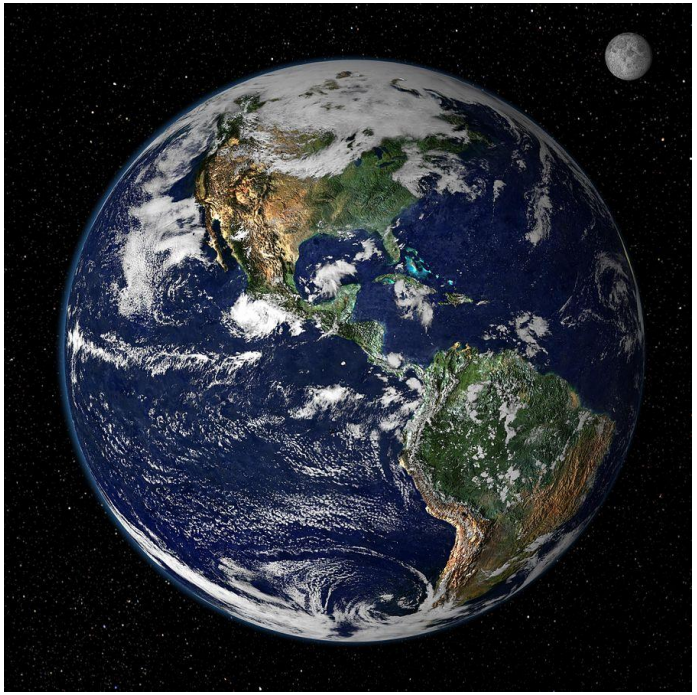
Astrobiology and Exoplanets Part 1

Astrobiology is the study of life in the universe, specifically life that is beyond the Earth system.

- Life on other bodies in our solar system
- Life on other bodies in other star systems

The important questions

- What is life?
- How does life originate?
- What kind of environment is necessary for life to survive?
- How can we identify a potentially habitable world?



Earth is the only model of a habitable world. Life on Earth is the only model of life we know. In order to search for life elsewhere in the universe, it is logical to seek places that have similar characteristics to Earth.

What are the characteristics of life?

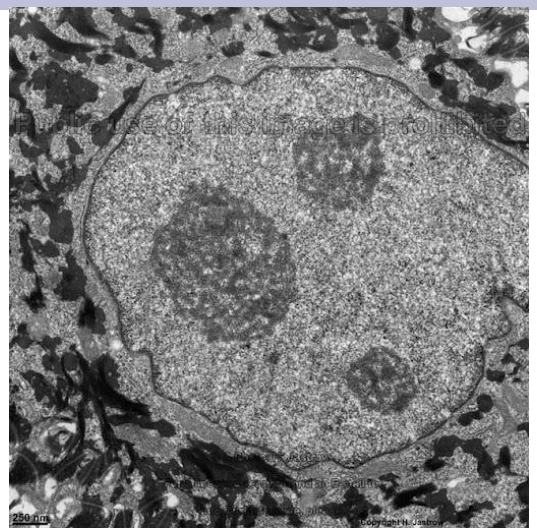
- Life replicates itself—reproduction.
- Life responds to environmental stimuli.
- Life adapts or evolves with its environment.
- Life uses energy (metabolism) and creates homeostasis within.
- Living organisms grow and mature.
- Cell theory. Living organisms are made of one or more cells.
- Made of complex **organic compounds**.

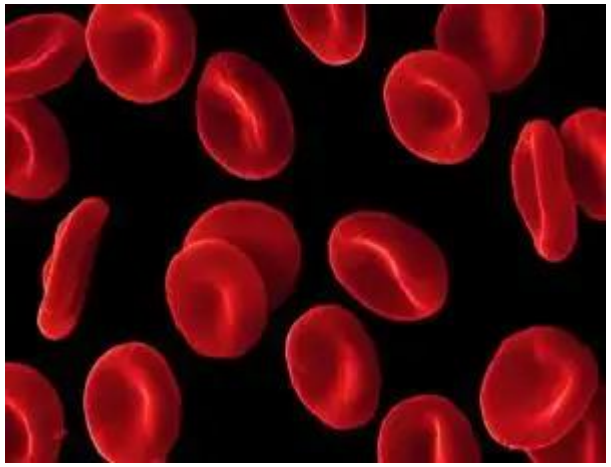
Living organisms have various levels of structure

