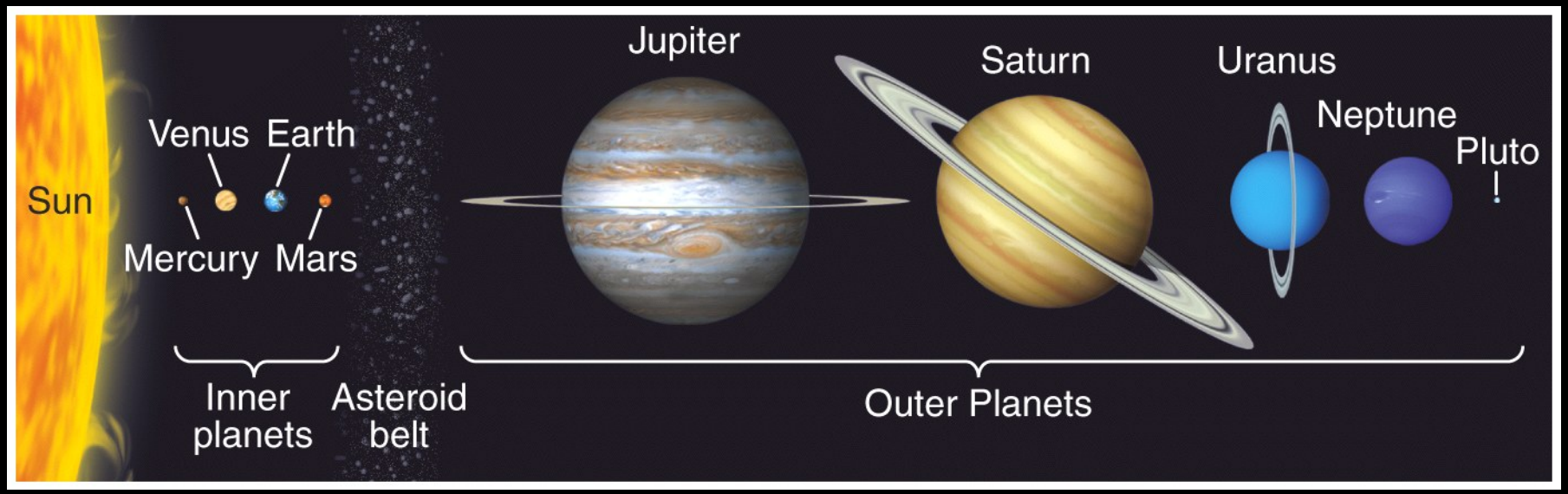


Formation of Protoplanets



Our Solar System




Sun
Venus
Earth
Mercury
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
!
Inner planets
Asteroid belt
Outer Planets

