SSC-I BIOLOGY
CHP#7 NOTES

1. Define metabolism, catabolism and anabolism with examples

Metabolism refers to all the chemical reactions occurring within an organism to maintain life. These reactions are divided into two main types: **catabolism** and **anabolism**.

- **Catabolism:**

Catabolism involves the breakdown of complex molecules into simpler ones, releasing energy in the process.

Example: Cellular respiration, where glucose is broken down into carbon dioxide and water, releasing energy.

- **Anabolism:**

Anabolism involves the synthesis of complex molecules from simpler ones, requiring energy input.

Example: Protein synthesis, where amino acids are linked together to form proteins.

2. Differentiate between Catabolism and Anabolism

Components	Catabolism	Anabolism
Introduction	It is a process which involves breaking complex molecules into simpler ones	It is a process or series of different reaction which involves in formation of molecules from the smaller components
Effect on Body	Calories and fats are burned in this process. It also uses the stored food within the cell to generate energy	Anabolism repairs the tissues and increases muscle mass by using energy and heat
Energy Conversion	In catabolism, potential energy is converted into kinetic	In anabolism, kinetic energy is converted into potential
Example	Digestion	Protein synthesis

3. Define Enzymes and describe their characteristics

Definition:

Enzymes are biological catalysts, typically proteins that speed up the rate of biochemical reactions without being consumed in the process.

Characteristics of Enzymes:

1. Specificity:

- **Definition:** Each enzyme is specific to a particular substrate, like a lock and key.
- **Example:** Lactase specifically breaks down lactose into glucose and galactose.

2. Efficiency:

- **Definition:** Enzymes significantly increase reaction rates, often millions of times faster than un-catalyzed reactions.
- **Example:** Catalase rapidly decomposes hydrogen peroxide into water and oxygen, protecting cells from oxidative damage.

3. Active Site:

- **Definition:** The active site is a specific region on the enzyme where the substrate binds.
- **Example:** In the enzyme-substrate complex, the substrate binds to the active site of the enzyme, forming a temporary bond.

4. Temperature and pH Sensitivity:

- **Definition:** Enzyme activity is optimal within a specific temperature and pH range.
- **Example:** Pepsin, a digestive enzyme in the stomach, works best in acidic conditions (pH 2), while trypsin, found in the small intestine, functions optimally in alkaline conditions (pH 8).

5. Reusability:

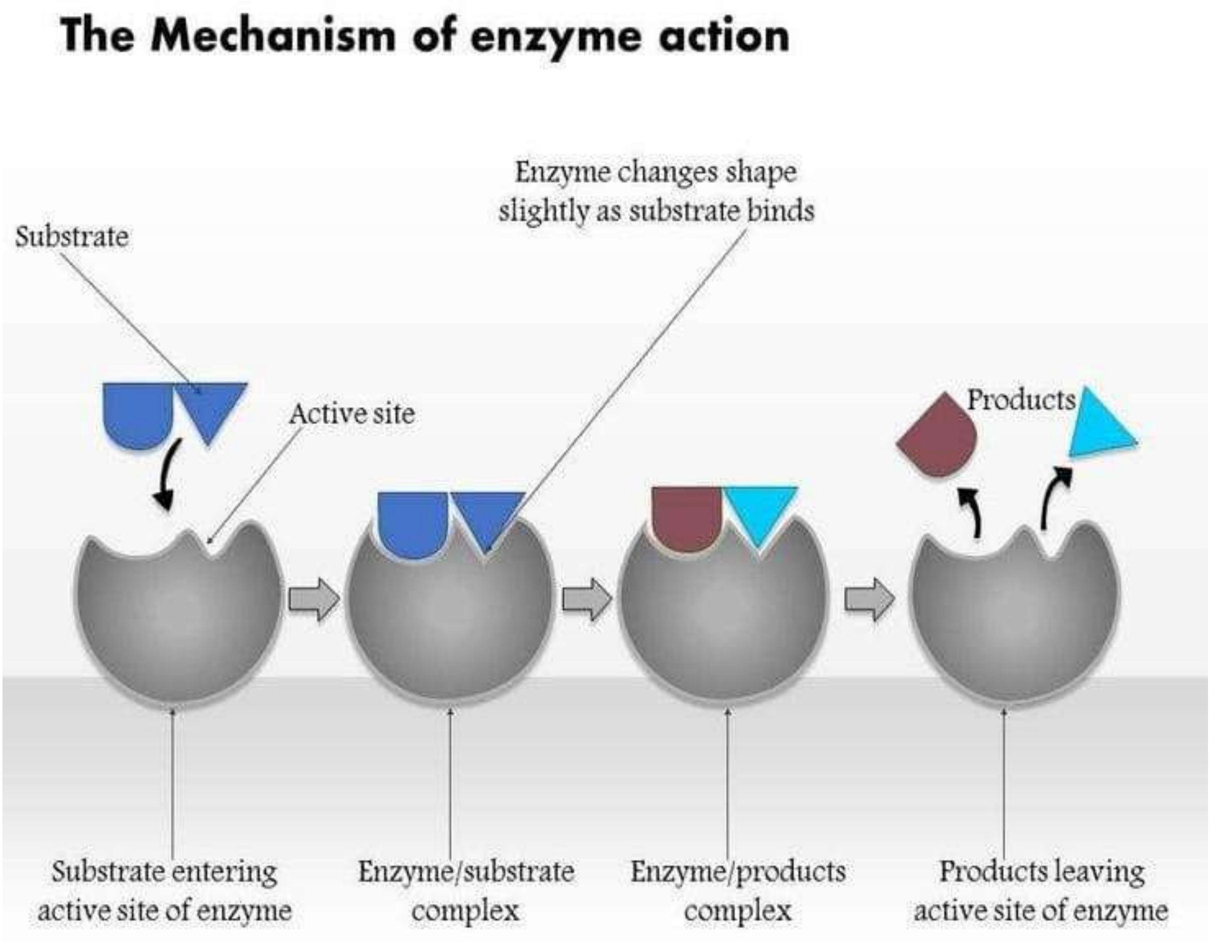
- **Definition:** Enzymes are not consumed in the reaction and can be reused multiple times.
- **Example:** A single enzyme molecule can catalyze thousands of reactions per second.

