وزارة التعليم
Ministry of Education

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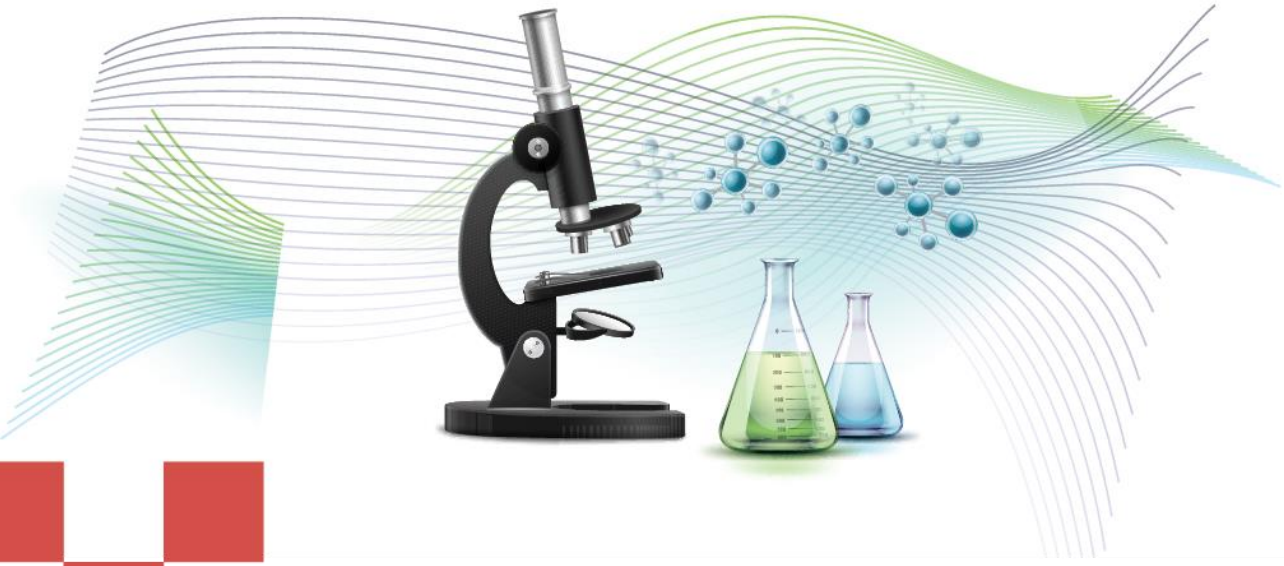
NSMO
National Science and
Mathematics Olympiad

Biology Team Training Pack
Phase One
Science



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Introduction

This course pack covers a set of fundamental concepts in biology, beginning with the study of the cell as the basic unit of life, moving through the biological processes that provide organisms with energy, and culminating in an understanding of how cells grow, divide, and integrate into complex systems within the human body.

The topics presented aim to provide a comprehensive overview of the essential components of life, the processes that sustain it, and the general structures that regulate the functioning of living organisms. They also explore the interrelationships among living creatures within ecosystems, the transfer of energy across trophic levels, the role of matter cycling in maintaining environmental sustainability, and the characteristics of major terrestrial and aquatic biomes. In addition, the pack examines biodiversity, animal behavior, and the various factors influencing it.

We have carefully designed this material to offer you both scientific content and an integrated vision that begins at the cellular level and extends to large-scale ecological systems. Presented in clear, engaging language, it aims to inspire your curiosity and encourage you to explore further challenges and the joy of learning.

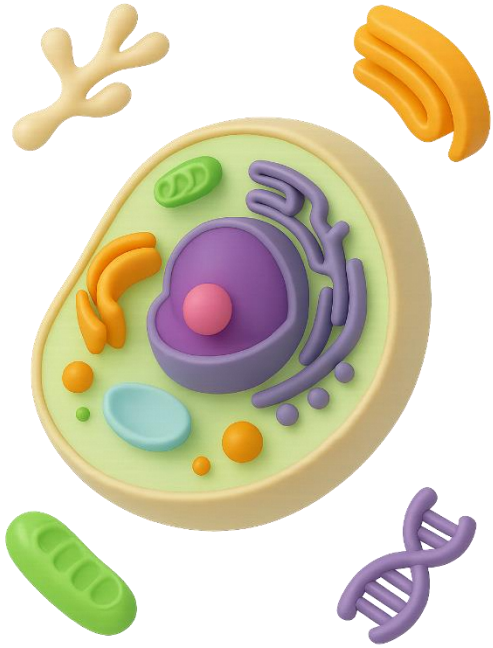
General Objectives

1- To build fundamental concepts in biology as a foundation for participation in scientific competitions.
2- To prepare students for the continuation of advanced studies in Olympiad-level biology.
3- To enrich the field with scientific material that supports and sustains the passion of those interested in Olympiad biology.
4- To promote and disseminate the culture of Olympiad participation.

Specific Objectives

1- For the student to be able to describe the different types of cells, their structures, and their functions.
2- For the student to recognize the chemical composition of the cell.
3- For the student to identify the sources of cellular energy and explain the mechanisms of its transfer.
4- For the student to explain the vital processes occurring within the cell, such as photosynthesis, cellular respiration, and cell division.

Chapter 1
Cell Structure and Function



Introduction

- **The Cell:** It is the structural and functional unit of a living organism
- **Types of cells:**
    - Prokaryotic cells: The genetic material is free and not surrounded by a membrane, such as in bacteria.
    - Eukaryotic cells: The genetic material is enclosed within a nucleus surrounded by a membrane, such as in plants and animals.
- Levels of organization in living organisms begin with the cell as follows:
- Cell → Tissue → Organ → System → Organism
- Tissue: A group of similar cells that perform the same function.
- Organ: A group of specialized tissues that perform specific functions.
- System: A number of organs working together to perform a certain task.
- Organism: May consist of a single cell, a number of tissues, a number of organs, or a number of systems.
- Protoplasm: Refers to what is inside the plasma membrane, including the cytoplasm and the nucleus.

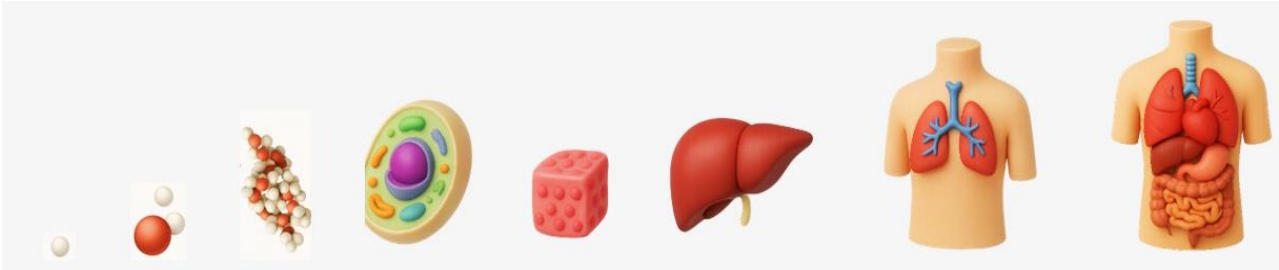
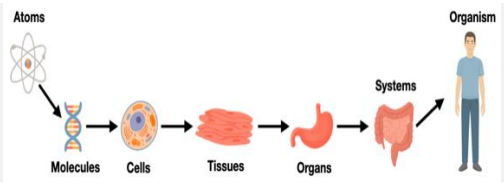
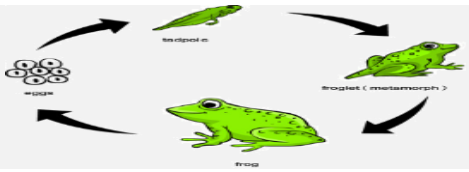
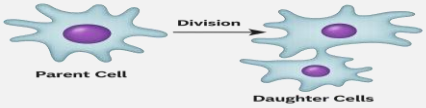
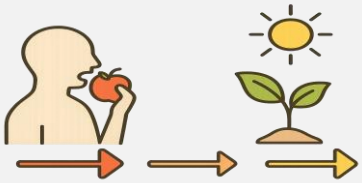
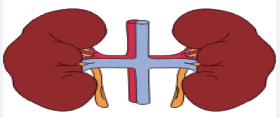


Figure 1 Levels of organization in living organisms

Characteristics of living organisms:

All living organisms, regardless of their sizes, share the following characteristics:

Property	Definition	Example
Organization	Presence of organs, starting from the cell and ending with the organ system.	
Growth	Increase in size and weight.	
Reproduction	Increase in the number of individuals of the species.	
Obtaining Energy	Through direct oxidation of food in heterotrophic organisms. In autotrophic organisms, they produce their own food.	
Response	Sensitivity to internal and external stimuli and producing an appropriate response.	
Excretion	Maintaining homeostasis by eliminating wastes.	
Adaptation	Making structural and behavioral changes to cope with the environment.	

Cell Theory:

The cell theory states that:-

1. All living organisms are composed of one or more cells.
2. The cell is the basic unit of structure and function in living organisms.
3. New cells arise only from pre-existing cells.

Comparison between Prokaryotes and Eukaryotes:

Feature	Prokaryotic Cells	Eukaryotic Cells
Number of Cells	Unicellular only	Unicellular or Multicellualr
Nucleus	No true nucleus; DNA is free in cytoplasm	True nucleus enclosed by a nuclear membrane
DNA structure	Circular DNA (plasmid may be present)	Linear DNA organized into chromosomes
Organelles	No membrane-bound organelles	Membrane-bound organelles (mitochondria, ER, etc.)
Cell wall	Usually present (peptidoglycan in bacteria)	In plants (cellulose) and fungi (chitin); absent in animals
Chromosome	Usually one (single circular chromosome)	More than one (multiple linear chromosomes)
Examples	Bacteria, Archaea	Plants, Animals, Fungi, Protists

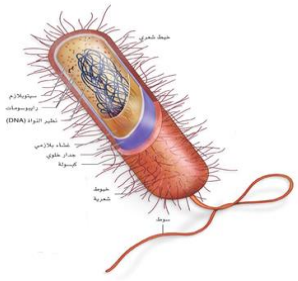


Figure 2 Prokaryotic Cells

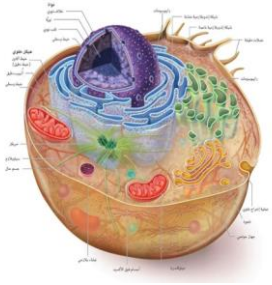


Figure 3 Eukaryotic Cells

Difference between Plant Cell and Animal Cell.

Structure	Plant Cell	Animal Cell
Cell Wall	Present	Absent
Nucleus Location	Peripheral	Central
Plastids	Present	Absent
Centrosome	Absent	Present
Vacuoles	One large vacuole	Several small vacuoles

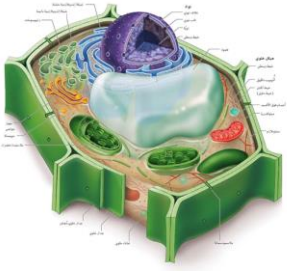


Figure 4 Plant Cell

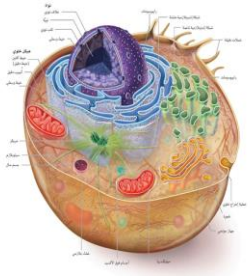
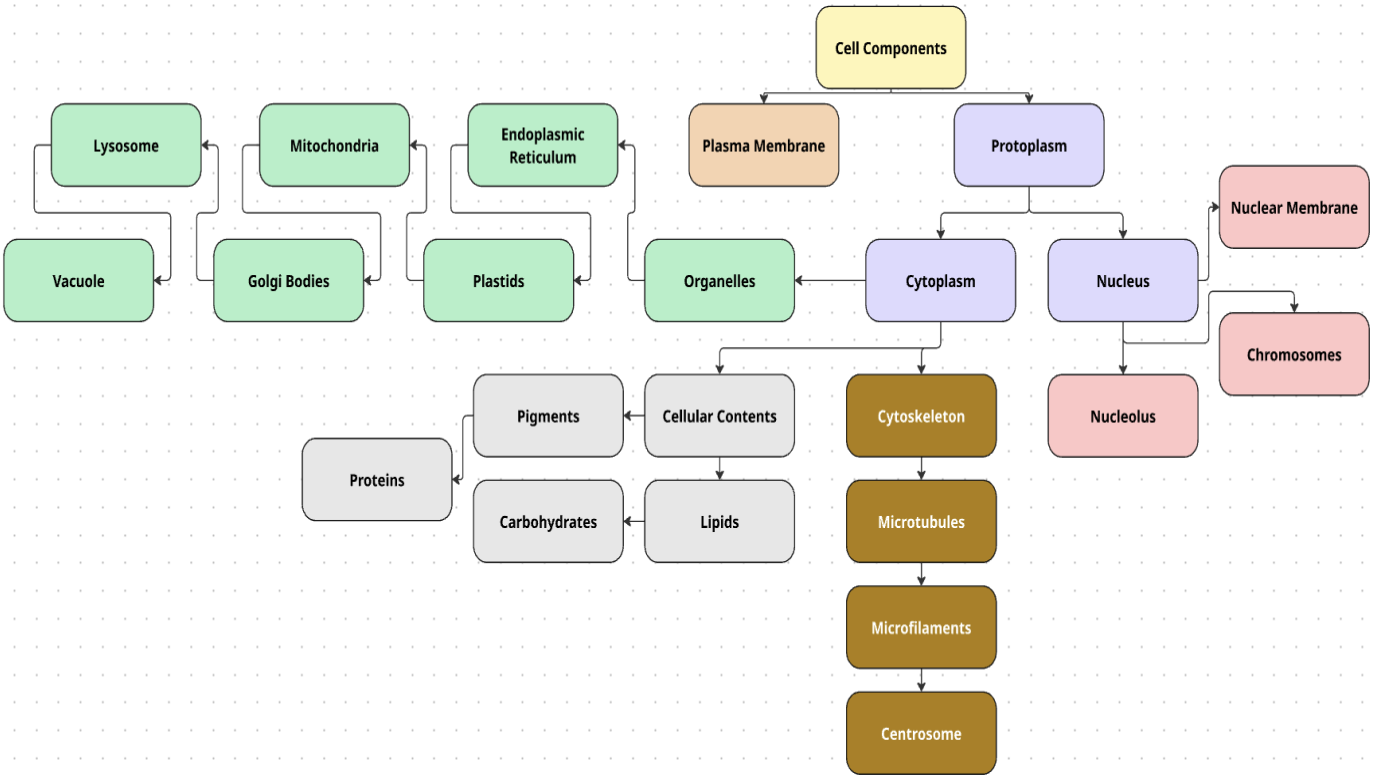


Figure 5 Animal Cell

Cell Contents Concept Map



Cytoskeleton: A network of protein filaments that supports the cell, gives it its sha pe, anchors organelles inside the cell, and also contributes to regulating the movement of organelles within the cell.

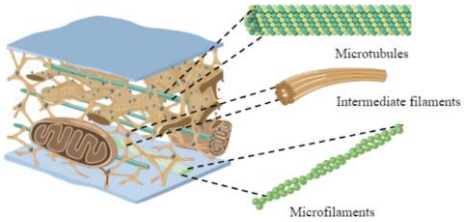
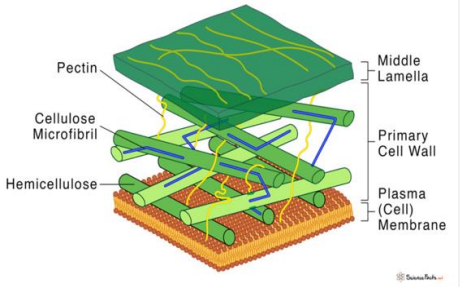
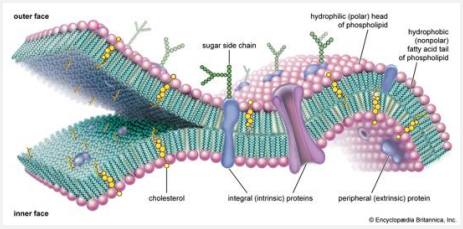
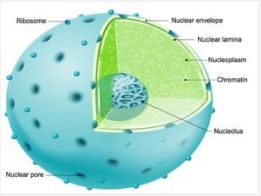
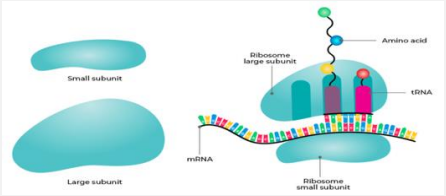
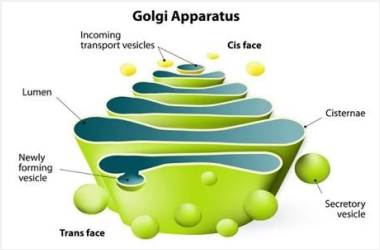
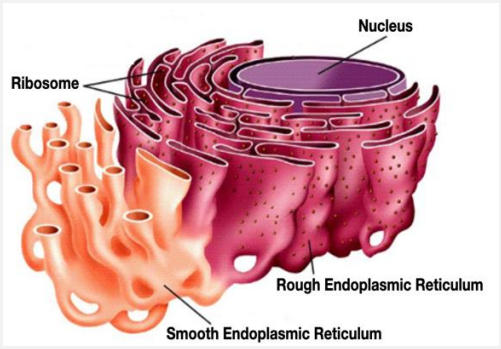
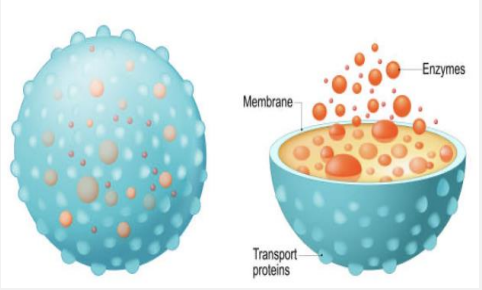