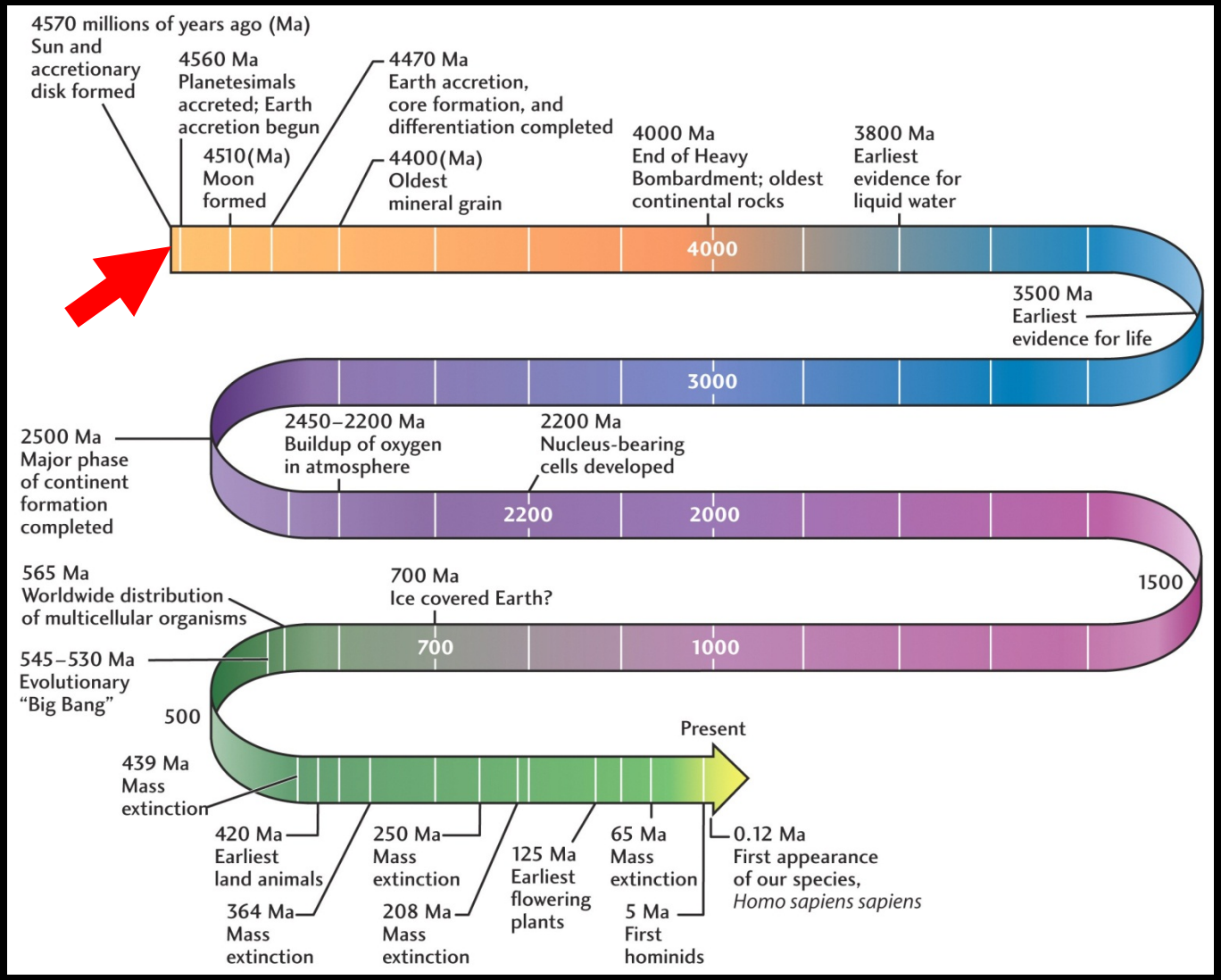
The Age of the Earth

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

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

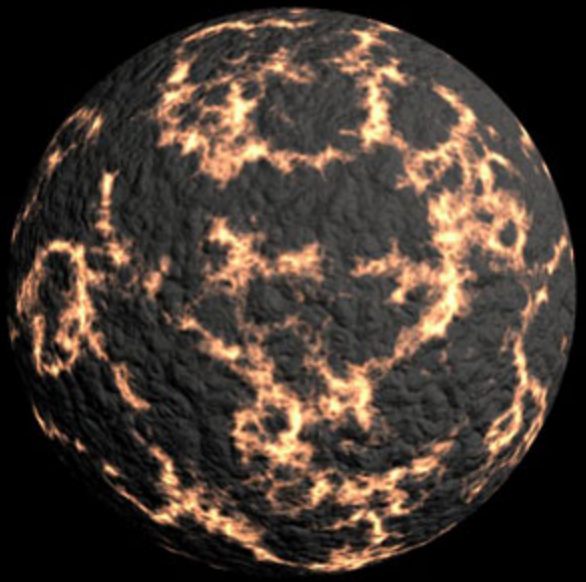
We can date meteorites using radioactive isotopes and their decay products

Geologic Time



The Early Earth Heats Up

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

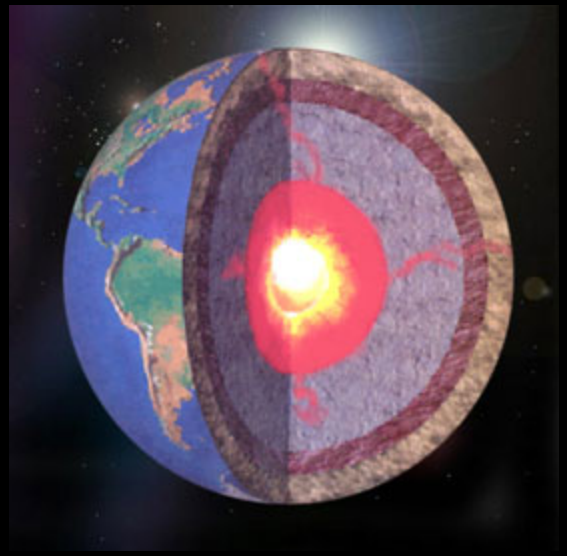


1. **Collisions (Transfer of kinetic energy into heat)**
2. **Compression**
3. **Radioactivity of elements (e.g. uranium, potassium, or thorium)**

