

MICROBIAL EVOLUTION

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PHYSICAL EVOLUTION OF EARTH

- ◎ **Big Bang** led to generation of our solar system and primitive Earth.
- ◎ 13.7 (+/- 0.17) billion years ago (Ba), this infinitely massive point-source exploded, very rapidly expanding the matter to ever-enlarging volume.
- ◎ Protons form (hydrogen ions) and neutrons form, then these merge to form the nucleus of helium.
- ◎ Slightly higher densities of hydrogen grew larger and clumpier until they coalesced via collisions to form stars ... and galaxies
- ◎ These stars gave rise to all the heavy elements via fusion reactions

- ◎ These disintegrating stars formed our solar system; most of the matter coalesced near the center to form Sol (our sun) and most of the remaining matter coalesced to form orbiting planetismals, then planetoids, then planets.
- ◎ **Planet Earth formed ~4.6 Ba (K40/Ar40 radiodating)**

- ◎ **primitive atmosphere**

- ◎ Iron exposed on the surface and would capture all molecular oxygen, so the primitive atmosphere would have consisted mostly of water, hydrogen, nitrogen, methane, and ammonia, with little carbon dioxide or monoxide.
- ◎ Most iron would have melted and flowed to the core, allowing oxygen to combine with carbon, and the primitive atmosphere would have consisted mostly of water, carbon monoxide and carbon dioxide, with some nitrogen, sulfides, methane and ammonia, but very little oxygen.

- ◎ **Liquid water** appeared on Earth's surface ~4 Ba as indicated by discovery of ~3.8 billion year-old sedimentary rocks (which require liquid water for their formation) in Greenland.
- ◎ Upon its release from volcanoes, water vapor expanded and cooled, then condensed and fell back towards the surface as rain.
- ◎ Because the crust was still very hot, rain evaporated before it reached the surface, resulting in continuing cycles of water expansion, cooling, condensation and rainfall, thus initiating the water cycle

- ◎ Because the rain was rather acidic (carbon dioxide, sulfur dioxide, etc. form acid when they dissolve in water) the flowing water (on its way to the lower elevation basaltic surface) dissolved some of the granitic material, generating salt water (the ocean is ~3% salt).

ORIGIN OF LIFE ON EARTH

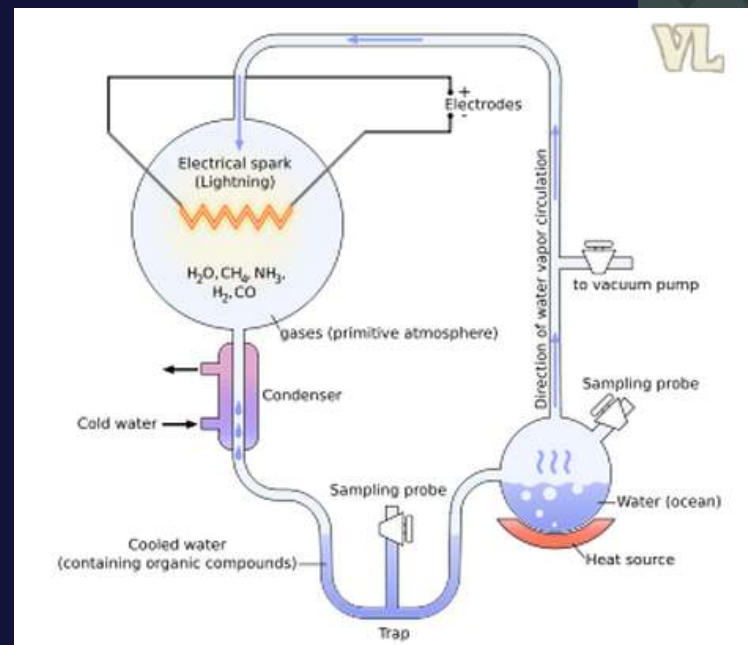
- ◎ **Primordial soup (solution) theories**
- ◎ Chemical reactions formed fatty acids, sugars, amino acids, purines, pyrimidines, nucleotides, and polymers of all these ~4.1 Ba when primitive (reducing) atmospheric gases were exposed to lightning and intense UV light while dissolved in the salty acidic water

- ◎ Pyrite theory - life started as a result of a metabolic process that could occur on iron pyrite surfaces.
- ◎ iron pyrite provides positive charges for bonding of phosphates, etc., thus fostering polymerization reactions.
- ◎ Polymerization of lipids formed semi-permeable membranes across which proton gradients could be generated and maintained, thus providing energy for synthetic reactions involving organic compounds generated either inside or outside of these membranes.