6. Regulation:

- **Definition:** Enzyme activity can be regulated by inhibitors and activators.
- **Example:** Competitive inhibitors, like malonate, compete with succinate for the active site of succinate dehydrogenase, slowing down the citric acid cycle.

4. Show the mechanism of enzyme action

- **Substrate Binding:** The enzyme has an active site, which is a specific region that binds to the substrate (the molecule the enzyme acts on). The substrate fits into the active site like a key in a lock.
- **Enzyme-Substrate Complex Formation:** The binding of the substrate to the active site forms an enzyme-substrate complex.
- **Enzyme-Product Complex Formation:** The enzyme catalyzes the reaction, converting the substrate into product. This forms an enzyme-product complex.
- **Product Release:** The product is released from the active site, and the enzyme is free to bind to another substrate molecule.



5. Assess the factors which could influence enzyme activity

Temperature

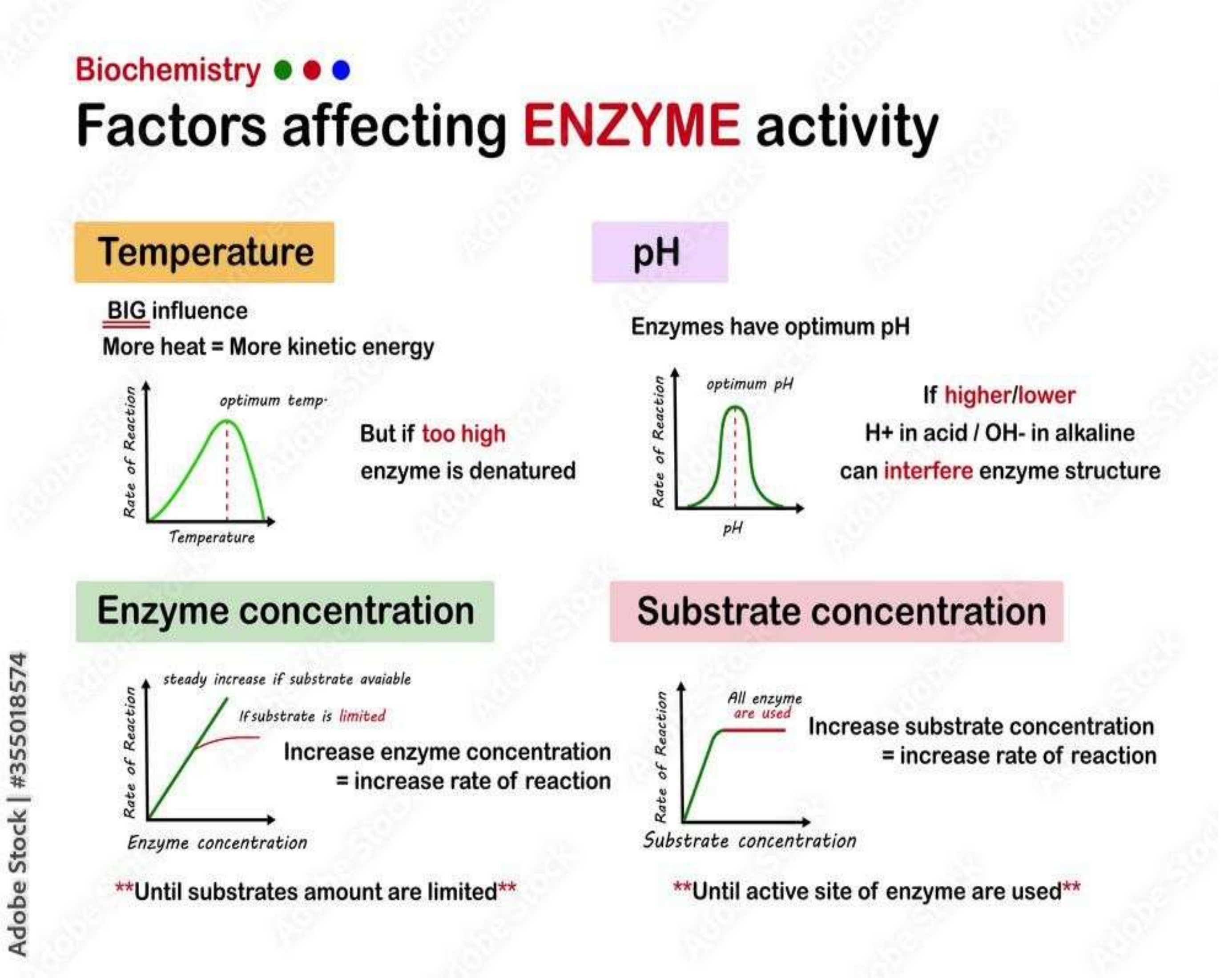
- **Optimal Temperature:** Enzymes in the human body often function optimally around 37°C. For example, enzymes involved in digestion in the stomach work best in acidic conditions, while those in the small intestine function best in alkaline conditions.
- **Low Temperature:** Refrigeration slows down food spoilage by reducing the activity of enzymes that cause decay.
- **High Temperature:** Fever can denature enzymes in the body, leading to various health issues. Cooking food denatures enzymes, making it easier to digest.

pH

- **Optimal pH:** Pepsin, an enzyme in the stomach, works best in a highly acidic environment (pH around 2). In contrast, trypsin, an enzyme in the small intestine, functions optimally in a slightly alkaline environment (pH around 8).
- **Extreme pH:** Exposure to strong acids or bases can denature enzymes, as seen in chemical burns.