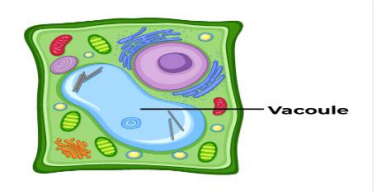
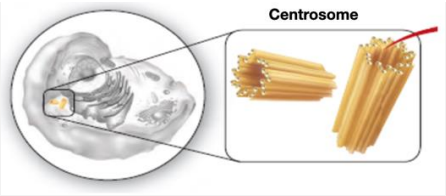
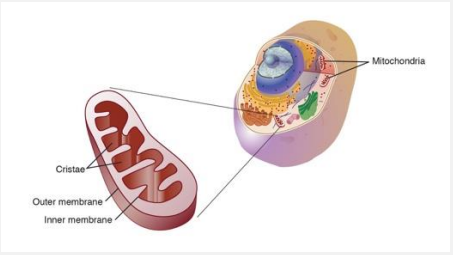
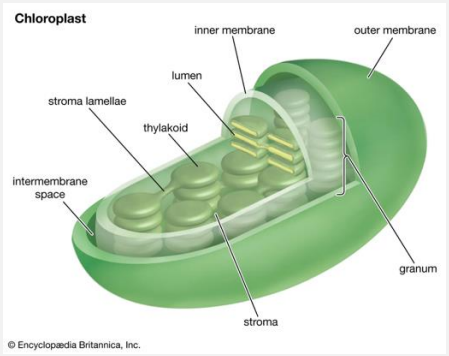
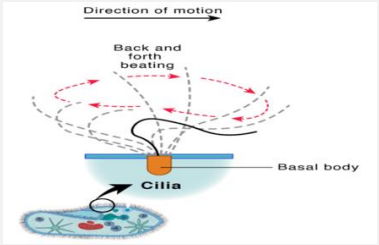
Figure 6 Cytoskeleton

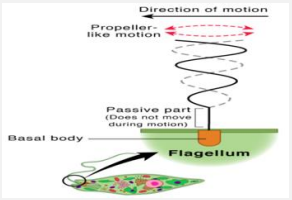
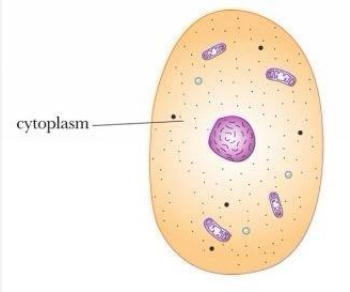
Cell Structures (Organelles):

Structure	Function	Figure
Cell Wall	- A perforated membrane that allows all materials to pass into and out of the cell. - Its function is support and protection. - It is found in all cells except animal cells and their counterparts.	

Cell Membrane	- A double layer of phospholipids and proteins. - Defines the boundaries of the cell and regulates the passage of molecules into and out of the cell (selective permeability).	
Nucleus	- Storage of genetic information - Production of DNA and RNA - Control and command center of the cell	
Ribosome	- Protein synthesis - Found free in the cytoplasm or attached to the endoplasmic reticulum	
Golgi Apparatus	- A system composed of stacked membranes. - It modifies, sorts, and packages materials into sacs called vesicles. - Responsible for the formation of lysosomes.	

Structure	Function	Figure
Endoplasmic Reticulum (ER)	A system consisting of interconnected channels, divided into two types: 1. Rough Endoplasmic Reticulum (RER) - Site of ribosome attachment - Responsible for protein synthesis and transport 2. Smooth Endoplasmic Reticulum (SER) - Lacks ribosome attachment - Responsible for the synthesis of carbohydrates and complex lipids, including phospholipids - In the liver, it detoxifies harmful substances from the body - Transports proteins	
Lysosome	-Originate from the Golgi bodies and the endoplasmic reticulum. -Carry out intracellular digestion (within the cell). -Responsible for programmed cell death (apoptosis).	

Vacuole	- Storage of materials. - Its size in plant cells is larger than in animal cells.	
Centrioles	- A pair of tubules. - Form the spindle fibers. - Play a role in animal cell division	
Mitochondria	- Cellular Respiration - The powerhouse of the cell - Surrounded by two membranes - Contains genetic material	
Chloroplast	- Photosynthesis - Surrounded by two membranes and contains genetic material - Colorless plastids store materials - Colored plastids give flowers and fruits their colors	
Cilia	- Short, numerous, hair-like projections. - Move in coordination to transport substances or aid cell movement. - Made of microtubules (9+2 arrangement).	

Flagella	- Long and few in number (usually 1–2 per cell). - Whip-like motion used mainly for locomotion. - Made of microtubules (9+2 arrangement).	
Cytoplasm	- Gel-like substance that fills the cell. - Composed of water, salts, and organic molecules. - Supports organelles and holds them in place. - Site of many metabolic reactions.	

Membranous Structure (Cell Membrane)

• The cell membrane is defined as the boundary separating the cell's protoplasm from the external environment, controlling the passage of substances into and out of the cell (selective permeability).

• It surrounds the cell externally, as well as the nucleus and organelles.

• It is composed of two layers of lipids (phospholipids) interspersed with proteins and carbohydrates.

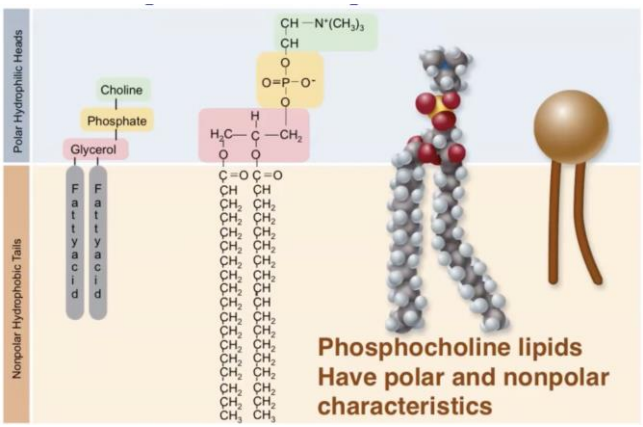


Figure 7 Phosphocholine lipids

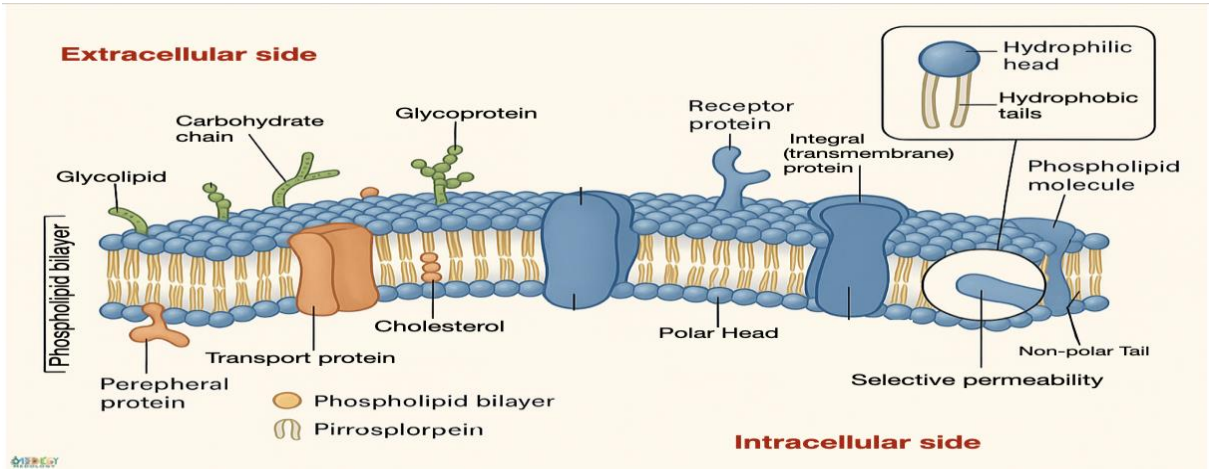


Figure 8 Membranous Structure

Membrane Structure

I. Lipid Molecules	
1) Cholesterol	Regulates the flexibility of the membrane depending on temperature.
2) Hydrophobic phospholipids	Allow the passage of non-polar, water-repelling molecules such as CO_2, O_2, and hydrocarbons.
3) Hydrophilic phospholipids	Permit the limited passage of polar, water-loving substances, such as small amounts of water through tiny pores between phospholipid molecules.
II. Protein Molecules	
1) Enzyme protein	Some membrane proteins act as enzymes that facilitate chemical reactions within the cell.
2) Transport protein	Helps specific substances pass through the cell membrane.
3) Receptor protein	Recognizes and binds to specific molecules outside the cell.

III. Carbohydrate Molecules	
1) Glycoprotein	A distinctive marker on the cell surface that gives each cell its identity, enabling immune cells to recognize the body's own cells and prevent them from being attacked. (This is the basis for immune rejection in organ transplantation.)
2) Membrane Carbohydrates	• Play a role in hormone reception. • Help in cell adhesion and binding. • Contribute to cell recognition within the same organism. • Therefore, they are important in immune interactions.

Transport of Substances Across the Membrane:

Osmosis

The process of moving solvent molecules (water) from a solution with a lower solute concentration to a solution with a higher solute concentration.

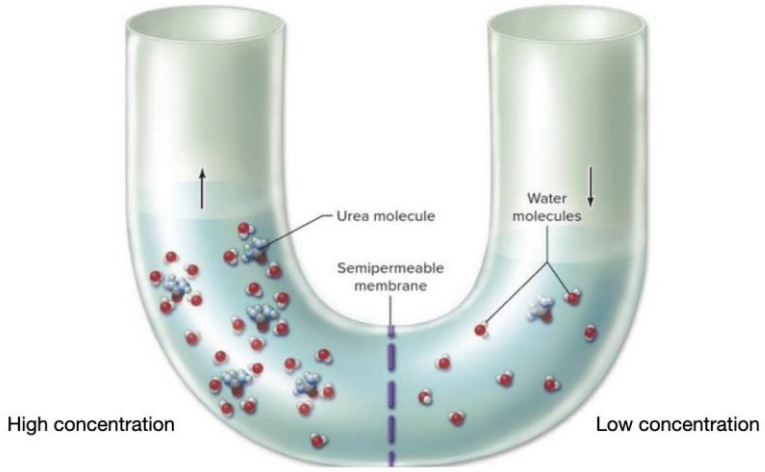


Figure 9 Osmosis

Solutions are classified according to their osmotic concentration into three types, each with a specific effect on the cell:

- Hypertonic solution: A solution with a high concentration of solute (salts).
- Hypotonic solution: A solution with a low concentration of solute (salts).
- Isotonic solution: A solution with an equal solute concentration (salts).

Example 1: Red blood cells placed in solutions of different concentrations

- When red blood cells are placed in a hypertonic solution:

The red blood cells shrink as a result of water leaving the cell.

- When red blood cells are placed in a hypotonic solution:

The red blood cells swell and may burst due to water entering the cell.

- When red blood cells are placed in an isotonic solution:

The red blood cells remain unchanged because the concentrations are balanced.

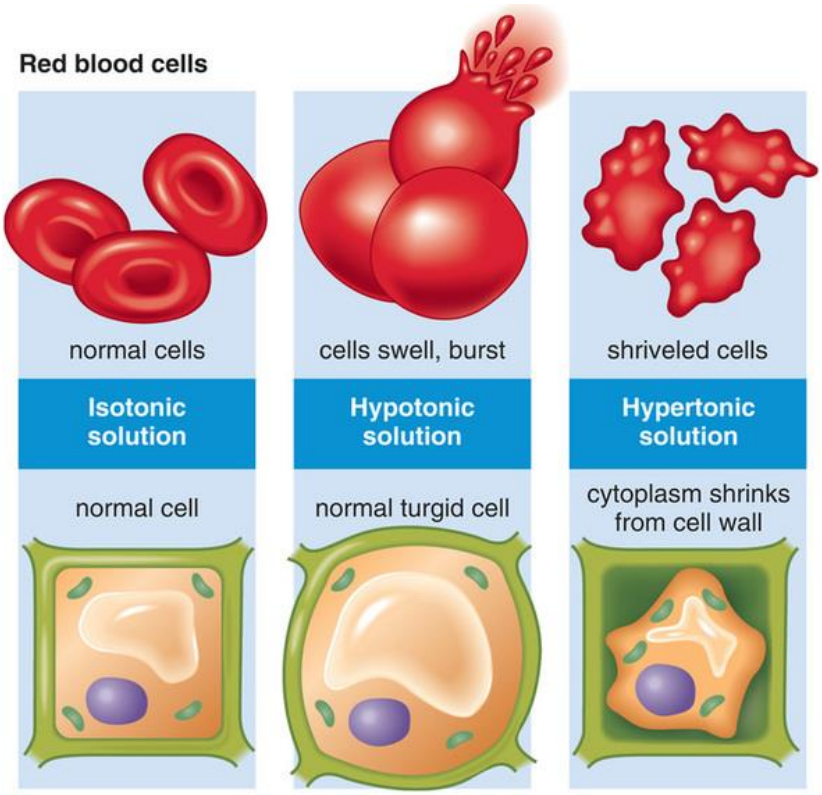


Figure 10 Shrinkage and swelling of red blood cells and plant cells in solutions of different concentrations

Simple Diffusion

The movement of molecules from an area of high concentration to an area of low concentration. This property plays an important role in the exchange of substances between the cell and its surrounding environment. Example: Oxygen, carbon dioxide, and substances that dissolve in lipids.

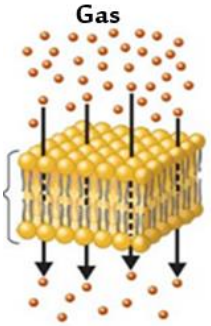


Figure 11 Simple Diffusion

Facilitated Diffusion

This process occurs along the concentration gradient of the transported substance (from a high concentration to a low concentration). Molecules that do not dissolve in lipids and cannot pass through the cell membrane pores are transported with the help of carrier proteins, known as transport proteins.

There are two main types of these proteins:

Type I: Forms channels through which certain ions can pass.

Type II: Binds to the molecule to be transported, carries it across the membrane, then releases it inside the cell and returns to its original position to bind to another molecule. This process involves temporary changes in the protein's shape.

Example: The rapid movement of glucose and fructose molecules from outside the cell to inside it.

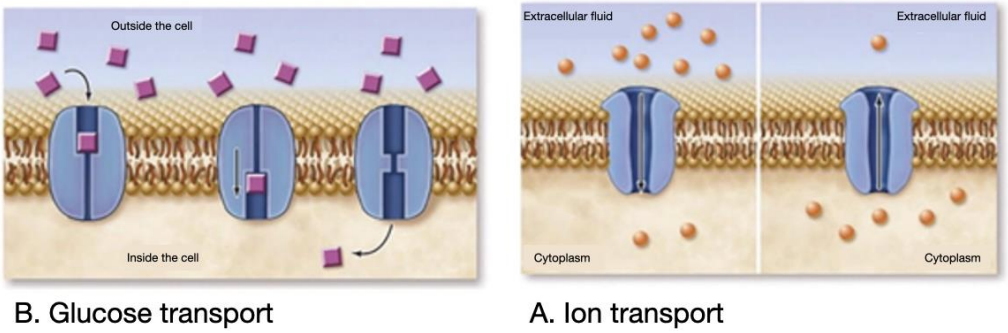


Figure 12 Facilitated Diffusion

Active Transport

The movement of substances from an area of low concentration to an area of high concentration, which requires the expenditure of energy to occur. In this process, the transported substance binds to a component of the cell membrane, which may be a protein or lipid.

Example: Ions

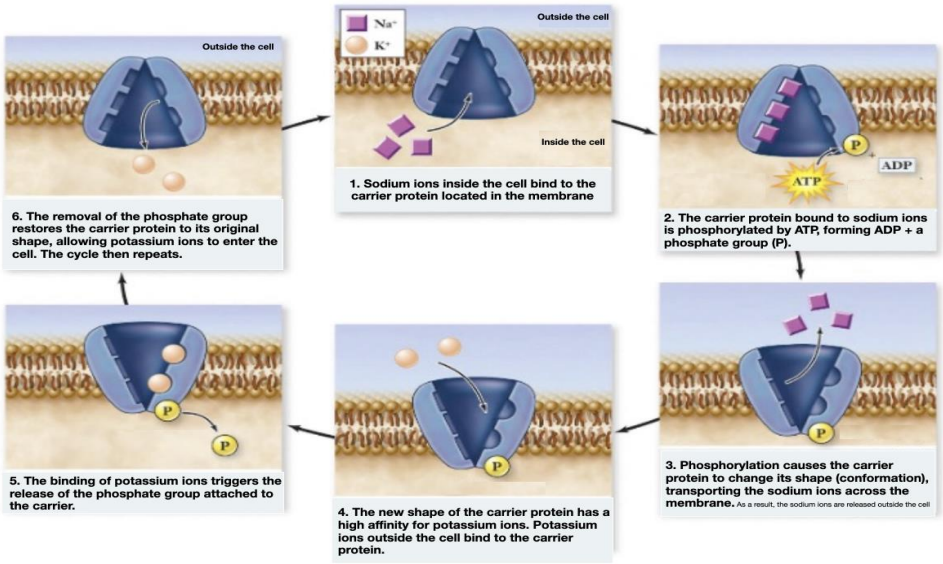


Figure 13 Active Transport

Endocytosis Exocytosis

Endocytosis → The plasma membrane has the ability to fold inward at the region where it contacts large particles, causing these particles to become enclosed within the fold, which gradually transforms into a vesicle within the cytoplasm. Endocytosis is divided into two types:

Phagocytosis (cell eating) → occurs when the materials ingested by the cell are solid.

