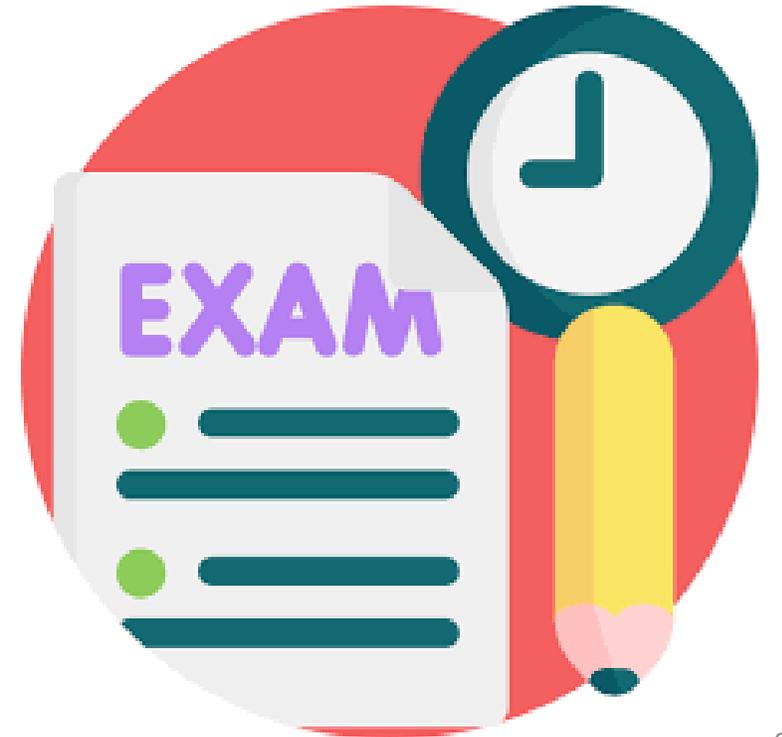


Biology

preparing students for exams

General instructions:

- The exam is evaluated from 0 to 200 points.
- The exam is based on 30 questions, 25 multiple-choice and 5 essay questions.
- Each multiple-choice question is marked out of 5.0 points and each essay question is marked out of 15.0 points.
- Only a blue or black pen may be used.
- The use of a broker is not allowed.
- All questions must be answered on the exam sheet.
- The exam lasts 90 minutes.



Exam structure:

| Type of knowledge and skills | Quote | |
|---|-------------|--------------|
| Diversity in the Biosphere | 20.0 points | 200.0 points |
| Transformation and use of energy by living beings | 20.0 points | |
| Regulation in living beings | 40.0 points | |
| Cell growth and renewal | 20.0 points | |
| Reproduction | 20.0 points | |
| Biological evolution | 40.0 points | |
| Systematics of living beings | 20.0 points | |

Exam date: 05/02/2026 (Thursday) at 3:00 pm



Model Exam resolution



1. Carefully read the following text:

Some antibiotics work by activating cellular respiration, which leads to the production of free radicals (oxidizing toxic substances). These radicals can cause the death of bacteria through the destruction of proteins, lipids, and DNA.

In four unrelated bacterial species, *Bacillus anthracis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*, the enzymes of the hydrogen sulphide (H₂S) synthesis pathway were inactivated, either chemically or by mutation of their genes. In the bacteria that underwent these procedures, the production of H₂S was inhibited. These bacteria survived with great difficulty in the presence of antibiotics.

Subsequently, the mutated strain of *E.coli* (inhibited from the production of H₂S) and the wild strain of *E.coli* (non-mutated and producing H₂S) were subjected to the action of three different antibiotics. It was found that, in bacteria unable to produce hydrogen sulfide, the DNA was cut into fragments.

The recent sequencing of numerous bacterial genomes has changed the idea that H₂S would be an excretory product since this substance can block the formation of free radicals and can also stimulate the activity of antioxidant enzymes.

1.1. The hypothesis being tested in these experiments was that

- (A) the free radicals produced cause the death of bacteria.
- (B) hydrogen sulfide compromises the effectiveness of antibiotics.
- (C) enzymes are necessary for the production of hydrogen sulfide.
- (D) antibiotics prevent the production of hydrogen sulfide.

ANSWER

To identify the hypothesis, we must look at what the researchers were trying to prove by manipulating the variables (the "cause and effect" relationship):

1.The Observation: Some antibiotics kill bacteria by creating toxic free radicals.

2.The Variable: The researchers inhibited the production of H₂S in several species.

3.The Result: When H₂S was absent, the bacteria "survived with great difficulty" and their DNA was destroyed by the antibiotics. When H₂S was present (wild strain), they were better protected.

4.The Conclusion: H₂S acts as a shield by blocking free radicals and stimulating antioxidant enzymes.

Therefore, the experiment was designed to test if **H₂S interferes with or weakens (compromises) the way antibiotics work.**

Why the other options are incorrect:

- **(A)** This is a **known fact** stated at the beginning of the text, not the specific hypothesis being tested by the H₂S manipulation.
- **(C)** This is a **biological requirement** for the synthesis to happen, but the experiment's goal wasn't just to prove enzymes make H₂S; it was to see what H₂S *does* in the presence of antibiotics.
- **(D)** This is **factually contradicted** by the text. The antibiotics don't prevent H₂S production; rather, the researchers manually inhibited H₂S to see if the antibiotics became more effective.

1.2. According to the data, hydrogen sulphide can act

- (A) increasing ATP production.
- (B) inhibiting antioxidant enzymes, which activate cellular respiration.
- (C) inhibiting cell multiplication.
- (D) activating enzymes that facilitate the destruction of free radical.

ANSWER

The final paragraph of the text provides the direct evidence for this conclusion:

"...this substance [H₂S] can block the formation of free radicals and **can also stimulate the activity of antioxidant enzymes.**"

Analysis of the Mechanism:

- **Antioxidant Enzymes:** These are biological catalysts specifically designed to neutralize (destroy) harmful oxidizing agents like free radicals.
- **Activation:** The text states H₂S "stimulates" these enzymes. In biological terms, stimulating or activating these enzymes increases the rate at which they break down toxic substances.
- **The Result:** By activating these enzymes, H₂S helps protect the bacteria's DNA, lipids, and proteins from the oxidative stress caused by the antibiotics.

Why the other options are incorrect:

- **(A):** While antibiotics may work by *activating* cellular respiration (which relates to ATP production), the text does not state that H₂S increases ATP production. Its role is protective, not metabolic.
- **(B):** The text states H₂S **stimulates** (activates) antioxidant enzymes; it does not inhibit them. Inhibiting them would make the bacteria more vulnerable, which is the opposite of what H₂S does.
- **(C):** There is no mention in the text regarding H₂S affecting the rate of cell division or multiplication; the focus is strictly on the survival/death mechanism via free radical management.

1.3. Antibiotics act on DNA, whose molecule has a

(A) $(A + T) / (C + G) = 1$, cutting it into fragments by an oxidation process.

(B) $(A + T) / (C + G) = 1$, cutting it into fragments by a reduction process.

(C) $(A + C) / (T + G) = 1$, cutting it into fragments by an oxidation process.

(D) $(A + C) / (T + G) = 1$, cutting it into fragments by a reduction process.

ANSWER

This question combines knowledge of **DNA chemistry (Chargaff's Rules)** with the information provided in the text.

1. The DNA Chemistry (Chargaff's Rules)

In a double-stranded DNA molecule, base pairing is specific: **Adenine (A)** always pairs with **Thymine (T)**, and **Cytosine (C)** always pairs with **Guanine (G)**.

- Therefore, $A = T$ and $C = G$.
- This means the total number of **Purines** ($A + G$) must equal the total number of **Pyrimines** ($T + C$).
- By rearranging the math: $(A + C) = (T + G)$.
- Thus, the ratio $\{A + C\} / \{T + G\} = 1$.

Note on Option A/B: The ratio $(A + T) / (C + G)$ is usually **not** equal to 1. This ratio varies between species (it is known as the "DNA base ratio") because the amount of A-T pairs does not have to equal the amount of C-G pairs.

2. The Process (Oxidation vs. Reduction)

The text explicitly states how the damage occurs:

- Antibiotics lead to the production of **free radicals**.
- The text describes these radicals as "**oxidizing** toxic substances."
- Oxidation is the process that leads to the destruction of proteins, lipids, and the fragmentation of DNA mentioned in the *E. coli* experiment.

1.4. The bacteria that produce H_2S have, in relation to those that do not produce this gas,

(A) increased resistance to antibiotics.

ANSWER

(B) lower respiratory activity.

(C) increased respiratory activity.

(D) less resistance to antibiotics.

Reasoning based on the provided text:

1. Protective Role of H_2S : The text explains that H_2S can "block the formation of free radicals" and "stimulate the activity of antioxidant enzymes".

2. Survival Statistics: In the experiments, bacteria where H_2S production was inhibited (the "non-producers") survived with "**great difficulty**" in the presence of antibiotics and suffered DNA fragmentation.

3. Comparison: Conversely, the "wild strain" (the H_2S producers) did not suffer the same level of damage. Therefore, the ability to produce H_2S provides a biological defense mechanism that allows the bacteria to withstand the oxidative stress caused by antibiotics, effectively **increasing their resistance**.

Why the other options are incorrect:

(B) and (C): While the text mentions that antibiotics *work* by activating cellular respiration, it does not provide data comparing the baseline respiratory rates of H₂S–producing bacteria versus non-producers. The primary focus of the data is the **survival/resistance** outcome.

(D): This contradicts the experimental results. The bacteria *unable* to produce H₂S were the ones that died more easily (less resistant).

1.5. Some antibiotics act on membrane proteins responsible for the active transport of Na^+ and K^+ ions, directly interfering

- (A) in the diffusion of these ions through the phospholipid bilayer.
- (B) in the diffusion of ions through proteins such as permeases.
- (C) maintenance of the concentration difference between intra and extracellular media.
- (D) in the maintenance of isotony that occurs between the intra and extracellular environments.

ANSWER

To understand why this is the correct answer, we must analyze the mechanism of **active transport** and its role in cell biology.

1. Understanding Active Transport

Active transport is the process by which cells move ions or molecules **against** their concentration gradient (from an area of lower concentration to an area of higher concentration).

- **Energy Requirement:** This process requires energy, usually in the form of ATP.
- **The Goal:** It is used to create and maintain specific concentration gradients that are essential for life. For example, cells naturally keep **Na⁺ concentration high outside** the cell and **K⁺ concentration high inside** the cell.

2. Why the "Maintenance of Difference" is Key

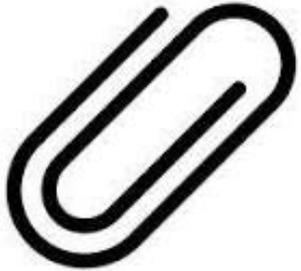
The proteins mentioned in the question (often called the Sodium-Potassium Pump or Na⁺/K⁺-ATPase) work constantly to ensure that these gradients do not disappear.

- If an antibiotic interferes with these proteins, the "pump" stops working.
- Without the pump, the concentrations would eventually equalize due to passive leakage.
- Therefore, the antibiotic directly interferes with the **maintenance of the concentration difference** between the inside and outside of the cell.

Why the other options are incorrect:

(A) and (B): These refer to **diffusion** (passive transport). Diffusion occurs through the phospholipid bilayer or via channel proteins/permeases *without* the use of energy. Active transport proteins are distinct from the mechanisms that facilitate diffusion.

(D): Isotony describes a state where the concentration is already equal on both sides. Active transport exists specifically to prevent isotony for these specific ions; it maintains **anisotony** (a state of difference) to allow for cellular functions like nerve impulses or osmotic regulation.



ADDITIONAL INFORMATION

[How Antibiotic Resistance Works | Kurzgesagt](#)

This video explains how bacteria develop antibiotic resistance through natural selection

[Antibiotic Resistance Explained | Khan Academy](#)

A clear explanation of antibiotic resistance mechanisms in bacteria

[Why Antibiotics Don't Work on Viruses | Osmosis](#)

Explains the difference between viruses and bacteria, and why antibiotics don't work on viruses



1.6. The gene expression for the synthesis of the antioxidant enzymes referred to in the text

- (A) implies the translation of mRNA in the rough endoplasmic reticulum.
- (B) implies the transcription of DNA into pre-messenger RNA molecules.
- (C) implies the transcription of DNA to deoxyribonucleotide molecules.
- (D) implies the translation of the RNA codon sequence by ribosomes.

ANSWER

To arrive at this answer, we must look at the standard process of **Gene Expression** in the context of the organisms mentioned (bacteria).

1. What are Antioxidant Enzymes?

Enzymes are **proteins**. The synthesis of any protein involves two main stages:

- **Transcription:** DNA is used as a template to create mRNA.
- **Translation:** Ribosomes read the mRNA sequence to assemble a chain of amino acids.

2. Why Option (D) is Correct

The text mentions that H₂S "can also stimulate the activity of antioxidant enzymes." For these enzymes to exist and function, the genetic code carried by the **mRNA** (in the form of **codons**) must be **translated** into a functional protein by **ribosomes**. This is the final step in gene expression that actually produces the enzyme molecule.

Why the other options are incorrect:

(A): This is a trap regarding **cell type**. The bacteria mentioned in the text (*E. coli*, *S. aureus*, etc.) are **prokaryotes**. Prokaryotes do **not** have a rough endoplasmic reticulum or any membrane-bound organelles. Their translation occurs on free-floating ribosomes in the cytoplasm.

(B): While transcription does occur, the term "**pre-messenger RNA**" (and the subsequent splicing process) is a characteristic of **Eukaryotes**. In Prokaryotes (bacteria), the mRNA is usually produced in its final form and can even begin translation while it is still being transcribed.

(C): This is biologically incorrect. Transcription is the synthesis of **RNA** (ribonucleotides) from a **DNA** template. Transcription does not produce **deoxyribonucleotide** molecules; those are the building blocks of DNA itself, used during DNA replication.

In molecular biology, the flow of genetic information follows the central dogma: DNA → RNA → Protein

This process involves transcription (DNA to mRNA) and translation (mRNA to protein)

mRNA Codons and Translation

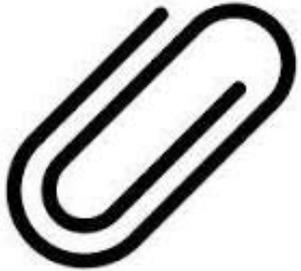
- Messenger RNA (mRNA) carries the genetic code from DNA to the ribosome, where proteins are synthesized. The mRNA sequence is read in sets of three nucleotides, known as codons, each specifying a particular amino acid. For example, the codon AUG codes for the amino acid methionine and also serves as the start signal for translation
- During translation, ribosomes read the mRNA codons sequentially, and transfer RNA (tRNA) molecules bring the corresponding amino acids. These amino acids are linked together to form a polypeptide chain, which folds into a functional protein

Substitution Mutations

A substitution mutation occurs when a single nucleotide in the DNA sequence is replaced by another. This change can lead to different outcomes in the resulting protein:

- **Silent Mutation:** The altered codon still codes for the same amino acid, resulting in no change to the protein's function
- **Missense Mutation:** The new codon codes for a different amino acid, which may affect the protein's function, depending on the role of the altered amino acid
- **Nonsense Mutation:** The substitution creates a stop codon, leading to premature termination of the protein, which is often nonfunctional

These mutations can have varying effects on an organism, from benign to causing diseases, depending on the importance of the affected protein



ADDITIONAL INFORMATION

[Mutations and Translation](#)

This video explains how mutations, including substitution mutations, affect the process of translation and protein synthesis

[The Different Types of Mutations](#)

Khan Academy provides a detailed overview of various mutation types and their impacts on proteins

[Identifying a Substitution Mutation](#)

This video guides viewers through the process of recognizing substitution mutations in DNA sequences



1.7. Match each of the descriptions of enzyme synthesis in Column I with the corresponding designation in Column II.

| Column I | Column II |
|--|--------------------|
| (a) A molecule having a ribonucleotide sequence complementary to a codon. | (1) DNA polymerase |
| | (2) Gene |
| (b) Polyribonucleotide that contains information for the synthesis of a polypeptide. | (3) mRNA |
| | (4) tRNA |
| (c) Deoxyribonucleotide sequence that contains information for the synthesis of an enzyme. | (5) rRNA |

1.8. Why is understanding food webs important in the context of human health and disease ecology?

- (A) It helps identify which animals are most nutritious for human consumption.
- (B) It allows for better agricultural crop yield predictions.
- (C) It explains how food preferences evolve in different cultures.
- (D) It aids in predicting how disruptions in ecosystems can influence the spread of zoonotic diseases.

ANSWER

Understanding food webs is a cornerstone of Disease Ecology, a field that studies how interactions between hosts, pathogens, and their environment lead to disease outbreaks.

1. The Dilution Effect and Biodiversity

A healthy, complex food web often acts as a buffer against disease. For example, if an ecosystem has high biodiversity, a pathogen (like the bacteria causing Lyme disease) might spend its time in "dead-end" hosts that don't pass the disease back to humans.

- Disruption: When a food web is simplified (e.g., losing top predators), certain "reservoir" species (like mice or rats) may overpopulate, increasing the risk of zoonotic spillover—where a disease jumps from animals to humans.

2. Bioaccumulation and Biomagnification

Food webs help us track how toxins move through the environment.

- The Process: Substances like mercury or certain pesticides are not easily excreted by organisms. As they move up the food chain, from plankton to small fish to large predators, the concentration increases.
- Human Health: Humans at the top of these food webs can ingest dangerous levels of these substances, leading to chronic health issues.

