

احجز مكانك واستعد للامتحان بثقة كاملة

Biology (Inspire) – 1st Term Grade 9 [ADV] 2027 Study Guide

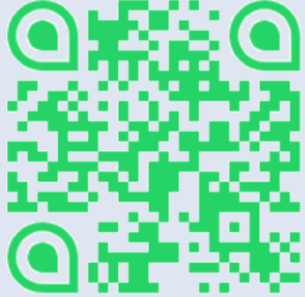
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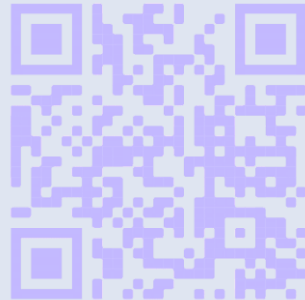




شرح الدروس



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شرح لدروس الفصل
الأول كامل

بـ 149
درهم فقط

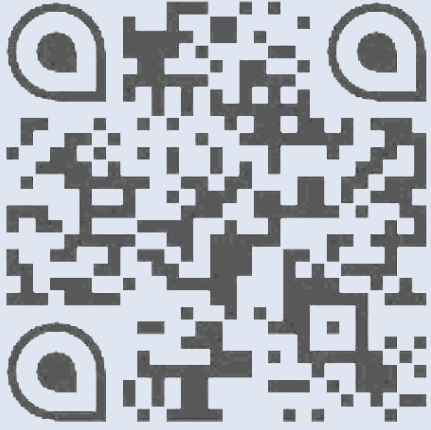
ملازم

اختبارات

Module (6): Chemistry in Biology

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Module (6): Chemistry in Biology

02

Second Lesson: Chemical Reactions



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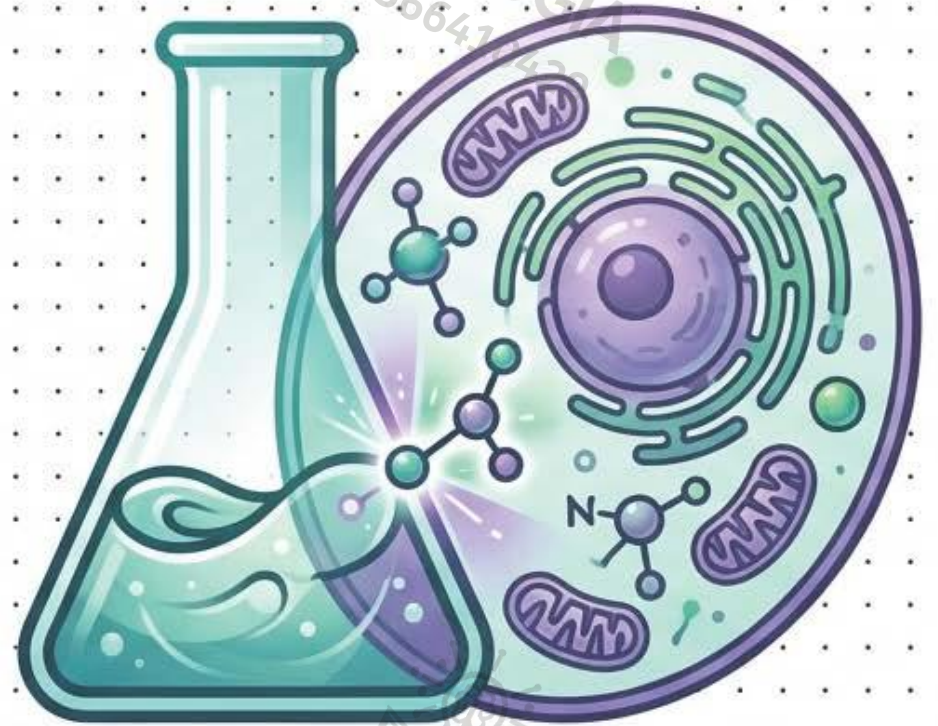


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Chemical Reactions & Enzymes

The Ultimate Biological Factory Explainer



The Change Matrix: Physical vs. Chemical

Physical Change

Alters a substance's appearance, but not its core composition.



Example: Water boiling in a beaker.

Chemical Reaction

Atoms are reorganized into completely different substances. Bonds are broken and formed. Clues include heat, light, or a new state.



Example: Oxygen reacting with iron to form rust (Iron Oxide, Fe_2O_3).

Reactants

The starting substances on the left side of the arrow.



Yields or reacts to form



Indicates the process of change

Products

The new substances formed during the reaction, on the right side.



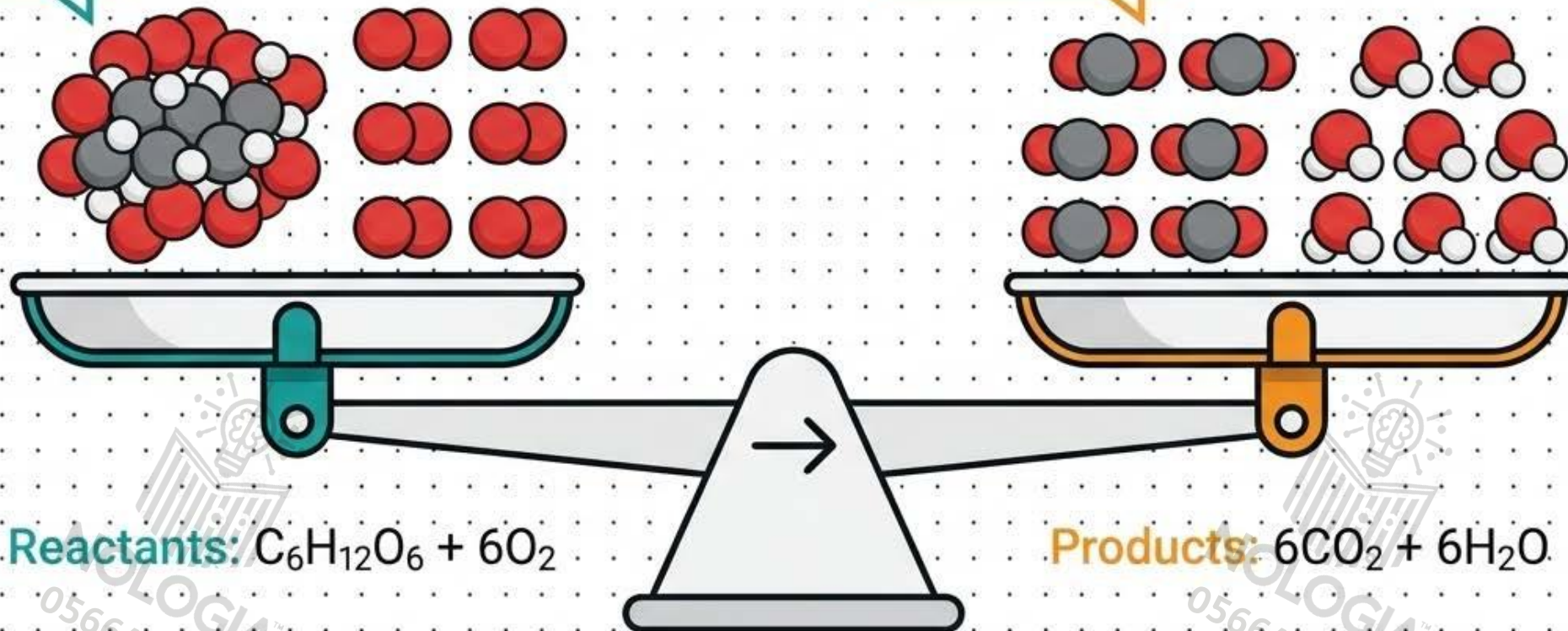
The Law of Conservation of Mass

Key Rule

Coefficients (the large numbers in front) are used to multiply the subscripts to achieve this perfect balance. Matter cannot be created or destroyed.

6 Carbon,
12 Hydrogen,
18 Oxygen

6 Carbon,
12 Hydrogen,
18 Oxygen

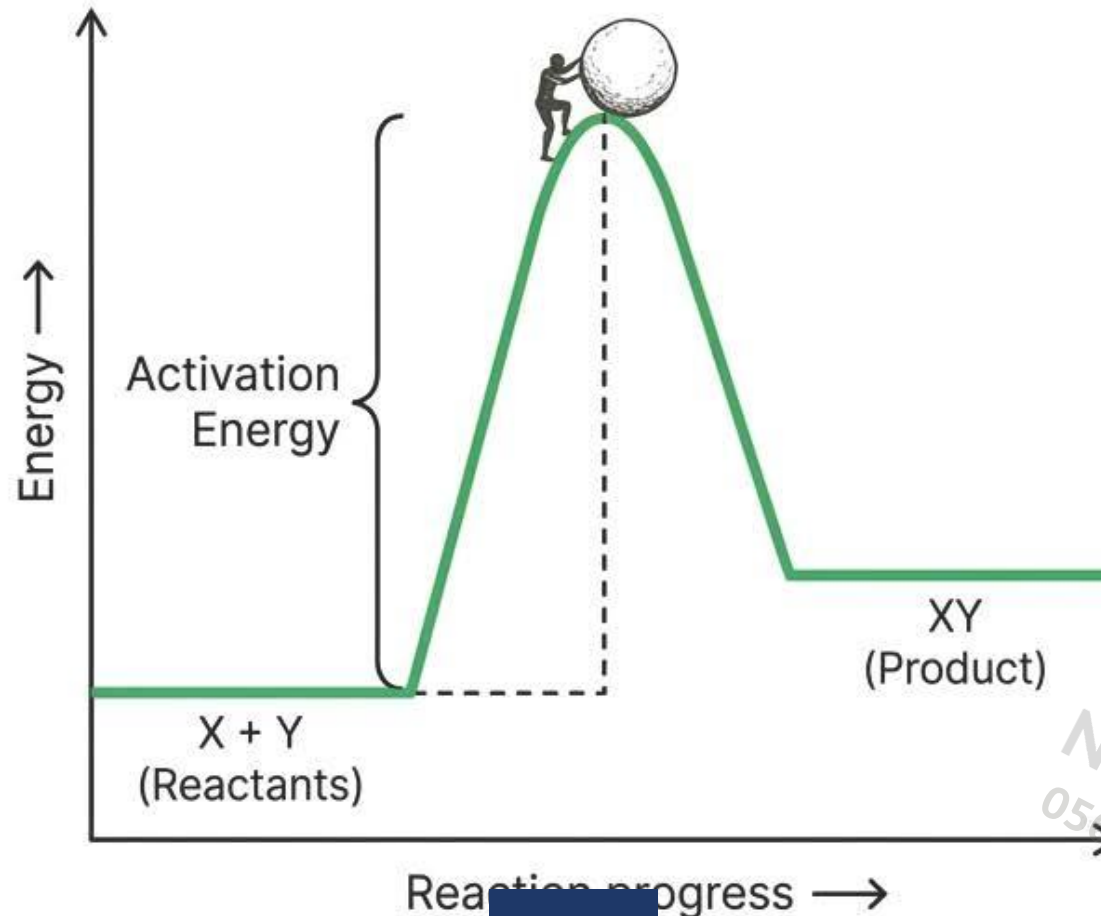


The Energy Requirement

Energy Diagram

Activation Energy

The minimum amount of energy needed for reactants to form products.

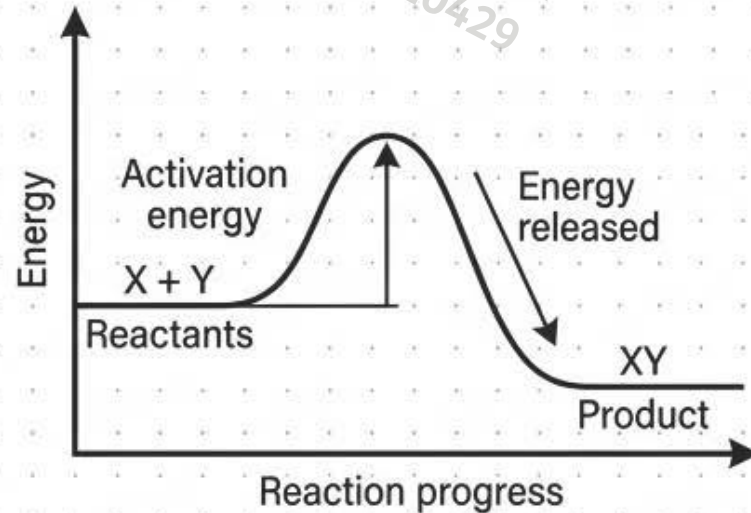


The Candle Metaphor:

A candle won't burn until you light the wick. The flame provides the activation energy. Once the reaction begins, it sustains itself.

The Energy Matrix: Exothermic vs. Endothermic

Exothermic Reactions

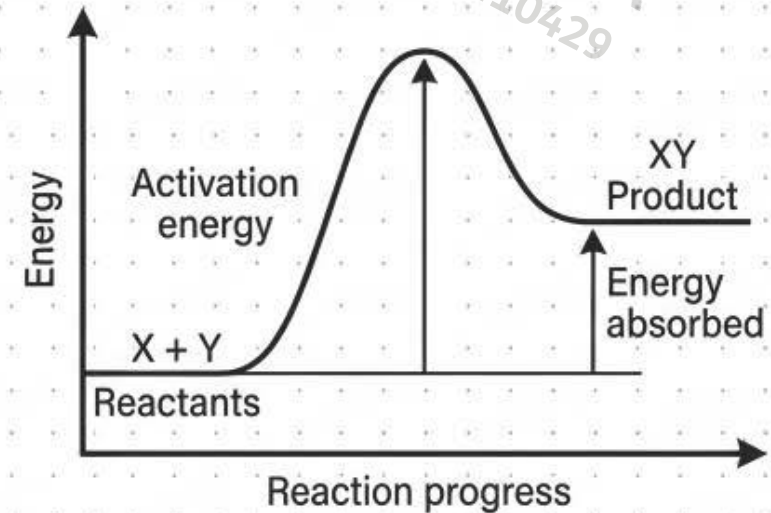


Key Trait: Energy is released (often as heat).

Energy State: Energy of products is LESS than reactants.

Biological Example: Cellular respiration (maintains body temperature).

Endothermic Reactions



Key Trait: Heat energy is absorbed.

Energy State: Energy of products is GREATER than reactants.

Biological Example: Photosynthesis, or an instant cold pack for first aid.

The Problem

Living things are like chemical factories driven by constant reactions. However, most compounds in living things cannot undergo chemical reactions without a massive input of energy.



The Constraint

If biological reactions relied only on ambient heat or proceeded at their natural, slow laboratory pace, life would be impossible. The activation energy required is simply too high.

The Transition

To be useful to cells, something must reduce the energy cost and speed up the biological assembly line.

The Biological Hero: Enzymes

The Catalyst

A substance that lowers the activation energy needed to start a chemical reaction, speeding it up thousands of times faster. It does not increase how much product is made and is NOT used up in the reaction.

The Enzyme

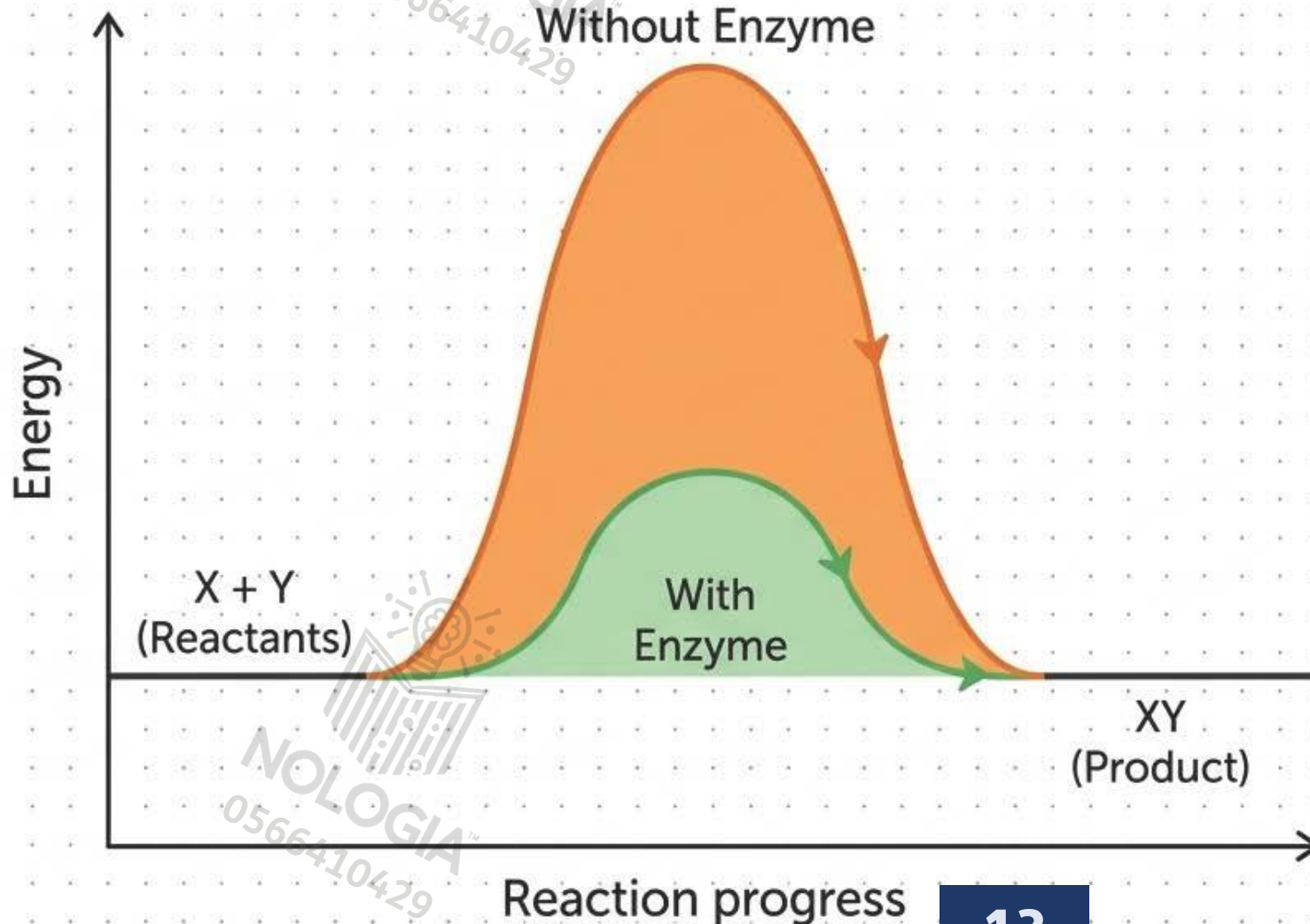
Special proteins that act as biological catalysts. They lower the activation energy of biochemical reactions and are absolutely essential to many life processes.

Naming Convention

An enzyme's name describes what it does:
Amylase: Breaks down amylose (starch).
Lipase: Breaks down fats (lipids).
Protease: Breaks down proteins.

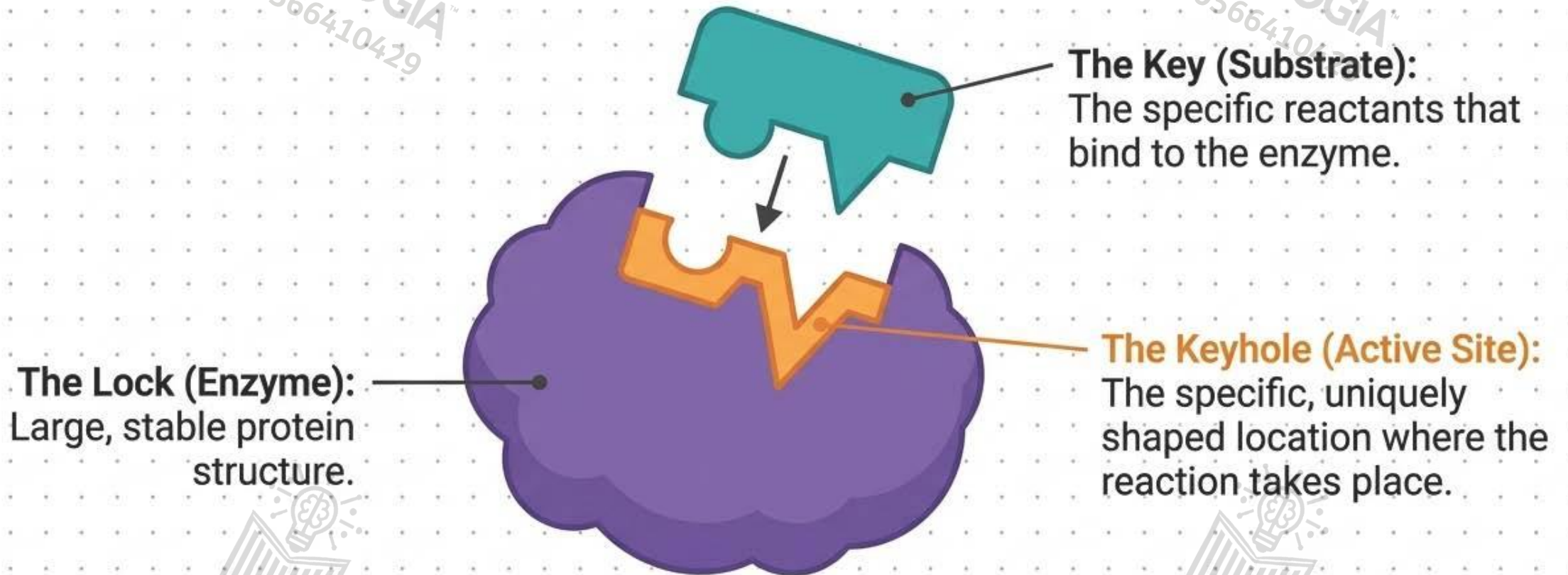


The Energy Hack: Lowering the Barrier



The Alternative Pathway:
The enzyme provides a lower-energy shortcut. It does not change the starting energy of the reactants or the final energy of the products—it only lowers the barrier to entry.

Anatomy of an Enzyme: Lock & Key



The Rule of Specificity: Only substrates with the exact complementary size and shape as the active site will bind, just like puzzle pieces. Structure is directly related to function.

The Catalytic Cycle

Step 3: Release



The newly formed products are released.

Step 1: Bind



Substrates enter the active site.

The Loop:

The enzyme remains unchanged and is immediately available to bind with more substrates.

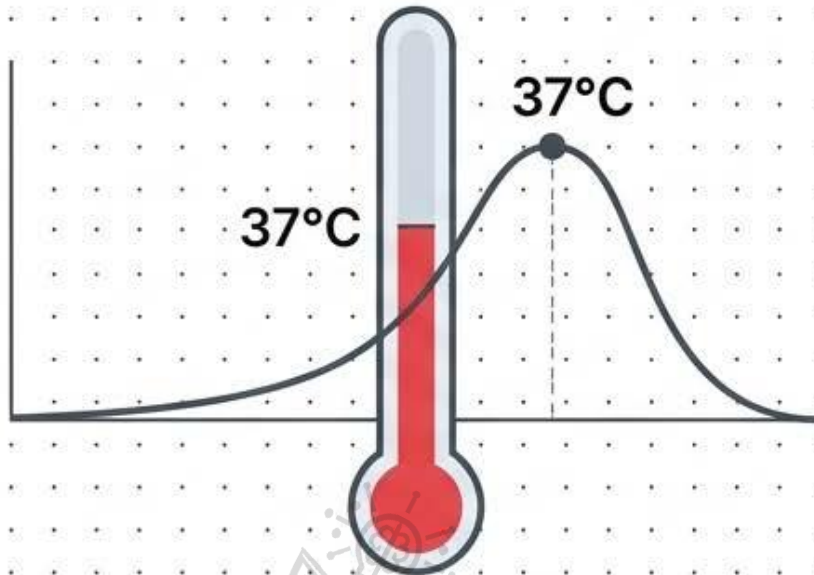
Step 2: React



The active site changes shape slightly to form the enzyme-substrate complex. This precise grip breaks old chemical bonds and forms new ones.

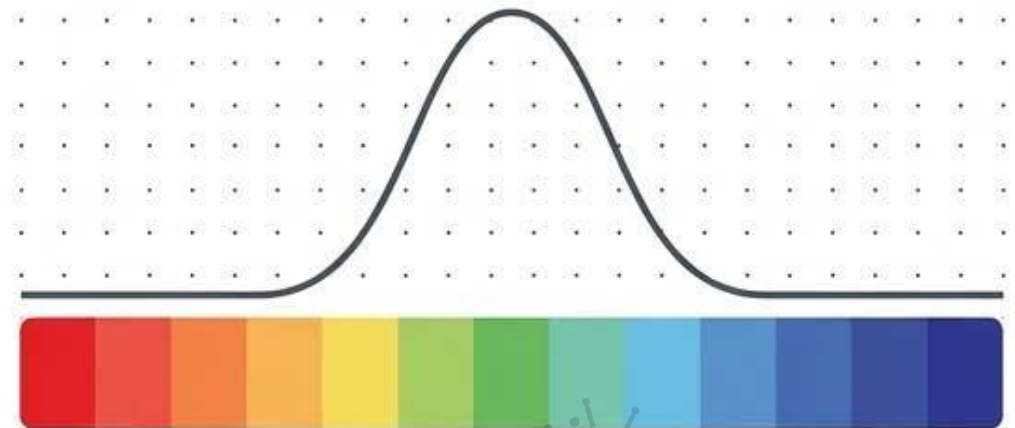
Environmental Vulnerabilities

Temperature



Human enzymes are most active at an optimal temperature close to **37°C**. Moving away from this **optimal zone decreases activity**. (Other organisms, like bacteria, have different optimal zones).

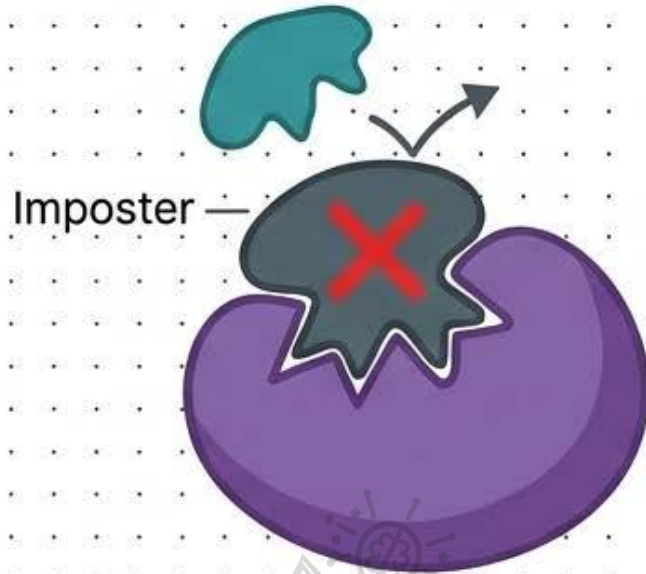
pH Levels



Enzymes have optimal pH levels. For example, digestive enzymes in the **stomach work best in a highly acidic environment**, whereas other enzymes require **neutral or basic conditions**.

External Threats: Inhibitors

Competitive Interference



Some inhibitors bind directly to the active site, physically blocking the substrate from entering.

Non-competitive Interference



Other inhibitors bind elsewhere on the enzyme, leaving the active site available, but changing its shape entirely, making it impossible for the substrate to fit.

Synthesis: The Journey of a Sugar Cookie



1. The Reactants

You eat a sugar cookie made of complex starches. These are the initial Reactants.

2. The Catalyst

Amylase, an Enzyme in your saliva, provides the active site.

3. Lowering the Barrier

The amylase drastically lowers the Activation Energy required to break down the starch.

4. The Equation

Matter is conserved (Conservation of Mass) as the complex starches are broken into simple sugars.

5. The Product

The reaction is Exothermic; cellular respiration eventually utilizes these broken-down sugars to release heat.

Module 06: Final Review

NOLOGIA

Balanced Equations

Must show an equal number of atoms for each element on both sides to satisfy the conservation of mass.

Activation Energy

The absolute minimum energy required to begin a chemical reaction.

Energy Shift

Exothermic releases energy (products < reactants).
Endothermic absorbs energy (products > reactants).

Catalysts & Enzymes

Biological proteins that speed up reactions by lowering activation energy without being consumed.

The Active Site

The specific location where the substrate binds to the enzyme, requiring precise, complementary shapes.

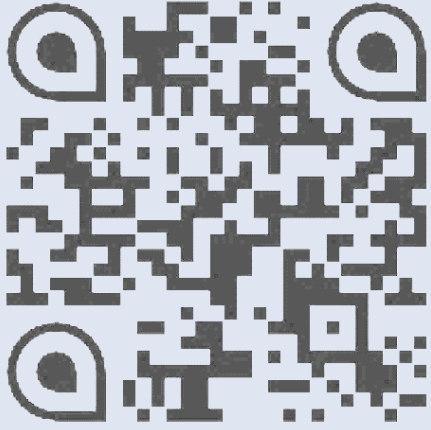
Environmental Factors

Temperature, pH levels, and external inhibitors directly affect and can completely block enzyme activity.



Exam Preparation

- 1) What is the definition of activation energy in a chemical reaction?
 - A. The total energy released at the end of a reaction.
 - B. The energy required to begin a chemical reaction.
 - C. The energy stored within the chemical bonds of the products.
 - D. The energy absorbed by a catalyst during a reaction.
- 2) How do enzymes affect biochemical reactions in living organisms?
 - A. They increase the activation energy required for the reaction.
 - B. They change the final products formed by the reaction.
 - C. They act as biological catalysts to lower the activation energy.
 - D. They eliminate the need for reactants in a reaction.
- 3) Which of the following environmental factors directly affect enzyme activity?
 - A. Mass and volume.
 - B. Color and odor.
 - C. pH and temperature.
 - D. Light intensity and sound.
- 4) According to the law of conservation of mass, a balanced chemical equation must show:
 - A. More atoms on the product side than the reactant side.
 - B. An equal number of atoms for each element on both sides.
 - C. Fewer molecules on the product side to conserve energy.
 - D. A change in the types of elements present from start to finish.



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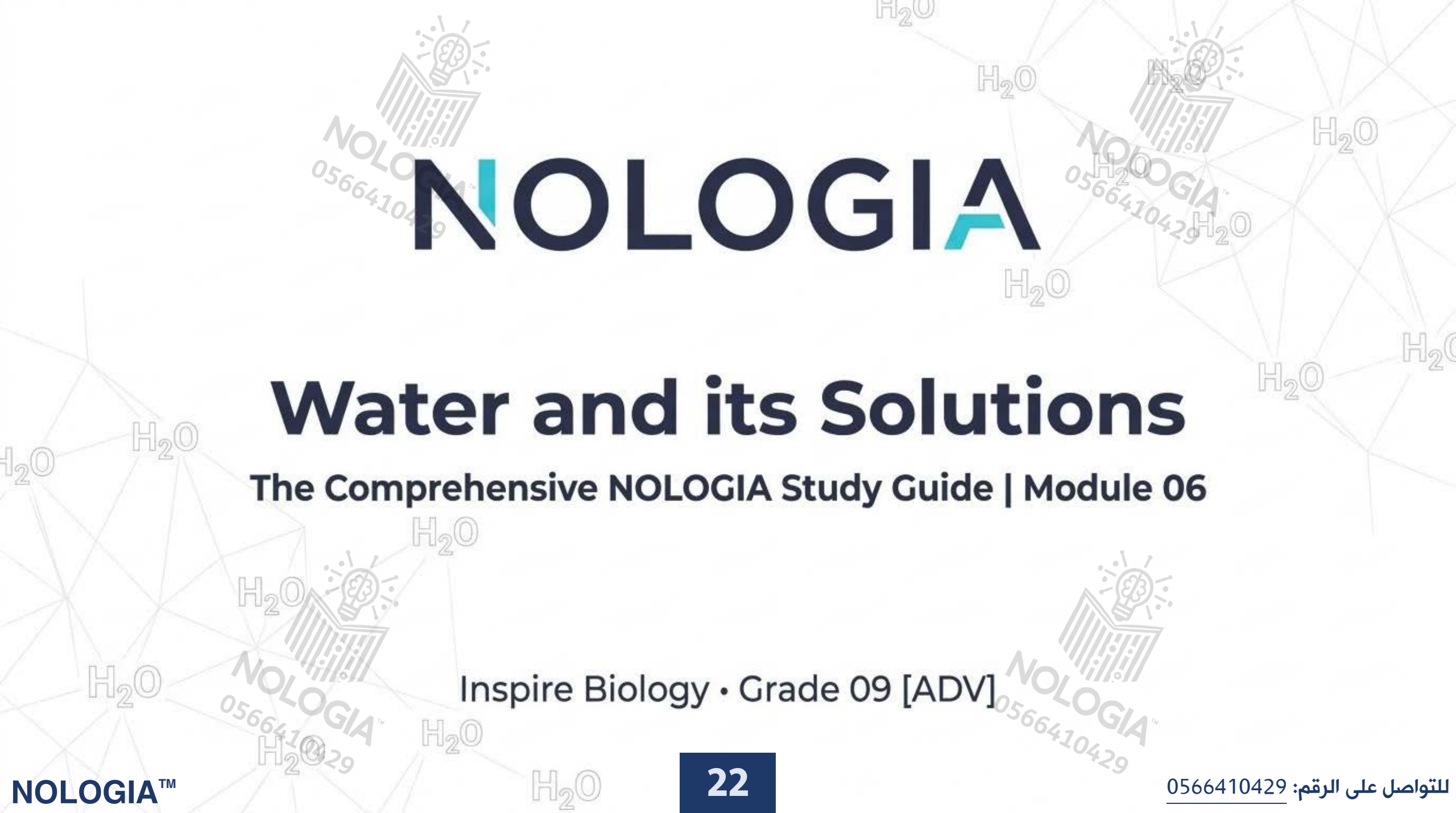
Module (6): Chemistry in Biology

03

Third Lesson: Water and Its Solutions



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Water and its Solutions

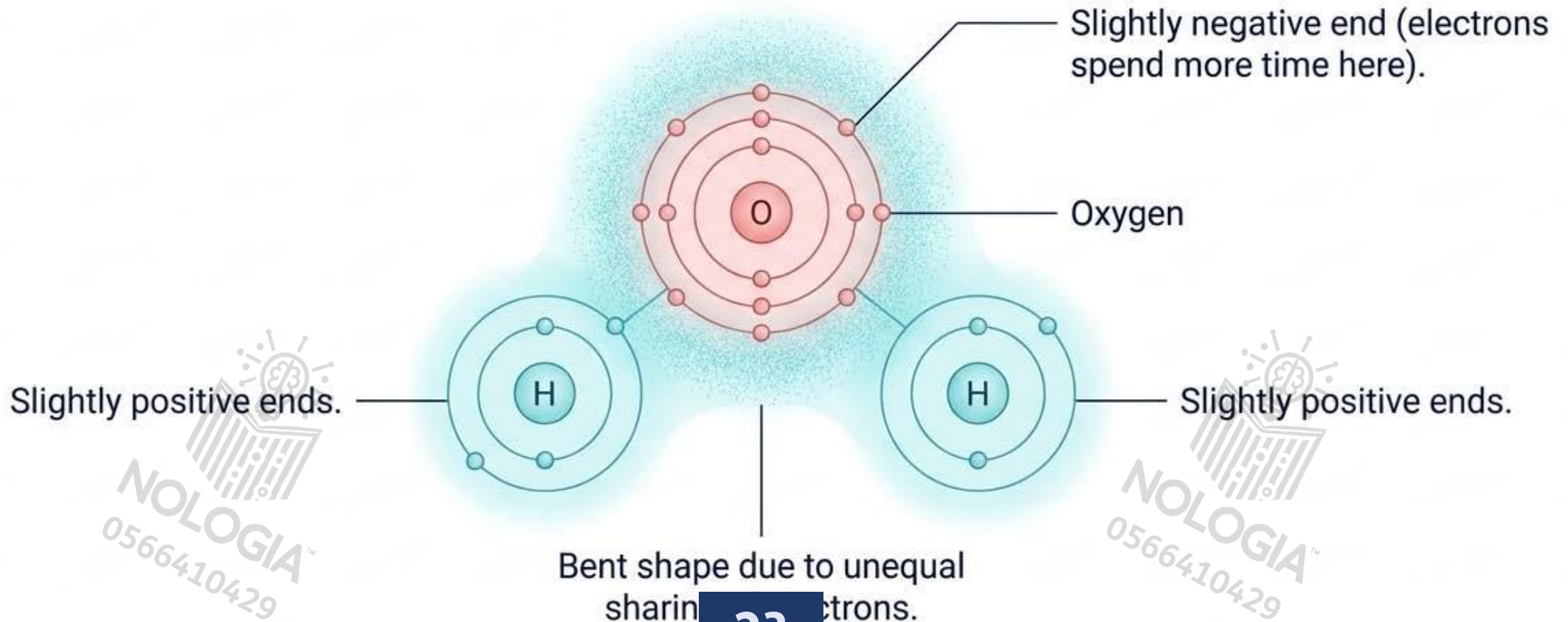
The Comprehensive NOLOGIA Study Guide | Module 06

Inspire Biology • Grade 09 [ADV]

The Foundation: Molecular Polarity

NOLOGIA Study Series • 01 Core Concepts

Polarity: The property of having two opposite poles or ends.



