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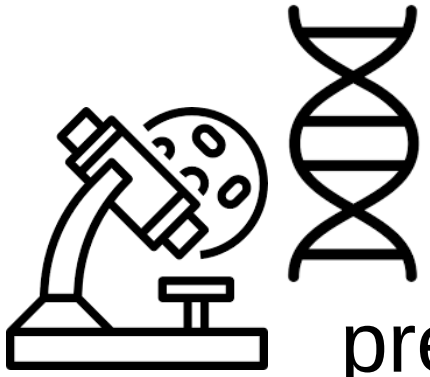


Biology

preparing students for exams

Ana Oliveira | June, 2025

Integrated Masters in Medicine
Model Exam | Special Admissions | 2025/2026

General instructions:

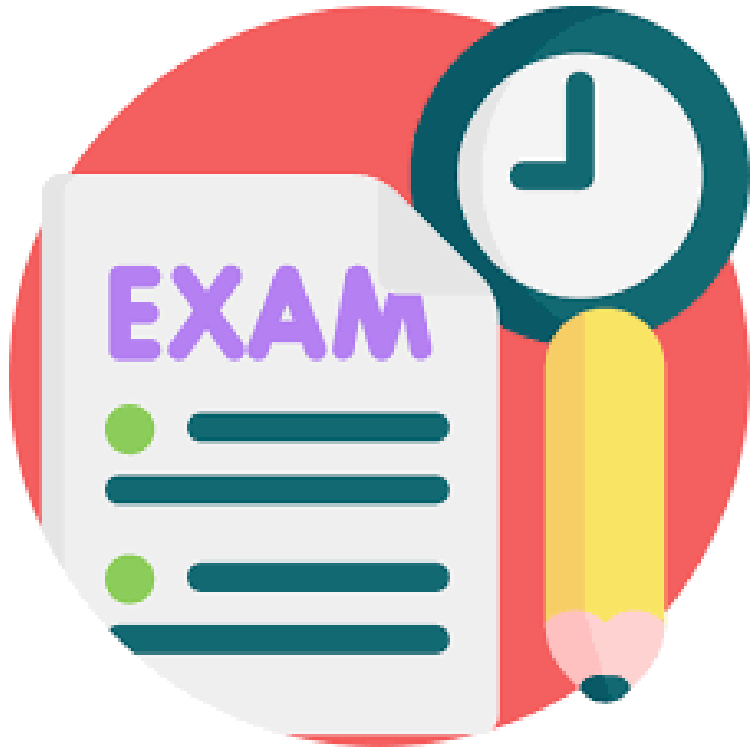
- The exam is evaluated from 0 to 200 points.
- The exam is based on 30 questions, 25 multiple-choice and 5 essay questions.
- Each multiple-choice question is marked out of 5.0 points and each essay question is marked out of 15.0 points.
- Only a blue or black pen may be used.
- The use of a broker 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: 18/06/2025 (Wednesday) at 10:00 am

Model Exam resolution



1. The Buçaco National Forest (BNF) constitutes a heritage of incalculable value. The forest is organized into several landscape units, including Vale dos Fetos and Mata Climácica. The latter is a plant formation, made up of autochthonous plants, which preserves the typical characteristics of the primitive forest that existed in this region before human occupation.

Vale dos Fetos, an enclosed valley that develops along a fault, is one of the darkest and coolest areas of BNF, where one can find a great diversity of mosses. Mosses are non-vascular plants, with the gametophyte generation more developed than the sporophyte generation and with biflagellate antherozoids (male gametes).

In sunny and dry places, there is an abundance of plants with fleshy leaves belonging to the Sedum genus. These succulent plants open their stomata only at night and, through the action of the PEP (phosphoenolpyruvate) carboxylase enzyme present in the cytosol, the absorbed carbon dioxide is stored in the vacuoles, in the form of malic acid ($C_4H_6O_5$). During the day, stored malic acid is transported to chloroplasts, where it is decarboxylated.

In the forest, close to small streams with clear, flowing water, lives the Lusitanian salamander, *Chioglossa lusitanica*, from the Salamandridae family, a species endemic to the northwest of the Iberian Peninsula (Portugal and Spain). Adult individuals of this species feed on small insects, arachnids, and molluscs, and have a capacity that is uncommon in amphibians: they release their tail when threatened (autotomy), regenerating it later. The Lusitanian salamander, which is distinguished from other salamander species by having a narrow and elongated body, can reach 15 cm in length as an adult, of which two thirds corresponds to the tail, and has essentially cutaneous respiration, as it does not have functional lungs.

1.1. The processes that occur in the life cycle of mosses lead to the formation of

(A) gametes, through meiosis, the life cycle being haplodiplontic.

(B) unicellular gametophytes, with postzygotic meiosis.

(C) diploid sporophytes, from genetically different spores.

(D) haploid spores, which mark the beginning of the gametophyte generation.

ANSWER

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):

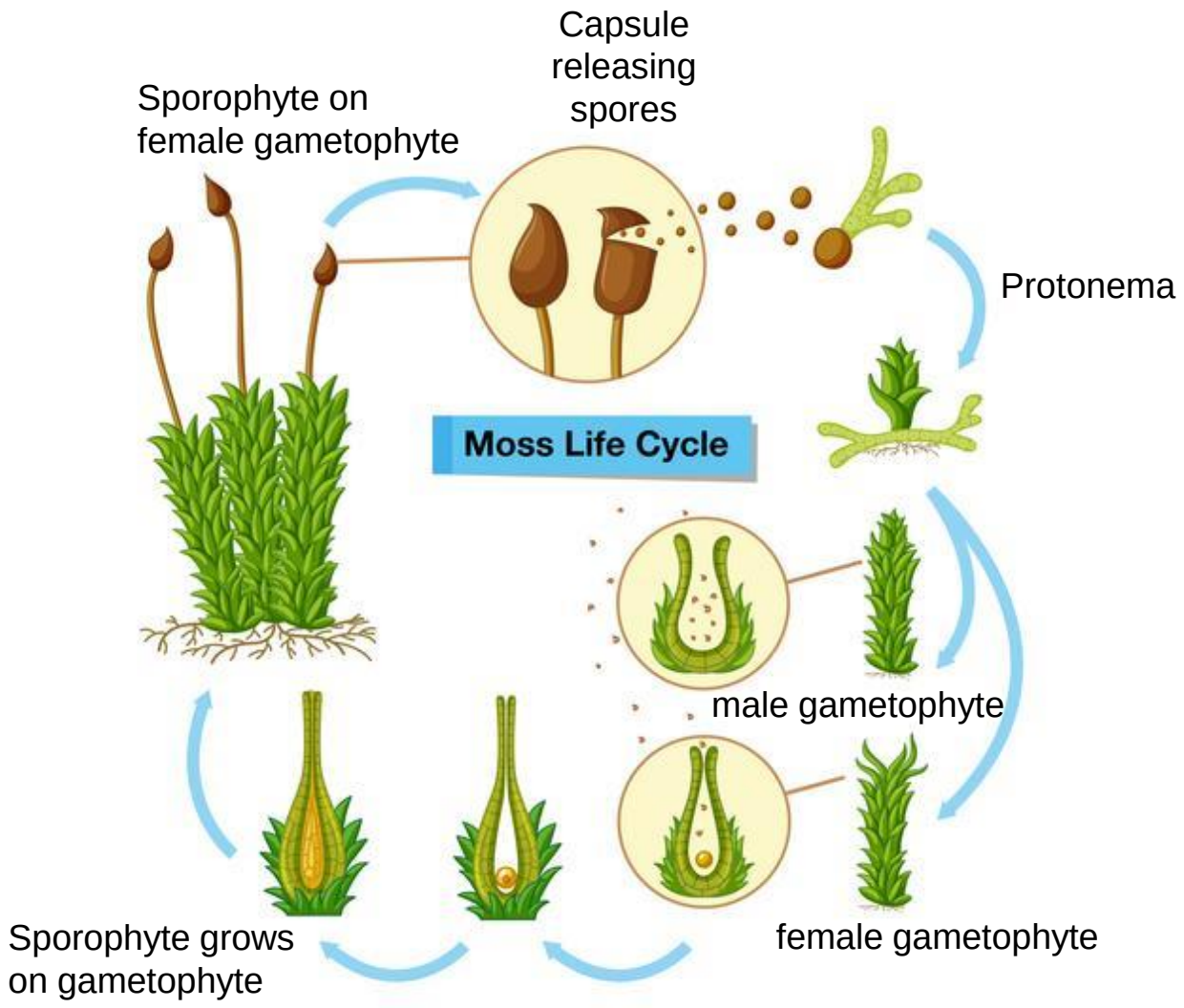
This is the diploid stage, which begins after fertilization. The sporophyte grows out of and remains physically attached to the gametophyte. Its main role is to produce haploid spores through **meiosis** inside a structure called the **sporangium**

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

ADDITIONAL INFORMATION

Bryophytes life cycle



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

1.2. The processes that occur during the night period in plants of the genus *Sedum* lead

(A) the downward movement of water in the xilemic vessels.

(B) the increase in osmotic pressure in the vacuoles.

ANSWER

(C) the temporal separation of CO_2 absorption and perspiration.

(D) the entry of CO_2 into cells by mediated transport.

Specialized photosynthetic pathway known as **Crassulacean Acid Metabolism (CAM)**, which is prevalent in *Sedum* species

In CAM plants, **stomata open at night** to minimize water loss in arid conditions. During this nocturnal period, the following processes occur:

1. CO_2 Uptake and Fixation: Atmospheric CO_2 enters the leaf through open stomata and is fixed by the enzyme **phosphoenolpyruvate carboxylase (PEPC)** into **oxaloacetate**, which is then converted to **malate**

2. Malate Accumulation in Vacuoles: The malate is transported into the vacuoles and stored as **malic acid**. This accumulation increases the concentration of solutes within the vacuoles

3. Increase in Osmotic Pressure: The elevated solute concentration raises the **osmotic pressure** inside the vacuoles, leading to water influx and increased **turgor pressure**. This process is crucial for maintaining cell rigidity and overall plant structure during the night

These nocturnal processes are integral to the CAM pathway, allowing *Sedum* plants to conserve water while maintaining metabolic functions

CAM Photosynthesis Explained

An overview of the CAM pathway, highlighting the temporal separation of CO_2 uptake and fixation

Plant Cell Vacuoles and Osmotic Pressure

Explains the role of vacuoles in maintaining osmotic balance within plant cells

Adaptations of CAM Plants

Discusses how CAM plants like *Sedum* adapt to arid environments through specialized physiological processes

1.3. Order the expressions identified by the letters A to E, in order to reconstruct the correct sequence of events that allow the absorption of CO_2 and its subsequent use in the production of organic matter, in plants of the *Sedum genus*.

A. Opening of the stomata.

B. K^+ entry into stomatal cells against the concentration gradient.

C. Occurrence of anabolic processes due to the action of PEP carboxylase.

D. Carbon incorporation during the Calvin cycle.

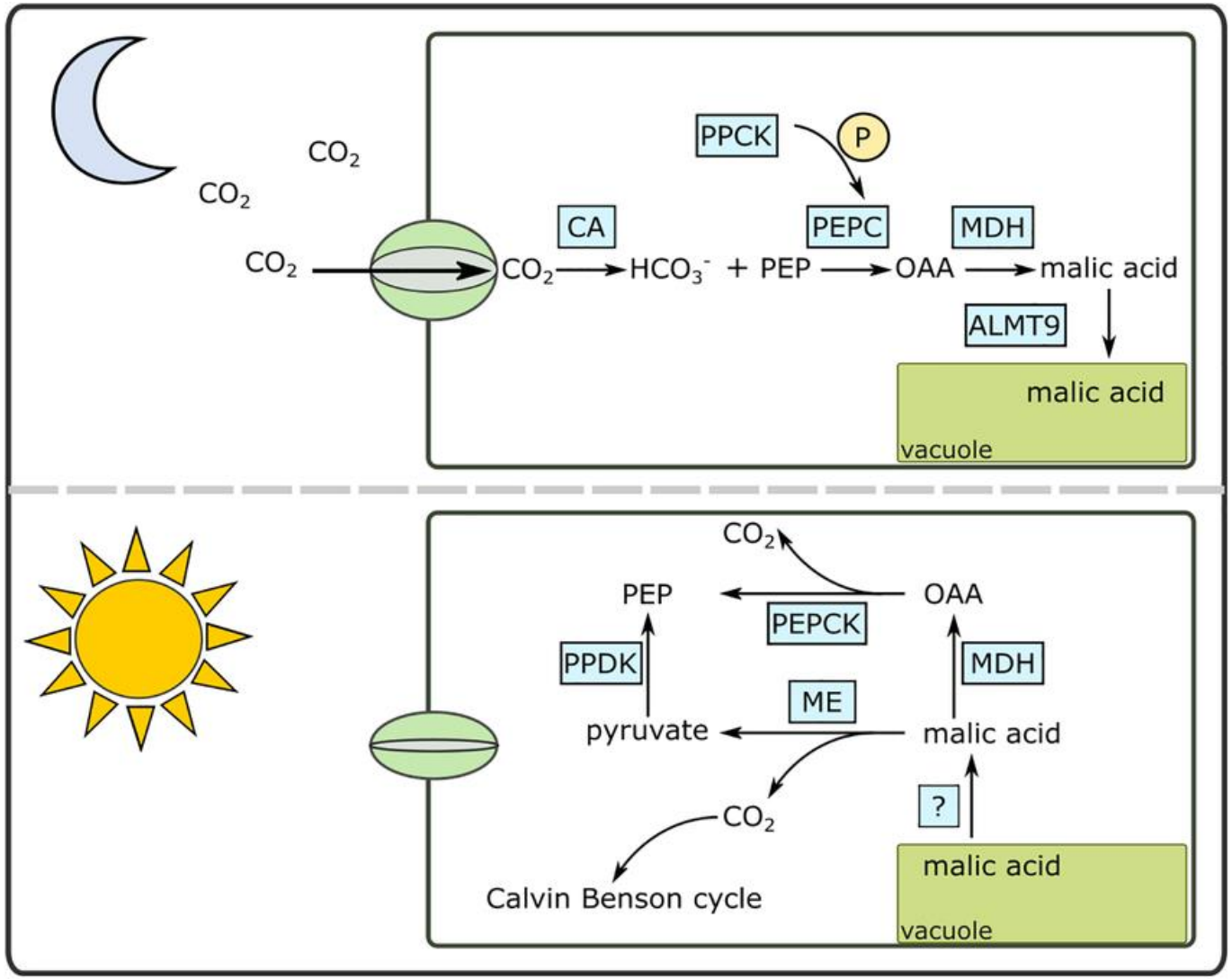
E. Transport of malic acid to chloroplasts.