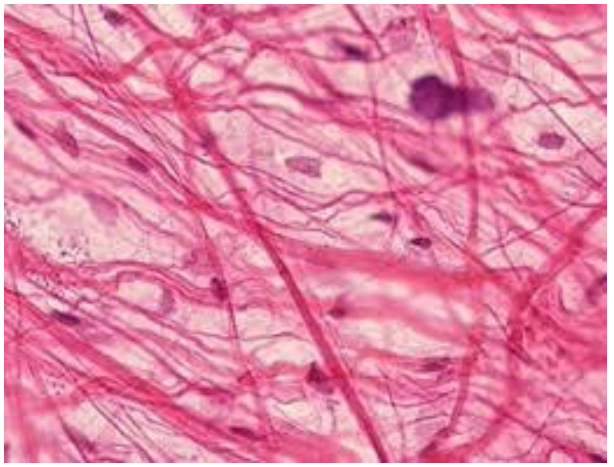
Organelle: Specialized structures that perform one or more functions inside of the cell.

Cell: Smallest self-sustaining unit of life that can survive on its own.

Tissues: masses of cells that have single function and structure.



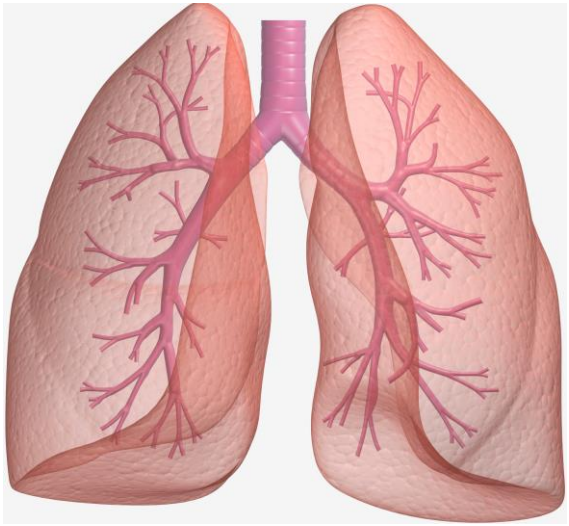


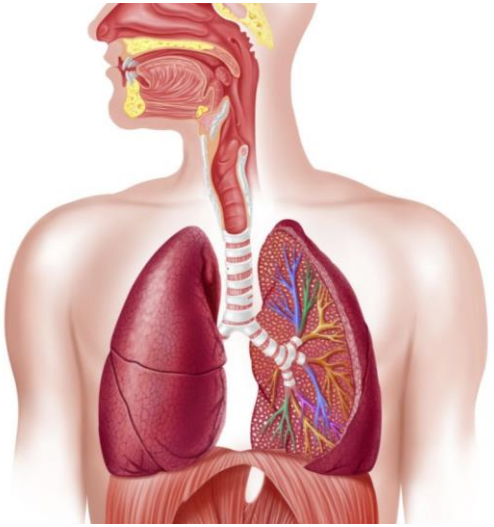


Organ: A structure that is composed of or more groups of tissues, have a specific function within the organism.

System: Groups of two or more organs that together to perform a certain function.

Organism: an independent individual living being.