3. Trophic Cascades and Vectors

When a predator is removed from a food web (a trophic cascade), it can lead to an explosion in the population of disease vectors (organisms that carry pathogens, like mosquitoes or ticks).

- Example: If a pond loses fish that eat mosquito larvae, the mosquito population surges, directly increasing the transmission rates of diseases like Malaria, Zika, or West Nile Virus to nearby human populations.

Why the other options are incorrect:

(A): While nutritional science is important, it focuses on biochemistry and dietetics rather than the **ecological interactions** that define a food web.

(B): Agricultural yield is primarily a matter of soil science, meteorology, and pest management. While pests are part of a food web, the primary goal of studying food webs in health is not commercial output.

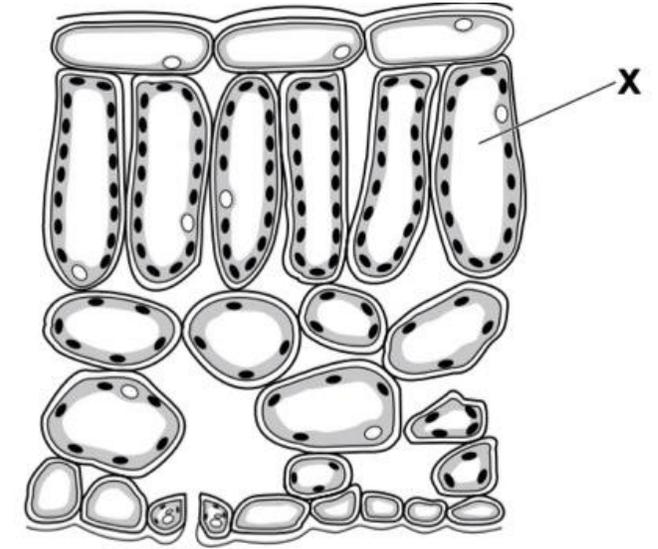
(C): Cultural food preferences are a subject of **anthropology and sociology**, not ecology or disease dynamics.

2. The diagram shows a cross-section of part of a leaf.

2.1. What is the name of the cell labelled X?

- (A) Epidermal cell
- (B) Guard cell
- (C) Palisade mesophyll cell
- (D) Spongy mesophyll cell

ANSWER



2.2. Which part of a plant cell controls the movement of substances into and out of the cell?

- (A) Cell membrane

ANSWER

- (B) Cell wall
- (C) Cytoplasm
- (D) Vacuole

3. Analyze the figure below and choose the most correct option, marking it with an X, for the legend of the same:

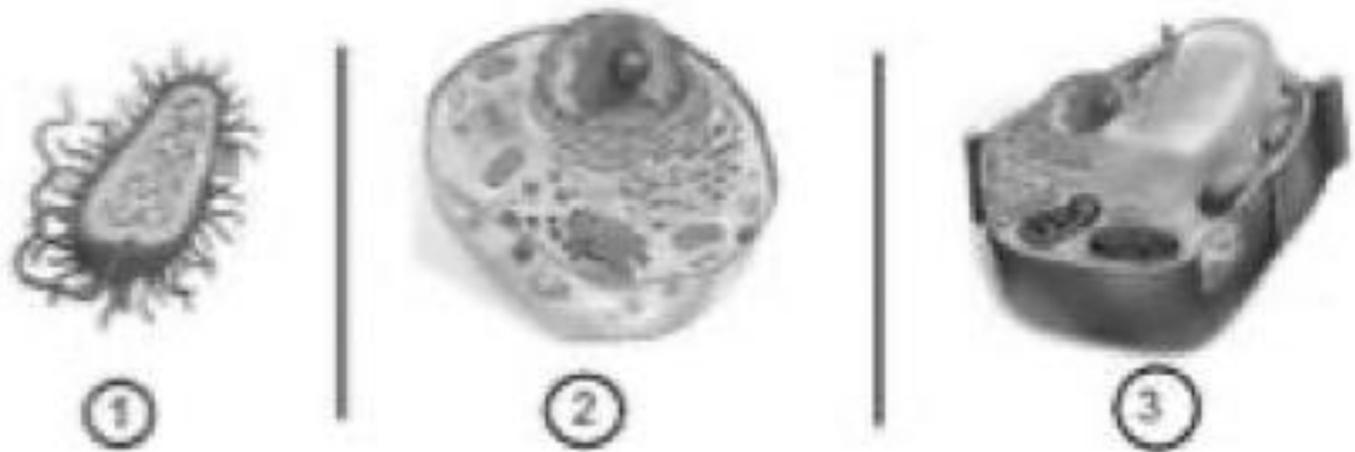
(A) 1. Plant cell; 2. Animal cell; 3. Bacterial cell

(B) 1. Bacterial cell; 2. Animal cell; 3. Plant cell

(C) 1. Animal cell; 2. Animal cell; 3. Plant cell

(D) 1. Bacterial cell; 2. Plant cell; 3. Animal cell

ANSWER



4. Consider the following statements:

I. Biological molecules with energy reserve function.

II. Biological molecules that store the cell's genetic information.

III. Biological molecules with cellular structure and defense function.

IV. Biological molecules with immediate energetic function.

The molecules referred to in each sentence are:

(A) I - Lipids; II - Nucleic acids; III - Proteins; IV - Carbohydrates

(B) I - Carbohydrates; II - Proteins; III - Lipids; IV - Nucleic acids

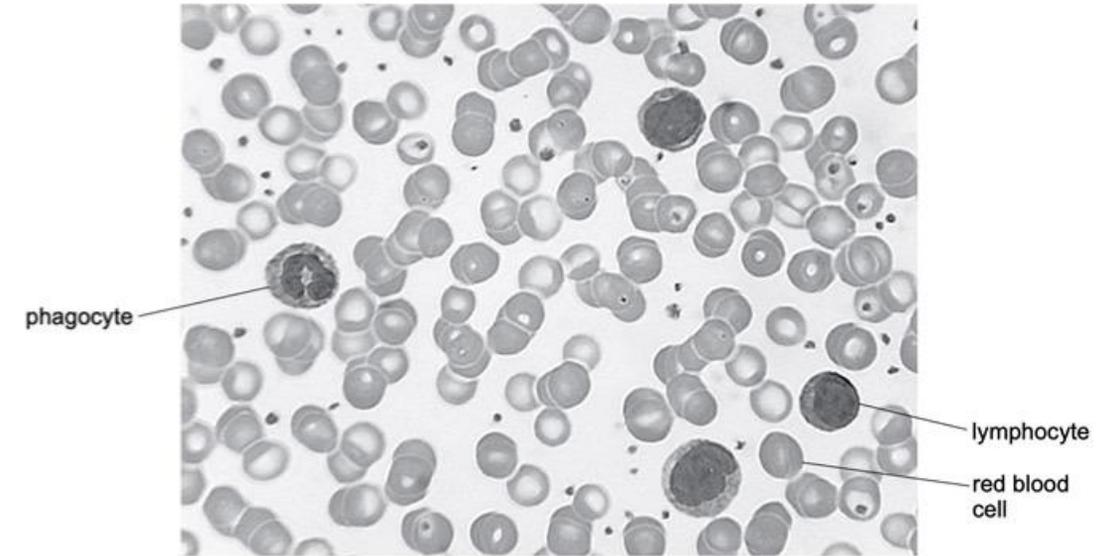
(C) I - Proteins; II - Carbohydrates; III - Nucleic acids; IV - Lipids

(D) I - Nucleic acids; II - Lipids; III - Carbohydrates; IV – Proteins

ANSWER

5. The figure shows a photomicrograph of human blood.

5.1. Describe the differences in appearance and the functions of the three cells labelled in the figure.



red blood cell:

appearance: biconcave (disc / shape) / no nucleus / red blood cells smaller than (named) white blood cell(s) / or

function: transports oxygen

lymphocyte:

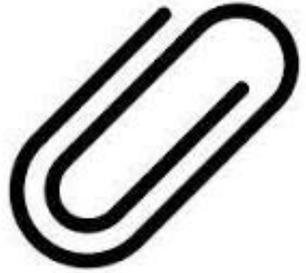
appearance: little cytoplasm / large(r) nucleus / nucleus fills most of the cell

function: ref. to active immunity / responds to, antigen(s) or vaccine(s) / produces antibodies / ref. to memory cells

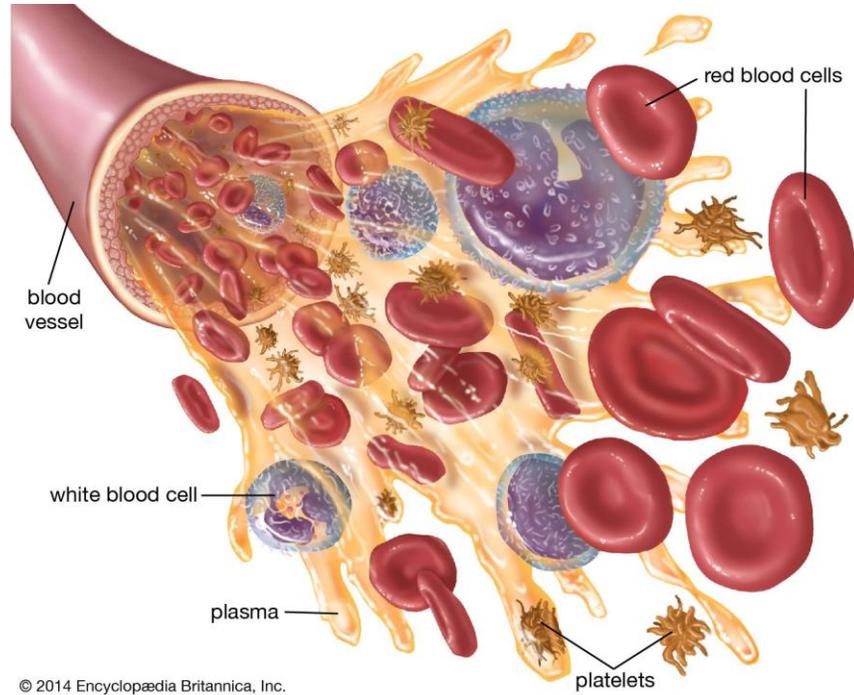
phagocyte:

appearance: lobed / irregular-shaped / C-shaped / AW, nucleus

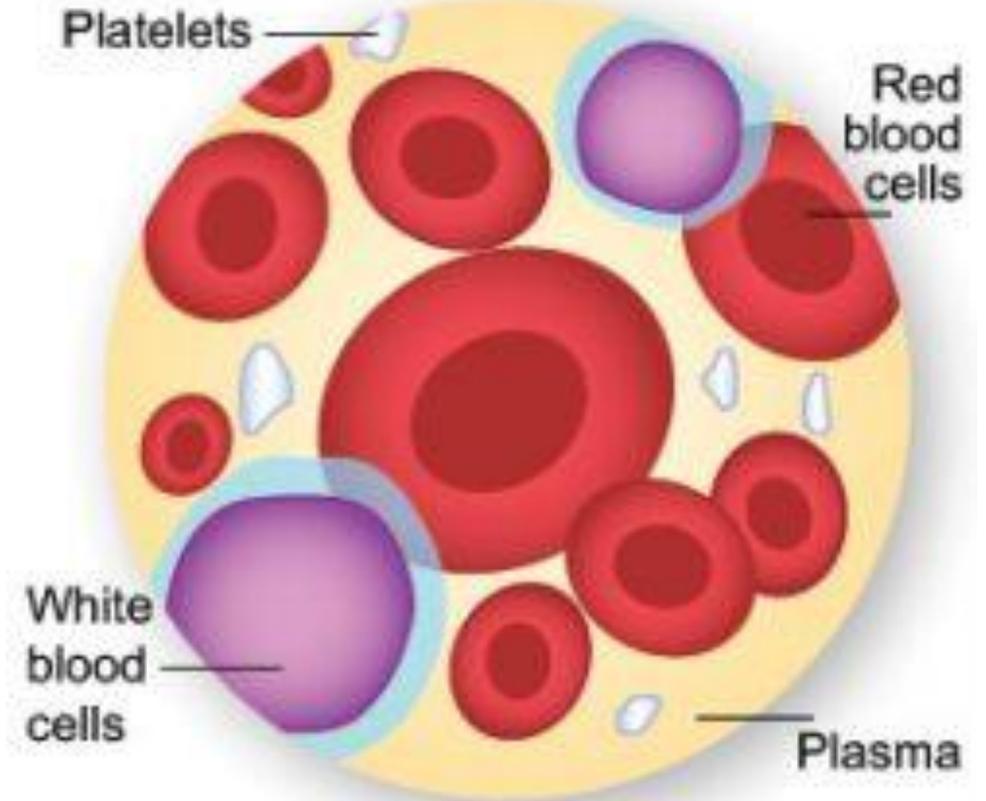
function: engulf pathogens / phagocytosis / AW

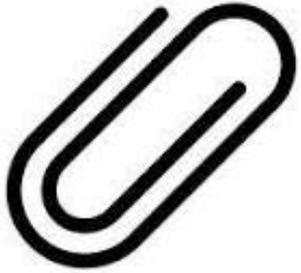


ADDITIONAL INFORMATION



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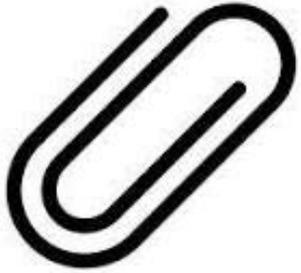
ADDITIONAL INFORMATION



Platelets, or thrombocytes, are small, anucleate cell fragments in the blood primarily known for their role in hemostasis, stopping bleeding by forming clots. However, they also play a crucial role in the immune system, contributing to disease prevention through various mechanisms.

Immune Functions of Platelets

- 1. Pathogen Detection and Clearance:** Platelets express pattern recognition receptors (PRRs) that allow them to identify and bind to pathogens such as bacteria and viruses. Upon recognition, they can directly neutralize these invaders or facilitate their clearance by other immune cells
- 2. Recruitment of Immune Cells:** Activated platelets release a variety of signaling molecules, including cytokines and chemokines, which attract and activate leukocytes (white blood cells) to sites of infection or injury, enhancing the body's immune response
- 3. Formation of Platelet-Leukocyte Aggregates:** Platelets can form complexes with leukocytes, known as platelet-leukocyte aggregates (PLAs), which facilitate communication between these cells and amplify inflammatory responses necessary for combating infections
- 4. Secretion of Antimicrobial Agents:** Platelets contain granules that store antimicrobial peptides and proteins. Upon activation, they release these substances to directly kill or inhibit the growth of pathogens
- 5. Modulation of Adaptive Immunity:** Beyond innate immunity, platelets influence adaptive immune responses by interacting with lymphocytes and presenting antigens, thereby aiding in the development of long-term immunity



ADDITIONAL INFORMATION



[Platelets and the Immune System](#): This video provides an overview of how platelets contribute to immune responses

[The Role of Platelets in Immunity](#): An in-depth look at the mechanisms by which platelets interact with pathogens and immune cells

5.2. Blood plasma transports many substances including excretory products and hormones.

Identify the names of two excretory products in humans:

(A) Carbon dioxide and Urea

(B) Amino acids and Cellulose

(C) Urea and Oxygen

(D) Glucose and Lipase

ANSWER

Excretion is the biological process by which an organism eliminates **metabolic waste products** – substances produced by chemical reactions inside cells that would be toxic if allowed to accumulate.

1. Carbon Dioxide (CO₂)

- **Source:** It is produced as a byproduct of **cellular respiration** in every living cell.
- **Transport:** It diffuses out of the cells into the blood plasma (mostly as bicarbonate ions) and is carried to the lungs.
- **Elimination:** It is excreted from the body during exhalation.

2. Urea

- **Source:** Produced in the **liver** during the breakdown of excess amino acids (a process called deamination).
- **Transport:** It is dissolved in the blood plasma and transported to the kidneys.
- **Elimination:** The kidneys filter the urea out of the blood and incorporate it into urine for excretion.

Why the other options are incorrect:

- **(B) Amino acids and Cellulose:** Amino acids are nutrients (the building blocks of proteins), not waste. Cellulose is a fiber found in plant cell walls; while humans cannot digest it and it leaves the body as feces, it is technically **egestion** (undigested food) rather than **excretion** (metabolic waste).
- **(C) Urea and Oxygen:** Urea is an excretory product, but **oxygen** is a reactant for respiration that we take *in*, not a waste product we excrete.
- **(D) Glucose and Lipase:** Glucose is a vital sugar used for energy. **Lipase** is a digestive enzyme (a protein) secreted into the gut to break down fats. Neither of these are waste products.

6. The cholera bacterium toxin causes dehydration and loss of salts from the blood in humans.

Which statement explains the reason for this?

(A) Chloride ions are secreted into the small intestine which causes water to move into the intestine by osmosis.

(B) Chloride ions are secreted into the small intestine which causes water to move out of the intestine by osmosis.

(C) Chloride ions are secreted into the small intestine where they increase the water potential.

ANSWER

(D) Chloride ions are secreted into the small intestine which causes the water potential of the blood to decrease.

Cholera is caused by the bacterium *Vibrio cholerae*. The primary symptom is severe, watery diarrhea (often called "rice-water stool"), which happens because of a specific disruption in the physiology of the small intestine.