Substrate Concentration

- **Low Concentration:** At low substrate concentrations, enzyme activity is limited. For instance, during fasting, when blood sugar levels are low, the activity of enzymes involved in glucose breakdown is reduced.
- **High Concentration:** In the presence of excess substrate, enzyme activity reaches a maximum point (saturation). This is why adding excessive amounts of detergent to laundry doesn't necessarily lead to significantly cleaner clothes.



6. **Differentiate between competitive, and non-competitive inhibition**

Difference between competitive and non-competitive inhibition

Competitive inhibition	Non-competitive inhibition
example: succinate dehydrogenase is inhibited by malonate	**example:** pyruvate kinase is inhibited by alanine
substrate and inhibitor are chemically similar & have same shape	substrate and inhibitor are chemically not similar & have different shape
inhibitor binds to active site	inhibitor binds away from the active site i.e. at allosteric site
inhibitor does not change the shape of the active site	inhibitor changes the shape of the active site

7. **At what pH do pepsin and trypsin enzymes act the best?**
Pepsin and trypsin are digestive enzymes that function optimally at specific pH levels. Pepsin, found in the stomach, works best in highly acidic conditions, around pH 2. This acidic environment is essential for pepsin to break down proteins into smaller peptides. In contrast, trypsin, located in the small intestine, functions optimally in alkaline conditions, around pH 8. This alkaline environment is ideal for trypsin to further digest the peptides produced by pepsin.

8. **What happens to an enzyme when it is frozen below 0°C?**
When an enzyme is frozen, its molecular motion slows down significantly, reducing its activity. However, freezing typically doesn't permanently denature the enzyme. The enzyme's structure remains intact, and it can regain its activity when thawed. This is why frozen food can be stored for Extended periods without significant spoilage.

9. **Which protein-digesting enzyme functions in an acidic medium?**
Pepsin is the primary protein-digesting enzyme that functions in the acidic environment of the stomach. It breaks down proteins into smaller peptides, initiating the process of protein digestion. The acidic conditions in the stomach are created by the secretion of hydrochloric acid, which activates pepsinogen, the inactive form of pepsin.

10. **Why are enzymes specific and why can't each one speed up many different reactions?**
Enzymes are highly specific due to the unique shape of their active site. This active site is complementary to the shape of a specific substrate molecule, allowing for a precise fit between the two. This lock-and-key mechanism ensures that only the correct substrate can bind to the enzyme, preventing other molecules from interfering with the reaction. The specificity of enzymes is essential for maintaining cellular processes and preventing unwanted side reactions.

11. **Why is a small quantity of enzyme enough for catalyzing a large number of substrate molecules into products?**

Enzymes are not consumed during the reaction. They can bind to many substrate molecules, catalyze the reaction, and release the products, repeating the process over and over again. This catalytic cycle allows a small amount of enzyme to catalyze a large number of substrate molecules, making enzymes incredibly efficient catalysts.

12. **According to the induced fit model, the active site is flexible. Does it mean that any substrate can attach with this flexible active site? If not, then explain.**

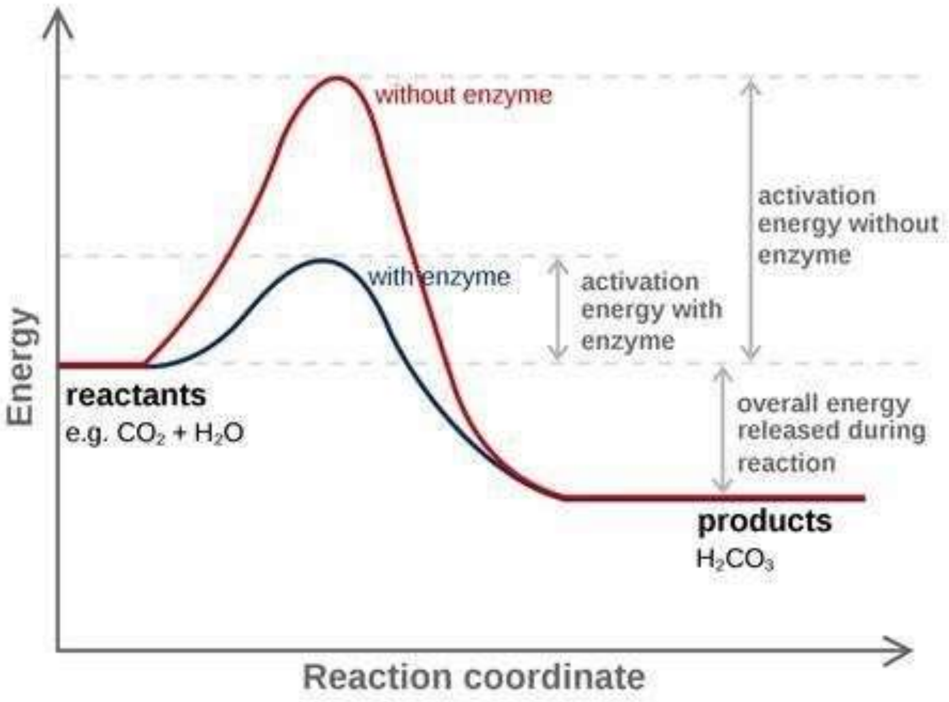
While the active site is flexible, it still has specific amino acid residues that interact with the substrate. The flexibility allows the active site to adjust its shape slightly to accommodate the substrate, but it must still have a compatible shape for binding. This ensures that the enzyme remains specific to its target substrate, preventing non-specific binding and unwanted reactions

13. **What is activation energy and how do enzymes lower it?**

Activation energy is the minimum amount of energy required for a chemical reaction to proceed. It's like the initial push needed to start a car uphill. Enzymes lower activation energy by:

1. **Providing a Better Environment:** The enzyme's active site creates the perfect conditions (like correct pH) for the reaction.
2. **Helping Molecules Fit:** Enzymes change the shape of the substrate slightly (induced fit) to make it easier for the reaction to happen.
3. **Adding a Chemical Group:** Enzymes might temporarily add a group (like phosphate) to the substrate to speed up the reaction.
4. **Changing Shape Temporarily:** The enzyme itself may alter its shape to help the substrate react more easily.