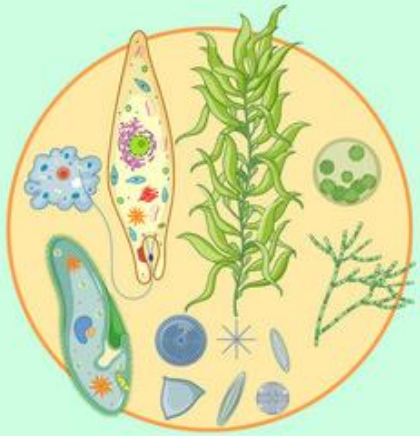


Living Organisms Come in Six Kingdoms

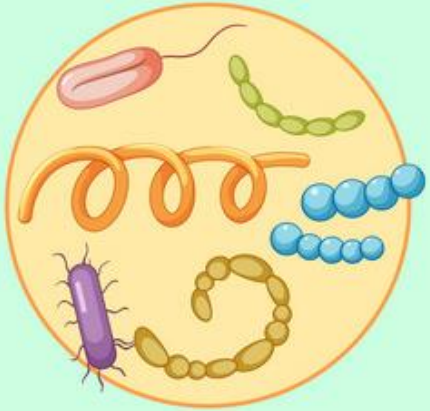
ANIMALS

PLANTS

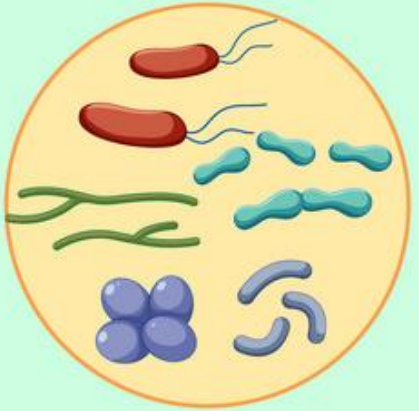
FUNGI



PROTISTS



BACTERIA



ANCIENT BACTERIA

Living Organisms are made of **organic compounds** that have specific functions within the organism.

- Organic compounds are made of one or more carbon atoms covalently-bonded together in long changes, with hydrogen and oxygen atoms, and often with nitrogen and sulfur.

Amino acids → Proteins

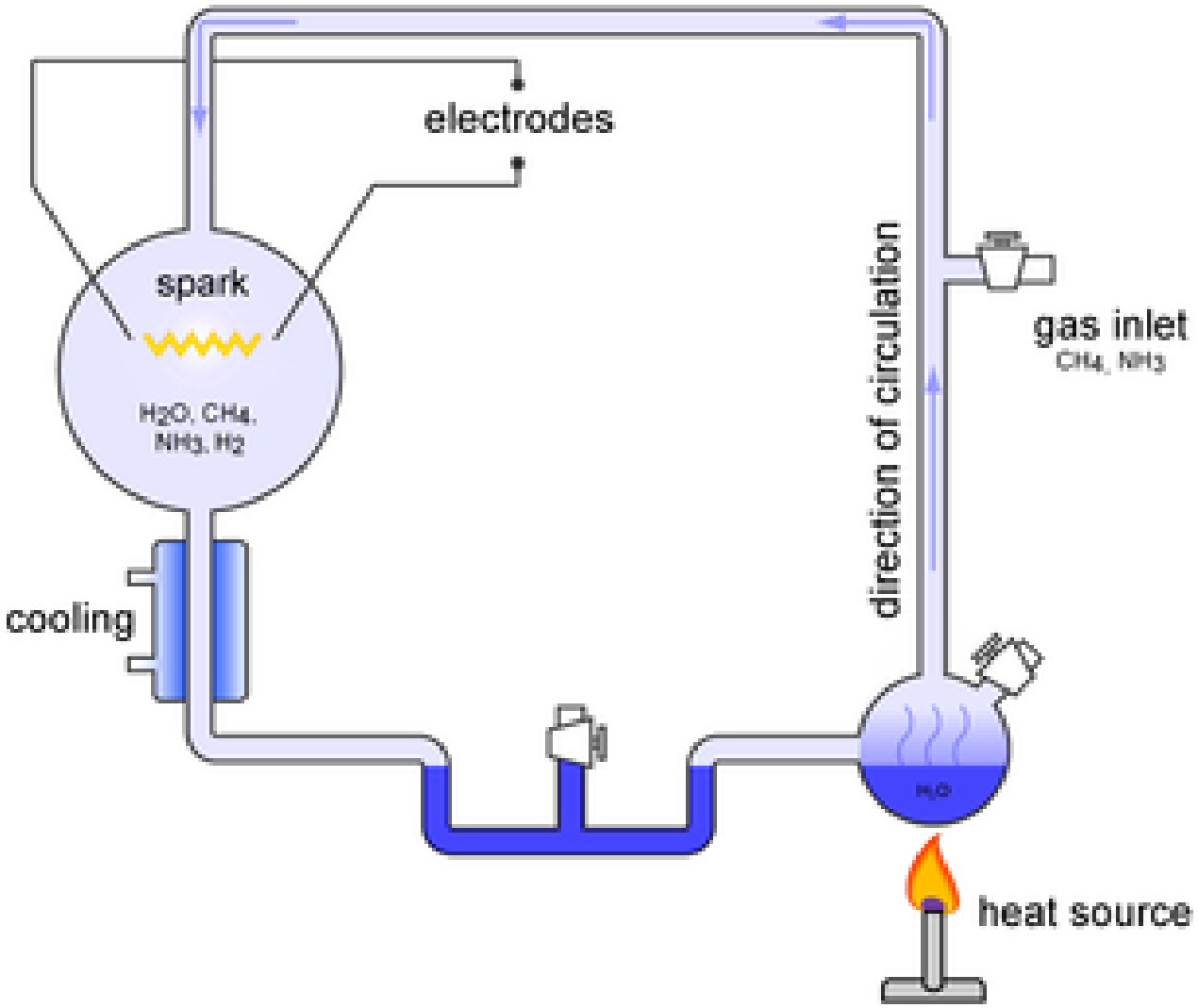
Carbohydrates → Sugars, starch, and cellulose