Intermolecular Forces: The "Molecular Velcro"

NOLOGIA Study Series • 02 Forces

Van der Waals Forces

- Weak electrostatic attractions between opposite charges of different molecules.
- Weaker than covalent or ionic bonds.
- Ideal for short-term biological interactions.
- Strength depends on molecule size, shape, and ability to attract electrons.

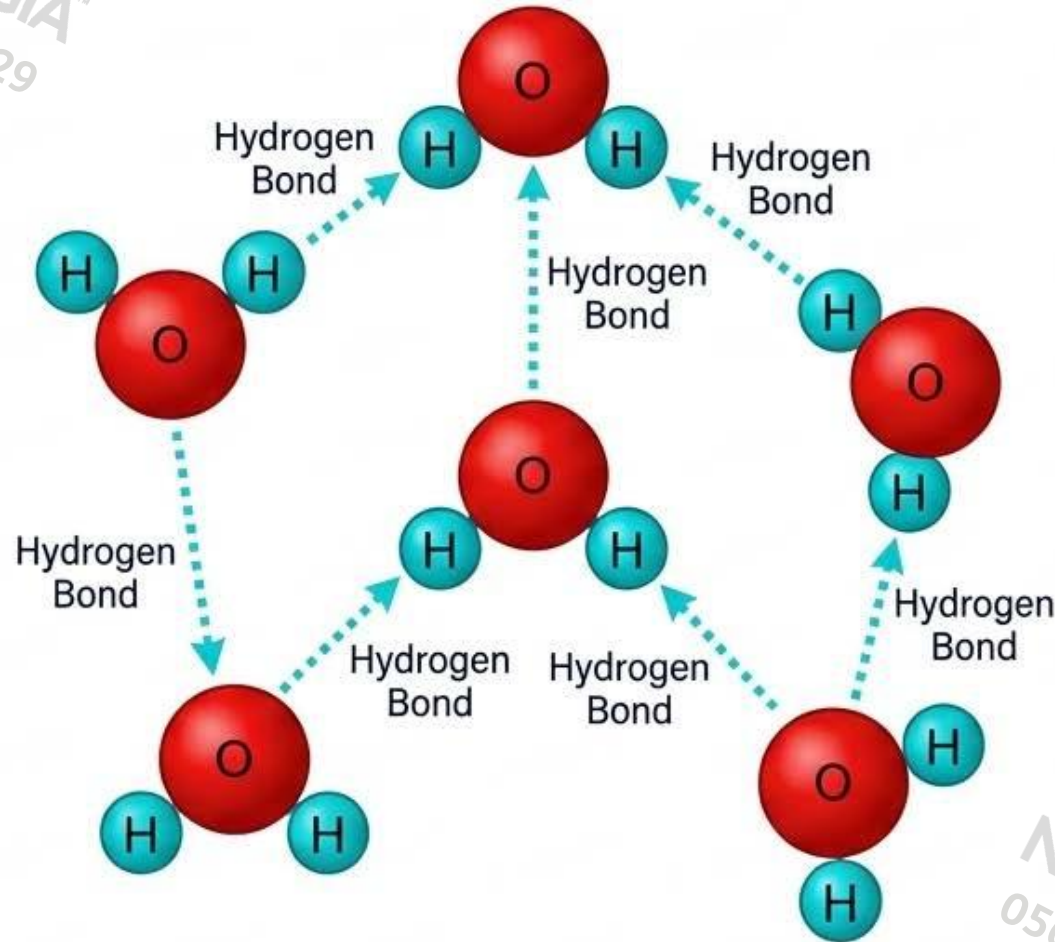
The Gecko Metaphor: Geckos climb smooth surfaces because of van der Waals forces between hairlike structures on their toes and the surface.



Hydrogen Bonds: Water's Super Glue

DEFINITION: Hydrogen Bond

A Hydrogen Bond is a strong type of van der Waals force involving a hydrogen atom and a fluorine, oxygen, or nitrogen atom from a different molecule.



CAUTION: Do not confuse with Covalent Bonds!

Covalent bonds hold the individual water molecule together (strong).

Hydrogen bonds hold **DIFFERENT** water molecules together (weak interaction).

Diagnostic Matrix: Bonds vs. Forces

NOLOGIA Study Series • 03 Synthesis

Covalent Bonds	Hydrogen Bonds	Van der Waals Forces
Within a molecule (atoms sharing electrons)	Between specific polar molecules (H + O/N/F)	Between any molecules with slightly charged regions
Very Strong ("Molecular Knot")	Moderate (Strongest intermolecular force)	Weak ("Molecular Velcro")
Linking Hydrogen and Oxygen to form H ₂ O	Connecting two different H ₂ O molecules	A gecko climbing a wall

Properties of Water: Cohesion & Adhesion

NOLOGIA Study Series • 04 Synthesis

Cohesion (Water + Water)

Mechanism: Molecules are attracted to each other due to hydrogen bonds.

Result: Creates surface tension.



Adhesion (Water + Other)

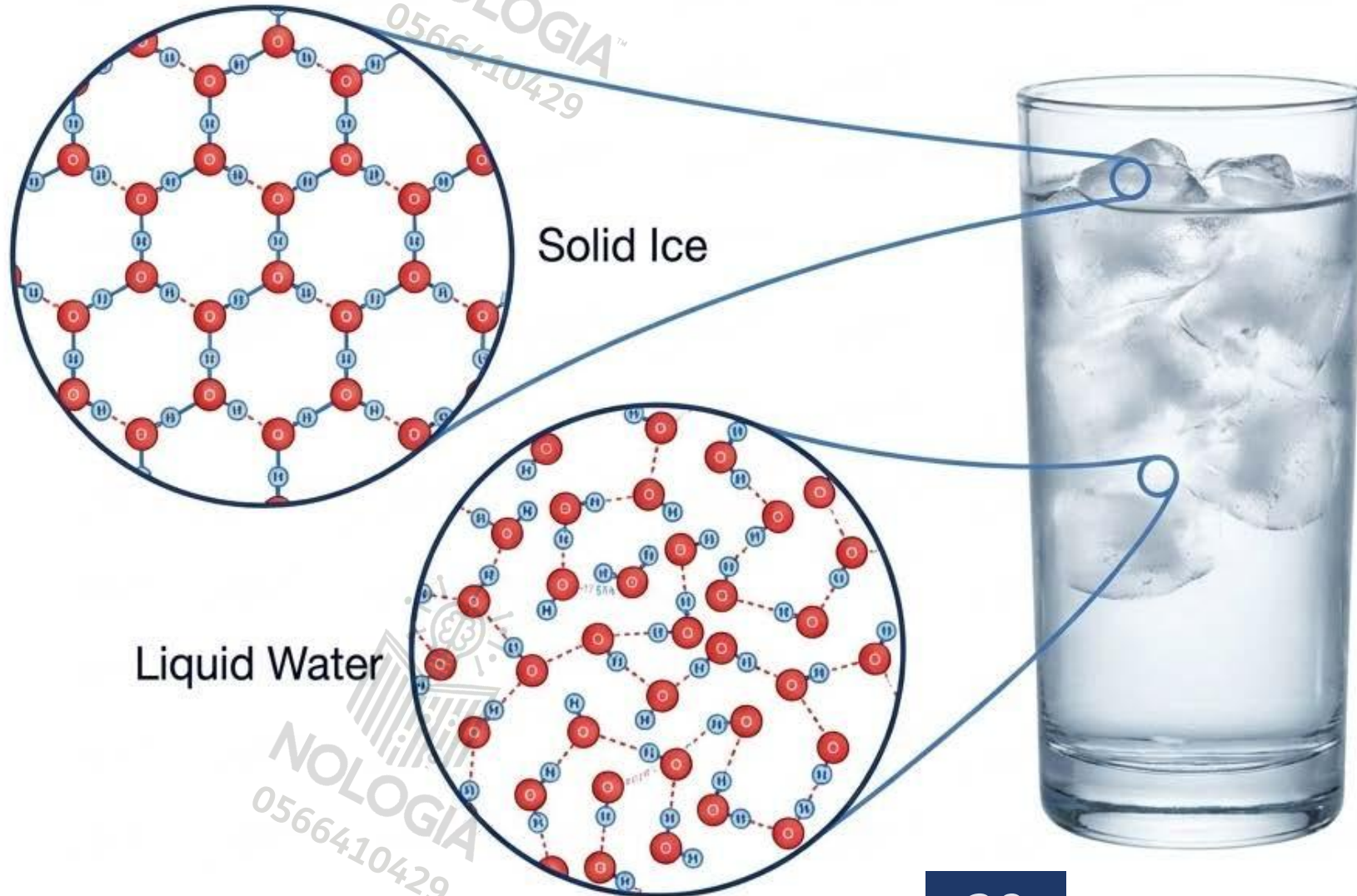
Mechanism: Water forms hydrogen bonds with molecules on other surfaces.

Result: Capillary action.



The Density Anomaly: Why Ice Floats

NOLOGIA Study Series • 05 Synthesis

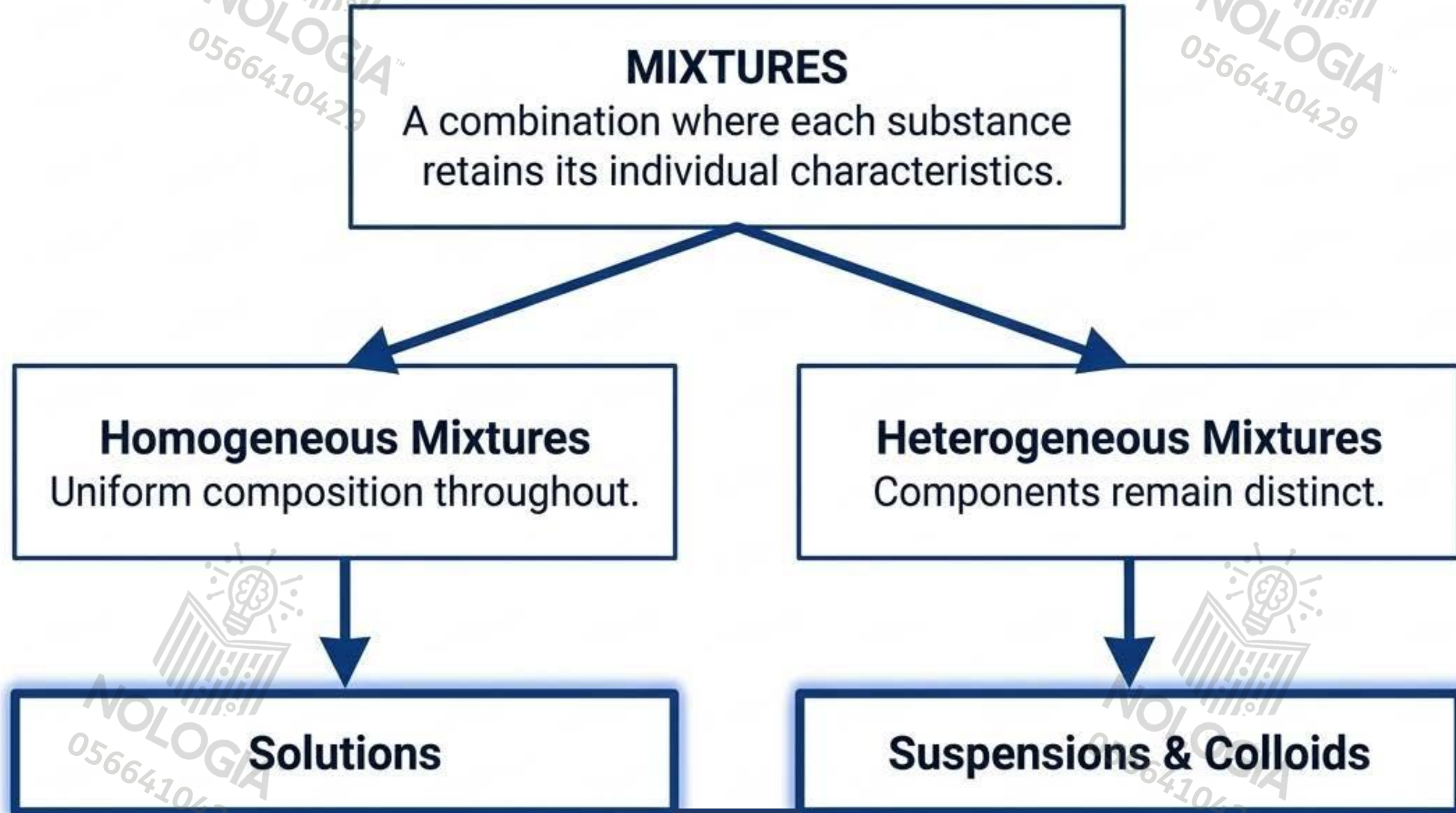


The Science: Liquid water becomes more dense as it cools to 4°C. However, ice is less dense than liquid water due to the rigid spacing of hydrogen bonds, which hold the water molecules further apart in a crystalline structure.

Biological Impact: This density anomaly allows nutrients to mix during spring/fall density changes, supporting aquatic ecosystems. Fish and other aquatic life survive winter because ice floats, insulating the liquid water beneath it from freezing solid.

Mixtures with Water: The NOLOGIA Taxonomy

NOLOGIA Study Series • 04 Mixtures



Homogeneous Mixtures: Solutions



Solvent

The substance in which another substance is dissolved (e.g., Water - the "Universal Solvent" due to its polarity).

Solute

The substance that is dissolved (e.g., Powder drink mix, salt).

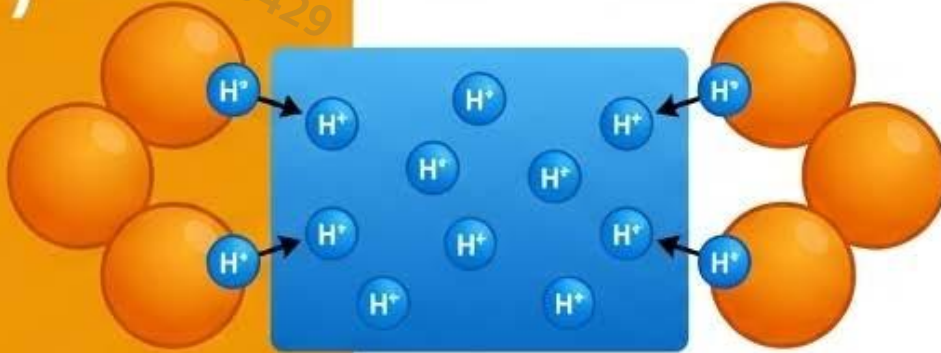
Biological Example: Saliva is a solution containing water, proteins, and salts that begins digestion.

Heterogeneous Mixtures: Suspensions vs. Colloids

Suspensions	Colloids
	
Definition: A mixture where particles settle out over time.	Definition: A mixture in which the particles do NOT settle out.
Example: Sand and water.	Example: Blood, milk, smoke, butter, ink.

The Chemistry of Acids and Bases

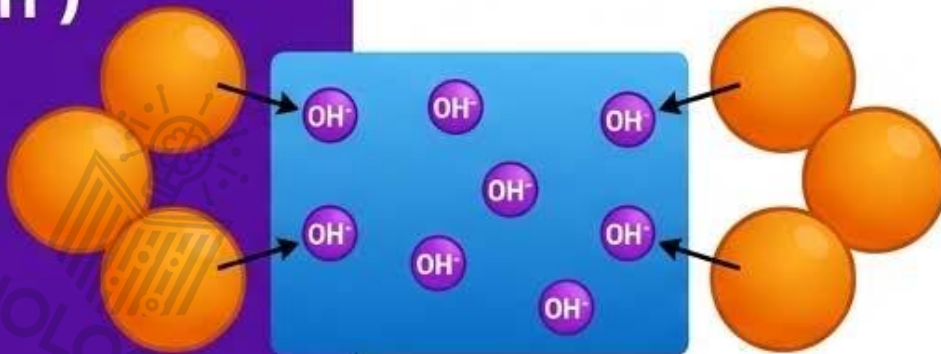
Acids (H^+)



Definition: Substances that release hydrogen ions (H^+) when dissolved in water.

Rule: The more H^+ released, the more acidic.
(**Example:** Gastric juices).

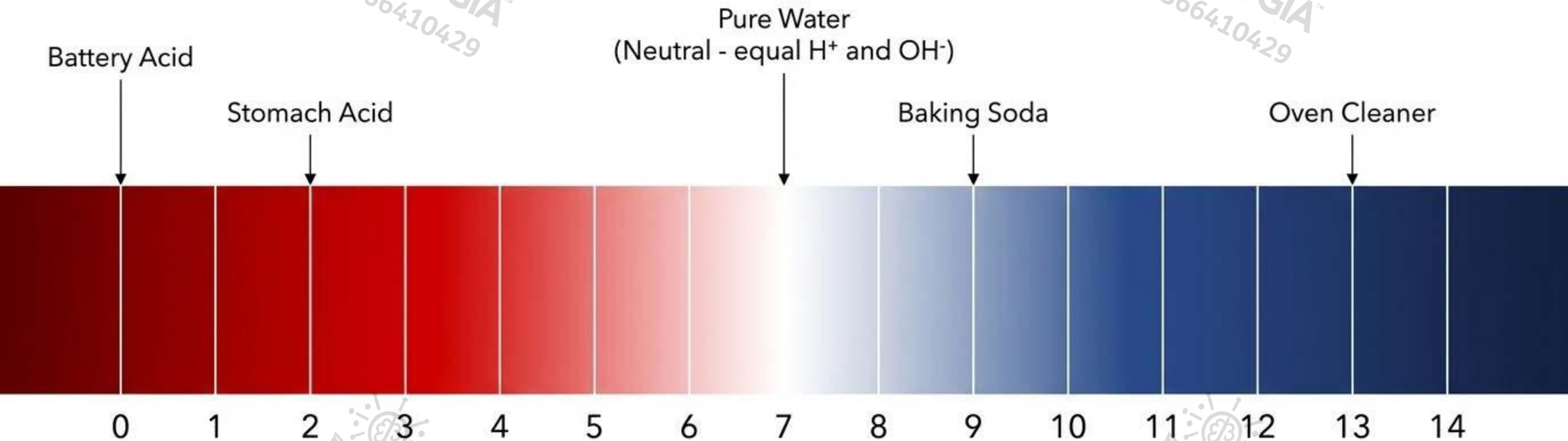
Bases (OH^-)



Definition: Substances that release hydroxide ions (OH^-) when dissolved in water.

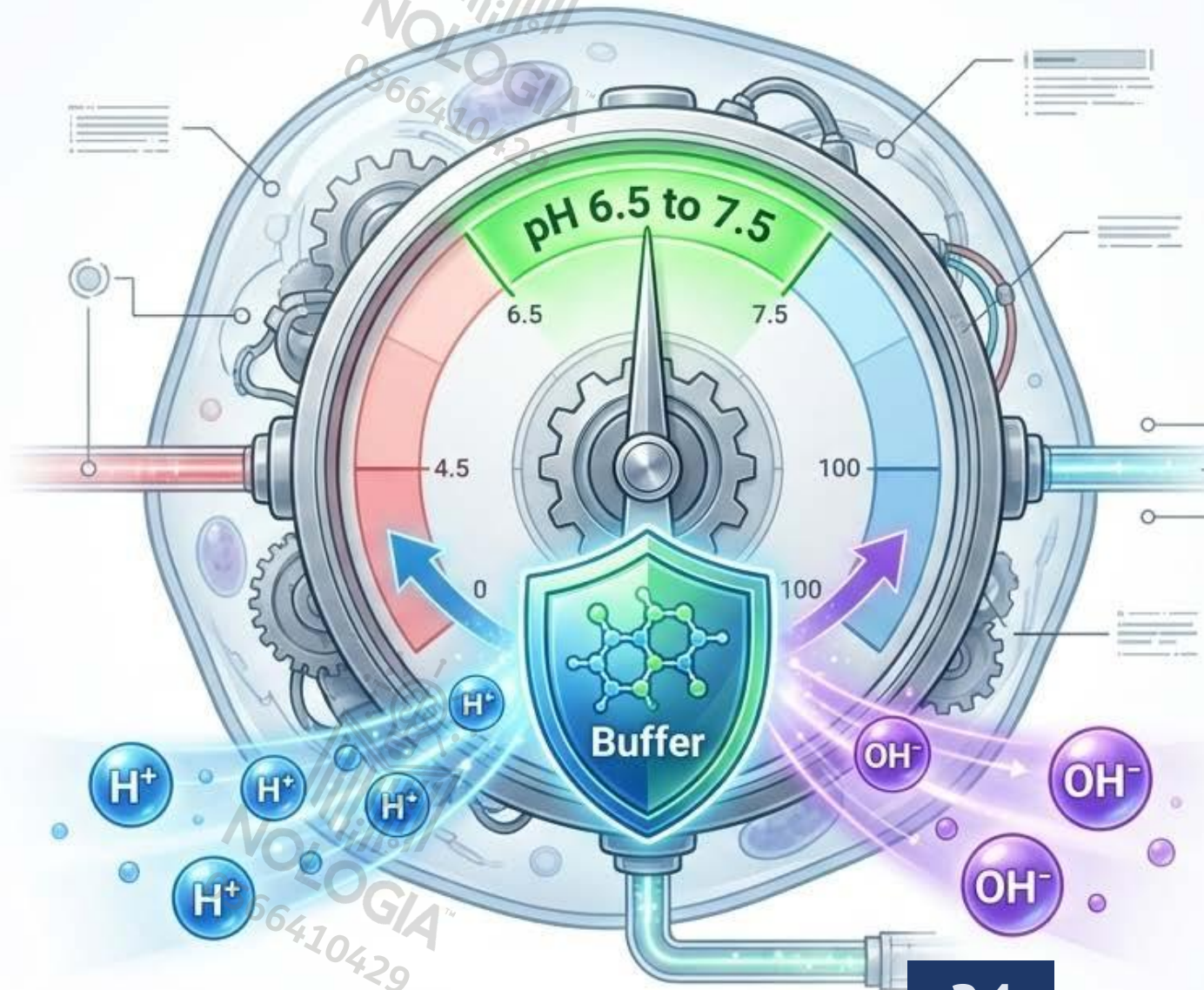
Rule: The more OH^- released, the more basic.
(**Example:** Sodium hydroxide - $NaOH$).

Measuring Concentration: The pH Scale



Key Concept: pH is the measure of concentration of H^+ in a solution.
Acidic = lower than 7. Basic = higher than 7.

Biology in Action: Buffers & Homeostasis



The Biological Rule:

Most cellular processes must occur between pH 6.5 and 7.5 to maintain homeostasis.

The Solution:

Buffers are mixtures that react with acids or bases to keep the pH within a particular range.

Real-world connection:

Taking an antacid to settle an upset stomach is introducing a buffer to control H^+ levels.

NOLOGIA Master Review Sheet

Forces & Properties	Mixtures & pH
Polarity: Unequal distribution of charges (e.g., Water's bent shape).	Solution: Homogeneous mixture (Solvent + Solute).
Van der Waals: Weak electrostatic attractions between molecules.	Suspension vs Colloid: Particles settle (sand) vs Particles do not settle (blood).
Hydrogen Bond: Strong van der Waals force connecting different polar molecules.	Acid vs Base: Releases H^+ ions vs Releases OH^- ions.
Cohesion / Adhesion: Water sticking to water (surface tension) / Water sticking to other surfaces (capillary action).	Buffer: Mixture that maintains pH homeostasis (keeps cells at 6.5-7.5).



Exam Preparation

1) Because water is a polar molecule, it has a unique structure that allows it to:

- A. Dissolve all nonpolar substances completely.
- B. Act effectively as a solvent for many solutes.
- C. Maintain a completely neutral pH of 14 at all times.
- D. Prevent homeostasis from occurring in organisms.

2) Which statement best describes a solution?

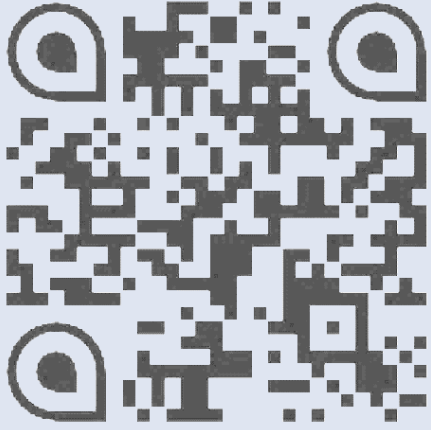
- A. A heterogeneous mixture where particles settle at the bottom over time.
- B. A chemical reaction that completely destroys the original atoms.
- C. A homogeneous mixture formed when a solute dissolves in a solvent.
- D. A pure substance that cannot be broken down by physical means.

3) How do acids and bases differ when they are dissolved in aqueous solutions?

- A. Acids release hydrogen ions H^+ , while bases release hydroxide ions OH^- .
- B. Acids release hydroxide ions OH^- , while bases release hydrogen ions H^+ .
- C. Both acids and bases release identical amounts of hydrogen ions H^+ .
- D. Neither acids nor bases alter the ion concentration of a solution.

4) What does the pH scale directly measure?

- A. The total volume of a solvent.
- B. The concentration of hydrogen ions H^+ in a solution.
- C. The rate at which a solute dissolves.
- D. The temperature changes during homeostatic regulation.



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Module (6): Chemistry in Biology

04

Fourth Lesson:

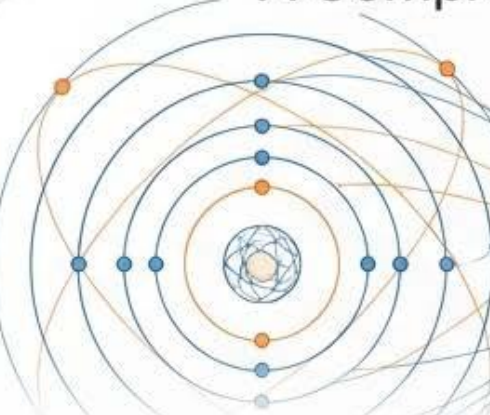
The Building Blocks of Life

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The Building Blocks of Life

A Comprehensive Visual Guide to Matter, Elements, and Chemical Bonds



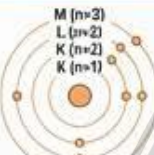
ATOMIC STRUCTURE & ENERGY

SUBATOMIC PARTICLES

- Proton (+)**
- Neutron (0)**
- Electron (-)**

Charger (+), (-)
Charges (+), (-)
Location in protons

ENERGY LEVELS



Quantized orbits;
Energy increases with
distance from nucleus.

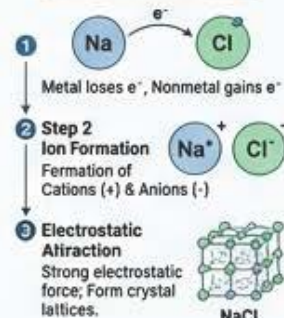
ISOTOPES



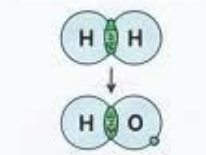
Carbon-12 Carbon-14
Same element, different
neutrons: Often radioactive
for dating & tracing.

CHEMICAL BONDS: THE FORCE OF ATTRACTION

IONIC BONDS

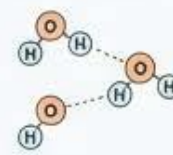


COVALENT BONDS



Sharing of electron pairs
between Nonmetals; Form
discrete molecules
(e.g., H_2O , DNA backbone).

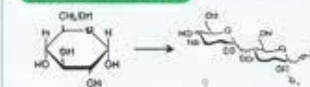
HYDROGEN BONDS



Weak attraction between $H^{\delta+}$ and
electronegative atom (O, N, F);
Crucial for DNA structure &
protein folding.

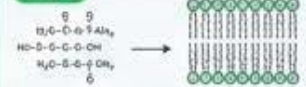
BIOLOGICAL MACROMOLECULES: BUILDING LIFE

CARBOHYDRATES



Sugars, Starches; Energy Storage,
Structural Support (e.g., Cellulose)

LIPIDS



Fats, Oils, Phospholipids;
Energy Storage, Cell Membranes
(e.g., Fats, Steroids)

PROTEINS



Amino Acids;
Catalysis (Enzymes),
Structure, Transport, Defense
(e.g., Hemoglobin)

NUCLEIC ACIDS



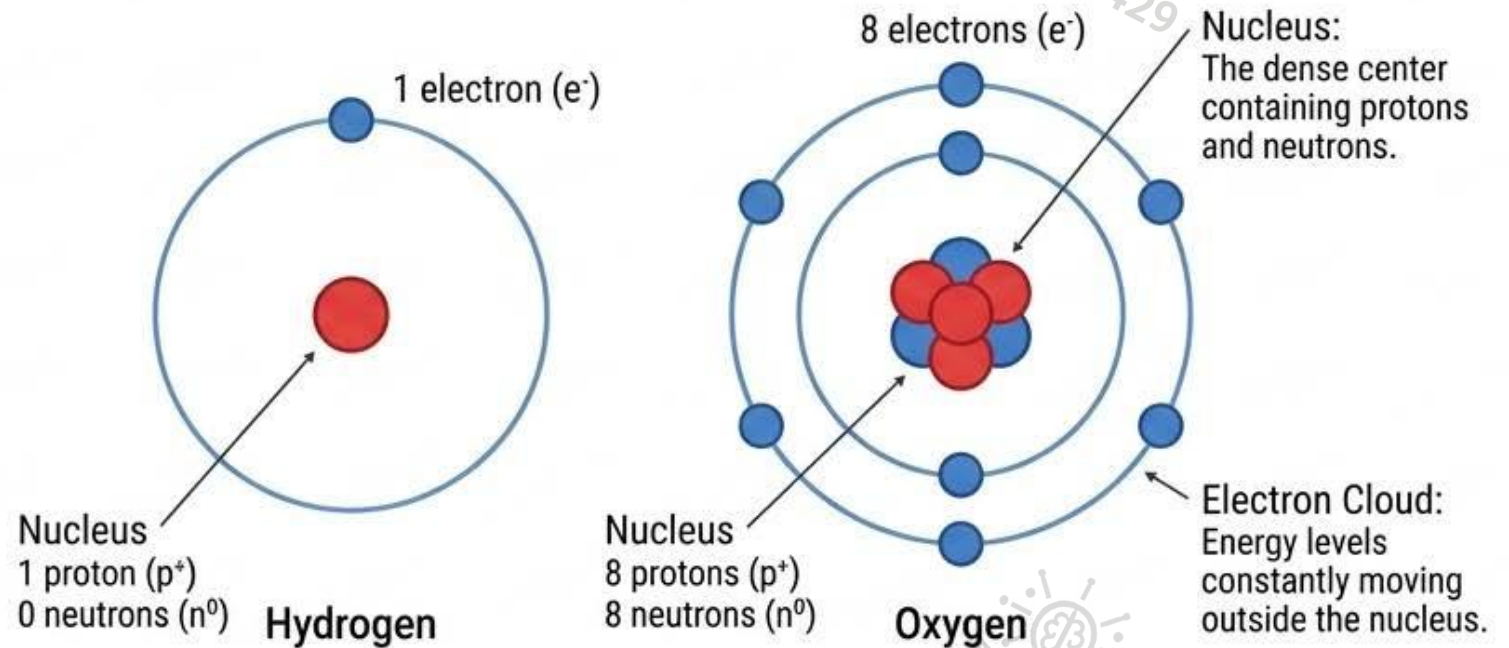
DNA, RNA;
Genetic Information Storage & Transfer
(e.g., Genes)

Matter: The Foundation of Biological Organisms

Chemistry is the study of matter—anything with mass that takes up space.

All living organisms are constructed from matter, and atoms are its fundamental building

blocks. An atom is so infinitesimally small that billions could fit on the head of a pin.



Core Principle: Atoms contain an equal number of protons (+) and electrons (-). The overall charge of a complete atom is exactly zero.

The Anatomy of an Atom: Subatomic Particles

Particle	Charge	Location	Mass / Role
 Proton	Positive (+1)	Inside the Nucleus	Determines atomic identity.
 Neutron	Neutral (0)	Inside the Nucleus	Contributes to atomic mass and stability.
 Electron	Negative (-1)	Outside the Nucleus (Energy Levels)	Constantly moving; directly involved in chemical bonding.

Elements: Pure Substances That Cannot Be Broken Down

An element is made of only one type of atom. Over 100 are known; 92 occur naturally.