1. Secretion of Chloride Ions (Cl⁻)

The cholera toxin binds to the cells lining the small intestine (enterocytes) and triggers a series of chemical signals. These signals force the cells to actively pump **chloride ions** out of the cells and into the **lumen** (the open space inside the intestine).

2. Water Potential and Osmosis

High Solute Concentration: The sudden influx of chloride ions into the intestinal lumen makes the fluid inside the gut very concentrated (it lowers the **water potential** inside the intestine).

The Osmotic Gradient: Because the water potential inside the intestine is now much lower than the water potential in the blood and surrounding tissues, water moves down the gradient.

Direction of Flow: Water leaves the blood and moves **into the intestine** by osmosis to try to dilute the high concentration of salt.

3. Result: Dehydration

The volume of water moving into the gut exceeds what the large intestine can reabsorb. This leads to massive fluid loss through diarrhea, causing rapid dehydration and a dangerous loss of salts (electrolytes) from the blood.

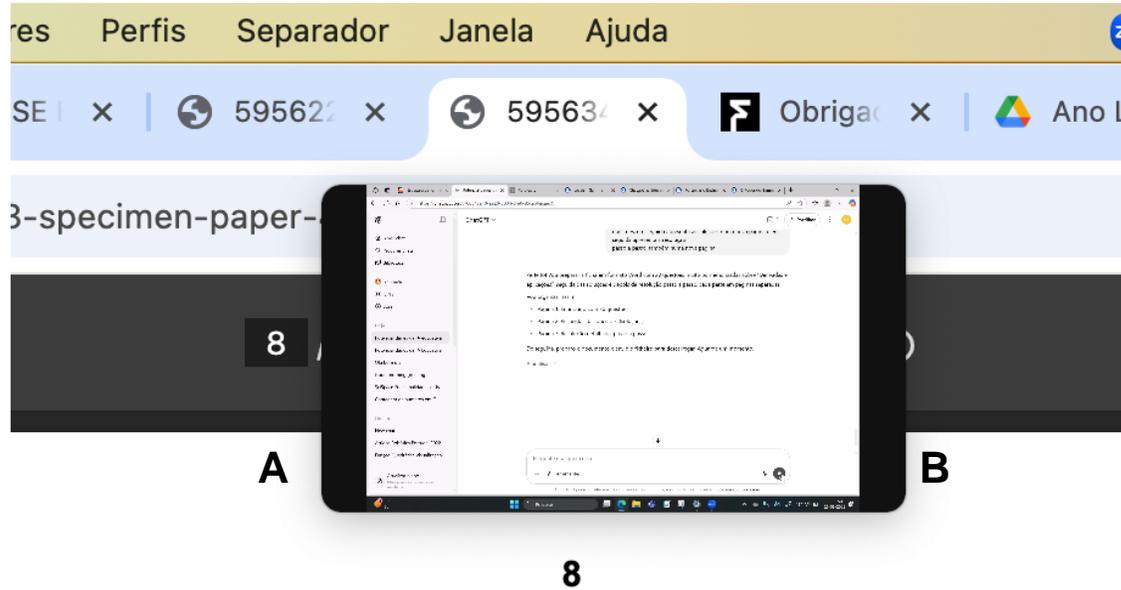
Why the other options are incorrect:

(B): Water moves **into** the intestine, not out of it. If water moved out of the intestine into the blood, it would hydrate the person, not cause diarrhea.

(C): Adding ions to a solution **decreases** its water potential; it does not increase it. Water potential is at its highest (zero) in pure water.

(D): While the blood does lose water, the *initial* cause of the water movement is the **decrease** in water potential inside the **intestine**, not a decrease in the blood's water potential (which would actually pull water back into the blood).

7. The figure below shows some of the stages of blood clotting.



2 shows some of the stages of blood clotting.



7.1. Complete the figure by filling in the two empty boxes (A and B) in the figure.

A – fibrinogen

B – fibrin

7.2. State two roles of blood clotting.

1. Prevention of Excessive Blood Loss

The most immediate role of a blood clot is to act as a physical plug. When a blood vessel is damaged, a cascade of chemical reactions converts the soluble protein fibrinogen into insoluble fibrin threads. These threads trap red blood cells and platelets to form a "mesh," sealing the break in the vessel and preventing the organism from bleeding to death.

2. Prevention of Pathogen Entry

By sealing a wound, the blood clot serves as a vital barrier for the immune system. Open wounds are direct entry points for bacteria, viruses, and fungi. The hardened clot (which eventually becomes a scab) prevents these pathogens from entering the bloodstream and causing systemic infections or localized sepsis.

8. Carefully read the following text:

Serra da Estrela (a mountain range in Portugal) is characterized by having a wide variety of habitats, which provides a high biodiversity, including some species that occur exclusively there (endemic species). Noteworthy is the plant *Silene foetida foetida*, which develops in fissures and small depressions in the rocks, with a distribution restricted to this mountain range, at altitudes above 1400 meters. River trout (*Salmo trutta fario*) and, due to the vulnerability of their populations, the Lusitanian salamander (*Chioglossa lusitanica*), an amphibian, are also mentioned.

Another plant found in the mountains, the wild thistle (*Cynara cardunculus*), is of great importance in the region's economy, as it is used in the manufacture of mountain cheese. This plant, characteristic of Mediterranean regions, grows up to 600 m altitude, has a deep root system and shows a good adaptation to environments characterized by high abiotic stress. The flower of this plant has several types of proteases (hydrolytic enzymes), such as cardosins, which accumulate in vacuoles, in the cell wall and in the extracellular space of female organs of the flower.

8.1. In the plant *Silene foetida foetida*, the ions resulting from the

(A) erosion of rocks are transported in phloem vessels.

(B) weathering rocks are transported in the sieve vessels.

(C) erosion of rocks are transported in the woody vessels.

(D) weathering rocks are transported in the xylem vessels.

ANSWER

This question tests your knowledge of **geological processes** (the source of minerals) and **plant physiology** (how those minerals move through the plant).

1. Weathering vs. Erosion

- **Weathering:** This is the chemical or physical **breakdown** of rocks into smaller particles and ions (like magnesium, potassium, and calcium). This process happens in situ (where the rock is). In the case of *Silene foetida foetida*, which grows in rock fissures, it relies on the chemical weathering of the rock to release essential minerals into the small amount of soil or water available.
- **Erosion:** This is the **transport** of those broken-down materials by wind, water, or ice. While related, the actual "production" of the ions that a plant absorbs is the result of weathering.

2. Xylem vs. Phloem (The Transport System)

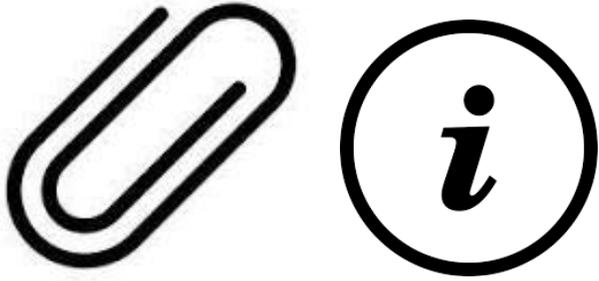
Plants have two main types of vascular tissue:

- **Xylem (Woody vessels):** These vessels transport **water and dissolved minerals** (ions) absorbed from the roots up to the rest of the plant. The flow is unidirectional (upwards).
- **Phloem (Sieve vessels):** These vessels transport **organic compounds**, primarily sugars (sucrose) produced during photosynthesis, from the leaves (source) to the rest of the plant (sink).

Why the other options are incorrect:

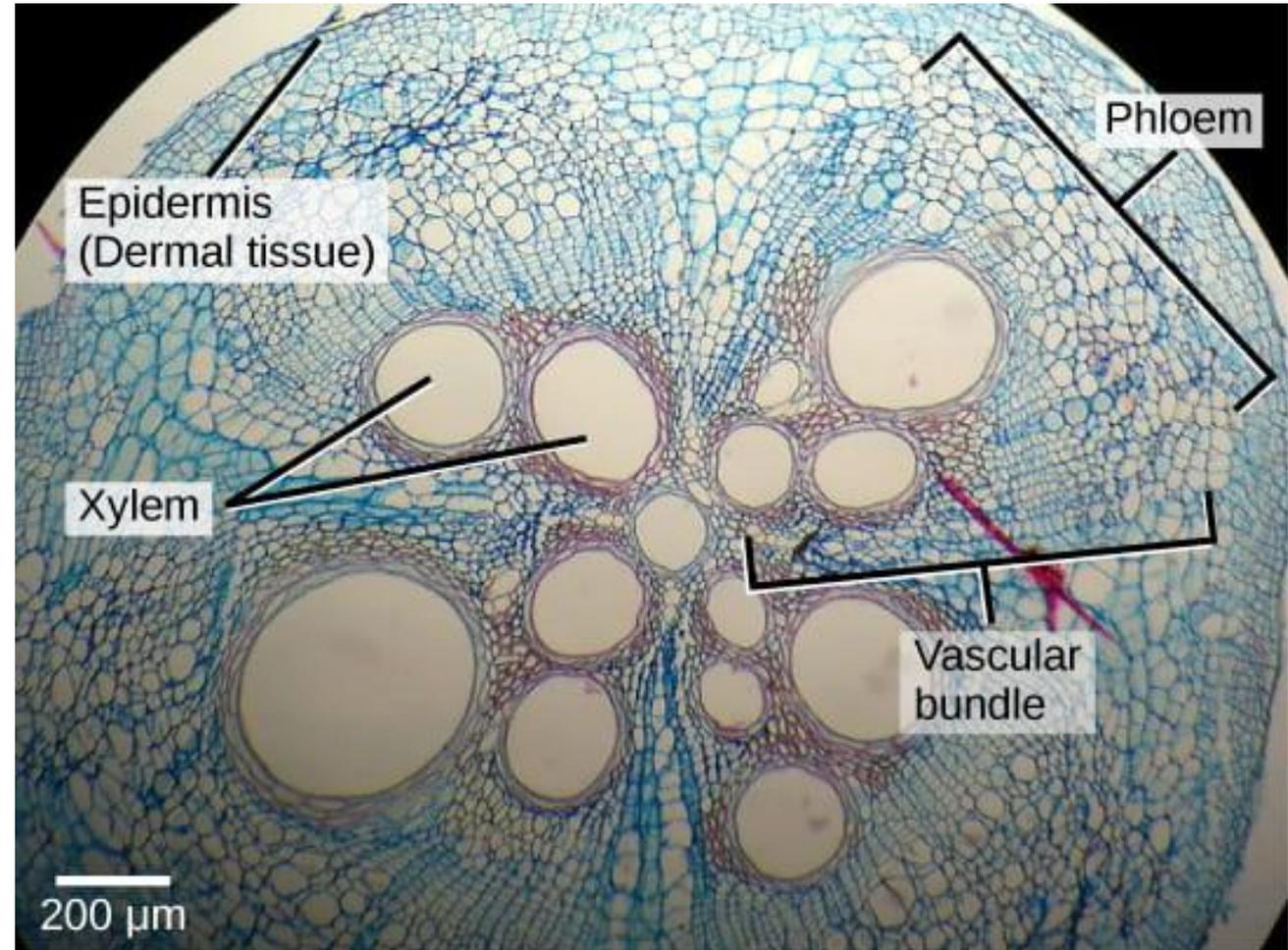
(A) and **(B)**: These mention **phloem/sieve vessels**. As noted above, these vessels are responsible for transporting sap rich in sugars, not the raw mineral ions absorbed from the environment.

(C): While it mentions "woody vessels" (another name for xylem), it uses the term **erosion**. Scientifically, the breakdown of rock that releases the chemical ions used by plants is more accurately defined as **weathering**.

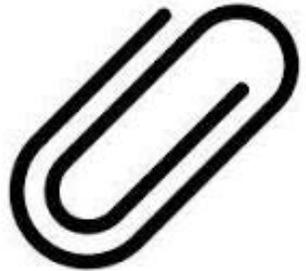


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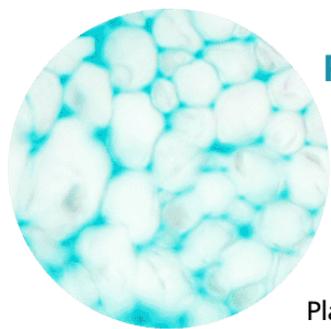
Plant tissue differentiation and function



<https://www.youtube.com/watch?v=gms6BrFl6mc>



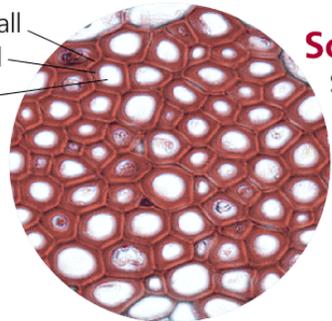
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Phloem

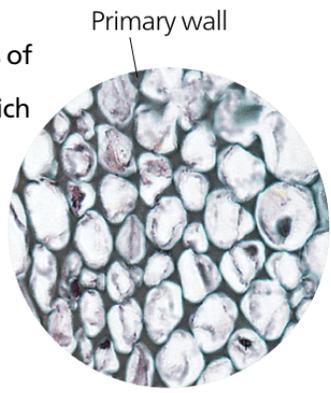
Phloem transports sugars and other items. In angiosperms, sieve-tube elements contain the sugar solution. Sieve-tube cells are surrounded by various support cells.

Primary wall
Secondary wall
Lumen



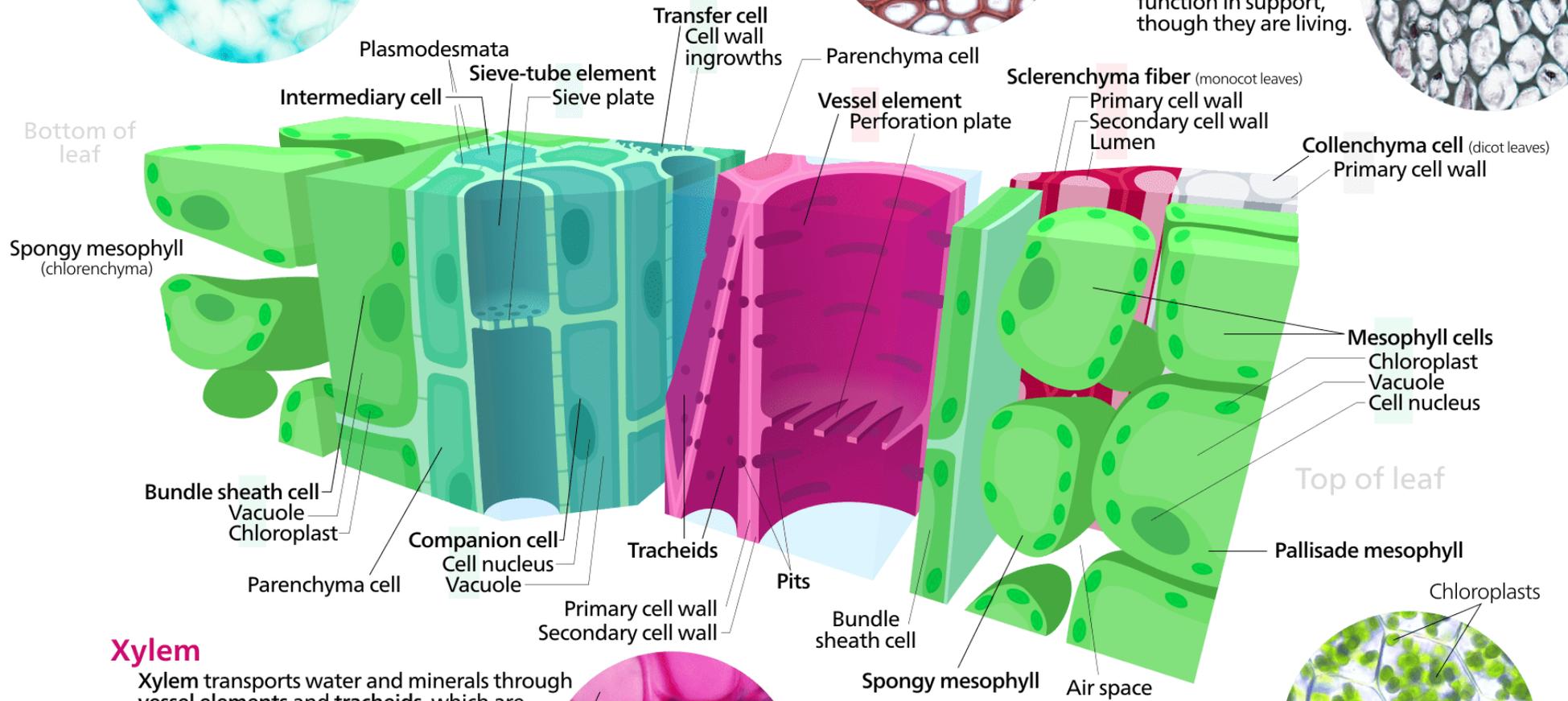
Sclerenchyma

Sclerenchyma mainly consists of dead cells that have primary and secondary cell walls which provide support.



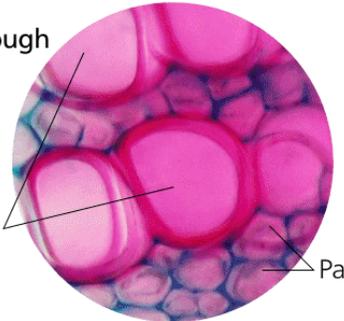
Collenchyma

Collenchyma cells also function in support, though they are living.