Nucleic acids → DNA and RNA

Fatty acids → Phospholipids and fatty tissues

Life can take many shapes on Earth. Would life on other bodies be identical or nearly identical to life on Earth?

Urey-Miller Experiment: 1952



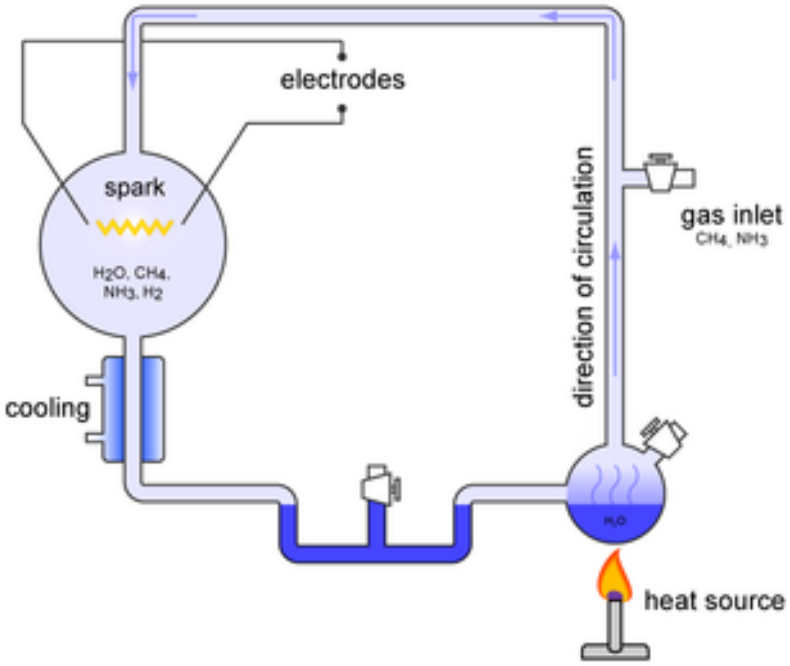
Urey-Miller Experiment: 1952

Earth's earliest, most primitive atmosphere was theorized to be a **reducing atmosphere**: No oxygen or carbon dioxide.

Earth's modern atmosphere is an **oxidizing atmosphere** with free oxygen.

The atmosphere contained

- Water vapor: H_2O
- Methane: CH_4
- Ammonia: NH_3
- Hydrogen: H_2



When the water vapor, methane, ammonia, and hydrogen were heated, refluxed (boiled and condensed repeatedly), and energized by electrical arcs, amino acid residues were created artificially.

The amino acid residues were not exactly like the biologically essential amino acids.
The residues were mixtures of C-N-O-H compounds with chemical make-up similar to essential amino acids.

Why was this important? From totally inorganic origins, chemical compounds that are needed for life and make up life can *form randomly outside of a biological system* if the necessary chemical ingredients are present.

Non-essential amino acids have been identified in trace amounts in meteorites and asteroids.

Amino acid-like compounds were formed by non-biological processes starting from totally inorganic components.

Panspermia is the theory that life or the precursors of life are contaminants on space dust, asteroids, meteors, comets, and planetesimals.