B, A, C, E, D

ANSWER

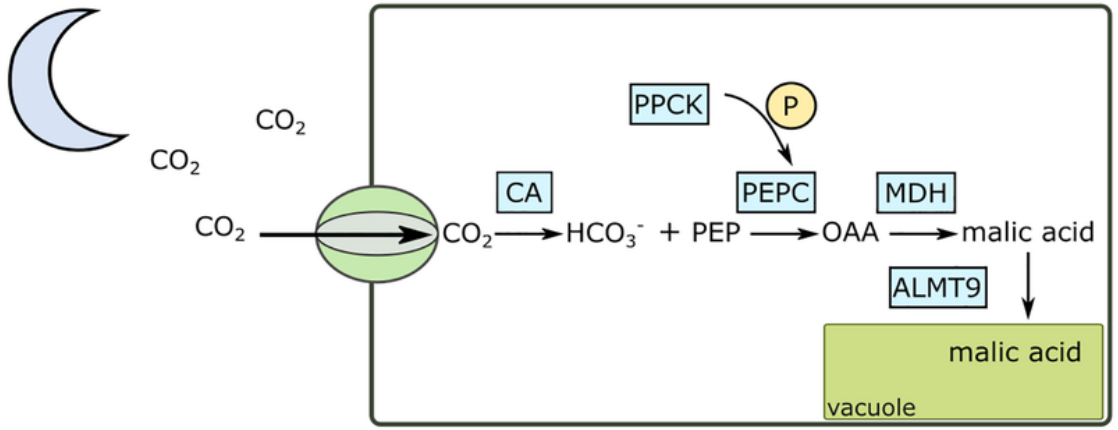
Plants of the *Sedum* genus utilize a specialized photosynthetic pathway known as **Crassulacean Acid Metabolism (CAM)**, which is an adaptation to arid environments

This mechanism allows them to optimize water use while efficiently producing organic matter



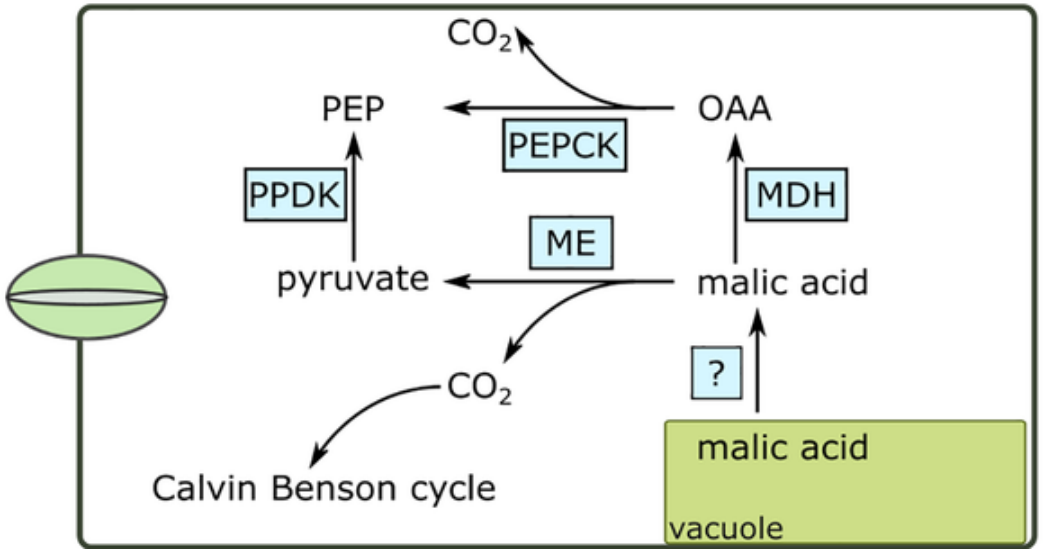
Nighttime: CO_2 Uptake and Storage

During the night, *Sedum* plants open their stomata to absorb atmospheric carbon dioxide (CO_2). This CO_2 is initially fixed into a four-carbon compound called **oxaloacetate** by the enzyme **phosphoenolpyruvate carboxylase (PEPC)**. Oxaloacetate is then converted into **malate**, which is stored in the vacuoles of plant cells as **malic acid**. This storage increases the osmotic pressure within the vacuoles, aiding in water retention and maintaining cell turgor pressure



Daytime: CO_2 Release and Sugar Production

In daylight, the stomata close to minimize water loss. The previously stored malic acid is transported from the vacuoles to the chloroplasts, where it is decarboxylated to release CO_2. This internally released CO_2 enters the **Calvin cycle**, leading to the synthesis of sugars and other organic compounds essential for the plant's growth and energy needs



CAM Photosynthesis Explained

An animated overview of the CAM pathway, highlighting the temporal separation of CO_2 uptake and fixation

Plant Cell Vacuoles and Osmotic Pressure

Explains the role of vacuoles in maintaining osmotic balance within plant cells

Adaptations of CAM Plants

Discusses how CAM plants like *Sedum* adapt to arid environments through specialized physiological processes

1.4. Although it evolved from ancestors with functional lungs, the Lusitanian salamander does not have functional lungs. This characteristic highlight that

(A) from a Darwinian perspective, lung atrophy resulted from the occurrence of a mutation.

(B) from a Lamarckian perspective, the variability of their ancestors ensured metabolism with cutaneous hematosis.

(C) the increase in the area/volume ratio favored the survival of salamanders in an environment with high humidity.

(D) the increased thickness of the integument allowed the salamanders to survive during periods of high dryness.

ANSWER

• The Lusitanian salamander (*Chioglossa lusitanica*) is a lungless amphibian endemic to the humid, forested regions of the Iberian Peninsula

• Despite descending from ancestors with functional lungs, this species has evolved to rely entirely on **cutaneous (skin) and buccopharyngeal (mouth and throat lining) respiration**

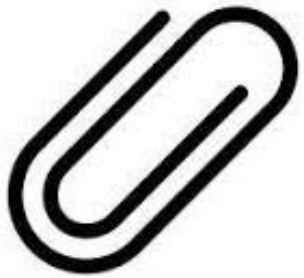
• This adaptation is closely linked to its **high surface area-to-volume (SA:V) ratio**, which enhances gas exchange efficiency in moist environments

Lungless Salamanders and Cutaneous Respiration

This video explains how certain salamanders have adapted to breathe through their skin and the importance of moist environments for their survival

Surface Area to Volume Ratio Explained

A detailed explanation of the surface area-to-volume ratio concept and its biological significance, particularly in relation to gas exchange and thermoregulation



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

1.5. Complete the following text, selecting the appropriate option for each space.

Write each letter on the answer sheet, followed by the number that corresponds to the selected option.

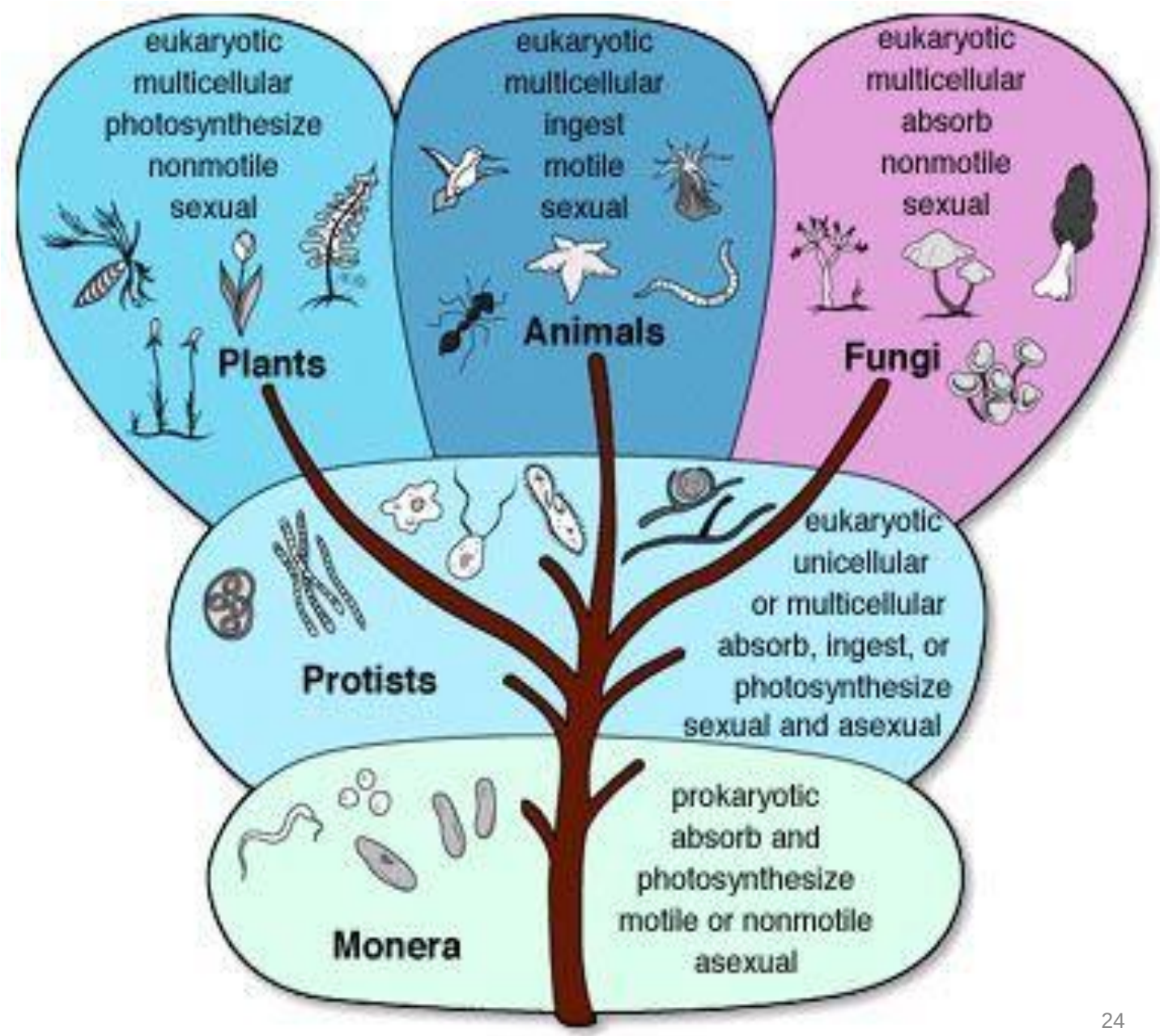
According to the criteria of the modified Whittaker classification system, Lusitanian salamanders have __a)__ . These amphibians, as adults, have circulation __b)__ and a heart with __c)__. Digestion of the prey they capture occurs __d)__.

a)	b)
1. absorption heterotrophism 2. prokaryotic cell structure 3. high tissue differentiation	1. simple 2. full double 3. incomplete double
c)	**d)**
1. two ventricles and one atrium 2. two atria and one ventricle 3. two atria and two ventricles	1. in a complete digestive tract 2. in a gastrovascular cavity 3. in an incomplete digestive tract

ANSWER

• 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



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

1.6. The Lusitanian salamander uses two different cell division mechanisms, one to reproduce and the other to regenerate its tail.

Associate with the division mechanisms, presented in Column I, the events described in Column II that correspond to them. Each number must be associated with only one letter, and all numbers must be used.

Column I	**Column II**
(a) Only in mitosis (b) Only in meiosis (c) In mitosis and meiosis	(1) There is replication of genetic information before nuclear division begins. (2) There is pairing of homologous chromosomes and exchange of segments with each other. (3) There is maintenance of ploidy and a reduction in the amount of DNA by half, compared to the mother cells in G2. (4) The centromeres divide, and the chromatids separate to opposite poles of the cell. (5) Haploid cells are formed from the division of diploid cells. (6) The nuclear membrane reorganizes around chromosomes made up of two chromatids. (7) Genetically identical daughter cells are formed.

ANSWER:

a) – (3), (7); (b) – (2), (5), (6); (c) – (1), (4)

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:

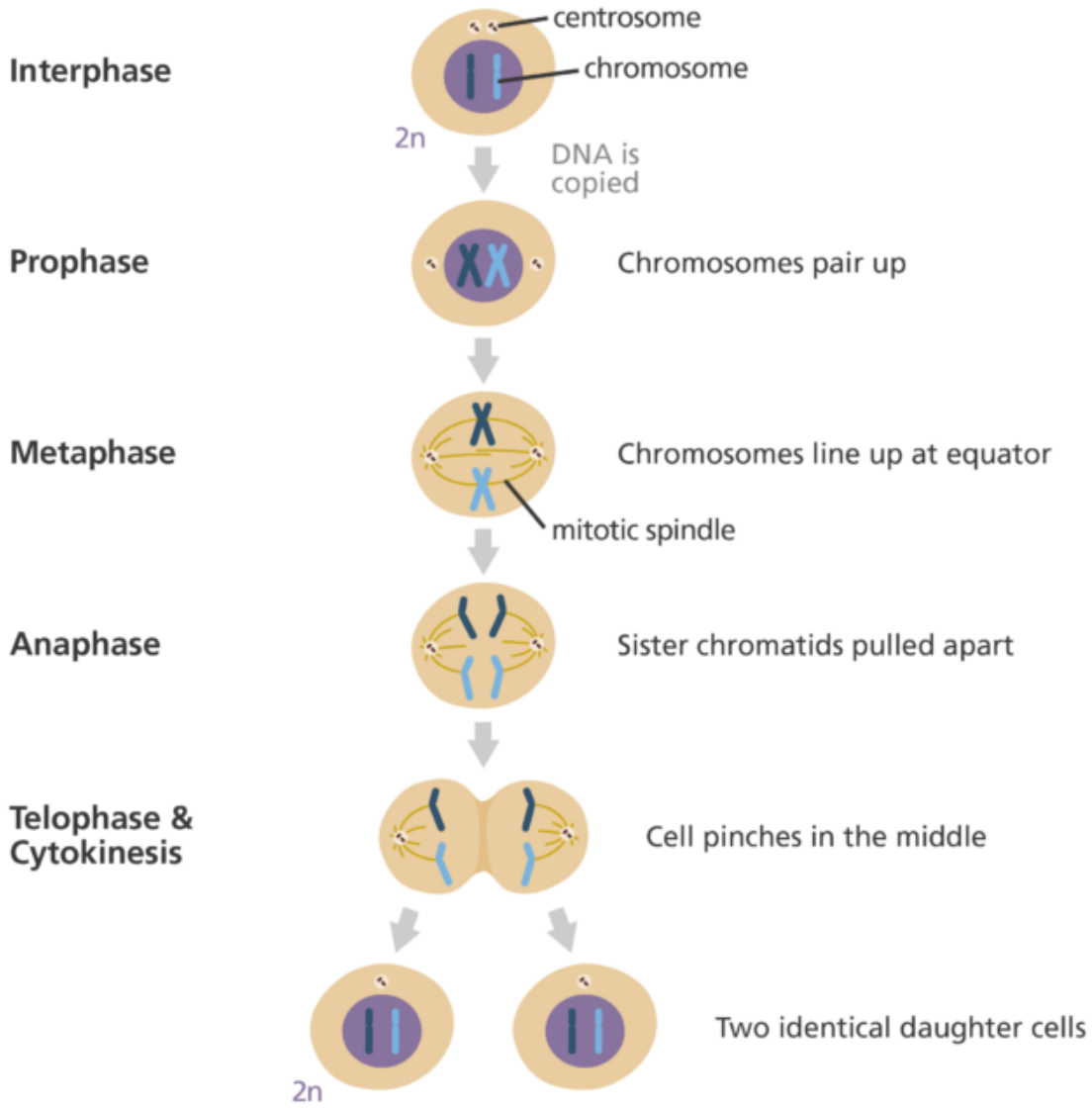
1. Prophase: Chromosomes condense, and the nuclear envelope begins to disintegrate