The diagram shows a yellow square tile representing the element Hydrogen. The tile contains the following information:

- Atomic Number:** 1 (top left)
- Symbol:** H (center)
- Element Name:** Hydrogen (bottom center)
- Atomic Mass:** 1.008 (bottom right)

Labels with leader lines point to these values:

- Atomic Number:** Number of protons (points to 1)
- Symbol:** Chemical shorthand (points to H)
- Element Name:** Hydrogen (points to Hydrogen)
- Atomic Mass:** Average mass of the atom (points to 1.008)

Organization Rules:

- **Horizontal Rows** = Periods
- **Vertical Columns** = Groups (Elements in the same group share chemical properties)

Periodic Table of the Elements

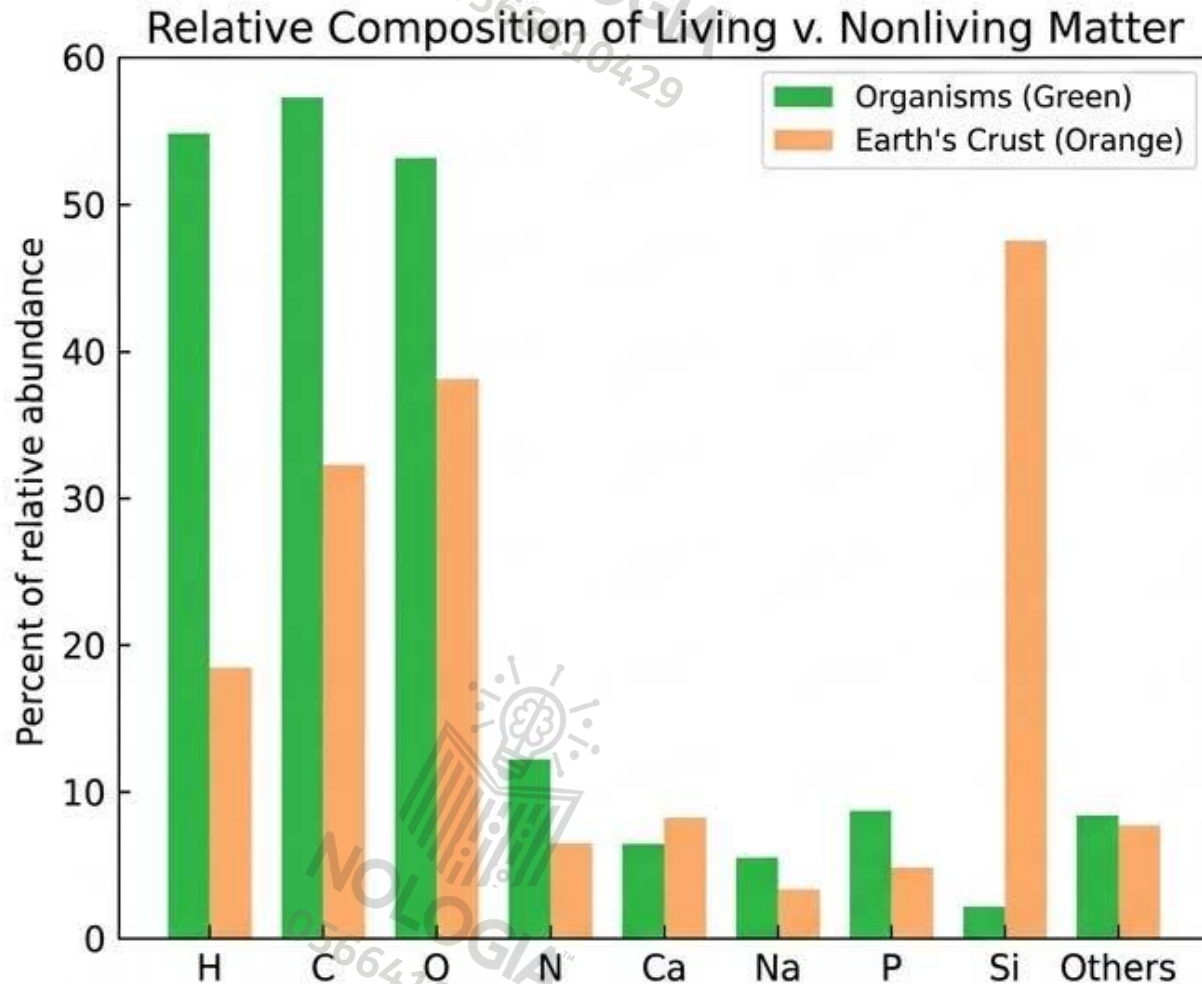
Periodic Table of the Elements																	
1 IA												16 VIA		17 VIIA			
1 H Hydrogen (1.008)	2 He Helium (4.003)											5 B Boron (10.81)	6 C Carbon (12.01)	7 N Nitrogen (14.01)	8 O Oxygen (15.99)	9 F Fluorine (18.99)	10 Ne Neon (20.18)
3 Li Lithium (6.94)	4 Be Beryllium (9.01)											13 Al Aluminum (26.98)	14 Si Silicon (28.09)	15 P Phosphorus (30.97)	16 S Sulfur (32.06)	17 Cl Chlorine (35.45)	18 Ar Argon (39.95)
11 Na Sodium (22.99)	12 Mg Magnesium (24.31)	3 IIIB	4 IIB	5 VB	6 VIB	7 VIIB	8 VIBS	9 VIBS	10 VIBS	11 IB	12 IIB						
19 K Potassium (39.10)	20 Ca Calcium (40.08)	21 Sc Scandium (44.96)	22 Ti Titanium (47.88)	23 V Vanadium (50.94)	24 Cr Chromium (52.00)	25 Mn Manganese (54.94)	26 Fe Iron (55.85)	27 Co Cobalt (58.93)	28 Ni Nickel (58.69)	29 Cu Copper (63.55)	30 Zn Zinc (65.38)	31 Ga Gallium (69.72)	32 Ge Germanium (72.64)	33 As Arsenic (74.92)	34 Se Selenium (78.96)	35 Br Bromine (79.90)	36 Kr Krypton (83.80)
37 Rb Rubidium (85.47)	38 Sr Strontium (87.62)	39 Y Yttrium (88.91)	40 Zr Zirconium (91.22)	41 Nb Niobium (92.91)	42 Mo Molybdenum (95.94)	43 Tc Technetium (98.91)	44 Ru Ruthenium (101.07)	45 Rh Rhodium (102.91)	46 Pd Palladium (106.36)	47 Ag Silver (107.87)	48 Cd Cadmium (112.41)	49 In Indium (114.82)	50 Sn Tin (118.71)	51 Sb Antimony (121.76)	52 Te Tellurium (127.60)	53 I Iodine (126.91)	54 Xe Xenon (131.29)
55 Cs Cesium (132.91)	56 Ba Barium (137.33)	73 Hf Hafnium (178.49)	74 Ta Tantalum (180.95)	75 W Tungsten (183.84)	76 Re Rhenium (186.21)	77 Os Osmium (190.23)	78 Ir Iridium (192.22)	79 Pt Platinum (195.08)	80 Au Gold (196.97)	81 Hg Mercury (200.59)	82 Tl Thallium (204.38)	83 Pb Lead (207.2)	84 Bi Bismuth (208.98)	85 Po Polonium (209)	86 At Astatine (210)	87 Rn Radon (222)	
87 Fr Francium (223)	88 Ra Radium (226)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (289)	118 Og Oganesson (294)	

Lanthanide

Actinide

87 La Lanthanum [57] 139.907 [57] 139.907	88 Ce Cerium [58] 140.12 [58] 140.12	89 Pr Praseodymium [59] 140.90765 [59] 140.90765	90 Nd Neodymium [60] 144.242 [60] 144.242	91 Pm Promethium [61] 144.9127 [61] 144.9127	92 Eu Europium [62] 151.964 [62] 151.964	93 Gd Gadolinium [63] 157.25 [63] 157.25	94 Tb Terbium [64] 158.92534 [64] 158.92534	95 Dy Dysprosium [65] 162.50015 [65] 162.50015	96 Ho Holmium [66] 164.93032 [66] 164.93032	97 Er Erbium [67] 167.2593 [67] 167.2593	98 Tm Thulium [68] 168.93274 [68] 168.93274	99 Yb Ytterbium [69] 173.05468 [69] 173.05468	100 Lu Lutetium [70] 174.967 [70] 174.967
90 Ac Actinium [89] 227.03373 [89] 227.03373	91 Th Thorium [90] 232.0377 [90] 232.0377	92 Pa Protactinium [91] 231.03626 [91] 231.03626	93 U Uranium [92] 238.02891 [92] 238.02891	94 Np Neptunium [93] 237.04817 [93] 237.04817	95 Pu Plutonium [94] 244.06422 [94] 244.06422	96 Cm Curium [96] 247.07643 [96] 247.07643	97 Bk Berkelium [97] 247.07125 [97] 247.07125	98 Cf Californium [98] 251.07958 [98] 251.07958	99 Es Einsteinium [99] 252.08321 [99] 252.08321	100 Fm Fermium [100] 257.10358 [100] 257.10358	101 Md Mendelevium [101] 258.10510 [101] 258.10510	102 No Nobelium [102] 259.10698 [102] 259.10698	103 Lr Lawrencium [103] 262.10782 [103] 262.10782

Elements in Biology vs. The Earth's Crust



Key Insight

While the same elements exist in both living and nonliving matter, biological organisms are overwhelmingly composed of three specific elements:

1
C
Carbon

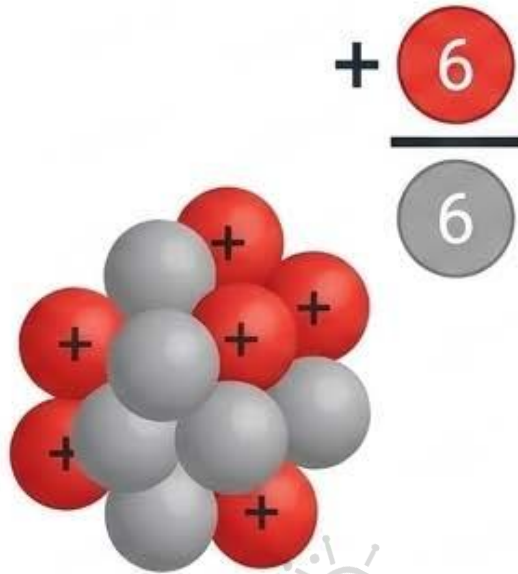
2
H
Hydrogen

3
O
Oxygen

Crosscutting Concept: Carbon is often called the "stuff of life" because it forms the structural backbone of all biological organisms.

Isotopes: Same Element, Different Number of Neutrons

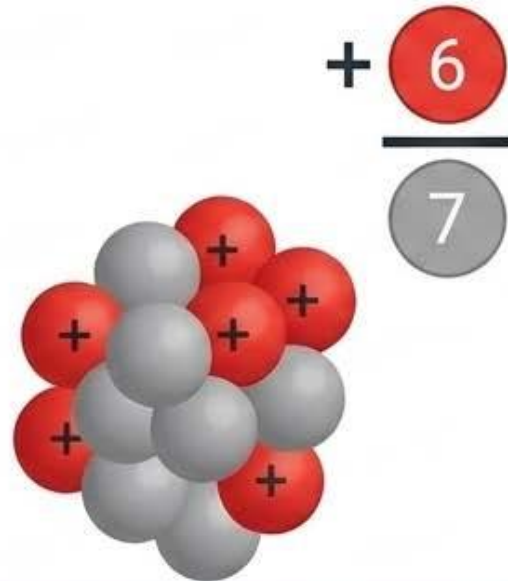
Atoms of the same element always have the same protons and electrons, but can have varying neutrons. They retain the **exact same chemical characteristics**.



Carbon-12

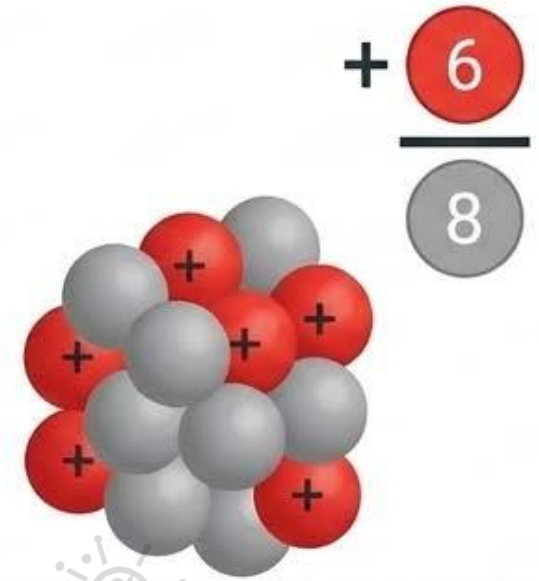
6 Protons (+) | 6 Neutrons (0)

Most abundant natural form.



Carbon-13

6 Protons (+) | 7 Neutrons (0)



Carbon-14

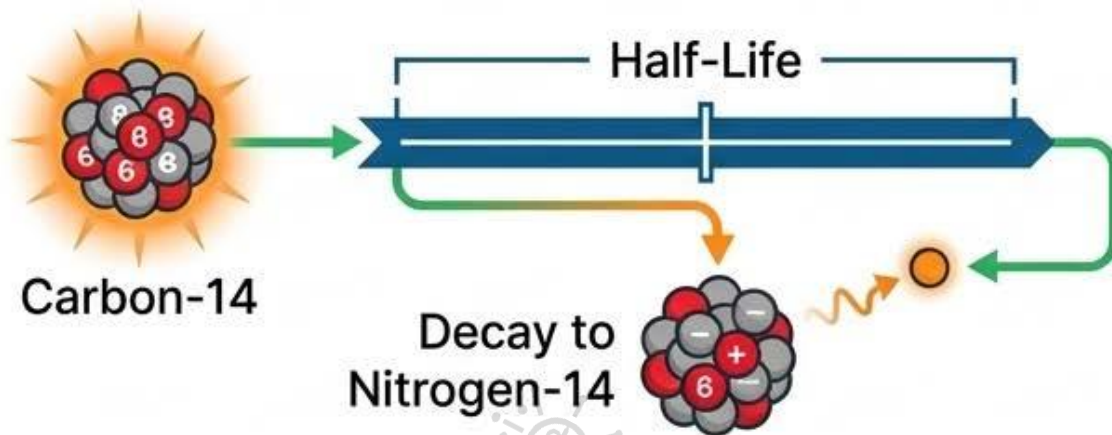
6 Protons (+) | 8 Neutrons (0)

Radioactive isotope.

Radioactive Isotopes: Decay and Application

Core Mechanism: Changing neutron count alters nucleus stability. Unstable nuclei break apart (**decay**), emitting detectable radiation.

Biological Dating



Scientists calculate the age of an object by measuring its half-life—the exact amount of time it takes for half of the Carbon-14 in a sample to decay.

Medical Diagnostics



Radioactive isotopes are tracked inside the human body to help doctors diagnose diseases, map neurological activity, and locate specific types of cancer.

Compounds: Elements Combining in Fixed Ratios

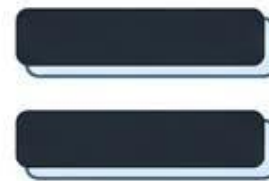
Definition: A pure substance formed when two or more different elements combine.



Sodium (Reactive Metal)



Chlorine (Toxic Gas)



Edible Table Salt, NaCl

NOLOGIA Blue

Rule 1: Fixed Ratios

Compounds always form in exact mathematical combinations. For example, Water is always exactly H_2O : two Hydrogen atoms, one Oxygen atom.

NOLOGIA Blue

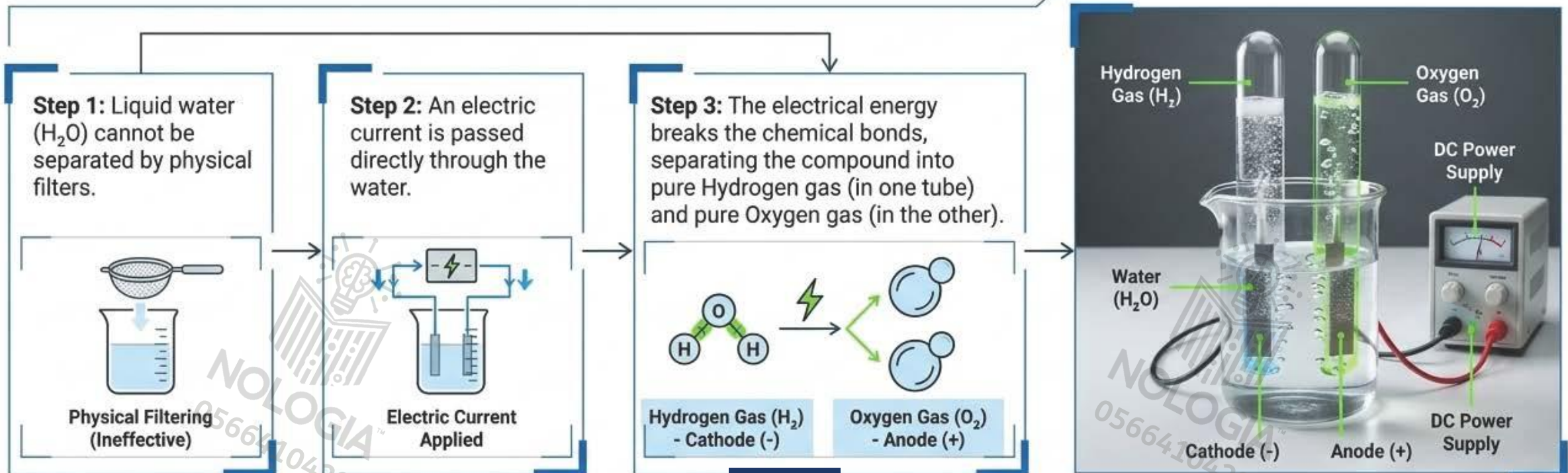
Rule 2: Unique Properties

Compounds are physically and chemically entirely different from the elements that comprise them. (e.g., Explosive Sodium + Toxic Chlorine = Edible Table Salt, NaCl).

Breaking Down Compounds Requires Chemical Means

The Rule: Compounds **CANNOT** be broken down by **physical means** (like **crushing or filtering**). They can only be dismantled by chemical processes.

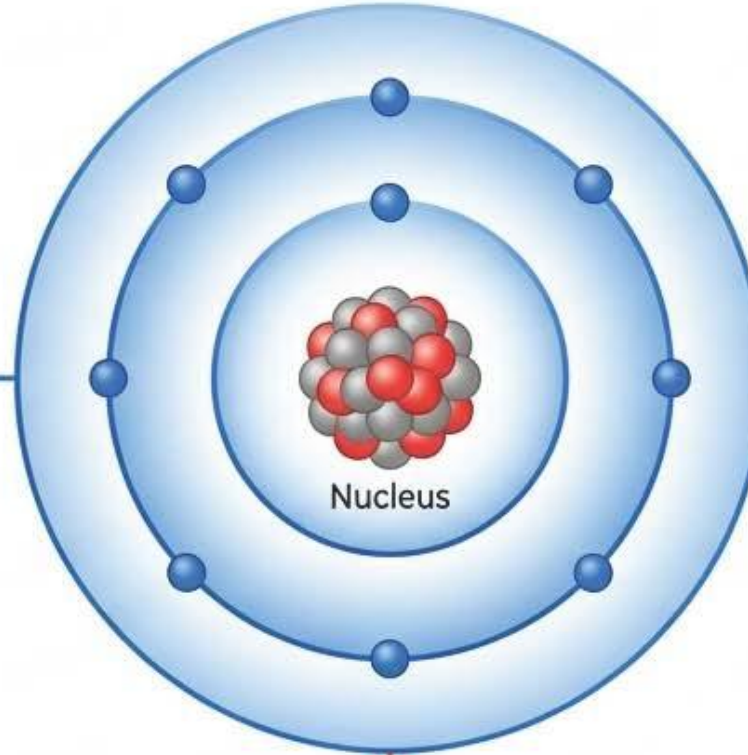
Case Study: Electrolysis of Water



Chemical Bonds: The Quest for Atomic Stability

The Role of Electrons

The force holding substances together is a chemical bond. Only electrons are directly involved in forming these chemical bonds.



The Capacity Rule

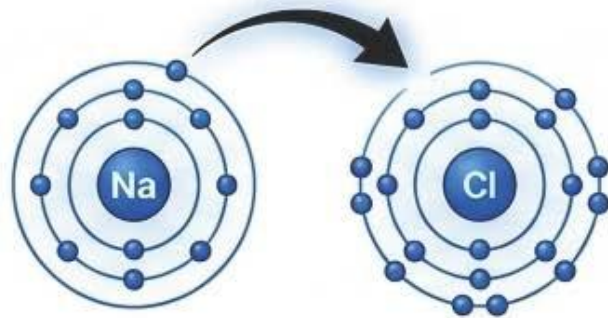
- **First Energy Level:** Closest to the nucleus, holds up to 2 electrons.
- **Second Energy Level:** Holds up to 8 electrons.

The Drive for Stability

A partially filled outer energy level is highly unstable. Atoms will lose, gain, or share electrons to completely empty or completely fill their outer levels. This fundamental drive to achieve stability is what forms all chemical bonds.

Ionic Bonds: The Transfer of Electrons

Step 1: The Donation

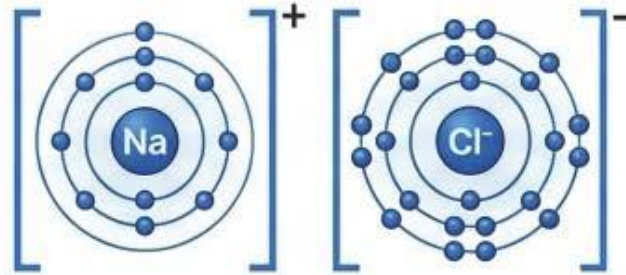


Sodium

Chlorine

Sodium (Na) has 1 electron in its outer level. It donates this electron to Chlorine (Cl), which needs exactly 1 to be full.

Step 2: Ion Formation

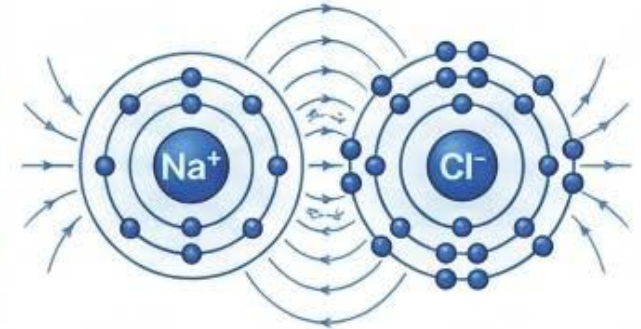


Na⁺ ion

Cl⁻ ion

Neutral atoms become charged ions. Sodium becomes a positive ion (Na⁺). Chlorine becomes a negative ion (Cl⁻). (Note: Metals donate; nonmetals accept).

Step 3: Magnetic Attraction



The oppositely charged ions attract each other electrically, locking together to form a highly stable Ionic Bond (NaCl).

Characteristics and Biological Roles of Ionic Compounds

Physical Properties



Most dissolve readily in water.



They are crystalline solids at room temperature.



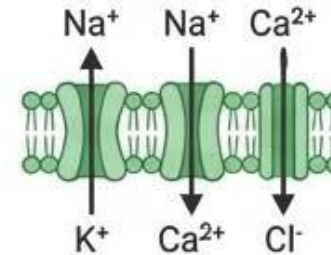
They possess generally higher melting points.



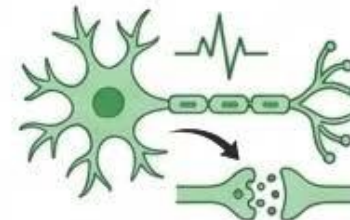
Earth Science Note

Ionic liquids are being developed as safe, eco-friendly solvents because they do not evaporate into the atmosphere.

Biological Importance



Ions (like Na^+ , K^+ , Ca^{2+} , Cl^-) travel in and out of cells to maintain homeostasis.

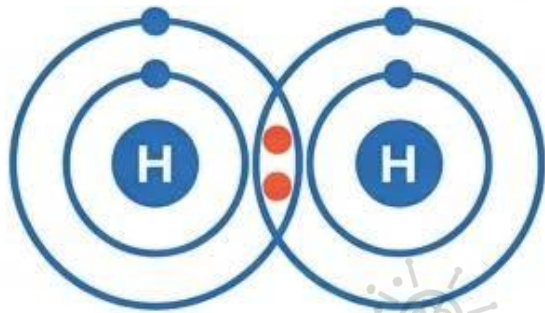


They are critical for transmitting electrical signals among cells, allowing you to see, taste, hear, feel, and smell.

Covalent Bonds: Forming Molecules Through Sharing

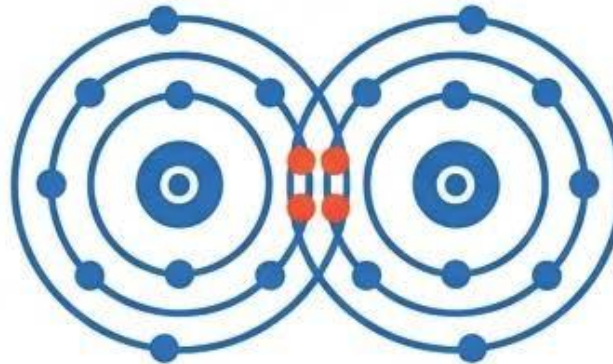
The Mechanism: Instead of transferring electrons, some atoms share pairs of electrons in **overlapping** outer energy levels. A compound held together by covalent bonds is called a molecule. These make up the vast majority of compounds in living organisms.

Single Bond (H_2)



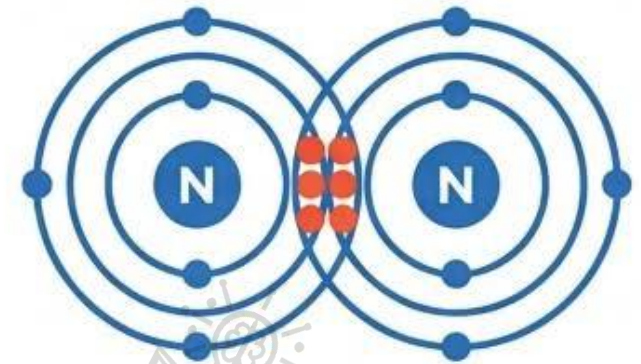
One pair of shared electrons.

Double Bond (O_2)



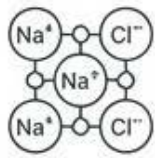
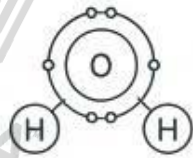
Two pairs of shared electrons.

Triple Bond (N_2)



Three pairs of shared electrons.

Master Review: Ionic vs. Covalent Bonds

	Ionic Bonds	Covalent Bonds
Mechanism	Electrons are transferred (donated/accepted).	Electrons are shared in overlapping outer levels.
Resulting Particles	Charged Ions (Positive and Negative).	Molecules (Neutral).
Binding Force	Electrical attraction between opposite charges.	Physical sharing of electron pairs.
Common Formation	Typically forms between Metals and Nonmetals.	Forms most compounds found in living organisms (Nonmetals).
Example	NaCl (Table Salt)  	H ₂ O (Water)  

Synthesis: The Chemical Architecture of Life

Biological Organisms

Complex living systems built primarily from C, H, O maintaining homeostasis via chemical interactions.

Compounds & Molecules

Elements bound via ionic or covalent bonds to achieve electron stability.

Elements & Isotopes

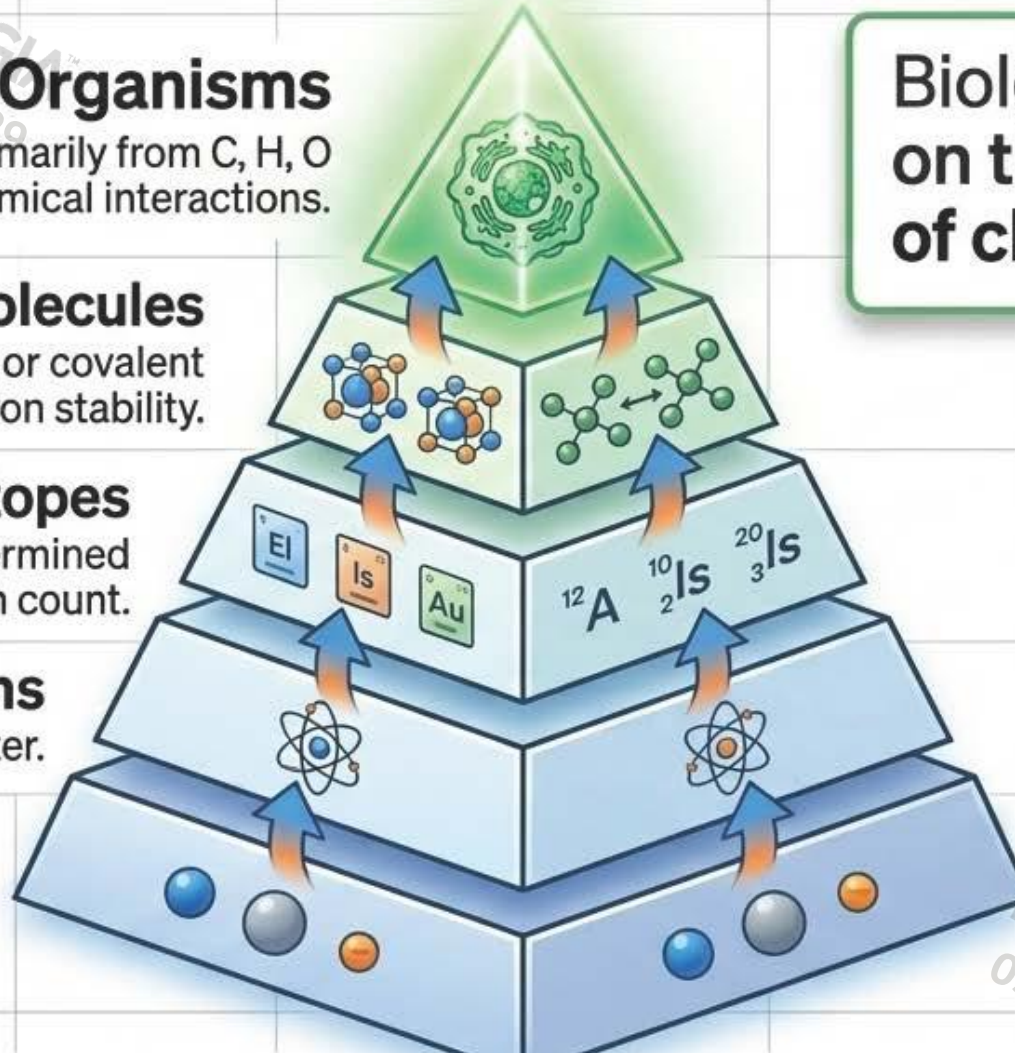
Pure substances determined strictly by proton count.

Atoms

The fundamental unit of matter.

Subatomic Particles

Protons, Neutrons, and Electrons construct the core.



Biology is built entirely on the rigorous rules of chemistry.



Exam Preparation

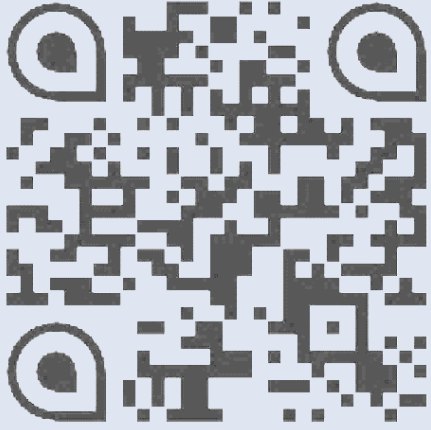
- 1) Which element serves as the primary building block for the organic compounds that make up living organisms?
 - A. Nitrogen.
 - B. Carbon.
 - C. Hydrogen.
 - D. Sodium.
- 2) Large biological macromolecules are typically formed by joining smaller organic units together into long chains known as:
 - A. Atoms.
 - B. Ions.
 - C. Polymers.
 - D. Elements.
- 3) What specific type of bond is responsible for joining amino acids together to form proteins?
 - A. Ionic bond.
 - B. Hydrogen bond.
 - C. Peptide bond.
 - D. Covalent bond.
- 4) A long chain composed of repeating nucleotide units forms which type of biological macromolecule?
 - A. Nucleic acid.
 - B. Carbohydrate.
 - C. Lipid.
 - D. Protein.

Module (7): Cellular Structure and Function

Lesson Title	Page
7-1 Cell Discovery and Theory	55
7-2 The Plasma Membrane	72
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7-4 Structures And Organelles	102

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Module (7): Cellular Structure and Function

01

First Lesson: Cell Discovery and Theory

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Cell Discovery and Theory

From the first microscopes to the foundational building blocks of life.

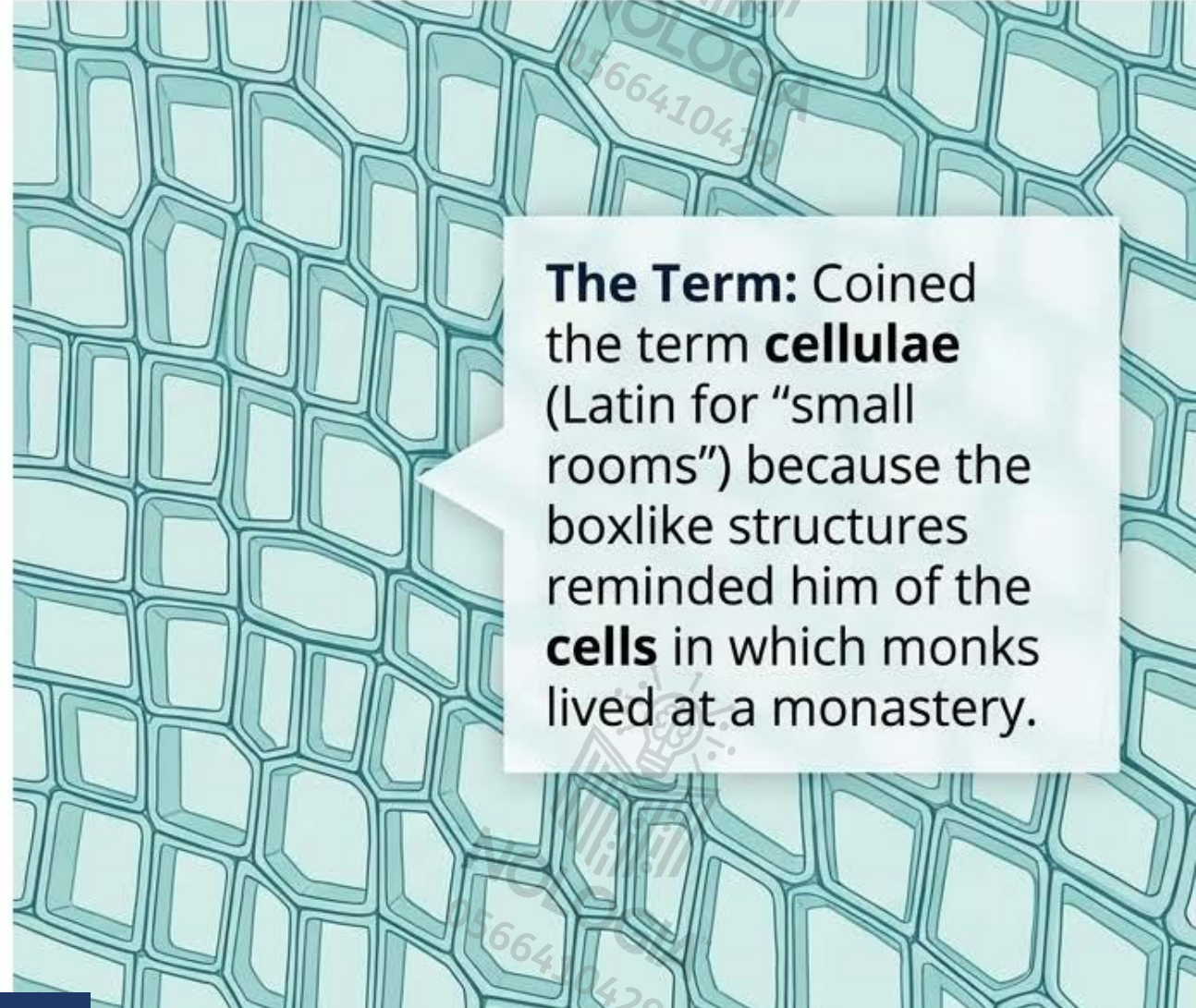


The NOLOGIA Lab Notebook



The Scientist: English scientist **Robert Hooke** (1665).

The Observation: Looked at dead **cells** of oak bark (cork).



The Term: Coined the term **cellulae** (Latin for "small rooms") because the boxlike structures reminded him of the **cells** in which monks lived at a monastery.



Timeline of Discovery: The Lens Crafters

1590 | The First Step

Dutch lens grinders **Hans & Zacharias Janssen** invent the first compound microscope by placing two lenses in a tube.

1665 | The Name

Robert Hooke observes cork, names the chambers "**cells**," and publishes *Micrographia*.

1683 | The Living World

Dutch biologist **Anton van Leeuwenhoek** discovers single-celled, animal-like organisms (now called **protozoans**) in pond water and milk.

Timeline of Discovery: The Theorists



1838 | The Botanist

German scientist **Matthias Schleiden** concludes that all plants are composed of **cells**.

1839 | The Zoologist

German scientist **Theodor Schwann** reports that animal tissues also consist of **individual cells**.



1855 | The Physician

Prussian physician **Rudolph Virchow** proposes that all cells are produced from the **division of existing cells**.



