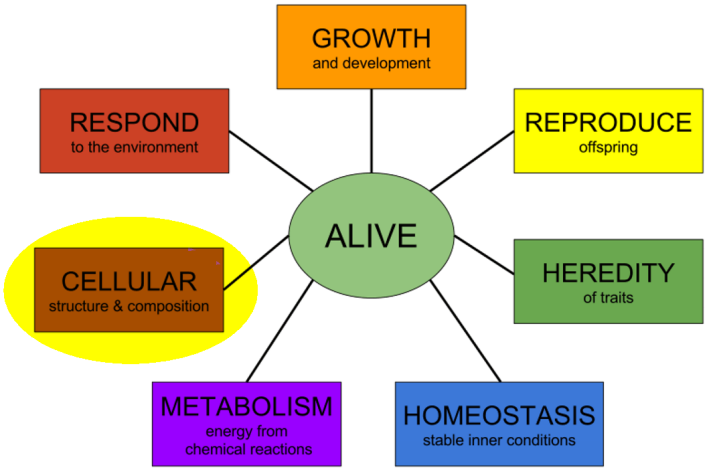
What is Life?

Life is made up of a different chemical elements that are essential for all living organisms. The **main ones** are hydrogen, carbon, oxygen, and nitrogen, which make up most of our bodies. In **smaller amounts**, elements like phosphorus, sulfur, calcium, sodium, magnesium, chlorine, and potassium are also important (but to a lesser extent). **Trace elements** such as iron, zinc, iodine, and others are needed in tiny amounts but are still vital for maintaining life processes

What features define living organisms?



- Life forms are made up of **cells**.
  - Cells are the fundamental building units of life.
  - All living organisms are composed of cells.
- Life contains **genetic information**.
  - This information is encoded in nucleic acids, such as DNA.
- Life forms grow and change over time.
  - This involves using and making new molecules.
- Life forms respond to the environment.
- Life forms extract and use **energy**.
- Life exists in populations and can **evolve**.
- Life can be characterized as a combination of **water and biomolecules**, including proteins, carbohydrates, lipids, and nucleic acids.

Are Viruses Alive?

The question of whether viruses are living is highly debated. Some argue they are alive because they can replicate and evolve, while others claim they are not, as they lack cells and cannot survive or reproduce without a host.

Arguments Supporting Viruses as Living:

- Viruses contain **genetic material**, specifically **nucleic acids**.
  - These nucleic acids can be either DNA or RNA.
- Viruses are capable of **replication**.
  - However, they can only replicate within a host cell, not independently.
- Viruses can **evolve** and adapt to their environment.
  - This is evidenced by their ability to develop resistance.

Arguments Against Viruses as Living:

- Viruses are **incapable of independent replication**.
  - They lack the necessary cellular machinery to replicate on their own.
  - They must hijack host cells to reproduce.
- Viruses do not perform their own **metabolic processes**.
  - They do not make ATP or extract energy.
  - They lack essential metabolic structures like ribosomes.
- Viruses are **not comprised of cells**.
  - They are non-cellular entities made of a genome, some glycoproteins, a capsid, a coat and sometimes a membrane.

How Did Life Arise on Earth?

Two main theories. (1) The **chemical evolution theory** proposes that Earth already had the basic molecules required to produce life. Over time, random chemical reactions led to the formation of more complex molecules, eventually giving rise to basic forms of life (eg single-cellular organisms). On the other hand, (2) **Extra-terrestrial theory** proposes that Earth did not have the required building blocks for life, but rather, that meteorites from outer space brought the required precursors

Timeline of Life on Earth

Eon (Time Period)	Key Events	Approximate Time
Hadean	The time *before* life evolved on Earth	≈ 4.6 to 4.0 billion years ago
Archean	**Early life** arose, likely in water. Prokaryotes, such as **cyanobacteria**, emerged. The first **stromatolites** formed	≈ 4.0 to 2.5 billion years ago
Proterozoic	**Photosynthesis** originated, leading to the **Great Oxygenation Event**. Prokaryotes diversified. The **first eukaryotes** appeared	≈ 2.5 billion to 542 million years ago
Phanerozoic	The rise of **multicellular organisms**. The **Cambrian Explosion**, a period of rapid diversification of life, occurred	≈ 542 million years ago to present

Stromatolites

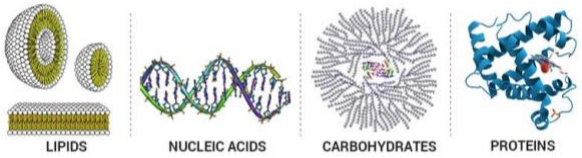
- **Stromatolites** are living fossils that indicate what life may have been like before the Cambrian explosion.
    - They are formed by cyanobacteria and are found in locations such as Australia.
    - Fossils found at the base of the Grand Canyon closely resemble stromatolites.
    - Scientists have found cyanobacteria on the surface of fossilized stromatolites and have identified a cell on the surface.

Water is the Matrix of Life

- Water is crucial to life as organic biomolecules cannot be separated from it, acting as a **universal solvent**.
- Water's polarity allows it to form hydrogen bonds, which allows it to remain liquid across a range of temperatures.
    - Water molecules surround ions and molecules through **ionic interactions**, maintaining them in solution.

Composition of Life

- Life is composed of **water and 4 major macromolecules**:
    (1) Lipids
    (2) Nucleic Acids
    (3) Carbohydrates
    (4) Proteins



	Monomer	Polymer
Lipids	Fatty acids + Glycerol	Lipid
Nucleic Acids	Nucleotide	Nucleic Acid
Carbohydrates	Monosaccharides	Polysaccharide
Proteins	Amino acids	Polypeptide