BIOLOGY

IMAT REVIEW COURSE 2024

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INTRO TO BIOLOGY FOR THE IMAT

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PROPERTIES OF LIFE

- Life is complex and diverse, with **unique** characteristics.
- These characteristics include **metabolism, growth and development, response to stimuli, maintaining balance (homeostasis), reproduction, and evolution.**
- By understanding these characteristics, we can better understand the complex world of **living organisms.**

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REPRODUCTION AND EVOLUTION

- Reproduction is the ability of **living** organisms to create **offspring**, either through **sexual or asexual means.**

- Sexual reproduction involves the **combination of gametes from two individuals,** resulting in genetically **diverse** offspring.

- Evolution is the process through which **living** organisms **gradually change** and **adapt over time,** allowing them to better **survive and reproduce** in evolving environments.

METABOLISM

- Metabolism is the process by which living organisms **convert energy and matter to sustain themselves.**
- It includes the transformation of **food** and other resources into **usable energy** for cellular activities.
- Metabolism is **crucial** for **maintaining life** and allows organisms to perform their **biological functions.**

GROWTH AND DEVELOPMENT

- This process, regulated by **genes**, involves the **creation of proteins** and other cellular components.

- Starting from a **fertilized egg,** organisms go through **various** developmental stages to become **fully formed adults.**

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MOLECULES

- Molecules are the **smallest units** of **biological** organization and serve as the fundamental **building blocks of life.**
- Examples include **DNA, proteins, and carbohydrates.**
- Molecules are crucial for **numerous biological processes** and are essential for the proper functioning of cells and organisms.

MEMBRANE-BOUND ORGANELLES

- Organelles are **specialized** structures within cells that carry out specific functions.
- Examples include **mitochondria**, which generate energy, and the nucleus, which contains genetic material.
- These organelles are crucial for the proper **functioning** and organization of cells.

CELLS

- Cells are the fundamental **unit of life** and are capable of performing all **essential life processes.**
- They can be either **prokaryotic** (without a nucleus, bacteria) or **eukaryotic** (with a nucleus, animals).
- Cells are the **building blocks of all living organisms** and vary greatly in structure and function.

PROKARYOTE VS EUKARYOTE

	PROKARYOTE	EUKARYOTE
DNA	Single circular chromosome	Organised into multiple chromosomes
NUCLEOUS	Dont have a nucleous	Has a nucleus enclosed by a membrane
ORGANELLES	No membrane bound organelles	Contain membrane bound organelles
EXAMPLES	Archaea, Bacteria	Plants, Animals, Fungi

TISSUES AND ORGANS

- Tissues are **collections** of similar **cells working together** to perform specific **functions**.
- Examples include **epithelial tissue and muscle tissue.**
- **Organs** are made up of **various tissues** and are specialized for particular functions, such as the **heart, lungs, and liver.**

ORGANISMS, POPULATIONS, COMMUNITIES

- Organisms can be **single individuals** or part of **larger groups**, such as an ant colony or a bird flock.
- Populations are **groups** of individuals of the **same species** living in the **same area.**
- Communities are made up of **various species** living **together** in a **shared** environment.

ECOSYSTEMS AND THE BIOSPHERE

- Ecosystems are **communities** of **living organisms** interacting with their **physical** and **chemical surroundings.**
- They include the **relationships between organisms** and their **environment**.
- The biosphere is the **global sum of all ecosystems**, encompassing **all living organisms and their environments on Earth.**

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CHEMICAL BONDS

- Chemical bonds are the forces that **connect atoms** to form **molecules and compounds.**
- **Covalent bonds** involve sharing electrons between atoms, while **ionic bonds** involve transferring electrons.
- Understanding chemical bonds is **essential** in chemistry, biology, and materials science.

COVALENT BONDS

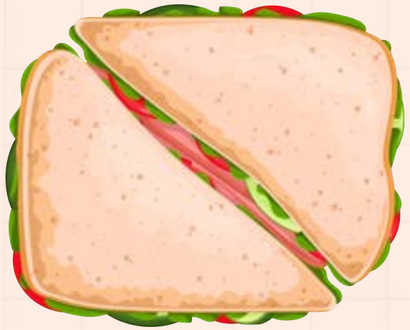
- Covalent bonds occur when **atoms share** a **pair of valence electrons.**
- This **sharing** creates a **stable molecule or compound.**
- **Nonpolar covalent bonds** involve **equal** sharing of **electrons**, whereas **polar** covalent bonds result in **partial charges due to unequal sharing.**
- Covalent bonds are crucial in both biological and chemical systems.

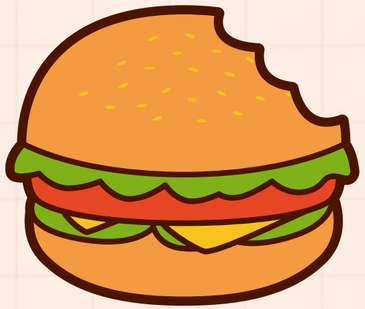
IONIC BONDS

- Ionic bonds form when positively and negatively charged ions attract each other.
- Ions are created when atoms either gain or lose electrons, resulting in positive or negative charges.
- Ionic bonds involve a complete transfer of electrons.
- An analogy with magnets can help illustrate the attraction between oppositely charged ions.