Pinocytosis (cell drinking) → occurs when the materials ingested by the cell are liquid

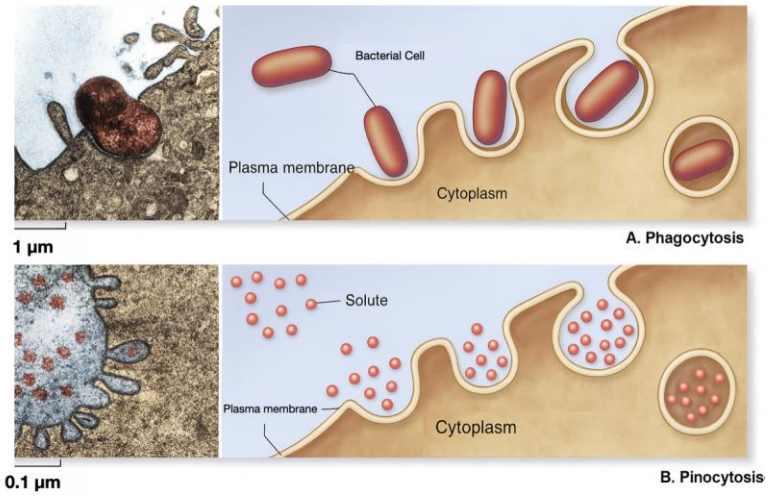


Figure 14 Phagocytosis & Pinocytosis

Exocytosis

The process of expelling materials outside the cell by forming special vesicles or vacuoles within the cell that fuse with the plasma membrane and release their contents outside the cell.

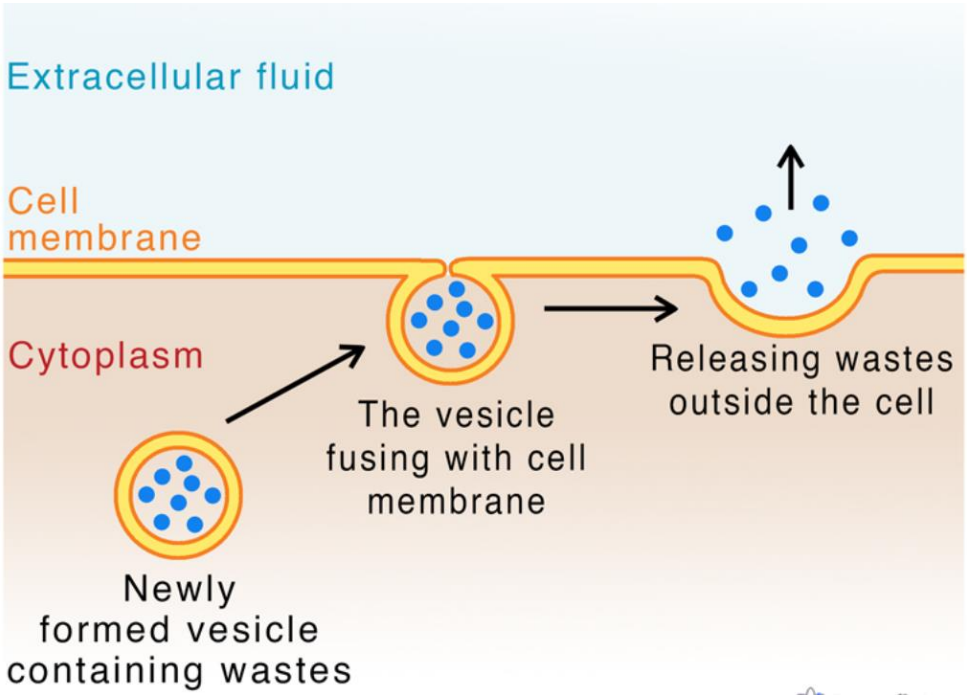
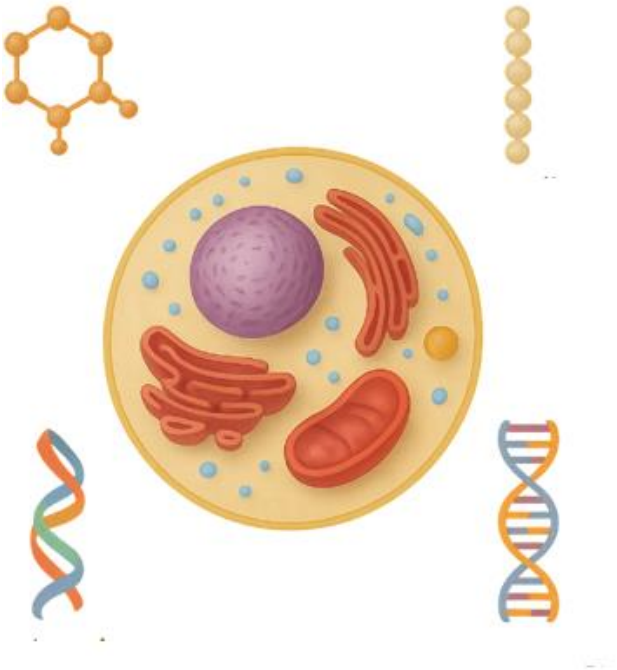


Figure 15 Exocytosis

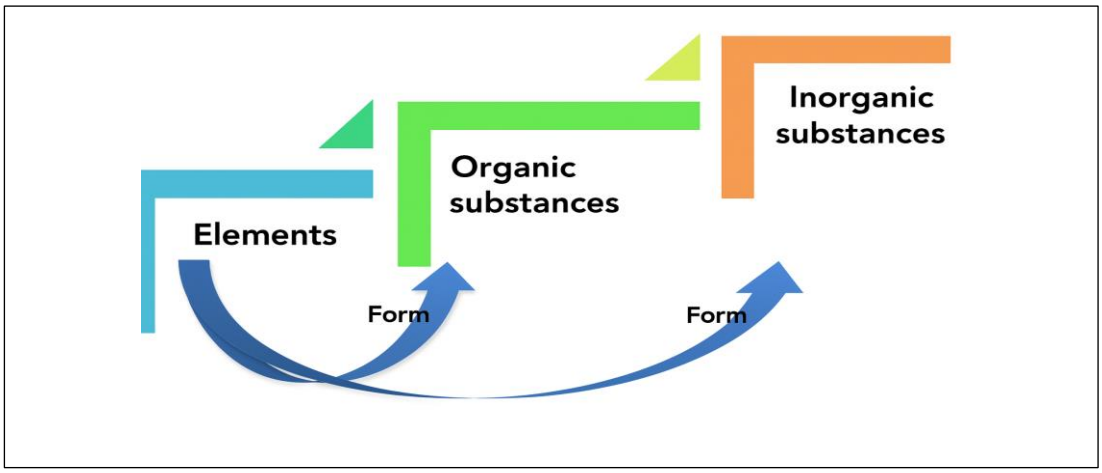
Chapter Two

Cell Chemistry



The Chemistry of The Cell:

- The cell, with all its components, is composed of chemical elements.
- All biological activities depend on chemical reactions.
- These reactions rely on chemically bonded elements arranged in a coordinated and organized manner.



What are the elements of living matter, and how do they exist?

Secondary (Microelements)	Primary 5% (Macroelements)	Major Elements 90%
Iron/ Aluminum/ Chlorine/ Zinc/ Iodine/ Boron/ Manganese/ Sodium	Calcium/ Sulfur/ Magnesium/ Potassium/ Phosphorus	Oxygen/ Hydrogen/ Carbon /Nitrogen

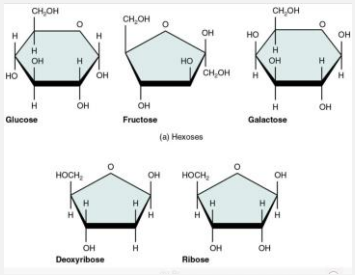
- The major and essential elements are found in all living organisms, whereas the secondary elements are present only in some.
- The major, essential, and secondary elements exist either in a free form or as compounds.
- The cells of living organisms are composed of compounds that contain carbon in their structure, called organic compounds.
- These compounds are known as macromolecules, and they include: carbohydrates, lipids, proteins, and nucleic acids.

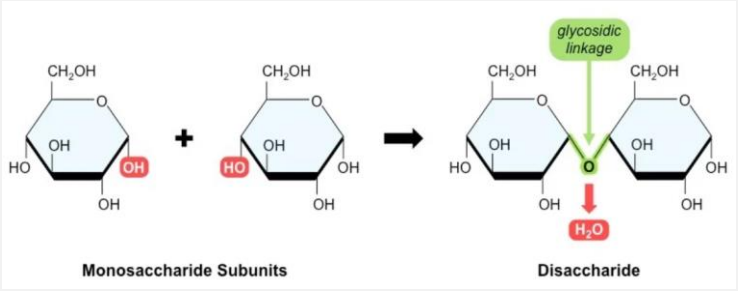
1- Carbohydrates	
Structure	Composed of C, H, and O in the ratio 1 : 2 : 1. General formula: $(CH_2O)_n$
Importance	Serve as a source of energy.
Types	- Monosaccharides: single molecule ($C_6H_{12}O_6$) such as glucose and fructose. - Disaccharides: formed by joining two monosaccharide molecules through the removal of a water molecule ($C_{12}H_{22}O_{11}$), such as sucrose and lactose. - Polysaccharides: composed of many monosaccharide units ($(C_6H_{10}O_5)_n$), such as glycogen, starch, and cellulose.

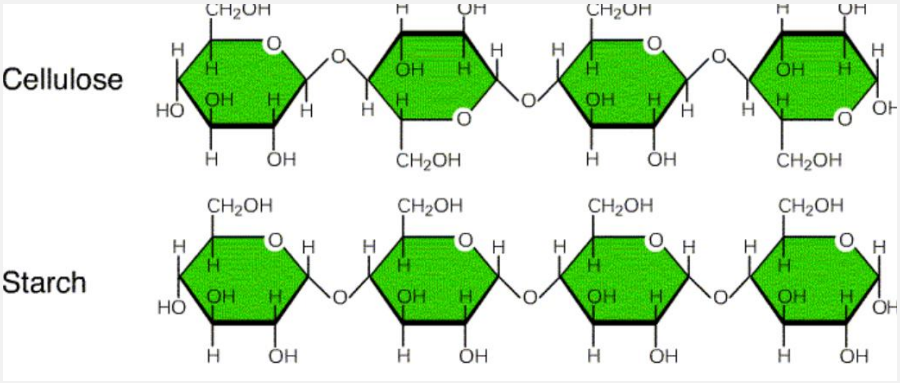
Main characteristics of monosaccharides and disaccharides:

- They can pass through cell membranes.
- They dissolve in water.

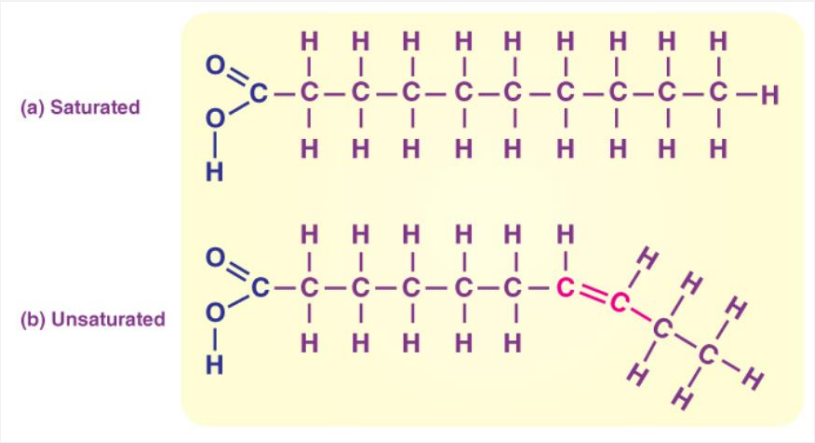
Polysaccharides cannot pass through membranes and do not dissolve in water>







2- Lipids	
Structure	Composed of C, H, and O.
Importance	Energy storage and protection.
Components	Fatty acids and glycerol.
Types	1. Saturated fats: Solid; contain single bonds between carbon atoms — e.g., animal fats. 2. Unsaturated fats: Liquid; contain double bonds between carbon atoms — e.g., vegetable oils.



3- Proteins	
Structure	Composed of C, H, O, and N.
Importance	Building tissues, transporting substances between cells, accelerating chemical reactions, and transmitting signals within the cell.
Components	Made up of 20 different amino acids linked together by peptide bonds to form proteins. Enzymes: Special types of proteins that act as catalysts for chemical reactions in the body. They lower the activation energy required for the reaction and are not consumed during the process. Examples: salivary amylase and pancreatic amylase.

Figure: Activation energy (E_a) of a biological reaction with and without enzymatic catalysis. ΔG_r represents the Gibbs free energy change of the

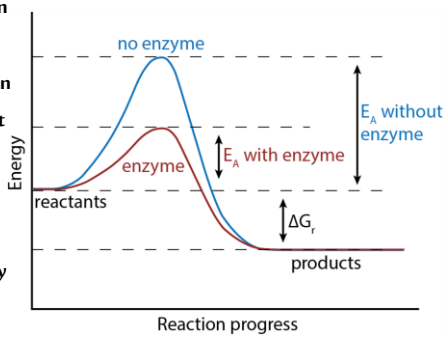


Figure 16 Enzymes that reduce activation energy and accelerate the reaction

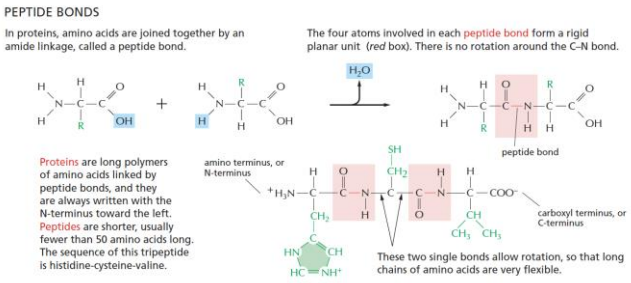


Figure 17 peptide bonds in proteins

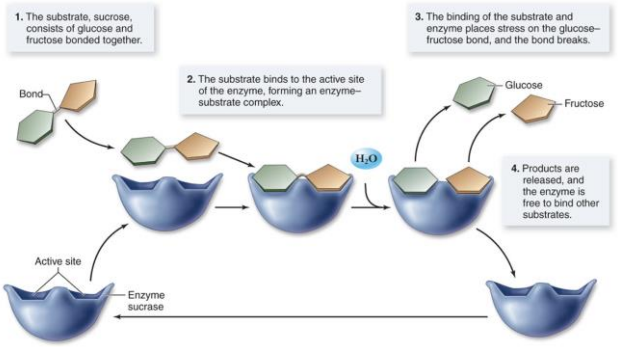


Figure 18 Enzyme binding to the substrate

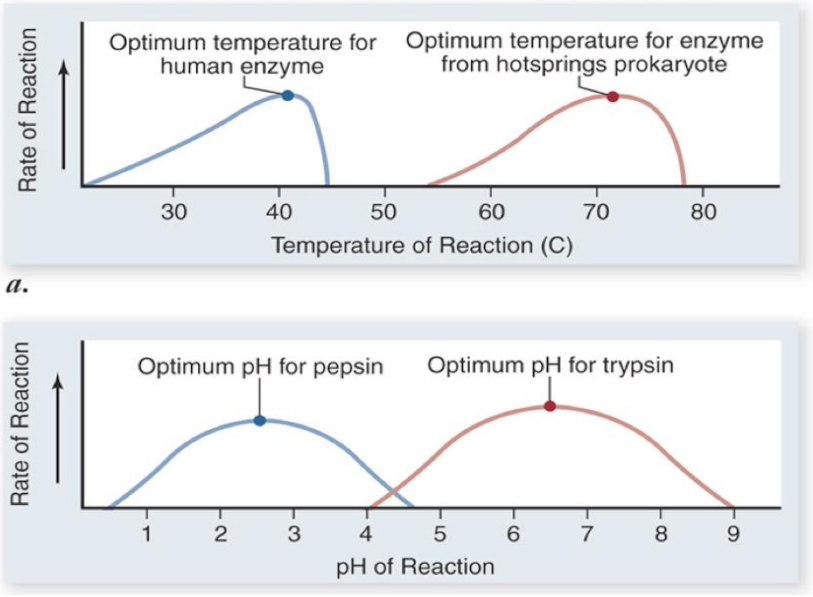
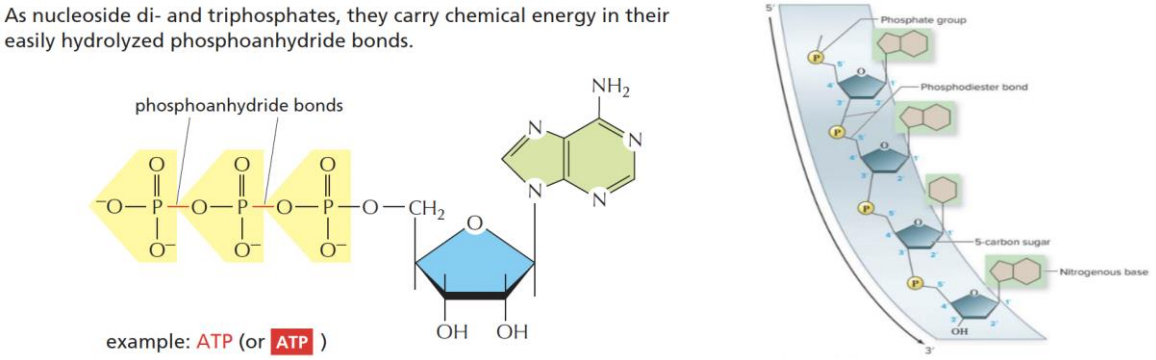


Figure 19 Optimal temperature and pH for enzymes

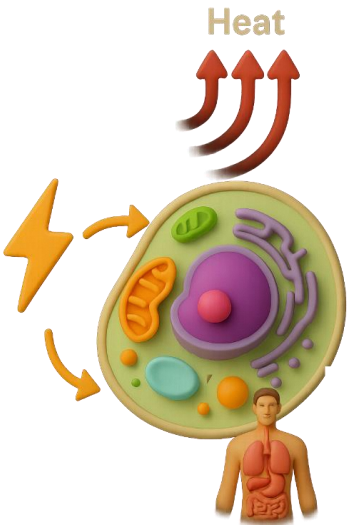
4- Nucleic Acids	
Structure	Composed of C, H, O, N, and P.
Function	Storage and transmission of genetic information.
components	A pentose sugar, a nitrogenous base, and a phosphate group.
Types	DNA and RNA.