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

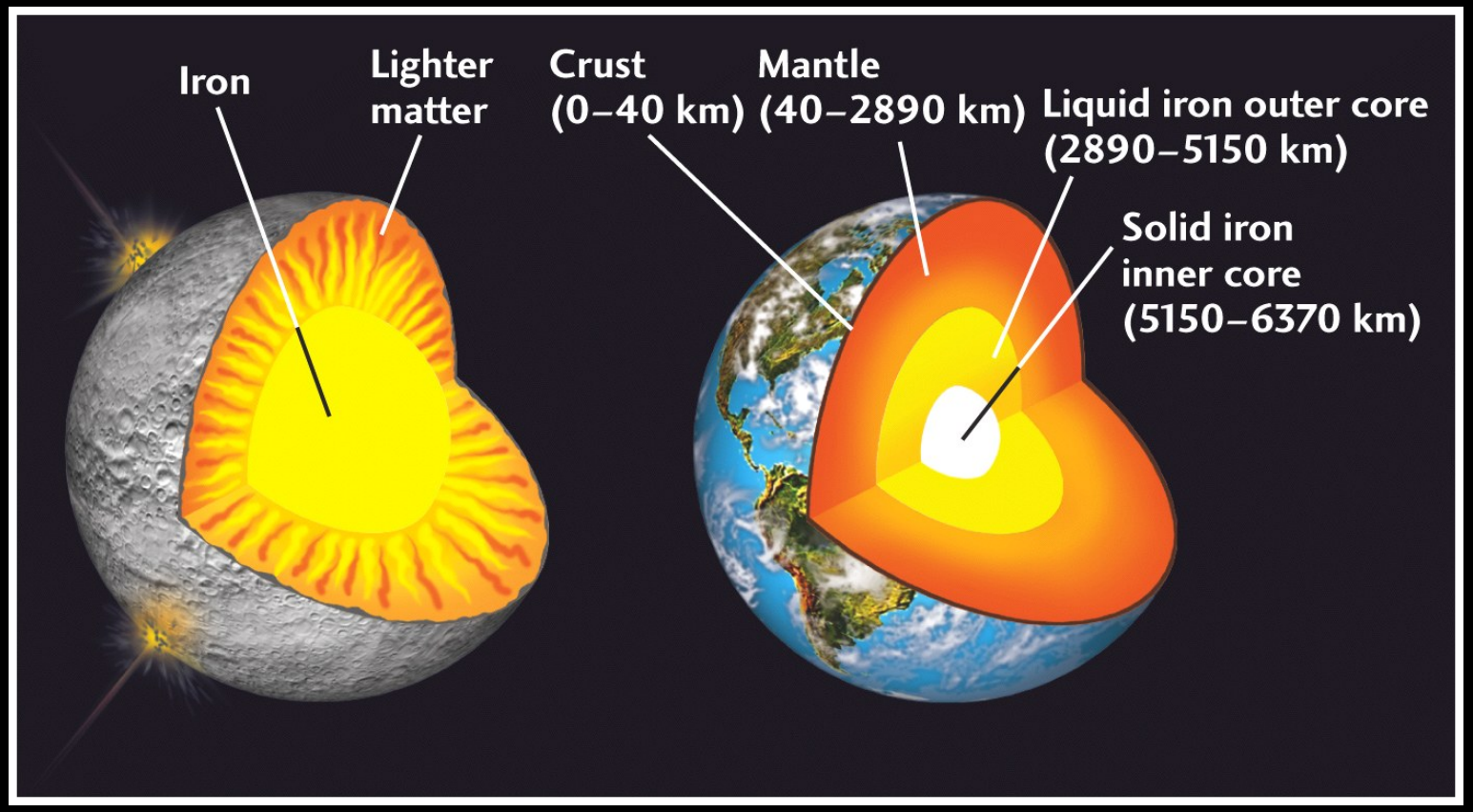
lead: 11.34

mercury: 13.54

gold: 19.30

Global Chemical Differentiation

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

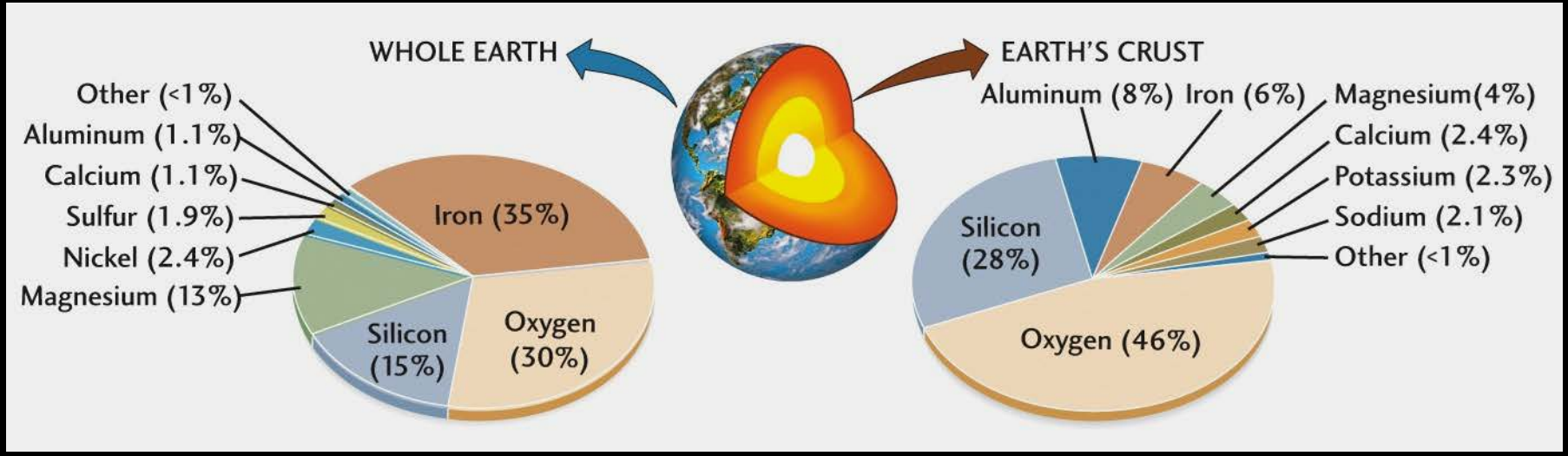


Chemical Composition of Earth

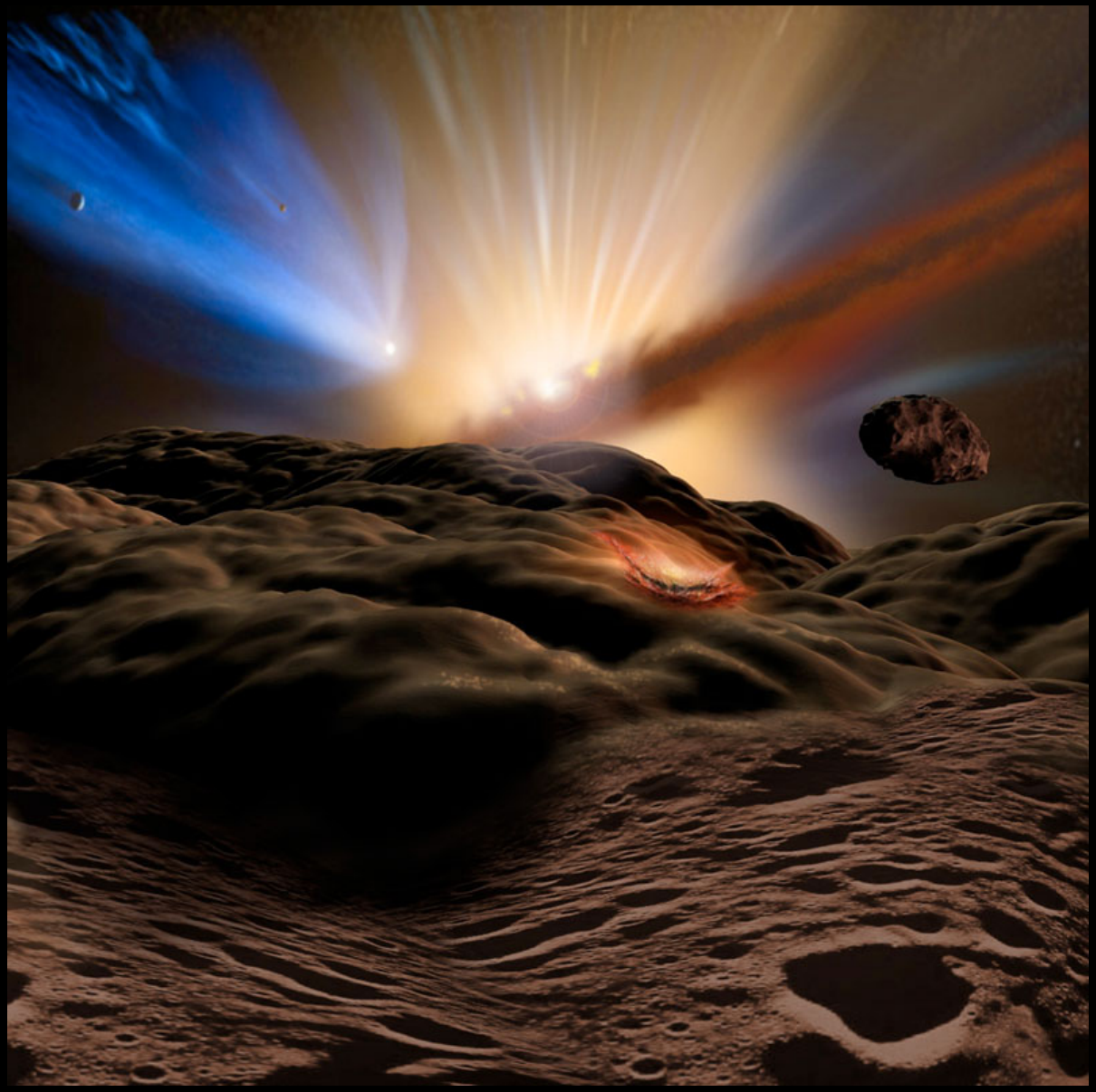
Each of the major layers has a distinctive chemical composition, with the crust being quite different from the Earth as a whole

Whole Earth:
Fe+O+Si+Mg = 93%

Crust:
Si+O+Al = 82%



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



PROTO-EARTH: 4.5 billion years ago The 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 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