1939 | The Cell Surface

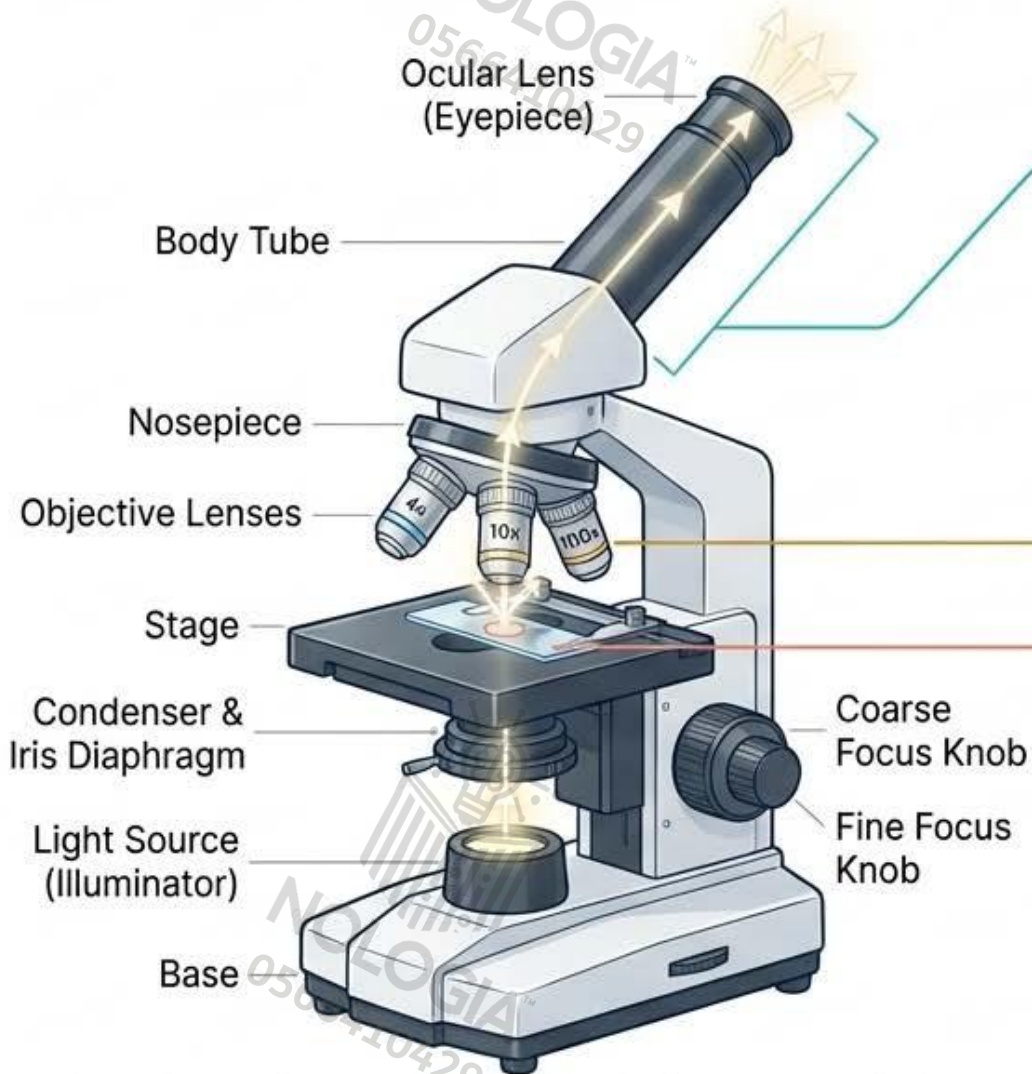
Ernest Everett Just writes the textbook ***Biology of the Cell Surface*** after years of studying cell structure and function.

All living organisms are composed of **one** or more **cells**.

Cells are the basic unit of **structure** and **organization** of all living organisms.

Cells arise only from **previously existing** cells, with cells passing copies of their **genetic material** on to their **daughter cells**.

Modern Microscope Technology: Optical



Mechanism:

Uses **visible light** and a series of **glass lenses** to magnify an object. (e.g., 10x objective lens × 10x ocular lens = 100x **magnification**).

Limitations:

Objects cause visible **light to scatter**, which **blurs images**. **Maximum magnification** without blurring is around 1000×.

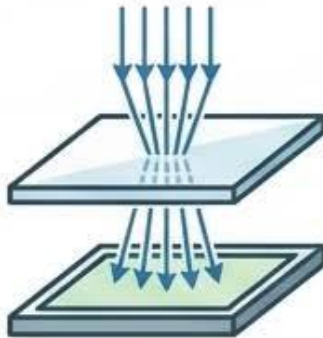
Preparation:

Because cells are **tiny, thin, and** translucent, scientists must often **stain the cells** to make individual components visible.

The Electron Leap: Non-Optical Microscopes

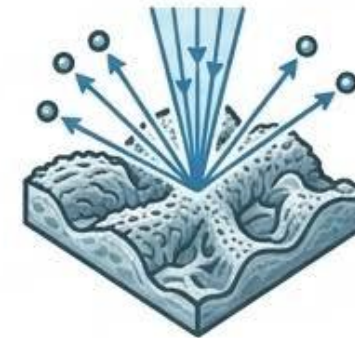
Developed in the **1930s** (Ernst Ruska).
Uses **magnets** to aim a beam of **electrons** instead of light lenses.

TEM (Transmission Electron Microscope)



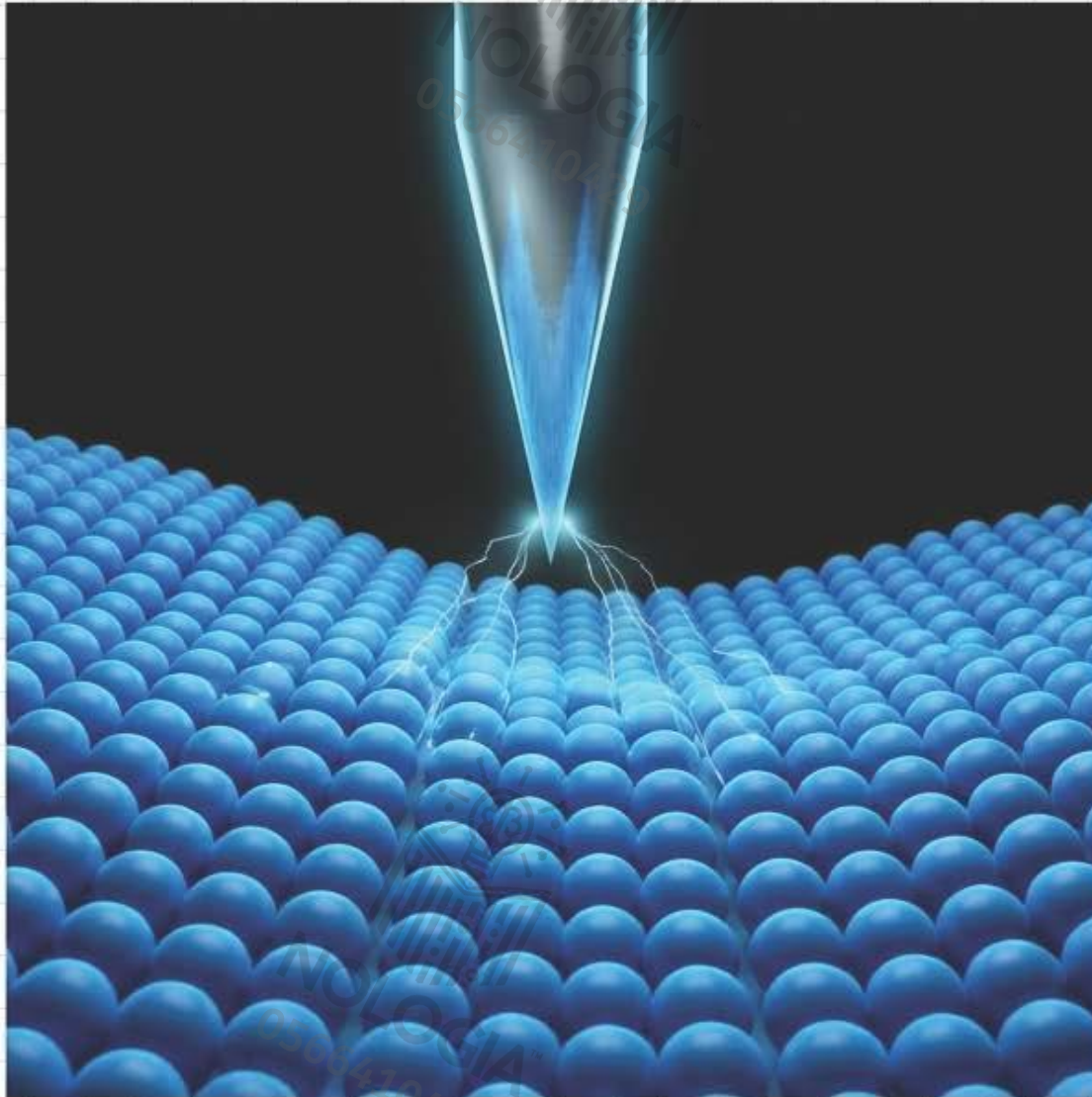
Action:	Electrons transmit through the specimen to a fluorescent screen.
Result:	Black-and-white, 2D shaded image. Up to 500,000× magnification.
Drawback:	Specimen must be dead, sliced incredibly thin, and stained with heavy metals.

SEM (Scanning Electron Microscope)



Action:	Directs electrons over the surface of the specimen.
Result:	Highly detailed, 3-dimensional images.
Drawback:	Only nonliving cells and tissues can be observed.

The Atomic Level: STM & 3-D SIM



STM (Scanning Tunneling Microscope) [1981]

Mechanism: Brings a **charged probe** extremely close to the specimen; **electrons "tunnel"** through the small gap.

Capability: Creates **3D computer images** of objects as small as **individual atoms**.

Advantage: Unlike TEM and SEM, STM can be used **with live specimens**.

3-D SIM [2008]

Three-dimensional **structured illumination microscopy**.

Combines a **3D view, high resolution, and multiple colors**.

NOLOGIA Synthesis: Microscope Diagnostic Table

Microscope Type	Illumination Source	Max Magnification	Image Output	Live Specimens?
Optical	Visible Light	~1,000×	2D	Yes (but staining often kills)
TEM	Electron Beam (Through)	~500,000×	2D (B&W)	No (Dead, thin, stained)
SEM	Electron Beam (Surface)	High	3D	No (Nonliving only)
STM	Electron Tunneling	Atomic Level	3D Computer	Yes



Basic Cell Types: Universal Traits

Central Concept: Despite immense diversity in shape, size, and function, all cells share common physical traits.



Trait 1: Plasma Membrane

A boundary that helps **control** what enters and leaves the cell. (Present in everything from skin cells to rattlesnake cells).

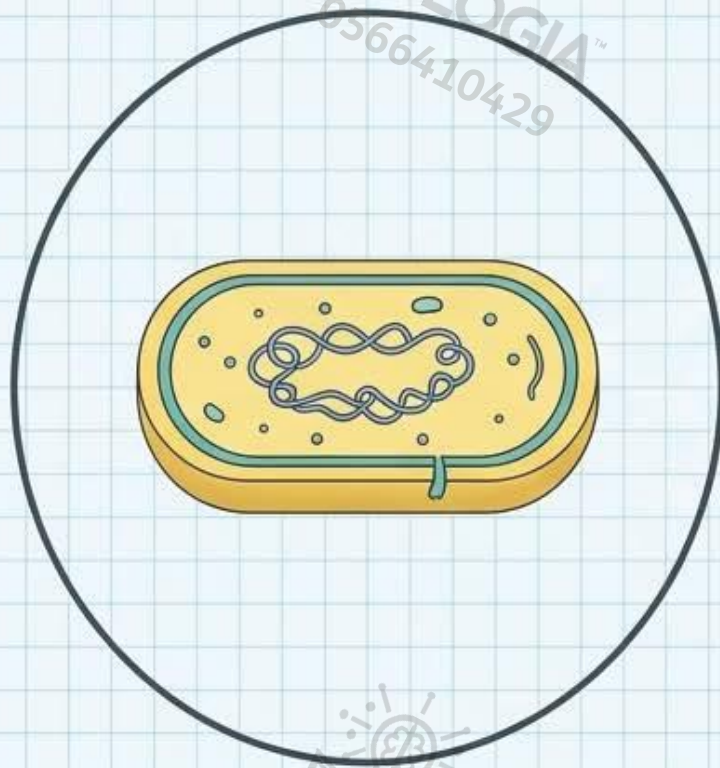
Trait 3: Energy Generation

The ability to **break down** molecules to generate necessary energy.

Trait 2: Genetic Material

Provides instructions for making the specific substances that the cell needs.

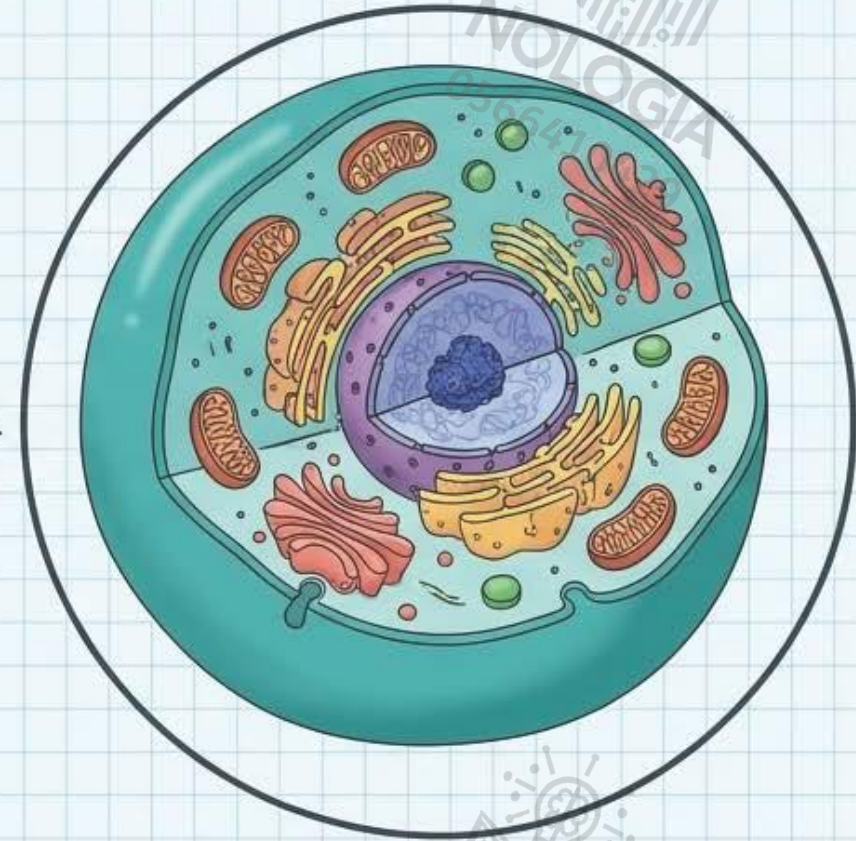
The Two Domains of Life



Prokaryotic Cells

Simpler, smaller base unit.

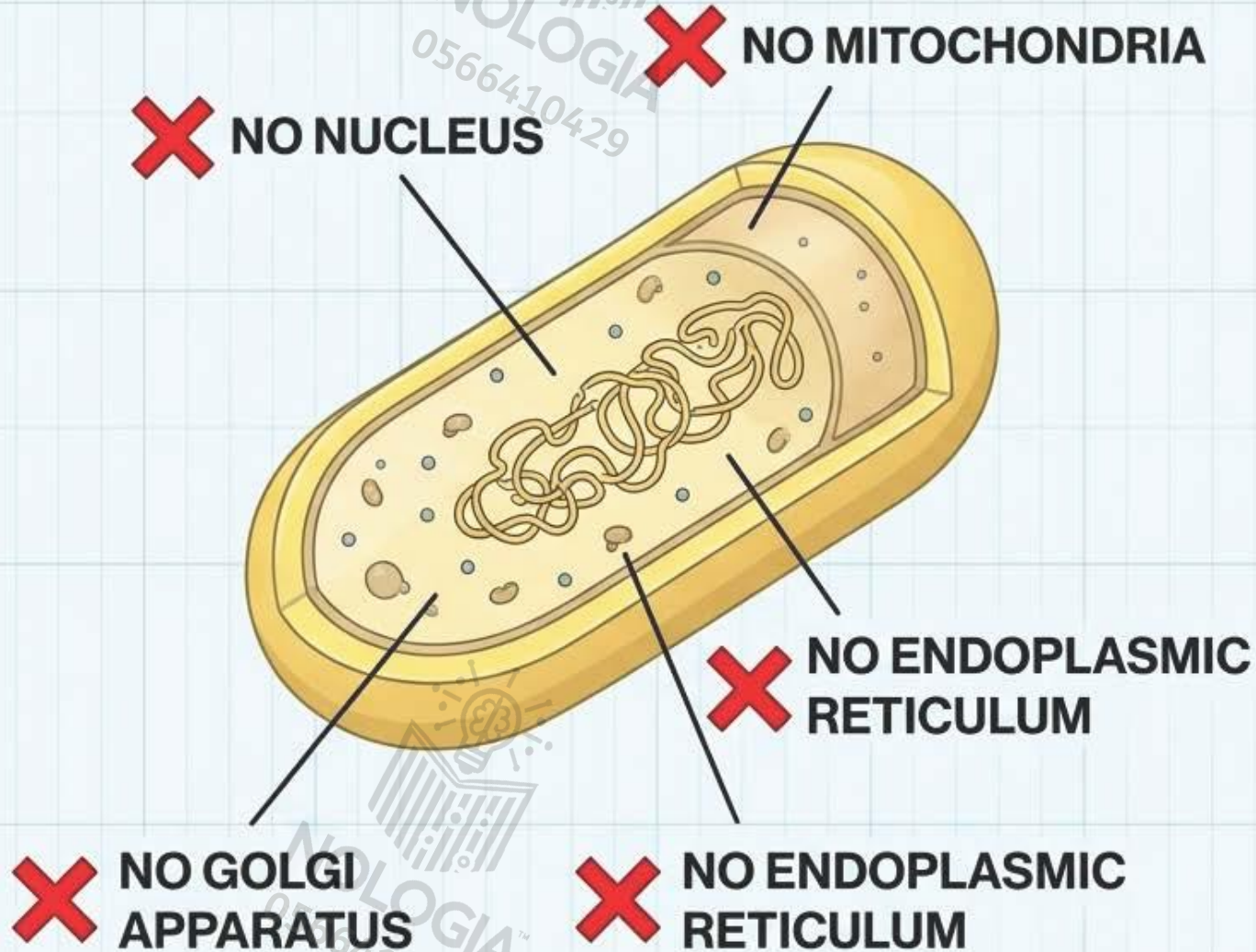
1-100×
Larger



Eukaryotic Cells

- Generally one to one hundred times (1-100×) larger.
- Contains distinct internal structures called **organelles** (specialized membrane-bound structures that carry out specific cell functions simultaneously).

Deep Dive: Prokaryotic Cells

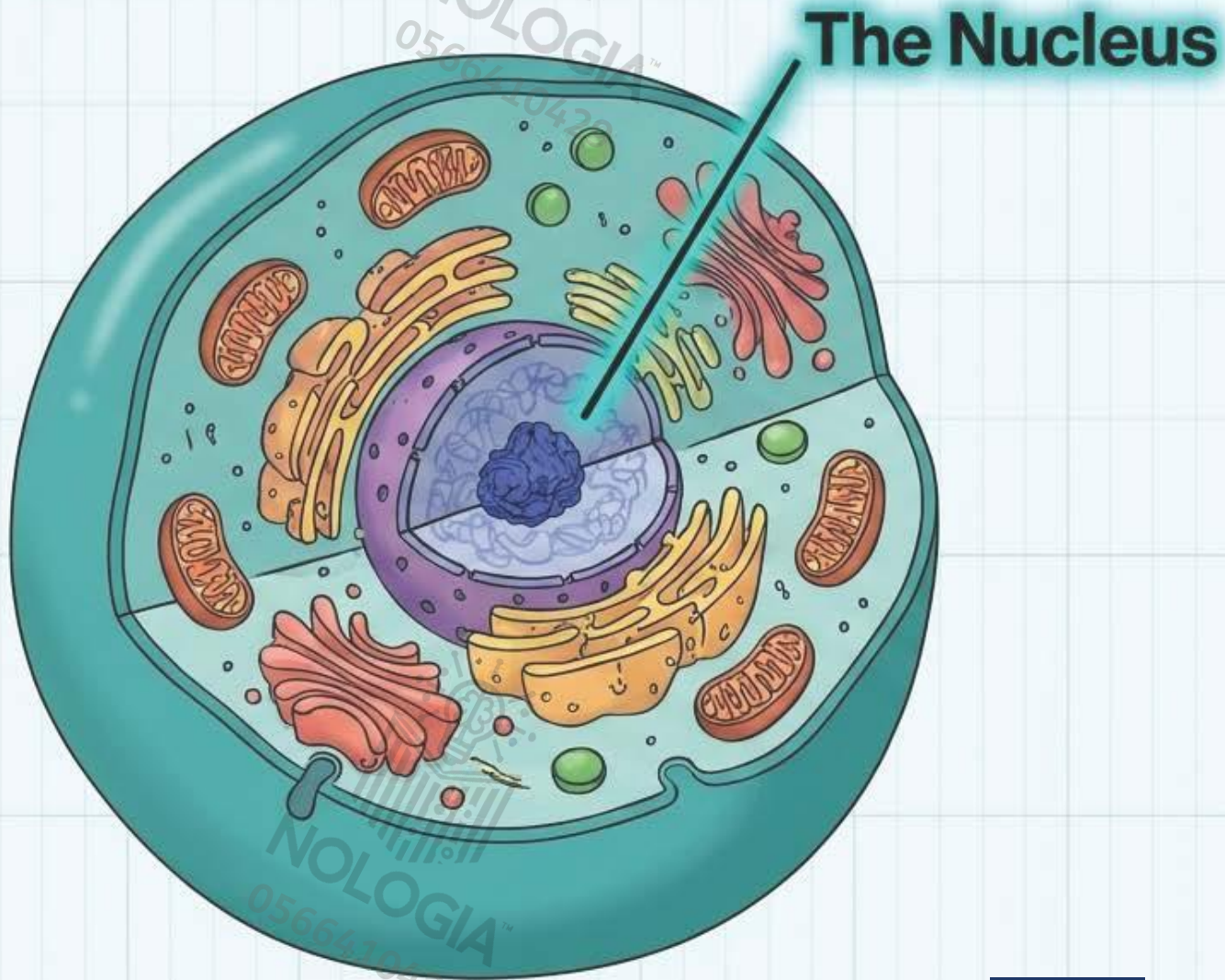


Definition: Cells defined by what they lack: they are **cells without a nucleus or other membrane-bound organelles.**

Organisms: Most **unicellular organisms**, such as **bacteria**, are prokaryotes.

Evolutionary Context: They are **simpler** than eukaryotic cells. Many scientists believe prokaryotes are similar to the very **first organisms** that lived on Earth.

Deep Dive: Eukaryotic Cells



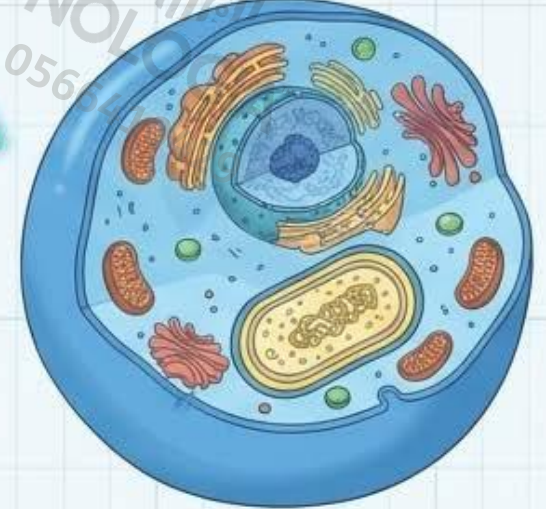
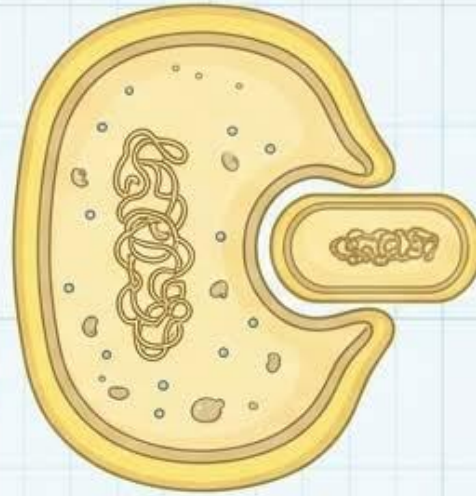
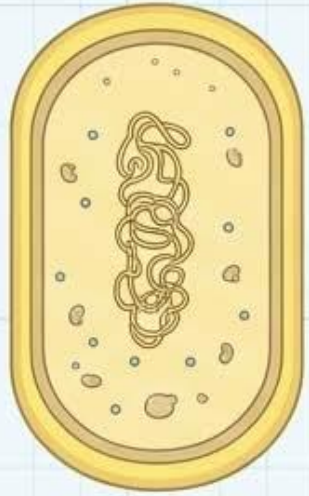
The Nucleus

Definition: Cells defined by what they possess: they contain a **nucleus** and other **organelles** bound by membranes.

The Nucleus: A central **organelle** that acts as the **vault**, containing the cell's genetic material in the form of **DNA**.

Organisms: **Multicellular** organisms (all **plants** and **animals**) are eukaryotes. Some **unicellular** organisms, such as certain **yeasts**, are also eukaryotes.

Origin of Cell Diversity: Endosymbiont Theory



Step 1: Separate simple cells.

Step 2: Symbiosis (Engulfment).

Step 3: Organelle evolution.

The Question: How did complex **eukaryotic cells** evolve from simple **prokaryotes** millions of years ago?

The Theory: Proposes a **symbiotic relationship** where one **prokaryotic cell** lived inside another.

The Result: Both cells benefited. This relationship led to the development of specific **organelles**, vastly increased **cell diversity**, and ultimately allowed for **complex life-forms**.

NOLOGIA Study Summary: Key Takeaways



The Spark: The invention of **microscopes** (Hooke, Leeuwenhoek) directly led to the **discovery of cells**.



The Law: Cell Theory dictates that all life is made of cells, they are the **basic unit of structure**, and they only come from existing cells.



The Tools: Electron Microscopes (TEM/SEM) offer **massive magnification** for dead/nonliving specimens, while **STM** allows atomic-level 3D imaging of live specimens.



The Divide: Prokaryotic cells (like bacteria) are small and **lack a nucleus**. **Eukaryotic cells** are much larger and contain a **nucleus** and specialized **organelles**.



The Origin: Complex **eukaryotic cells** likely evolved from a **symbiotic relationship** between simple **prokaryotes** (Endosymbiont Theory).



Exam Preparation

1) Which technological invention directly enabled scientists to discover and study cells?

- A. Telescope.
- B. Spectrometer.
- C. Microscope.
- D. Centrifuge.

2) The core framework of cell biology that summarizes the fundamental principles of cellular life is known as the:

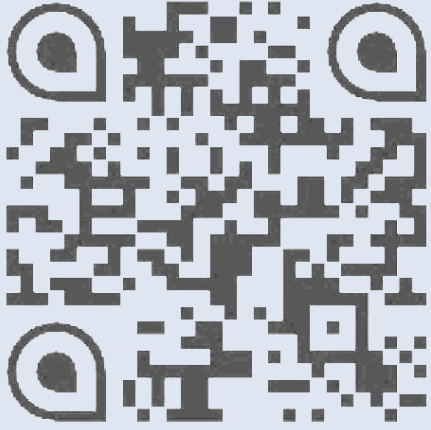
- A. Law of segregation.
- B. Cell theory.
- C. Theory of evolution.
- D. Gene-chromosome theory.

3) Living organisms can be broadly classified into two major groups based on cell structure: prokaryotic cells and eukaryotic cells. Which of the following is a primary characteristic used to distinguish between them?

- A. The presence of a cell wall.
- B. The presence of a membrane-bound nucleus.
- C. The ability to reproduce.
- D. The presence of cytoplasm.

4) If a microscope uses a combination of two lenses to reach an overall magnification of 30x, and one of the lenses has a magnification of 5x, what is the magnification of the second lens?

- A. 6x
- B. 15x
- C. 25x
- D. 150x.



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Module (7): Cellular Structure and Function

02

Second Lesson: The Plasma Membrane



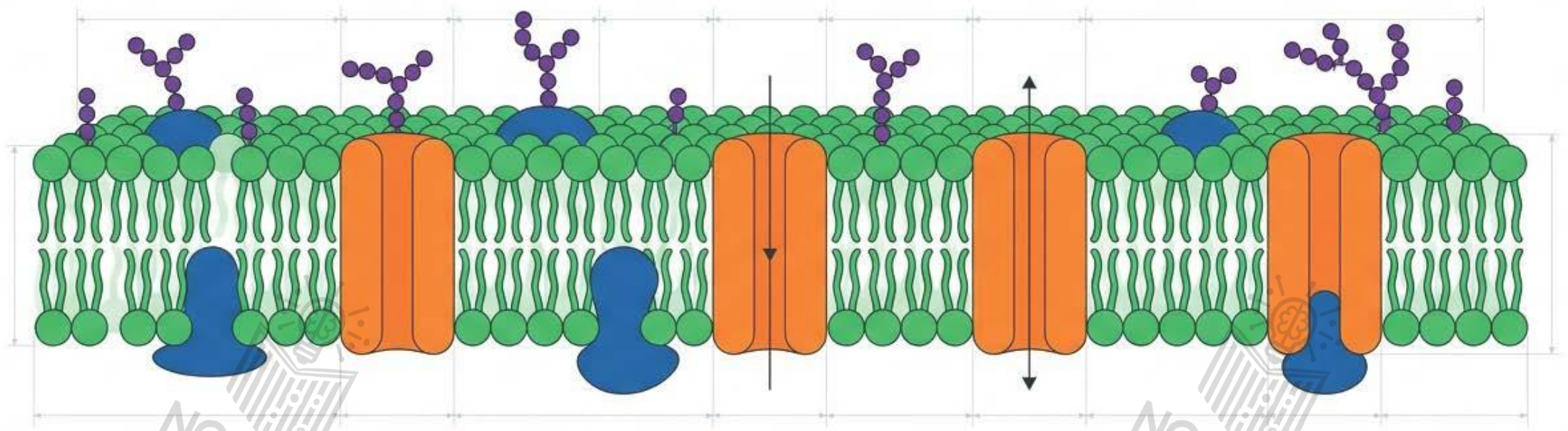
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NOLOGIA

The Plasma Membrane

The Ultimate Biological Boundary

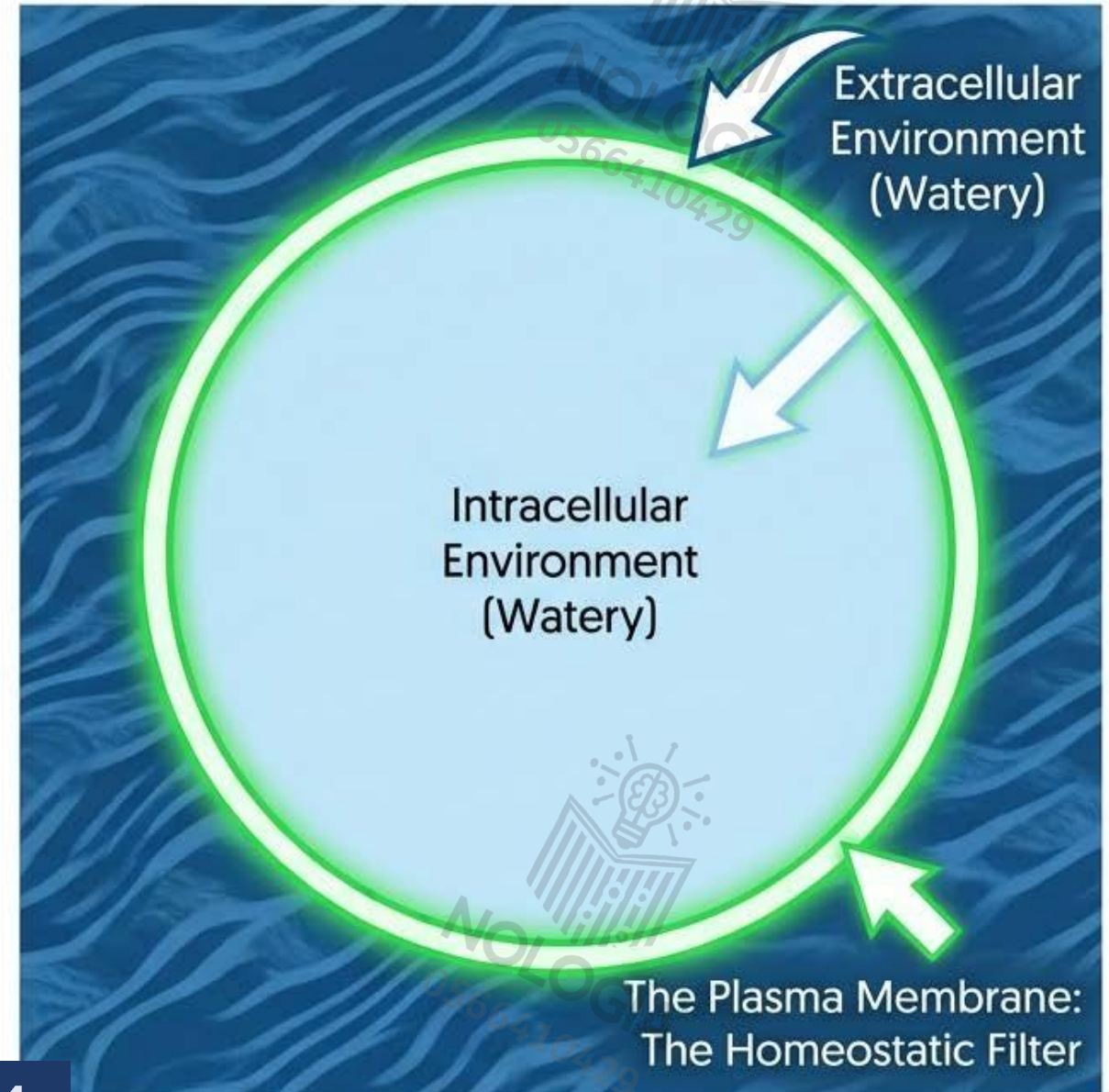


The Universal Boundary

- All cells (prokaryotic and eukaryotic) require a thin, flexible boundary separating them from their watery environments.

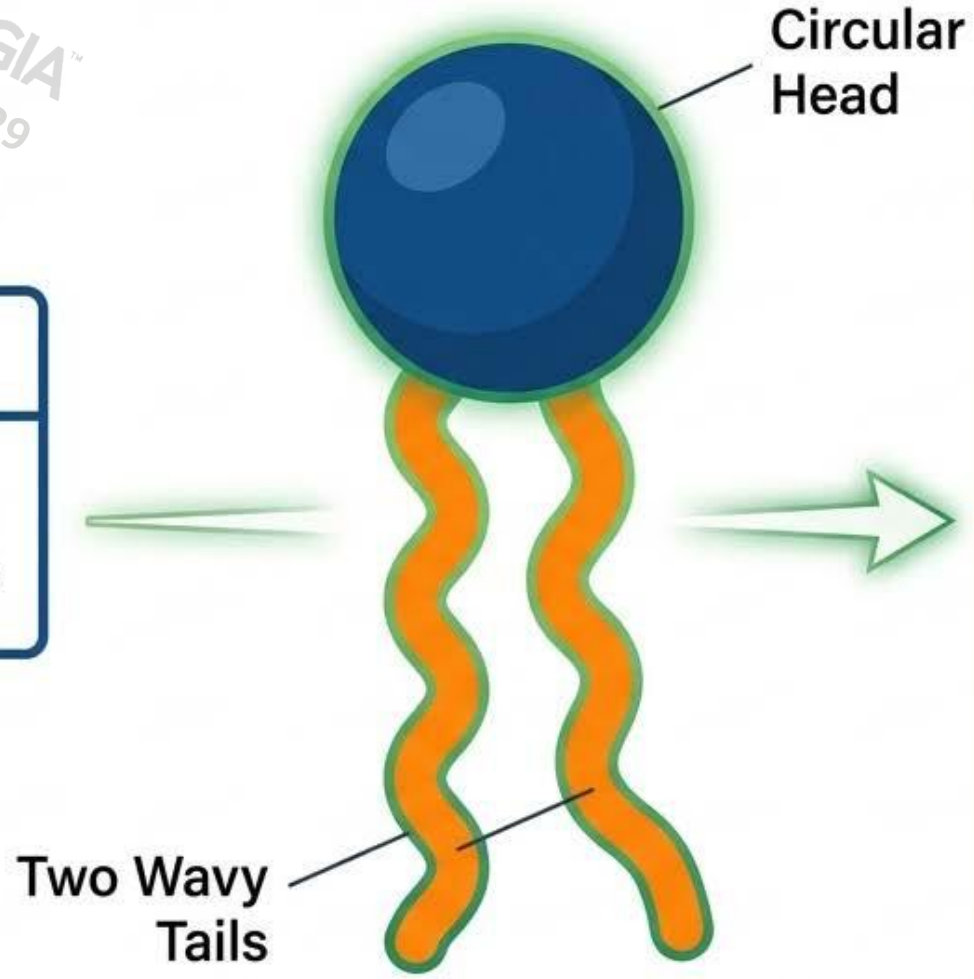
Core Function: Homeostasis

The process of maintaining balance in an organism's internal environment. Essential for survival.