Nucleotide: The basic unit of nucleic acids, composed of a phosphate group, a nitrogenous base, and a ribose sugar.

Chapter Three

Cellular Energy



Metabolism:

Metabolism is the sum of all the biochemical processes that occur within the body of a living organism.

Metabolic processes are divided into:

a) Catabolism: releases energy, e.g. digestion and respiration.

b) Anabolism: consumes energy, e.g. photosynthesis.

How do living organisms obtain energy?

- Energy is the ability to do work.
- The main source of energy on Earth is the Sun.
- The direct source of energy for living organisms is food (nutrients).

Laws of Thermodynamics:

First Law (Law of Energy Conservation):

- States that energy can be transformed from one form to another, but cannot be created or destroyed except by God's will.
- Example: the energy stored in nutrients is converted to chemical energy when you eat, and then to mechanical energy when you run.

Second Law:

- States that energy is lost whenever it is transformed from one form to another.
- The lost energy is released as heat.
- The food chain is an example of this law.

The Energy Molecule – ATP:

- It is the cellular unit of energy.
- It consists of adenine + ribose sugar + three phosphate groups.
- It stores chemical energy used by cells in their reactions.
- ATP releases energy when the bond between the second and third phosphate groups is broken.
- This produces ADP + a free phosphate group.
- Energy is stored in the phosphate bond when ADP combines with a free phosphate group to form ATP again.

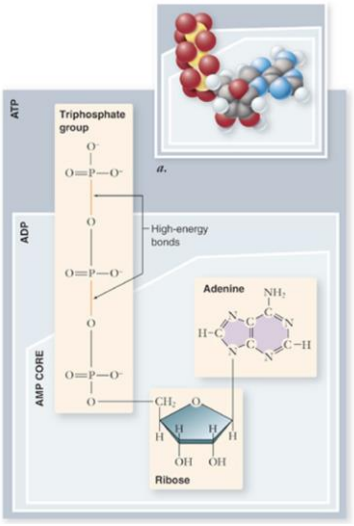


Figure 20 The Energy Molecule – ATP

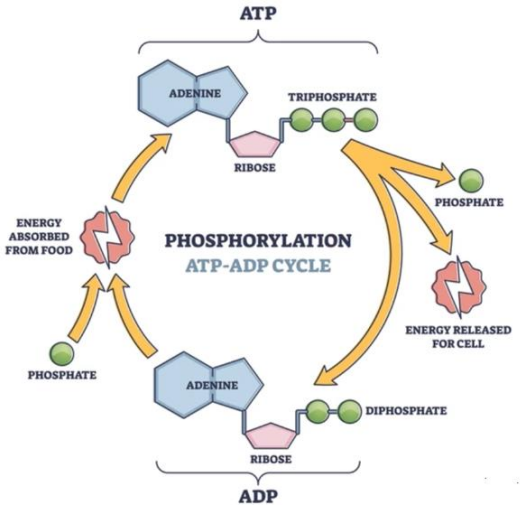


Figure 21 Phosphorylation Cycle

Photosynthesis:

- The process of converting light energy into chemical energy.
- Photosynthesis takes place in the chloroplasts.
- It is a common process among all organisms that contain chloroplasts.
- It occurs through a series of reactions that produce a molecule of glucose.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Chloroplast:

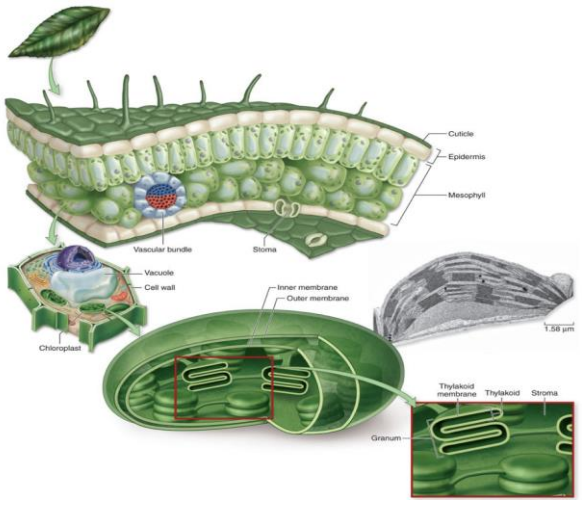


Figure 22 Chloroplast

Structure of the Chloroplast:

- Large, disc-shaped organelles.
- Contain the pigment chlorophyll, which absorbs light energy.
- Composed of:
  1. Thylakoids: stacks of flattened membrane sacs (disc-like structures) that form the grana.
  2. Stroma: the fluid that fills the spaces surrounding the grana.

Pigments:

Colored molecules located in the thylakoid membranes that absorb specific wavelengths of light.

Types:

1. Chlorophyll (a) and (b): the main pigments in plants.
   - Light absorption by chlorophyll a and b is highest in the red and violet regions of the spectrum.
2. Carotenoids: red, yellow, and orange pigments.
   - These pigments become visible in autumn as chlorophyll molecules break down, giving leaves their different colors.

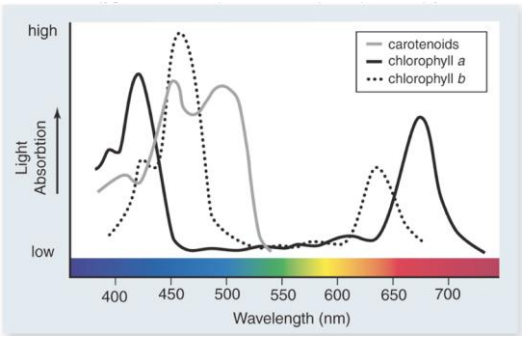


Figure 23Light absorption spectra of plant pigments

Photosynthesis occurs in two stages:

1. **Light Reactions:**

   • Occur in the grana, where chlorophyll pigments absorb light energy and convert it into chemical energy in the form of NADPH and ATP, which are used to build glucose.

   • Oxygen is released as a byproduct due to the splitting of water molecules.

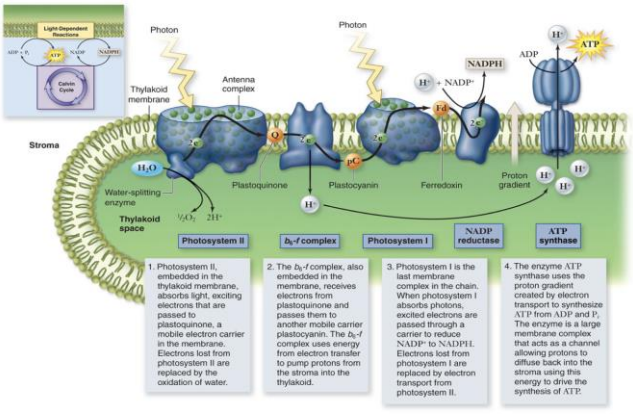


Figure 24 Light Reactions

2. Dark Reactions (Light-Independent Reactions):

• Occur in the stroma, where the energy produced from the light reactions (ATP and NADPH) along with CO_2 is used to form a molecule of glucose.

• Take place through a series of reactions known as the Calvin Cycle.

• Do not require the presence of light.

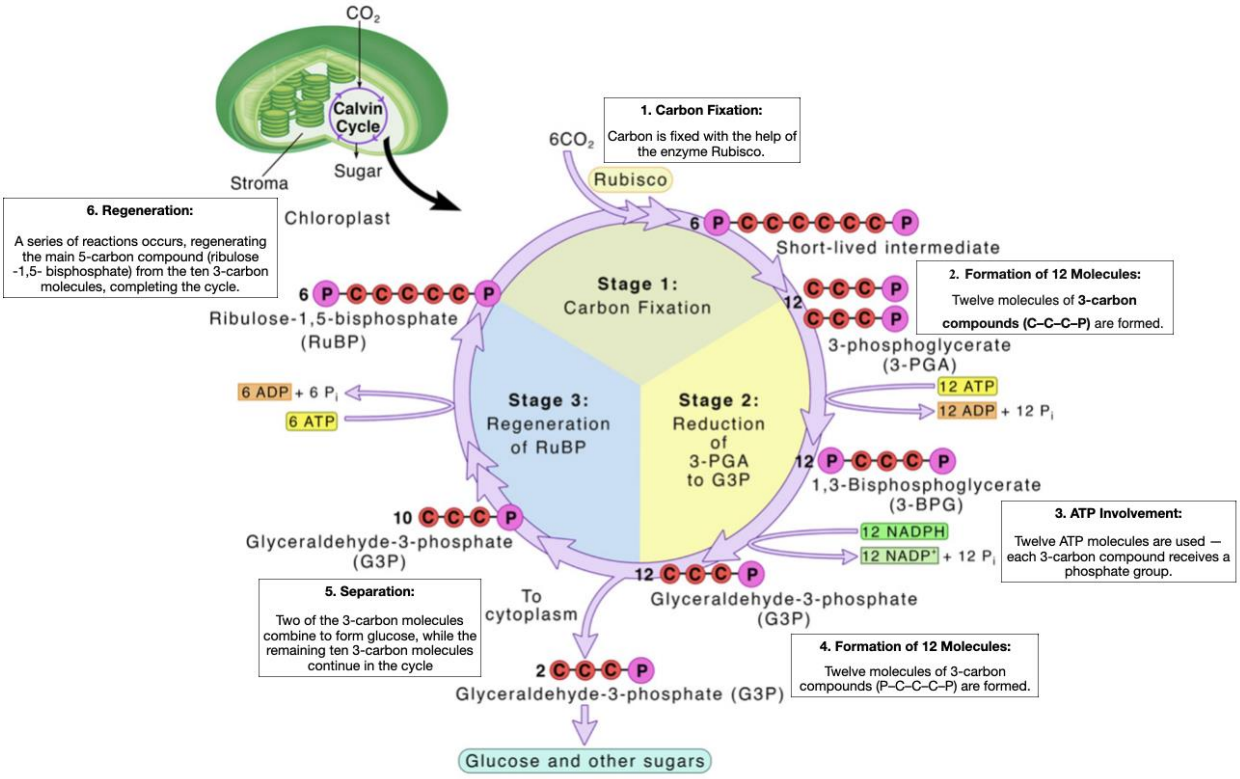


Figure 25 Light-Independent Reactions

Cellular Respiration:

- The process of oxidizing nutrients to obtain energy.
- Involves the intake of O_2 and the release of CO_2.
- Takes place inside the mitochondria.
- There are two types of respiration: 1. Aerobic respiration: occurs in the presence of oxygen. / 2. Anaerobic respiration: occurs in the absence of oxygen

Aerobic Respiration:

$$C_6H_{12}O_2 + 6O_2 \longrightarrow 6H_2O + 6CO_2$$

Aerobic respiration goes through four stages:

1. Glycolysis:

- Glucose is broken down in the cytoplasm.
- Two molecules of pyruvic acid are produced.
- The net energy yield from this stage is 2 NADH + 2 ATP.
- The carbon-containing compounds move on to the next stage.
- The energy-carrying molecules proceed directly to the final stage to enter the electron transport chain reactions.

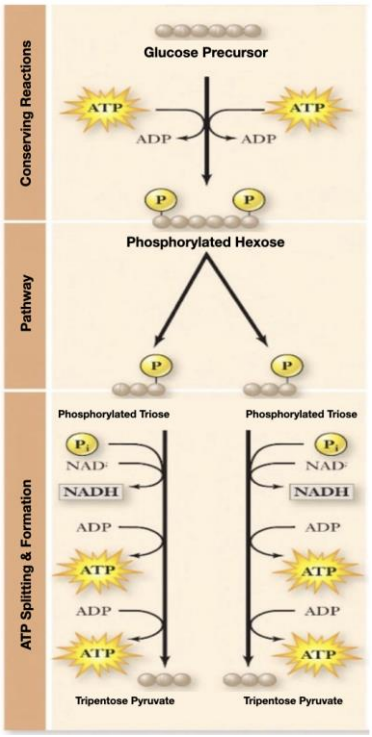


Figure 26 Glycolysis

2- Conversion of Pyruvic Acid to Acetyl CoA:

- This stage occurs in the mitochondrial membrane.
- When oxygen is available, pyruvic acid enters the mitochondrion.
- The acetyl group combines with coenzyme A (CoA) to form acetyl-CoA.
- The products of this stage (from 2 pyruvates) are: 2 Acetyl-CoA + 2 CO_2 + 2 NADH

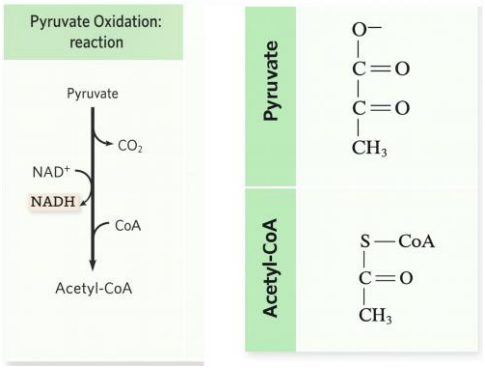


Figure 27 Conversion of Pyruvic Acid to Acetyl CoA

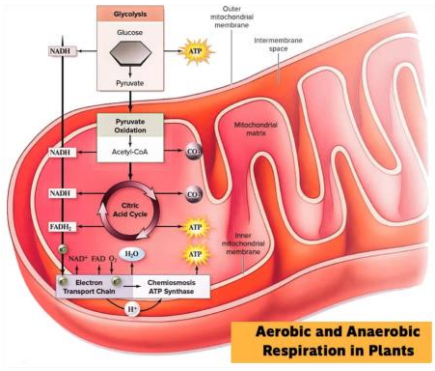


Figure 28 Aerobic and Anaerobic Respiration

3- Krebs Cycle:

Occurs in the mitochondrial matrix.

a) The acetyl group from acetyl-CoA combines with a four-carbon compound to form a six-carbon compound (citric acid).

b) A series of oxidation reactions and atom rearrangements occur, allowing the cycle to repeat.

Products of this stage:

- From one cycle: → 2 CO_2 + 1 ATP + 1 $FADH_2$ + 3 NADH
- From two cycles: → 4 CO_2 + 2 ATP + 2 $FADH_2$ + 6 NADH

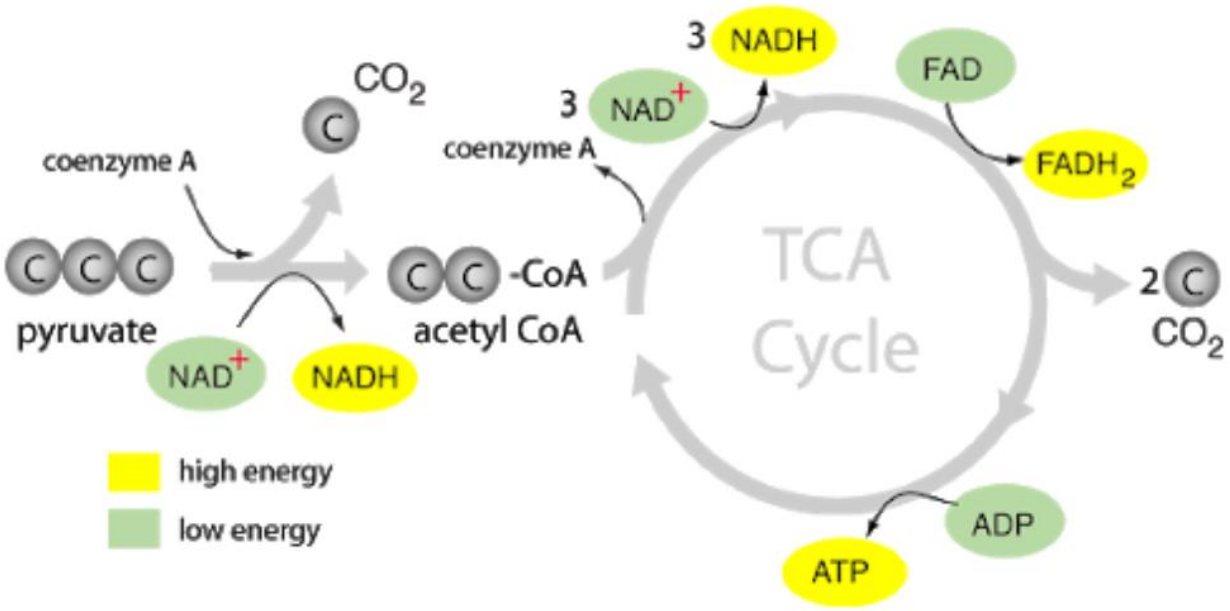


Figure 29 Krebs Cycle

4- Electron Transport Chain:

- Occurs in the mitochondrial membrane.
- It is the final stage of aerobic respiration.
- In this stage, most ATP molecules are produced.
- High-energy electrons from NADH and $FADH_2$ (generated in the Krebs cycle and during pyruvate formation) are used. The difference in hydrogen ion concentration across the membrane is utilized to convert ADP into ATP.
- Each NADH molecule produces 3 ATP molecules.
- Each $FADH_2$ molecule produces 2 ATP molecules.