Xylem

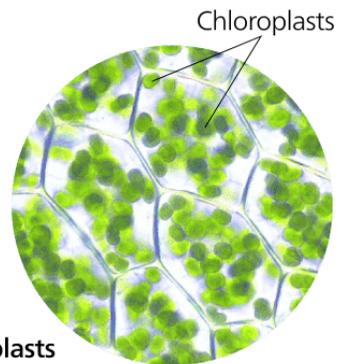
Xylem transports water and minerals through vessel elements and tracheids, which are dead at maturity and have a primary and secondary cell wall. In pits, the secondary wall is thin or missing, allowing water to flow laterally.



Tracheids
Parenchyma cells

Parenchyma

Parenchyma cells are unspecialized cells that carry out most of a plant's metabolism. Parenchyma cells with chloroplasts are called chlorenchyma cells.



Chloroplasts

8.2. Make the association between the reproduction processes presented in Column I and the characteristics of Column II that may correspond to them. Each of the characteristics must be associated with only one letter and all characteristics must be used.

Write each letter in Column I on the answer sheet followed by the corresponding number or numbers (from 1 to 9).

| Column I | Column II |
|---|---|
| | (1) Development of the adult individual by successive mitoses. (2) Production of reproductive cells by meiosis. (3) Formation of two cells similar to each other from a single-celled organism. |
| (a) Asexual reproduction | (4) Occurrence of genetic recombination phenomena. |
| (b) Sexual reproduction | (5) Formation of new organisms by the development of eggs without fertilization having taken place. |
| (c) Reproduction by both processes | (6) Favoring the rapid growth of a population. |
| | (7) Occurrence of mutations as a source of variability. |
| | (8) Formation of beings genetically equal to the parent. |
| | (9) Restoration of the number of chromosomes characteristic of the species. |

8.3. Order the expressions identified by the letters from A to E, in order to reconstruct the sequence of events that lead to the synthesis and incorporation of cardosines in the wall and in the extracellular space of female organs of the *Cynara cardunculus* flower.

A. Protein synthesis by ribosomes associated with the endoplasmic reticulum.

B. Fusion of Golgian vesicles with the cytoplasmic membrane.

C. Synthesis of a pre-messenger RNA molecule.

D. Post-translational modifications at the level of the Golgi complex.

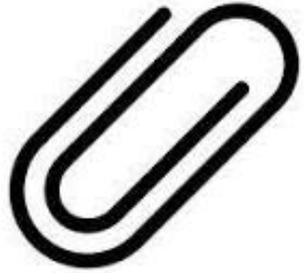
E. Migration of a messenger RNA molecule into the cytoplasm.

C, E, A, D, B

8.4. From a Darwinian perspective, the survival of *Cynara cardunculus* in the wild in Serra da Estrela is due to the

- (A) differential reproduction of plants resistant to water stress.
- (B) need for survival in regions with high precipitation.
- (C) occurrence of mutations that allowed adaptation to granitic soils.
- (D) natural selection of plants adapted to shallow soils.

ANSWER



**ADDITIONAL
INFORMATION**



| | Lamarck | Darwin |
|-------------------------------|----------------------------------|---|
| Origin of life | Permanent spontaneous generation | Derived from an ancestral form |
| 'Driver' for evolution | Complexification over time | Natural selection |
| Modifications | Adaptation to the environment | Spontaneous variations transmitted to the progeny |
| Species extinction | No, unless due to humans | Yes |

Charles Darwin's theory of evolution by **Natural Selection** is based on the idea that individuals with traits best suited to their environment are more likely to survive and, crucially, **reproduce**.

1. Differential Reproduction

The core of Darwinism is not just "survival of the fittest," but **differential reproduction**. This means that individuals with advantageous traits (like the thistle's "deep root system" mentioned in the text) leave more offspring than those without those traits. Over generations, the frequency of these favorable traits increases in the population.

2. Adaptation to Abiotic Stress

The text describes *Cynara cardunculus* as having a "deep root system" and "good adaptation to environments characterized by high abiotic stress" (Mediterranean regions often face prolonged droughts). In a Darwinian context:

- There was natural variation in the ancestral population (some had deeper roots, some shallower).
- During periods of **water stress** (drought), those with deeper roots survived and reproduced more successfully.
- The "resistance to water stress" became a dominant characteristic of the species in that region.

Why the other options are incorrect:

- **(B) Need for survival:** This phrasing suggests **Lamarckism** (the idea that an organism changes because it "needs" to). Darwinism does not operate on "need," but on the selection of existing variations. Furthermore, Mediterranean climates are characterized by dry periods, not necessarily "high precipitation."
- **(C) Mutations:** While mutations are the ultimate source of genetic variation, the **Darwinian perspective** focuses on the *selection* of existing traits in the population. The specific mention of "mutations" as the driver of adaptation is more characteristic of **Neo-Darwinism** (Synthetic Theory of Evolution), which combined Darwin's ideas with modern genetics.
- **(D) Adaptation to shallow soils:** The text explicitly states that the wild thistle has a **deep root system**. Deep roots are an adaptation for deep or permeable soils where water is stored far below the surface, which contradicts the idea of being adapted to "shallow" soils (where deep roots would be impossible to grow).

8.5. The subspecies *Silene foetida foetida* is considered endangered in the wild, according to the International Union for Conservation of Nature (IUCN).

Match the endemism of *Silene foetida foetida* with the conservation category assigned by the IUCN.

In your answer, you should refer to the genetic variability of this plant.

1. Matching Endemism and Conservation Status

- **Endemism:** *Silene foetida foetida* is a **narrow endemic** (or micro-endemic). Its distribution is restricted exclusively to a specific mountain range (Serra da Estrela) and further limited to high-altitude rocky habitats (above 1400 meters).
- **IUCN Conservation Category:** Because its total area of occupancy is very small and its habitat is specialized, it is classified as **Endangered (EN)**. This means it faces a very high risk of extinction in the wild in the near future.

2. Genetic Variability and Risk Factors

The relationship between this plant's endemism and its "Endangered" status is deeply tied to its **genetic variability**:

Low Genetic Diversity: Small, isolated populations typically have low genetic variability. When a species is restricted to a tiny geographic area (like the fissures of rocks at the top of one mountain), the "gene pool" is very limited. There is less variation for natural selection to act upon.

The Inbreeding Effect: Because the population is small and isolated, there is a higher probability of **inbreeding** (mating between closely related individuals). This can lead to the expression of harmful recessive traits and a further reduction in the biological fitness of the population.

Vulnerability to Change: High genetic variability acts as "insurance" for a species. If the environment changes (e.g., rising temperatures due to climate change or a new disease), a diverse population is more likely to have some individuals with the traits needed to survive. Since *Silene foetida foetida* likely has low variability, a single negative event could wipe out the entire subspecies.

The "Altitude Trap": Because the plant already lives at the highest peaks (above 1400m), it has nowhere to "climb" if the climate warms. This geographic isolation prevents gene flow from other populations, keeping its genetic variability stagnant and low.

8.6. The fish *Salmo trutta fario* and the amphibian *Chioglossa lusitanica* have a digestive tract

- (A) full and simple circulation.
- (B) incomplete and double circulation.
- (C) complete and closed circulatory system.
- (D) incomplete and open circulatory system.

ANSWER

This question evaluates your knowledge of the **digestive system** and the **circulatory system** of vertebrates.

1. The Digestive Tract: "Complete"

Both the River trout (*Salmo trutta fario*) and the Lusitanian salamander (*Chioglossa lusitanica*) are vertebrates. All vertebrates possess a **complete digestive tract**.

- **Definition:** A complete digestive system has two separate openings: a **mouth** (where food enters) and an **anus** (where waste is expelled).
- This allows for the one-way movement of food and specialized compartments for digestion and absorption.

2. The Circulatory System: "Closed"

Similarly, all vertebrates have a **closed circulatory system**.

- **Definition:** The blood is always contained within a network of blood vessels (arteries, veins, and capillaries) and is pumped by a heart. It does not normally leave the vessels to bathe the tissues directly.
- This is more efficient for transporting oxygen and nutrients under high pressure to meet the metabolic needs of active animals like fish and amphibians.

Why the other options are incorrect:

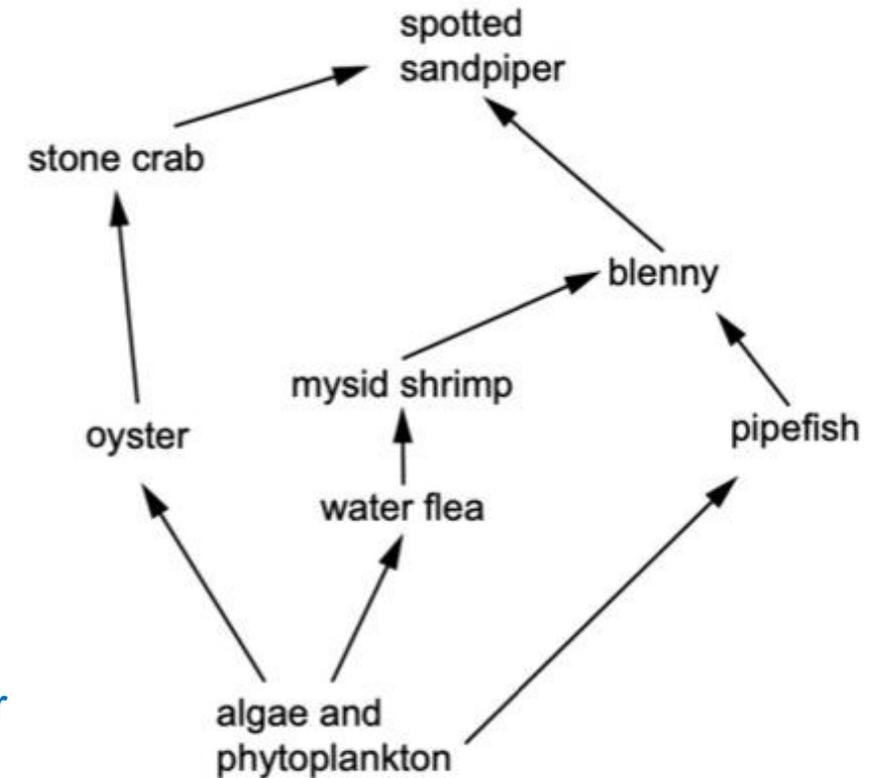
- **(A) Full and simple circulation:** While the fish has **simple** circulation (blood passes through the heart once per circuit), the amphibian has **double** circulation (blood passes through the heart twice). More importantly, "full" (or "complete") is a term usually used for hearts where oxygenated and deoxygenated blood do not mix (like in mammals/birds), but it doesn't describe the "tract" or the "system" as a whole in this context.
- **(B) Incomplete and double circulation:** While the amphibian has double circulation, the digestive tract is **complete**, not incomplete.
- **(D) Incomplete and open circulatory system:** An open circulatory system is characteristic of many invertebrates (like insects or mollusks), but not vertebrates. An incomplete digestive tract (only one opening) is found in simpler organisms like flatworms or jellyfish.

9. Wetlands are important ecosystems.

Researchers studied the feeding relationships between the organisms in an area of coastal wetland.

The figure shows part of the food web that they studied.

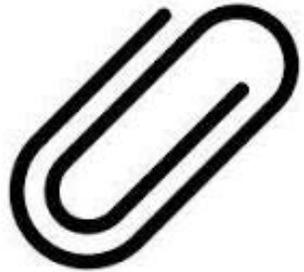
Using the food web in the figure, identify one producer, one secondary consumer, and one organism that feeds at two different trophic levels.



Producer – algae / phytoplankton

Secondary consumer – stone crab / mysid shrimp / blenny

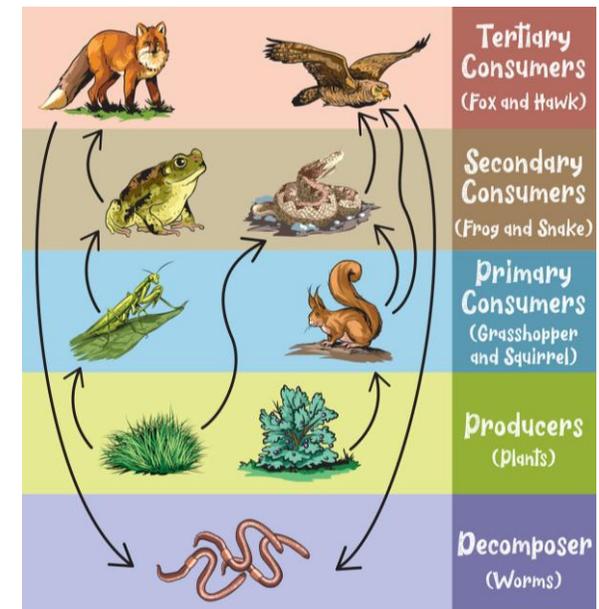
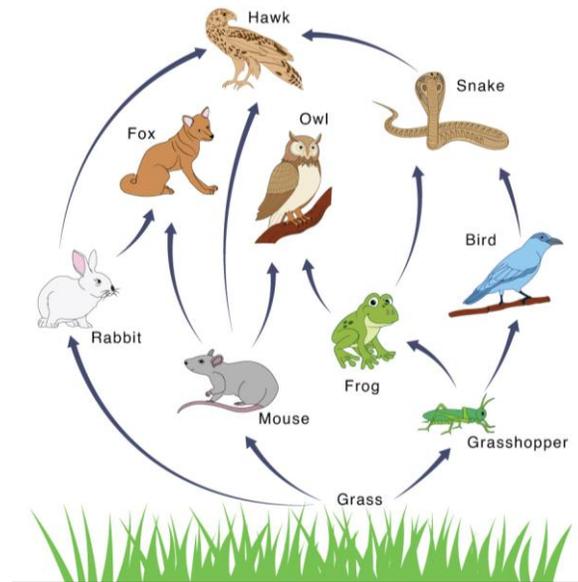
Animal that feed at two trophic levels – blenny / spotted sandpiper

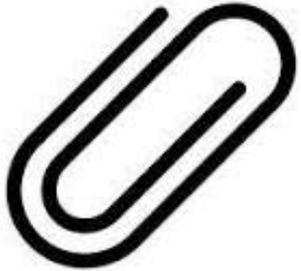


ADDITIONAL
INFORMATION



- A **food web** is a complex network of interconnected food chains within an ecosystem
- It shows how different organisms – producers, consumers, and decomposers – are linked through feeding relationships
- Unlike a single food chain, a food web illustrates multiple pathways through which energy and nutrients flow, highlighting the interdependence of species in an ecosystem
- Food webs help us understand the balance and stability of ecosystems





ADDITIONAL INFORMATION

[Food Webs | Ecosystems | Biology | FuseSchool](#)

This video explains food webs in a clear and engaging way, ideal for beginners

[Food Chains and Food Webs | Khan Academy](#)

A detailed explanation covering the difference between food chains and food webs

[What is a Food Web? | Science for Kids | FreeSchool](#)

A kid-friendly video that introduces the concept of food webs with simple examples

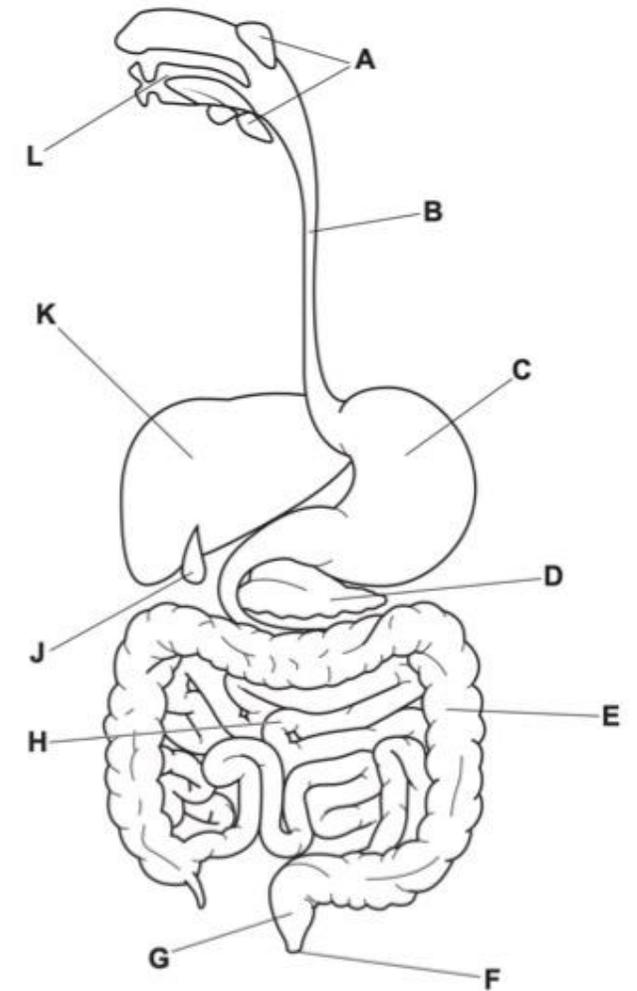


10. The figure is a diagram of the digestive system.

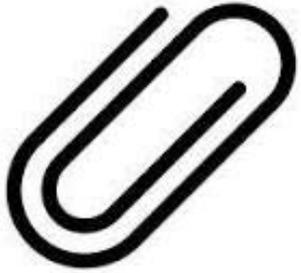
Each letter may be used once, more than once or not at all.