The Base Lipid

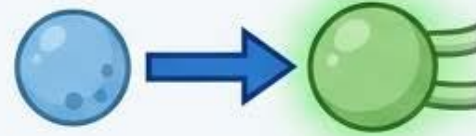
Normal lipids =
Glycerol + 3 Fatty Acids



The Phospholipid Transformation

- A Phosphate Group replaces one fatty acid.
- Phospholipid =
Glycerol Backbone +
2 Fatty Acid Chains +
1 Phosphate-containing group.

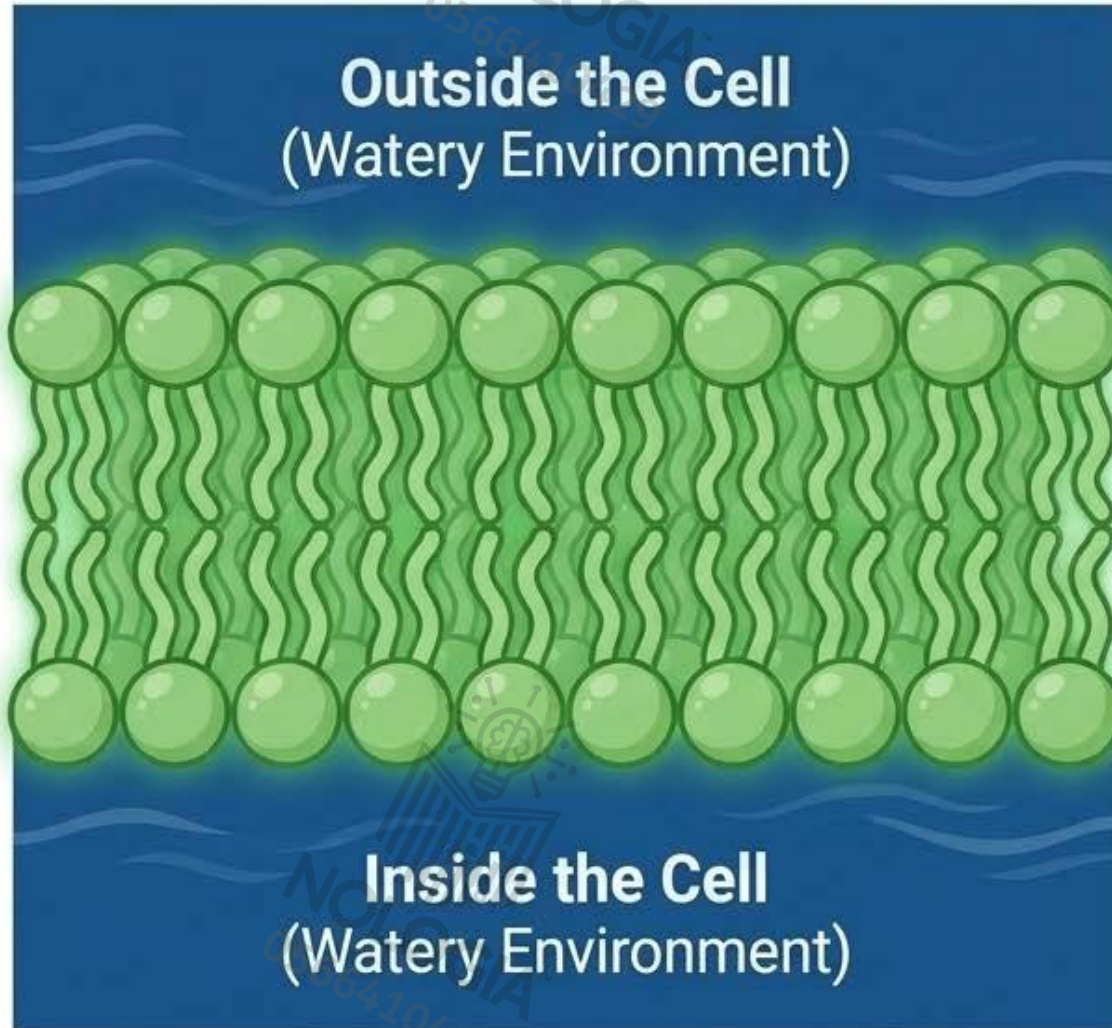
NOLOGIA | Chemical Blueprint: Polarity Matrix



Feature	The Phosphate Head	The Fatty Acid Tails
Polarity	Polar (Positively & negatively charged ends)	Nonpolar
Water Affinity	Attracted to water	Repelled by water
Position in Membrane	Faces outward (toward watery environments)	Faces inward (hiding from water)

⚠ Science vs. Common Usage: In science, 'polar' means having completely opposite charged ends (like magnets), not relating to the Earth's North/South poles.

NOLOGIA | Structural Design: The Phospholipid Bilayer



1

The Threat

Water exists both inside and outside the cell.

2

The Solution

Two layers of phospholipids arrange themselves tail-to-tail.

3

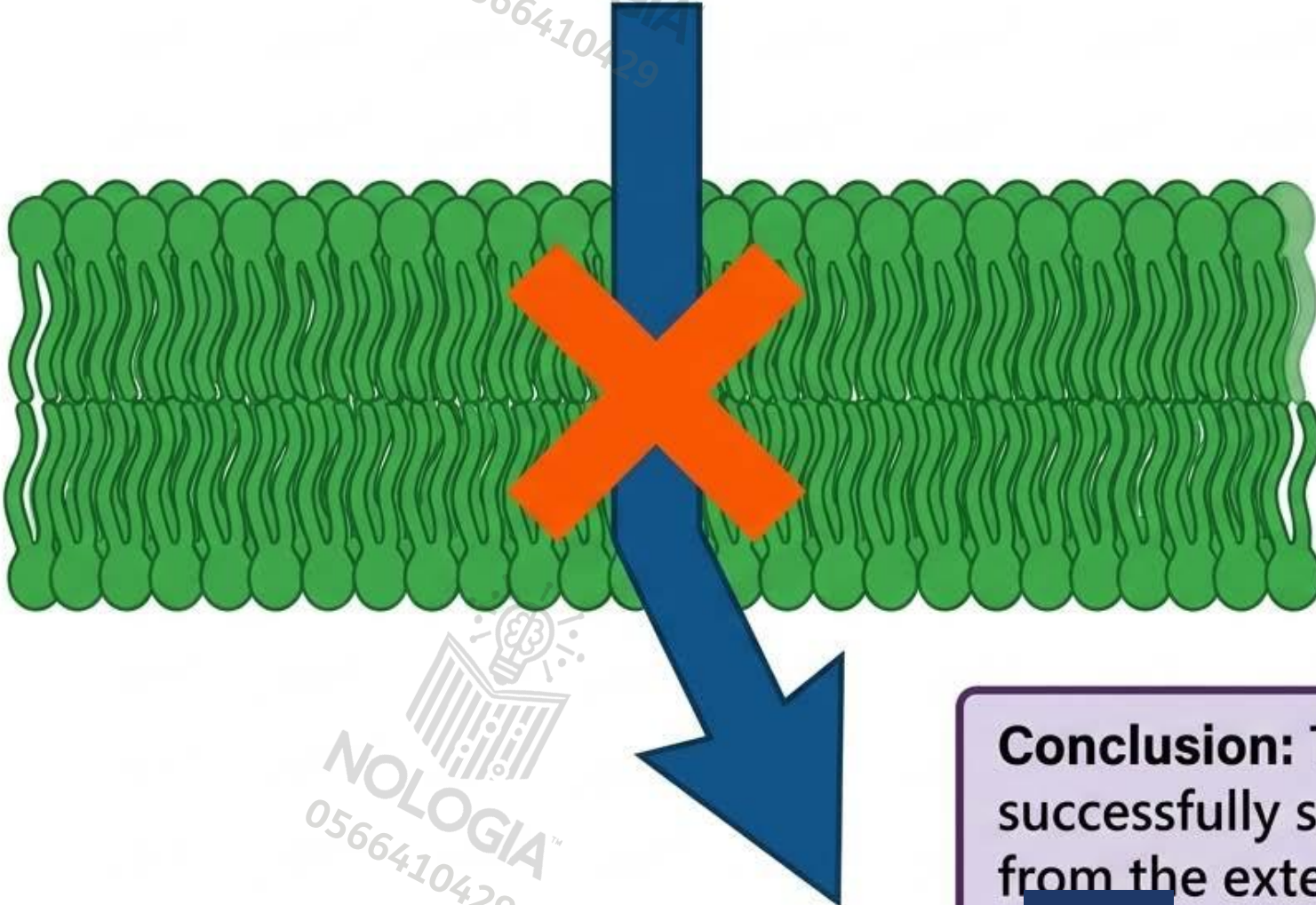
The "Sandwich" Effect

The polar heads form the "bread" (closest to water molecules).

The nonpolar tails form the "filling" (farthest away from water).

NOLOGIA | The Barrier Effect

Water-Soluble Substances



- The surfaces are polar.
- The middle is strictly nonpolar.
- Water-soluble substances cannot move easily through the nonpolar middle; they are stopped.

Conclusion: This specific chemical barrier successfully separates the internal environment from the external environment.

NOLOGIA | System Components: The Complete Matrix

Phospholipids



Basic barrier structure.

Proteins



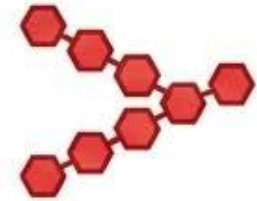
Signals, support, and selective transport tunnels.

Cholesterol



Prevents sticking; maintains fluidity.

Carbohydrates



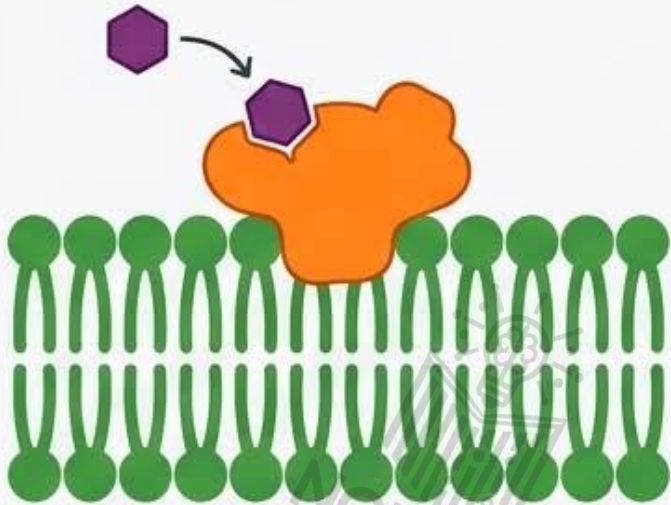
Cell identification and chemical signaling.

Note: Moving with and among the phospholipids are cholesterol, proteins, and carbohydrates.

NOLOGIA | Deep Dive: Membrane Proteins

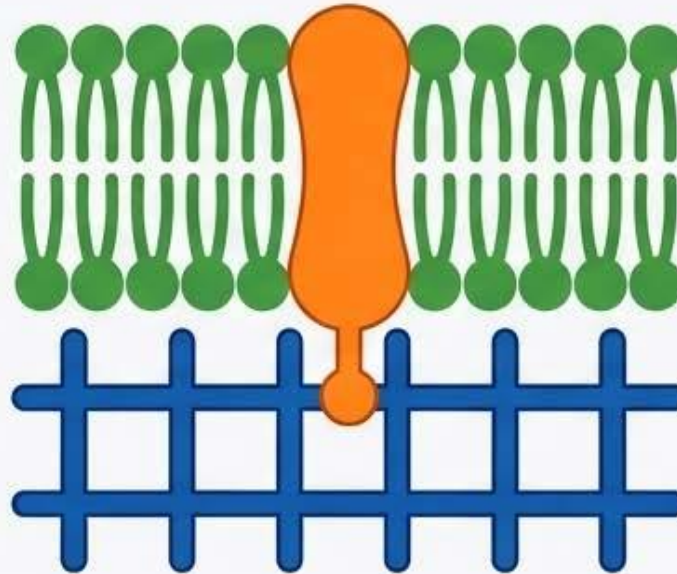
Receptor Proteins

- **Location:** Outer surface.
- **Function:** Transmit signals to the inside of the cell.



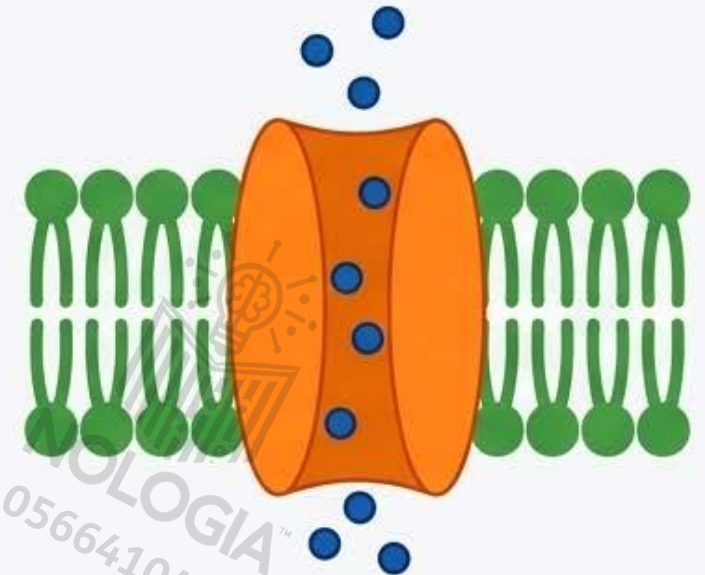
Anchor Proteins

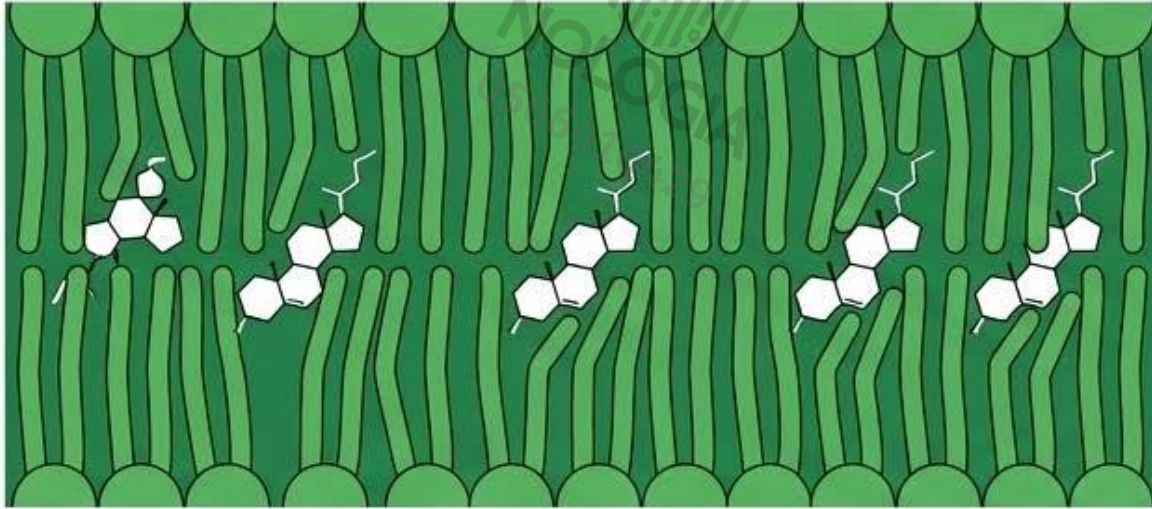
- **Location:** Inner surface.
- **Function:** Attach to the cell's internal support structure; give the cell its shape.



Transport Proteins

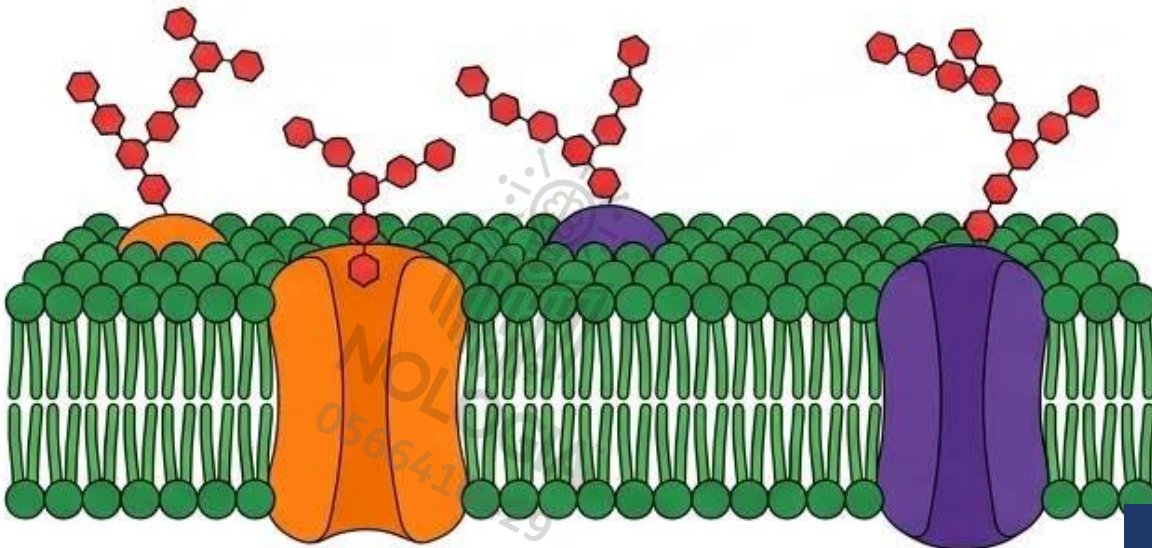
- **Location:** Spanning the entire membrane.
- **Function:** Create tunnels for needed substances or waste to enter/leave. Contributes to selective permeability.





Cholesterol (The Spacers)

- Mechanism: Nonpolar cholesterol is repelled by water, hiding among the tails.
- Benefit: Prevents fatty-acid tails from sticking together. Critical for maintaining fluidity and cellular homeostasis.



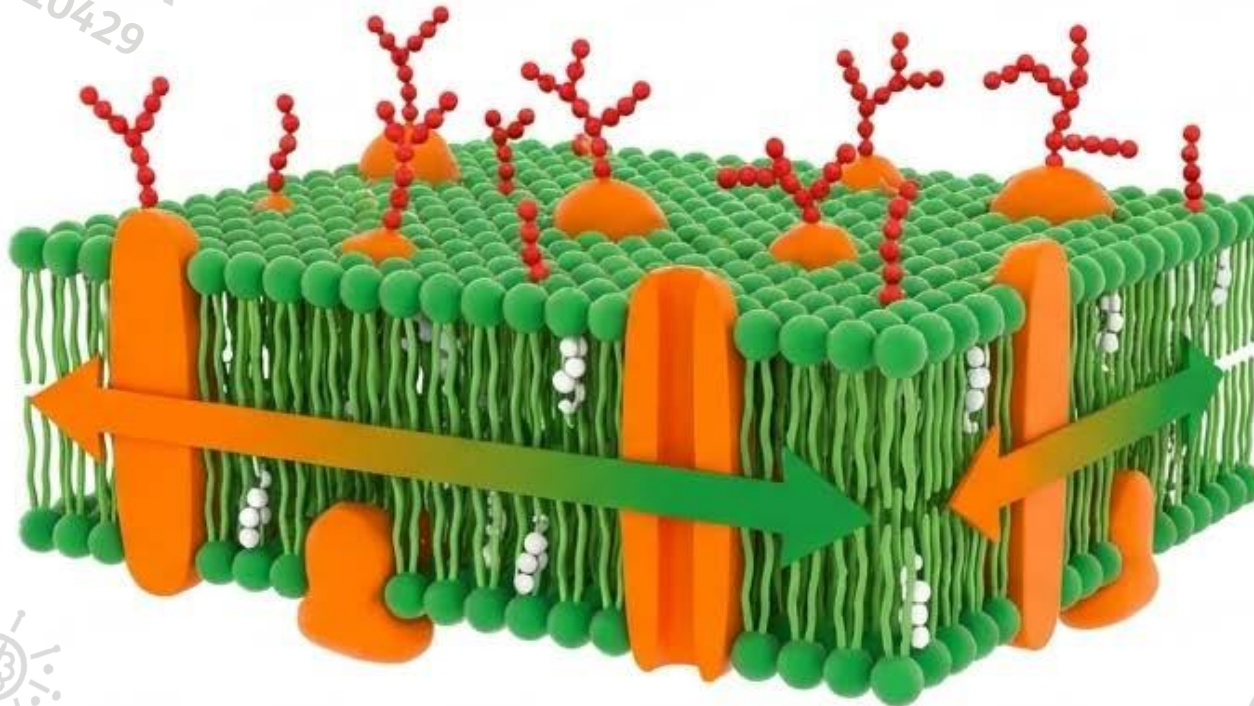
Carbohydrates (The Antennas)

- Mechanism: Stick out from the plasma membrane surface into the external environment.
- Benefit: Defines cell characteristics; helps cells identify chemical signals.

The Fluid Sea

Phospholipids create a “sea” in which other molecules can float. They move sideways continuously.

Analogy: Like apples floating in a barrel of water.



The Mosaic Pattern

Because there are different substances (proteins, carbs) moving among the lipids, a shifting pattern—or mosaic—is created on

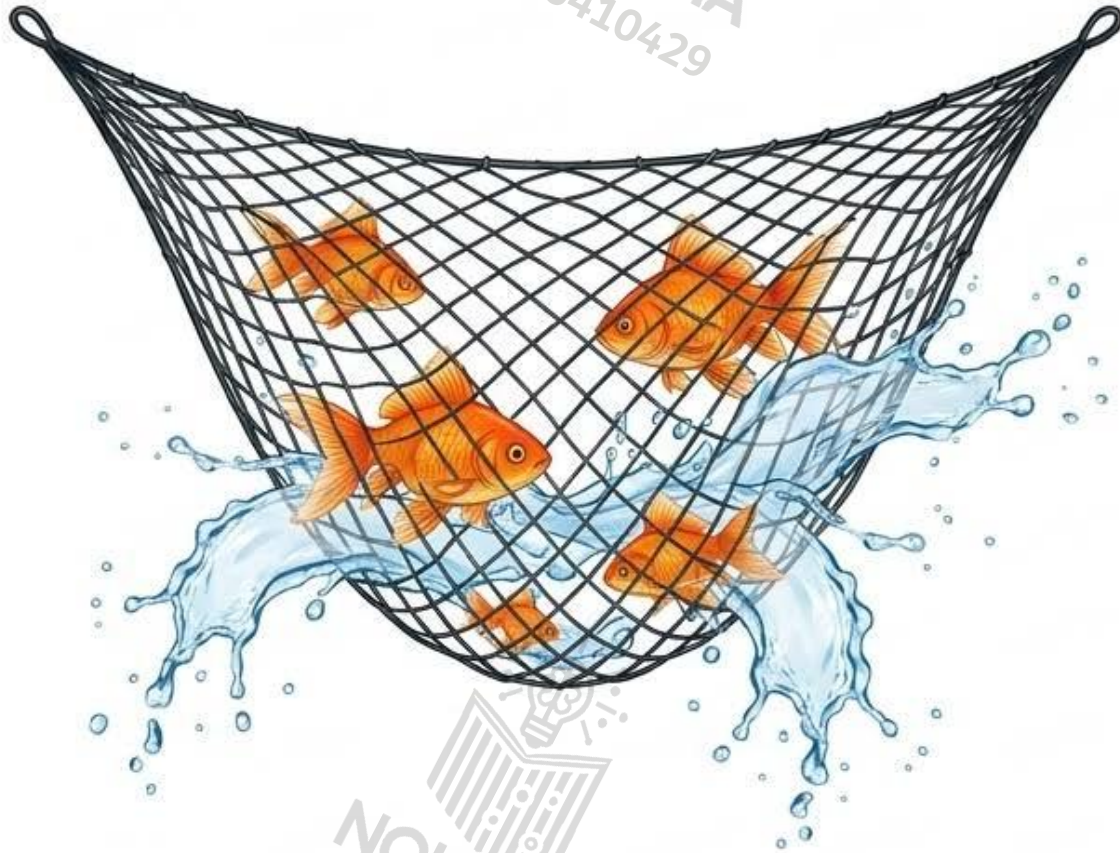
The Mosaic Pattern

Because there are different substances (proteins, carbs) moving among the lipids, a shifting pattern—or mosaic—is created on the surface.



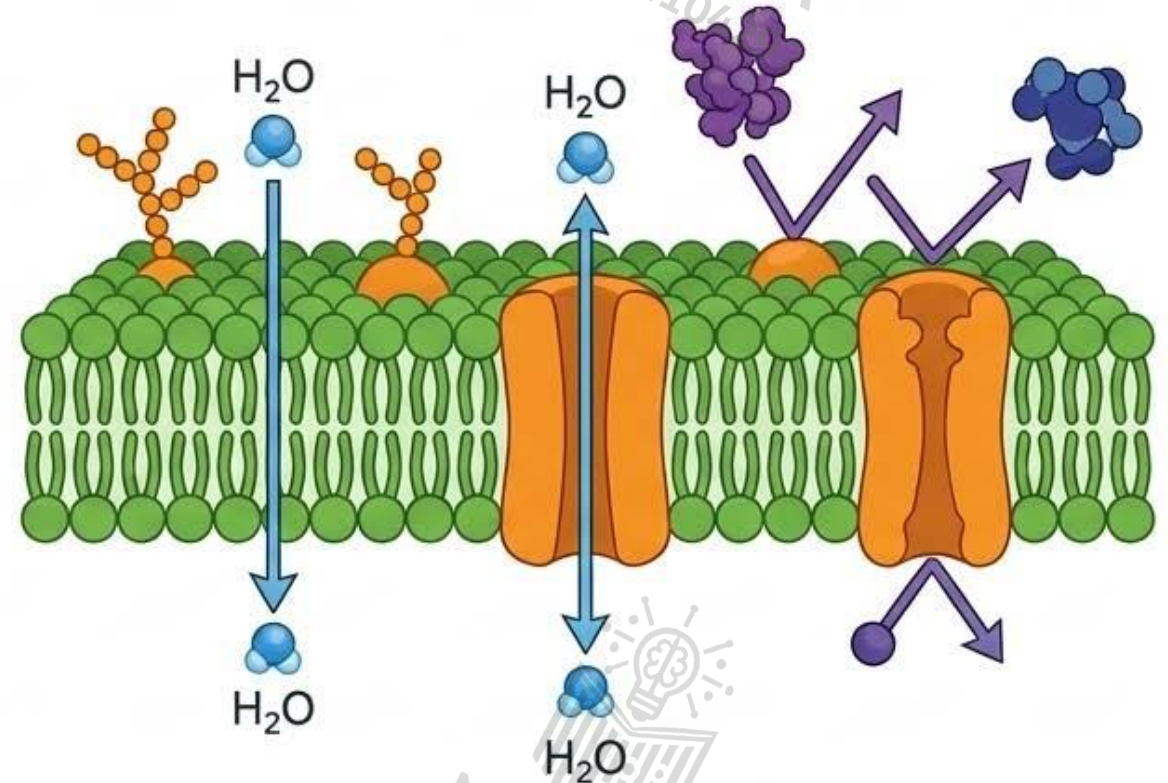
The components of the plasma membrane are in constant motion, sliding past one another.

The Fish Net



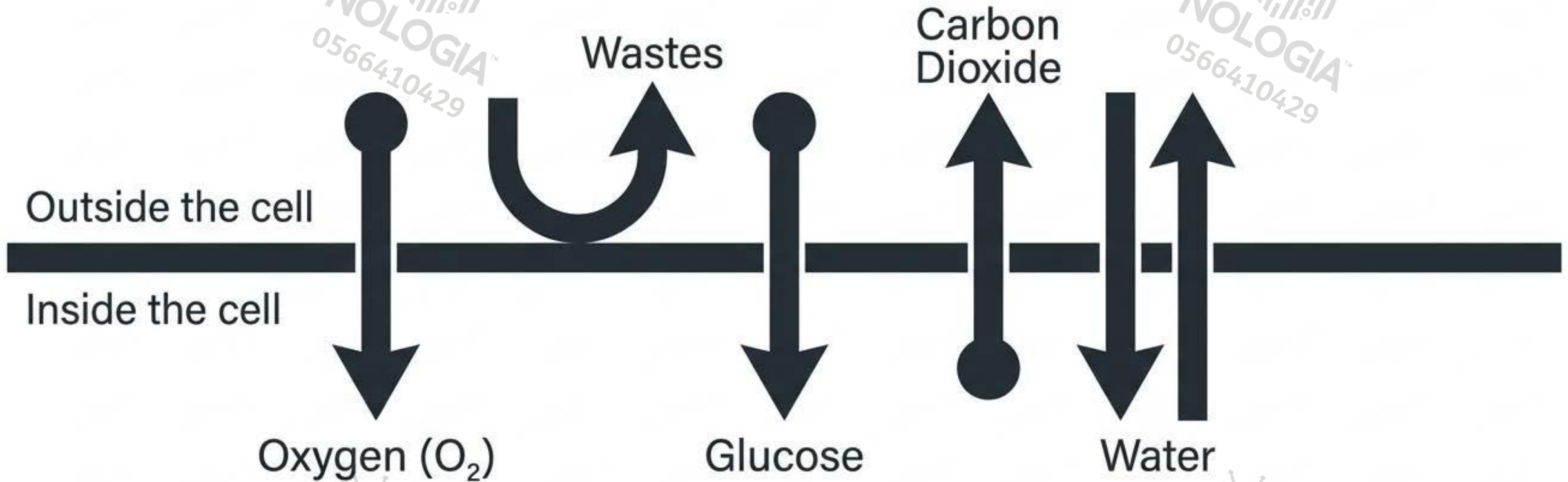
The net has holes that allow water and debris to pass through, but physically traps the fish.

The Plasma Membrane



Selective Permeability: A key property that allows some substances to pass through while keeping others out.

Control of how, when, and how much enters and leaves



Key Rule: Control of these substances relies entirely on the structure of the plasma membrane.

The Phospholipid Bilayer
(Chemical polarity repels water-soluble items)



Transport Proteins & Cholesterol
(Create controlled tunnels & maintain fluidity)



Selective Permeability
(Controlling exactly what enters and exits)



HOMEOSTASIS

The cell's internal balance is successfully maintained, ensuring the survival of the organism.



Exam Preparation

1) The plasma membrane of a cell is primarily composed of two layers of which type of molecule?

- A. Nucleic acids.
- B. Phospholipids.
- C. Amino acids.
- D. Carbohydrates.

2) Which model is used by biologists to describe the structural layout and dynamic behavior of the components within the plasma membrane?

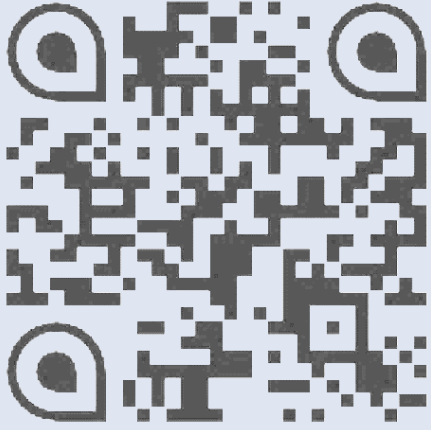
- A. Lock and key model.
- B. Double helix model.
- C. Fluid mosaic model.
- D. Sliding filament model.

3) The plasma membrane is selectively permeable, which means it directly controls homeostasis by:

- A. Allowing all substances to pass through freely.
- B. Preventing any molecules from entering or leaving the cell.
- C. Regulating specifically what enters and leaves the cell.
- D. Changing its shape to engulf neighboring cells entirely.

4) Which two components embedded in the plasma membrane function specifically to stabilize membrane fluidity and assist in moving substances across the barrier?

- A. Glucose and cellulose.
- B. Nucleotides and ribose.
- C. Cholesterol and transport proteins.
- D. Glycerol and glycogen.



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NOLOGIA™

Module (7): Cellular Structure and Function

03

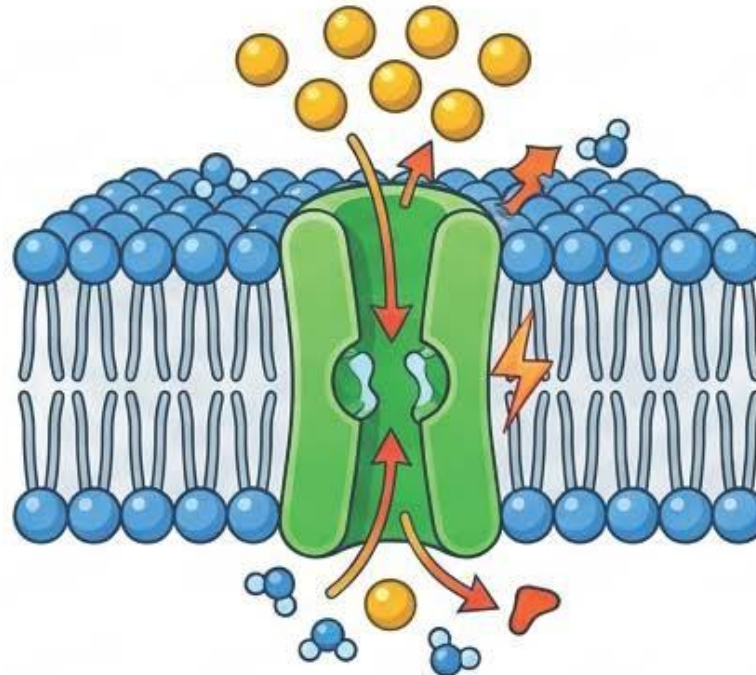
Third Lesson: Cellular Transport



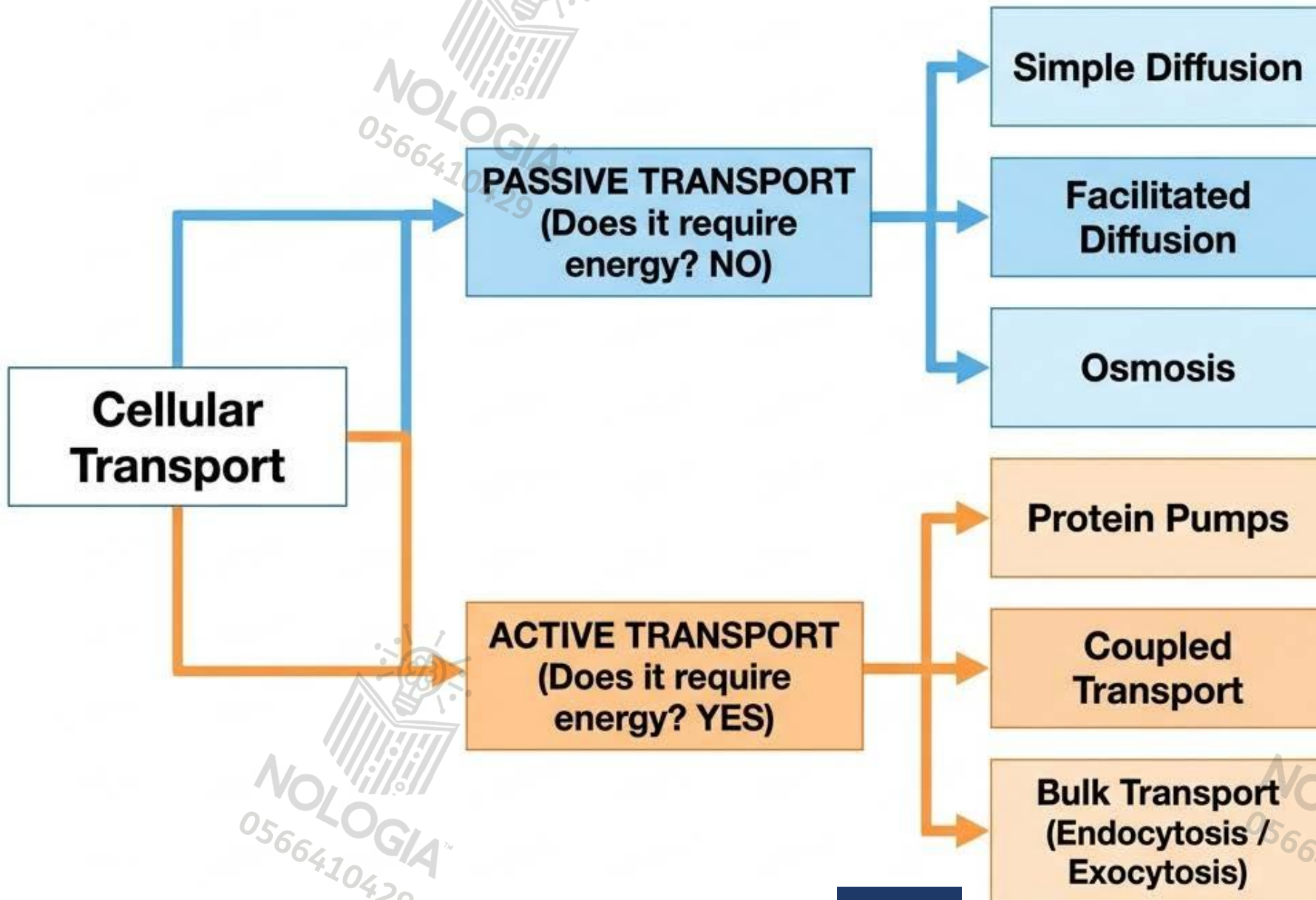
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Cellular Transport: The Complete Blueprint

A **comprehensive guide** to the mechanisms of cellular movement, dynamic equilibrium, and homeostasis.