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

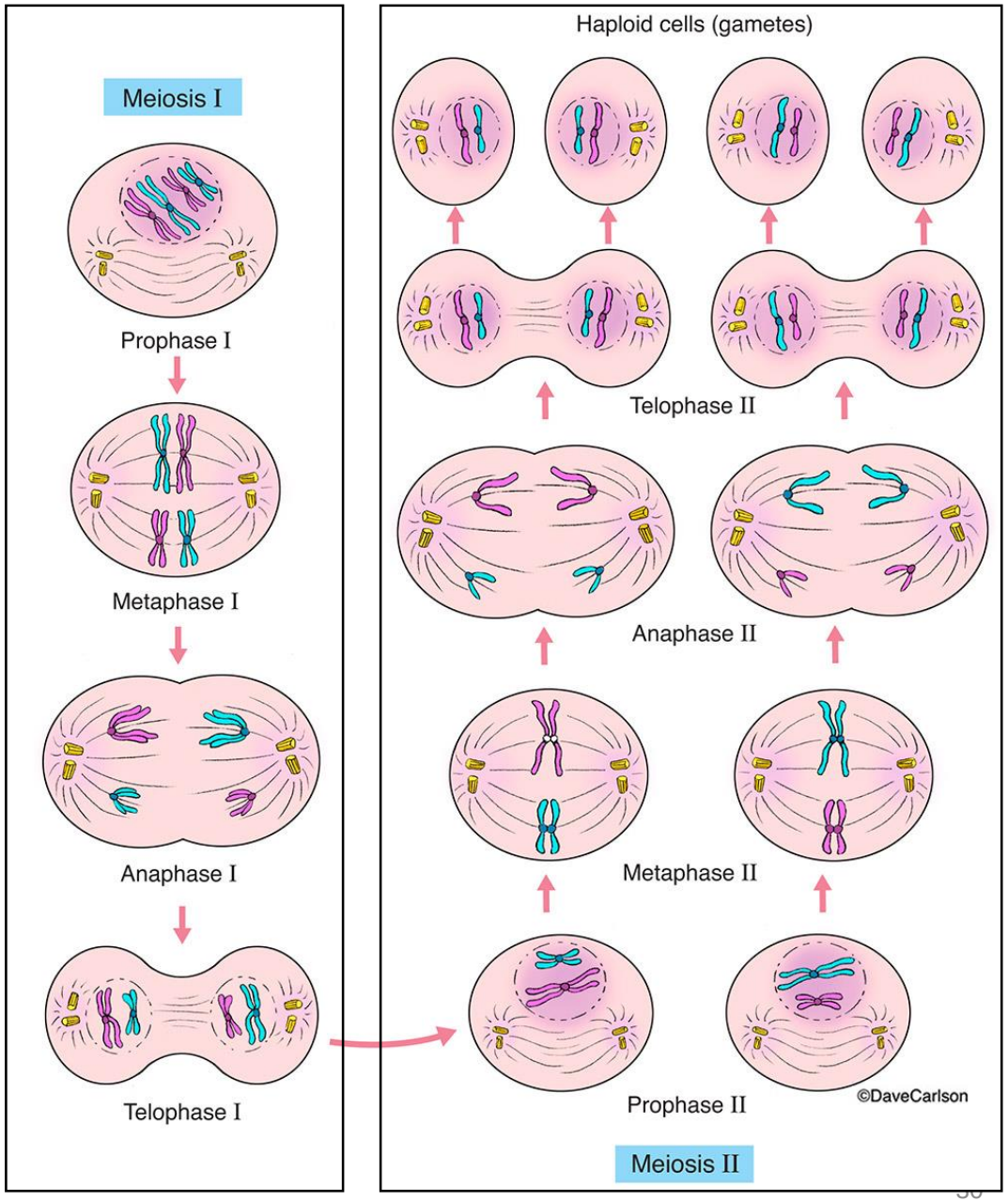
This process is essential for:

- **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



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

2. The diagram shows the structure of insulin.

From the diagram, what can be concluded about the structure of insulin?

(A) It is composed of two polypeptide chains stabilized by disulfide bonds.

ANSWER

(B) It is a simple protein composed of one continuous polypeptide chain.

(C) It is a fibrous protein.

(D) Its molecules do not display quaternary structure.

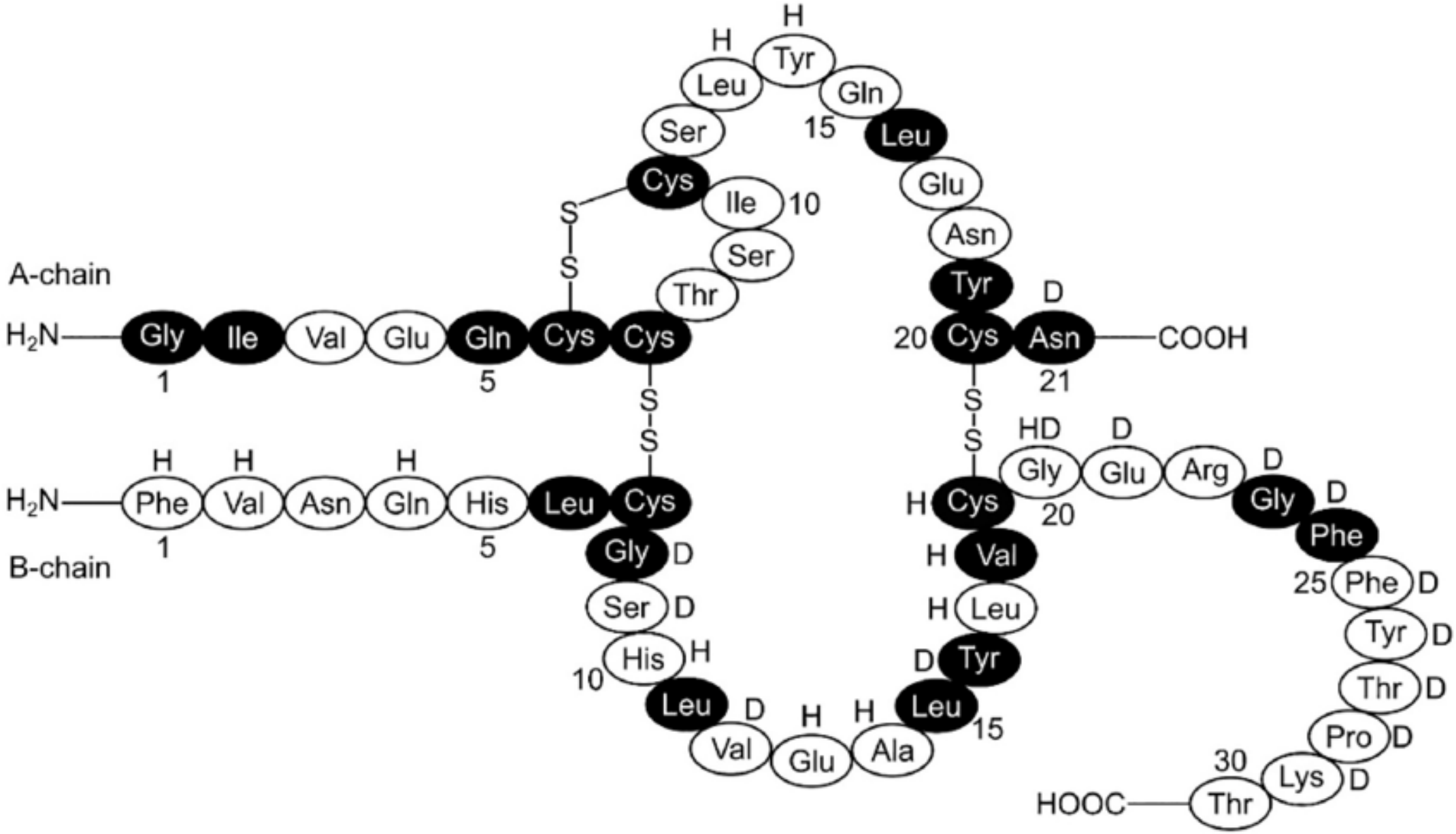
The hormone **insulin** is a small protein crucial for regulating blood glucose levels. Its structure comprises two polypeptide chains:

- **A-chain**: 21 amino acids
- **B-chain**: 30 amino acids

These chains are connected and stabilized by **three disulfide bonds**:

- Two **interchain** disulfide bonds link the A and B chains at positions A7-B7 and A20-B19
- One **intrachain** disulfide bond within the A-chain connects positions A6-A11

These covalent bonds, formed between cysteine residues, are essential for insulin's proper folding and biological activity. Without these disulfide bridges, insulin cannot attain its functional three-dimensional conformation


A-chain
B-chain
H2N
COOH
HOOC
Gly Ile Val Glu Gln Cys Cys
Phe Val Asn Gln His Leu Cys
Gly Ser His Leu Val Glu Ala Leu Tyr Leu Val Cys Gly Glu Arg Gly Phe Phe Tyr Thr Pro Lys Thr
Tyr Leu Ser Cys Ile Ser Thr Gln Leu Glu Asn Tyr Cys Asn
S S
S S
S S
1
5
10
15
20
21
25
30
H
D
HD

Insulin Structure and Release Explained

This video provides a clear overview of insulin's structure, including the significance of its polypeptide chains and disulfide bonds

Disulfide Bridge Formation: Cysteine to Cystine

An informative explanation of how disulfide bonds form between cysteine residues, crucial for stabilizing protein structures like insulin

Insulin Formation via Disulfide Bonds

This video demonstrates the formation of insulin through the connection of A and B chains via disulfide bonds

3. Malaria is a disease caused by protozoa introduced into human blood through the bite of the female *Anopheles gambiae* mosquito. The female, when feeding on blood, acquires an abundant nutritional supplement with ten essential amino acids, which provides her with a higher reproductive rate.

Mosquitoes control the coagulation system during their meals by having anticoagulant substances in their saliva. One of these substances – anopheline – is a peptide molecule that inhibits the thrombin enzyme. This enzyme converts fibrinogen, a soluble plasma protein, into fibrin, an insoluble protein, forming clots that impede blood circulation.

The mosquito detects odors through the axonal endings of the olfactory neurons of the antennae, which, on their surface, have receptors to which odorant molecules bind.

Precisely manipulating the behavior of mosquitoes through their olfactory faculties is a strategy that can help save many lives.

3.1. The parasite introduced into the bloodstream by the *Anopheles gambiae* mosquito, being a protozoan, is a

(A) unicellular prokaryotic.

(B) multicellular prokaryotic.

(C) eukaryotic unicellular.

(D) eukaryotic multicellular.

ANSWER

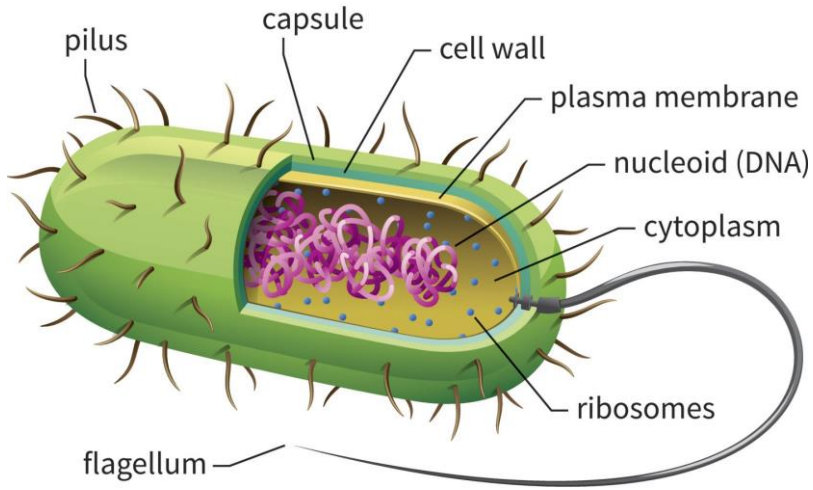
Prokaryotic and eukaryotic cells represent the two primary types of cellular organization in living organisms. Understanding their differences is fundamental to biology.