State the letter of the part shown in figure:

- i) that produces bile.
- ii) that produces gastric juice.
- iii) that produces urea.
- iv) where maltose is digested.
- v) where trypsin acts.



i) K; ii) C; iii) K; iv) H; v) H

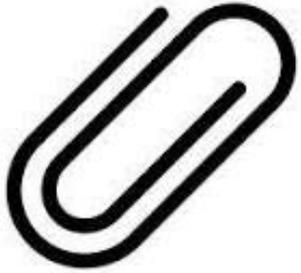


**ADDITIONAL
INFORMATION**



[Major Organ Functions & Anatomy | Quick & Easy Learning Video](#)

A concise and informative video that covers the major organs of the human body, detailing their functions and anatomical features

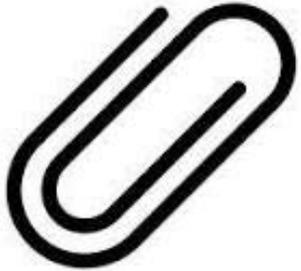


ADDITIONAL INFORMATION



Major Excretory Products in Humans

- 1. Urea:** Produced in the liver through the breakdown of amino acids, urea is the primary nitrogenous waste in humans. It is transported via the bloodstream to the kidneys for excretion
- 2. Uric Acid:** Formed from the metabolism of nucleic acids, uric acid is eliminated through urine. Excessive accumulation can lead to gout or kidney stones
- 3. Creatinine:** A byproduct of muscle metabolism, creatinine levels are a key indicator of kidney function
- 4. Carbon Dioxide (CO₂):** Generated during cellular respiration, CO₂ is expelled from the body through the lungs during exhalation
- 5. Excess Salts and Water:** The kidneys regulate the balance of salts and water, excreting any surplus to maintain homeostasis
- 6. Bile Pigments:** Resulting from the breakdown of hemoglobin, bile pigments like bilirubin are excreted via the liver into the digestive tract and eliminated in feces



ADDITIONAL INFORMATION

[Human Excretory System](#): This video provides an overview of the human excretory system, detailing its components and functions

[Excretory System and the Nephron](#): An in-depth look at the nephron's role in filtering blood and forming urine

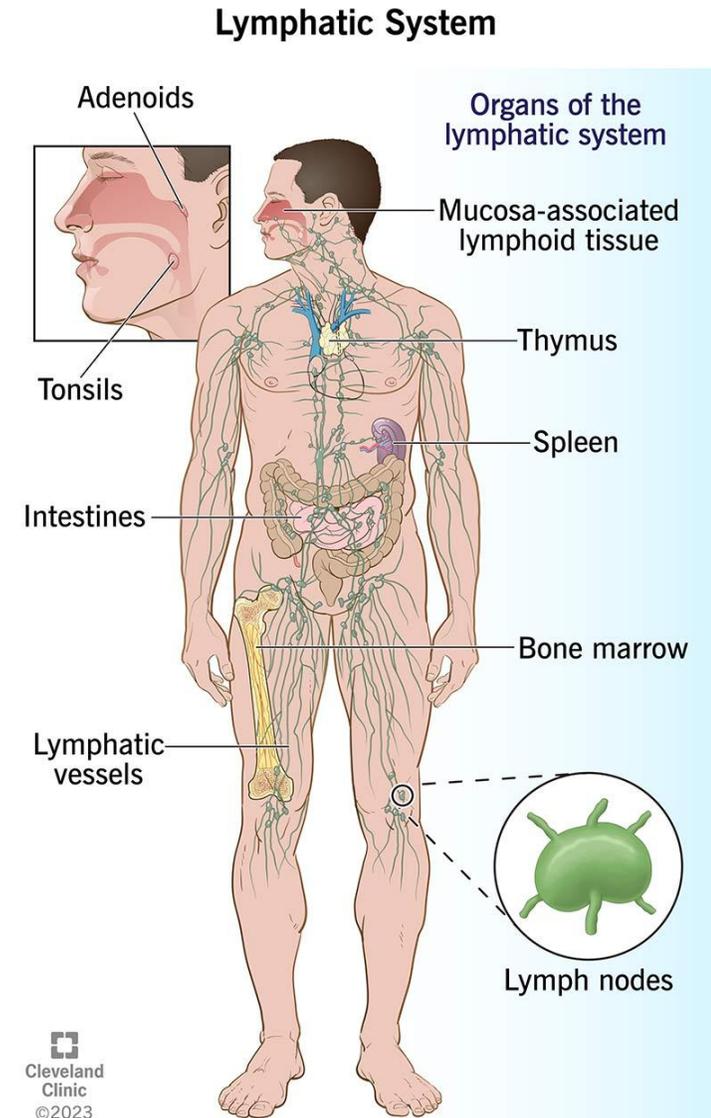
[The Excretory System: From Your Heart to the Toilet](#): This video traces the journey of waste products from their origin in the body to their elimination

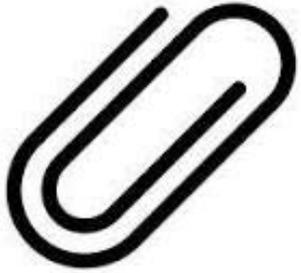


The lymphatic system is a vital component of the body's immune system, responsible for maintaining fluid balance, absorbing dietary fats, and defending against infections.

Key Functions of the Lymphatic System

- 1. Fluid Balance:** The lymphatic system collects excess interstitial fluid (fluid between cells) and returns it to the bloodstream, preventing tissue swelling (edema)
- 2. Fat Absorption:** Specialized lymphatic vessels called lacteals, located in the lining of the small intestine, absorb fats and fat-soluble vitamins from the digestive system and transport them to the bloodstream
- 3. Immune Defense:** Lymph nodes filter lymph fluid, trapping bacteria, viruses, and other foreign substances, which are then destroyed by specialized white blood cells called lymphocytes





ADDITIONAL INFORMATION

[How Does the Lymphatic System Work?](#)

This video provides an overview of the lymphatic system's structure and functions



[Normal Lymphatic Anatomy and Flow](#)

An animated explanation of lymphatic anatomy and fluid movement within the system



The innate immune system serves as the body's first line of defense against pathogens, providing a rapid and non-specific response to a wide range of invaders

Key Cells of the Innate Immune System

1. Macrophages: These long-lived cells reside in tissues and are among the first responders to infection. They engulf pathogens through phagocytosis and release cytokines to recruit other immune cells to the site of infection

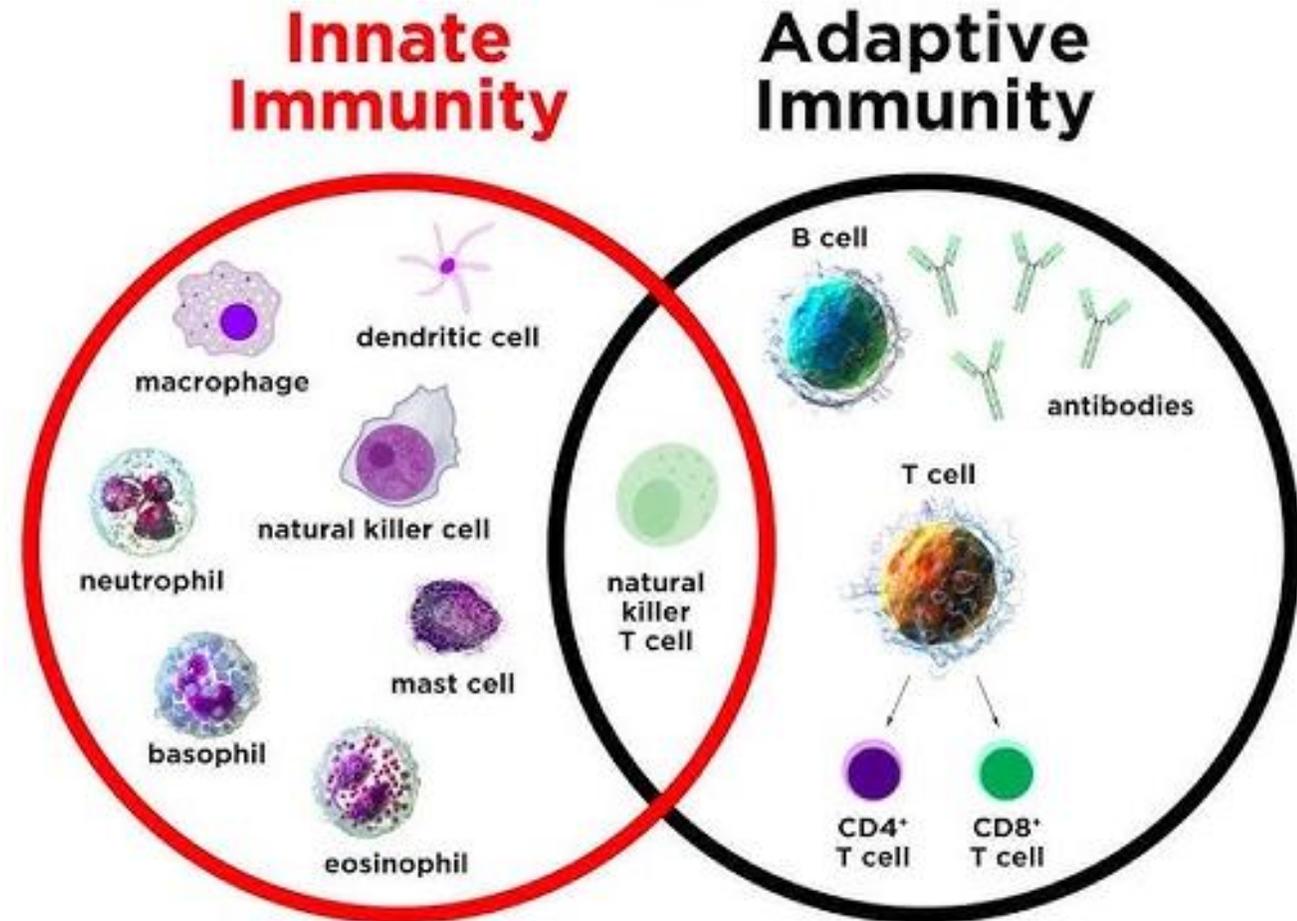
2. Neutrophils: As the most abundant type of white blood cells, neutrophils rapidly migrate to infection sites, where they ingest and destroy pathogens. They are short-lived but play a crucial role in controlling infections

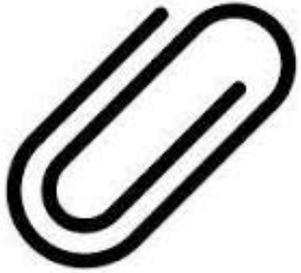
3. Dendritic Cells: These cells act as messengers between the innate and adaptive immune systems. They capture antigens from pathogens and present them to T cells, initiating the adaptive immune response

4. Natural Killer (NK) Cells: NK cells identify and destroy virus-infected cells and tumor cells by recognizing changes in the expression of surface molecules. They release cytotoxic substances to induce cell death in compromised cells

5. Mast Cells, Basophils, and Eosinophils:

These cells are involved in the defense against parasites and play roles in allergic reactions. They release histamine and other mediators that contribute to inflammation and recruit other immune cells



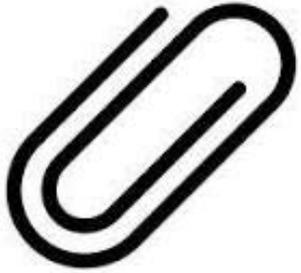


ADDITIONAL INFORMATION



Mechanisms of Action

- **Pattern Recognition Receptors (PRRs):** Innate immune cells possess PRRs that detect pathogen-associated molecular patterns (PAMPs) common to many microbes. This recognition triggers immune responses to eliminate the invaders
- **Phagocytosis:** Macrophages and neutrophils engulf and digest pathogens, effectively removing them from the body
- **Inflammation:** The release of cytokines and chemokines by innate immune cells leads to inflammation, which helps contain infections and signals other immune cells to the affected area
- **Complement System:** This group of proteins enhances the ability of antibodies and phagocytic cells to clear microbes and damaged cells, promoting inflammation and attacking the pathogen's cell membrane



ADDITIONAL INFORMATION



[Innate Immune System: Overview](#): This video provides a comprehensive overview of the innate immune system's components and functions

[Innate Immunity Explained](#): This animation explains how the innate immune system detects and responds to pathogens

11. The horse, *Equus ferus*, and the donkey, *Equus asinus*, are able to interbreed. The offspring they produce is called a mule.

Which statement is correct?

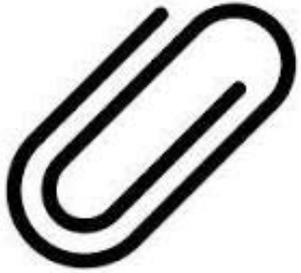
- (A)** The horse and the donkey are the same genus; the mule is infertile.
- (B)** The horse and the donkey are the same genus; the mule is fertile.
- (C)** The horse and the donkey are the same species; the mule is fertile.
- (D)** The horse and the donkey are the same species; the mule is infertile.

ANSWER

Understanding the genetics of mules provides insight into the complexities of hybrid animals and the importance of chromosomal compatibility in reproduction

The horse (*Equus ferus caballus*) and the donkey (*Equus africanus asinus*) are distinct species within the same genus, *Equus*. Despite differences in chromosome numbers – horses have 64 chromosomes and donkeys have 62 – they can interbreed. The offspring of a male donkey (jack) and a female horse (mare) is called a **mule**

- Mules inherit 63 chromosomes, an odd number that disrupts the normal pairing of chromosomes during meiosis, the process that produces reproductive cells (sperm and eggs)
- This mismatch typically renders mules sterile, as their cells cannot divide evenly to form viable gametes
- While rare cases of female mules producing offspring have been documented, such instances are exceptional and not the norm



ADDITIONAL INFORMATION



[Why Are Mules Sterile? – SciShow](#): This video delves into the genetic reasons behind mule sterility

[Why Can't Mules Have Babies? – ScienceABC](#): An informative piece discussing the chromosomal challenges in mule reproduction

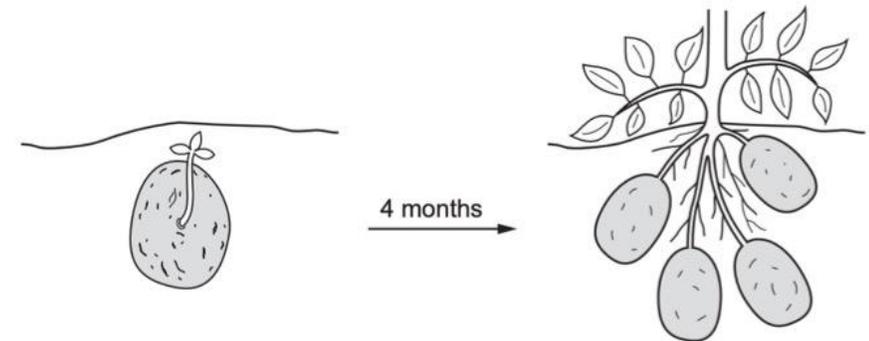
12. Potatoes are stem tubers. A tuber can be placed in the ground to grow into another plant, which can grow many more tubers.

The diploid number of the potato plant is 24.

How many chromosomes will there be in the cells of the stem, the leaf and the pollen?

| | stem | leaf | pollen |
|-----|------|------|--------|
| (A) | 24 | 24 | 12 |
| (B) | 48 | 12 | 24 |
| (C) | 24 | 12 | 48 |
| (D) | 48 | 48 | 12 |

ANSWER



Mitosis and **meiosis** are two fundamental processes of cell division in eukaryotic organisms, each serving distinct purposes in growth, development, and reproduction.