In the diagram, the black line represents the energy pathway with an enzyme, and the red line represents the pathway without an enzyme. As you can see, the enzyme lowers the peak of the energy hill, making it easier for the reaction to proceed.



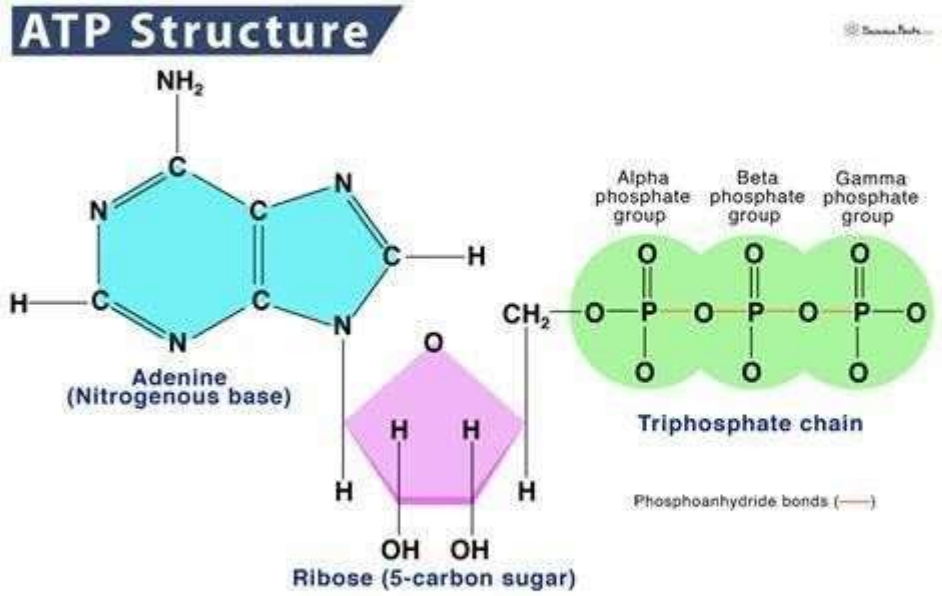
14. Differentiate between:

Feature	Lock-and-Key Model	Induced-Fit Model
Proposed by	Emil Fischer	Daniel Koshland
Shape of Active Site	Active site has a fixed shape.	Active site is flexible and can change shape.
Fit of Substrate	Substrate fits exactly into the active site, like a key fits into a lock.	Enzyme changes its shape slightly to fit the substrate properly.
Flexibility of Enzyme	Enzyme is rigid (not flexible).	Enzyme is flexible.
Explanation of Enzyme Action	Explains enzyme specificity but not enzyme flexibility.	Better explains how enzymes actually work and bind substrates.
Analogy	Lock and key.	Hand fitting into a glove.
Modern Acceptance	Older model; simpler explanation.	More accepted and accurate model today.

1. Sketch the structure of ATP

ATP (Adenosine Triphosphate) is made up of three main parts:

1. **Adenine** – A nitrogenous base.
2. **Ribose** – A five-carbon sugar.
3. **Three phosphate groups** – Connected in a chain.



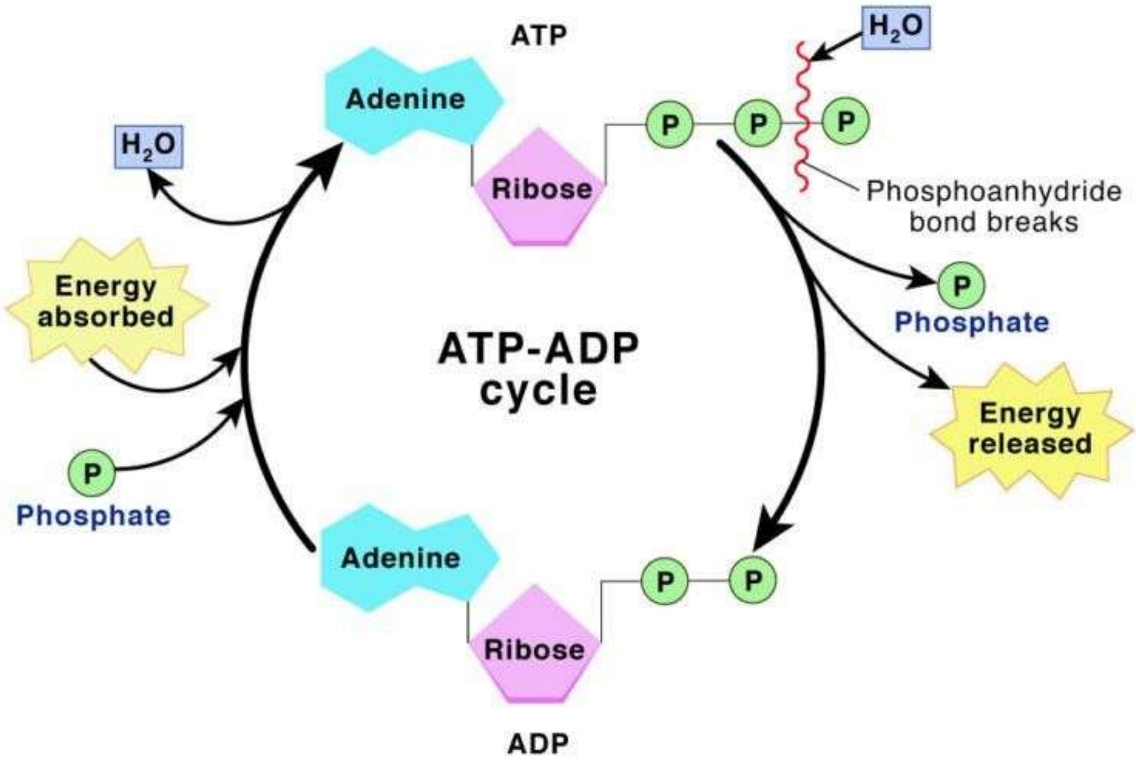
2. Justify with reason that how ATP acts as an energy currency of the cell

ATP, or Adenosine Triphosphate, is often termed as the "energy currency" of the cell due to its crucial role in providing energy for various cellular processes. The key to ATP's energy-storing capacity lies in its **High-energy phosphate bonds**.

