IDX G9 Biology H
Study Guide Issue S1 M1

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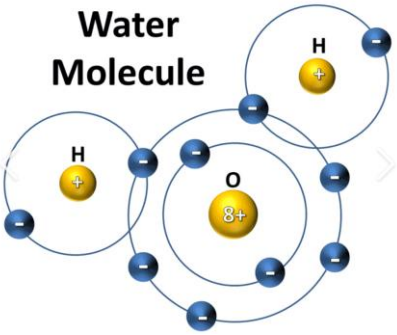
Contents:

2-2 Properties of Water

Different Types of Bonds

- **Ionic** Bond
  - **A bond formed where an atom directly gives another electron to achieve a stable stage.**
- **Covalent** Bond
  - **A bond formed where an atom shares with another electrons to achieve a stable stage.**
  - **Water molecules have covalent bonds**

The Water Molecule



- Has **polarity**
    - **Greater probability of finding shared electrons in water close to oxygen atom, so the oxygen atom carries a more negative charge than the hydrogen atoms.**
    - **Polar is the word for charge unevenly distributed in a molecule.**
- Can form **hydrogen bonding**
    - **Attraction between one hydrogen atom and one water molecule due to different charges.**
    - **Explains water's ability to dissolve many other substance**
- Has **cohesion**
    - **Attraction between molecules of the same substance**
    - Causes water to have **surface tension**
        - **A force that is formed by cohesion of water, creating a smooth surface.**
- Has **adhesion**
    - **Attraction between molecules of different substances.**
    - Forms the **capillary action**
        - **A force that draws water out of the roots of a plant and up into its stems and leaves.**
- Has high **heat capacity**
    - **The amount of heat energy required to increase its temperature.**
    - Supports the most stable environment (ocean).
    - Regulates cellular temperature.
- **Water expands slight upon freezing makes ice less dense than liquid water**
- Found as part of a **mixture**
    - **Material composed of two or more elements or compounds that are physically mixed together.**

- Can form **solutions**
    - **A mixture that all of its components are evenly distributed throughout.**
    - Has **solute** and **solvent**
        - **Solute: The substance that is dissolved**
        - **Solvent: The substance in which the solute dissolves**
        - Water can dissolve ionic compounds and other polar molecules
- Can form **suspensions**
    - **Mixtures of water and nondissolved material**

The pH Scale

- Indicates the concentration of H^+ ions in a solution.
- Ranges from 0 to 14.
- At pH of 7, the solution is neutral, having equal concentration of H^+ ion and OH^- ion.
- Lower pH value indicates an **acidic** solution
    - **Acid: Any compound that forms H^+ ions in solution.**
    - **Acidic: Contain higher concentration of H^+ ion than pure water. (pH value below 7)**
    - Strong acids have pH values from 1 to 3.
- Higher pH value indicates a basic solution
    - **Base: A compound that produces hydroxide ions (OH^-)**
    - **Basic: Contain lower concentration of H^+ ions than water and has pH value above 7.**

- **Buffers** can regulate the pH values
    - **Weak acids or bases that can react with strong acids or bases to prevent sudden changes in pH.**
    - Important for maintaining homeostasis in organisms.

3.1 What is Ecology?

Ecological Methods

- **Observation** is an ecological method that uses your senses to gather basic knowledge and this often leads to questions or hypotheses
- **Experimentation** is used to test wether a hypotheses is true or not
- **Modeling** helps ecologists understand complex processes
    - E.g. earthquake models or global warming models

The Biosphere

- The **biosphere** consists of all life on earth and all parts of earth in which life exists (including land, water and the atmosphere)
- The biosphere contains all organisms ranging from 8 km above Earth's surface to as far as 11 km below the surface of the ocean

The Science of Ecology

- **Ecology is the scientific study of interactions among organisms and between organisms and their physical environment**
    - The root of the word *ecology* is the Greek word *oikos,* which means "house"
    - Organisms respond to the environment but can also change their environments
    - Contains atmosphere lithosphere hydrosphere
- Ecology's relationship with Economics is that both concern with exchange of material and how that material is allocated (e.g. the biosphere provides essentials such as water, and in economics it studies how water can be bought and sold or traded)

Levels of Organizations

- A **species or individual** is a group of similar organisms that can breed and produce fertile offspring.
- A **population** is a group of individuals that belong to the same species and live in the same area
- An assemblage of different populations that live together in the same area is called a **community**.
- All the organisms that live in a place, together with their environment, is known as an **ecosystem**.
- A **biome** is a group of ecosystems that share similar climates and typical organisms.
- Our entire planet, with all its organisms and environments, is known as the **biosphere.**