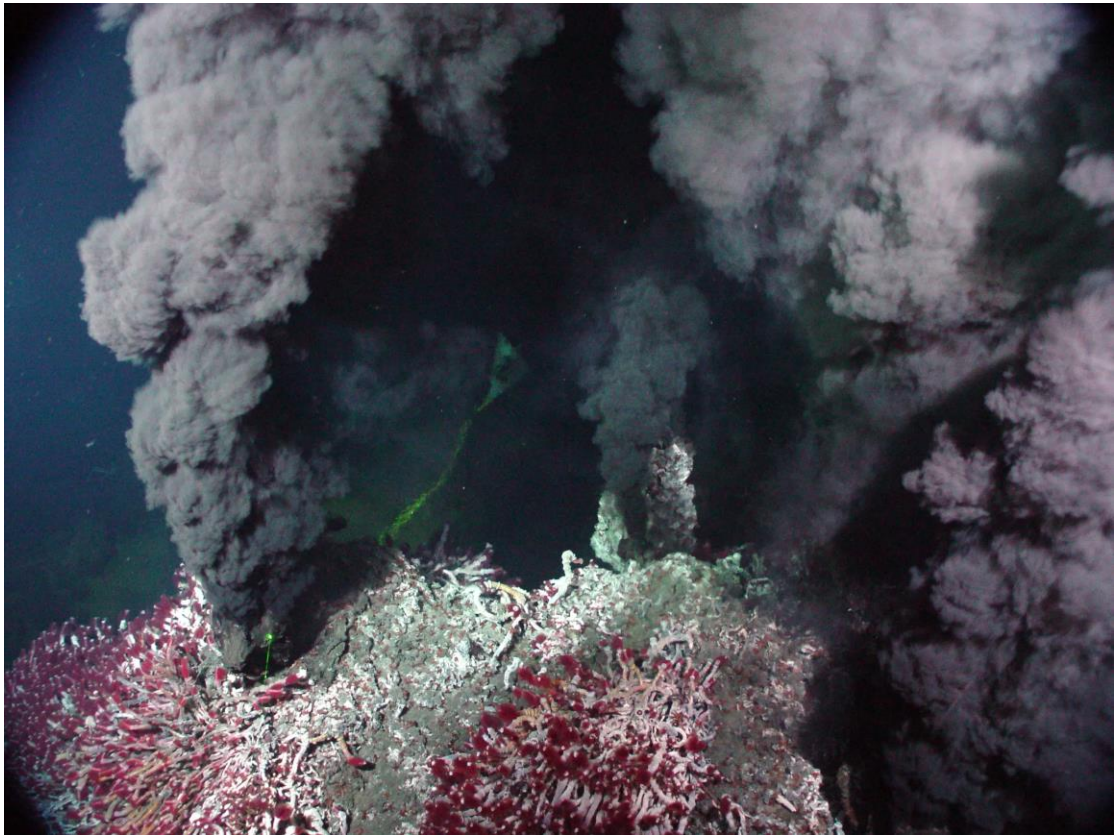
- Those precursors of life are formed by totally abiotic processes.
- The traveling bodies (dust, asteroids, comets) deliver those precursors to suitable, hospitable environments that will foster the transition into life.

Extremephiles are organisms that live and gain energy from extremely harse or inhospitable environments.

- Low pH (acidic)
- High pH (alkaline)
- Hypersaline (saltier than the ocean)
- Extreme cold/ice covered
- Extreme hot/boiling
- Anaerobic (without oxygen)
- Extreme pressure (bottom of ocean)

- Most extremophiles are single-celled organisms (bacteria and algae).
- Some extremophiles are complex, but are very, very small in size.
- Most extremophiles are so specialized to their niche that they have limited to zero mobility.

Hydrothermal vents (boiling water volcanoes) at the bottoms of the oceans near plate boundaries are called **black smokers**. Black smokers provide a source of heat, the mineral and energy rich dark plumes of water, a structure for organisms to attach to.



Pressure of 2000-3000 meters of water above.

No sunlight, total darkness.

Extremephile organisms are probably the most likely candidates for life on other bodies in our solar system.

- Extreme cold: Europa and Enceladus
- Limited water and nutrients in soil: Mars surface
- Reduced or organic atmosphere: Titan