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

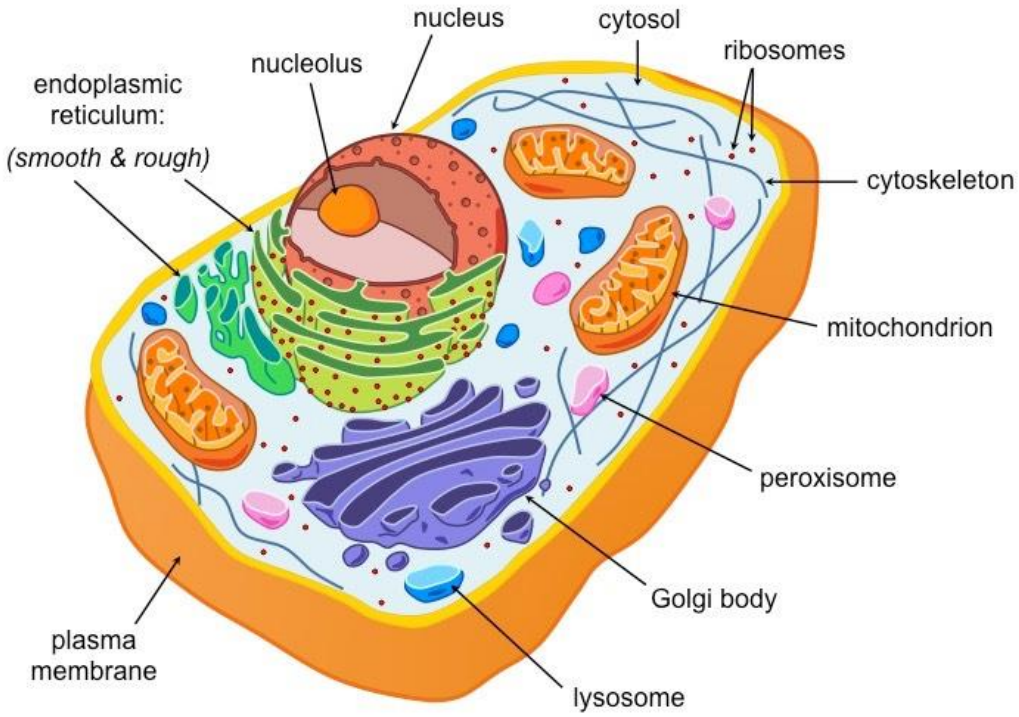


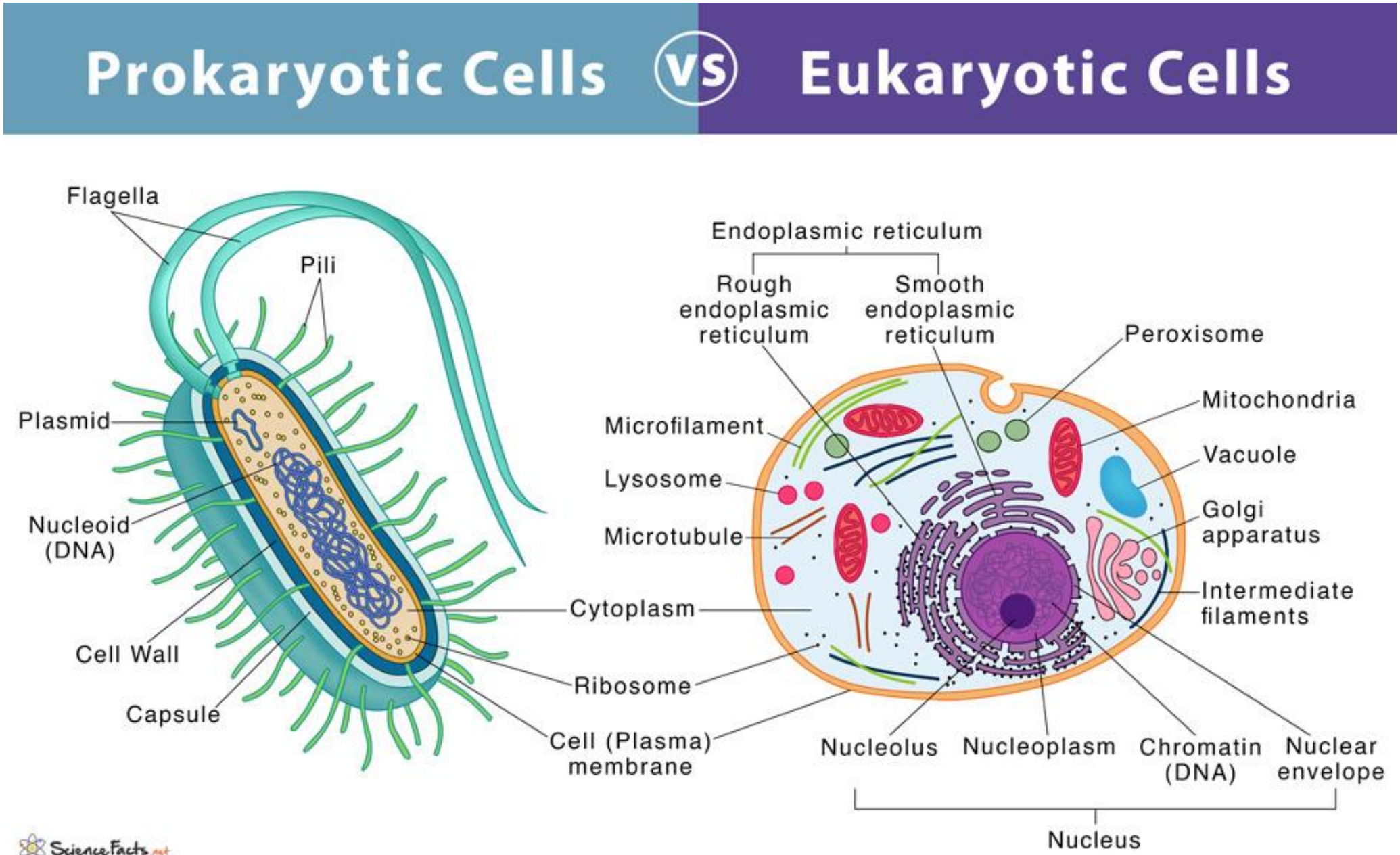
Eukaryotic Cells

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
Flagella
Pili
Plasmid
Nucleoid (DNA)
Cell Wall
Capsule
Cytoplasm
Ribosome
Cell (Plasma) membrane
Endoplasmic reticulum
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Peroxisome
Mitochondria
Microfilament
Vacuole
Lysosome
Golgi apparatus
Microtubule
Intermediate filaments
Nucleolus
Nucleoplasm
Chromatin (DNA)
Nuclear envelope
Nucleus
ScienceFacts.net

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

3.2. The nutritional supplement obtained from the diet of female *Anopheles gambiae* mosquitoes allows the synthesis of

(A) carbohydrates in anabolic pathways.

(B) protides in anabolic pathways.

(C) carbohydrates in catabolic pathways.

(D) protides in catabolic pathways.

ANSWER

The blood meal provides the necessary amino acids that fuel anabolic pathways in *Anopheles gambiae* females, leading to the synthesis of proteins essential for reproduction

- Female *Anopheles gambiae* mosquitoes require a blood meal to initiate egg development. This blood meal provides essential nutrients, particularly proteins, which are digested into amino acids. These amino acids serve as building blocks for the synthesis of protides (proteins) through anabolic pathways

- Upon ingesting blood, the mosquito's midgut secretes proteolytic enzymes, such as trypsins, that break down blood proteins into free amino acids. These amino acids enter the hemolymph (mosquito's circulatory system) and are transported to the fat body, an organ analogous to the vertebrate liver. Here, the amino acids are utilized in anabolic processes to synthesize vital proteins like vitellogenin, a yolk protein crucial for oocyte (egg) development

- This process is regulated by hormonal and signaling pathways. The influx of amino acids activates the Target of Rapamycin (TOR) pathway in the fat body, promoting protein synthesis and egg maturation

Mosquito Reproduction and Blood Feeding

An overview of how blood feeding influences mosquito reproduction

Protein Synthesis in Mosquitoes

Detailed explanation of protein synthesis pathways post blood meal

Anopheles gambiae: Blood Meal to Egg Development

Focuses on the role of blood meals in egg development of *Anopheles gambiae*

3.3. The mosquito's olfactory neurons send signals to a

(A) nervous center through motor neurons.

(B) effector organ through sensory neurons.

(C) effector organ through motor neurons.

(D) nervous center through sensory neurons.

ANSWER

- Mosquitoes possess olfactory sensory neurons (OSNs) located primarily on their antennae, maxillary palps, and labella

- These neurons are housed within structures called sensilla, which are hair-like projections on the mosquito's sensory appendages

- Each OSN expresses specific odorant receptors that bind to odor molecules, such as carbon dioxide or human skin volatiles

- Upon binding an odorant, the OSN generates an electrical signal (action potential) that travels along its axon to the mosquito's brain

How Mosquitoes Use Smell to Find Humans

This video explains the role of olfactory neurons in mosquito host-seeking behavior

The Neuroscience of Mosquito Olfaction

An in-depth look at how mosquitoes process olfactory information in their brains

Mosquito Sensory Systems and Behavior

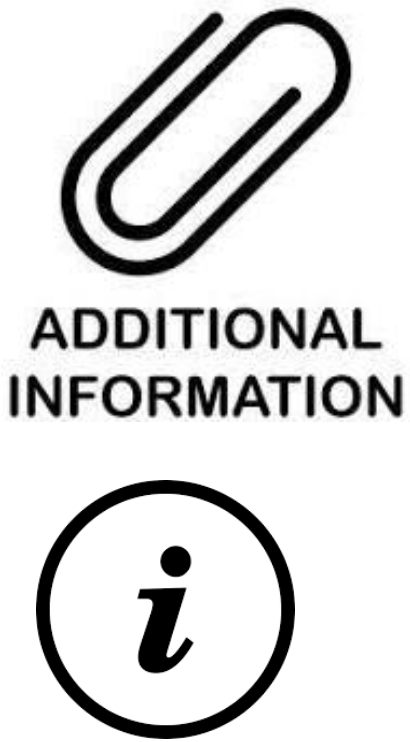
An overview of the sensory systems in mosquitoes, focusing on olfaction

3.4. Explain how anopheline can be the basis for the development of a new drug intended for the prevention and treatment of cardiovascular diseases.

ANSWER:

Answer topics:

- *Reference to thrombin inhibition by anopheline;*
- *Reference to non-formation of fibrin/clots;*
- *Relationship between minimizing the formation (or non-formation) of clots and the prevention/treatment of cardiovascular diseases.*



Key Salivary Proteins with Therapeutic Potential

1. Anopheline Antiplatelet Protein (AAPP): AAPP binds directly to collagen in blood vessels, inhibiting platelet aggregation. This action prevents clot formation, facilitating uninterrupted blood flow during the mosquito's feeding process. Scientists have explored AAPP's potential as a template for designing antiplatelet therapies

2. Anophelin: Anophelin targets thrombin, a central enzyme in the blood coagulation cascade. By inhibiting thrombin, anophelin effectively prevents clot formation. Researchers have enhanced anophelin's anticoagulant activity through sulfation, achieving a 100-fold increase in potency compared to its unmodified form

Mosquito Saliva and Blood Clotting

An overview of how mosquito saliva components prevent blood clotting during feeding

Anophelin: A Novel Anticoagulant

A detailed look at the discovery and potential therapeutic applications of anophelin

From Mosquitoes to Medicine: Developing New Anticoagulants

Explores the process of translating mosquito saliva proteins into drug candidates

4. The table shows the mRNA codons for three amino acids.

Valine	Threonine	Proline
GUU	ACU	CCU
GCC	ACC	CCC
GCA	ACA	CGA
GCG	ACG	CCG

Which substitution mutation of a base triplet on a DNA strand will lead to the same polypeptide being formed at translation?

(A) GCT to GGA

(B) CGT to CTA

(C) CAA to CGA

(D) TGA to TCA

ANSWER

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

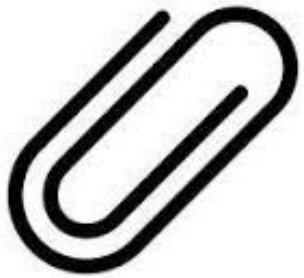
• During translation, ribosomes read the mRNA codons sequentially, and transfer RNA (tRNA) molecules bring the corresponding amino acids. These amino acids are linked together to form a polypeptide chain, which folds into a functional protein

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

5. . What is a function of the lymphatic system?

(A) absorption of glucose

(B) blood clotting

(C) circulation of body fluids

(D) temperature regulation

ANSWER

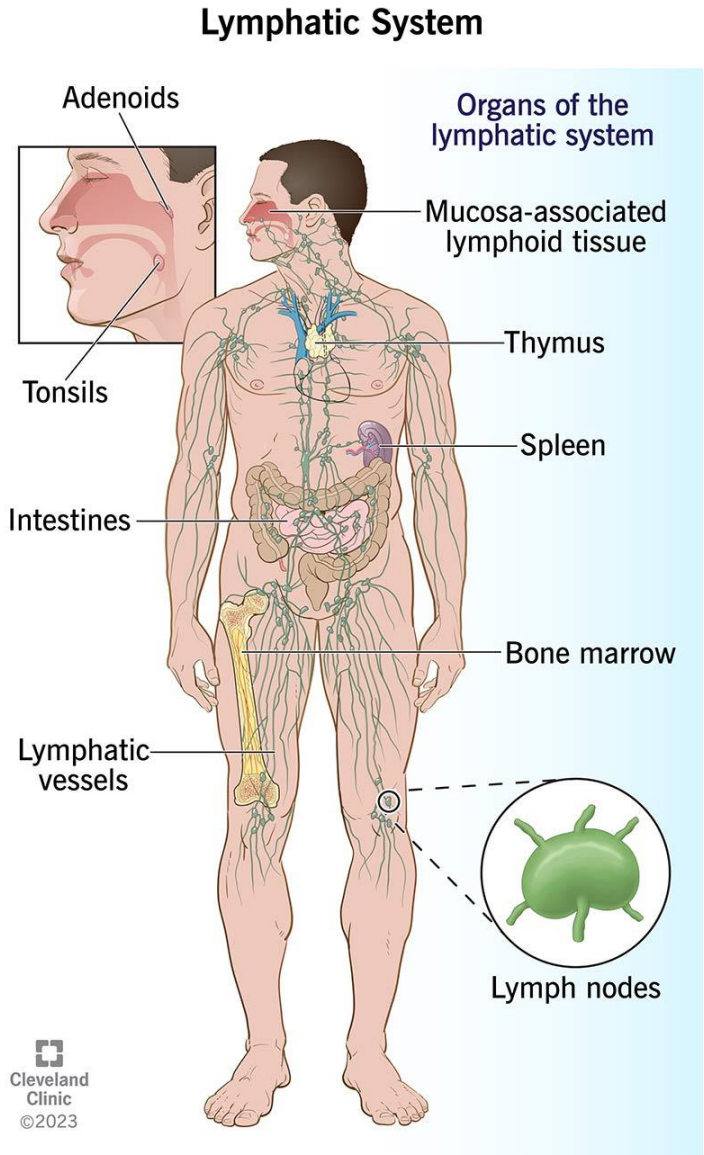
The lymphatic system is a vital component of the body's immune system, responsible for maintaining fluid balance, absorbing dietary fats, and defending against infections.

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



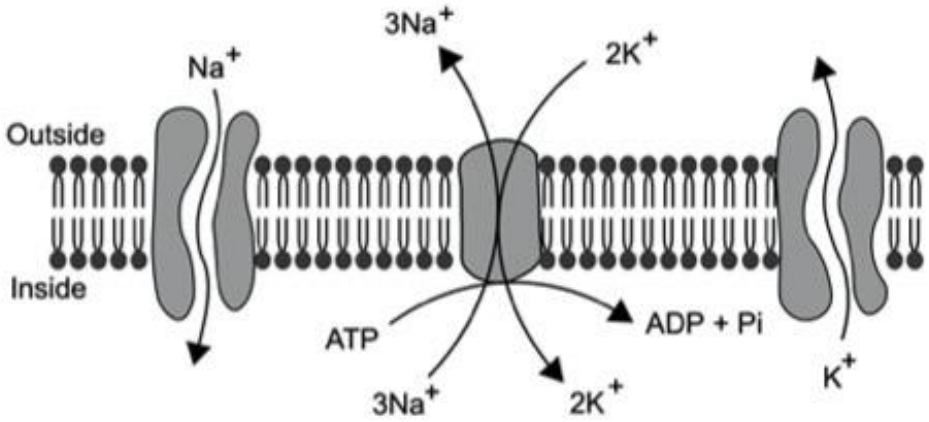
How Does the Lymphatic System Work?

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

6. The diagram shows the movement of ions that can occur across the membrane of a neuron.



From the diagram, what can be deduced about the movement of sodium ions?

(A) They are actively pumped out and some re-enter by simple diffusion.

(B) They are actively pumped out and some re-enter by facilitated diffusion.

(C) They diffuse out of the cell along with potassium ions.

(D) There is a net movement of sodium ions into the cell.