Mitosis: Growth and Repair

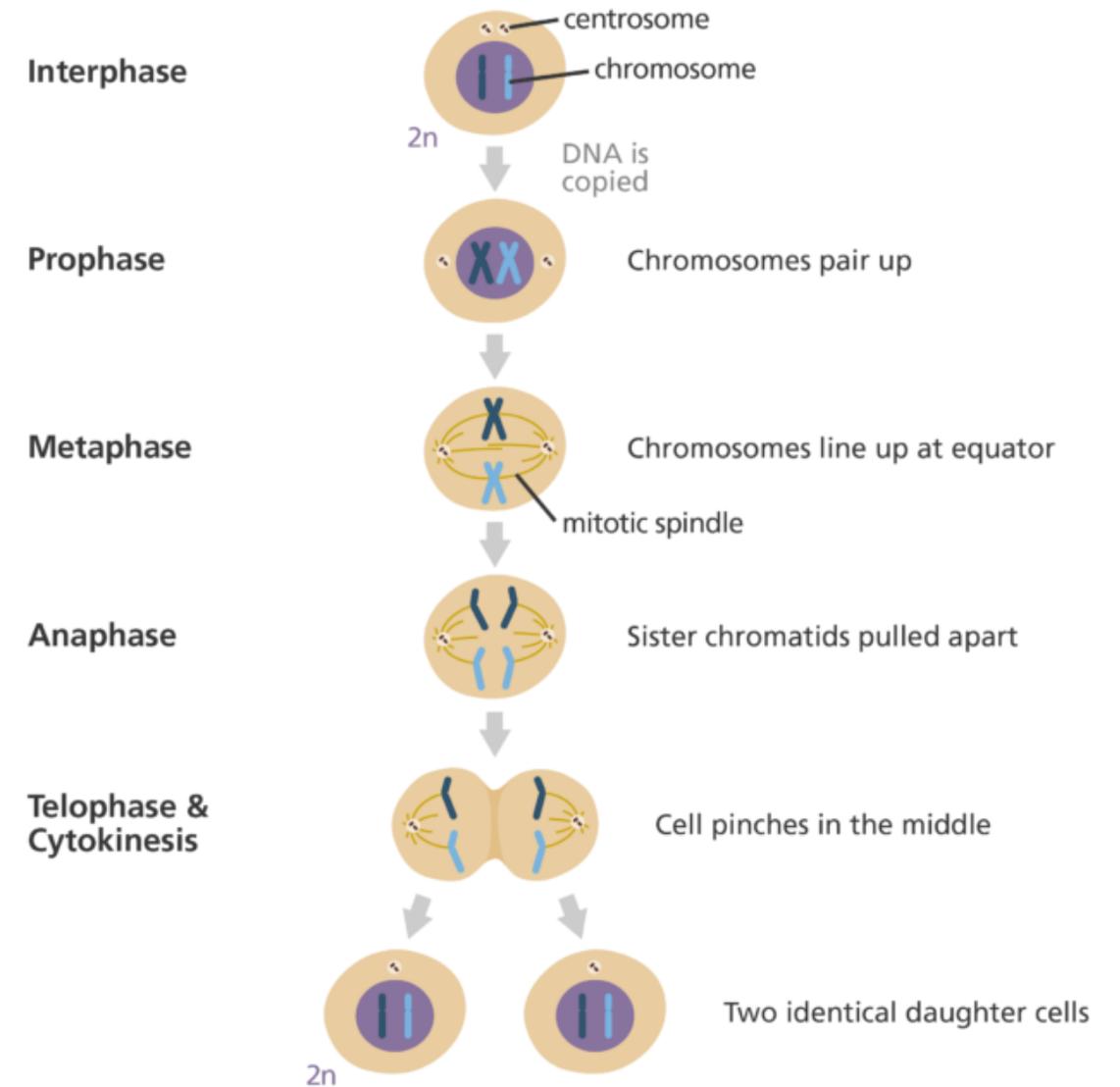
Mitosis is the process by which a single cell divides to produce two genetically identical daughter cells, each maintaining the same number of chromosomes as the parent cell

This mechanism is crucial for:

- **Growth:** Enabling organisms to increase in size
- **Repair:** Replacing damaged or dead cells
- **Asexual reproduction:** In certain organisms

The stages of mitosis include:

- 1. Prophase:** Chromosomes condense, and the nuclear envelope begins to disintegrate
- 2. Metaphase:** Chromosomes align at the cell's equatorial plane
- 3. Anaphase:** Sister chromatids are pulled apart to opposite poles
- 4. Telophase:** Nuclear membranes reform around the separated chromatids
- 5. Cytokinesis:** The cytoplasm divides, resulting in two separate cells



$2n$ - diploid

Meiosis: Genetic Diversity in Reproduction

Meiosis is a specialized form of cell division that reduces the chromosome number by half, producing four genetically distinct haploid cells

This process is essential for:

- **Sexual reproduction:** Generating gametes (sperm and eggs)
- **Genetic variation:** Through recombination and independent assortment

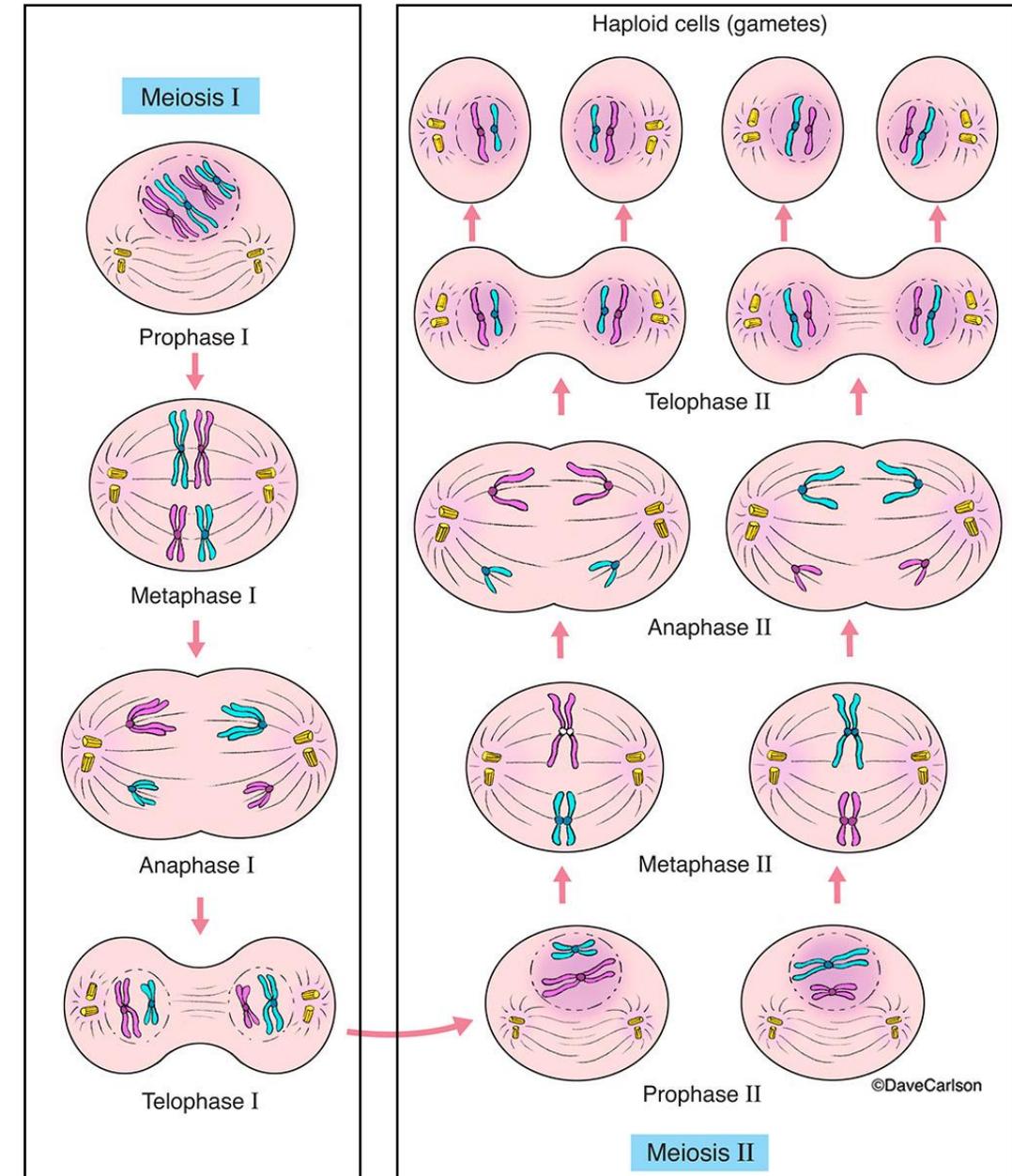
Meiosis consists of two successive divisions:

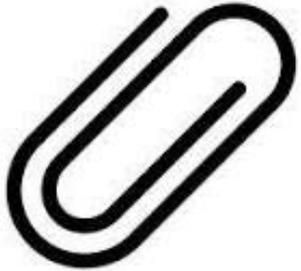
1. Meiosis I:

1. **Prophase I:** Homologous chromosomes pair and exchange genetic material (crossing over)
2. **Metaphase I:** Paired homologs align at the cell's center
3. **Anaphase I:** Homologous chromosomes are separated to opposite poles
4. **Telophase I and Cytokinesis:** Two haploid cells are formed

2. Meiosis II:

1. Resembles mitosis, where sister chromatids are separated, resulting in four haploid daughter cells





ADDITIONAL INFORMATION

[Mitosis vs. Meiosis: Side by Side Comparison](#)

This video provides a clear comparison between mitosis and meiosis, highlighting their differences and similarities

[Cell Division: Meiosis vs. Mitosis](#)

An animated explanation of both mitosis and meiosis, detailing each phase and its significance

[Mitosis vs Meiosis](#)

A concise overview of the two types of cell division, emphasizing their roles in the life cycle



13. The diagram shows the inheritance of albinism in one family. Albinism is an inherited condition caused by a recessive allele.

Which individuals must be heterozygous for this condition?

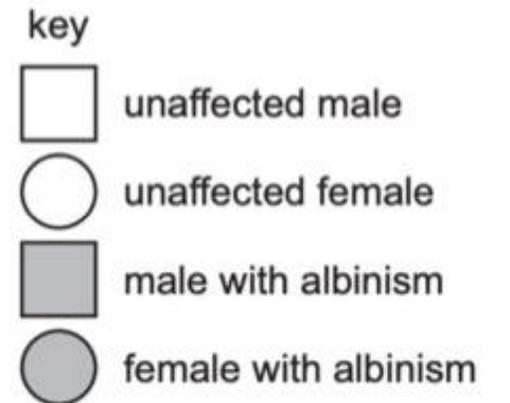
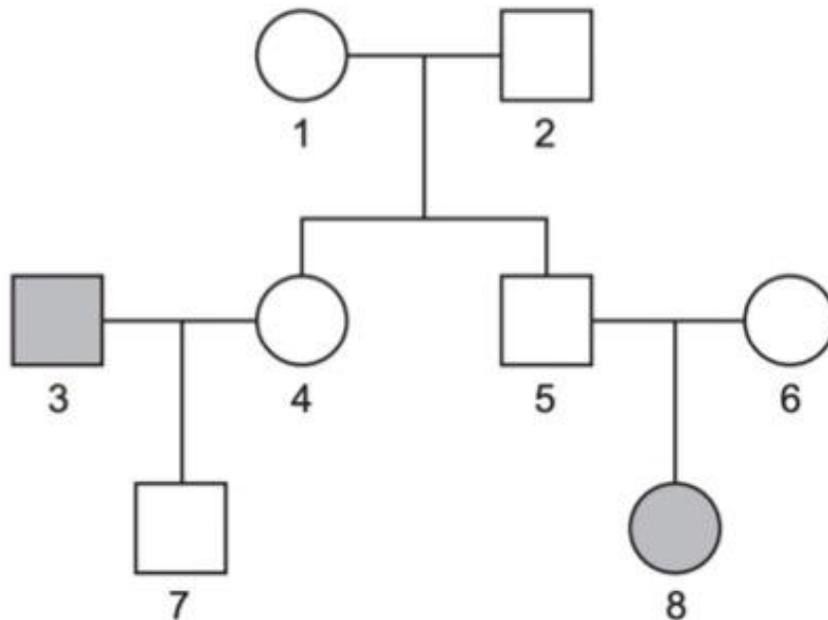
(A) 1 and 2

(B) 4 and 7

(C) 5, 6 and 7

(D) 5 and 6 only

ANSWER



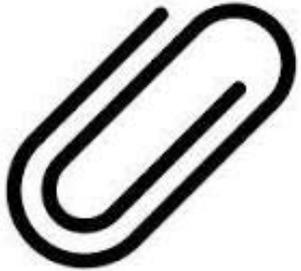
Offspring can inherit the same or different blood groups from their parents based on the combination of alleles they receive. The ABO blood group system is determined by a single gene with three alleles: **A**, **B**, and **O**

- **A and B alleles are co-dominant**, meaning that if both are present, both will be expressed, resulting in the **AB** blood type
- **The O allele is recessive**, so an individual will have the **O** blood type only if they inherit two O alleles

Each parent contributes one allele to their child, leading to various possible combinations:

- **AA or AO** → Blood type A
- **BB or BO** → Blood type B
- **AB** → Blood type AB
- **OO** → Blood type O

For example, if one parent has genotype AO (blood type A) and the other has BO (blood type B), their children could have any of the four blood types: A, B, AB, or O, depending on the allele combination inherited



ADDITIONAL INFORMATION



[Multiple Alleles \(ABO Blood Types\) and Punnett Squares](#)

This video explains how to use Punnett squares to predict blood type inheritance, using the ABO system as an example

[Blood Type Genetics Explained](#)

A clear explanation of the genetics behind blood types, including how different combinations of alleles result in the various blood groups

[Blood Types and Punnett Squares](#)

This video provides an overview of using Punnett squares to determine genetic outcomes for blood types

[How Humans Inherit A, B, and O Blood Types | Britannica](#)

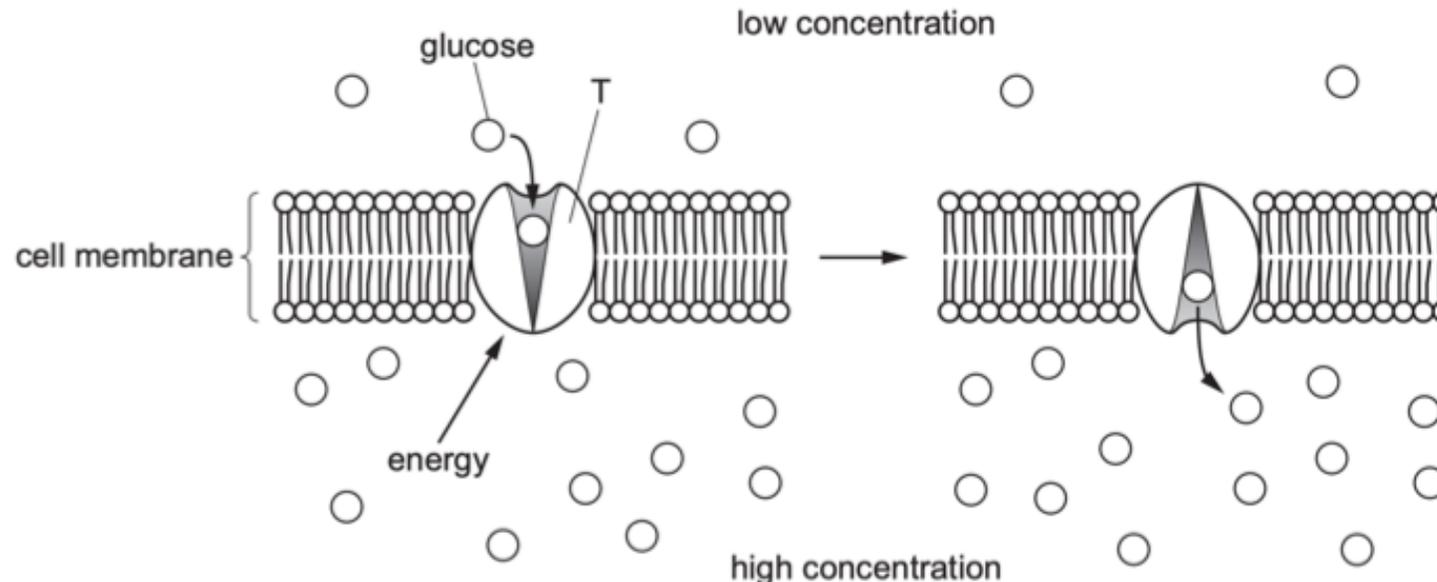
An informative video from Britannica that discusses the inheritance patterns of ABO blood types using Punnett squares

14. The diagram shows the movement of glucose molecules across a cell membrane.

Which statement describes molecule T?

- (A) It is a fat molecule used to transport glucose down a concentration gradient.
- (B) It is a protein molecule used to transport glucose against a concentration gradient.
- (C) It is a protein molecule used to transport glucose down a concentration gradient.
- (D) It is a fat molecule used to transport glucose against a concentration gradient.

ANSWER



15. Some cells are specialised to perform a particular function. Column I show the names of some specialised cells and Column II show the functions of some specialised cells.