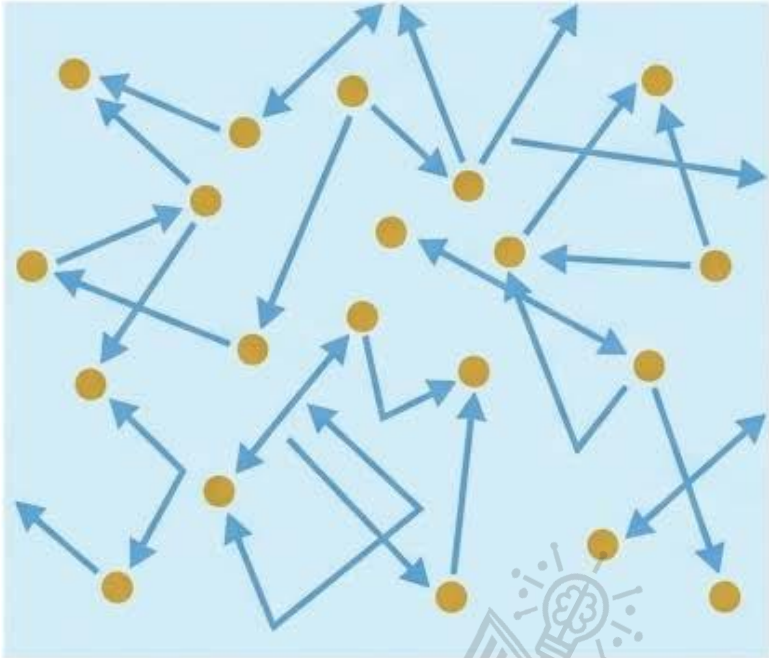
How Do Substances Cross the Membrane?



Keep this map in mind. We will explore the top branch (Passive) first, then move to the bottom branch (Active).

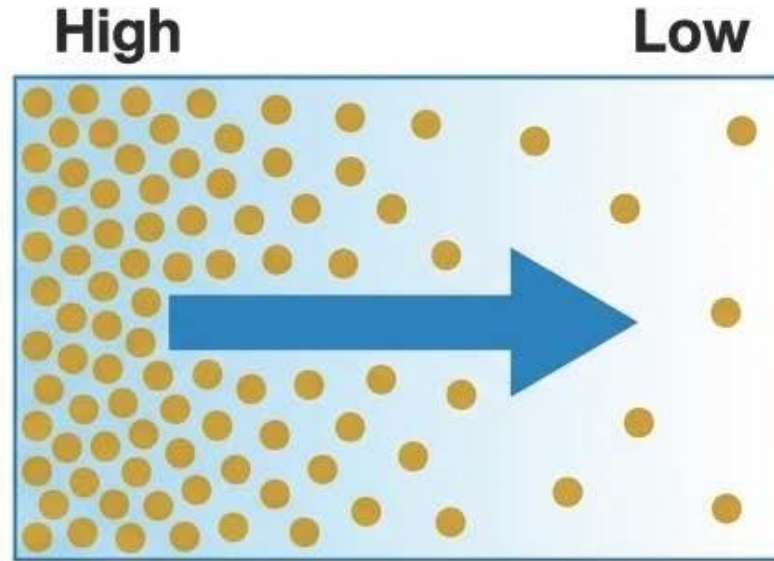
The Laws of Molecular Movement

Brownian Motion



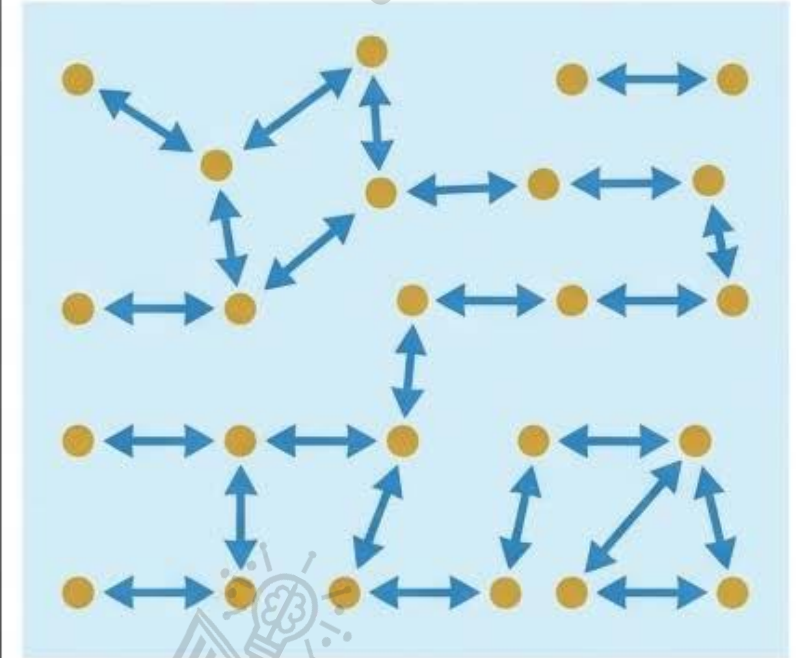
Substances dissolved in water are in constant, random motion. They collide and bounce.

Concentration Gradient



Diffusion is the net movement of particles from an area of many particles (High) to fewer particles

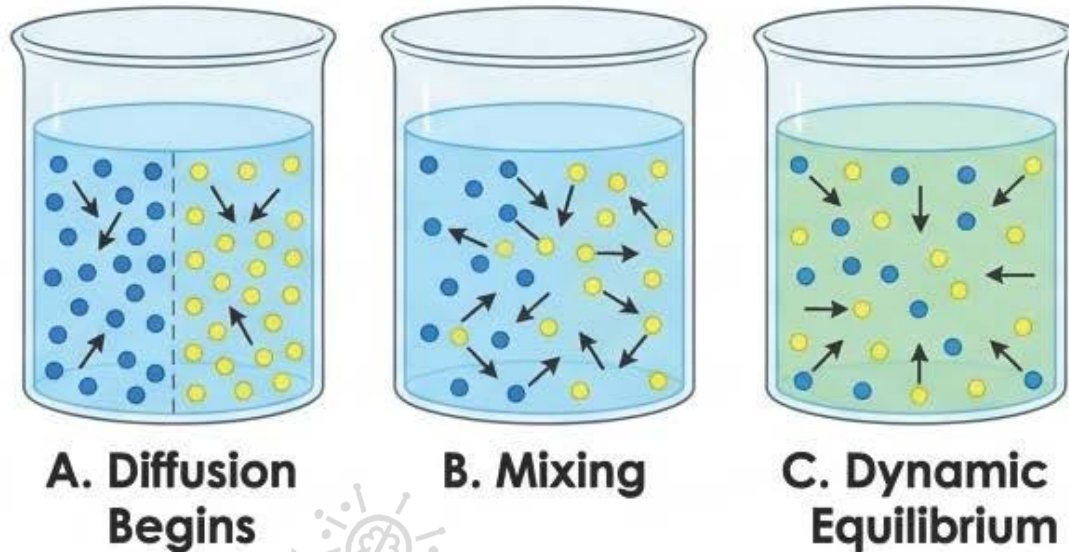
Dynamic Equilibrium



Particles continue to move randomly, but there is no overall change in concentration.

Simple Diffusion & The Speed of Transport

The Process



Simple Diffusion: Movement of particles without additional energy input. Ends when dynamic equilibrium is reached.

The Dashboard



High Concentration
= More particles to collide = **FASTER**



High Temperature =
Particles move faster
& collide more
= **FASTER**

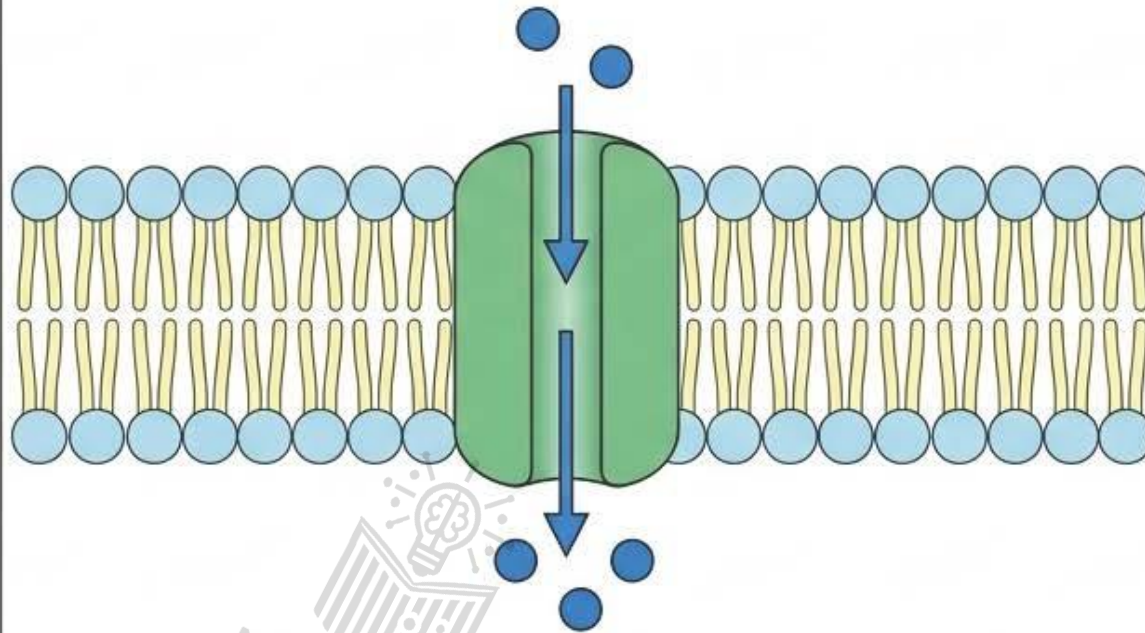


High Pressure =
Particles pushed
closer together
= **FASTER**

Facilitated Diffusion: Getting Help Across the Border

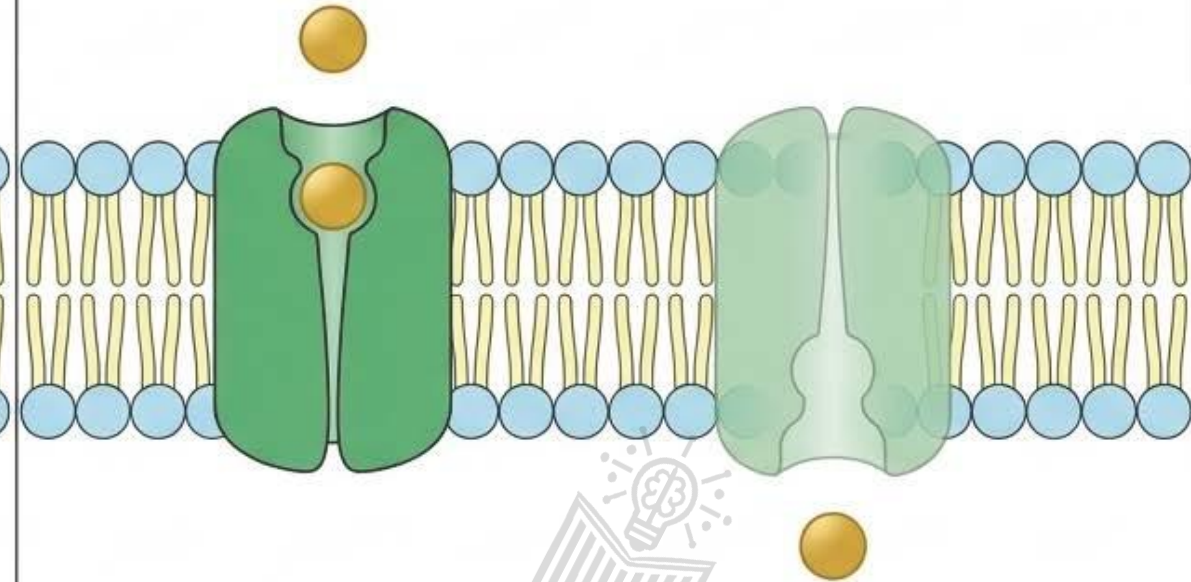
Water, ions, and small molecules (like sugars) use transport proteins to bypass the hydrophobic membrane core. Zero energy required.

Channel Proteins



The Tunnel: Opens and closes to allow substances to flow straight through

Carrier Proteins

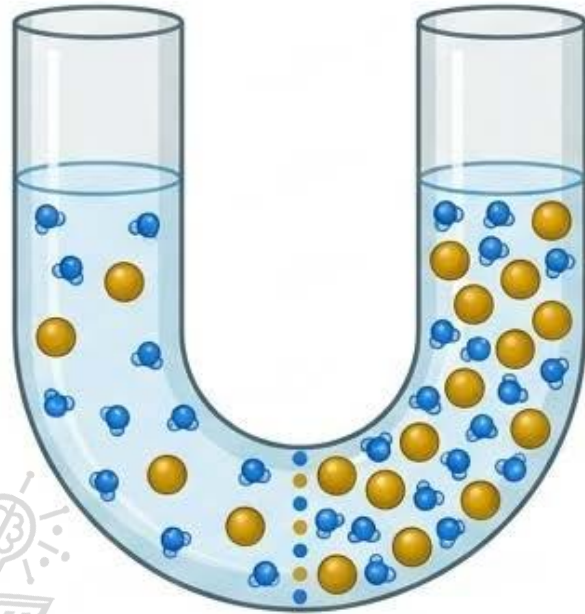


The Shape-Shifter: Binds to the particle and physically changes shape to move it across

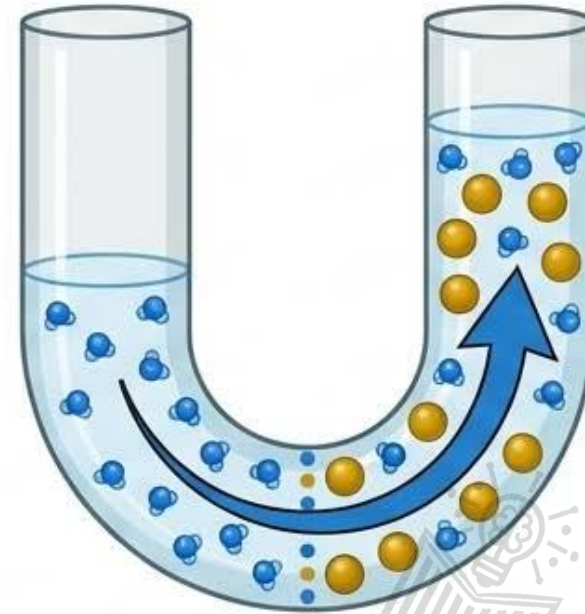
Osmosis: The Diffusion of Water

Concept Anchor: Aquaporins: Specialized channel proteins composed of tiny holes that allow water to pass rapidly.

Before osmosis



After osmosis



The Crucial Rule: If the solute (sugar) **CANNOT** cross the membrane, the solvent (water) **MUST** cross to equalize the concentration.

The Cellular Solutions Matrix

Isotonic Solution (Iso = Equal)	Hypotonic Solution (Hypo = Under)	Hypertonic Solution (Hyper = Above)
Concentration Water and solute are equal inside and outside.	Concentration Lower solute OUTSIDE the cell.	Concentration Higher solute OUTSIDE the cell.
Water Movement Enters and leaves at the same rate.	Water Movement Net movement of water INTO the cell.	Water Movement Net movement of water OUT of the cell.
Net Result Equilibrium.	Net Result Osmotic pressure increases.	Net Result Pressure decreases.

Visual Evidence: Cells Under Osmotic Pressure

Animal Cell (Red Blood Cell)

Isotonic



Retains normal shape.

Hypotonic



May swell until they burst.

Hypertonic



Shrivels due to decreased pressure.

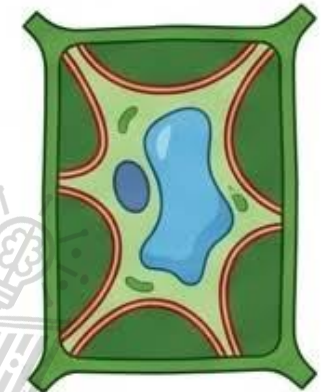
Plant Cell



Normal structure.

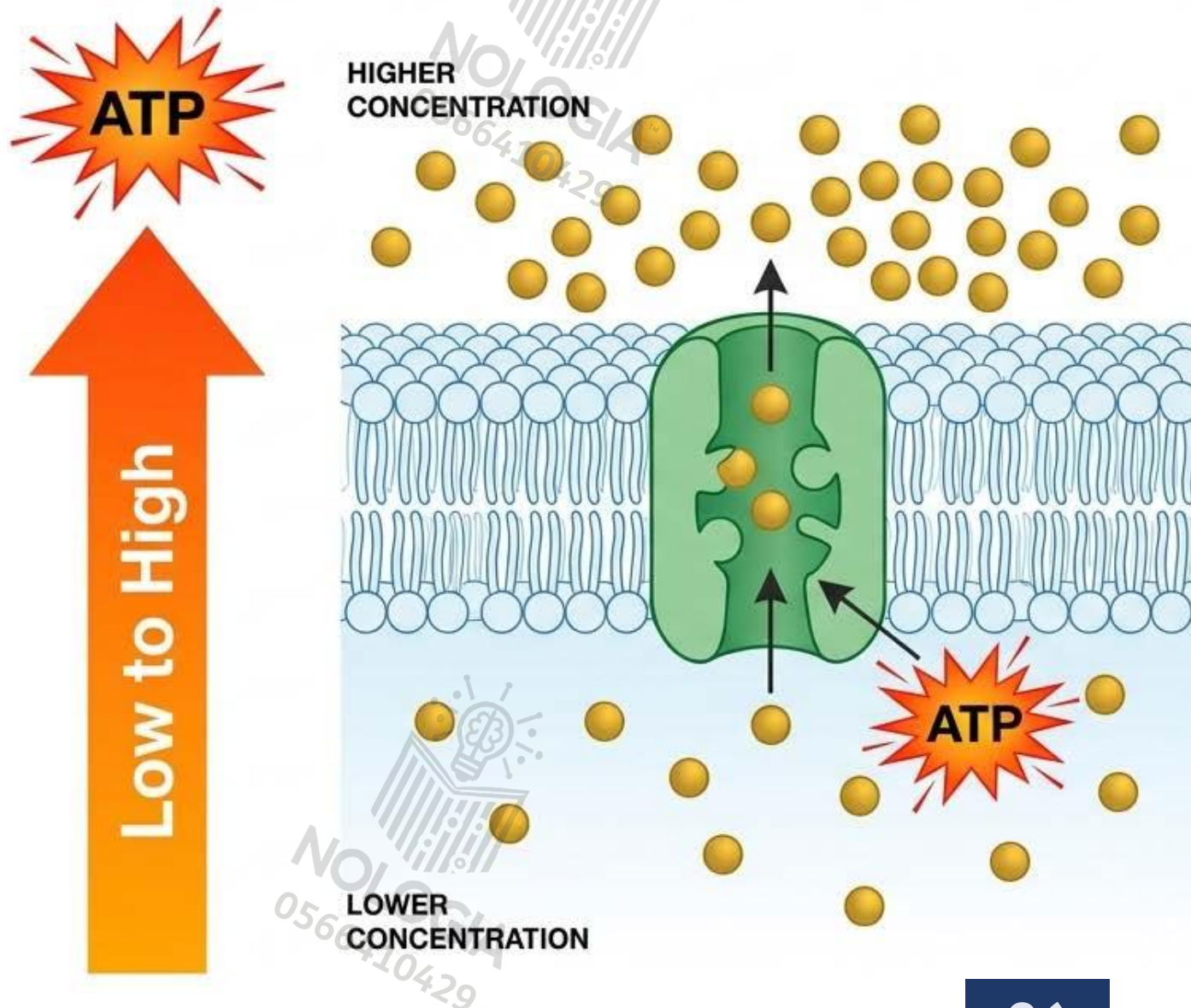


Cell wall prevents bursting. Vacuole fills, pushing against wall (firmer).



Membrane shrinks away from wall (wilting).

Active Transport: Moving Against the Current



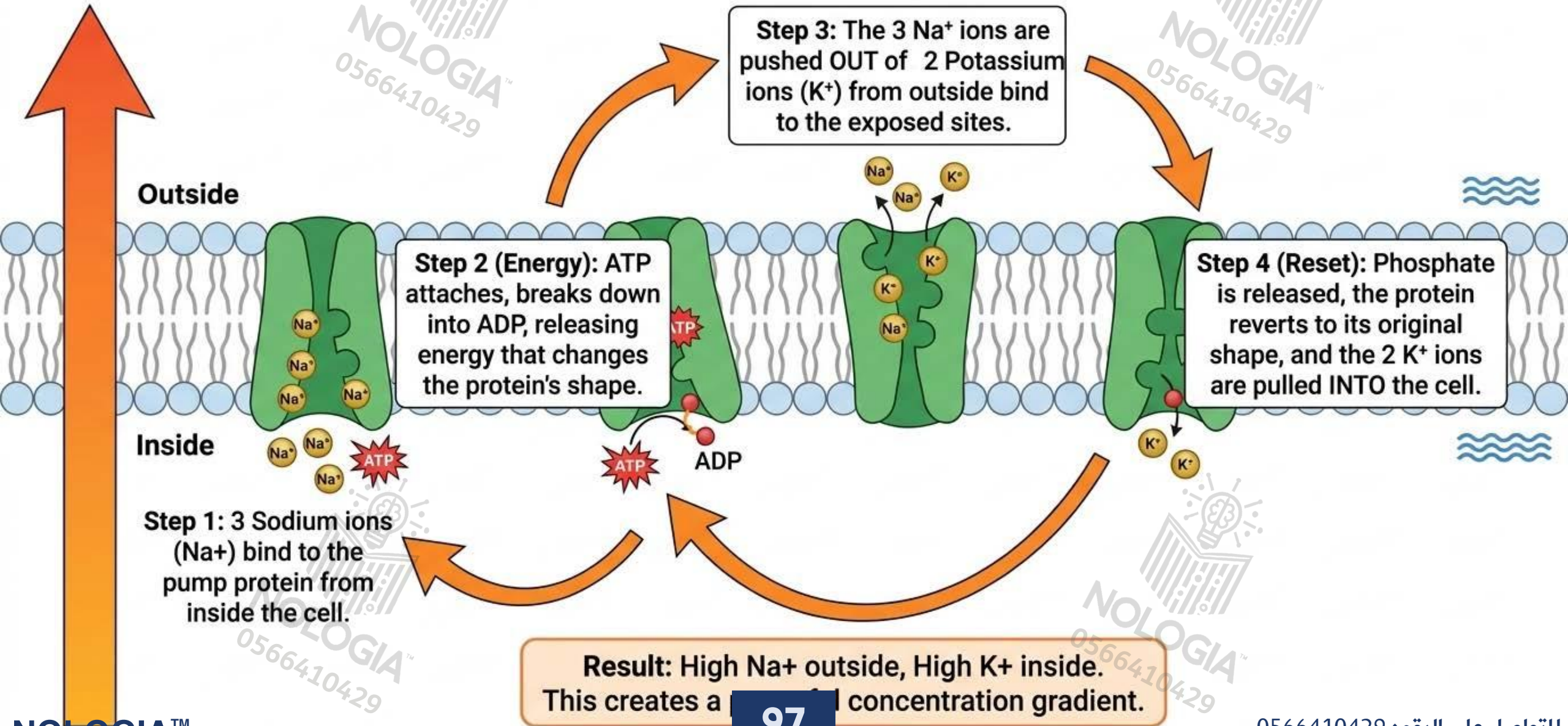
The Challenge: Sometimes cells must move substances from a region of lower concentration to a region of higher concentration.

The Solution: Carrier proteins called pumps.

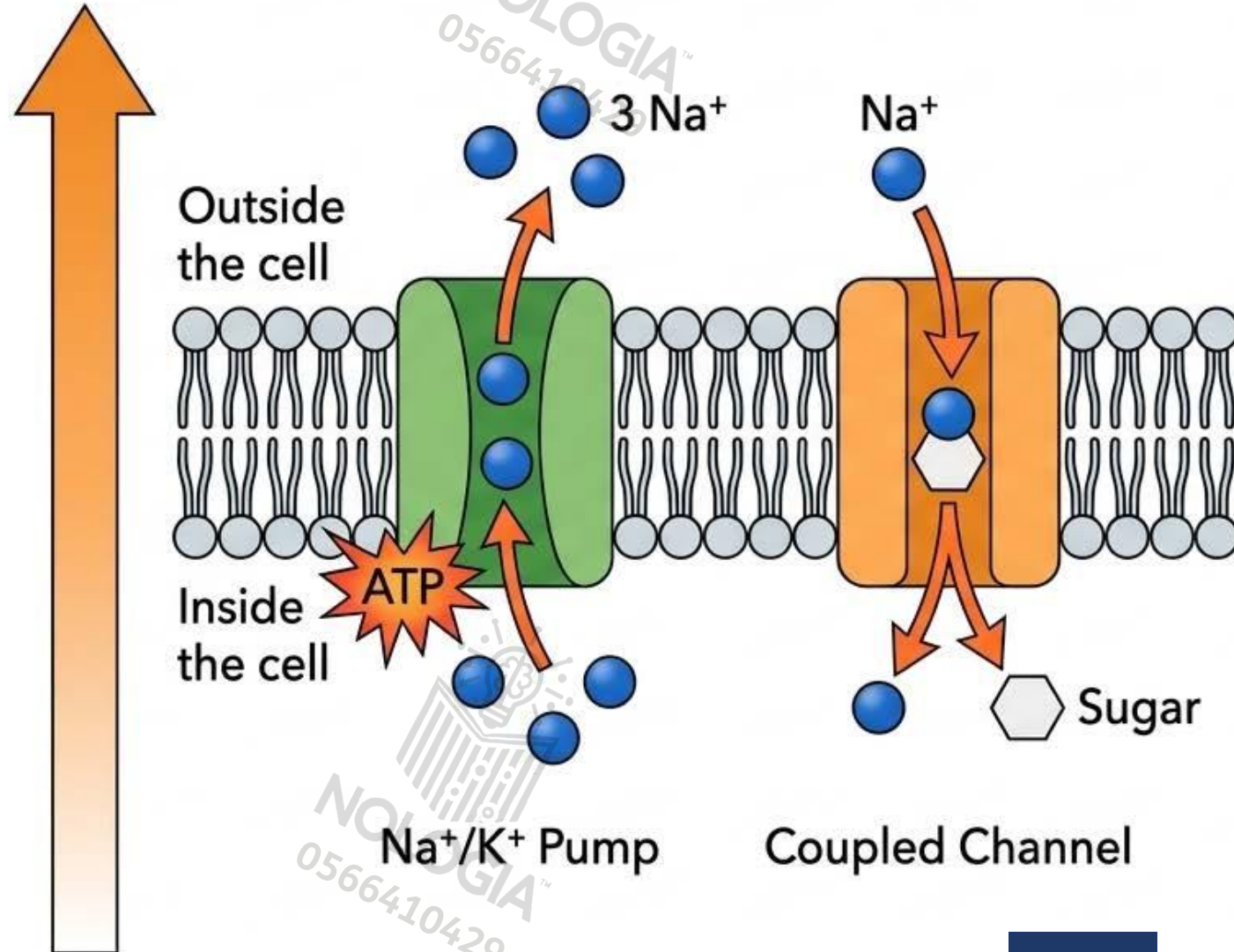
The Cost: Requires cellular energy (ATP).

The Purpose: Essential for maintaining homeostasis (keeping the proper balance of substances regardless of the outside environment).

The Engine of the Animal Cell: Na^+/K^+ ATPase Pump



Coupled Transport: The Piggy-Back Mechanism



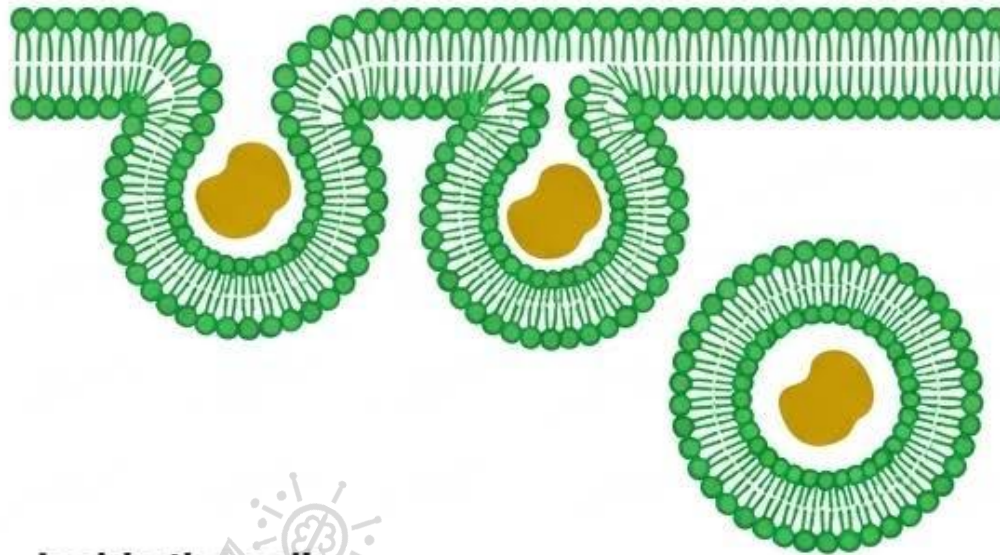
The Mechanism

1. The Na^+/K^+ pump spends ATP to stockpile Na^+ outside the cell.
2. Na^+ naturally wants to rush back in (facilitated diffusion).
3. A sugar molecule couples with a Na^+ ion.
4. As Na^+ rushes through the coupled channel, it pulls the sugar in with it—against the sugar's gradient, but without spending additional ATP.

Metaphor: Like a waterwheel, the cell uses the rushing river of Sodium to power the entry of Sugar.

Bulk Transport: Moving the Heavy Cargo

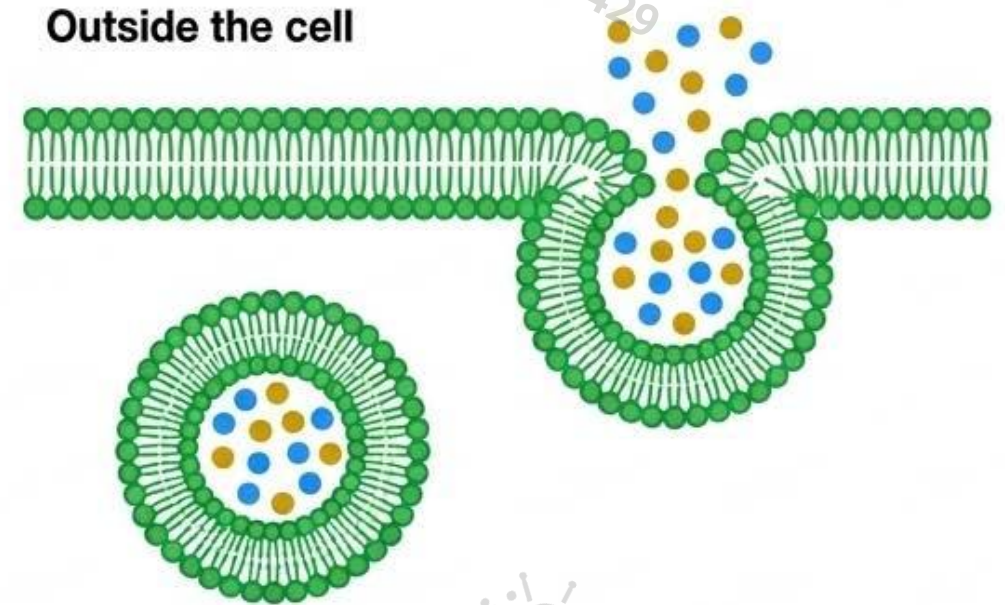
Endocytosis (Entering)



Inside the cell

Cell surrounds a substance in the outside environment. The membrane pinches off, leaving the substance inside.

Exocytosis (Exiting)



Inside the cell

Secretion of materials. Cells use this to expel wastes and secrete hormones.

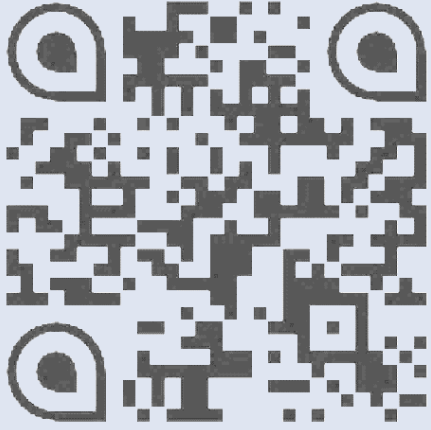
The NOLOGIA Synthesis: Cellular Transport Master Compare & Contrast

Variables	Passive Transport	Active Transport
Energy Required?	NO.	YES (ATP).
Direction of Movement	High to Low (With the Gradient).	Low to High (Against the Gradient).
Goal / Result	Reach Dynamic Equilibrium.	Maintain Homeostasis / Build Concentration Gradients.
Types of Transport	Simple Diffusion, Facilitated Diffusion, Osmosis.	Pumps (Na ⁺ /K ⁺), Coupled Transport, Endo/Exocytosis.
Examples of Particles Moved	Oxygen, Water, Small Ions.	Large sugars, Bulk waste, stockpiling Na ⁺ .



Exam Preparation

- 1) Which two primary mechanisms do cells use to move substances across the cell membrane to maintain homeostasis?
 - A. Endocytosis and exocytosis.
 - B. Mitosis and meiosis.
 - C. Passive transport and active transport.
 - D. Photosynthesis and cellular respiration.
- 2) The rate of diffusion across a semipermeable membrane is directly influenced by which group of environmental factors?
 - A. Concentration, temperature, and pressure.
 - B. Light intensity, gravity, and mass.
 - C. Volume, surface area, and color.
 - D. pH, humidity, and sound velocity.
- 3) An animal cell placed in a solution maintains a stable volume without swelling or shrinking. What type of solution is this environment considered?
 - A. Hypotonic
 - B. Isotonic
 - C. Hypertonic
 - D. Concentrated.
- 4) Cells move exceptionally large molecules completely into the cell by engulfing them in a vesicle, a process known as:
 - A. Exocytosis.
 - B. Diffusion.
 - C. Endocytosis.
 - D. Osmosis.