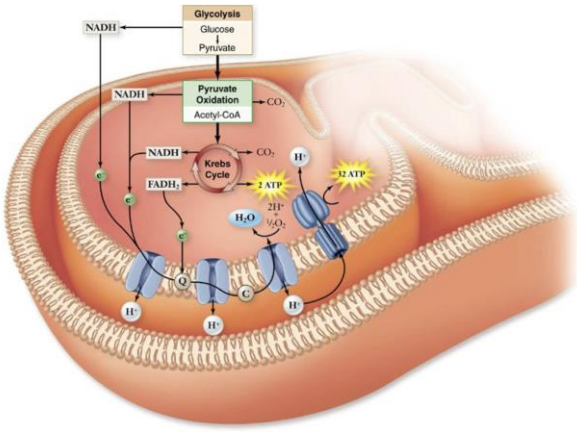


Figure 30 Electron Transport Chain

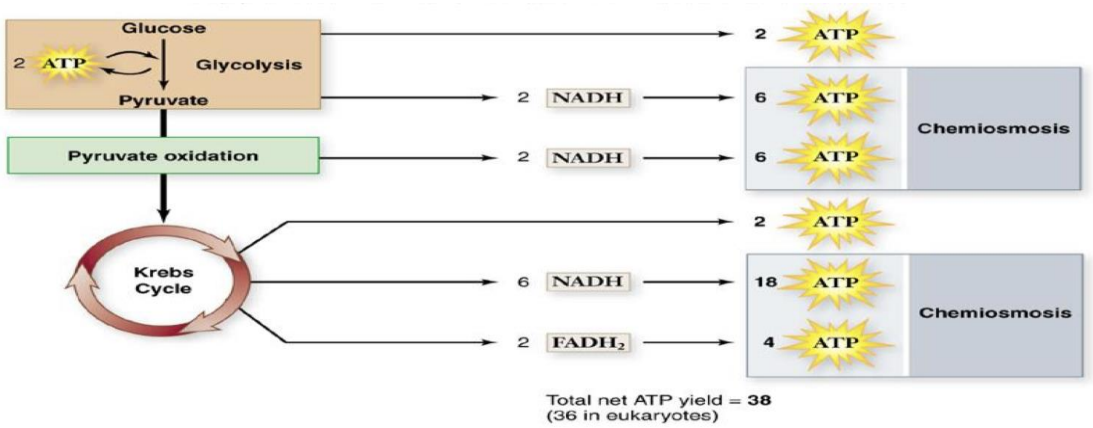


Figure 31 Total net ATP

Anaerobic Respiration:

1- Lactic Acid Fermentation:

- Glucose is converted into pyruvate, producing ATP and NADH.
- Through the action of enzymes, pyruvate is converted into lactic acid.
- This process occurs in muscles during fatigue and oxygen deficiency.
- No CO_2 is produced in this process.
- Final products: 2 Lactic acid + 2 ATP

2- Alcoholic Fermentation:

- Glucose is converted into pyruvate, producing ATP and NADH.
- Pyruvate is then converted into ethanol.
- This process occurs in yeast and certain bacteria.
- CO_2 is produced during this process.
- Final products: 2 Ethanol + 2 ATP + 2 CO_2

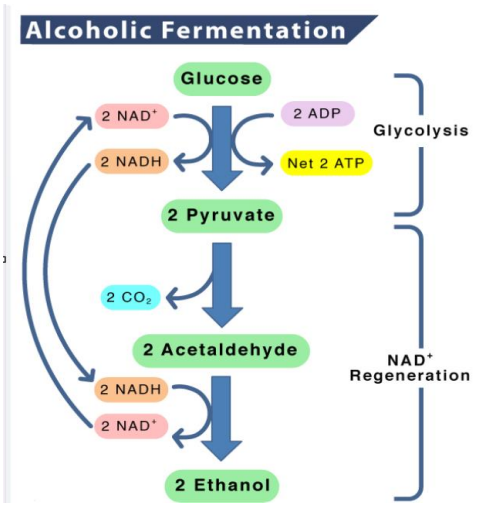


Figure 32 Alcoholic Fermentation

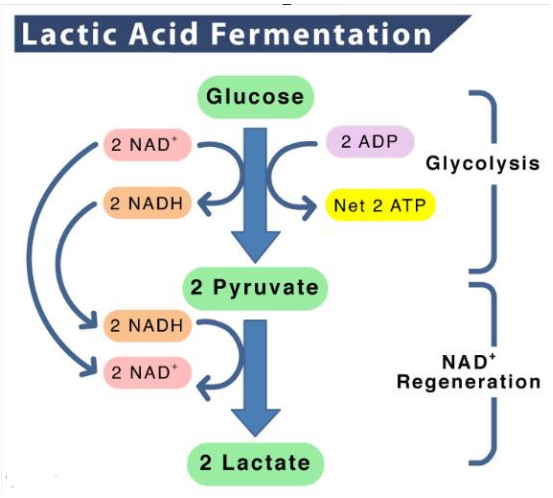
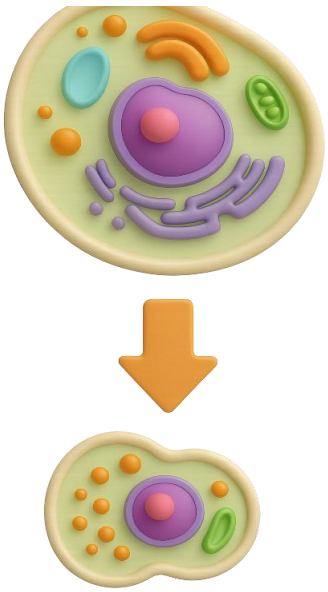


Figure 33 Lactic Acid Fermentation

Chapter Four

Cell Division

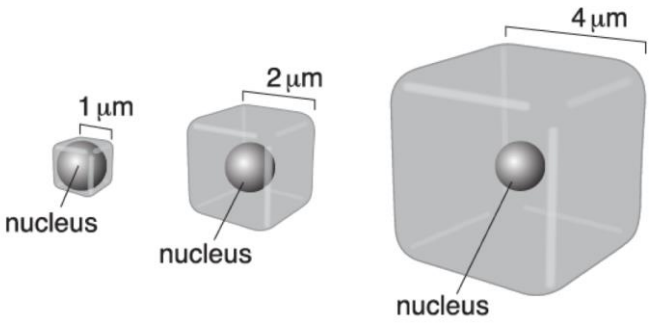


Cell Growth:

- The diameter of most cells is less than 100 µm (1 micrometer = 10^{-6} meter).
- As a cell continues to grow, its volume increases while its surface area decreases, making it harder to obtain nutrients and remove wastes.
- Therefore, it is better for a cell to remain small in order to perform its functions more efficiently.
- As cell size increases, surface area decreases, which in turn reduces the cell's ability to exchange materials with its environment and lowers its activity.
- The main factor determining cell size is the surface area-to-volume ratio. The surface area refers to the area covered by the plasma membrane.

demonstration

Calculate and compare the surface area of a 1 µm cell and a 2 µm cell as shown in the following figure.



Given Data:

- Surface area of the cell = length × width × number of faces
- Cell volume = length × width × height

Cell Division in Bacteria:

Cell division in bacterial cells is the most common method of reproduction and is called binary fission.

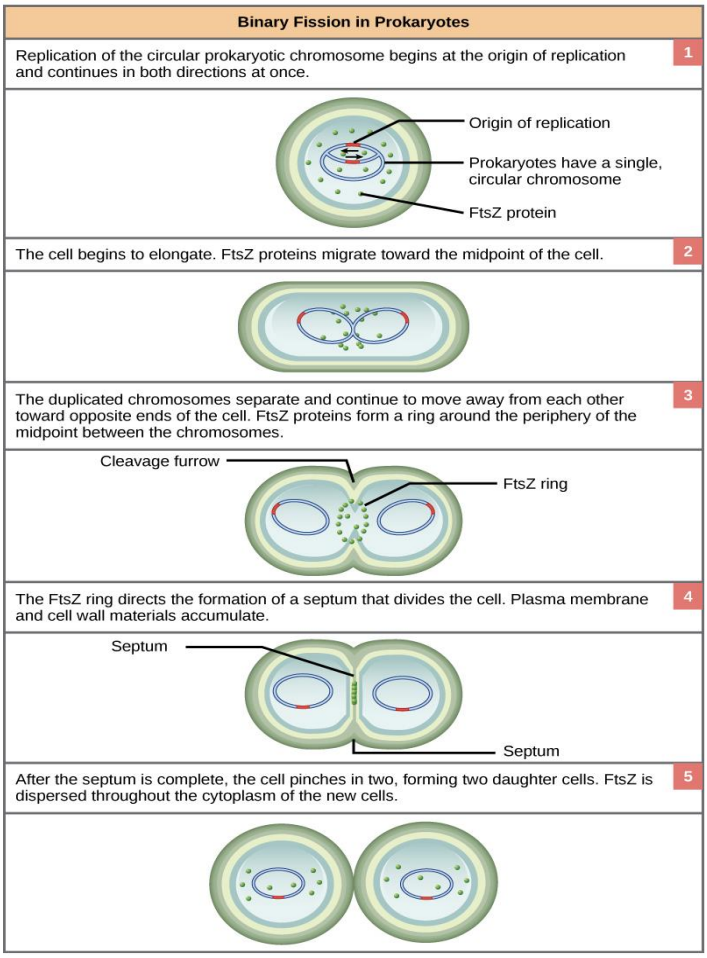


Figure 34 Cell Division in Bacteria

Cell Division in Eukaryotes:

Cell Cycle:

• The time interval between two successive divisions, including all the stages and phases in between.

• The cell cycle passes through three main stages:

1. Interphase
2. Mitosis (Equational Division)
3. Cytokinesis (Cytoplasmic Division)

First. Interphase

1- G_1 Phase (First Growth Phase):

- Begins immediately after cell division.
- The cell grows, organelles double, and it performs its normal functions.
- The cell spends the longest period of its life in this phase.

2- S Phase (DNA Synthesis Phase):

- The cell's genetic material (DNA) is replicated and duplicated.

3- G_2 Phase (Second Growth Phase):

- Proteins are synthesized, and the cell prepares for division.

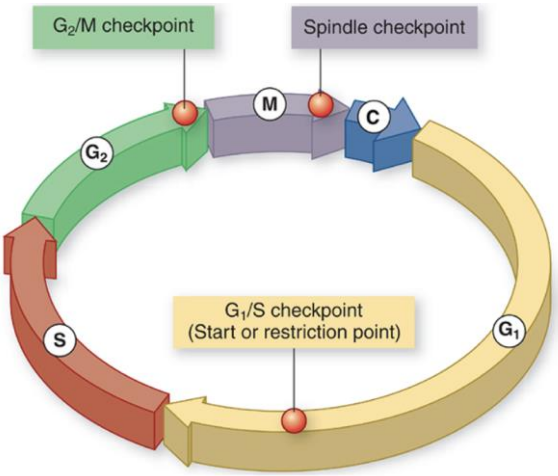


Figure 35 Cell Cycle

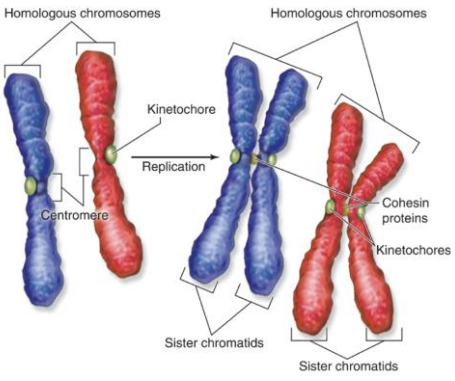


Figure 37 The chromosome after replication

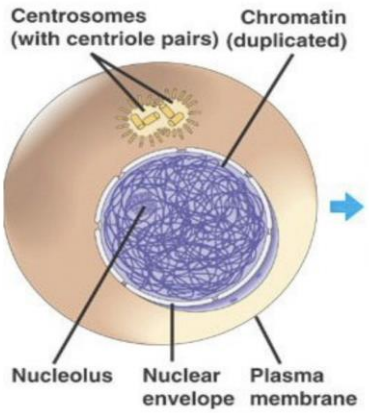


Figure 36 The cell at the end of interphase

Second. Mitosis: The Equational Division

- Occurs in somatic cells (2n), meaning diploid cells that contain two sets of chromosomes. The duplicated genetic material separates, and the cell divides into two daughter cells, each having the same number of chromosomes (2n).
- The purpose of mitosis is growth and replacement of damaged cells.
- Mitosis occurs in four stages:

1. Prophase:

- The nuclear envelope disintegrates.
- The nucleolus disappears.
- Chromosomes condense and become visible.
- Spindle fibers form between the two poles of the cell.

2. Metaphase:

- Chromosomes attach to the spindle fibers at the centromere.
- Chromosomes align along the equatorial plane of the cell.

3. Anaphase:

- Spindle fibers contract and shorten.
- Sister chromatids are pulled toward opposite poles of the cell.

4. Telophase:

- Chromosomes reach the opposite poles.
- A new nuclear envelope forms around each set of chromosomes.
- The nucleolus reappears.
- Chromosomes uncoil and return to a less condensed state.
- Spindle fibers disappear.

- In all stages of mitosis, the cell remains diploid (2n).

Third. Cytokinesis (Cytoplasmic Division):

In animal cells, the cell membrane constricts until the cell splits into two daughter cells, each containing the same number of chromosomes. In plant cells, a cell plate forms between the two newly formed nuclei, and then a cell wall develops, resulting in two genetically identical cells.

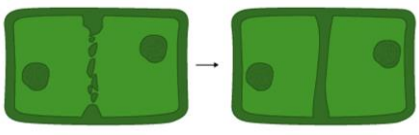


Figure 38 Cytoplasmic Division

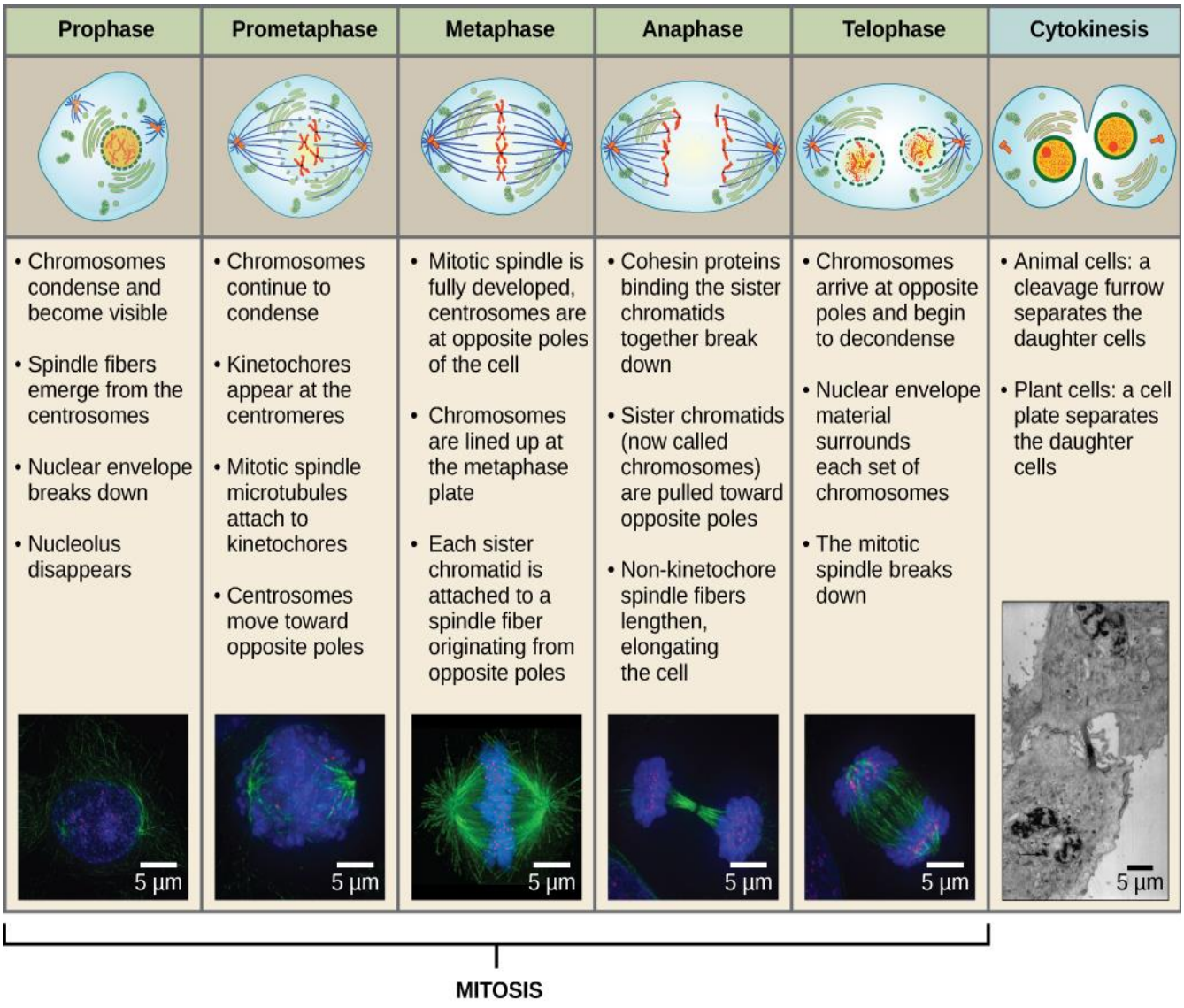


Figure 39 Stages of Mitosis

Regulation of the Cell Cycle:

- The rate of cell division varies depending on the type of cell.
- Cyclins (regulatory proteins) and kinase enzymes play a vital role in controlling the normal progression of the cell cycle.
- Checkpoints exist after each phase of the cell cycle, and the cycle can be halted if an error occurs.
- When cells fail to respond to the control mechanisms that regulate their life cycle, cancerous cells may result.