When a phosphate group is cleaved from ATP, forming ADP (Adenosine Diphosphate), a significant amount of energy is released. This energy can be harnessed by the cell to power various functions, such as Muscle contraction, Nerve impulse transmission, Active transport

3. What is ATP-ADP Cycle?

- The ATP-ADP cycle is a continuous process in cells that involves the inter-conversion of adenosine triphosphate (ATP) and adenosine di-phosphate (ADP).
    - **ATP Hydrolysis:**
- ATP loses a phosphate group, releasing energy.
    - ATP + H_2O → ADP + Pi + Energy
    - **ATP Synthesis:**
- ADP gains a phosphate group, requiring energy input.
    - ADP + Pi + Energy → ATP + H_2O
- This cycle allows cells to store and release energy efficiently, powering various cellular processes.



4. **Briefly describe mechanism for photosynthesis and enlist each step in it.**

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy. This energy is stored in the form of sugar, which is later used as food.

The process of photosynthesis involves two main stages:

Light-Dependent Reactions:

- **Light Absorption:** Chlorophyll pigments in the chloroplasts absorb sunlight.
- **Electrolysis of Water:** Water molecules are split into oxygen and hydrogen ions.
- **Electron Transport Chain:** High-energy electrons are transported through a series of proteins, generating ATP.
- **NADPH Production:** NADP+ is reduced to NADPH, a high-energy electron carrier.

Light-Independent Reactions (Calvin Cycle):

- **Carbon Fixation:** Carbon dioxide from the atmosphere is fixed into organic molecules.
- **Energy Utilization:** ATP and NADPH from the light-dependent reactions are used to convert the fixed carbon into glucose.
- **Regeneration of RuBP:** The starting molecule, RuBP, is regenerated for the cycle to continue.

Ultimately, photosynthesis converts light energy into chemical energy stored in glucose, which can be used by plants and other organisms for energy and growth.

5. **Explain the Light Dependent Reaction in Detail (Long).**

Light-Dependent Mechanism of Photosynthesis

The **light-dependent reactions** are the first stage of photosynthesis. These reactions occur in the **thylakoid membranes** of the chloroplasts and require **light energy** to take place.

1. Location

- Occurs in the **thylakoid membranes** of the chloroplasts.
- Thylakoids contain **chlorophyll**, a green pigment that absorbs light energy.

2. Raw Materials Needed

- **Light energy** (from the sun)
- **Water (H_2O)**
- **$NADP^+$** (carrier molecule)
- **ADP + P_i** (used to form ATP)

3. Steps of Light-Dependent Reactions

Step 1: Absorption of Light Energy

- Chlorophyll in **photosystem II** absorbs light energy.
- This energy excites **electrons** in chlorophyll, causing them to move to a higher energy level.

Step 2: Photolysis of Water

- Light energy splits water molecules into:
  - **Electrons (e^-)** – Replace lost electrons in chlorophyll.
  - **Protons (H^+)** – Used to form NADPH.
  - **Oxygen (O_2)** – Released as a byproduct.

Equation:

$2H_2O \rightarrow 4H^+ + 4e^- + O_2$

Step 3: Electron Transport Chain (ETC)

- Excited electrons move through a series of proteins called the **electron transport chain**.
- As electrons move, they release **energy**, which is used to:
  - Pump **H^+ ions** into the thylakoid space (creating a proton gradient).

Step 4: Formation of ATP (Chemiosmosis)

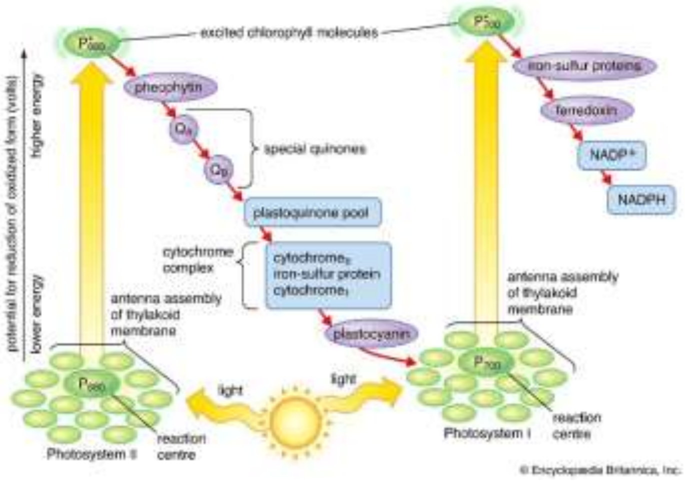
- The H^+ ions (protons) flow back into the stroma through an enzyme called **ATP synthase**.
- This flow generates energy to convert **ADP + P_i** into **ATP**.
  - **ATP** is the energy currency of the cell.

Step 5: Formation of NADPH

- Electrons from the electron transport chain are transferred to **$NADP^+$**.
- $NADP^+$ combines with **H^+ ions** to form **NADPH**.
- **NADPH** is an energy-rich molecule used in the next stage of photosynthesis (Calvin cycle).

4. Products of Light-Dependent Reactions

1. **ATP** – Provides energy for the Calvin cycle (light-independent reactions).
2. **NADPH** – Provides reducing power (hydrogen and electrons) for the Calvin cycle.
3. **Oxygen (O_2)** – Released as a byproduct into the atmosphere.