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Module (7): Cellular Structure and Function

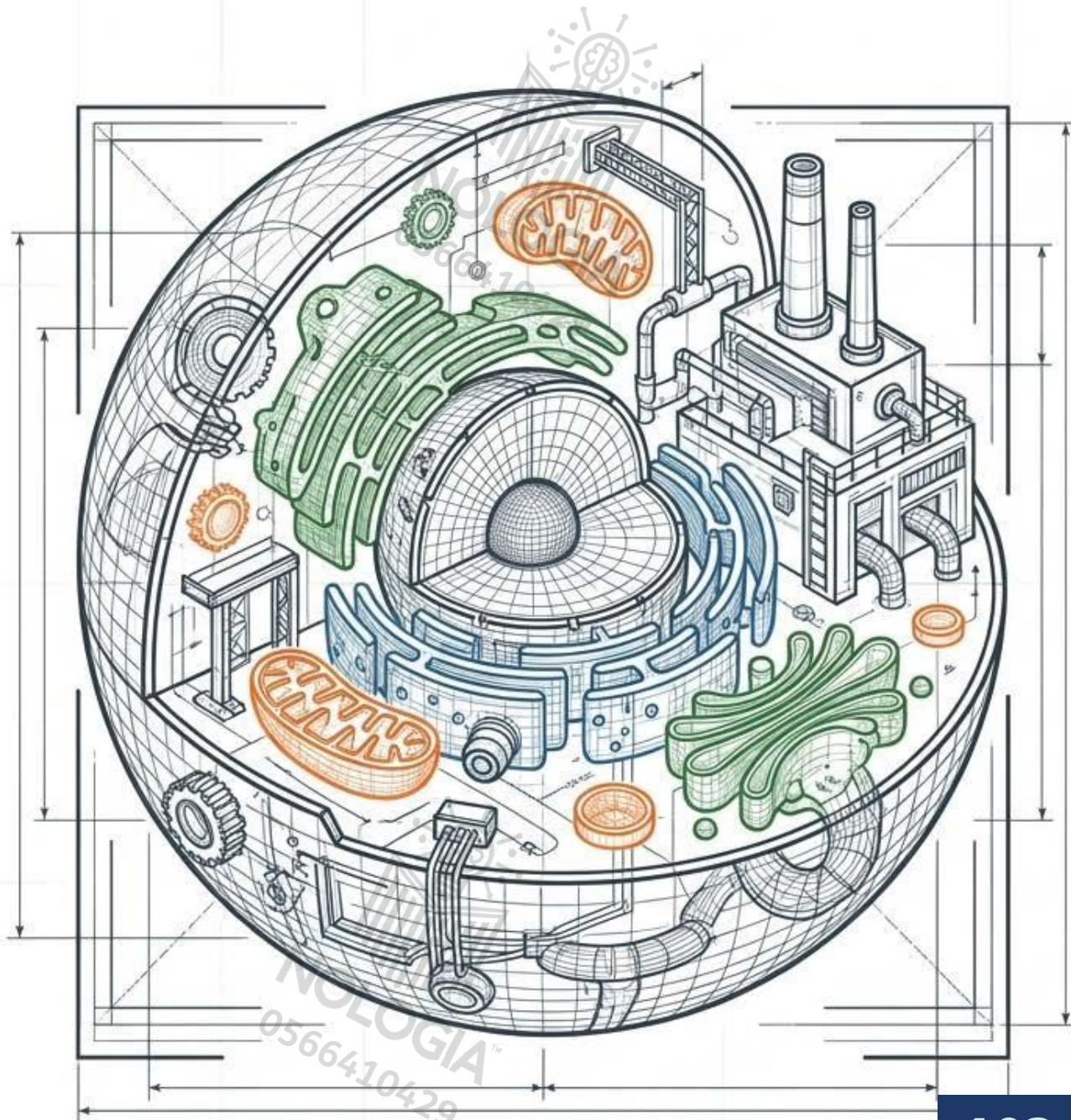
04

Fourth Lesson: Structures And Organelles



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NOLOGIA

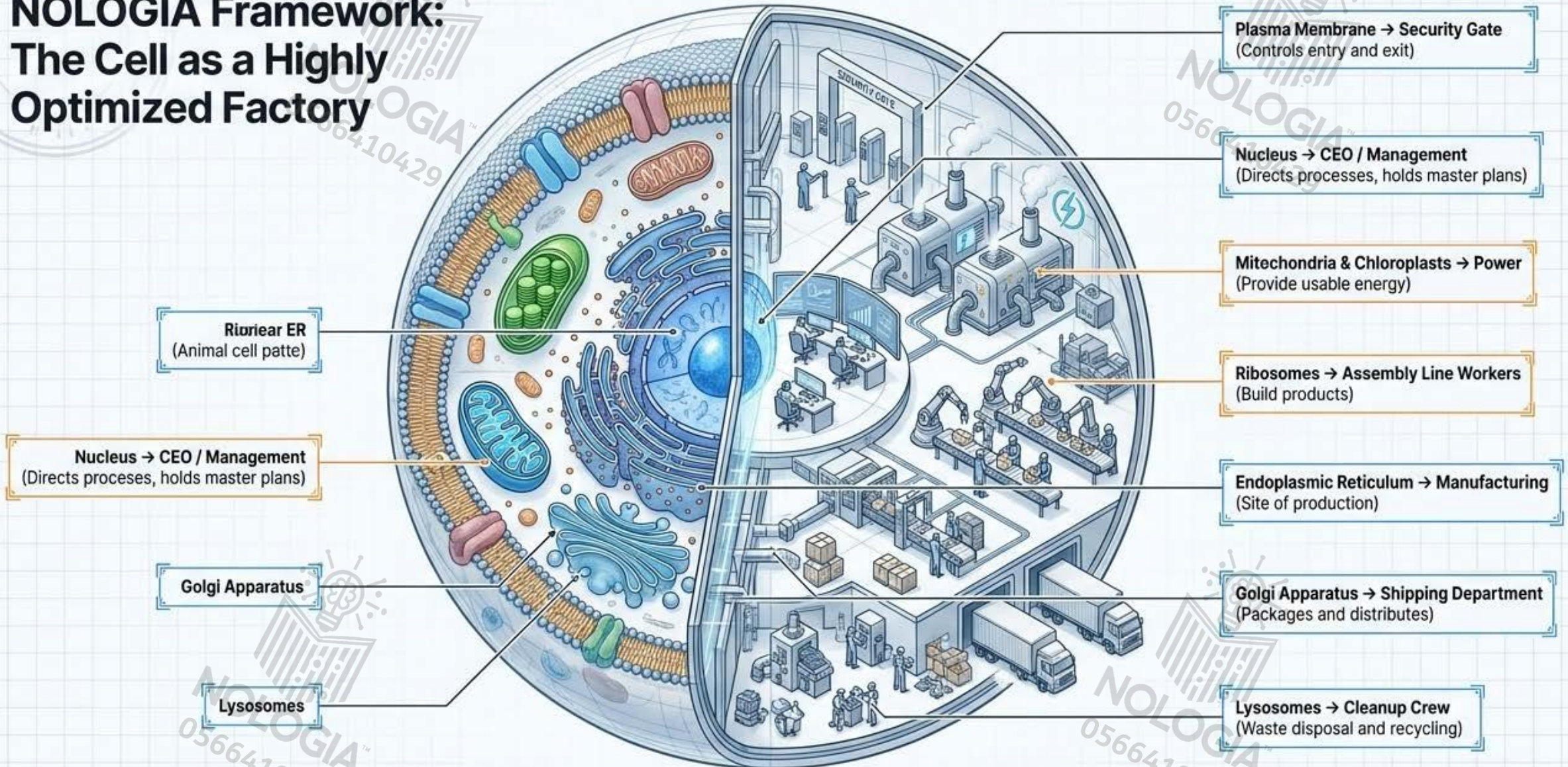
Cell Structures & Organelles

The Ultimate Study Guide:
A comprehensive blueprint from
Prokaryotes to Eukaryotes.

Visual Legend

-  Shared & Prokaryotic Features
-  Animal Cell Features
-  Plant Cell Features

NOLOGIA Framework: The Cell as a Highly Optimized Factory

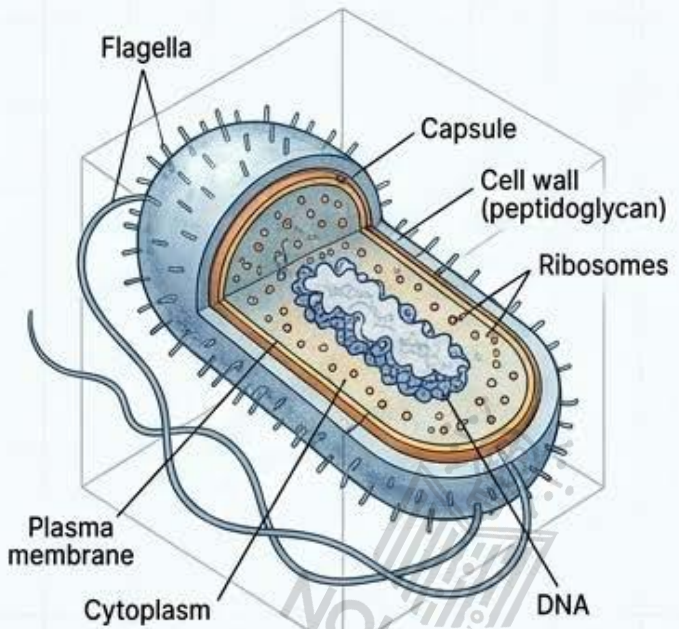


Visualizing the Three Primary Cell Architectures



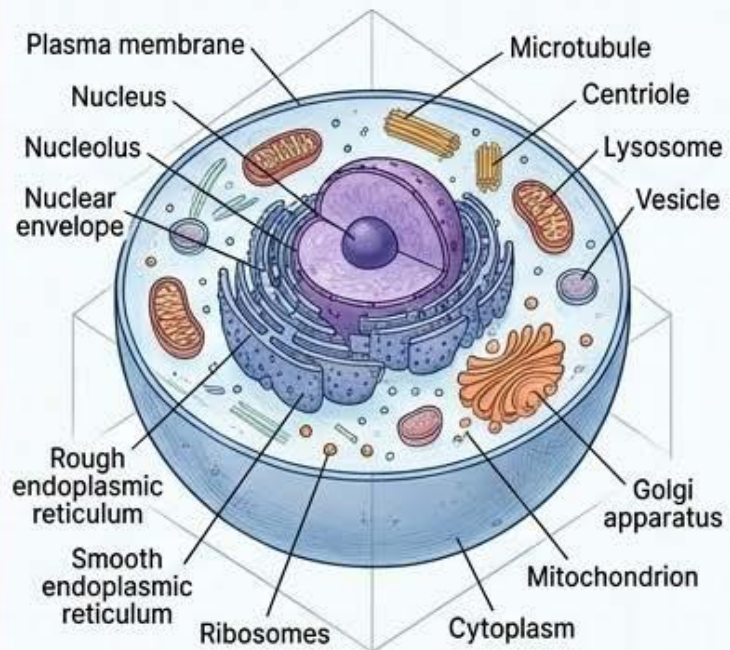
Prokaryotic Cell

Key Fact: All chemical processes take place directly in the cytoplasm; no membrane-bound organelles.



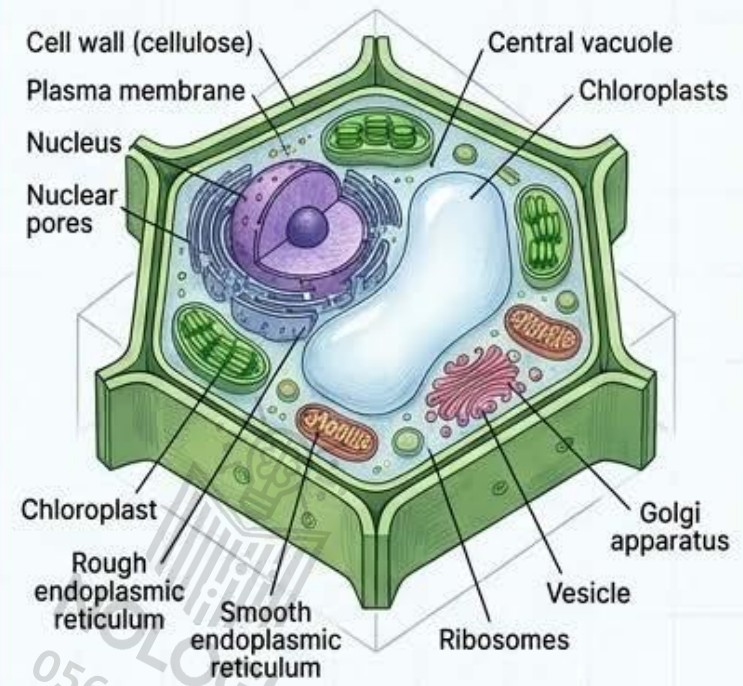
Animal Cell (Eukaryotic)

Key Fact: Contains membrane-bound organelles for simultaneous, specialized chemical processes.



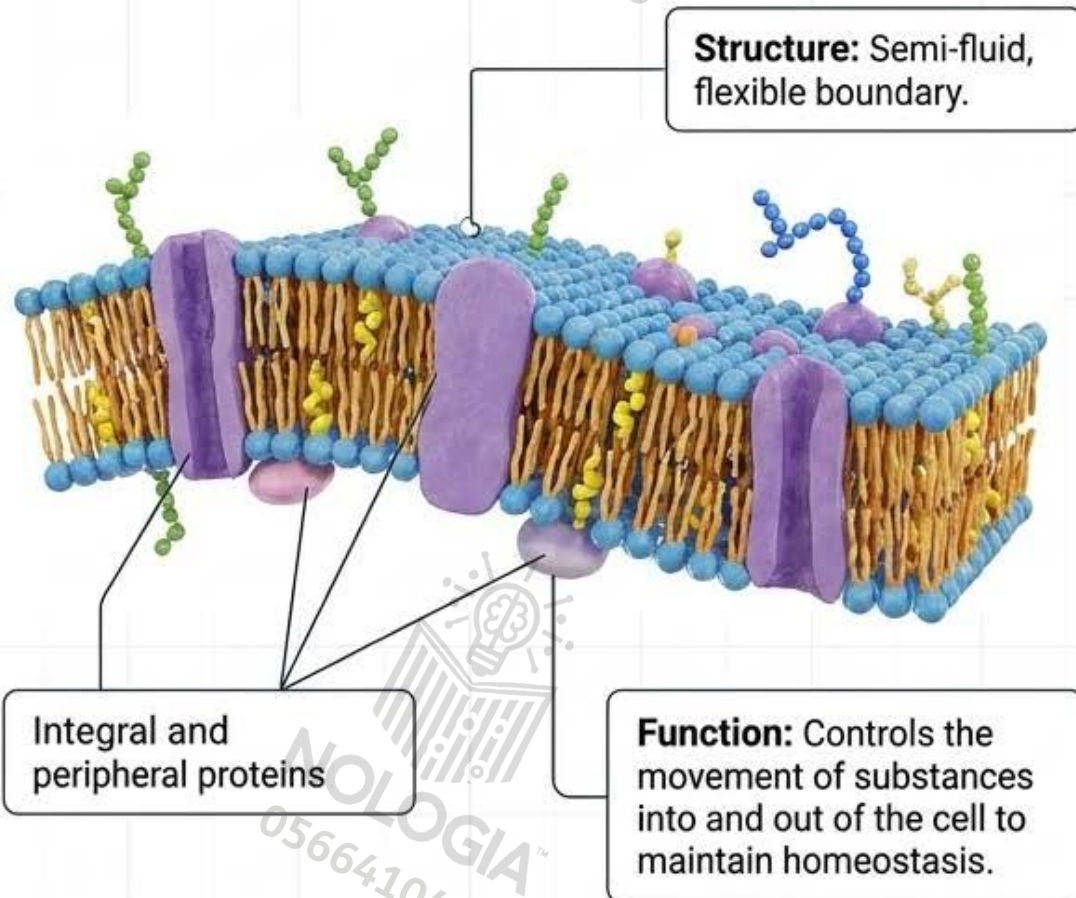
Plant Cell (Eukaryotic)

Key Fact: Specialized for rigidity and photosynthesis, featuring a massive central vacuole.



Defining the Perimeter: Membranes and Walls

Plasma Membrane (All Cells)



Cell Wall (Plants & Prokaryotes)

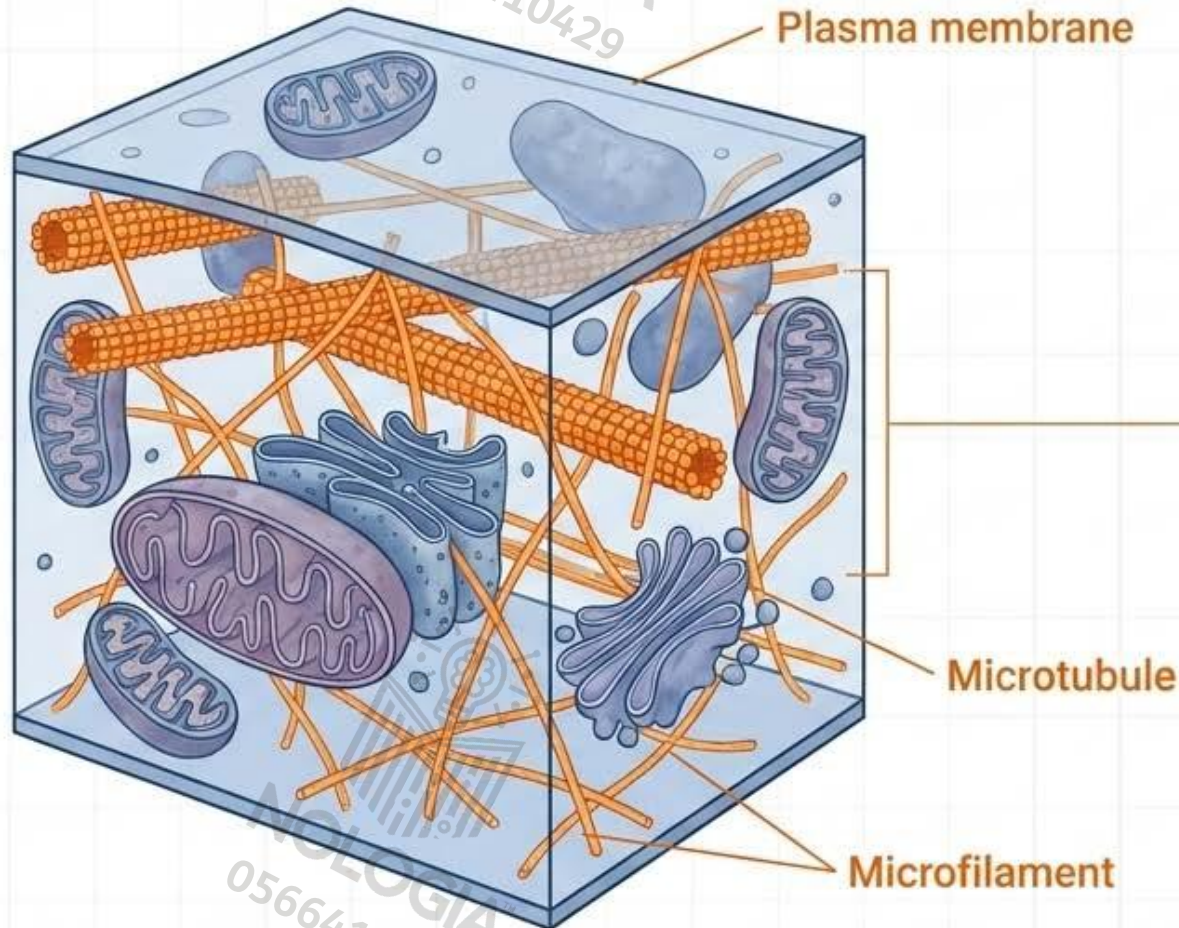


Plant Cell Wall: Thick, rigid mesh of fibers made of a carbohydrate called cellulose. Allows plants to stand at immense heights.



Prokaryotic Cell Wall: Provides rigid support, but is made of peptidoglycan (disaccharides and peptide fragments), not cellulose.

Internal Infrastructure: The Cytoskeleton Framework



The Cytoplasm

The semifluid environment inside the plasma membrane. In prokaryotes, this is where all chemical processes occur directly.

The Cytoskeleton

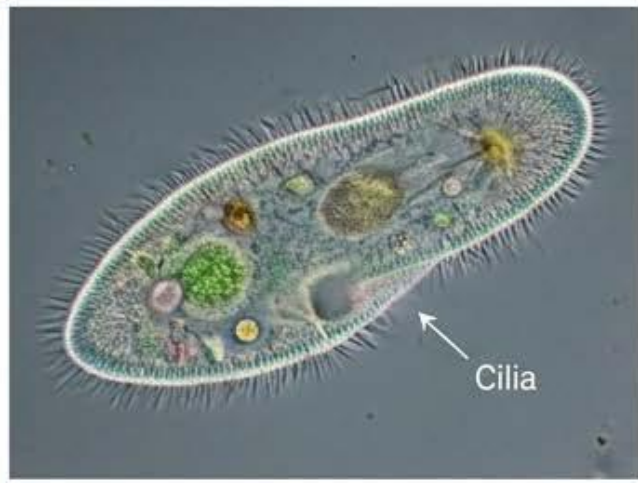
A supporting network of long, thin protein fibers that rapidly assembles, disassembles, and slides to allow cellular movement.

Component Breakdown

- **Microtubules:** Long, hollow protein cylinders forming a rigid skeleton and assisting substance movement.
- **Microfilaments:** Thin protein threads that give the cell shape and enable entire parts to move.

Cell Appendages: Mechanisms for Mobility

Cilia



Description:
Short, numerous projections.

Motion:
Moves like oars in a rowboat. Also found on stationary cells to sweep substances along surfaces.

Microtubule Configuration



9 + 2 configuration

Both appendages are composed of complex proteins arranged in a 9 + 2 configuration (nine pairs of microtubules surrounding two single central microtubules).

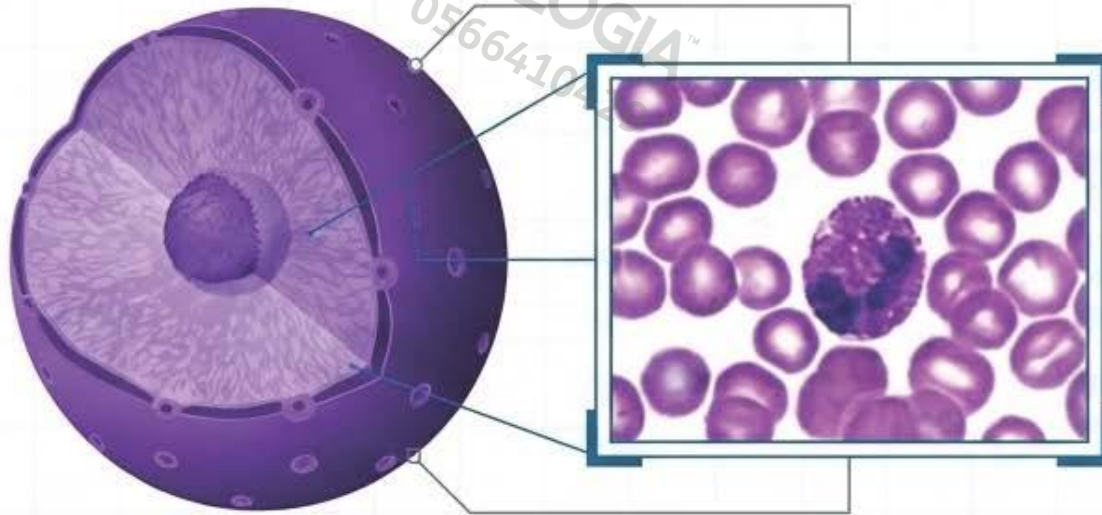
Flagella



Description:
Longer, less numerous (typically one or two per cell).

Motion:
Moves with a rapid, whiplike motion.

The Control Center: Nucleus and Centrioles



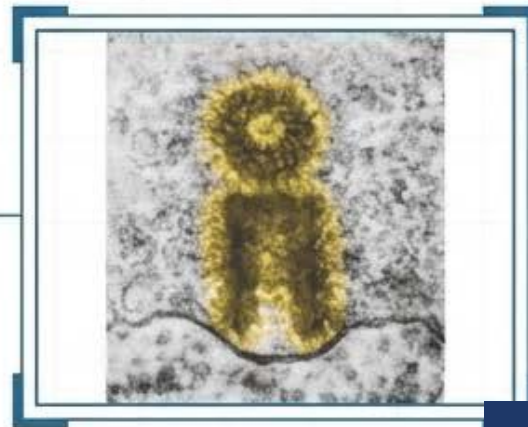
The Nucleus [Eukaryotes]

Function: The managing structure containing most of the cell's DNA (instructions for growth, function, and reproduction).

Envelope: Surrounded by a double-membrane with nuclear pores for selective substance transport.

Chromatin: Complex DNA attached to protein, spread throughout the interior.

Nucleolus: The dense central site dedicated to ribosome production.



Centrioles ■

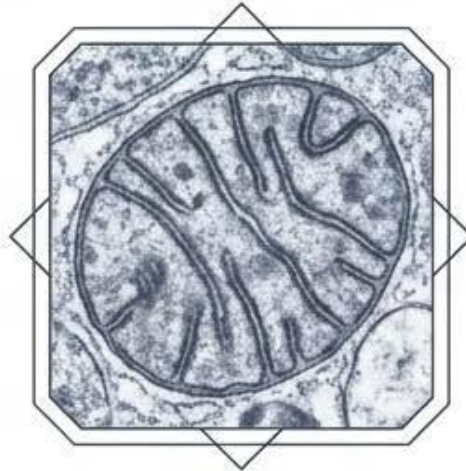
Function: Play a critical role during cell division.

Structure: Microtubule groups typically located near the nucleus in the cytoplasm of animal cells.

Processing Energy: The Power Plants



Mitochondria: The Generators



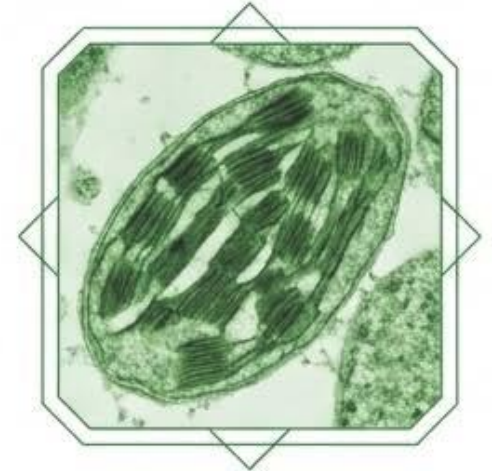
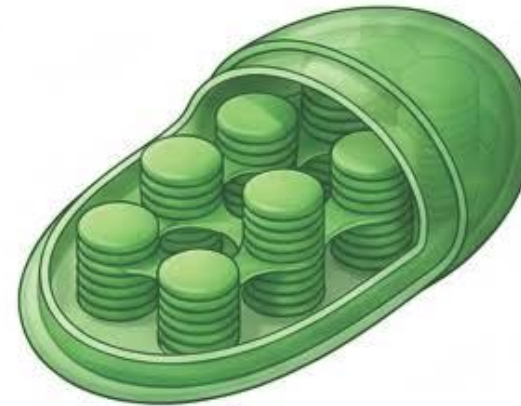
Found In: All Eukaryotes

Function: Converts fuel (mainly sugars) into usable chemical energy.

Structure: Features a highly folded inner membrane providing massive surface area for breaking bonds in sugar molecules. Energy is stored in bonds for later use.



Chloroplasts: The Solar Panels



Found In: Plant Cells & some other Eukaryotes

Function: Captures light energy and converts it to chemical energy via photosynthesis.

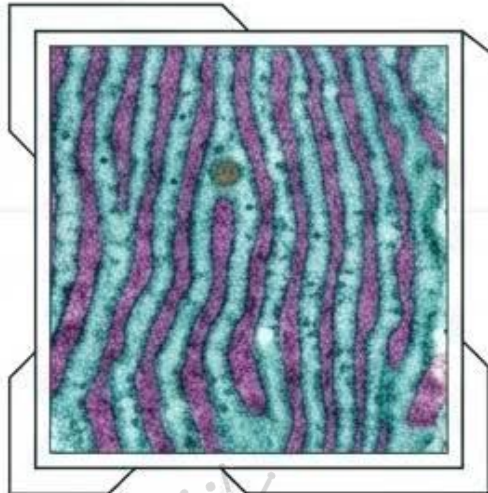
Structure: Double membrane containing stacked, disk-shaped compartments called thylakoids, which trap energy from sunlight using the green pigment chlorophyll.

Manufacturing Molecules: Ribosomes & The ER



Ribosomes (The Workers)

- Manufactured in the nucleolus, composed of RNA and protein.
- Not bound by a membrane.
- Free-floating ribosomes produce proteins for internal cell use, while bound ribosomes produce proteins for export.

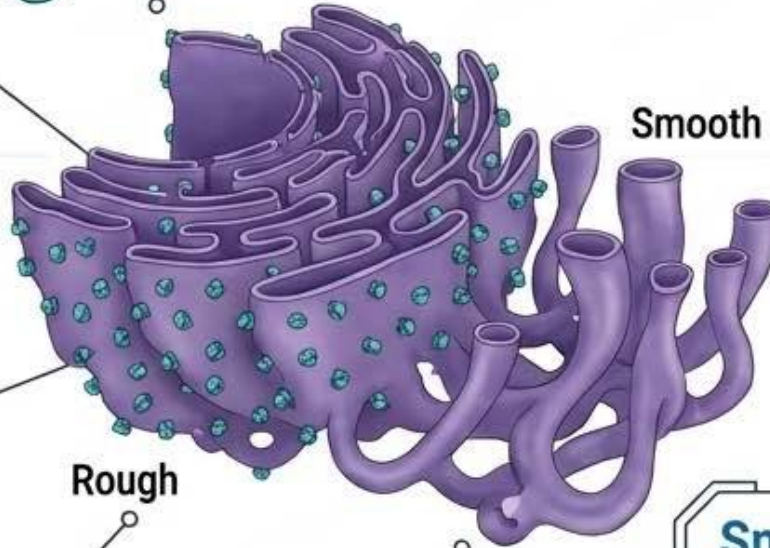


Rough

Rough Endoplasmic Reticulum

- A membrane system of folded sacs studded with attached ribosomes (creating a bumpy appearance).
- It serves as the primary assembly line for protein synthesis.

Smooth



Smooth Endoplasmic Reticulum

- Features no attached ribosomes.
- Synthesizes complex carbohydrates and lipids (including phospholipids).
- Also functions as a detoxification center for harmful substances.

Logistics, Storage, and Cleanup



Golgi Apparatus (The Shipping Dept)

Energetic Orange

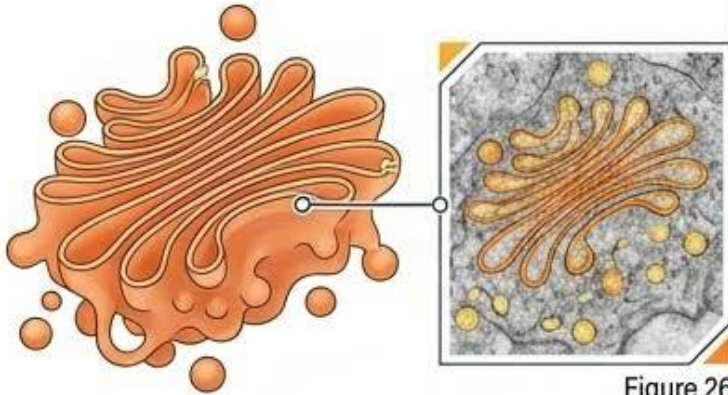


Figure 26

A flattened stack of membranes. It modifies, sorts, and packages proteins into sacs called vesicles, which can fuse with the plasma membrane to release proteins outside the cell.



Vacuoles (The Warehouse)

Biological Green

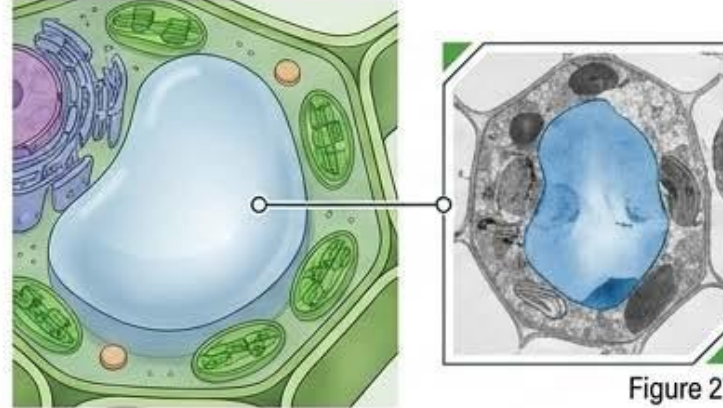


Figure 27

Sacs used to store food, enzymes, or waste. Plant cells contain massive central vacuoles. Animal cells usually do not contain them (or they are very small).



Lysosomes (The Cleanup Crew)

Organic Blue

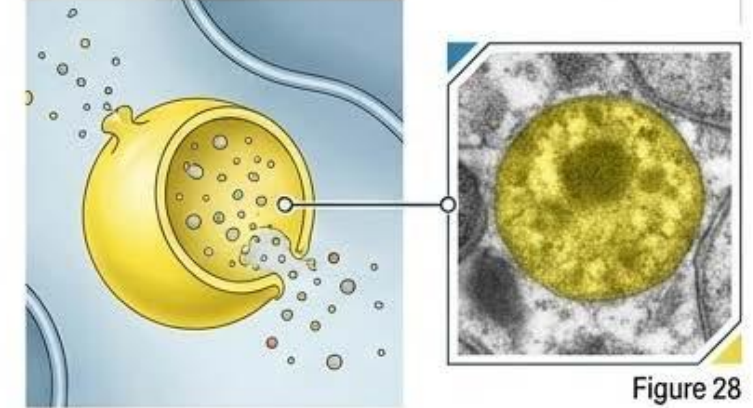


Figure 28

Vesicles containing potent digestive enzymes. They break down excess/worn-out organelles, food particles, bacteria, and viruses. The surrounding membrane protects the rest of the cell.



Synthesis Arc: The Journey of a Protein



NOLOGIA Diagnostic Matrix: Plant vs. Animal Cells

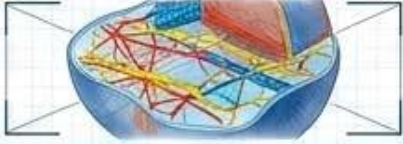
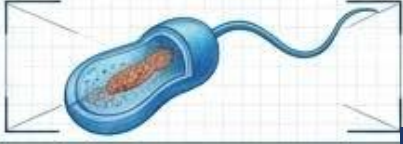
Biological Feature	Plant Cell 	Animal Cell 
Cell Wall	✓ Yes (Thick, made of cellulose)	✗ No (Plasma membrane only)
Chloroplasts	✓ Yes (Required for photosynthesis)	✗ No
Vacuoles	✓ One massive central vacuole	✗ Rare (Very small if present)
Centrioles	✗ No	✓ Yes (Critical for cell division)
Lysosomes	✗ Rare	✓ Yes (Primary cellular cleanup mechanism)
General Shape	Rigid, geometric structure	Flexible, varied forms

The Great Divide: Eukaryotic vs. Prokaryotic Domains

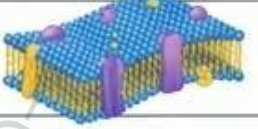
Eukaryotic Cells		Prokaryotic Cells	
Nucleus Presence	✓ Present (Contains and protects DNA)	Nucleus Presence	✗ Absent (DNA is free-floating in cytoplasm)
Membrane-Bound Organelles	✓ Yes (Contains Golgi, ER, Mitochondria, etc.)	Membrane-Bound Organelles	✗ No (All processes occur directly in cytoplasm)
Size & Complexity	Larger, highly complex, compartmentalized	Size & Complexity	Smaller, significantly simpler structure
Cell Wall Composition	Cellulose (in plants) or Chitin (in fungi)	Cell Wall Composition	Peptidoglycan (disaccharides and peptide fragments)

Shared Universal Traits: Both domains possess a Plasma Membrane, Cytoplasm, Ribosomes, and Genetic Material.