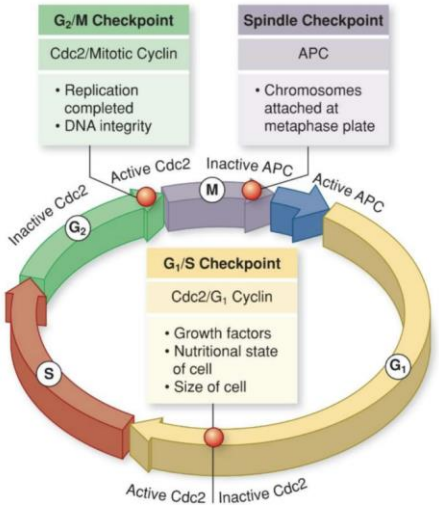


Figure 40 Cell Cycle

- Normal Cell Cycle

Role of Cyclins	Role of Cyclin–CDK Complexes
- Regulate the normal progression of the cell cycle. - Activate the cell cycle in eukaryotic cells when they bind to cyclin-dependent kinases (CDKs), sending a signal to initiate cell division.	- During the G_1 phase of interphase: • Their binding sends a signal to start the cell cycle. - During the cell cycle: • Different cyclin–CDK combinations send signals to initiate other activities, including DNA replication, protein synthesis, and nuclear division. • Another group of cyclins sends a signal to end the cell cycle.

- Abnormal Cell Cycle (Cancer Disease)

Cancer	Uncontrolled and irregular growth and division of cells.
Causes of Cancer	• Mutations or changes in segments of DNA that control the production of proteins responsible for regulating the cell cycle. • Environmental factors and certain substances that cause cancer, known as carcinogens.
Carcinogens	Asbestos, smoking, ultraviolet (UV) radiation, and X-rays.
Genetic Inheritance of Cancer	An individual who inherits one or more genetic mutations from either parent is at a higher risk of developing cancer than someone who does not inherit such changes.

Programmed Cell Death (Apoptosis)

- A process that occurs in certain cells, leading to the death of all cells produced from those divisions.
- It happens when cells shrink and condense in a controlled and organized manner.
- Apoptosis helps protect living organisms from the growth of cancerous cells.

Examples:

- In humans — during the development of the hands and feet, cells occupying the spaces between the fingers and toes die.
- In plants — apoptosis occurs when cells die, causing leaves to fall during autumn.

Stem Cells:

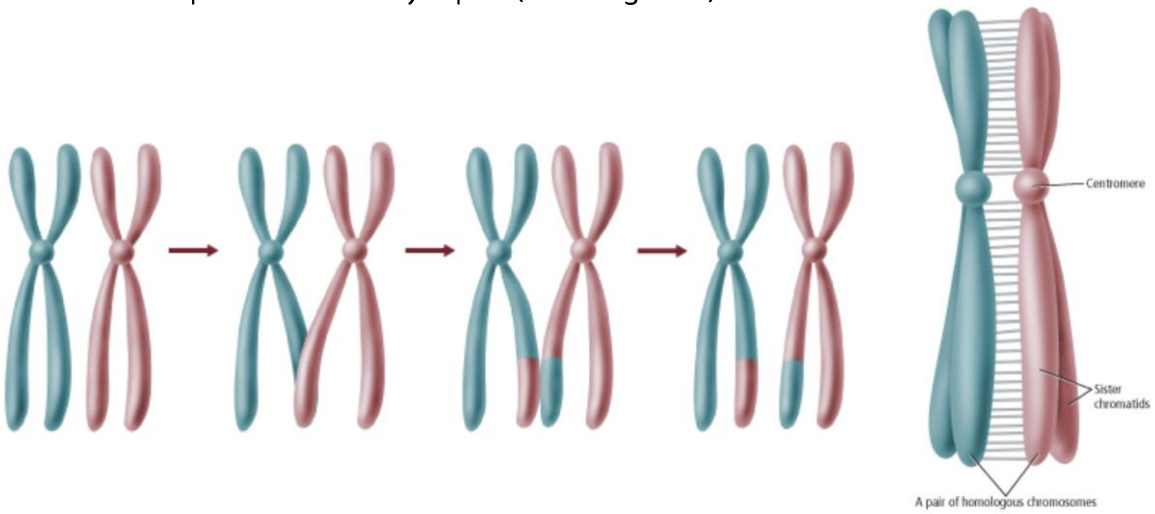
- Undifferentiated cells capable of dividing and developing into specialized cells according to the type of tissue they join.
- Embryonic stem cells are more effective than adult stem cells.
- Stem cells contribute to treating many diseases, such as paralysis and organ dysfunction.

Types of Stem Cells:

1. Embryonic stem cells. / 2. Adult stem cells

Meiosis (Reduction Division):

- Reproductive cells that carry genetic traits from parents to offspring reproduce through meiosis.
- Meiosis produces haploid gametes (1n) — cells containing half the number of chromosomes.
- The number of chromosomes in human somatic cells is 46 chromosomes, or 23 pairs — these are diploid (2n) cells.
- The number of chromosomes in human gametes is 23 chromosomes, which are haploid (1n).
- When a female gamete (1n) fuses with a male gamete (1n), a zygote is formed containing the full set of chromosomes (2n).
- Chromosomes are structures in the nucleus that contain DNA, which is composed of several genes.
- Genes are segments of the DNA strand responsible for expressing specific traits.
- Homologous chromosomes are pairs of chromosomes that have the same length, centromere position, and genes controlling the same inherited traits — one inherited from the father and the other from the mother. These pairs pair up during meiosis in a process called synapsis (crossing over).



Stages of Meiosis:

Meiosis occurs in two successive divisions, ending with the formation of gametes (1n reproductive cells).

First Stage: Meiosis I (Reduction Division I)

This stage includes four phases:

Prophase I – Metaphase I – Anaphase I – Telophase I

What distinguishes these phases:

- In prophase I and metaphase I, the chromosomes appear as homologous pairs.
- In anaphase I and telophase I, the chromosomes appear as duplicated chromosomes.

Cells in all phases of Meiosis I are diploid (2n) because the cell has not yet divided.

Second Stage: Meiosis II (Reduction Division II)

This stage also includes four phases:

Prophase II – Metaphase II – Anaphase II – Telophase II

What distinguishes these phases:

- In prophase II and metaphase II, chromosomes appear as duplicated chromosomes.
- In anaphase II and telophase II, they appear as single chromosomes.

The second meiotic division closely resembles mitosis in somatic cells, except that:

- In Meiosis II, the cells are haploid (1n).
- In Mitosis, the cells are diploid (2n).

Cells in all phases of Meiosis I remain diploid (2n) until division is complete.

	Stage	Event	Outcome
INTERPHASE	S phase	Nuclear envelope; Centrosomes (with centriole pairs); Chromatin	Chromosomes are duplicated during interphase. The resulting sister chromatids are held together at the centromere. The centrosomes are also duplicated.
MEIOSIS I	Prophase I	Sister chromatids; Spindle; Chiasmata; Tetrad	Chromosomes condense, and the nuclear envelope fragments. Homologous chromosomes bind firmly together along their length, forming a tetrad. Chiasmata form between non sister chromatids. Crossing over occurs at the chiasmata. Spindle fibers emerge from the centrosomes.
MEIOSIS I	Prometaphase I	Centromere (with kinetochore)	Homologous chromosomes are attached to spindle microtubules at the fused kinetochore shared by the sister chromatids. Chromosomes continue to condense, and the nuclear envelope completely disappears.
MEIOSIS I	Metaphase I	Microtubule attached to kinetochore; Metaphase plate	Homologous chromosomes randomly assemble at the metaphase plate, where they have been maneuvered into place by the microtubules.
MEIOSIS I	Anaphase I	Sister chromatids remain attached.; Homologous chromosomes separate.	Spindle microtubules pull the homologous chromosomes apart. The sister chromatids are still attached at the centromere.
MEIOSIS I	Telophase I and Cytokinesis	Cleavage furrow	Sister chromatids arrive at the poles of the cell and begin to decondense. A nuclear envelope forms around each nucleus, and the cytoplasm is divided by a cleavage furrow. The result is two haploid cells. Each cell contains one duplicated copy of each homologous chromosome pair.
MEIOSIS II	Prophase II		Sister chromatids condense. A new spindle begins to form. The nuclear envelope starts to fragment.
MEIOSIS II	Prometaphase II		The nuclear envelope disappears, and the spindle fibers engage the individual kinetochores on the sister chromatids.
MEIOSIS II	Metaphase II		Sister chromatids line up at the metaphase plate.
MEIOSIS II	Anaphase II	Sister chromatids separate.	Sister chromatids are pulled apart by the shortening of the kinetochore microtubules. Non kinetochore microtubules lengthen the cell.
MEIOSIS II	Telophase II and Cytokinesis	Haploid daughter cells	Chromosomes arrive at the poles of the cell and decondense. Nuclear envelopes surround the four nuclei. Cleavage furrows divide the two cells into four haploid cells.

Figure 41 Stages of Meiosis

Chapter five

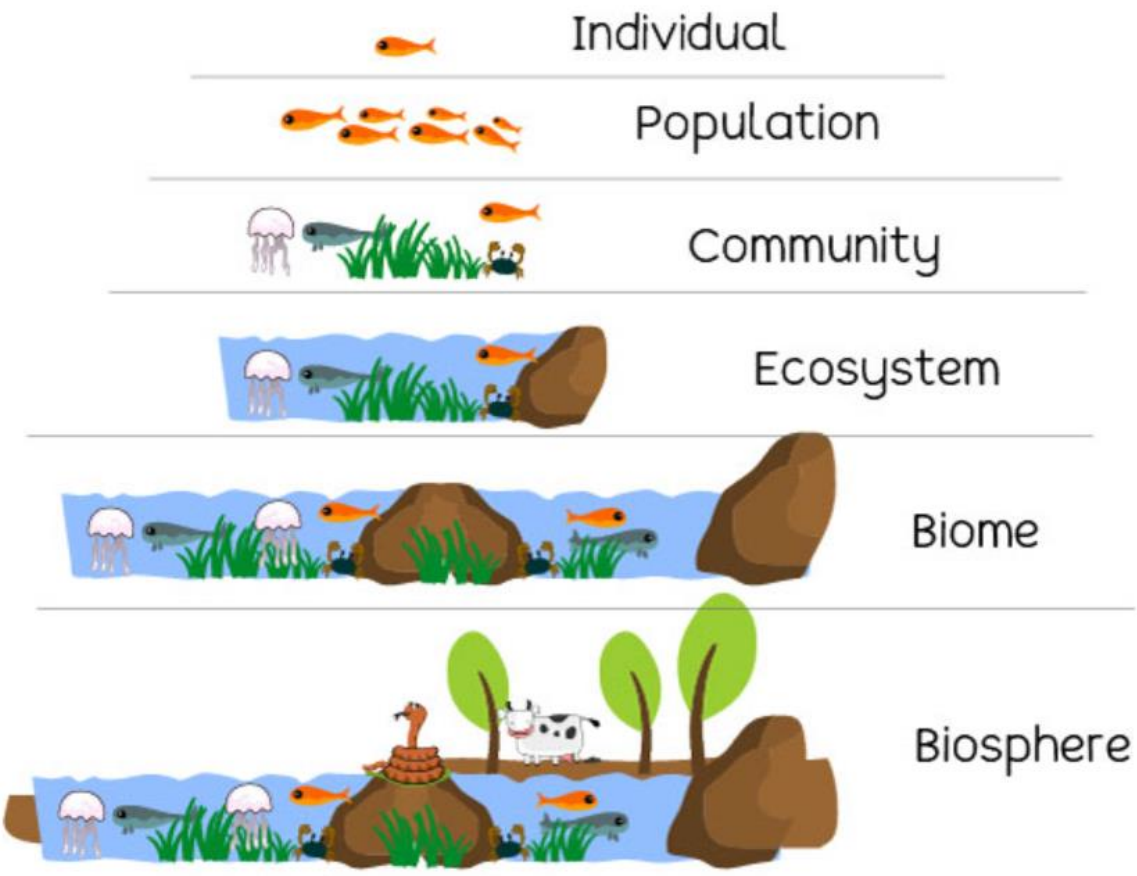
Ecology

Ecology:

It is the science that studies the relationships between living organisms and their interactions with their environments.

- All living organisms, regardless of their types and habitats, exist within a system called the biosphere.
- The biosphere includes two types of factors: biotic and abiotic.
- Biotic Factors: include all living organisms (plants, bacteria, animals, etc.).
- Abiotic Factors: are the non-living components in an organism's environment (water, air, temperature, etc.).

Level of Organization:



Ecosystem Interaction

Habitat: the area where an organism lives.

Niche: the role an organism plays in its environment.

Community Interactions	
Competition	• Occurs when more than one organism uses the same resources at the same time. • Competition may also be for a mating partner. • Usually, the weaker is eliminated and the stronger survives.
Predation	• The act of one organism consuming another. • Some plants, such as the Venus flytrap, are carnivorous and capture insects to obtain nitrogen.

Symbiosis			
A close relationship in which two or more living organisms live together.			
Examples	**Description**	**Type of Relationship**	
Algae and fungi in lichens, birds and buffalo, clownfish and sea anemones	A relationship between two or more organisms living together where both benefit from each other.	Mutualism	**Beneficial**
Birds building nests on trees, lichens growing on plants	A relationship between two organisms where one benefits while the other is neither helped nor harmed.	Commensalism	
External parasites like ticks, internal parasites like bacteria	A symbiotic relationship in which one organism benefits while the other is harmed.	Parasitism	**Harmful**

Flow of Energy in Ecosystem

- Producers (Autotrophic): self-feeding organisms such as plants and algae.
- Consumers: heterotrophic organisms that depend—directly or indirectly—on plants for their food.
- Decomposers: play an important role in breaking down waste and organic compounds in the ecosystem.

Models of Energy Flow

- Trophic Level represents each step in a food chain or food web.
- The first level is represented by the producers.
- The subsequent levels are represented by the consumers.
- Living organisms at each level obtain their energy from the trophic level below them.
  - Food Chains: a sequence in which energy is transferred from producers through a series of consumers.
  - Food Web: a model that represents the interconnecting and diverse food chains within an ecosystem.
  - Ecological Pyramids: a diagram that shows the relative amounts of energy, biomass, and number of organisms at each trophic level in an ecosystem. These include:

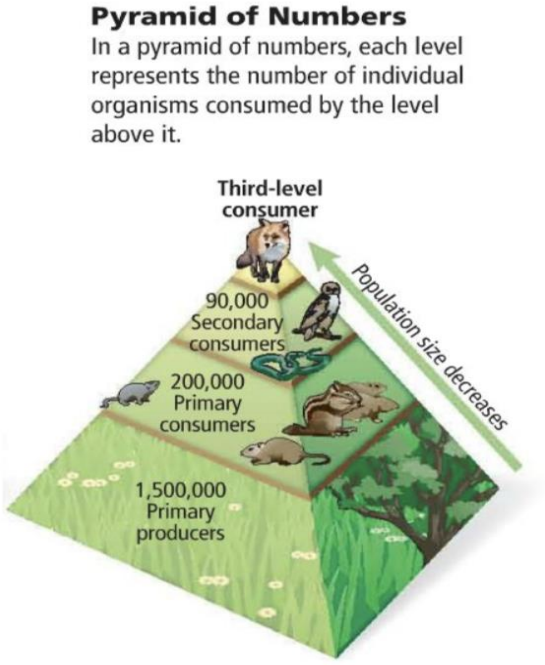


Figure 42 Pyramid of Numbers

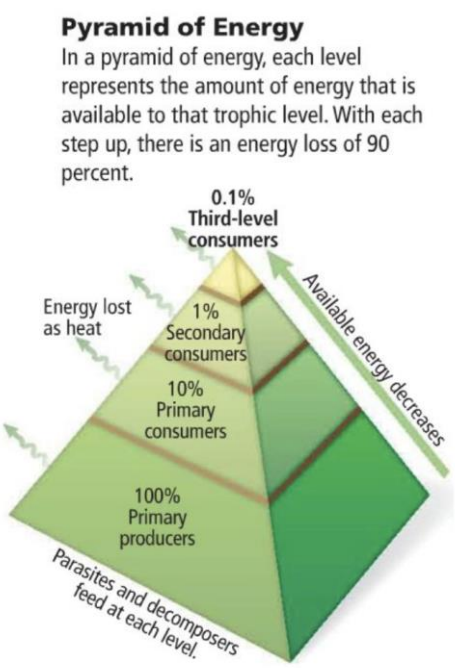


Figure 43 pyramid of Energy

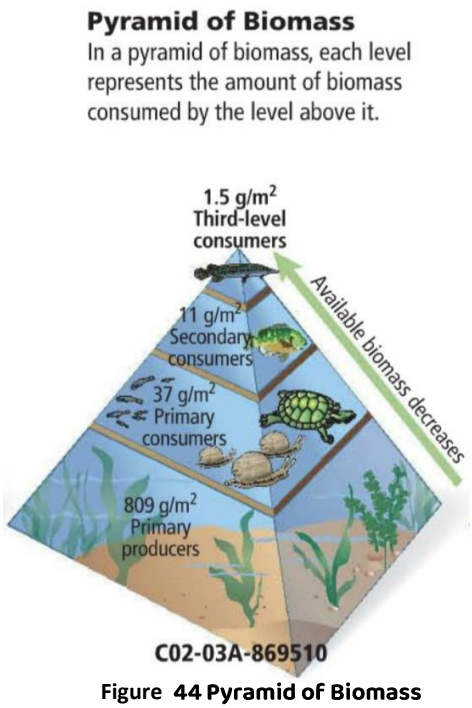


Figure 44 Pyramid of Biomass

Cycling of Matter

Cycles in The Biosphere

- Provide living organisms with the nutrients they need to carry out their functions.