Biotic and Abiotic Factors

- Environmental conditions include biotic factors and abiotic factors
- **Biotic factors** are the biological influences on organisms
    - This includes any living part of the environment in which the organism might interact with (e.g. animals and plants or bacteria)
- **Abiotic factors** are the physical components of an ecosystem
    - This includes only the non living parts of the environment (e.g. sunlight, rainfall, water)
        - Note: Not all parts of the environment counts as abiotic factors for example grass is a living thing therefore a biotic factor, do not confuse with this
    - Biotic and Abotic factors together shape every unique environment
        - Abiotic factors can be affected by living organisms
        - E.g. Forest canopies (biotic) can affect the precipitation or sunlight exposure of a particular area (abiotic)

3.2 Energy, Producers, and Consumers

Autotrophs

- Organisms that uses solar or chemical energy to produce food.
- Assemble **inorganic compound** into **organic compound**
- Only algae, certain bacteria, and plants are autotrophs.
- They store energy in forms that make it available to other organisms that eat them.
- They are also called **primary producers**.
    - **First producers of energy rich compounds that are later used by other organisms.**
- Use **photosynthesis** and **chemosynthesis** to produce food.
    - **Photosynthesis:** A process in which producers captures light energy and uses it to power chemical reactions that convert carbon dioxide and water into oxygen and carbohydrates.
    - **Chemosynthesis:** Chemical energy is used to produce carbohydrates. (Carbon dioxide+ Hydrogen sulfide+Oxygen to Carbohydrates + Sulfur compounds)

Consumers

- Includes animals, fungi, and many bacteria.
- Known as **heterotrophs**
    - Organisms that must acquire energy from other organisms.
    - Also called **consumers**
        - Organisms that rely on other organisms for energy and nutrients.

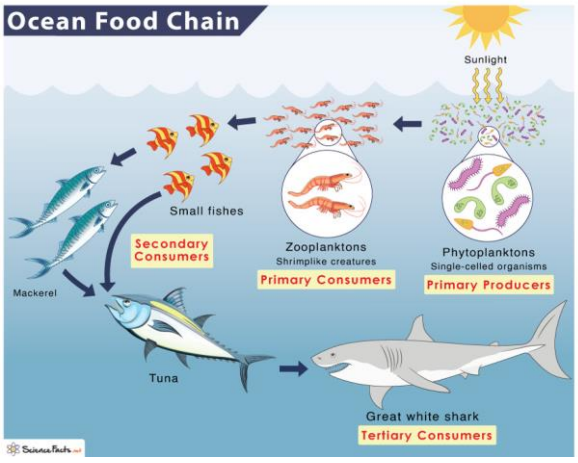
Types of Heterotroph

- **Carnivores:** Kill and eat other animals, e.g. dogs, cats, snakes.
- **Herbivores:** Obtain energy and nutrient by eating plants (including leaves, roots, seeds, or fruits), e.g. cows, deer, sheep.
- **Omnivores:** Animals who feed on a variety of foods containing both plants and animals, e.g. humans, bears, pigs.
- **Scavengers:** Animals that consume the carcasses of other animals, e.g. vultures.
- **Decomposers (Saprotrophs) :** Organisms that chemically break down organic matter which forms **detritus**, e.g. bacteria and fungi.
    - **Recycle nutrients to the environment**
- **Detritivores:** Organisms that feed on detritus particles, chewing and grinding them to smaller pieces, e.g. mites, snails, shrimps.

3.3 Energy Flow in Ecosystem

Food Chains

- A series of steps in which organisms transfer energy by eating and being eaten.
- In acquatic food chains, phytoplankton is the primary producer.
- Composed of primary producers, primary consumers, secondary consumers, tertiary consumers, and sometimes quartenary consumers.



Food Webs

- A network of feeding interactions that describes a more complicated feeding relationship.
- Contain multiple food chains.
- Decomposers are important in the food webs.
- In marine food webs, **zooplankton** is a common primary consumer that feeds on phytoplanktons.
- Change of population size of one organism can disturb other organism in the food web

Tophic Levels and Ecological Pyramids

- **Trophic level**
    - Each step in a food chain or food web.
    - E.g. primary producers are the first trophic level.
- **Ecological Pyramids**
    - Show the relative amount of energy or matter contained within each trophic level in a given food chain or food web.
    - Three types: **pyramids of energy, pyramids of biomass, and pyramids of numbers.**
    - Important facts about **pyramids of energy:**
        - The efficiency of energy transfer from one trophic level to another is about **10%**
        - The rest 90% of energy is lost through heat or not fully abosorped by the organism (e.g. not ingested, not digested, excreted)
        - Always in the shape of a normal, upright pyramid. No exceptions.
    - Important facts about **pyramids of biomass:**
        - **Biomass:** Total amount of living tissue within a given trophic level.
        - Illustrates the relative amount of living organic matter available at each trophic level.
    - Important facts about **pyramids of numbers:**
        - Shows relative number of individual organisms at each trophic level in an ecosystem.