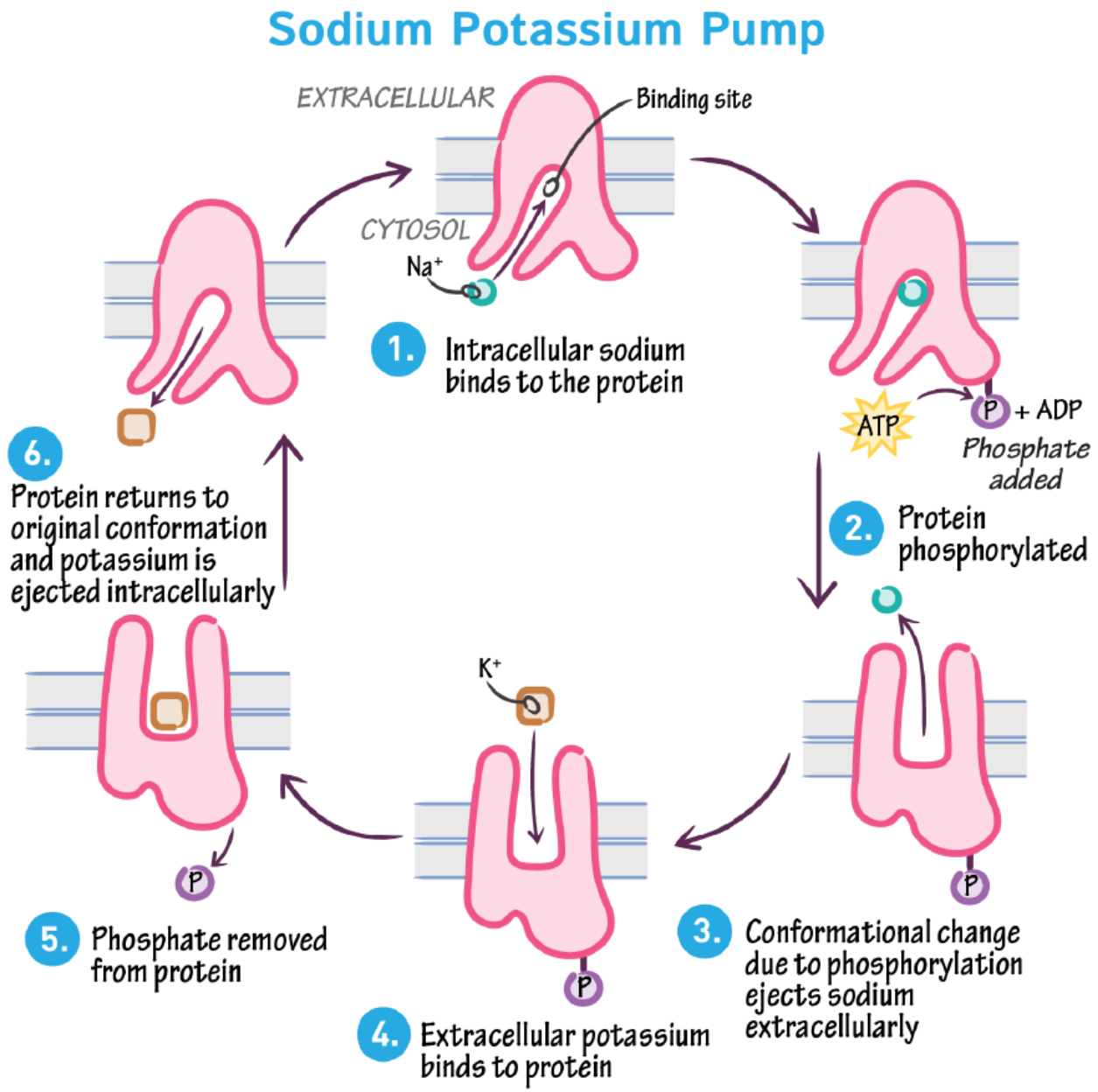
ANSWER

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 gradientes
- 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 – Khan Academy

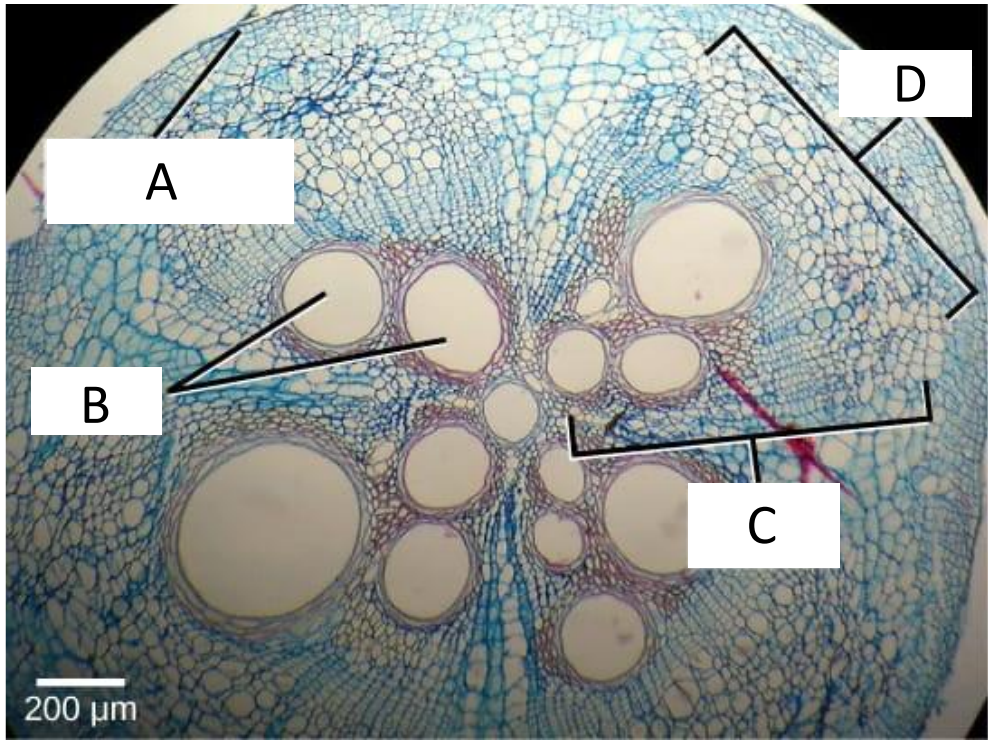
This video details how the sodium-potassium pump functions to maintain cellular ion gradients

Passive and Active Transport with Facilitated Diffusion

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

7. The diagram shows a cross-section through a leaf.

7.1. Make the legend of the figure.



ANSWER:

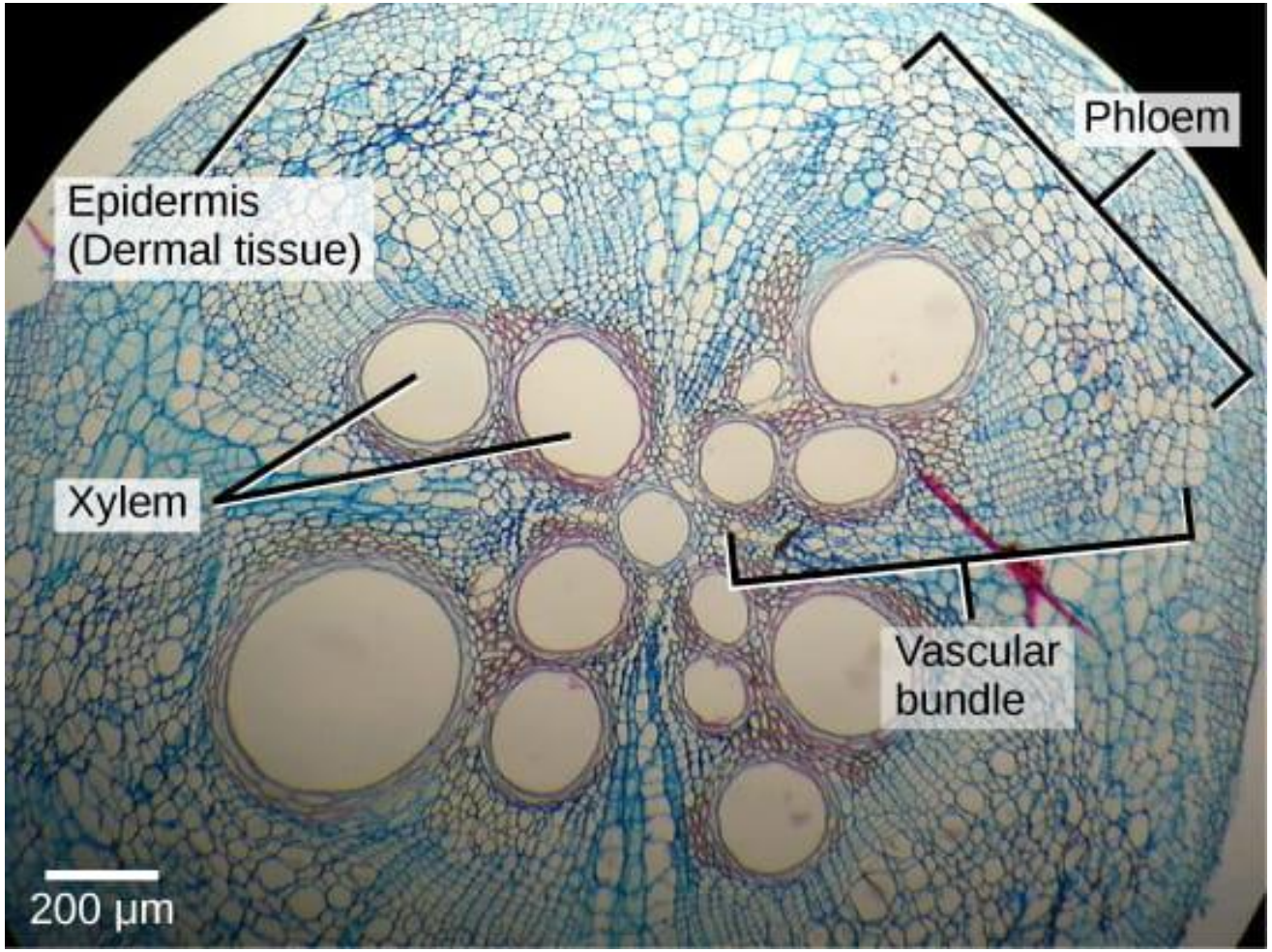
A – Epidermis (dermal tissue)

B – Xylem

C – Vascular bundle

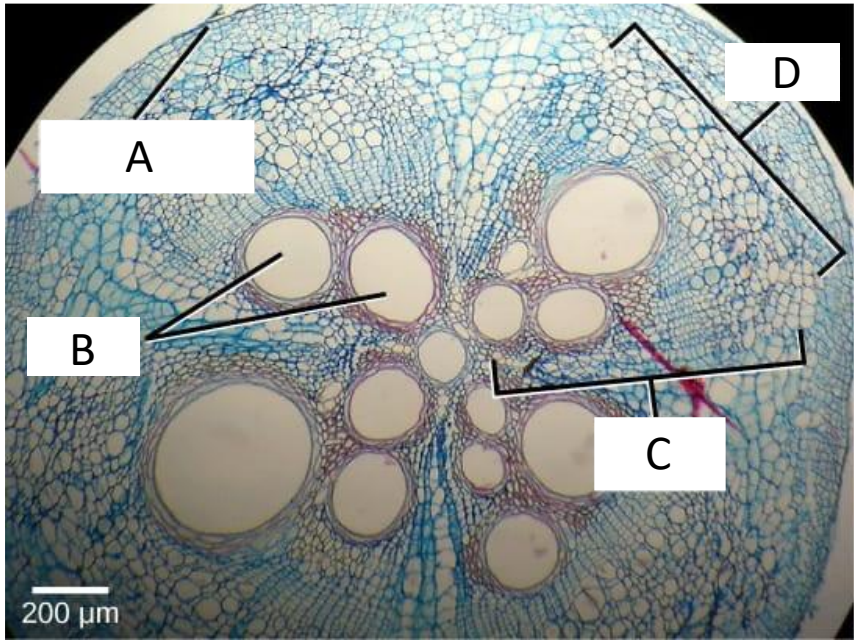
D – Phloem

Plant tissue differentiation and function



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

7.2. Explain the function of the tissues represented by the letters B and D.



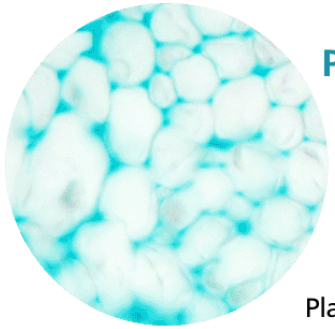
ANSWER:

Xylem (letter B) transports water and minerals through vessel elements and tracheid, which are dead at maturity and have a primary and secondary cell wall. Xylem transports and stores water and water-soluble nutrients in vascular plants.

Phloem (letter D) transports sugars and other items. Phloem is responsible for transporting sugars, proteins, and other organic molecules in plants

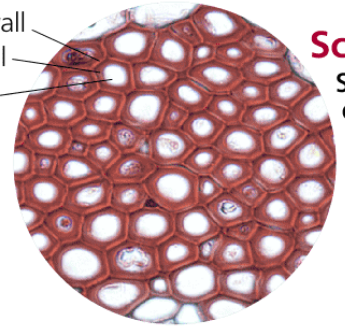
CATOLICA
FACULDADE DE MEDICINA
LISBOA

ADDITIONAL INFORMATION



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 .

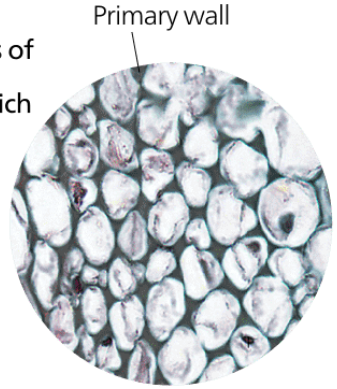


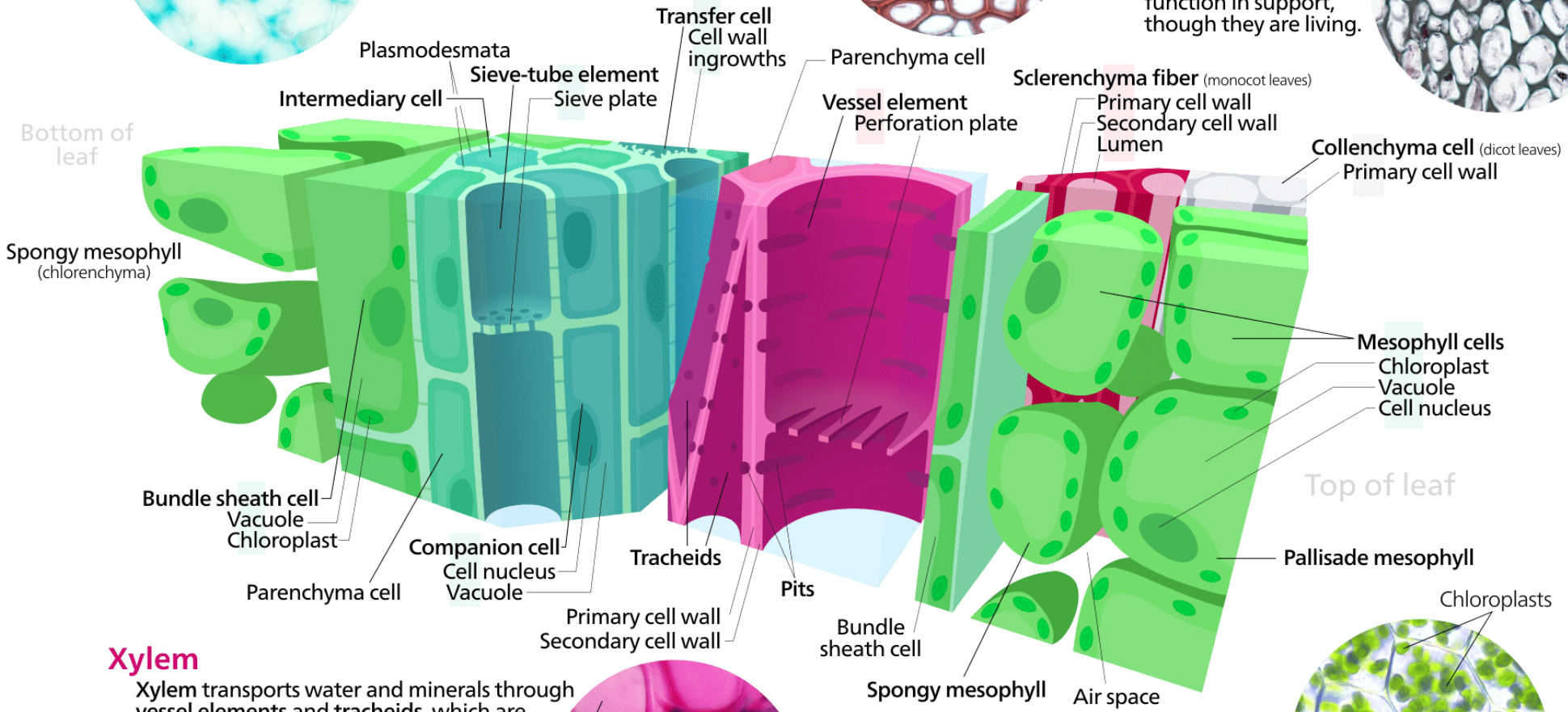
Sclerenchyma

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

Collenchyma

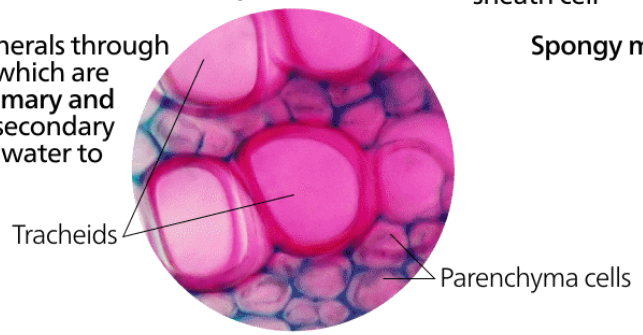
Collenchyma cells also function in support, though they are living.