Nutrient: a chemical substance that an organism must obtain from its environment to carry out life processes and sustain life.

- The bodies of all living organisms are made up of water and nutrients, including carbon and nitrogen.

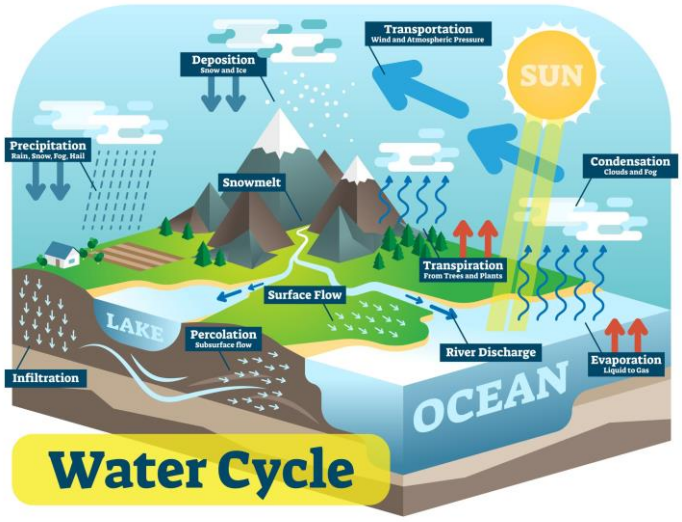


Figure 45 Water Cycle

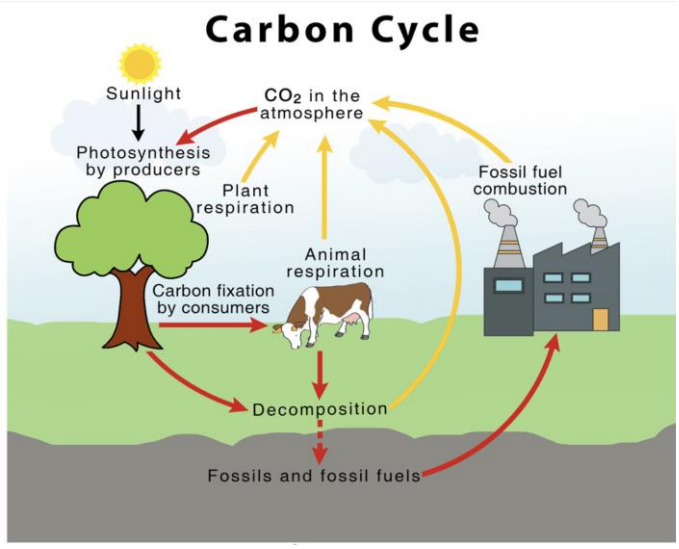


Figure 47 Carbon Cycle

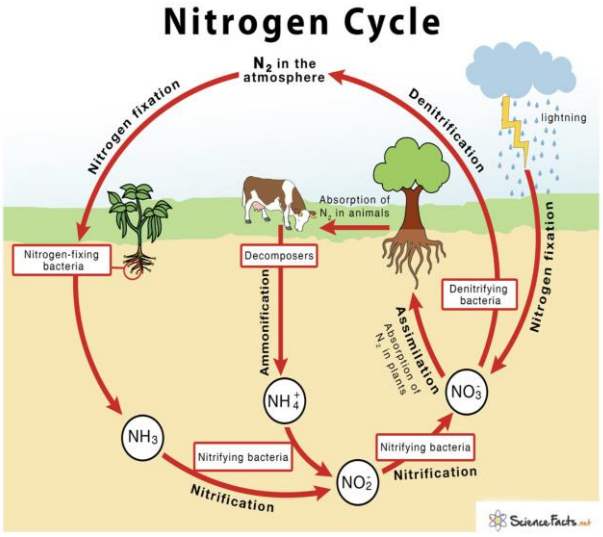


Figure 46 Nitrogen Cycle

Ecological Succession

It occurs when one biological community is replaced by another as a result of changes in biotic and abiotic factors.

Scientific Term in Ecological Succession

Definition	Scientific Term
occurs after an entire biological community, along with the soil, has been removed.	Primary Succession
occurs after an entire biological community has been removed, but the soil remains.	Secondary Succession
appear during primary succession to initiate the formation of a new biological community, such as lichens and mosses.	Leading Species
refers to a stable biological community in which little change occurs.	Climax Community
the state of the atmosphere at a specific place and time.	Weather
the average weather conditions in a particular region.	Climate
a protective layer in the atmosphere that absorbs most harmful ultraviolet rays, concentrated mainly above the South Pole.	Ozone

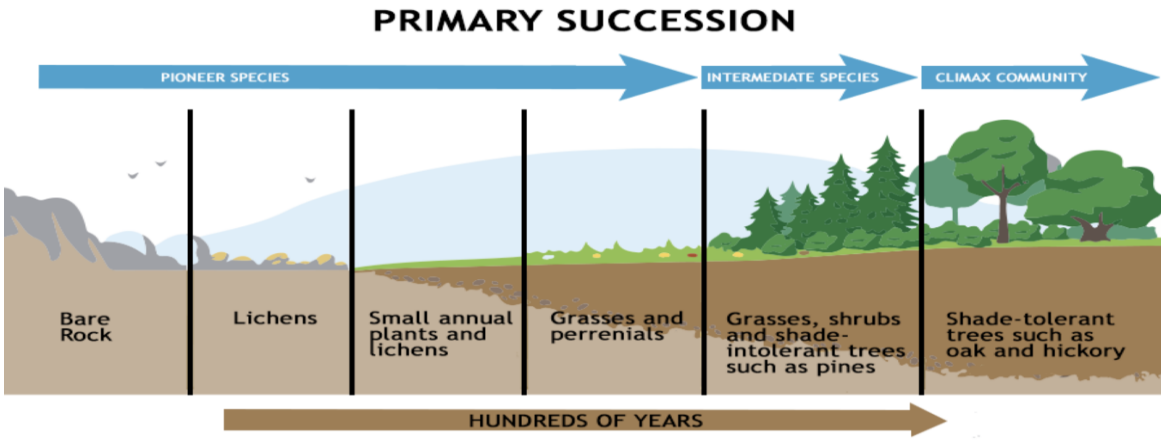


Figure 48 Primary succession

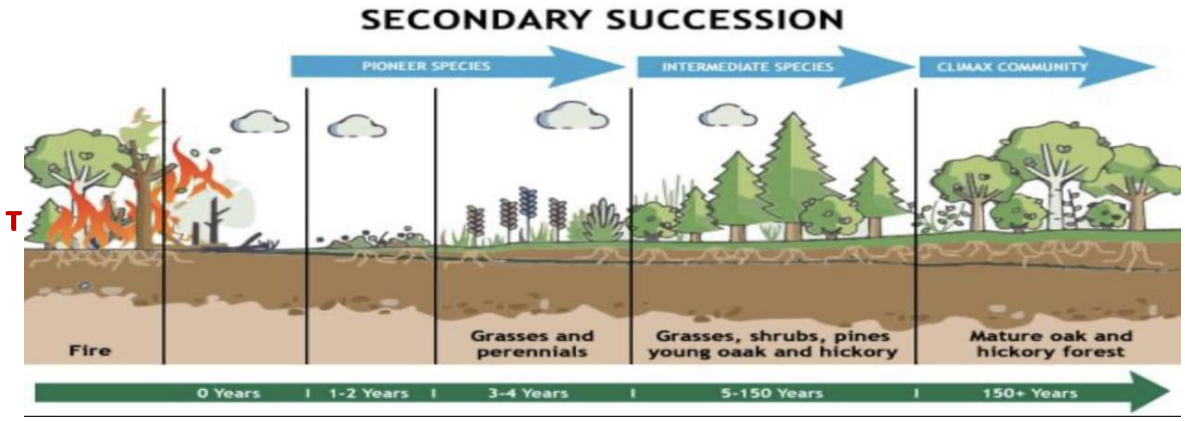
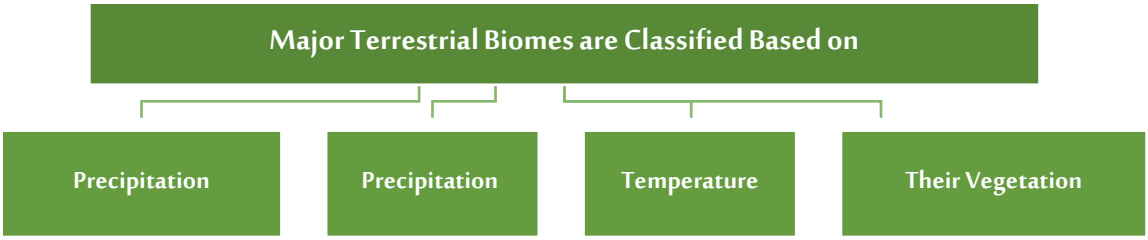


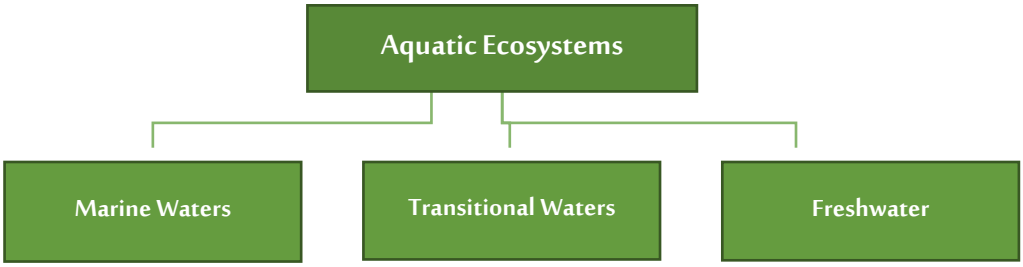
Figure 49 Secondary succession

Terrestrial Biomes

Major Land Biomes:



Aquatic Ecosystems:



Biodiversity

The variety of living organisms found in a particular place that interact with one another is called biodiversity.

Extinction: the disappearance or death of the last individual of a species within the biosphere.

The Importance of Biodiversity

- Stability of the ecosystem.
- Contributes to the quality of the biosphere.
- Has direct economic importance, such as providing food, shelter, medicine, and clothing.
- Has indirect economic value, such as supplying the atmosphere with oxygen, removing carbon dioxide, and maintaining soil fertility.

Factors That Threaten Biodiversity

1-Overexploitation	2- Habitat Loss.	3- Fragmentation of Habitat
4- Pollution	5- Acid Precipitation	6- Biological Magnification
7- Eutrophication		8- Introduced Species

Conserving Biodiversity

Protecting Biodiversity

It involves reducing consumption, recycling materials, and conserving ecosystems.

Restoring Ecosystem

Ecosystem restoration can be done in two ways:

1. **Bioremediation:**
   The use of living organisms—such as prokaryotes, fungi, or plants—to remove toxic substances from a polluted area.
2. **Biological Augmentation:**
   The introduction of natural predatory organisms into a disturbed ecosystem to help restore its balance.

Animal Behavior

Behavior: A way in which animals respond to a stimulus.

Types of Animal Behavior

Definition	Type
Behavior that depends solely on inheritance.	**Innate Behavior**
Behavior that depends on previous experiences.	**Learned Behavior**

Examples of Innate Behavior:

- Some birds sing during mating seasons in response to male hormones.
- Some young animals walk immediately after birth.

Examples of Learned Behavior:

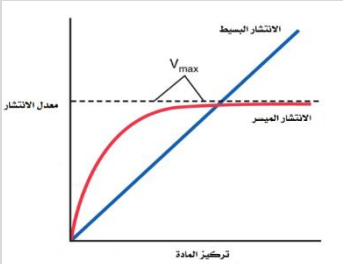
- Swimming.
- Habituation.

Ecological Behaviors

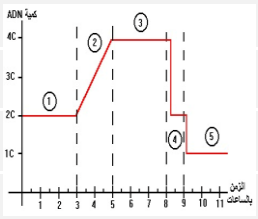
Example	Definition	Type
Fighting between male deer or bears. Female chickens or monkeys showing hierarchy. Male birds or leopards marking territory with urine.	1. Aggressive behavior: fighting between two individuals of the same species, where the winner gains control over food, territory, and mating partner. 2. Dominance hierarchy: individuals with higher ranks in the group can access resources without conflict with others. 3. Territorial behavior: selecting and defending an area of specific size.	Competitive Behavior
Many herbivores such as elephants and buffaloes.	The ability of an organism to obtain food and overcome obstacles while searching for it.	Foraging Behavior
The migration of salmon for reproduction.	The movement of animals from one place to another in search of survival opportunities.	Migratory Behavior

Exercises

1- The bacterial cell is described as prokaryotic because:	
It does not have genetic material	A
It does not have a cell wall	B
It cannot be seen with the naked eye	C
Its genetic material is not surrounded by a membrane	D
2- Which of the following statements does NOT correctly describe the structure?	
Performs several functions	A
Composed of a number of specialized cells	B
Composed of tissues that have the same function	C
Has a role in one of the body's systems	D
3- Which of the following images represents a behavioral adaptation?	
Desert plants close their stomata during the day.	A
The presence of hairs on some desert plant leaves	B
Birds that feed on flower nectar have tubular beaks	C
The camel has a hump to store water and fat	D
4- During the examination of a bacterial cell, the following are expected to be observed:	
Nucleus	A
Plastids	B
Mitochondria	C
Ribosomes	D
5- Which of the following organelles replicate independently?	
Nucleus	A
Golgi Apparatus	B
Mitochondria	C
Ribosomes	D
6- One of the following components controls the elasticity and fluidity of the plasma membrane.:	
Phosphorus	A
Proteins	B
Cholesterol	C

Sugars	D
7- The taste of plants differs from one another due to differences in their components of.....	
succulent vacuoles	A
Cell Wall	B
Plastids	C
Ribosomes	D
8-A complex and harmonious chemical system, in which all aspects of life during reproduction take place..	
Cytoplasm	A
Endoplasmic reticulum	B
Vacuoles	C
Nucleic fluid	D
9-Based on the graph, which of the following statements correctly describes the difference between simple diffusion and facilitated diffusion? 	
Both processes require energy and transport substances against the concentration gradient	A
In simple diffusion, the rate of diffusion increases linearly with concentration, while in facilitated diffusion, it reaches a maximum rate (Vmax) due to carrier saturation.	B
In facilitated diffusion, substances move faster as concentration increases without limit.	C
Simple diffusion occurs through protein channels, while facilitated diffusion occurs directly through the lipid bilayer	D
10-How many NADH molecules are produced from the Krebs cycle when 6 glucose molecules are broken down?	
6 molecules	A
12 molecules	B
16 molecules	C

36 molecules	D
11-Which of the following represents the site of O2 release in photosynthesis? I. Thylakoid membrane II. Inside the stroma III. Light-independent reactions IV. After hydrolysis	
I ,II , V	A
I , III , IV	B
II , IV , V	C
III , IV , V	D
12-Cellular respiration is a process…	
Anabolism consumes energy.	A
Catabolism consumes energy.	B
Anabolism produces energy.	C
Catabolism produces energy.	D
13-A middle lamella is formed in a plant cell due to:	
Absence of centrioles	A
Because the nucleus is lateral	B
Because of the large size of the vacuole	C
Because of the presence of a cell wall	D
14-Which of the following is NOT true regarding mitosis in plant cells?	
Chromosomes duplicate during interphase.	A
Spindle fibers originate from centrioles during prophase.	B
A middle plate forms during telophase.	C
The cell divides into two cells, each with the same number of chromosomes.	D
15-In which phase of mitosis can chromosomes be seen and counted?	
Prophase	A
Metaphase	B
Anaphase	C
Telophase	D

16-How many mitotic divisions are expected to occur in a single cell to produce 128 cells?	
7 times	A
14 times	B
27 times	C
32 times	D
17-In the following diagram, which stage of meiosis does the number 2 represent?	
G1 	A
G2	B
S phase	C
Meiotic I	D
18-If a germ cell has 32 chromosomes before meiosis, how many chromosomes does it have in anaphase I?	
8	A
16	B
32	C
64	D
19-The genetic crossing over occurs in:	
Prophase I	A
Prophase II	B
Interphase	C
Prophase of mitosis	D
20-Which of the following tasks would be performed by an ecologist?	
Exploring the medical uses of nectar	A
Examining the effect of cyanide on algae	B
Studying and classifying mollusk fossils	C
Vaccinating livestock against a disease	D
21- What is considered a weakness of traditional food webs when facing complex environmental problems?	
The food web does not represent all connections in the real ecosystem	A