6. Explain Light In-dependent reaction in Detail (Long). Light-Independent Reactions of Photosynthesis (Calvin Cycle)

The **light-independent reactions** are the second stage of photosynthesis. These reactions do not require light directly but use the energy-rich molecules **ATP** and **NADPH** produced during the light-dependent reactions. The light-independent reactions are also called the **Calvin Cycle** or **dark reactions**.

1. Location

- Occurs in the **stroma** of the chloroplasts (the fluid-filled space surrounding the thylakoids).

2. Raw Materials Needed

- **Carbon dioxide (CO_2)** – From the atmosphere.
- **ATP** – Provides energy (from the light-dependent reactions).
- **NADPH** – Provides electrons and protons (from the light-dependent reactions).

3. Steps of the Light-Independent Reactions (Calvin Cycle)

The Calvin Cycle occurs in **three main stages**:

1. **Carbon Fixation**
2. **Reduction**
3. **Regeneration of RuBP**

Step 1: Carbon Fixation

- Carbon dioxide (CO_2) from the atmosphere combines with a **5-carbon compound** called **Ribulose-1, 5-bisphosphate (RuBP)**.
- This reaction is catalyzed by an enzyme called **Rubisco** (Ribulose-1, 5-bisphosphate carboxylase/oxygenase).
- The result is an unstable **6-carbon compound**, which immediately breaks into **two molecules of 3-phosphoglycerate (3-PGA)** (a 3-carbon compound).

Step 2: Reduction

- The two molecules of **3-PGA** are converted into **Glyceraldehyde-3-phosphate (G3P)**.
- This process requires:

- ATP (provides energy).
- **NADPH** (provides electrons and protons).

- **G3P** is an energy-rich molecule and the main product of the Calvin Cycle.

Summary of Step 2:

- ATP → ADP + P_i (energy used).
- NADPH → $NADP^+$ (electrons used).

Step 3: Regeneration of RuBP

- Some of the **G3P** molecules are used to regenerate **RuBP** (the starting compound).
- This step also requires **ATP**.
- Regenerating RuBP allows the cycle to continue and fix more carbon dioxide.

Summary of Step 3:

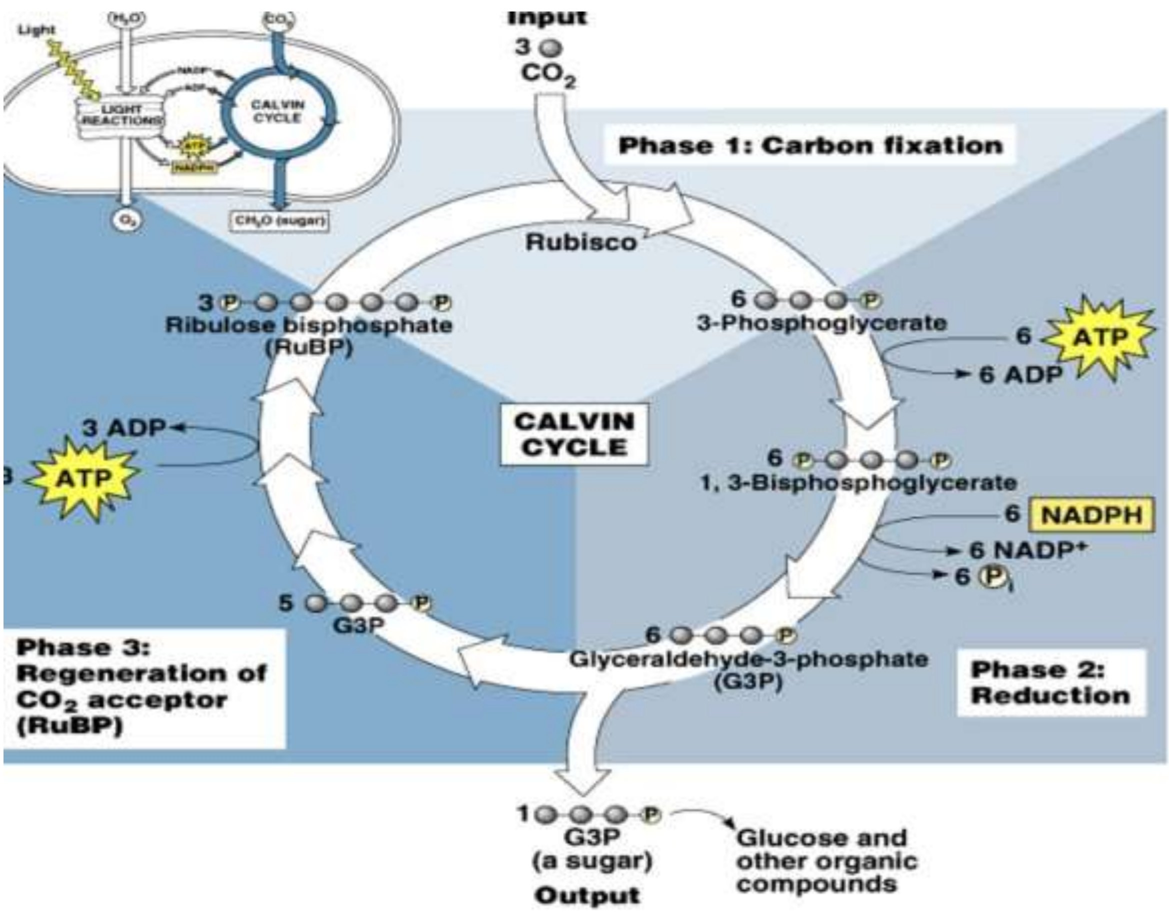
- G3P → RuBP (using ATP).