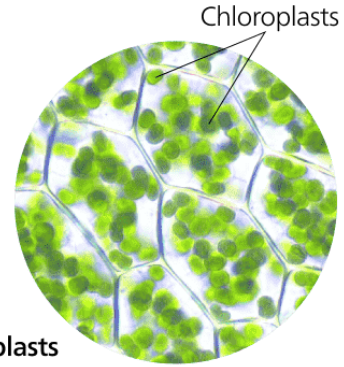




Xylem

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.





Parenchyma

Parenchyma cells are un-specialized cells that carry out most of a plant's metabolism. Parenchyma cells with **chloroplasts** are called **chlorenchyma cells.**

8. The diagram shows the circulatory system of a fish.

Where in the circulatory system is the oxygen concentration lowest

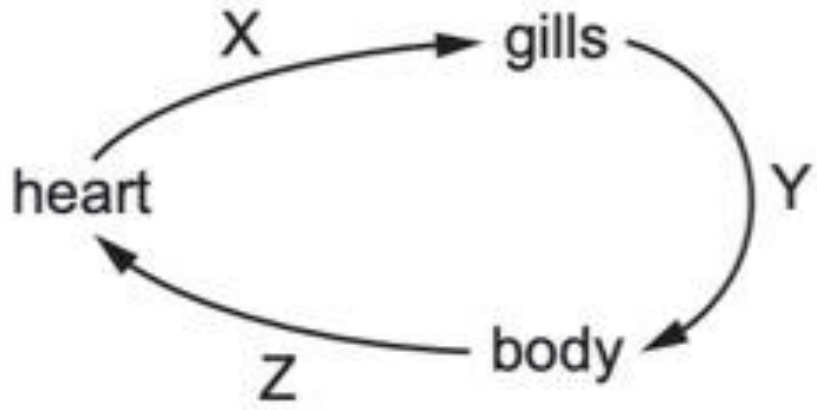
(A) Y and Z

(B) X and Y

(C) Y only

(D) X only

ANSWER

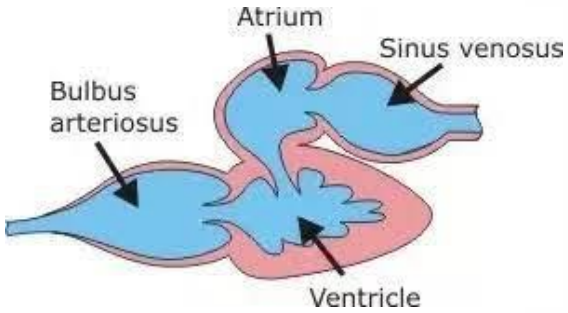


Fish have a **single-circuit closed circulatory system** powered by a **two-chambered heart** comprising one atrium and one ventricle. Blood flows in a unidirectional loop:

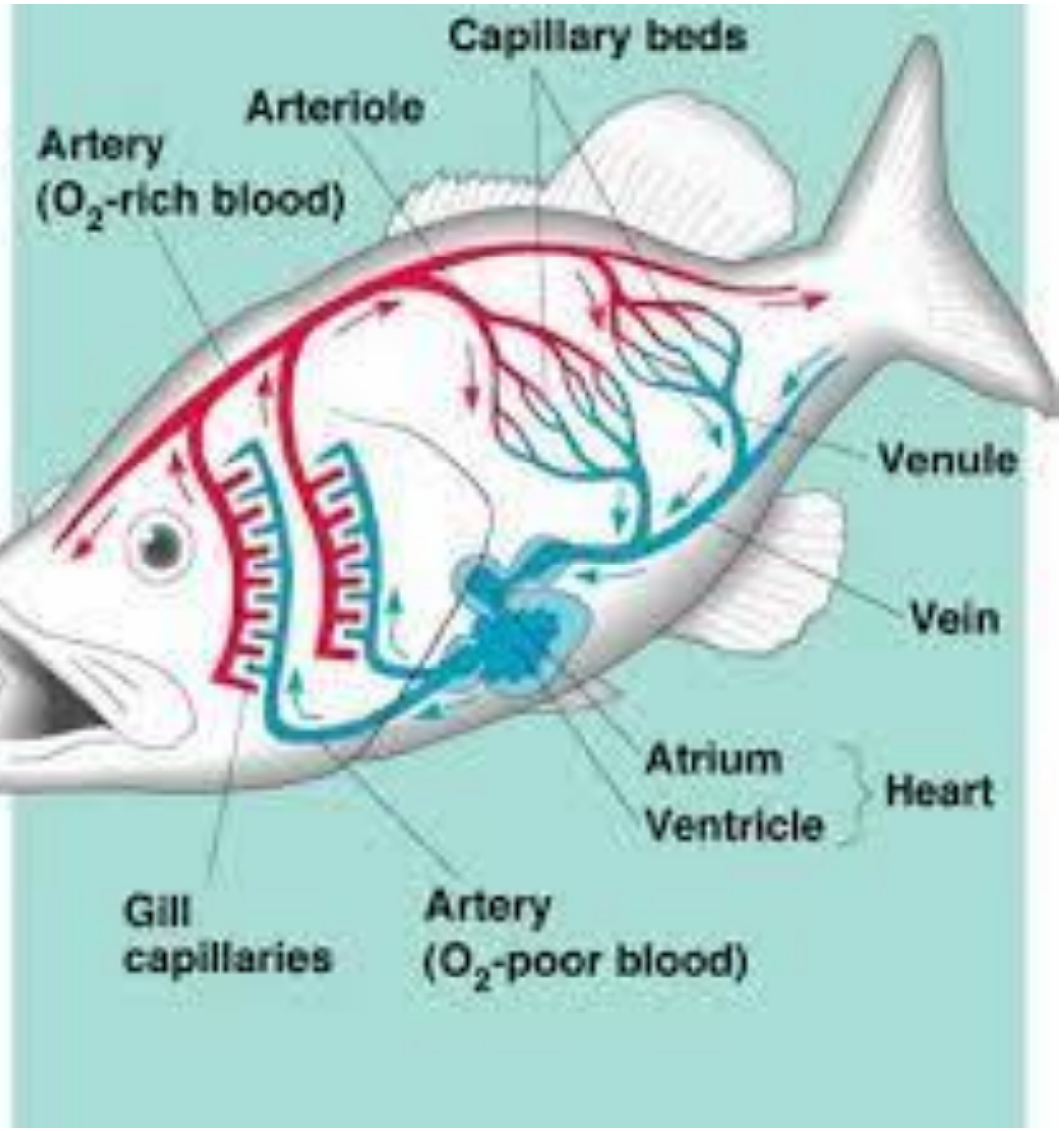
1. **Heart to Gills**: Deoxygenated blood is pumped from the heart to the gills via arteries
2. **Gas Exchange in Gills**: At the gills, blood releases carbon dioxide and absorbs oxygen through a process called **countercurrent exchange**, where blood and water flow in opposite directions across the 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

Fish heart



Circulatory system in fish



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

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

9. Which cell is a component of the innate immune system?

(A) Phagocyte

(B) T lymphocyte

(C) B lymphocyte

(D) B memory cell

ANSWER

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

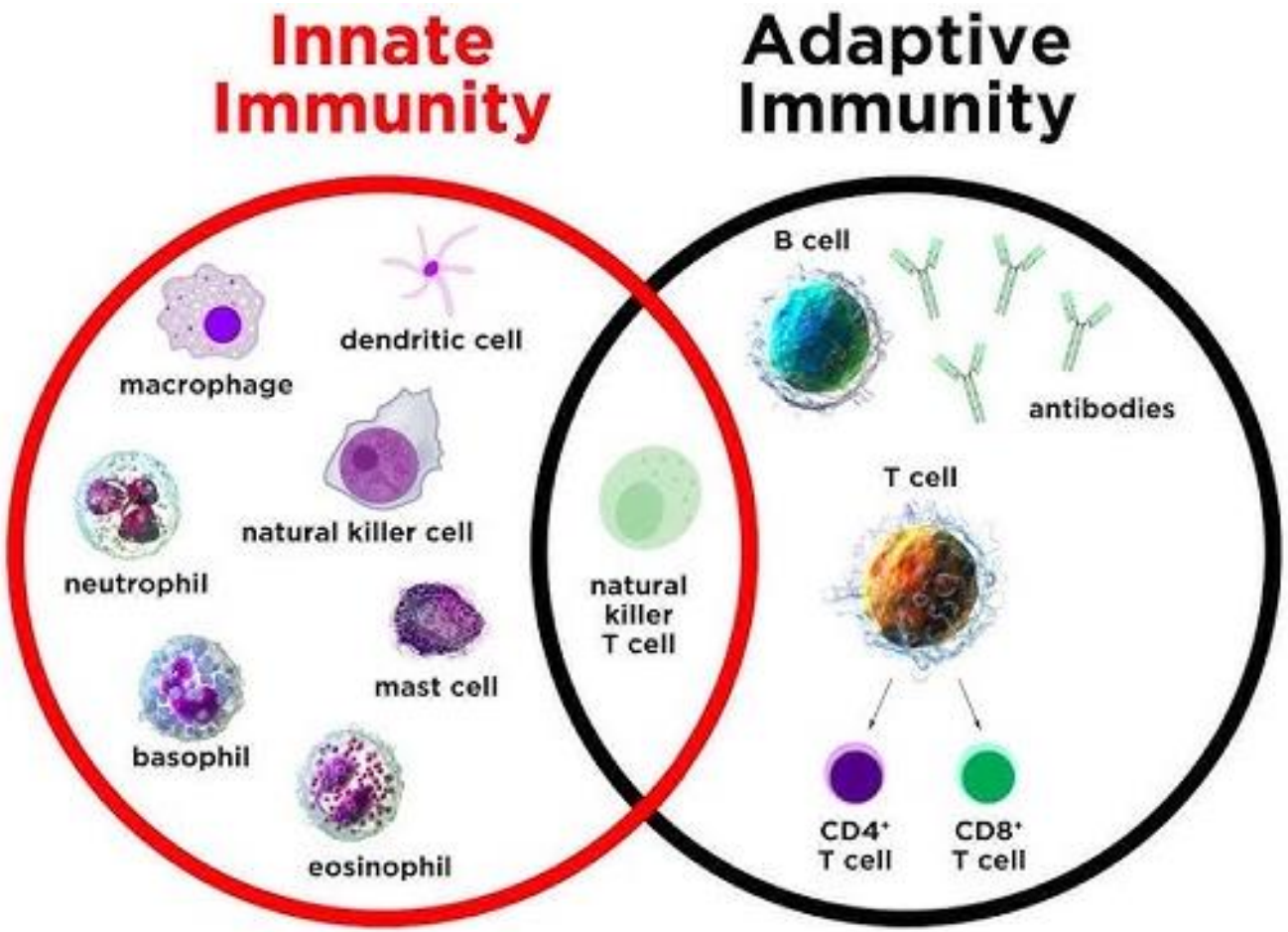
1. Macrophages: These long-lived cells reside in tissues and are among the first responders to infection. They engulf pathogens through phagocytosis and release cytokines to recruit other immune cells to the site of infection

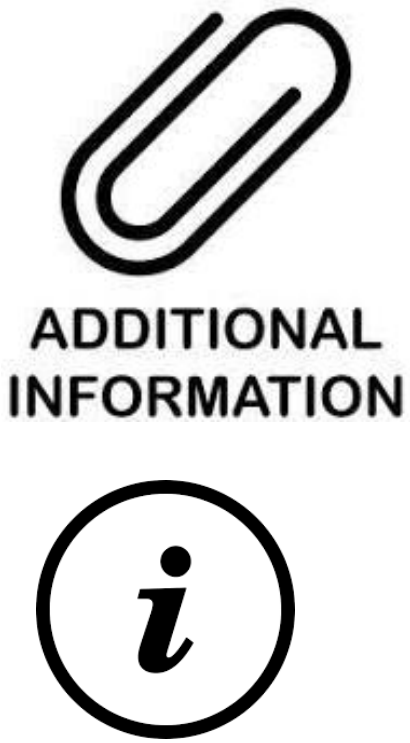
2. Neutrophils: As the most abundant type of white blood cells, neutrophils rapidly migrate to infection sites, where they ingest and destroy pathogens. They are short-lived but play a crucial role in controlling infections

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





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

10. 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 species; 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 genus; the mule is infertile.

ANSWER

(D) The horse and the donkey are the same species; the mule is fertile.

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

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

11. The diagram shows a plant.

Which characteristic of living organisms is shown by the plant in the diagram?