Write each letter in Column I on the answer sheet followed by the corresponding number of Column II

| Column I - Specialised cells | Column II - Functions |
|------------------------------|----------------------------|
| | (1) absorption of water |
| (a) ciliated cell | (2) transport of oxygen |
| (b) neurone | (3) conduction and support |
| (c) palisade mesophyll cell | (4) conduction of impulses |
| (d) red blood cell | (5) movement of mucus |
| (e) root hair cell | (6) photosynthesis |

OTHER TOPICS TO STUDY

Bryophytes life cycle

Biological concept of **alternation of generations**, a defining characteristic of bryophytes, such as mosses

In mosses, the life cycle alternates between two multicellular stages:

1. Sporophyte Generation (2n):

This is the diploid stage, which begins after fertilization. The sporophyte grows out of and remains physically attached to the gametophyte. Its main role is to produce haploid spores through **meiosis** inside a structure called the **sporangium**

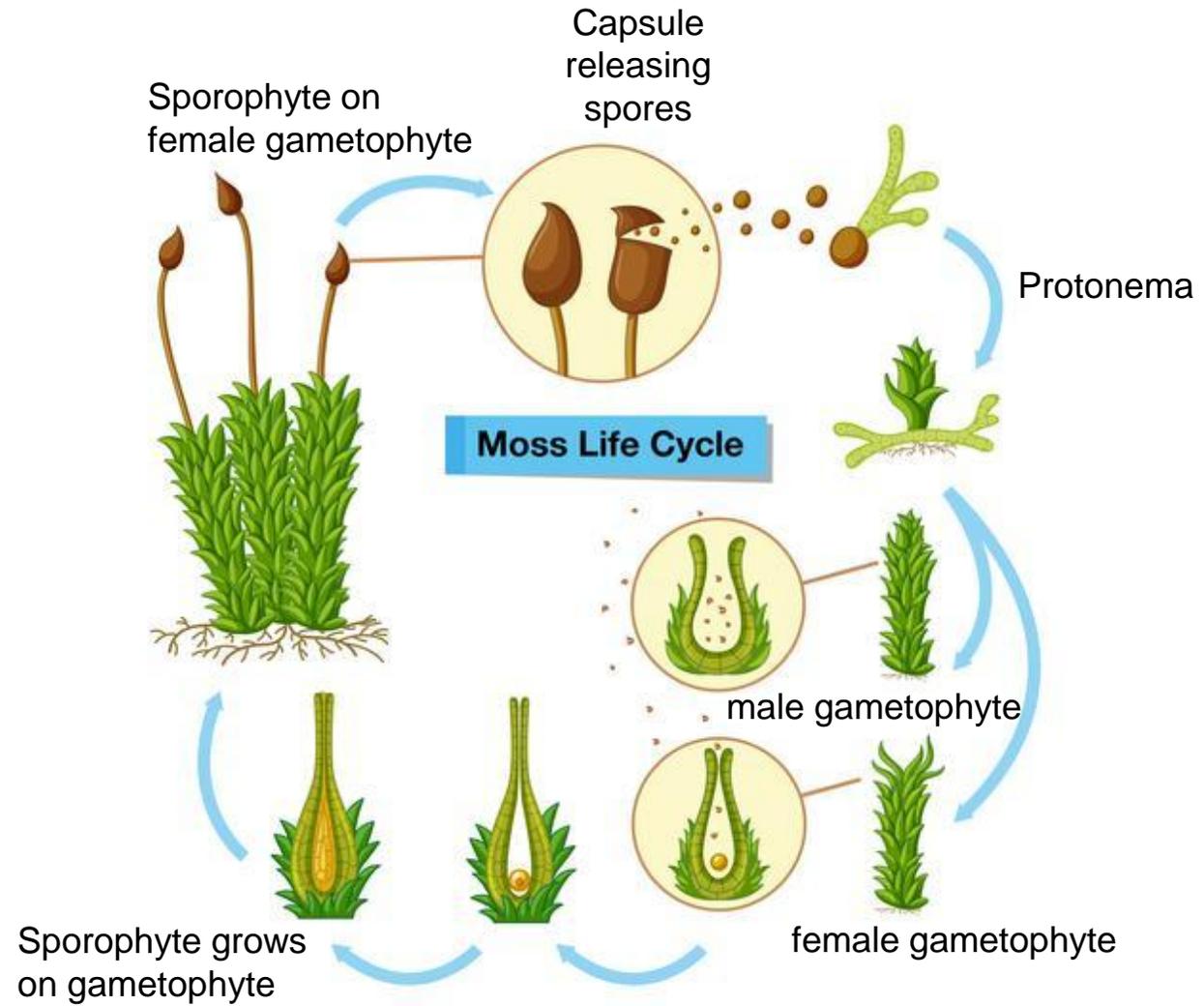
2. Gametophyte Generation (n):

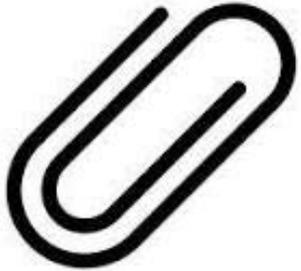
This is the dominant stage in mosses and is haploid. The **haploid spores** produced by the sporophyte germinate and grow into gametophytes, which are responsible for producing gametes (sperm and eggs).

When the haploid spores are released and find suitable conditions, they germinate into a **protonema**, an early growth stage that eventually develops into the mature gametophyte. Thus, **the formation of haploid spores marks the beginning of the gametophyte generation** in the moss life cycle

Bryophytes life cycle

ADDITIONAL
INFORMATION





ADDITIONAL INFORMATION

[Moss Life Cycle – Biology Animation by Frank Gregorio](#)

A clear and engaging overview of the moss life cycle, covering both gametophyte and sporophyte phases



[Moss Life Cycle Under The Microscope – Exploring Nature With Microscopy](#)

Microscopic view of moss development, showing real-life structures like sporophytes and gametophytes



[Bryophyta \(Moss\) Life Cycle Explained – Learnpedia](#)

A step-by-step explanation of reproduction and the alternation of generations in mosses

Prokaryotic and eukaryotic cells

Prokaryotic and eukaryotic cells represent the two primary types of cellular organization in living organisms.

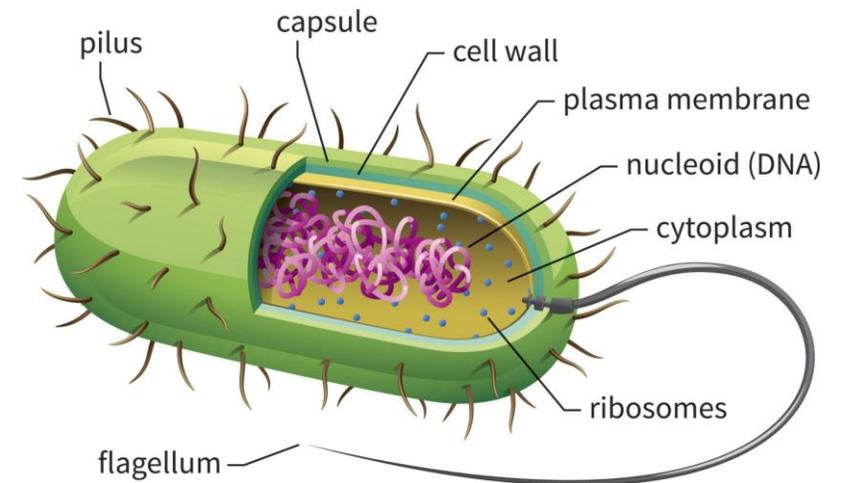
Understanding their differences is fundamental to biology.

Prokaryotic Cells

Prokaryotic cells are simpler and typically smaller than eukaryotic cells. They lack a true nucleus; instead, their genetic material resides in a region called the nucleoid. These cells also do not possess membrane-bound organelles. Prokaryotes include organisms such as bacteria and archaea

Key Features:

- **Nucleus:** Absent
- **DNA:** Single, circular chromosome located in the nucleoid
- **Organelles:** No membrane-bound organelles
- **Size:** Generally 0.1–5 μm in diameter
- **Examples:** Bacteria, Archaea

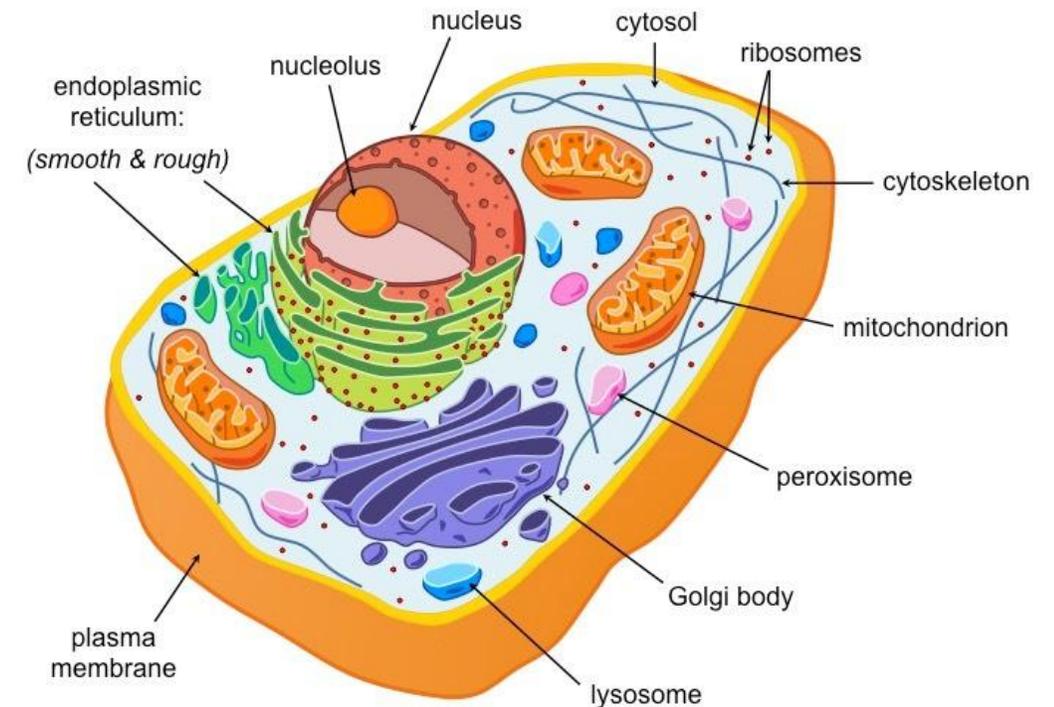


Eukaryotic Cells

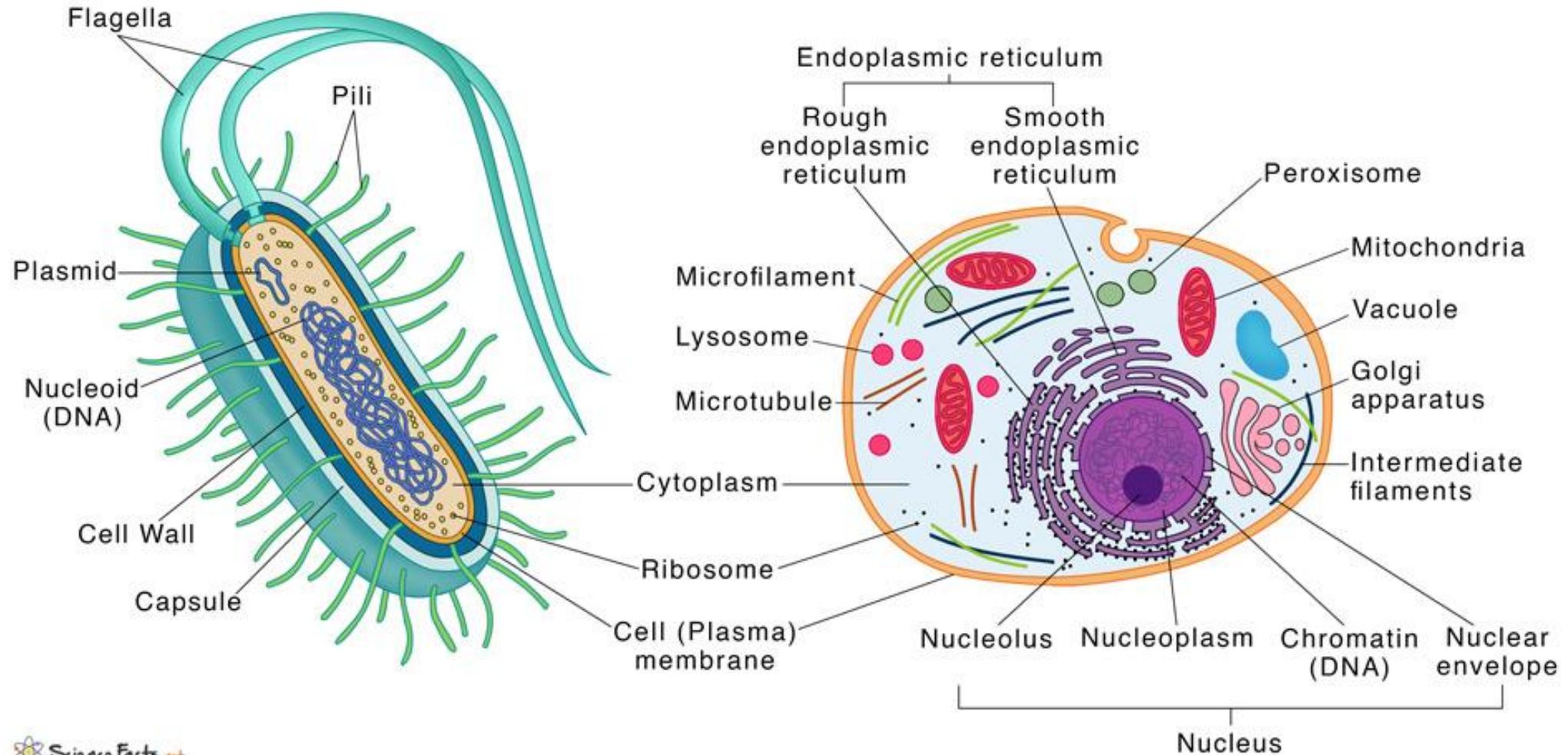
Eukaryotic cells are more complex and usually larger. They have a true nucleus enclosed by a nuclear membrane and contain various membrane-bound organelles, such as mitochondria, endoplasmic reticulum, and Golgi apparatus. Eukaryotes encompass organisms like plants, animals, fungi, and protists

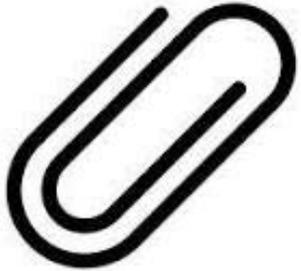
Key Features:

- **Nucleus:** Present, enclosed by a nuclear membrane
- **DNA:** Multiple, linear chromosomes within the nucleus
- **Organelles:** Numerous membrane-bound organelles
- **Size:** Generally 10–100 μm in diameter
- **Examples:** Plants, Animals, Fungi, Protists



Prokaryotic Cells vs Eukaryotic Cells





ADDITIONAL INFORMATION

[Prokaryotic vs. Eukaryotic Cells \(Updated\)](#)

This video provides a comprehensive comparison between prokaryotic and eukaryotic cells, highlighting their structural differences and similarities

[Prokaryotic vs Eukaryotic: The Differences | Cells | Biology](#)

An informative overview that explains the key distinctions between these two cell types

[Prokaryotic and Eukaryotic Cells](#)

A detailed explanation from Khan Academy covering the characteristics and functions of prokaryotic and eukaryotic cells

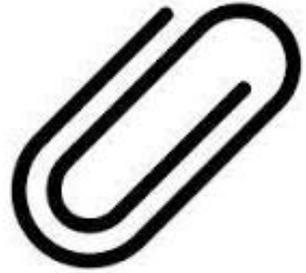


The Sodium-Potassium Pump

Sodium ions (Na^+) are essential for numerous cellular functions, and their movement across cell membranes involves two key mechanisms: active transport and facilitated diffusion

Active Transport: The Sodium-Potassium Pump

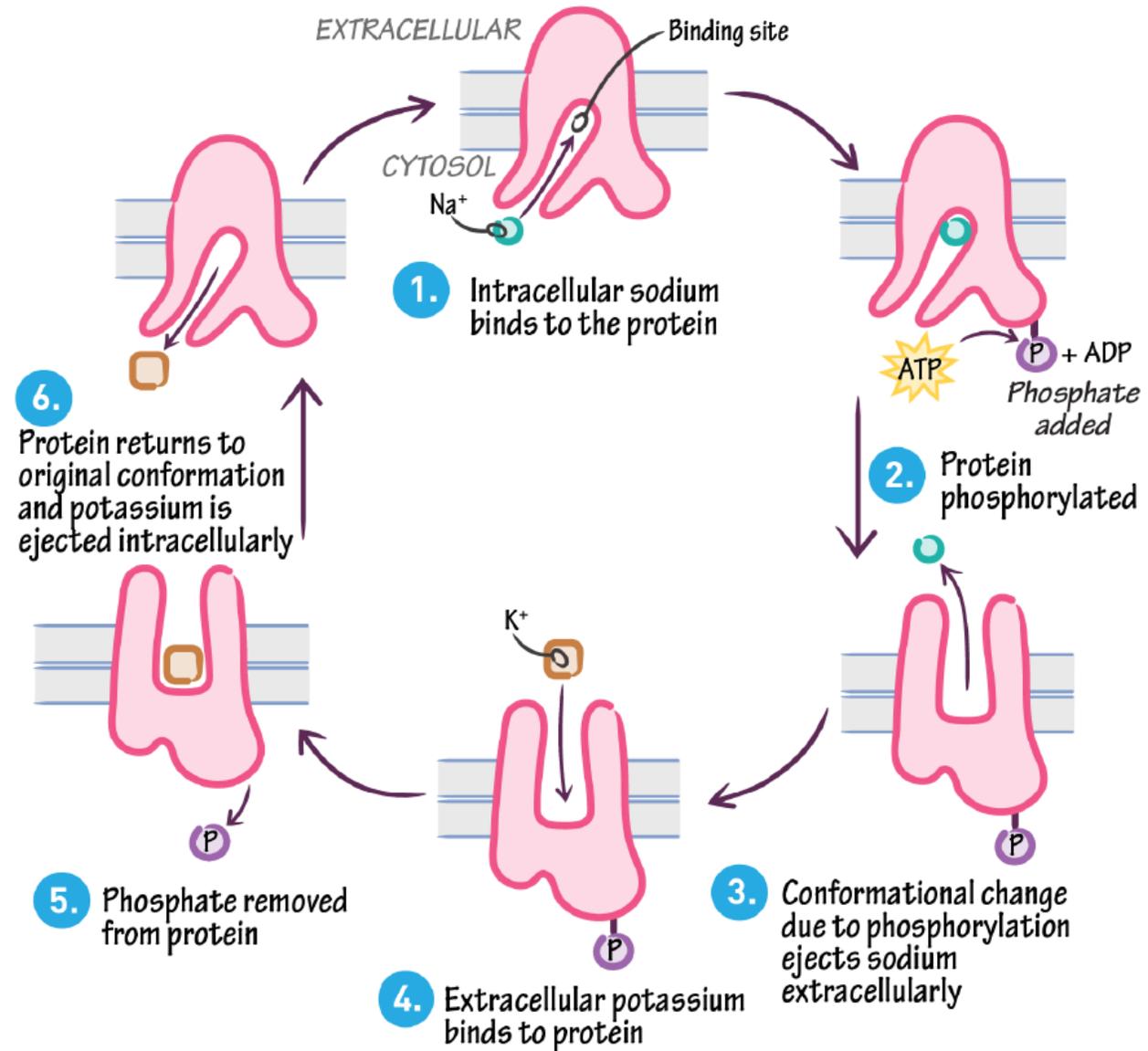
- The sodium-potassium pump (Na^+/K^+ -ATPase) is a vital membrane protein that actively transports sodium and potassium ions against their concentration gradients
- This process requires energy from ATP
- For each ATP molecule consumed, the pump expels three sodium ions from the cell and imports two potassium ions
- This activity maintains a high concentration of sodium outside the cell and a high concentration of potassium inside, which is crucial for functions like nerve impulse transmission and muscle contraction

