

MODULE 1: WHAT IS LIFE?

- Life is defined by:
 - Composed of a common set of elements
 - **Grow and change** (using and making molecules)
 - Respond to the **environment** and can evolve
 - Are comprised of **cells and genetic information**
 - Use **energy**
- Life could have **spontaneously** arisen on early Earth (as a result of the early reducing environment facilitating the formation of organic molecules) or from outer space (**panspermia**)
 - Miller and Urey conducted an experiment that mimicked Earth's environment 4 million year ago, and **produced organic molecules** (nucleic acid bases, all naturally occurring amino acids, sugars, fatty acids and vitamins)
 - Life arose on Earth after the formation of liquid water around 3,5 million years ago
 - Stromatolites are evidence of early life
 - Murchison meteorite samples contained amino acids, DNA bases and sugars
- Life is comprised mainly of H, C, O and N. Smaller amounts of P, S, Ca, Na, Mg, Cl and K and only traces of the metals
 - Life = Water + Biomolecules (Proteins, carbohydrates, lipids and nucleic acids)
- **Nucleic acids:**
 - **DNA** (deoxyribonucleic acid)
 - Formed from 4 bases: A (adenine), C (Cytosine), G (guanine), T (thymine)
 - Double stranded
 - **RNA** (ribonucleic acid)
 - T is replaced by U (uracil)
 - Single stranded but can fold. (mRNA, tRNA, rRNA)
 - Both form linear chains that never branch
 - **Bases:**
 - Pyrimidines (single ring): C, T and U
 - Purines (double ring): A and G
 - Always bond T/U=A and C≡G
 - Nucleotides are linked together by **phosphodiester bonds** to form nucleic acids

 - DNA strands go in **opposite, parallel** directions
 - Sugar-phosphate backbone and **hydrogen bonding** between the bases
 - Composed of coding regions (genes) between non-coding regions
 - **Genes are always 5' to 3'**

- 3' to 5' direction is only a template for mRNA to be produced through transcription (non-coding strand/anti-sense), which then uses the code created (complementary to the template) to create proteins in ribosomes
- **Proteins:**
 - Polypeptide chains of 20 amino acids (amino group and carboxyl group bonded to an α -C and a variety of different side chains ®)
 - Peptide forms between amino acids by bonding carboxyl group of one to amino group of another and removing H₂O (condensation)
 - Have an **N-terminus and C-terminus**
 - Each triplet in the 5' to 3' strand (coding strand) is a codon and codes for a specific amino acid
 - Four levels
 - Primary structure: amino acid chain
 - Secondary structure: conformation changes due to electrostatic and hydrogen bonds
 - Tertiary structure: the final form of one polypeptide chain of minimal free energy
 - Quaternary structure: multiple polypeptide chains bonded together to form one structure
- **Carbohydrates** (polysaccharides or sugars)
 - Source of chemical energy and structural components
 - General formula (CH₂O)_n
 - Straight chain form contains a carbonyl at one end
 - Straight chains with 5 or more C's form rings
 - Can be α (1,2-OH groups point in the same direction) or β (1,2-OH groups in opposite directions)
 - Contain **chiral C's** and have **enantiomers**
 - Two monosaccharides can bond to form a disaccharide with a **glycosidic (sugar) bond** through a **condensation reaction**
 - Starch is a polysaccharide of α -glucose which serves as the main energy storage compound in plants
 - Glycogen would be the "starch" of animals and fungi (but more branched than starch)
 - Cellulose is a polysaccharide of β -glucose which serve as a structural component in plant cell wall
 - Chitin is a major component of fungal cell walls and exoskeletons of arthropods
- **Lipids**
 - Organic molecules (insoluble in water) formed mainly of C, H and O (P and N), contain less O than sugars
 - Store the most energy of all macromolecules because many C-H bonds
 - Also, for insulation
 - **Fatty acids:** long chains of C ending in a COOH group
 - Can be **saturated** (only single bonds) or **unsaturated** (not only single bonds/also double bonds)
 - Waxes are long C chains bonded together through an ester group
 - **Triglycerides:** three fatty acids connected to a single glycerol molecule
 - **Phospholipids** are main component of membranes