- The shape could be an upside down pyramid, when the number of consumers exceed the number of producers, e.g. A single tree can support many insects.

3.4 Cycles of Matter

Basic Knowledge

- **Elements** combine to form the building blocks of all organisms
- **Matter** is anything that has mass and takes up space
    - Matter is never created or destroyed, only changed

Recycling in the Biosphere

- **Energy** enters as light (photosynthesis) and loses as heat in a **one-way flow cannot be reused or recycled**
- Matter and nutrients are always recycled between and within ecosystems
- Elements are passed throughout the biosphere through **biogeochemical cycles**
    - Biological processes (involving living organisms)
    - Geological processes (long term processes including volcanic and tectonic movements)
    - Chemical/Physical processes (precipitation, lightning, flow of water)
    - Human activity (burning fossil fuels, use of fertilizers

Energy Flows and Nutrient Cycles

- Energy enters from sunlight > producers capture sunlight
- Energy transfer is approximately 10% from one level to the next
- Energy passes to detritivores or decomposes in dead organic matter
- Heat energy is lost through cellular respiration
    - Energy loss can also be due to material not completely consumed

- **Nutrients** are absorbed by producers from the ecosystem > consumers feed on producers (energy transfer moves along the food-chain)
- Nutrients are then recycled from dead organisms by decomposition

The Water Cycle

- water continuously moves along the oceans, the atmosphere , land and between or inside living organisms

- water molecules typically enter the atmosphere by **evaporation** (liquid to vapor)
- They can also move to the atmosphere by evaporating from plant leaves, a process known as **transpiration**
- in the air, cooling water vapor may form water droplets around dust particles (**condensation**)
- during **precipitation**, water droplets fall from the sky in the form of rain, sleet, hail or snow
- on land, the precipitation flows along the surface which is called **surface runoff**
- it can also flow through a process called **percolation**, when water is gradually filtering through a porous surface
- precipitation can enter underground as well, and via roots they can enter the plants
    - the water underground is known as groundwater, and some groundwater can penetrate deeper underground to become part of underground reservoirs
- water that re-enters the atmosphere through transpiration or evaporation begins the cycle again

Nutrient Cycles

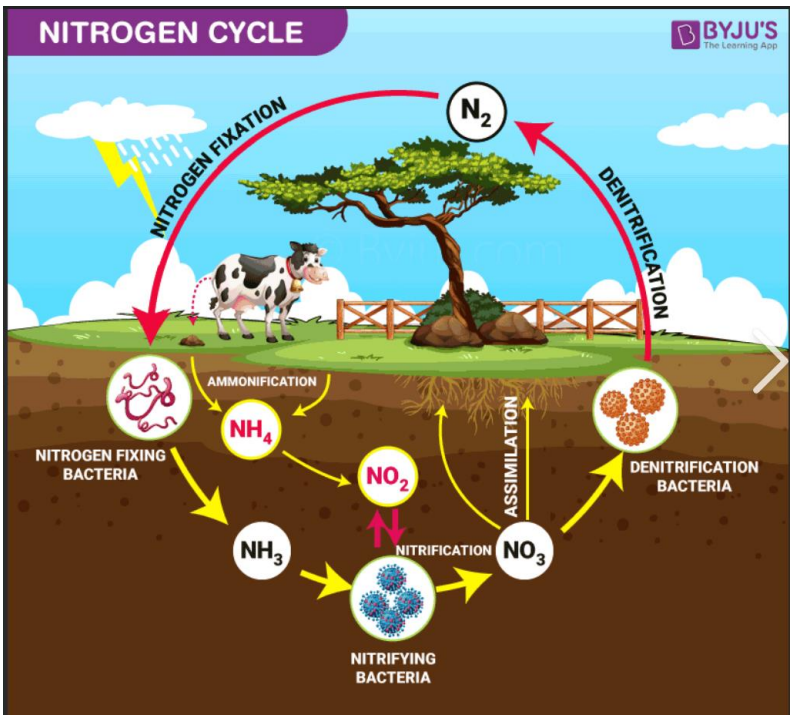
- a **nutrient** is a chemical substance that an organism must obtain from its environment to sustain life
- Three main nutrients: carbon, phosphorus and nitrogen (oxygen is carried together with them through some processes)