4. Products of the Calvin Cycle

1. **Glucose ($C_6H_{12}O_6$):** After several cycles, some G3P molecules combine to form glucose, which is used for energy and growth.
2. **Regenerated RuBP:** Allows the cycle to continue.
3. **$NADP^+$ and ADP:** These return to the light-dependent reactions to be reused.

5. Summary of the Calvin Cycle

- **Purpose:** To produce glucose (a sugar) from carbon dioxide using ATP and NADPH.
- **Key Steps:**
  1. Carbon fixation (CO_2 combines with RuBP).
  2. Reduction (3-PGA is converted to G3P using ATP and NADPH).
  3. Regeneration (G3P regenerates RuBP).
- **Key Products:** Glucose, $NADP^+$, ADP, and RuBP



7. Differentiate between Light Dependent and Light In-Dependent Reaction (Long)

Feature	Light-Dependent Reactions	Light-Independent Reactions (Calvin Cycle)
Location	Thylakoid membrane	Stroma
Light Requirement	Requires light	Does not directly require light, but products of light-dependent reactions are essential
Primary Products	ATP, NADPH, and O_2	Glucose
Key Process	Photophosphorylation and photolysis of water	Carbon fixation and sugar synthesis
Energy Source	Sunlight	ATP and NADPH from light-dependent reactions
Electron Carrier	NADP+ is reduced to NADPH	NADPH is oxidized to NADP+
Water Involvement	Water molecules are split to release electrons and protons	Water is not directly involved
Enzyme Involvement	Photosystems I and II, cytochrome complex, ATP synthase	Rubisco, other enzymes of the Calvin cycle
Cyclic vs. Non-Cyclic	Both cyclic and non-cyclic electron flow	Non-cyclic pathway only

8. Why a phase of Photosynthesis is called Dark Reaction, Justify.

The **dark reaction** (light-independent reaction) is called so because it **does not require light directly**. Instead, it uses **ATP** and **NADPH** produced during the light-dependent reactions to fix carbon dioxide into glucose. It occurs in the **stroma** of the chloroplast. While it doesn't need light, it usually happens during the day as it depends on the products of the light-dependent phase.

9. What are the Limiting factors for photosynthesis

The main limiting factors for photosynthesis are:

- **Light Intensity:** Insufficient light intensity can limit the rate of photosynthesis, as it directly affects the light-dependent reactions. As light intensity increases, the rate of photosynthesis increases until it reaches a plateau, where other factors become limiting.
- **Carbon Dioxide Concentration:** Low levels of CO_2 can restrict the rate of photosynthesis, particularly during the light-independent reactions (Calvin cycle). Increasing the CO_2 concentration can boost photosynthetic rates up to a certain point.
- **Temperature:** Temperature affects the enzymes involved in photosynthesis. Optimal temperatures allow for efficient enzyme activity, maximizing the rate of photosynthesis. However, extremely high or low temperatures can denature enzymes, reducing photosynthetic rates.

10. Briefly Describe respiration and enlist it's steps

Respiration is a cellular process that involves the breakdown of glucose to release energy in the form of ATP. This process can be categorized into two main types: aerobic and anaerobic respiration.

Aerobic Respiration

Aerobic respiration involves the breakdown of glucose in the presence of oxygen. It consists of four main stages:

- **Glycolysis:** Glucose is broken down into pyruvate.
- **Formation of Acetyl Co-A:** Pyruvate is converted into acetyl-CoA.
- **Krebs cycle (Citric Acid Cycle):** Acetyl-CoA is oxidized to produce CO_2, NADH, $FADH_2$, and ATP.

- **Electron Transport Chain:** NADH and $FADH_2$ donate electrons to the electron transport chain, generating ATP through oxidative phosphorylation.

Anaerobic Respiration

Anaerobic respiration occurs in the absence of oxygen. It is less efficient than aerobic respiration and produces less ATP. The two main types of anaerobic respiration are:

- **Alcoholic Fermentation:** Glucose is broken down into ethanol and carbon dioxide.
- **Lactic Acid Fermentation:** Glucose is broken down into lactic acid.

11. Explain Fermentation and its types in detail (Long).

1. Fermentation:

- It is a **metabolic process** that produces **ATP** by breaking down glucose in the absence of oxygen.
- Unlike aerobic respiration, fermentation produces much less ATP.
- It is essential for organisms that live in oxygen-limited environments or during short-term oxygen deficiency.
- **Location:** In the **cytoplasm** of cells.
- Occurs in both prokaryotic (e.g., bacteria) and eukaryotic cells (e.g., muscle cells under anaerobic conditions).

2. Types of Fermentation

Fermentation is of **two main types**:

1. **Alcoholic Fermentation**
2. **Lactic Acid Fermentation**

Type 1: Alcoholic Fermentation

Process:

- Carried out by **yeast** and some bacteria.
- Glucose is broken down into **ethanol (alcohol)**, **carbon dioxide (CO_2)**, and a small amount of energy (ATP).

Steps:

1. Glucose ($C_6H_{12}O_6$) is broken down into **pyruvate** through glycolysis.
2. Pyruvate is converted into **ethanol** and **CO_2**.

Equation:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH$ (Ethanol/Ethyl Alcohol) + $2CO_2$ + Energy

Examples of Alcoholic Fermentation:

- Used in **brewing** to produce alcoholic beverages like beer and wine.
- Used in **baking** to make bread rise (CO_2 causes the dough to expand).

Type 2: Lactic Acid Fermentation

Process:

- Carried out by **certain bacteria** and **animal muscle cells** during vigorous activity.
- Glucose is broken down into **lactic acid** and a small amount of energy (ATP).

Steps:

1. Glucose ($C_6H_{12}O_6$) is broken down into **pyruvate** through glycolysis.
2. Pyruvate is converted into **lactic acid**.

Equation:

$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ (Lactic Acid) + Energy

Examples of Lactic Acid Fermentation:

- Occurs in **muscle cells** during strenuous exercise when oxygen is insufficient, causing muscle fatigue.
- Used by bacteria (e.g., **Lactobacillus**) to produce yogurt, cheese, and fermented foods.