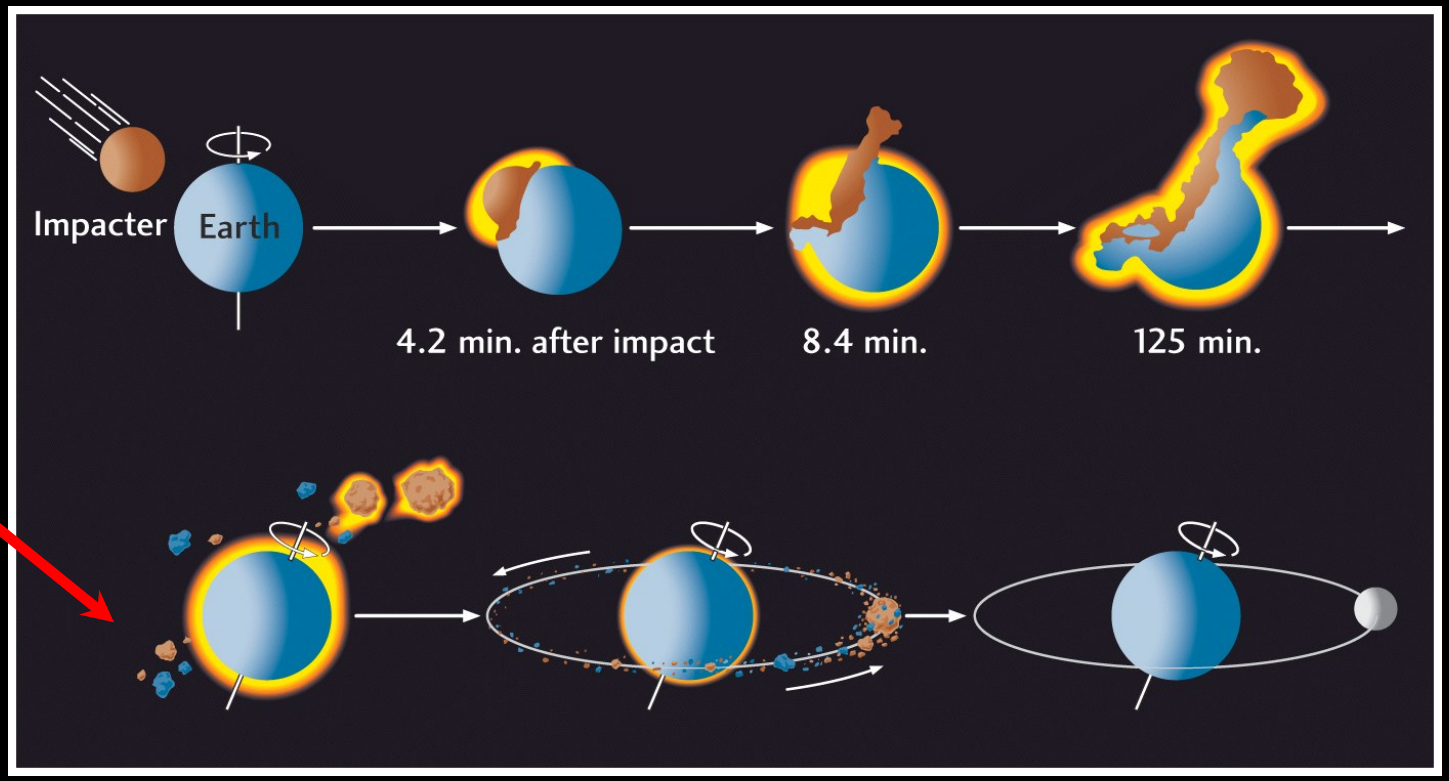
The Giant Impact Hypothesis –

~ 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.