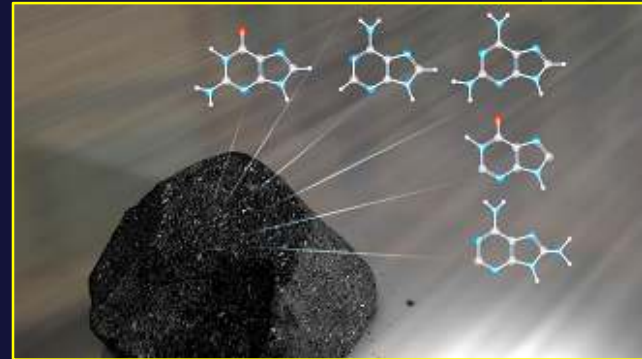
MILLER - UREY EXPERIMENT

- ◉ While evidence preserved in rock layers in present day Greenland tell us that life existed on Earth during that time it doesn't explain how it came to exist.
- ◉ The classic experiment demonstrating the mechanisms by which inorganic elements could combine to form the precursors of organic chemicals was the 1950 experiment by Stanley Miller.
- ◉ He undertook experiments designed to find out how lightning simulated by repeated electrical discharges might have affected the primitive earth atmosphere.

- ◉ He discharged an electric spark into a mixture thought to resemble the primordial composition of the atmosphere.
- ◉ In a water receptacle, designed to model an ancient ocean, amino acids appeared.
- ◉ Amino acids are widely regarded as the building blocks of life.



- Although the primitive atmosphere is no longer believed to be as rich in hydrogen as was once thought, the discovery that the Murchison meteorite contains the same amino acids obtained by Miller, and even in the same relative proportions, strongly suggests that his results are relevant.



AMINO ACID	MURCHISON METEORITE	DISCHARGE EXPERIMENT
GLYCINE	• • • •	• • • •
ALANINE	• • • •	• • • •
α -AMINO- <i>N</i> -BUTYRIC ACID	• • •	• • • •
α -AMINOISOBUTYRIC ACID	• • • •	• •
VALINE	• • •	• •
NORVALINE	• • •	• • •
ISOVALINE	• •	• •
PROLINE	• • •	•
PIPECOLIC ACID	•	•
ASPARTIC ACID	• • •	• • •
GLUTAMIC ACID	• • •	• •
β -ALANINE	• •	• •
β -AMINO- <i>N</i> -BUTYRIC ACID	•	•
β -AMINOISOBUTYRIC ACID	•	•
γ -AMINOBUTYRIC ACID	•	• •
SARCOSINE	• •	• • •
<i>N</i> -ETHYLGLYCINE	• •	• • •
<i>N</i> -METHYLALANINE	• •	• •

EARLY EVOLUTION OF ORGANISMS WITH INCREASING COMPLEXITY

- ◎ Fossils are prevalent in rocks formed during Precambrian time ... as early as the Archaean Era 3.8-2.5 Ba and continuing through the Proterozoic Era 2.5-0.543 Ba ... and up to current time.

BACTERIAL FOSSILS

- ◉ Stromatolites and oncolites -
- ◉ Oncolites are sedimentary structures composed of oncoids, which are layered structures formed by bacterial growth.
- ◉ The oncoids often form around a central nucleus, such as a shell fragment, and a calcium carbonate structure is deposited by encrusting microbes.



- ◉ Mutations caused by high levels of UV irradiation (and other mutagens) occurred continually, and selection among them allowed adaptations that led to development of more complex microorganisms with cell walls, greater biosynthetic capabilities, more extensive membranes, cytochromes, and chlorophylls, thus giving rise to phototrophs, which derive energy from sunlight and carbon from inorganic compounds.

- ◎ **Anoxygenic photosynthesizers** -
- ◎ evolved ~0.2 billion years after the first organisms
- ◎ use photosystem I exclusively - purple or green photosynthetic bacteria probably formed the original stromatolites, since they are anaerobic photosynthesizers and conditions on Earth were still anoxic

OXYGENIC PHOTOSYNTHESIZERS

- ◉ Evolved ~1.2 billion years after the first organisms
- ◉ Use a combination of photosystem I and photosystem II



Thankyou