ANALOGY

- Nonpolar covalent bonds can be compared to two friends equally sharing a sandwich, where each person takes half, resulting in an even distribution.
- Polar covalent bonds are like two friends sharing a sandwich where one person takes a larger portion, leaving the other with less.
- These analogies help to visualize how electrons are shared equally in nonpolar covalent bonds and unequally in polar covalent bonds.





WEAK CHEMICAL INTERACTIONS

- Hydrogen Bonds: These occur between **electronegative atoms** and help stabilize **biological molecules.**
- Van der Waals Interactions: These involve **fluctuations** in electron density and influence the **three-dimensional shape of large molecules.**
- Hydrophobic Interactions: These occur between **nonpolar** molecules when they are in the presence of **water.**

ROLE OF WEAK CHEMICAL INTERACTIONS

- **Hydrogen bonds** stabilize structures such as the DNA double helix.
- **Van der Waals** interactions help determine the three-dimensional structure of proteins.
- **Hydrophobic interactions** are important for protein folding and the formation of membranes.
- **Weak chemical interactions** are essential for the structure and interactions of biomolecules.

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PROPERTIES OF WATER

- **Water’s Unique Shape:** Water's shape allows it to form hydrogen bonds with other water molecules.
- **Excellent Solvent:** Water effectively dissolves ions and polar molecules.
- **Heat Retention:** Water's ability to retain heat contributes to temperature stability in living organisms.

"LIKE DISSOLVES LIKE" AND SOLUBILITY

- The phrase "like dissolves like" describes how substances tend to dissolve in solvents with similar properties.
- Polar substances dissolve well in polar solvents, while nonpolar substances dissolve better in nonpolar solvents.
- This principle explains why oil and water do not mix well, as they have different properties.

MORE UNIQUE PROPERTIES

- **Density**: Water is less dense as a **solid**, causing ice to float on liquid water.
- **Cohesiveness**: Water molecules stick to each other effectively due to cohesive properties.
- **Human Body Composition:** About **60-70%** of the human body is water, highlighting its essential role in life.

WATER'S IMPORTANCE FOR LIFE

- **Universal Solvent:** Water facilitates the transport of nutrients, waste, and molecules within organisms.
- **Medium for Reactions:** It provides a medium for biochemical reactions, enabling vital chemical processes.
- **Temperature Regulation**: Water’s **high heat capacity** helps maintain stable conditions for biological functions.

WATER'S IMPORTANCE FOR LIFE

- **Cellular Component:** Water is a fundamental part of cells, providing **structure and support.**
- **Lubrication:** It reduces friction and **protects** organs from damage.
- **Dissolving Substances:** Water’s ability to **dissolve** various substances is crucial for transportation and regulating **body temperature.**

HIGH HEAT CAPACITY OF WATER

- **Heat Absorption:** Water can absorb or release large amounts of heat without significant changes in temperature.
- **Hydrogen Bonds:** Its high heat capacity is due to the hydrogen bonds between water molecules.
- **Specific Heat Capacity:** Water has the highest specific heat capacity among liquids.

ROLE IN BODY TEMPERATURE REGULATION

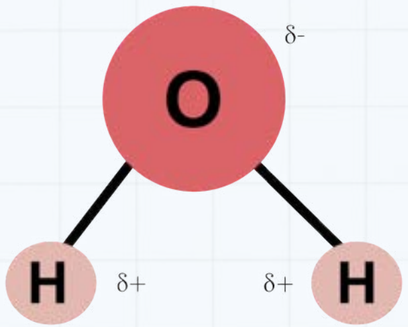
- **Thermal Buffer:** Water evenly distributes heat throughout the body, helping to maintain a stable temperature in warm-blooded animals.
- **Heat Transfer:** It transfers heat from warmer areas to cooler areas, similar to a car's cooling system.

HEAT OF VAPORIZATION

- **Energy Requirement:** The energy needed to **convert** water from liquid to gas is high.
- **High Heat of Vaporization:** Water requires **significant energy** to transition to the **gaseous phase (steam).**
- **Evaporation:** As water evaporates, it absorbs energy, leading to a **cooling** effect in the environment.