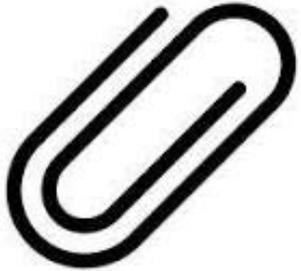


ADDITIONAL
INFORMATION



Sodium Potassium Pump





ADDITIONAL INFORMATION

[Sodium-Potassium Pump – Khan Academy](#)

This video details how the sodium-potassium pump functions to maintain cellular ion gradients



[Passive and Active Transport with Facilitated Diffusion](#)

This tutorial discusses the differences between passive and active transport, including facilitated diffusion

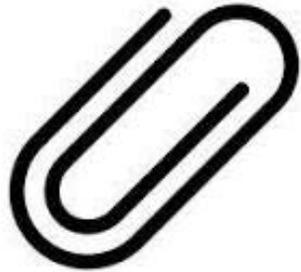


Circulatory system in fish

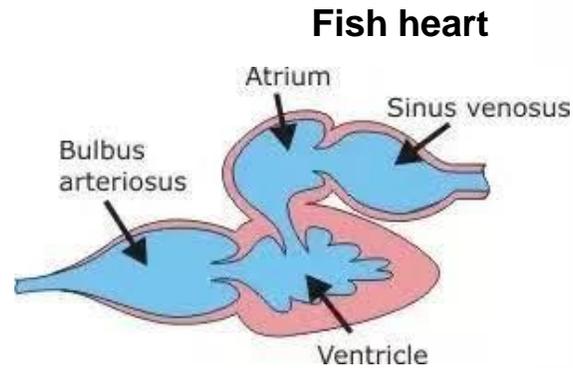
Fish have a **single-circuit closed circulatory system** powered by a **two-chambered heart** comprising one **atrium and one ventricle**. Blood flows in a unidirectional loop:

- 1. Heart to Gills:** Deoxygenated blood is pumped from the heart to the gills via arteries
- 2. Gas Exchange in Gills:** At the gills, blood releases carbon dioxide and absorbs oxygen through a process called **countercurrent exchange**, where blood and water flow in opposite directions across the gill membranes. This mechanism maximizes oxygen uptake efficiency
- 3. Oxygenated Blood to Body:** The now oxygen-rich blood travels from the gills to the rest of the body, delivering oxygen to tissues and organs
- 4. Return to Heart:** After circulating through the body and delivering oxygen, the deoxygenated blood returns to the heart, completing the loop

This single-circuit system means that blood passes through the heart only once during each complete circulation, which can result in lower blood pressure after passing through the gills, potentially limiting the speed at which oxygenated blood reaches body tissues

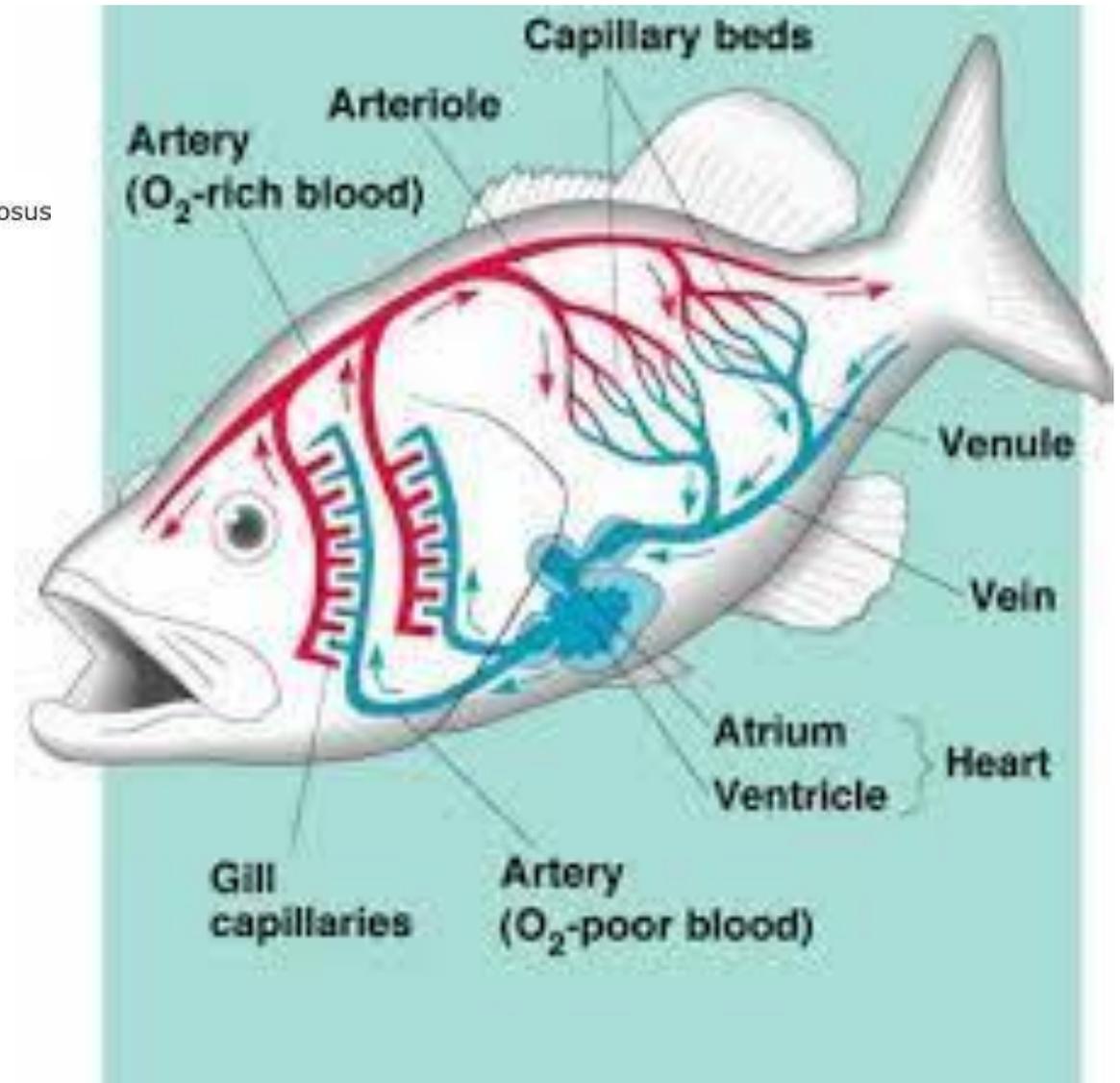


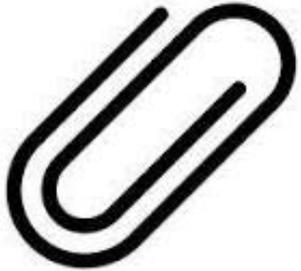
ADDITIONAL
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Circulatory system in fish

Closed circulatory system, where the blood stays within blood vessels, and the heart has with two cavities





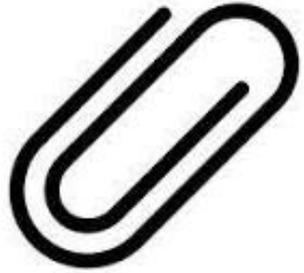
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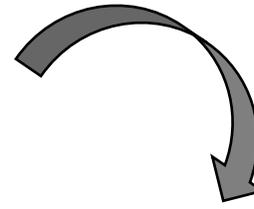
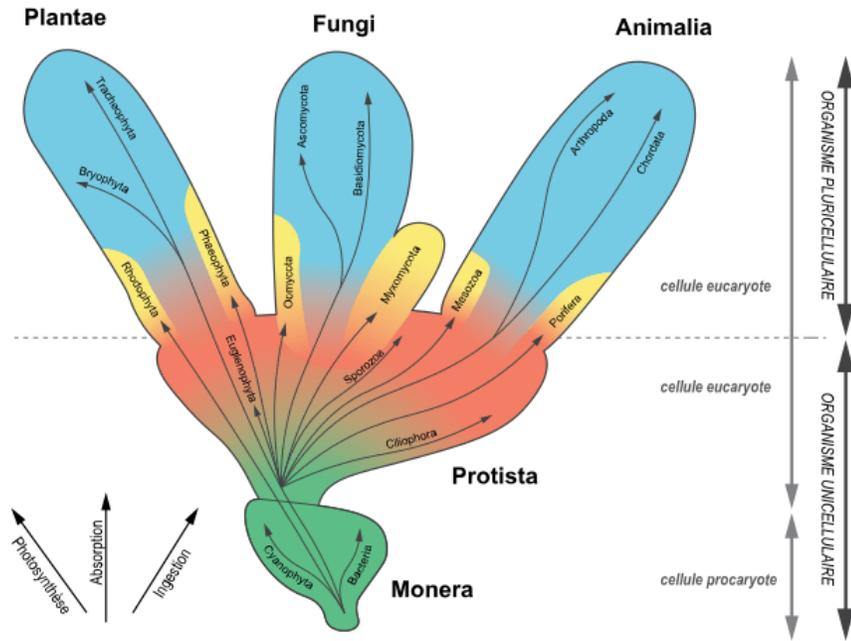
Fish Circulatory System Explained: This video provides a detailed overview of the fish circulatory system, including the heart structure and blood flow

Q17 The diagram shows the circulatory system of a fish. Where in the circulatory system is the oxygen concentration lowest?: This video discusses oxygen concentration levels within the fish circulatory system

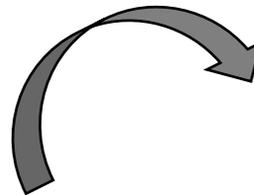
Kingdoms



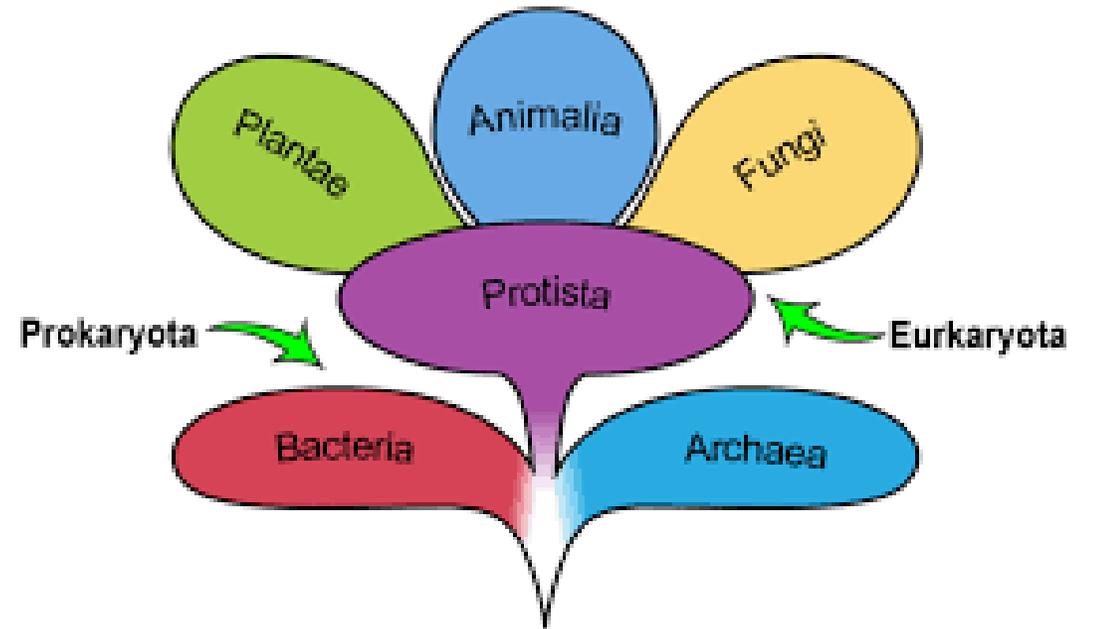
ADDITIONAL
INFORMATION



5 kingdoms of life

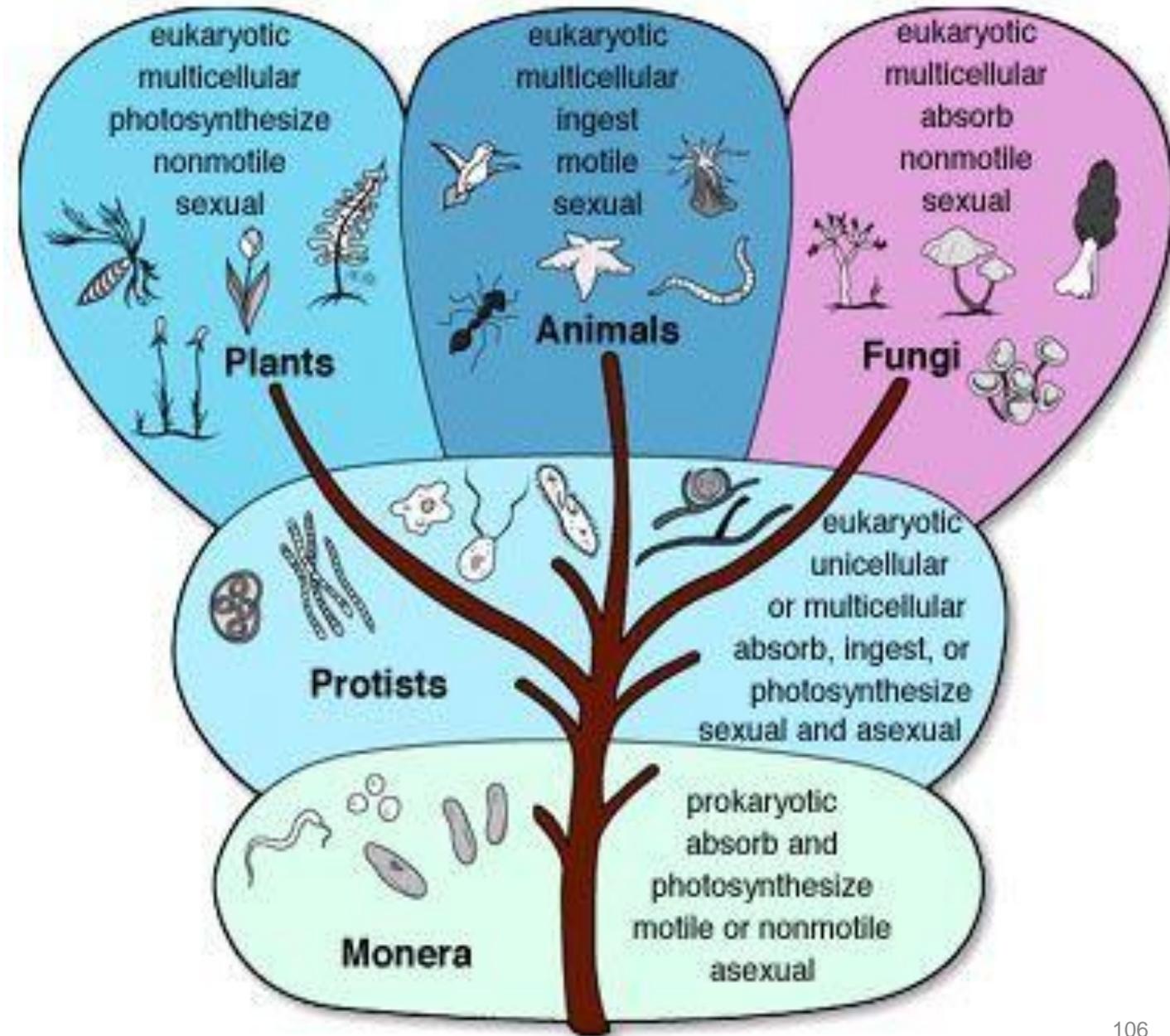


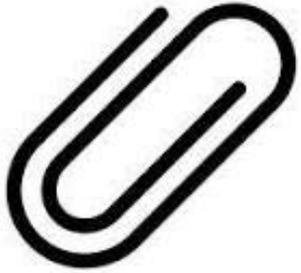
6 kingdoms of life



- The **modified Whittaker classification system** builds upon the original five-kingdom model proposed by Robert H. Whittaker in 1969

- This system categorizes living organisms into five distinct kingdoms based on characteristics such as cell structure, mode of nutrition, reproduction, and phylogenetic relationships





ADDITIONAL INFORMATION



[5 Kingdoms | Animals, plants, fungi, bacteria & protists](#): An overview of the five traditional kingdoms, explaining their characteristics and differences

[Six Kingdoms of Classification](#): This video delves into the six-kingdom system, providing detailed explanations and examples for each kingdom

[Five Kingdom System of Classification – Biology](#)

This video lesson explains Whittaker's system of classification, detailing the characteristics of each kingdom

[Whittaker's Five Kingdom Classification \(Summarized Chart\)](#)

A concise overview of the five-kingdom classification, highlighting key features and examples of organisms in each kingdom



Biology Exam

Good study!