Food webs do not take invasive species into account.	B
The numerous food chains within a food web make it difficult to use.	C
Trophic levels are not considered when creating a food web.	D
22-Which of the following processes is an example of mutualism?	
A male peacock performing courtship rituals for a female.	A
A fish protecting a shrimp that, in return, builds a shared burrow.	B
A shrimp and a minnow resting under the same rock.	C
Two snake species with the same coloration displaying their venom.	D
23- Which of the following represents the beginning of primary succession?	
Lichens growing on cooled volcanic lava	A
A forest area developing from grasslands	B
A new plant species growing in a floodplain	C
Trees growing after a forest fire.	D
24-What explains the low number of animal species living in a fast-flowing river?	
Cold water reduces dissolved oxygen levels.	A
Strong currents prevent the accumulation of most organic matter.	B
Few animals are adapted to withstand high-speed water.	C
Surface water reflects sunlight away from autotrophic organisms.	D
25-Which of the following actions would violate the CITES (Convention on International Trade in Endangered Species)?	
Cutting down rainforests	A
Polluting lakes	B
Selling elephant tusks.	C
Hunting mountain goats.	D
26-Which of the following is an example of innate behavior?	
Chirping of chicks after hatching	A
Bears learning to catch fish.	B
A small child pronouncing a few words.	C
Ducks walking together to the pond to feed	D

27- Complete the table by placing a (✓) in the appropriate column to identify the type of pollution described in each of the following statements:

Eutrophication	Biological Magnification	Acid Rain	Statement	
			Fertilizers cause excessive growth of algae, which reduces oxygen levels in the water.	A
			Sulfur dioxide reacts with water in the atmosphere to form sulfuric acid.	B
			Pesticides accumulate in the bodies of organisms at the top of the food chain.	C
			Accumulation of DDT in the tissues of eagles and sea eagles during the 1970s.	D

Answer Key Guide

1	2	3	4	5	6	7	8	9	10
D	C	A	D	C	C	A	A	B	D
11	12	13	14	15	16	17	18	19	
A	D	D	B	B	A	C	C	A	
20	21	22	23	24	25	26			
B	A	B	A	B	C	A			

27	A	B	C	D
	Eutrophication	Acid Rain	Biological Magnification	Biological Magnification

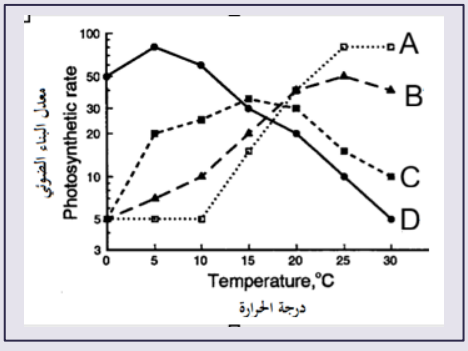
Challenges

1. When we describe any living organism as autotrophic, this organism can:	
Get energy from organic sources	(A)
Convert energy from sunlight into chemical energy	(B)
Depend on the energy produced by other creatures as an energy source.	(C)
Live in isolation from other living organisms	(D)
Use only soil elements	(E)

2. Organisms that have not changed in thousands of years may:	
Be poorly adapt.	(A)
Mate more often.	(B)
Be fierce competitors.	(C)
live in stable environments.	(D)
Do not depend on plants.	(E)

3. One of the scientists who experimented with (algae) using ultraviolet rays was able to produce new mutant cells that do not contain chloroplasts. To preserve these cells alive, the scientist had to:	
Provide them a light with high intensity.	(A)
Keep them in the dark.	(B)
Provide them with a sugar solution.	(C)
Give them chlorophyll.	(D)
Increase the temperature.	(E)

4. The graph below shows the relationship between photosynthetic rate and temperature. Based on these results, which species from (a to d) is best adapted to arctic conditions where the growth season average temperature does not exceed 8 C°?



A) a	B) b	C) c & d	D) d	E) a & b

5. Although the function of each organ shown in the attached pictures is different, but they share one principle that makes them more efficient in carrying out their functions. What is this principle?

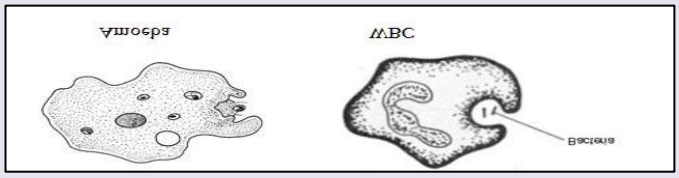
Intestinal villi	Root hairs	Gills
		

Resists mechanical shocks.	(A)
Increase the surface area.	(B)
The large number of cellular organelles in it.	(C)
Maintaining the members 'moisture.	(D)

6. One of the following structures is <u>not a common</u> ingredient between a bacterial cell and a plant cell:

Mitochondria	(A)
Cellular wall	(B)
Chromosomes	(C)
Plasma membrane	(D)
Cytoplasm	(E)

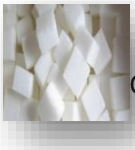
7. We always look at white blood cells and amoebas as similar. Read the following statements about them:



I. Amoeba and white blood cells do not move.
II. Amoeba and white blood cell have genetic material.
III. Amoeba and white blood cells can change their shape.
IV. Amoeba and white blood cell have a cell membrane.
Which of the previous statements are correct:

I - II	(A)
II - IV	(B)

I – II - III	(C)
II – III-IV	(D)
I – II – III -IV	(E)



2 Glucose

1

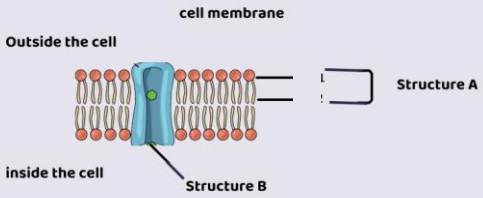
8. Which of the substances described in the following forms represent the substances needed by the plant to conduct photosynthesis?

4

3

1 & 2	(A)
2 & 3	(B)
3 & 4	(C)
1 & 4	(D)

9. What kind of molecule is structure A?

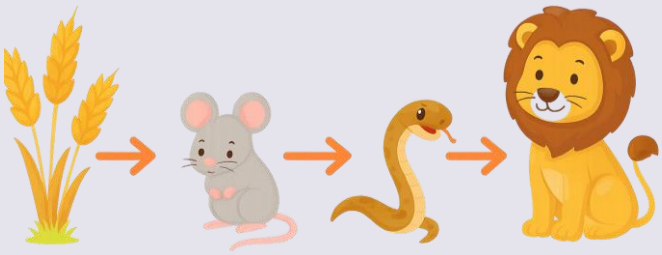


Proteins	(A)
Carbohydrate	(B)
Phospholipid	(C)
Nucleic acid	(D)
Cholesterol	(E)

10. Within the mitochondria, a series of chemical reactions produces energy. which of the following organs may be more affected when mitochondrial dysfunction?

Muscles	(A)
Skin	(B)
Teeth	(C)
Liver	(D)

11. Which of the organisms in the next food chain have more energy transferred?



Wheat	(A)
Mouse	(B)
Snake	(C)
Lion	(D)

12. Natural resources are part of the Earth's environment and provide the necessary materials, used for the survival of living organisms. Which of the following options represents renewable resources?

2

1

4

3

1	(A)
2 & 3	(B)
3	(C)
1 & 4	(D)

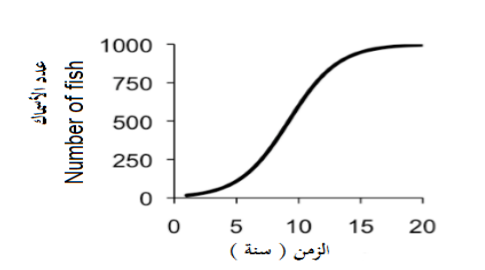
13. The insect shown in the picture collects pollen and nectar for food, but at the same time helps to a Plant reproduction. What does this relationship explain?

Predation	(A)
Commensalism	(B)
Mutualism	(C)
Parasitism	(D)
Competition	(E)

14. On World Environment Day, attention is drawn to Earth-friendly practices. Among these practices a shopper is strongly advised to bring his cloth bag to carry his purchases. What is the name of this practice?

Reducing waste	(A)
Decrease consumption	(B)
Reuse	(C)
Trash disposal	(D)
Best use	(E)

15. The attached graph shows the growth of a population of fish in a pond over time. Selling the fish, you catch from this pond is your livelihood, and you free to harvest as many fish as possible at once. How many fish should you leave in the pond at a time to ensure an increase in the production rate of fish?



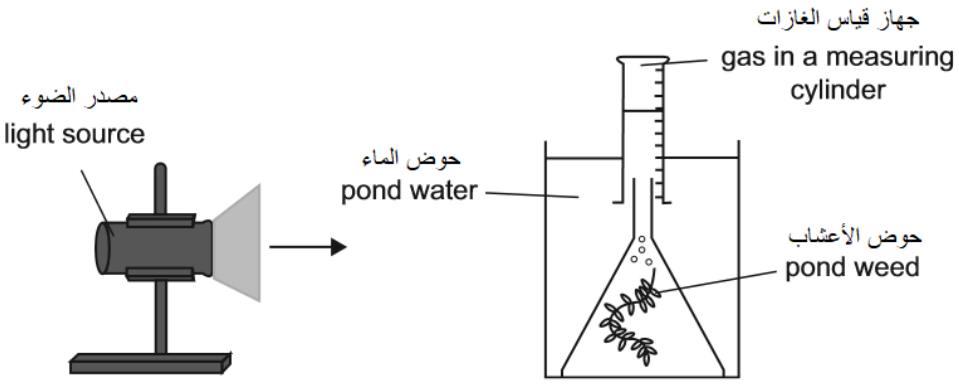
A) 2	B) 100	C) 500	D) 750	E) 1000

Answer Keys for the Challenging Exercises

1	2	3	4	5	6	7	8	9	10
B	D	C	D	B	A	D	D	C	A
11	12	13	14	15					
B	B	C	B	C					

Mock Exam

1. A student set up an experiment to measure the rate of photosynthesis, as shown in the diagram.



Data was collected and plotted on a graph.

If plotted, which of the following (From 1 To 3) variables would give a gradient that is directly proportional to the rate of photosynthesis?

	x-axis	y-axis
1	Time	volume of CO_2 released
2	number of gas bubbles released per minute	Time
3	Time	released volume of O_2

1	A
3	B
1-2	C
2-3	D

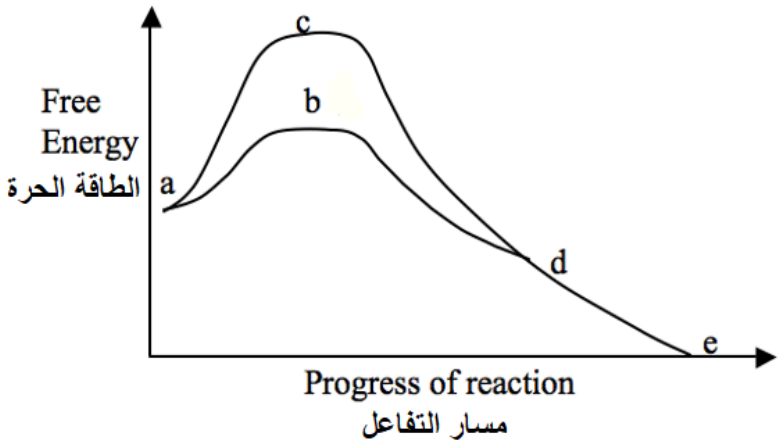
2. Bacteria reproduce asexually by dividing into two by binary fission. If binary fission occurs every 20 minutes, how many cells will be produced in 24 hours?

2^2	A
2^3	B
2^{24}	C
2^{72}	D

3. The molecular formula for glucose is $C_6H_{12}O_6$. What would be the molecular formula for a molecule made by linking three glucose molecules together by dehydration reactions?

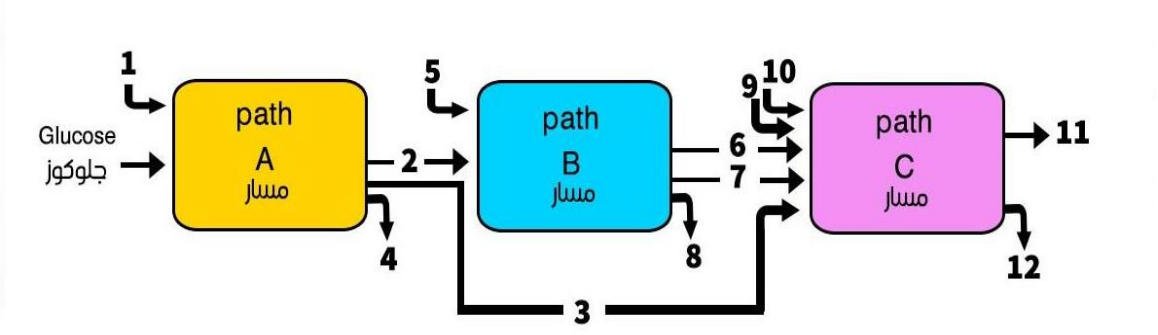
$C_{18}H_{36}O_{18}$	A
$C_{18}H_{32}O_{16}$	B
$C_{18}H_{10}O_{15}$	C
$C_3H_6O_3$	D

4. The graph below compares the rates of protein digestion when catalyzed by the digestive enzyme pepsin and when left uncatalyzed. one curve represents the catalyzed reaction, and the other represents the uncatalyzed reaction. Which point on the graph (a, b, c, d) represents the point in the catalyzed reaction when the reactants have gained their activation energy and the reaction can proceed?



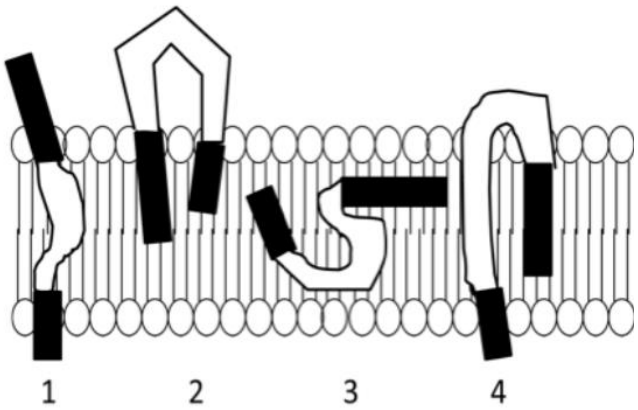
	A	A
	B	B
	C	C
	D	D

5. In the attached figure, if path A is glycolysis, path B is a Krebs cycle, and C path is an electron transport chain, then Arrow number 2 represents:



A. Oxygen	B. Pyruvate	C. Water	D. ATP

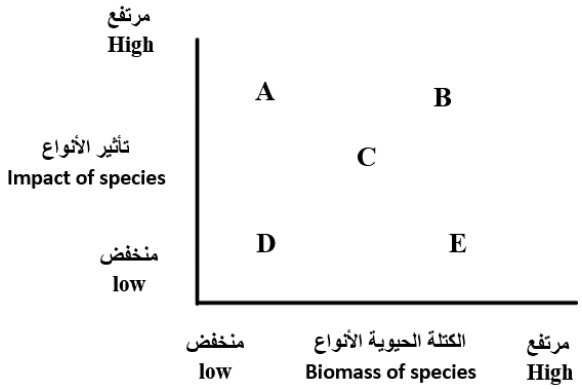
6. The diagram at right illustrates five possible arrangements (numbered 1 to ٤) of a protein that could associate with a phospholipid bilayer. The black regions of the protein are composed of polar and charged amino acids, and the white region of the protein is composed of nonpolar amino acids. Which arrangement is most likely to occur?



A	B	C	D
1	2	3	4

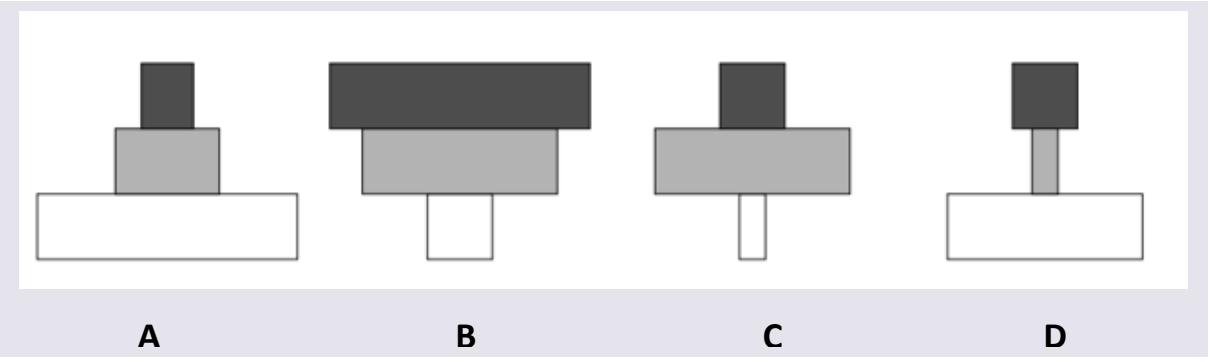
7. In the figure below, A to E denote five different species in an ecosystem. Which of the species is most likely to be a keystone species

A	B	C	D	E
A	B	C	D	E



8. An ecological pyramid is a diagrammatic representation of the relationship between various organisms in an ecosystem. These pyramids can be drawn to represent the organic material (biomass), or number, or energy at each trophic level.

Which of the following pyramids represents a Number pyramid of an ecosystem consisting of a tree, caterpillars and mynas



A B C D

Answer Key For the mock Exa

1	2	3	4
B	D	B	B
5	6	7	8
B	A	A	C

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