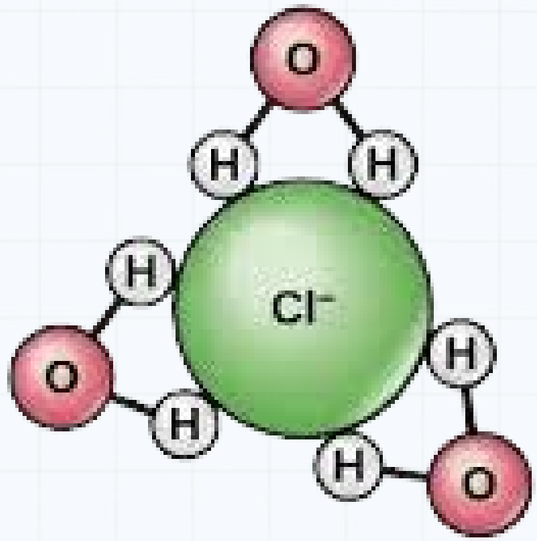
WATER AS A SOLVENT

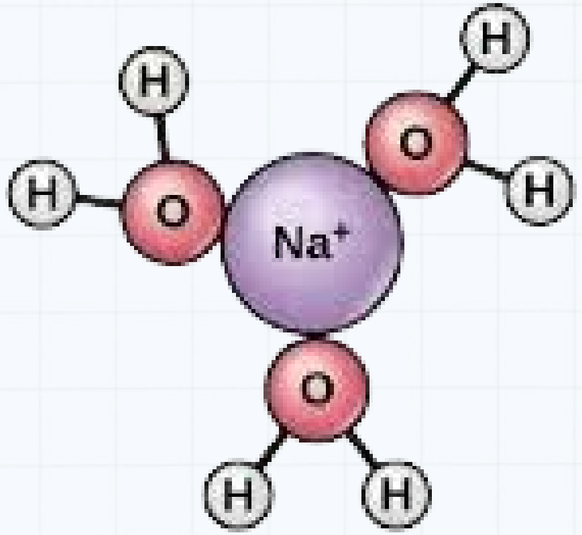
- **Polarity**: Water is a **polar** molecule with **positive** and **negative** ends due to its oxygen and hydrogen atoms.
- **Dissolving Capability:** Water's **polarity** allows it to dissolve **polar** molecules and **ionic** compounds.
- **Hydration Shell**: When **ions or polar** molecules are added to water, **hydrogen bonds** form around them, creating a hydration shell that keeps them dispersed.



WATER AS A SOLVENT

- This creates a **hydration** shell or sphere of hydration around the particles, keeping them separated or dispersed in water.





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COHESION AND ADHESION OF WATER

- **Cohesion**: Water molecules **stick to each other due to hydrogen bonding**. This creates surface tension and allows water to form **droplets**.
- **Adhesion**: Water molecules **stick to other surfaces**, such as plant cell walls, also through hydrogen bonding.
- **Capillary Action**: Cohesion and adhesion are crucial for **capillary action,** which enables water to move up plant stems against gravity.
- **Biological Implications:** These properties are important for hydration in organisms and facilitate movement in creatures like water striders.

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ACID VS BASE

- **Acids** release **hydrogen ions (H^+)** in water, while **bases** release **hydroxide ions (OH^-).**
- The **strength** of an acid or base is measured by its **dissociation constant.**
- Biological molecules, **such as amino acids, can be acidic or basic,** influencing their structure and function.
- pH levels affect enzyme activity, and biological systems tightly **regulate pH through buffering systems.**

ACIDS

- Acids release **hydrogen** ions (H^+) when **dissolved** in water.
- They play key roles in biological processes, such as **enzyme** activity and energy transfer.
- **Hydrochloric acid (HCl)** assists in **digestion**, and **carbonic acid (H_2CO_3)** helps **maintain pH balance** in biological fluids.
- **High concentrations** of acids can be detrimental by lowering pH and denaturing proteins.

BASES

- Common bases in biological systems include **sodium hydroxide (NaOH) and ammonia (NH_3).**
- Bases are crucial for **enzyme function** and the **removal of protons during metabolism.**
- **High** concentrations of bases can be **harmful by raising pH and denaturing biomolecules.**
- Biological systems have **mechanisms to regulate base** concentrations and maintain **stable pH levels.**

ACID VS BASE

	ACID	BASE
Definition	Release hydrogen ions in water	Release Hydroxide ions in water
Chemistry	Dissociation of H+ Ions	Dissociation of OH- Ions
Function	Help with digestion, enzyme activity.	pH regulation, proton removal in metabolism
Effect on pH	Decrease	Increase pH
Examples	Hydrochloric acid (HCl), Carbonic Acid (H_2CO_3)	Sodium Hydroxide (NaOH), Ammonia (NH_3)

pH BUFFERS

- pH buffers are crucial for **maintaining stable pH levels** in the body, which is essential for proper functioning and preventing harm.

- Examples of buffers include those found in **blood, stomach, and urine.**

BICARBONATE BUFFER SYSTEM

- The bicarbonate buffer system is the **primary buffering mechanism** in the body.
- It involves an **equilibrium reaction** between carbonic acid (H_2CO_3) and bicarbonate ions (HCO_3^-).
- This system regulates the **concentrations of bicarbonate and hydrogen ions in the blood.**
- It helps maintain **pH balance** by neutralizing excess **hydrogen** ions or bicarbonate ions.

pH BALANCE IN THE BLOOD

- When blood pH becomes too **acidic**, bicarbonate ions **react** with excess hydrogen ions to form **carbonic acid.**
- Carbonic acid then **breaks down into water** and **carbon dioxide**, which helps **remove the excess hydrogen ions.**
- When blood pH is too **basic**, the process **reverses**, breaking down carbonic acid to **release** additional bicarbonate ions.

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ANY QUESTIONS?

MESSAGE ON WHATSAP

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