AP Biology
Unit 3 - Cellular Energetics

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1. Enzyme Function:

- Enzyme: protein catalyst; speeds up a reaction without being consumed
- Polypeptide: chain of amino acids conjoined and connected by peptide bonds
- Protein: biological molecule made of one or more polypeptides.
- Amino acid: polypeptide monomers.
- Peptide bond: covalent bond between the carboxyl group on one amino acid and the amino group on another
- Primary structure: The level of protein structure referring to the specific sequence of amino acids.
- Secondary structure: The localized folding of the polypeptide backbone of a protein due to hydrogen bond formation between constituents of the backbone.
  - Alpha helix: A spiral shape
  - Beta pleated sheet: chain folded back and forth..
- Tertiary structure:protein folding a result of interactions between side chains
  - hydrophobic interactions, ionic bonds, hydrogen bonds, and disulfide bonds
- Quaternary structure: shape of an overall protein that is formed by the conjoining of multiple polypeptides
- Denaturation: occurs when protein unravels and loses shape
  - Protein become inactive or dysfunctional
  - Can be a direct result of changes in pH, salt concentration, and temperature
- Chaperonin: A protein molecule that assists in the proper folding of other proteins.
- Active site: The specific region of an enzyme that attaches to the substrate.
  - Enzyme substrate: The reactant that an enzyme acts on

- Induced-fit model: Theory; enzyme and a substrate bind together, making the active site change shape to favor the substrate, thereby allowing the reaction to proceed faster.
- Cofactors: Minerals; assist in enzyme function
- Coenzymes: vitamins; assist in enzyme function
- Allosteric enzymes: Help in the regulation of enzyme activity by having allosteric sites that when activated by a certain substrate, inhibit enzyme function
- Feedback inhibition: process of enzyme activity control; end product of a metabolic pathway acts as an inhibitor of an enzyme within that pathway.
- Competitive inhibition: when a non-reactant molecule competes with a substrate for access to the active site, thus inhibiting enzyme activity
- Noncompetitive inhibition: when a non-reactant molecule is produced somehow and attaches to an enzyme's allosteric site)separate from active site), thereby changing the enzyme's shape and inhibiting enzyme activity (substrate no longer fits into active site)

2. Environmental Impacts on Enzyme Function:

- Active sites: substrate specific, and can be changed due to factors in the environment.
  - Changes in temperature, pH, enzyme concentration, substrate concentration, regulatory, molecules, cofactors, compartmentalization, feedback inhibition can change active sites
- higher temperature = higher rate of reaction
  - Extreme high temperatures can cause an enzyme to lose its shape (denature).
- Each enzyme has an optimum pH range. Changing the pH outside of this range will slow enzyme activity. Extreme pH values can cause enzymes to denature.
- Increasing enzyme concentration = speed up the reaction to an extent, if there is substrate available to bind to..
- Increasing substrate concentration = increases the rate of reaction to a certain point.
- In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity
- Regulatory molecules: Inhibitors prevent or mitigate enzyme activity.
- Allosteric regulation: may either inhibit or stimulate an enzyme's activity; involves the use of allosteric sites
- Cooperativity (regarding enzymes): the substrate itself serves as an allosteric activator: when it binds to one active site, the activity of the other active sites goes up. This is considered allosteric regulation because the substrate affects active sites far from its binding site.
- Cofactors: Any non protein molecule or ion that is required for the proper functioning of an enzyme.
- Coenzymes: An organic molecule that is necessary in some reactions involving enzymes
- ATP is an allosteric inhibitor of some of the enzymes
  - ADP, on the other hand, serves as a positive allosteric regulator (an allosteric activator) for some of the same enzymes that are inhibited by

ATP. Thanks to this pattern of regulation, when ADP levels are high compared to ATP levels, cellular respiration enzymes become very active and will make more ATP through cellular respiration.