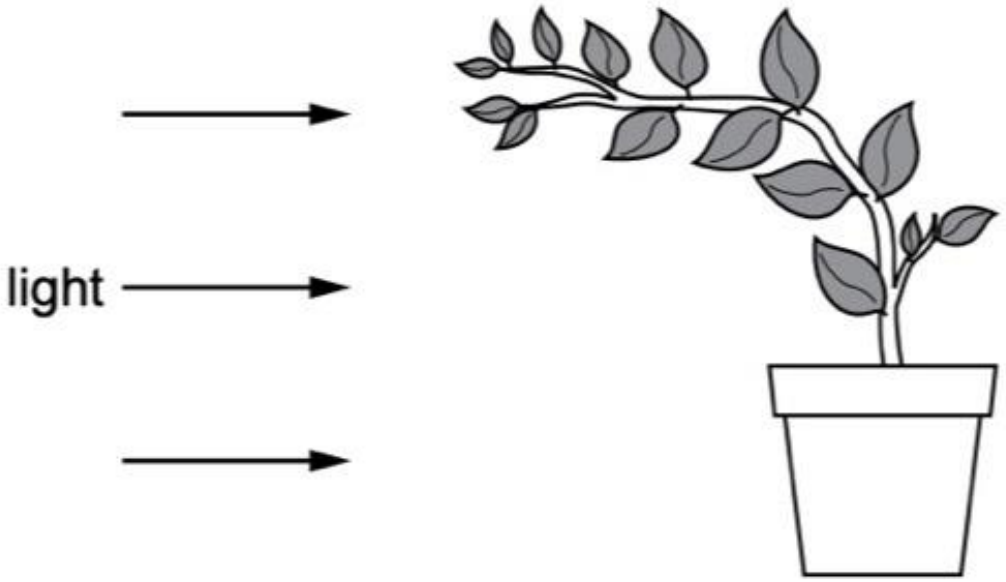
(A) excretion

(B) reproduction

(C) respiration

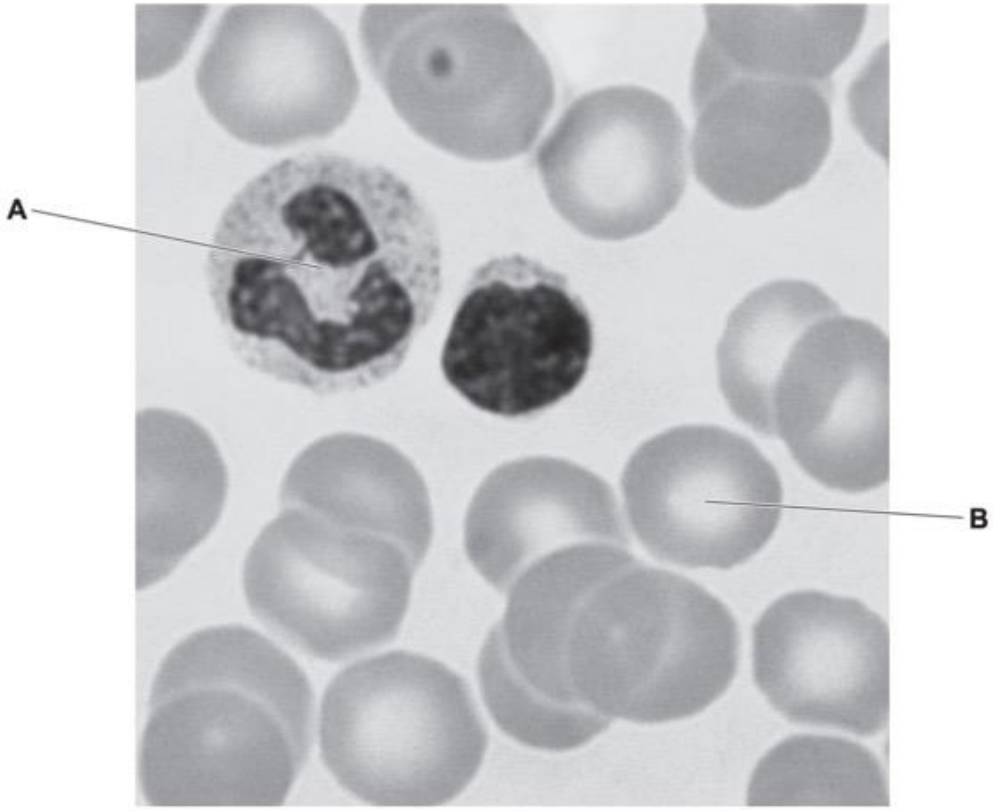
(D) sensitivity

ANSWER



12. The figure is a photomicrograph of a sample of human blood.

12.1. Identify and describe the functions of the cells labelled A and B in the figure.

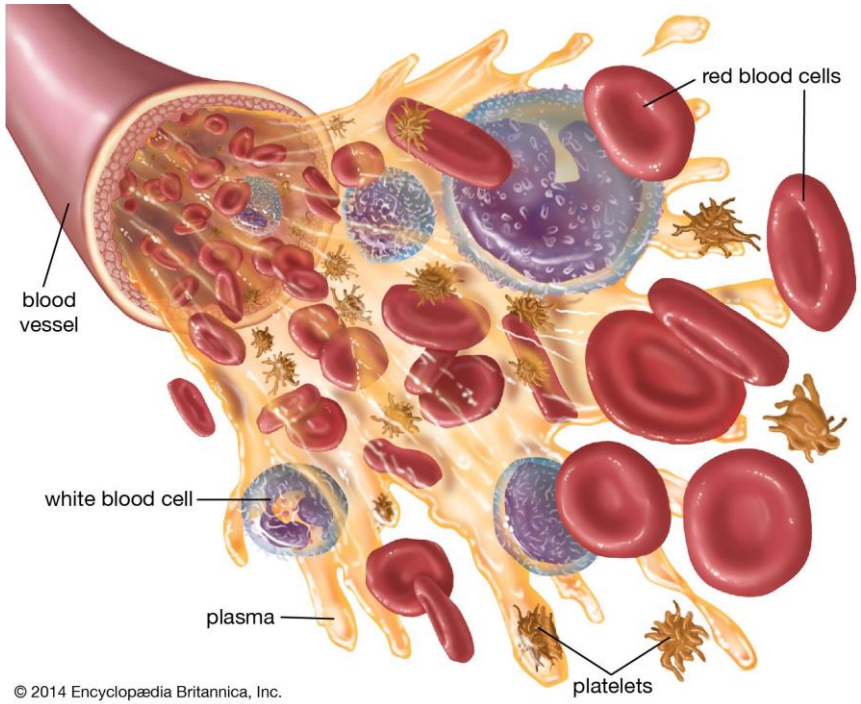


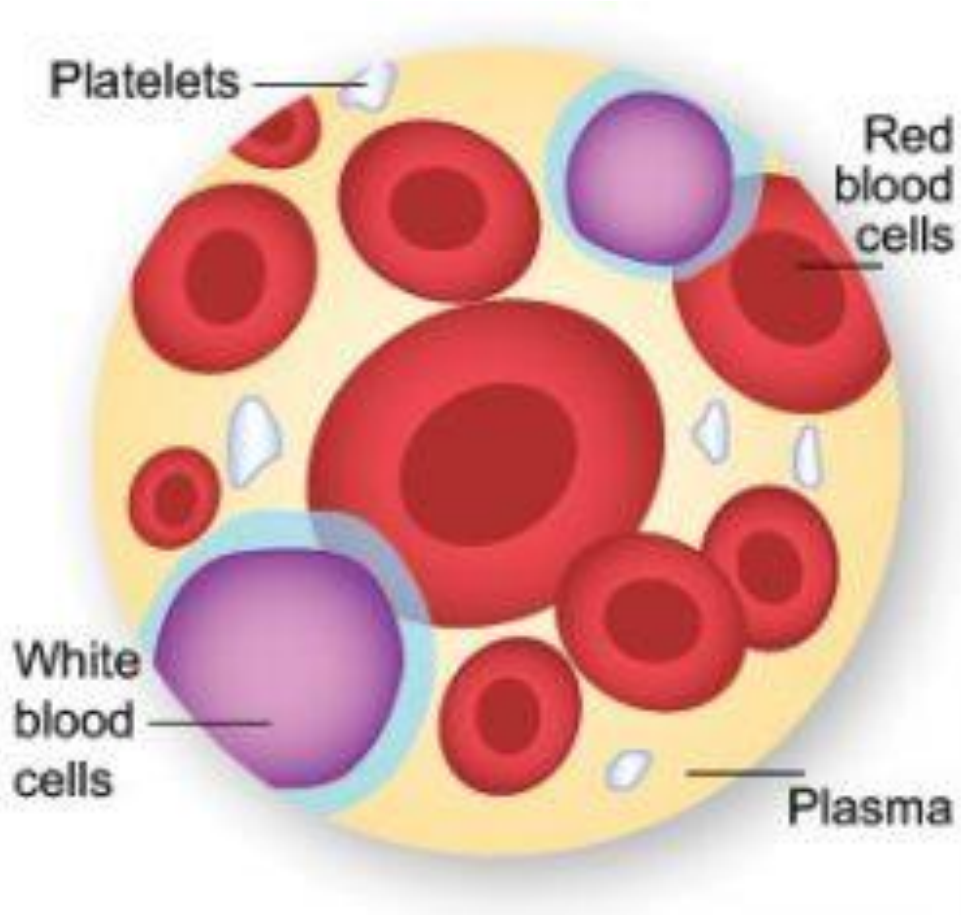
ANSWER:

A is a white blood cell, produces antibodies / phagocytosis (described)

B is a red blood cell, transports oxygen

ADDITIONAL INFORMATION





12.2. Describe how platelets in the blood prevent disease.

ANSWER:

Platelets help prevent disease by playing a crucial role in the body's defense against blood loss and infection through the process of blood clotting (also called coagulation). Here's how they work:

- Injury Response: When a blood vessel is injured, platelets quickly gather at the site of the damage.
- Clot Formation: They stick to the broken vessel wall and to each other, forming a temporary platelet plug.
- Release of Chemicals: Platelets release substances that activate clotting factors in the blood, leading to the formation of a fibrin mesh that strengthens the clot.
- Barrier Against Pathogens: This clot seals the wound, preventing excessive bleeding and also blocking the entry of pathogens (like bacteria and viruses), reducing the risk of infection.

In summary, platelets help prevent disease by stopping blood loss and creating a barrier to infection at injury sites.

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

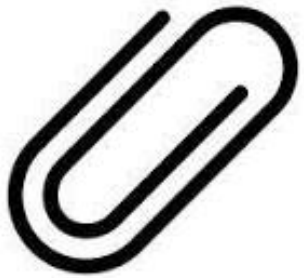
1. Pathogen Detection and Clearance: Platelets express pattern recognition receptors (PRRs) that allow them to identify and bind to pathogens such as bacteria and viruses. Upon recognition, they can directly neutralize these invaders or facilitate their clearance by other immune cells

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

12.3. Blood plasma transports many substances including excretory products and hormones. Identify the names of two excretory products in humans:

(A) Amino acids

(B) Cellulose

(C) Carbon dioxide

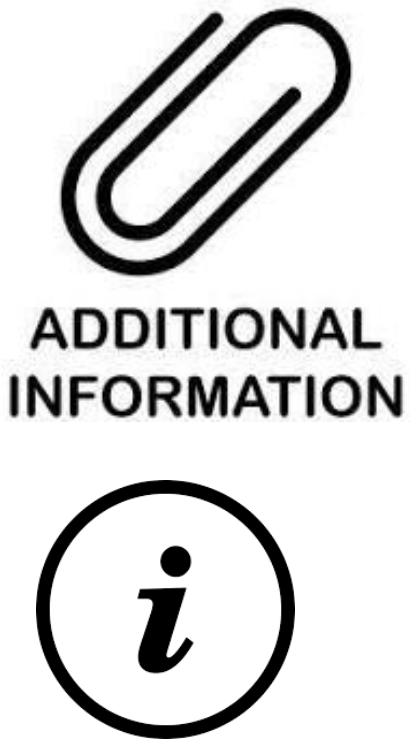
(D) Glucose

(E) Lipase

(F) Oxygen

(G) Urea

ANSWER



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

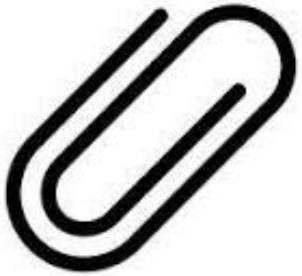
2. Uric Acid: Formed from the metabolism of nucleic acids, uric acid is eliminated through urine. Excessive accumulation can lead to gout or kidney stones

3. Creatinine: A byproduct of muscle metabolism, creatinine levels are a key indicator of kidney function

4. Carbon Dioxide (CO_2): Generated during cellular respiration, CO_2 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

13. Lichens are formed from two different organisms living together. Organism X and organism Y are found in most lichens. The table shows some of the characteristics of organism X and organism Y.

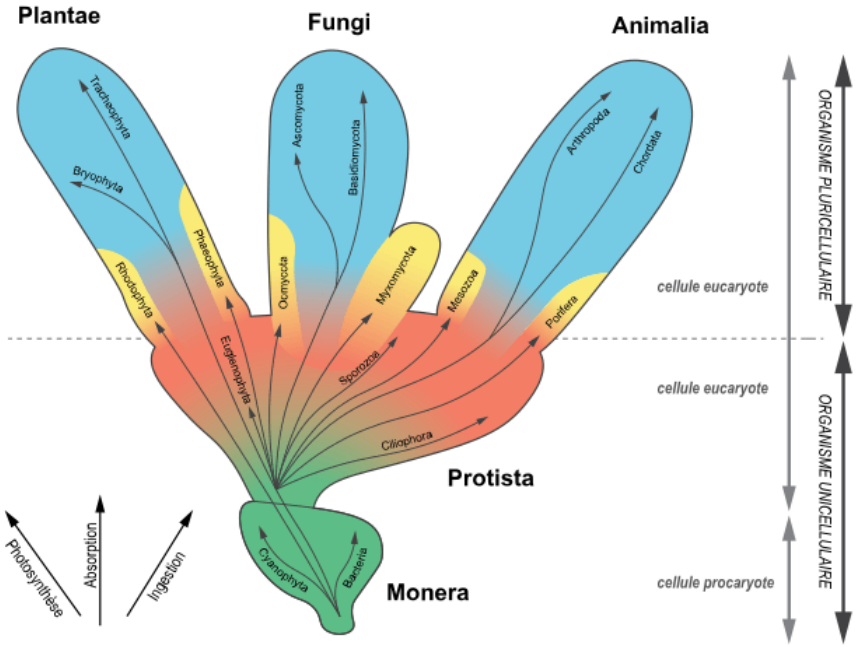
X	**Y**
made of strands called hyphae	single-celled
hyphae have cell walls and many nuclei	cell contains a nucleus and chloroplasts

Which kingdoms do X and Y belong to?