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**

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

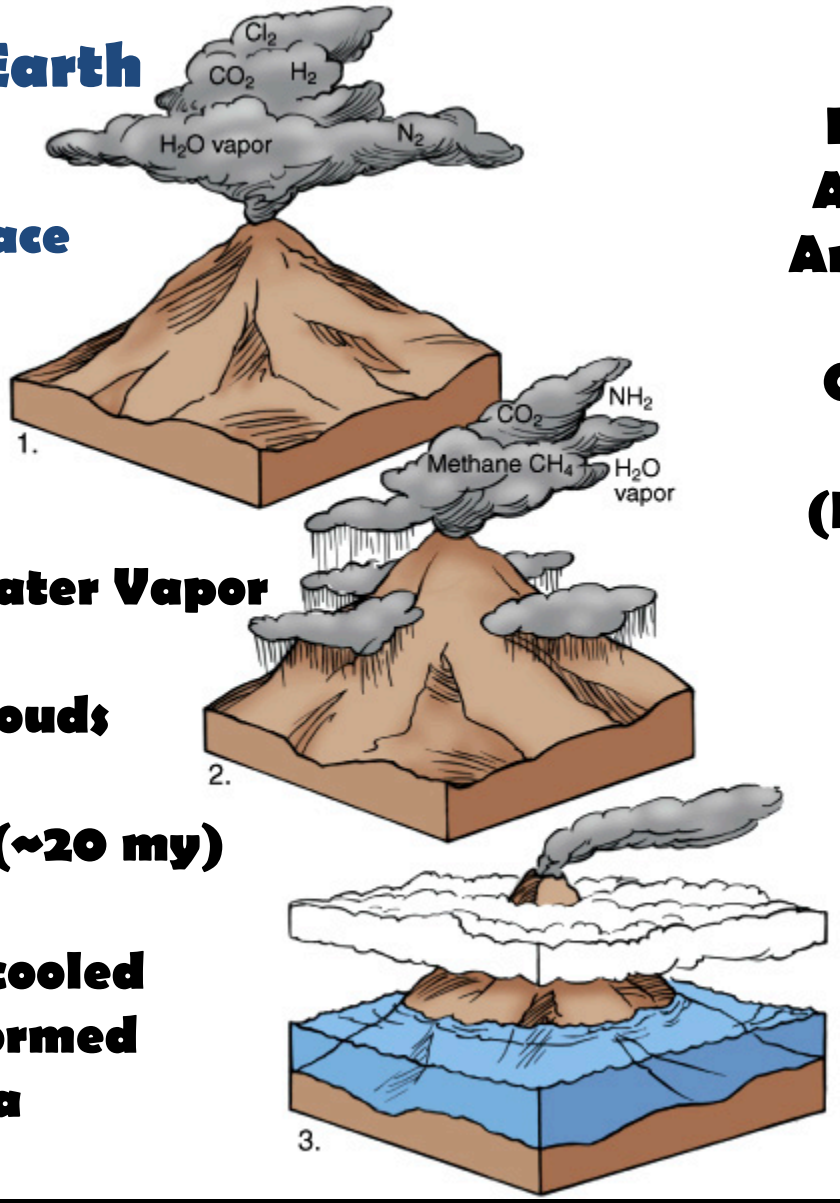
Early Solid Earth

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)

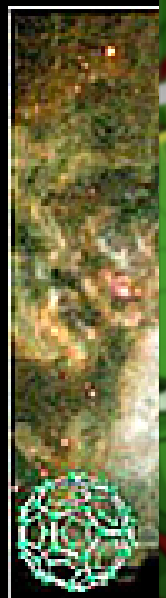
d)Atmosphere (why?)

e)Stable energy source

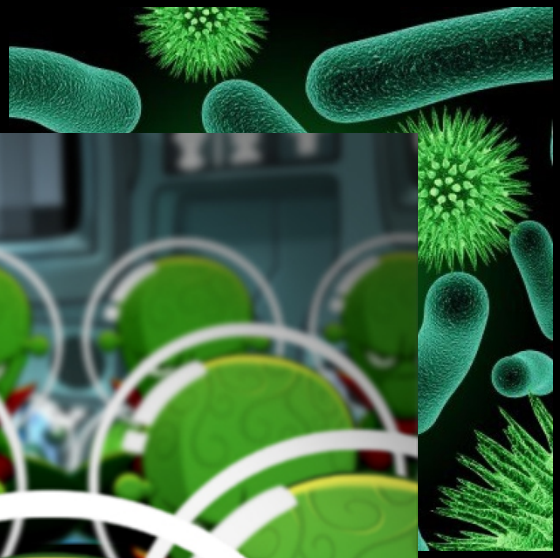
Ok – so where did life on earth come from?