NOLOGIA Master Summary: Organelles (Part 1)

Cell Structure	Visual Icon	Function	Cell Type
Cell wall		An inflexible barrier that provides support and protects the plant cell	Plant cells, fungi cells, and some prokaryotes
Centrioles		Organelles that occur in pairs and are important for cell division	Animal cells and most protist cells
Chloroplasts		A double-membrane organelle with thylakoids containing chlorophyll; where photosynthesis takes place	Plant cells and some protist cells
Cilia		Projections from cell surfaces that aid in locomotion and feeding; also used to sweep substances along surfaces	Some animal cells, protist cells, and prokaryotes
Cytoskeleton		A framework for the cell within the cytoplasm	All eukaryotic cells
Endoplasmic reticulum		A highly folded membrane that is the site of protein synthesis	All eukaryotic cells
Flagella		Projections that aid in locomotion and feeding	Some animal cells, prokaryotes, and some plant cells

NOLOGIA Master Summary: Organelles (Part 2)

Cell Structure	Visual Icon	Function	Cell Type
Golgi apparatus		A flattened stack of tubular membranes that modifies proteins and packages them for distribution outside the cell	All eukaryotic cells
Lysosome		A vesicle that contains digestive enzymes for the breakdown of excess or worn-out cellular substances	Animal cells and rare in plant cells
Mitochondria		A membrane-bound organelle that makes energy available to the rest of the cell	All eukaryotic cells
Nucleus		The control center of the cell that contains coded directions for the production of proteins and cell division	All eukaryotic cells
Plasma membrane		A flexible boundary that controls the movement of substances into and out of the cell	All cells
Ribosome		Organelle that is the site of protein synthesis	All cells
Vacuole		A membrane-bound vesicle for the temporary storage of materials	Plant cells—one large; rarely animal cells—a few small



Exam Preparation

1) What is a defining structural characteristic of eukaryotic cells?

- A. They lack a distinct cytoplasm.
- B. They contain membrane-bound organelles that perform specific functions.
- C. They are completely devoid of any internal structures.
- D. They do not utilize proteins to carry out cellular activities.

2) Which cellular organelle serves as the primary site for protein synthesis?

- A. Mitochondrion.
- B. Ribosome.
- C. Lysosome.
- D. Vacuole.

3) Which organelle is frequently referred to as the "powerhouse" of the cell due to its role in energy production?

- A. Nucleus.
- B. Endoplasmic reticulum.
- C. Mitochondrion.
- D. Golgi apparatus.

4) Which statement accurately describes the organelle composition of plant and animal cells?

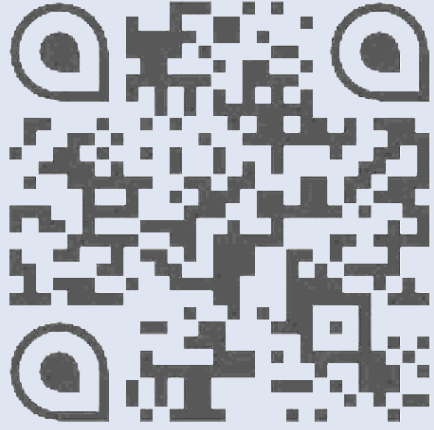
- A. They share many of the same organelles, though certain organelles are unique to each cell type.
- B. They share absolutely no common internal structures or organelles.
- C. Animal cells contain chloroplasts, while plant cells lack them entirely.
- D. Plant cells are prokaryotic, whereas animal cells are eukaryotic.

Module (19): Introduction to plants

	Lesson Title	Page
19-2	Plant Structure and Function	120

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Module (19): Introduction to plants

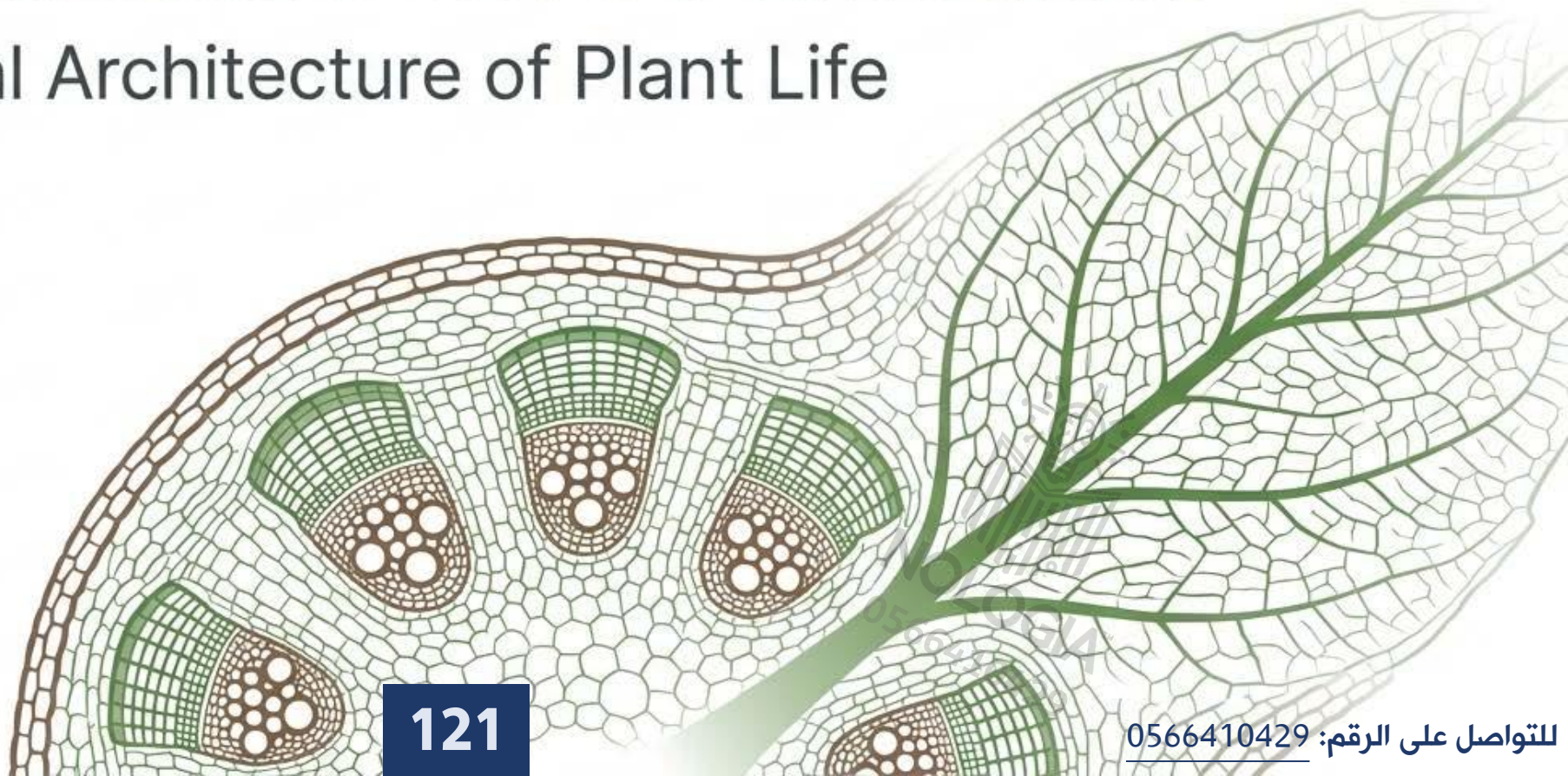
02

Second Lesson: Plant Structure and Function

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Plant Structure and Function

The Hierarchical Architecture of Plant Life



The Hierarchical Blueprint

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Tier 4



Organism & Responses: The Living System

Tropisms and Nastic movements

Tier 3



Organs: The Machinery

Roots, Stems, Leaves

Tier 2



Tissues: The Fabric

Dermal, Vascular, Ground, Meristematic

Tier 1



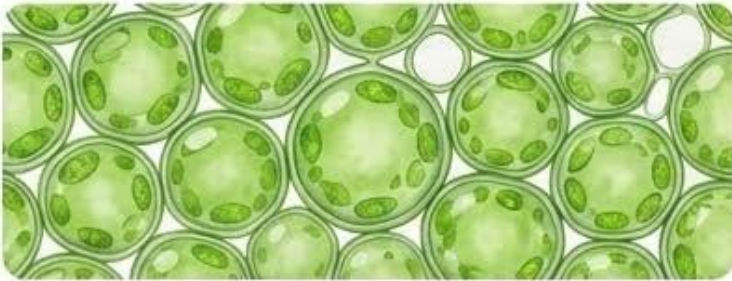
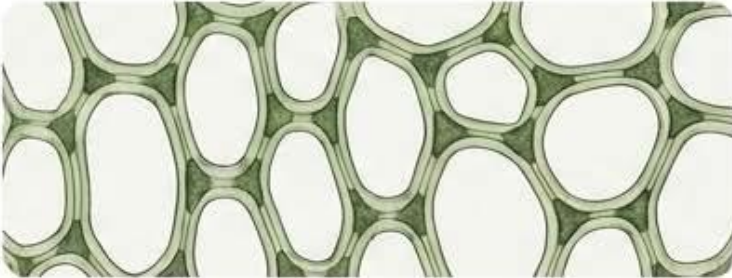
Cells: The Building Blocks

Parenchyma, Collenchyma, Sclerenchyma



Plant Cells: The Fundamental Building Blocks

NOLOGIA

Cell Type	Microscopic Structure	Core Functions
Parenchyma		Storage, Photosynthesis, Gas exchange
Collenchyma		Flexible support, Transport of materials
Sclerenchyma		Rigid support, Lacks cytoplasm at maturity

The Four Plant Tissue Systems

NOLOGIA

Meristematic (Growth)

Regions of rapid cellular division.
Apical meristem (length),
Vascular cambium, and Cork
cambium (diameter).

Dermal (Protection)

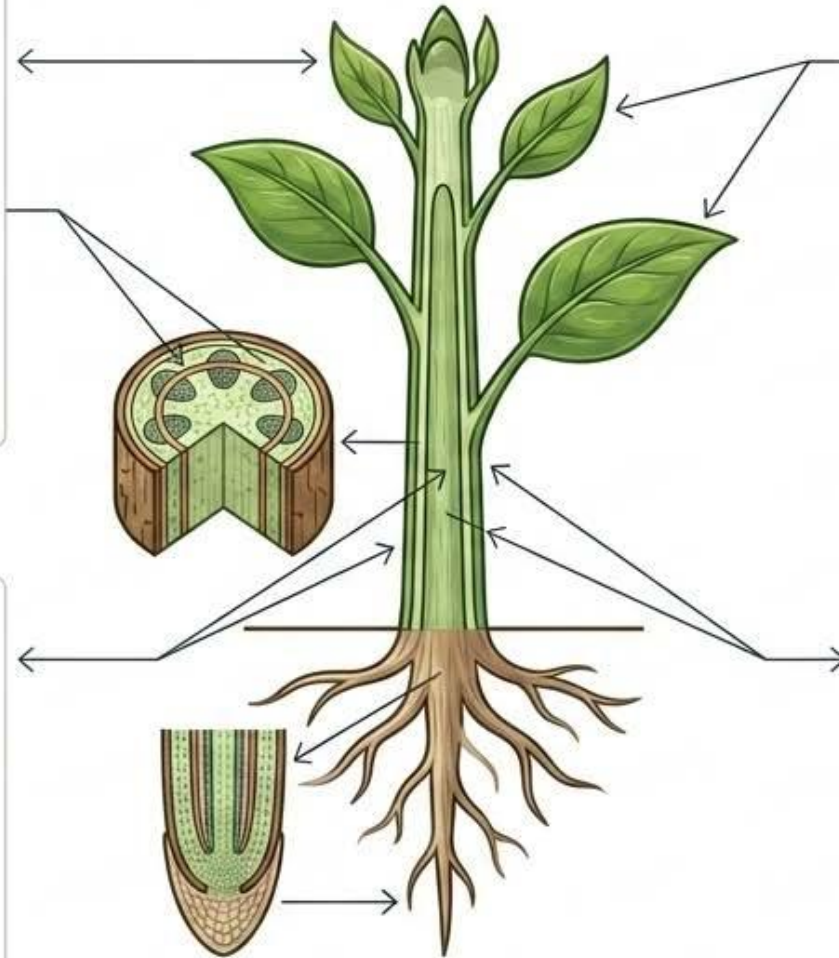
The outer epidermis covering.
Acts as the plant's armor against
water loss and pathogens.

Vascular (Transport)

The internal plumbing system.
Xylem transports water up;
Phloem transports food
throughout.

Ground (Support & Storage)

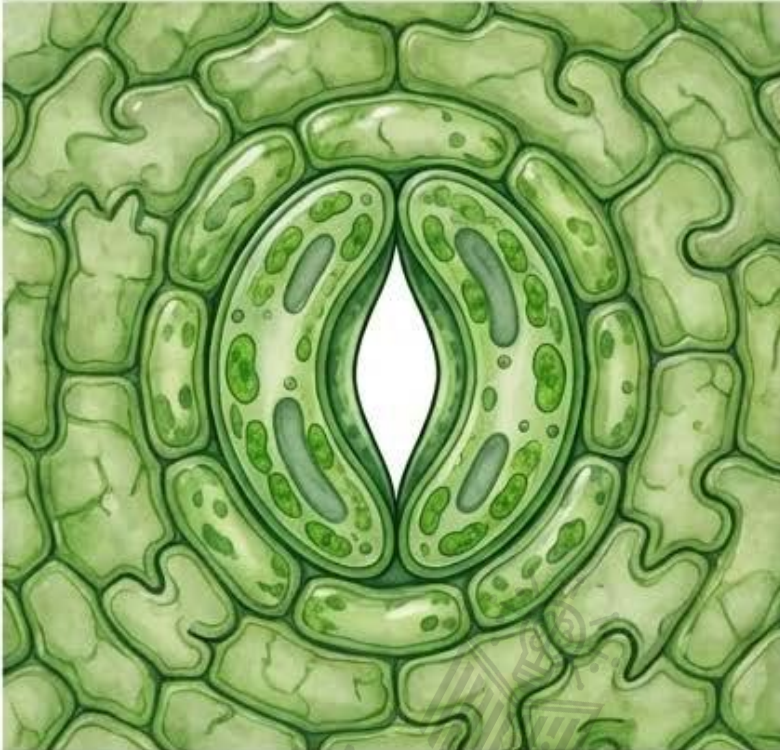
The bulk of the plant mass.
Responsible for photosynthesis,
storage, and structural support.



Dermal Adaptations: The Plant's Armor

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Stomata & Guard Cells



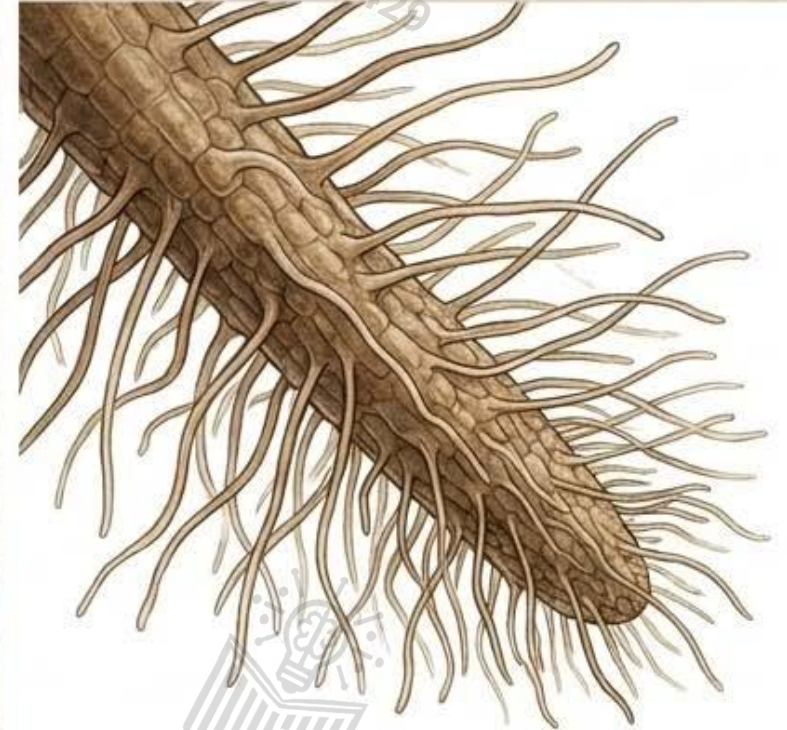
Regulates gas exchange and actively prevents water loss through opening and closing.

Trichomes



Hairlike projections that give a fuzzy appearance, protect against predators, and can contain toxic substances.

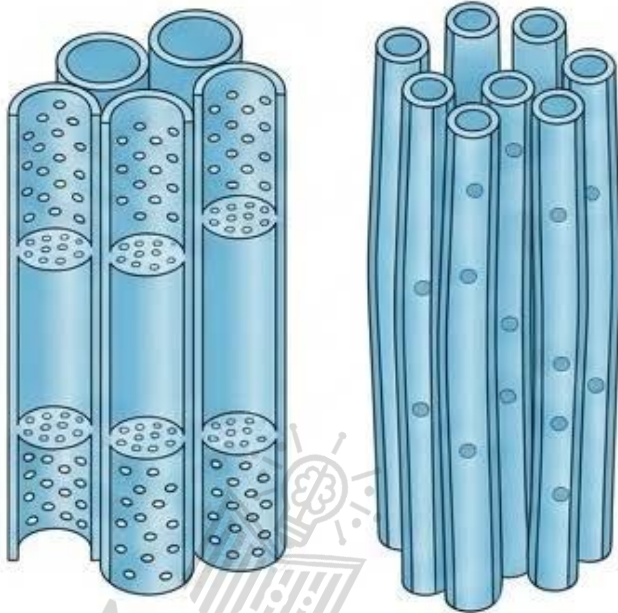
Root Hairs



Fragile extensions of root epidermal cells that exponentially increase surface area for maximum water absorption.

Xylem

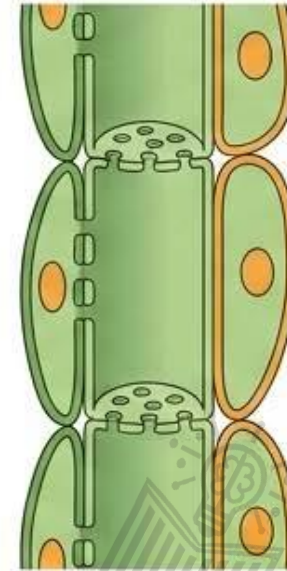
- **Direction:** One-way (Roots to Leaves)
- **Cargo:** Water and dissolved minerals



Lacks cytoplasm at maturity to allow free flow of water.

Phloem

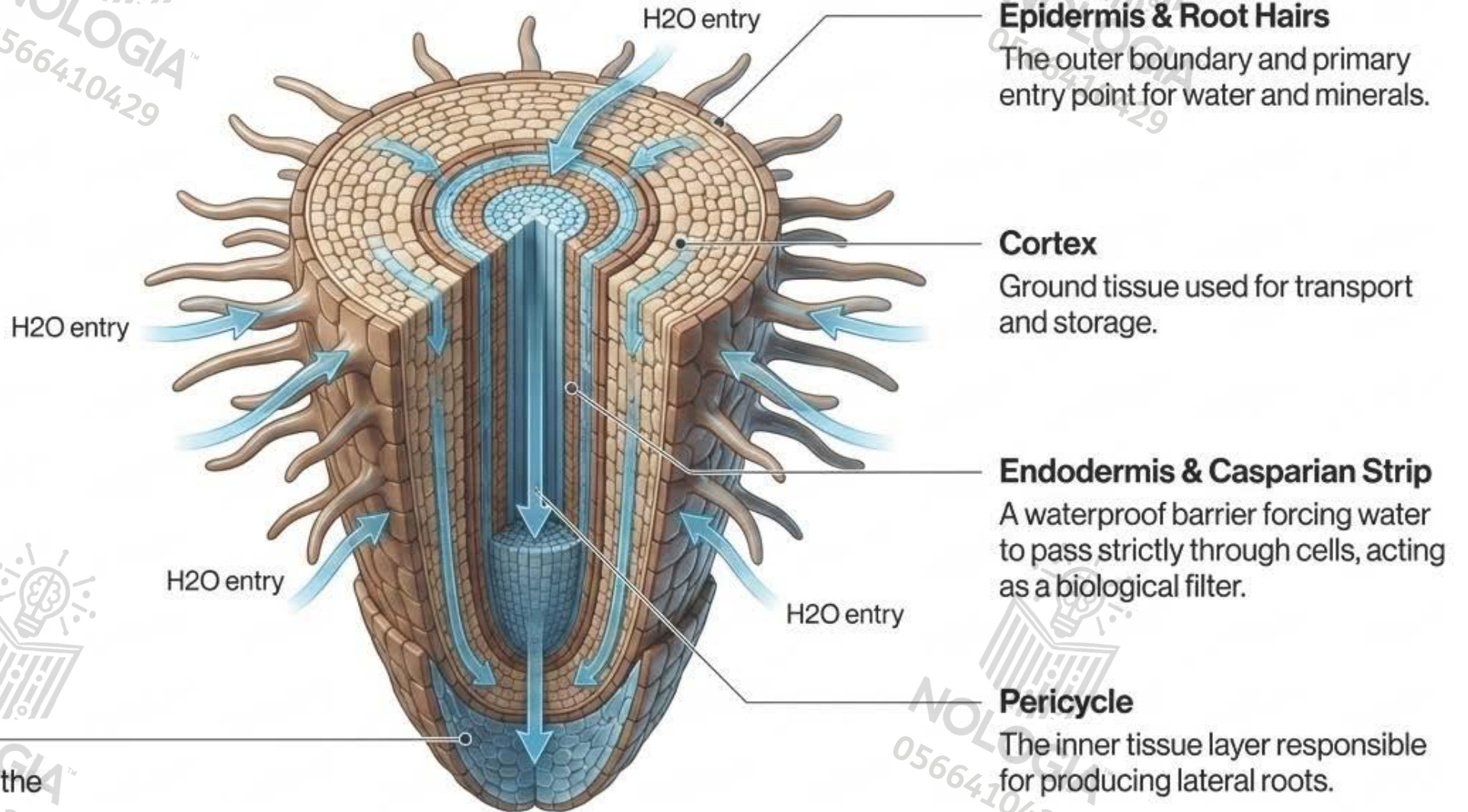
- **Direction:** Two-way transport
- **Cargo:** Dissolved sugars and organic compounds



Sieve tubes contain cytoplasm but no nucleus; paired with nucleus-bearing companion cells.

Root Anatomy: Anchorage and Absorption

NOLOGIA

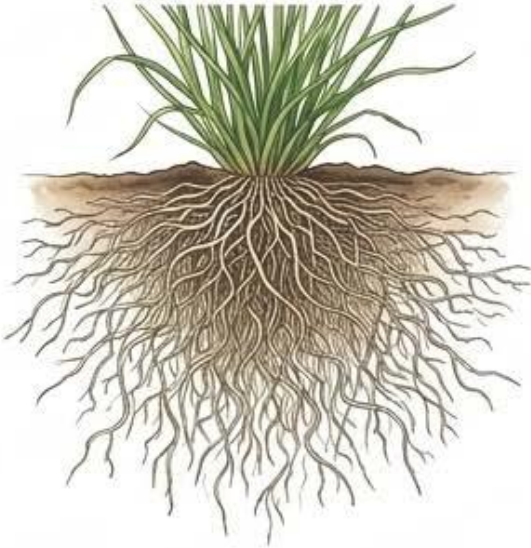


Root Cap

Parenchyma cells protecting the growing apical meristem.

Root Systems and Environmental Adaptations

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Taproot System	Fibrous Root System	Pneumatophores (Modified)	Adventitious (Prop Roots)
			
Function: Deep anchorage, substantial food and water storage.	Function: Rapid water storage, extensive surface-level anchorage.	Function: Supplying vital oxygen to fully submerged root systems.	Function: Providing extra structural support for plant stems in unstable environments.

Stem Structure: Support and Elevation



Herbaceous Stems

Soft, flexible, and green. Chloroplasts are present, meaning the stem is actively capable of photosynthesis. Typical of annual plants.

NOLOGIA



The Annual Ring

Tree age is estimated by counting rings produced by the vascular cambium. Rings indicate high moisture; narrow rings severe drought.

Woody Stems

Sturdy, rigid, and covered in protective bark. Bark acts as corky tissue shielding against physical damage and insect invasion.

Stem Adaptations: Beyond Support



Tuber

Function: Food storage



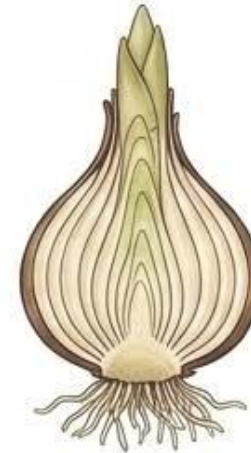
Rhizome

Function: Food storage and asexual reproduction



Runner

Function: Asexual reproduction running horizontally along the ground



Bulb

Function: Food storage within fleshy, compressed leaves

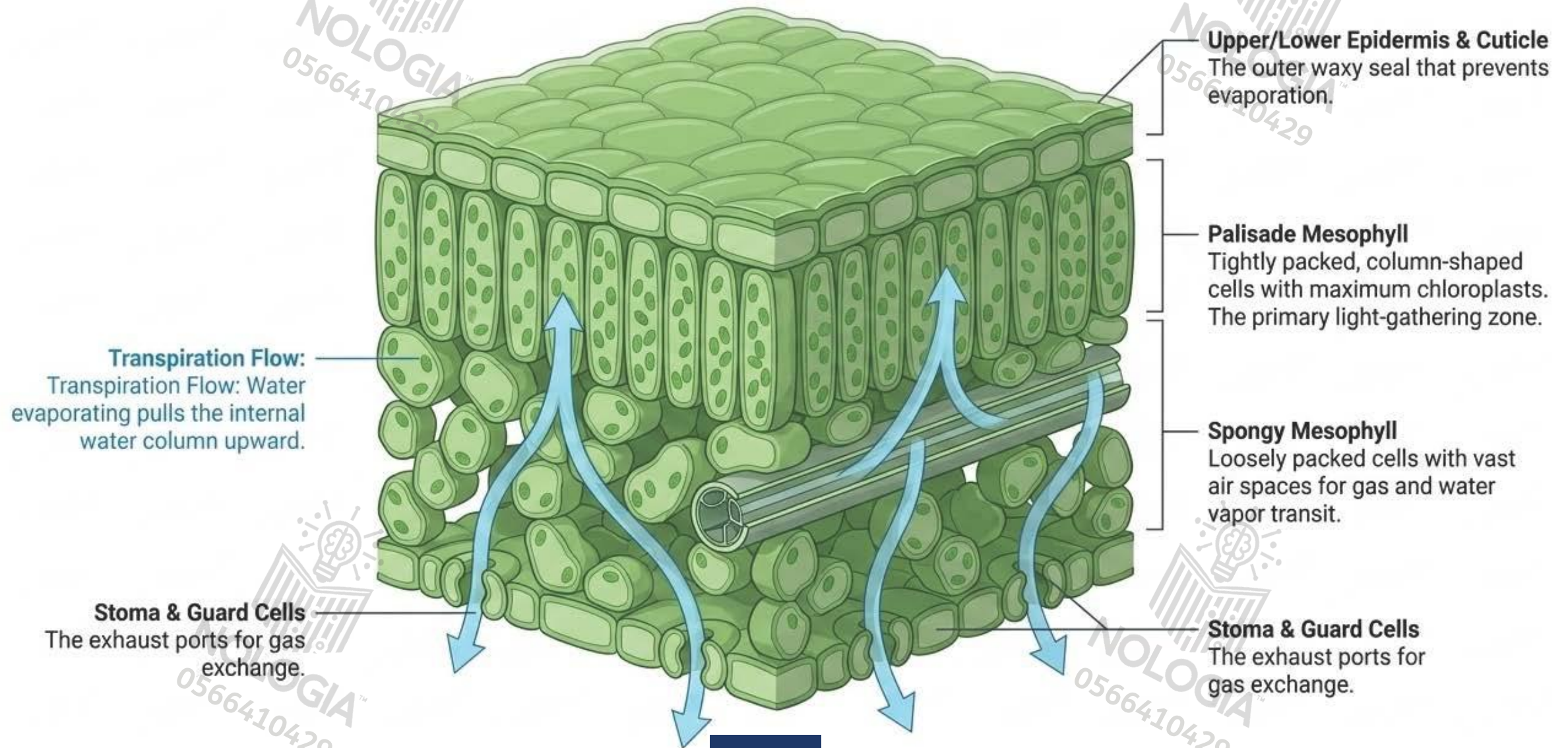


Corm

Function: Food storage composed entirely of solid stem tissue

Leaf Anatomy: The Photosynthesis Engine

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Leaf Classification Taxonomy

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Leaf Type

A



Simple

B



Compound

Leaf Venation

A



Palmate

B



Pinnate

C



Parallel

Leaf Arrangement

A



Opposite

B



Alternate

C



Whorled

Nastic Responses



Definition: Movement that is NOT dependent on the direction of the stimulus.

Characteristics: Not a growth response, fully reversible, and repeatable.

Trigger: Mechanical (e.g., an insect touching hairs).

Tropic Responses (Tropisms)

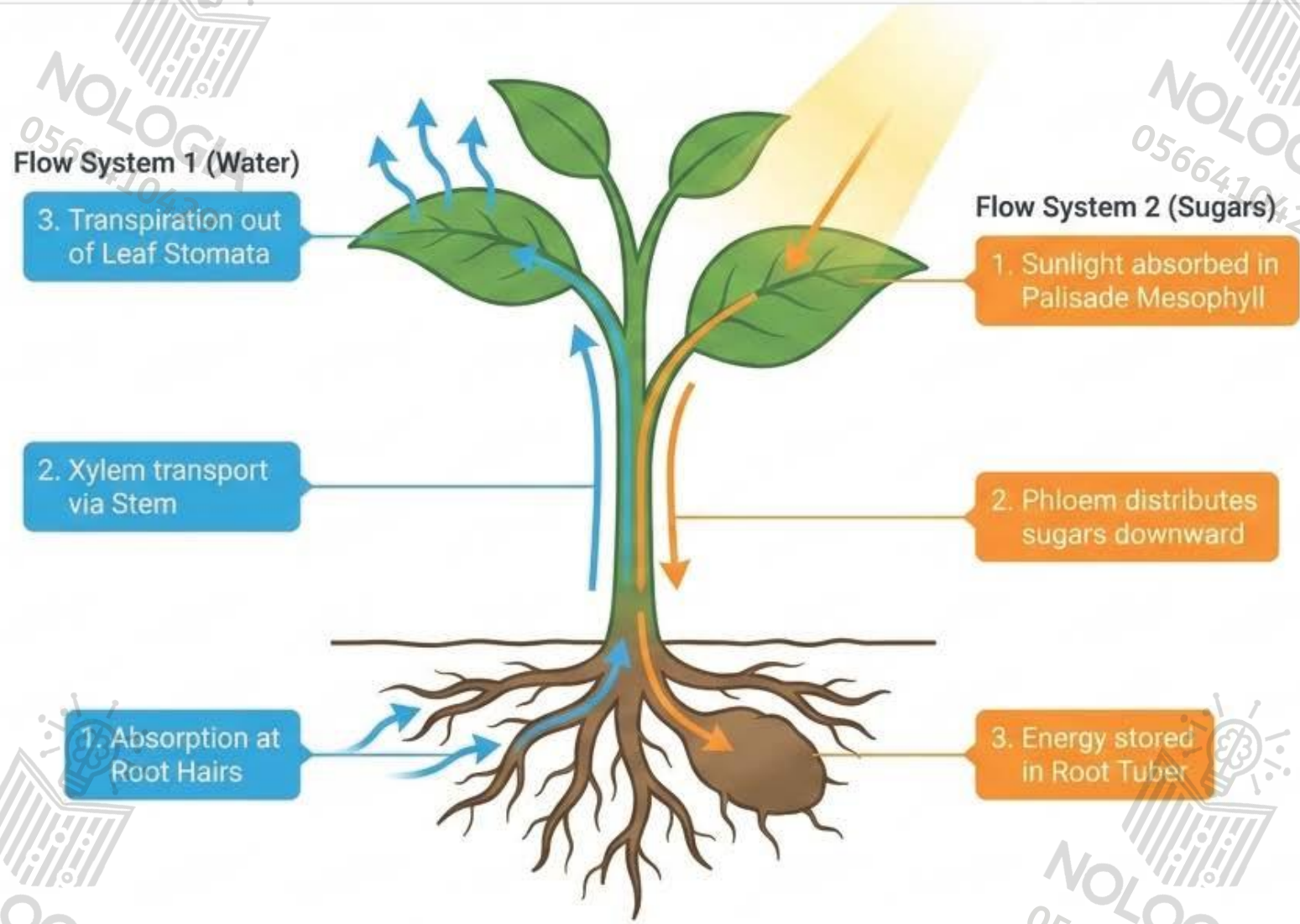


Definition: A plant's biological growth response to an external stimulus.

Characteristics: Directional (Positive = toward stimulus, Negative = away from stimulus), based on cellular growth, permanent.

The Tropism Matrix

Phototropism	Gravitropism	Thigmotropism
		
Stimulus: Light Response: Growth toward the light source (Positive).	Stimulus: Gravity Response: Positive downward growth (roots), Negative upward growth (stems).	Stimulus: Mechanical / Contact Response: Growth toward and around the specific point of contact.



Crosscutting Concept: Energy and Matter — The ultimate takeaway is that all microscopic plant structure is precisely designed for its microscopic systemic function.



Exam Preparation

1) Which of the following correctly lists the primary types of plant tissues?

- A. Epithelial, connective, muscle, and nervous tissues
- B. Meristematic, dermal, vascular, and ground tissues
- C. Xylem, phloem, epidermis, and cortex tissues
- D. Root, stem, leaf, and flower tissues.

2) What are the three main organs of a plant?

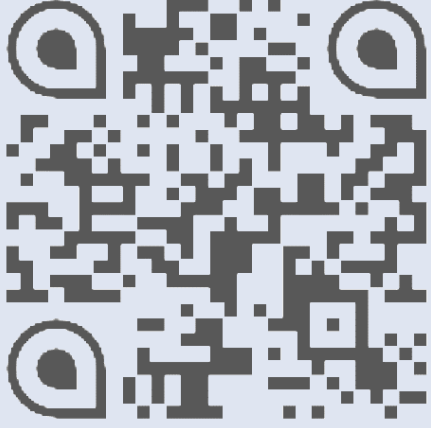
- A. Seeds, cones, and flowers.
- B. Chloroplasts, cell walls, and vacuoles.
- C. Roots, stems, and leaves.
- D. Xylem, phloem, and cambium.

3) How do nastic plant responses differ from tropisms?

- A. Nastic responses are permanent structural changes, while tropisms are temporary.
- B. Nastic responses depend on the direction of the stimulus, while tropisms do not.
- C. Nastic responses occur only in roots, while tropisms occur only in leaves.
- D. Nastic responses are independent of the direction of the stimulus, while tropisms are directional responses.

4) The overall structural design of plant cells and tissues is most directly adapted to support their:

- A. Microscopic size.
- B. Specific function.
- C. Ability to move.
- D. Total mass.



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تكون هذه الملزمة قد حققت
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