	X	**Y**
(A)	fungus	prokaryote
(B)	fungus	protoctist
(C)	protoctist	fungus
(D)	protoctist	plant

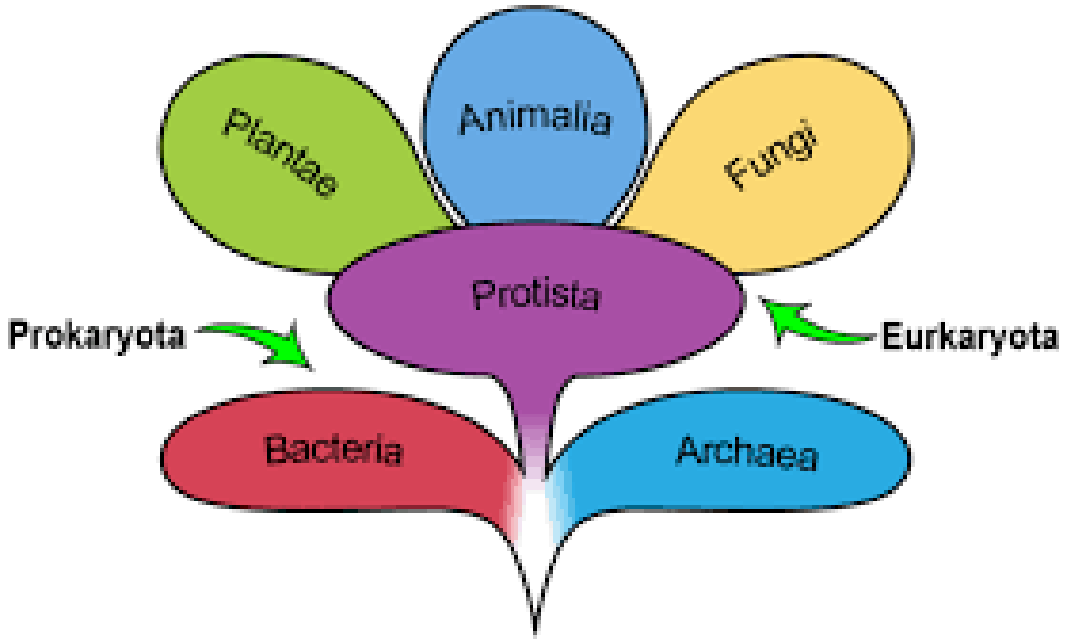
ANSWER

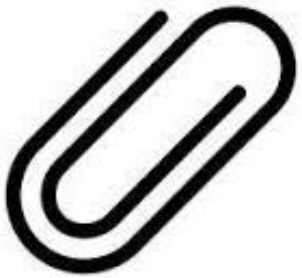
ADDITIONAL INFORMATION



5 kingdoms of life

6 kingdoms of life





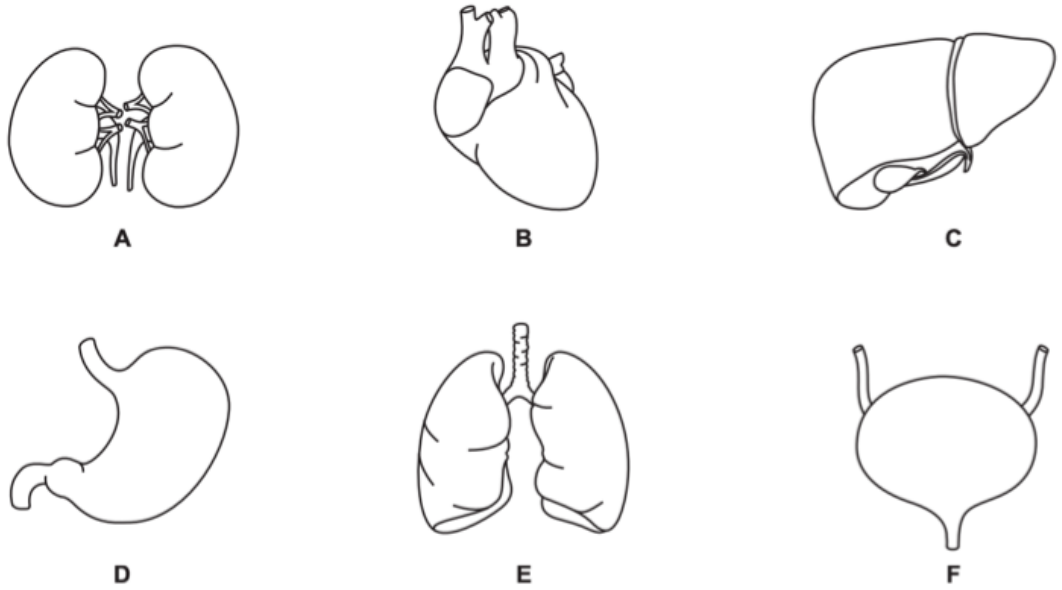
ADDITIONAL INFORMATION

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

14. The following figure is a diagram showing some of the organs in the human body.

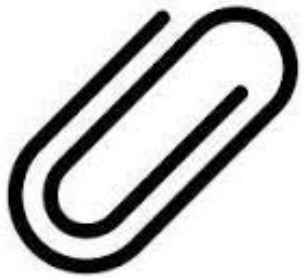
The table below lists the names of several organs shown in the diagram, along with their identifying letters and functions. Match and replace the numbers in the table with the correct information to complete it accurately.



Name of the organ	Letter in the Figure	Function
1	2	excretes carbon dioxide from the body
Heart	3	4
5	F	stores urine
6	7	excretes urea, excess water and ions

ANSWER:

1 - lungs; 2 – E; 3 - B; 4 - pumps blood; 5 - (urinary) bladder; 6 - kidney; 7 - A



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

15. Which parents could produce offspring with blood group O?

(A) heterozygous father with blood group A and heterozygous mother with blood group B.

(B) heterozygous father with blood group A and homozygous mother with blood group B.

(C) homozygous father with blood group A and heterozygous mother with blood group B.

(D) homozygous father with blood group A and homozygous mother with blood group O.

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

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

16. Figure shows a simple food web.

16.1. Based on the food web shown in the figure, it is correct to identify the following: ____ as a producer, ____ as an herbivore, and ____ as a secondary consumer.

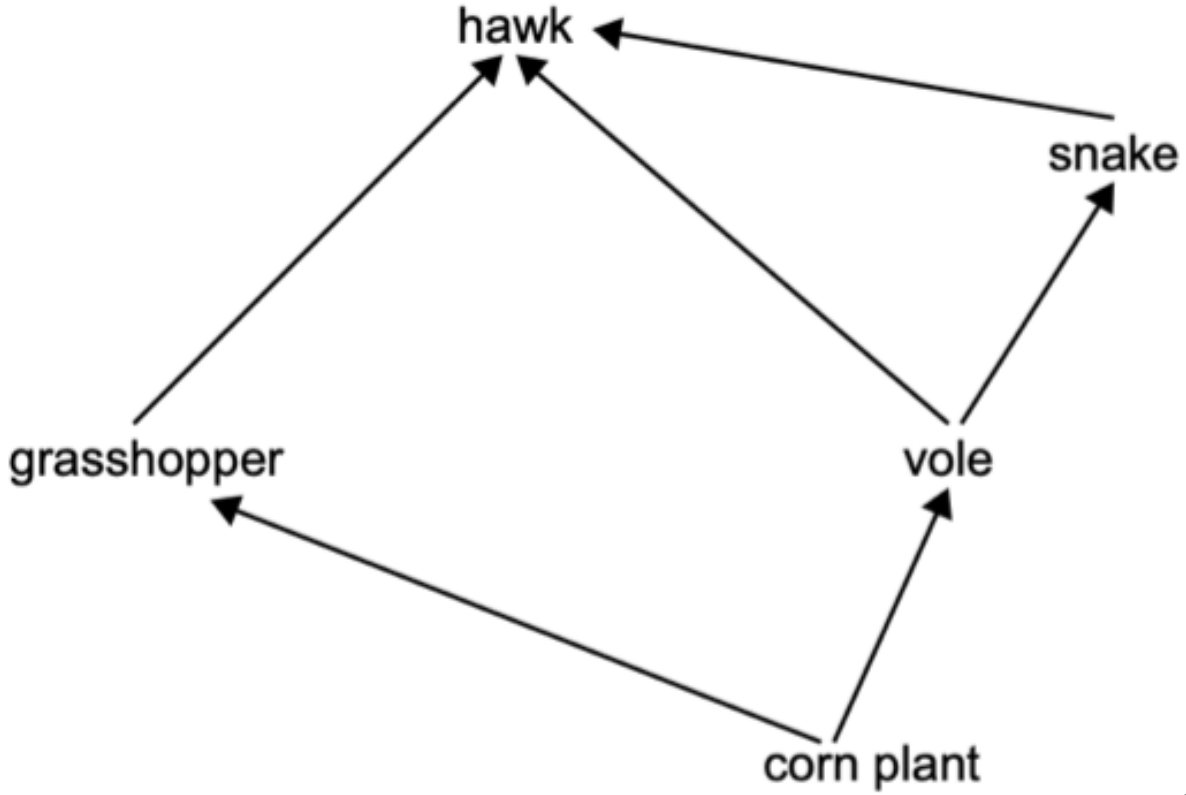
(A) corn plant / vole / hawk

ANSWER

(B) corn plant / grasshopper / snake

(C) corn plant / snake / hawk

(D) corn plant / vole / grasshopper



16.2. The organism that feeds at more than one trophic level is the

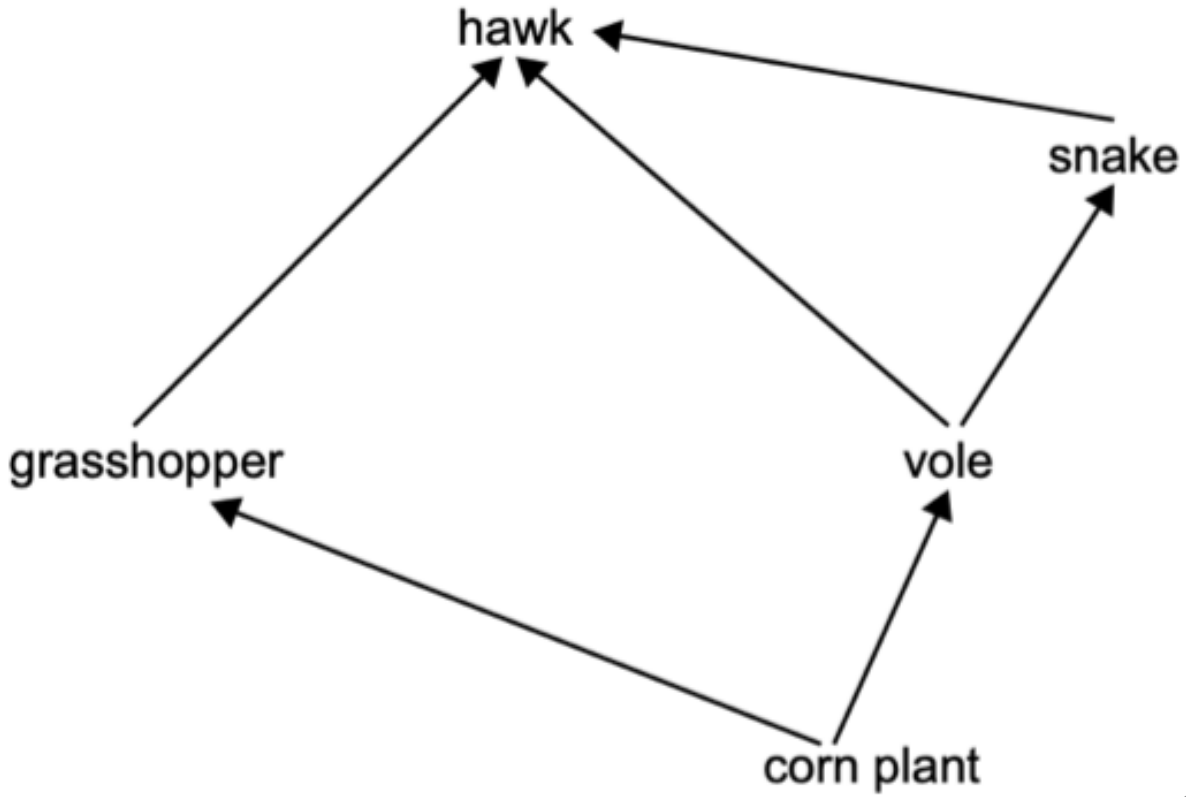
(A) snake.

(B) hawk.

(C) vole.

(D) grasshopper.

ANSWER



16.3. In a complex food web, the removal of a keystone species is most likely to result in:

(A) A slight increase in biodiversity due to reduced predation pressure

(B) Minimal impact, as most species are functionally redundant

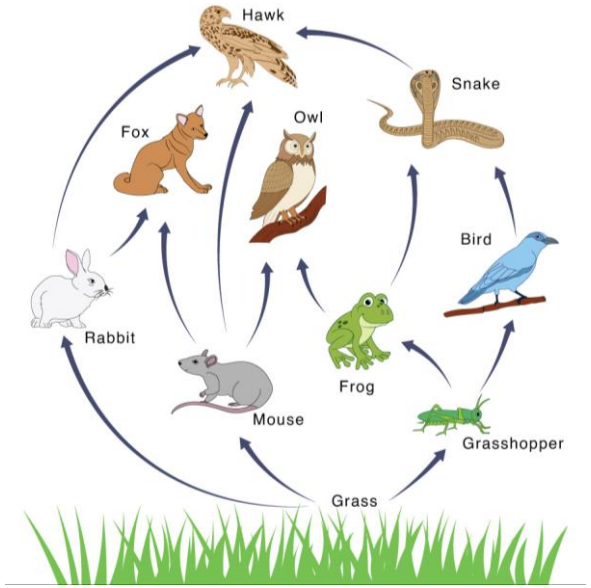
(C) A trophic cascade that significantly alters the structure and biodiversity of the ecosystem

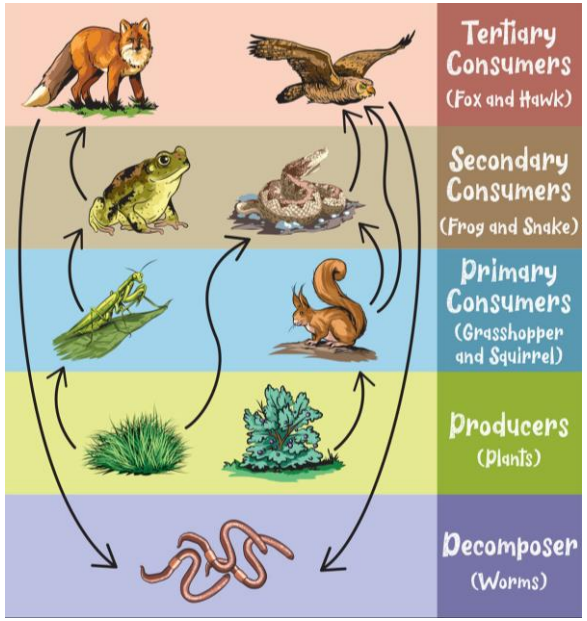
(D) A temporary decrease in biomass, followed by quick ecological compensation

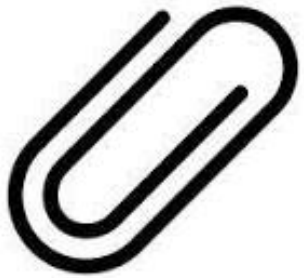
ANSWER

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

17. What is a correct statement about antibiotics?

(A) Bacteria may become resistant to antibiotics as a result of artificial selection.

(B) Bacteria may become resistant to antibiotics as a result of natural selection.

(C) Viruses may become resistant to antibiotics as a result of artificial selection.

(D) Viruses may become resistant to antibiotics as a result of natural selection.

ANSWER

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

Biology Exam

Good study!