Different ideas….. But 3 main ones

1. Panspermia
2. Frozen Ocean Theory
3. Hydrothermal Vents

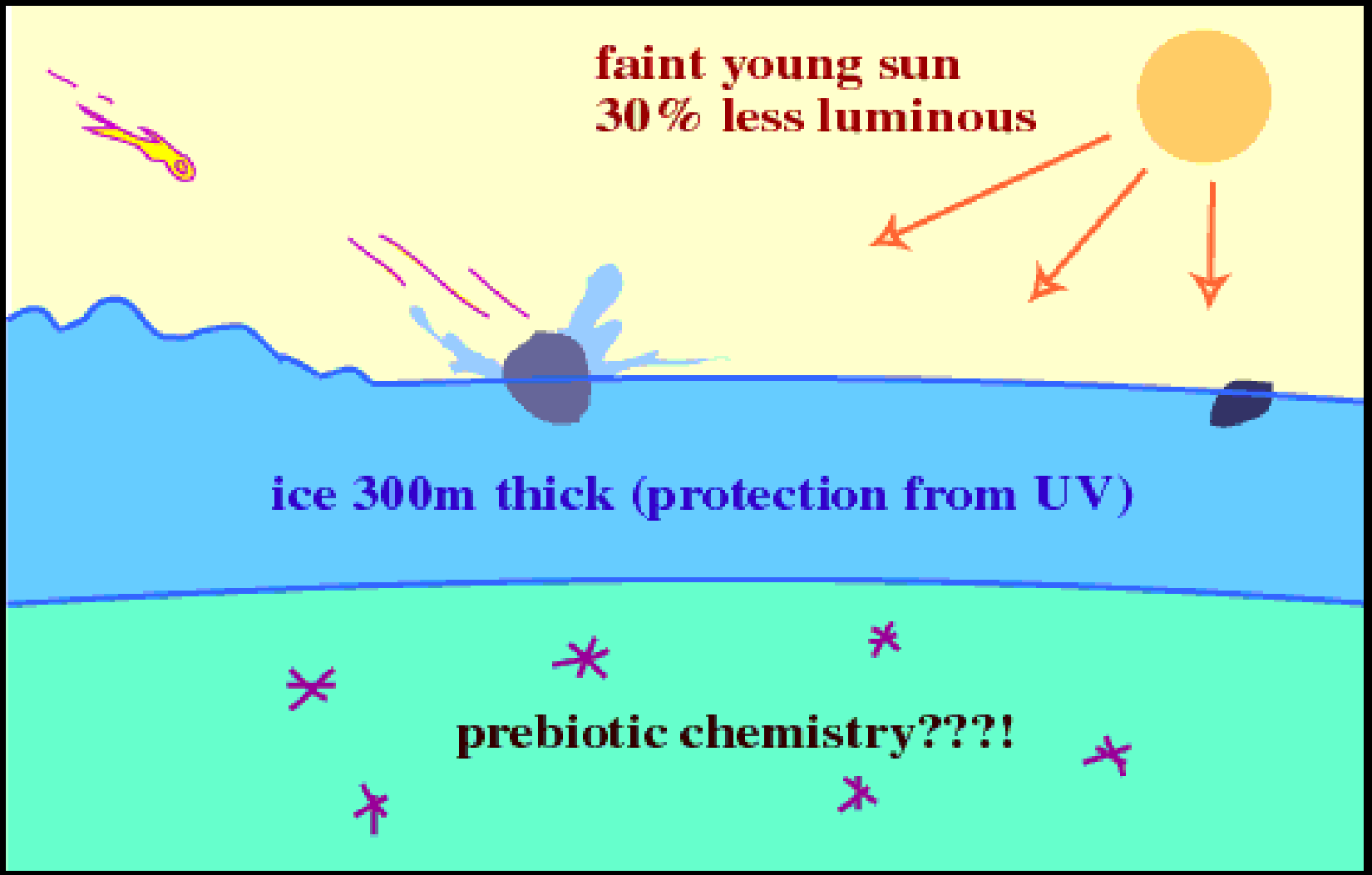


FULLERE

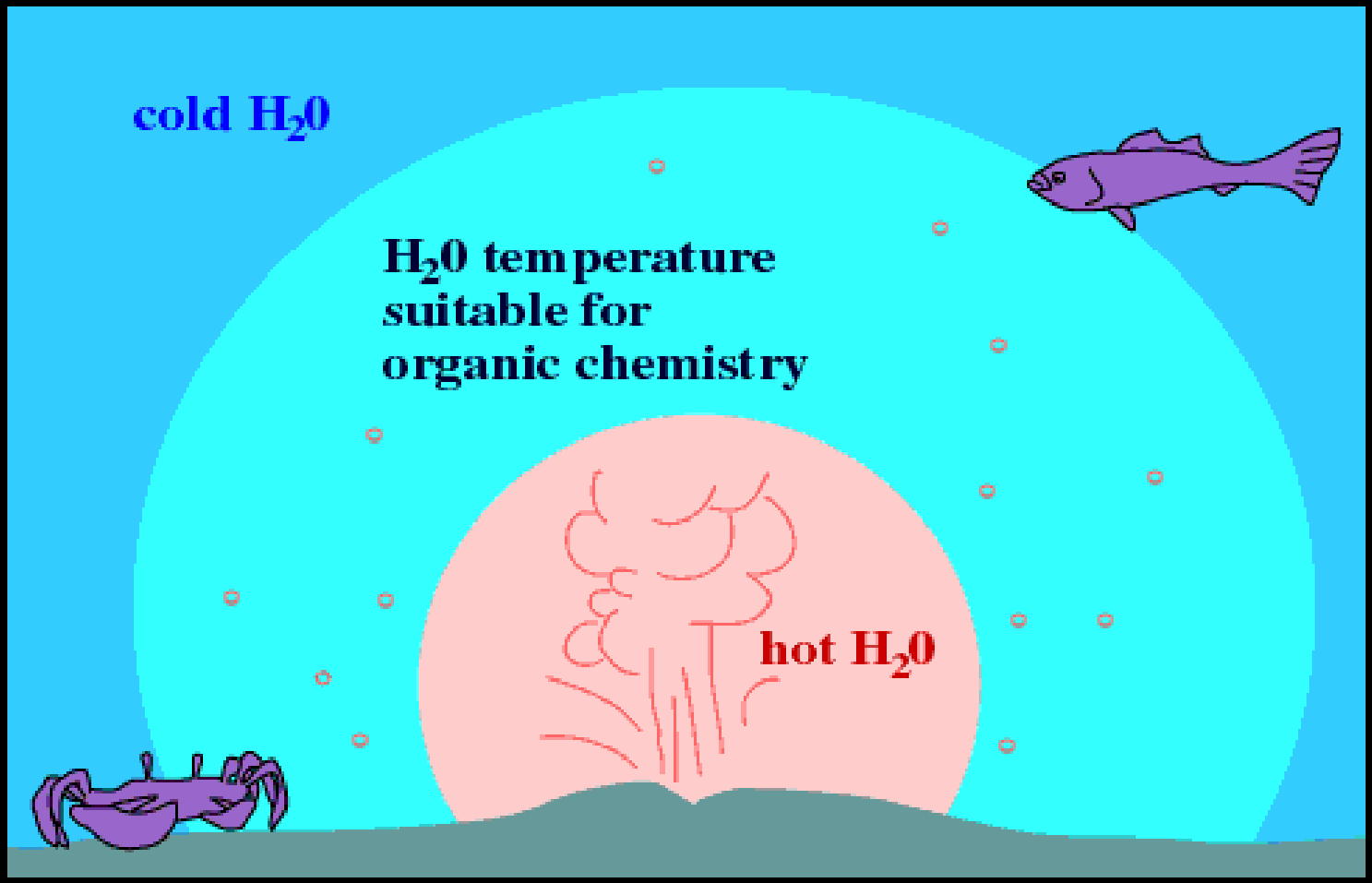