3. Cellular Energy:

- Adenosine triphosphate (ATP): important energy molecule for multiple reactions
- Heterotroph: Organism that obtains energy from sources outside of itself (cannot produce its own energy, so it consumes it from other sources)
- Autotroph: Organism produces its own energy by converting solar energy into chemical energy
- Photosynthesis: process by which producers use light energy to create their own chemical energy from carbon and water
- Pigment: molecule that works to absorb light; important in photosynthesis
    - Chlorophyll: important pigment
- Thylakoid: Sac-like photosynthetic membrane found in chloroplasts
- Stroma: Region outside the thylakoid membranes in chloroplasts
- NADP+: One of the carrier molecules a transfer to high-energy electrons from chlorophyll to other molecules
- Light dependent reactions: reactions of photosynthesis that use light energy
- Light independent reactions: photosynthetic reactions that do not require light energy to proceed
- Cellular respiration: opposite process of photosynthesis
    - works to release energy by breaking down glucose in the presence of O_2
- Photosynthesis equation: $6\ CO_2 + 6\ H_2O = C_6H_{12}O_6 + 6O_2$ is the balanced equation
- Calvin Cycle: cycle in plants that makes sugar from carbon dioxide, H+ ions, and high-energy electrons carried by NADPH. The enzymes are located outside the thylakoids and dissolved in the stroma.
- Stomata (singular stoma): pores in a leaf; allow for the entrance of CO_2 and the exit of O_2
- Photosystem: cluster of chlorophyll and other molecules in a thylakoid
- Light Reactions: take place in the membranes of thylakoids in the chloroplast. pigments like chlorophyll absorb light energy, and use it to split hydrogen and oxygen and water
- Electron transport chain: a series of electron carrier proteins that shuttle high-

energy electrons during ATP-generating reactions

- ATP synthase: proteins located in the thylakoid membrane, it spans the membrane and allows H+ ions to pass through it
- NADP+ is turned into NADPH when a hydrogen atom is added to NADP+
- Light independent reactions produce O2, ATP, and NADPH.
- Light dependent reactions produce glucose, NADP+ and ADP.
- Dark reactions (dependent on light reactions but largely independent of light itself), use ATP and NADPH to produce energy molecules.

4. Photosynthesis:

- Mesophyll: inner tissue of a leaf, contain many chloroplasts
- Grana: thylakoid stacks
- Stomata: leaf pores
  - Guard cells: responsible for opening and closing stomata
- NADP+: an electron acceptor that is reduced and is used to fuel the calvin cycle
- Calvin cycle: the series of reactions where ATP and NADPH are used to form G3P which is then used to form glucose and other organic molecules including amino acids and nucleic acids
- Products of light reactions: NADPH + ATP + O2
- Reactants of Calvin cycle: NADPH + ATP + CO2
- Water molecule splits and allows for an electron to be bumped up to the primary electron acceptor in photosystem II
- p700: chlorophyll located in photosystem I
- p680: chlorophyll located in photosystem II
  - Happens FIRST, before photosystem I
- Photorespiration: process where o2 gets substituted for CO2 in the calvin cycle
- Electron Transport Chain: A sequence of electron carrier molecules (membrane proteins) that shuttle H+ protons into the thylakoid stack to create a concentration gradient. This is the process of chemiosmosis
- ATP Synthase: Large protein that uses energy from H+ ion diffusion into the stroma; used to bind ADP and a phosphate group, resulting in the desired ATP molecule

5. **Cellular Respiration:**

- Calvin Cycle (Light and Dark Reactions)
  - The inputs for light reactions: H_2O, $NADP^+$, ADP + Pi, Light
  - The outputs of light reactions: O_2, ATP, NADPH
  - The inputs of Dark Reactions: CO_2, ATP, NADPH
  - The outputs of Dark Reactions: Sucrose, $NADP^+$, ADP + P
  - Light dependent reactions occur in the thylakoid membrane
  - Dark reactions occur in the stroma
  - Dark Reactions (Calvin Cycle) use ATP and NADPH to convert CO_2 to G3P, return ADP, inorganic phosphate, and $NADP^+$ to light reactions, light-dependent reactions convert light energy to chemical energy of ATP and NADPH which split H_2O and release O_2
- The process of cellular respiration is OPPOSITE to photosynthesis
  - Glycolysis: reactant is glucose, products are 2 pyruvates, from glycolysis, 2 electrons are delivered to oxidative phosphorylation through NADH. Net output of 2 ATP
  - Pyruvate Oxidation: 2 Acetyl CoA. 2 NADH leave
  - Citric Acid Cycle: Inputs: 1 Acetyl CoA, 3 NAD^+, 1 ADP + Pi, 1 FAD. Outputs: 2 CO_2, 3 NADH, 1 ATP, 1 FADH
  - Oxidative Phosphorylation: Electron Transport Chain to chemiosmosis to output of ATP.
- Fitness is better covered and explained in Unit 7.

Sources

- www.khanacademy.org