12. Comparison Between Alcoholic and Lactic Acid Fermentation

Feature	Alcoholic Fermentation	Lactic Acid Fermentation
End Products	Ethanol and CO_2	Lactic Acid
Carried Out By	Yeast and some bacteria	Bacteria and animal muscle cells
Examples	Brewing, baking	Yogurt production, muscle fatigue
ATP Produced	2 ATP	2 ATP

13. Write Importance of Fermentation

- **Energy Production:** Provides energy (ATP) under anaerobic conditions.
- **Industrial Applications:**
  - Alcoholic fermentation is used in brewing and baking industries.
  - Lactic acid fermentation is used in dairy and food industries (e.g., yogurt, cheese).
- **Survival Mechanism:** Allows organisms to survive in oxygen-limited environments.
- **Muscle Activity:** In humans, lactic acid fermentation provides energy during intense exercise.

14. Explain Aerobic Respiration in Detail (Long).

Aerobic respiration is a process in which glucose is broken down in the presence of **oxygen** to produce **energy (ATP)**, carbon dioxide (CO_2), and water (H_2O). It is the most efficient way of generating energy in living organisms. The first step (glycolysis) occurs in the **cytoplasm**. The remaining steps occur in the **mitochondria** of the cell.

1. Stages of Aerobic Respiration

Aerobic respiration occurs in **four main stages**:

1. **Glycolysis**
2. **Formation of Acetyl Co-A**
3. **Krebs Cycle (Citric Acid Cycle)**
4. **Electron Transport Chain (ETC) and Oxidative Phosphorylation**

Step 1: Glycolysis

- **Location:** Cytoplasm
  - **Process:**
    - One molecule of glucose ($C_6H_{12}O_6$) is broken down into **two molecules of pyruvate** (3-carbon compound).
    - ATP and NADH are produced.
  - **Products:**
    - **2 Pyruvate**
    - **2 ATP** (net gain)
    - **2 NADH**

Step 2: Formation of Acetyl Co-A

- **Location:** Mitochondrial matrix
  - **Process:**
    - Pyruvate (from glycolysis) is converted into **Acetyl-CoA** (2-carbon molecule).
    - Carbon dioxide (CO_2) is released, and NADH is produced.
  - **Products:**
    - **Acetyl-CoA**

- **1 CO_2** per pyruvate
- **1 NADH** per pyruvate

Step 3: Krebs cycle (Citric Acid Cycle)

- **Location:** Mitochondrial matrix
  - **Process:**
- Acetyl-CoA enters the cycle and combines with a 4-carbon compound (**oxaloacetate**) to form **citrate** (6-carbon compound).
- Through a series of reactions, citrate is broken down, releasing CO_2, and producing ATP, NADH, and $FADH_2$.
- **Products (per Acetyl-CoA):**
  - **2 CO_2**
  - **3 NADH**
  - **1 $FADH_2$**
  - **1 ATP**

Step 4: Electron Transport Chain (ETC) and Oxidative Phosphorylation

- **Location:** Inner membrane of the mitochondria
  - **Process:**
- NADH and $FADH_2$ (produced in earlier steps) donate electrons to the **Electron Transport Chain**.
- As electrons move through the chain, energy is released and used to pump protons (H^+) across the membrane, creating a **proton gradient**.
- Protons flow back through an enzyme called **ATP synthase**, which generates ATP.
- At the end of the chain, **oxygen** acts as the final electron acceptor, combining with protons and electrons to form **water** (H_2O).
- **Products:**
  - **Approximately 34 ATP**
  - **H_2O**

15. Differentiate between Aerobic and An-aerobic Respiration (Long).

Feature	Aerobic Respiration	Anaerobic Respiration
Oxygen Requirement	Requires oxygen	Does not require oxygen
Final Electron Acceptor	Oxygen	Organic molecules (like pyruvate)
ATP Yield	High (36-38 ATP per glucose molecule)	Low (2 ATP per glucose molecule)
End Products	Carbon dioxide and water	Lactic acid or ethanol and carbon dioxide
Efficiency	Highly efficient	Less efficient
Location in Cell	Mitochondria	Cytoplasm
Examples of Organisms	Most animals, plants, and many microorganisms	Bacteria, yeast, and muscle cells during intense exercise

16. Write Equations for Photosynthesis, Fermentation, and Aerobic Respiration

- **Photosynthesis**
  Equation: $6CO_2 + 6H_2O + \text{Sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$
- **Fermentation:**
- **Alcoholic Fermentation:** $C_6H_{12}O_6 \rightarrow 2C_2H_5OH$ (Ethanol/Ethyl Alcohol) $+ 2CO_2$ + Energy
- **Lactic Acid Fermentation:** $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ (Lactic Acid) + Energy
- **Aerobic Respiration**

Equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy (ATP)

17. How are photosynthesis and aerobic respiration interlinked with each other?

Photosynthesis and aerobic respiration are interconnected because:

1. **Photosynthesis** produces **glucose** and **oxygen**, which are used as reactants in **aerobic respiration**.
2. **Aerobic respiration** releases **carbon dioxide** and **water**, which are used as reactants in **photosynthesis**.

Summary:

- Photosynthesis: Converts CO_2 and H_2O into glucose and O_2 (stores energy).
- Aerobic respiration: Breaks down glucose and O_2 to release energy (produces CO_2 and H_2O).

This forms a **cycle** that maintains the balance of oxygen and carbon dioxide in the atmosphere.

- **YouTube Links For Topics:**
- https://youtu.be/CMiPYHNNg28?si=efG2Tb4jHDO-zTlJ
- https://youtu.be/eJ9Zjc-jdys?si=nkEAHUIcl04xk477
- https://youtu.be/23ZzI6WZS28?si=23WFCny-7Qtr0vNr