ACETYLENE

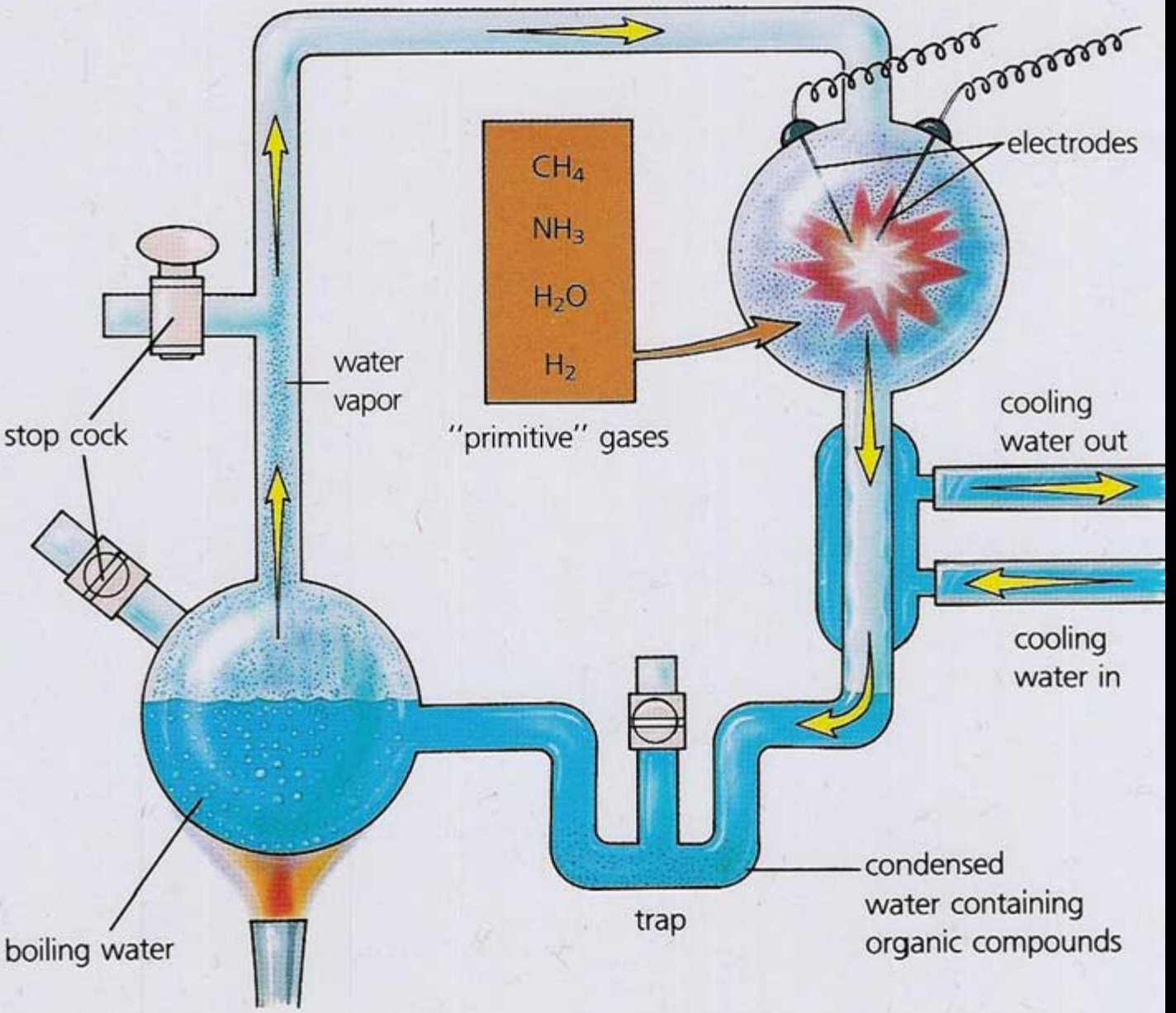
Frozen Ocean Theory



Hydrothermal Vents



18. Stanley Miller's Experiment



QUIZ

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