The Carbon Cycle

- Forms of carbon on earth:
    - carbon compounds in living organisms
    - atmosphere — CO_2
    - hydrosphere — dissolved CO_2
    - lithosphere — carbonate rocks(contains calcium carbonate $CaCO_3$, fossil fuels and natural gas
- Some processes in the carbon cycle include **photosynthesis, respiration, feeding, decomposition, fossilization and combustion(CO_2 in the air)**

The Nitrogen Cycle

- All organisms require nitrogen to produce amino acids which are used to build proteins, and nucleic acids such as DNA or RNA



- Forms of nitrogen on earth
    - in the air, it is known as nitrogen gas N2 (78 % of the atmosphere)
    - in the soil, there is …
        - NH3/NH4+(ammonia/ammonium)
        - NO3- (nitrate)
        - NO2- (nitrites)
    - in plants/animals, there are organic nitrogen compounds (e.g. protein, nucleic acids)
- All forms of Nitrogen on the Earth
    - **N2 Nitrogen Gas**
    - **NO Nitric Oxide**
    - **NO2 Nitrogen Oxide**
    - **N2O Nitrous Oxide**
    - **NH3 Ammonia**
    - - - - - - - - - boundary between soil(below) and atmosphere(above)
    - **NH4+ Ammonium**
    - **NO2- Nitrite**
    - **NO3- Nitrate**
- Processes or events in the nitrogen cycle
    - for a clearer diagram please refer to the link above

1) **Nitrogen** Fixation
    - N2 in the air —> Nitrogen in soil

- There is **biological nitrogen fixation** (done by Nitrogen fixing bacteria)
  - those bacteria (named *Rhizobium*)are free-living, symbiotic with legumes(types of beans/peas)
  - they live on the nodules of roots
  - They transform N2 into NH3/NH4+
- And there is **abiotic nitrogen fixation**
  - lightning converts a small amount of N2 into usable forms of NO3-

2) **Nitrification**

- two types of soil bacteria, two methods of nitrification
  - First type: bacteria converts ammonia and ammonium into NO2-
  - Second type: bacteria converts NO2- into NO3- that producers can use

3) **Assimilation**

- plants will absorb NO3-/NH4+ in soil and convert it to organic nitrogen (nucleic acids and proteins)

4) **Ammonification**

- decomposes break down organic nitrogen compounds in dead matter and release NH4+ to the environment

5) **Denitrification**

- denitrifying bacteria convert NO3- in soil back to N2 and N2O in the air

- Humans add nitrogen to the biosphere through the manufacture and use of fertilizers
  - excess fertilizer is carried into surface water or groundwater by precipitation

The Phosphorus Cycle

- Phosphorus form a part of vital molecules such as DNA or RNA
  - It is not abundant in the biosphere
- Forms of Phosphprus on Earth
  - Inorganic Phosphorus (phosphate PO43-) in land, rock, minerals, soil and ocean
  - Organic compounds in living things
- The Cycles

- Short-term: Phosphorus in phosphate solutions is cycled from the soil to producers, and then onto consumers
- Long-term: Weathering and erosion of rocks that contain phosphorus slowly adds it to the cycle

Nutrient Limitation

- if ample sunlight and water are available, the primary productivity of an ecosystem may be limited by th availability of nutrients
  - **primary productivity**- the rate at which primary producers create organic material
- The nutrient whose supply limits productivity is called the **limiting nutrient**

Nutrient Limitation in Aquatic Ecosystems

- oceans are nutrient poor compared to many land areas
  - in oceans and saltwater environments, nitrogen is often the limiting factor
  - In freshwater environments, phosphorus is typically the limiting factor
  - Sometimes, an aquatic ecosystem may receive large inputs of limiting nutrients from runoffs of heavily fertilized fields
- **Algal Bloom** — a dramatic increase in algae and other primary producers due to increase in nutrients
  - if not enough consumers eat the algae, then the ecosystem's functioning will be disrupted
    - algae covers the water surface, blocking essential solar energy for other organisms
  - **Eutrophication Process**
    - fertilizer runoff or leaching (increases nutrients in the aquatic ecosystem)
    - dramatic increase in algae
    - algae blocks the sunlight
    - large amounts of algae overshoots the carrying capacity of the ecosystem
    - algae die
    - decomposition process uses up oxygen
    - fish and other species affected

End of the whole review content, good luck on your monthlies !