

Associazione Studenti e Prof di Medicina Uniti Per

9th May 2020

IMAT simulation

***International Medical
Admission Test***



Studenti e Prof Uniti Per



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In collaboration with Tutor Office of
School of Medicine of Padua



Associazione Studenti e Prof di Medicina Uniti Per

LOGIC & GENERAL CULTURE



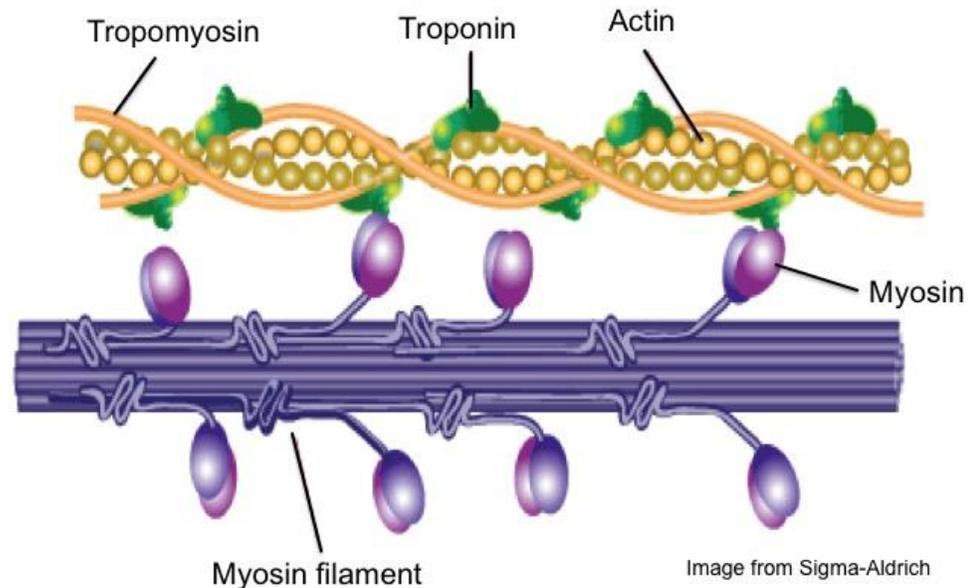
1. Muscle fiber generates tension through the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. Although the term contraction implies shortening, when referring to the muscular system, it means muscle fibers generate tension with the help of motor neurons. For voluntary muscles, all contraction (excluding reflexes) occurs as a result of conscious effort originating in the brain. The brain sends signals, in the form of action potentials, through the nervous system to the motor neuron that innervates several muscle fibers. In the case of some reflexes, the signal to contract can originate in the spinal cord through a feedback loop with the grey matter. Involuntary muscles such as the heart or smooth muscles in the gut and vascular system contract as a result of non-conscious brain activity or stimuli endogenous to the muscle itself. Other actions such as locomotion, breathing, and chewing have a reflex aspect to them: the contractions can be initiated consciously or unconsciously.

What can be inferred from the passage?

- A) Referring to the muscles, the term contraction doesn't imply shortening
- B) The signal to contract a muscle always originates from the brain
- C) The stimulus to contract a muscle cannot originate inside the muscle itself
- D) Some muscular actions can be both conscious and unconscious
- E) The brain is not always involved in muscular contraction

QUESTION NO. 1

“Inferred” means deducing, extrapolating a reasoning that is not explicitly stated. Option E is explicitly stated in the sentence “ Involuntary muscles such as the heart or smooth muscles in the gut and vascular system contract as a result of non-conscious brain activity or stimuli endogenous to the muscle itself”, therefore it is not an inferred information. A, B and C are wrong and refuted by the text itself; the only information we can deduce is D.



1. Muscle fiber generates tension through the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. Although the term contraction implies shortening, when referring to the muscular system, it means muscle fibers generate tension with the help of motor neurons. For voluntary muscles, all contraction (excluding reflexes) occurs as a result of conscious effort originating in the brain. The brain sends signals, in the form of action potentials, through the nervous system to the motor neuron that innervates several muscle fibers. In the case of some reflexes, the signal to contract can originate in the spinal cord through a feedback loop with the grey matter. Involuntary muscles such as the heart or smooth muscles in the gut and vascular system contract as a result of non-conscious brain activity or stimuli endogenous to the muscle itself. Other actions such as locomotion, breathing, and chewing have a reflex aspect to them: the contractions can be initiated consciously or unconsciously.

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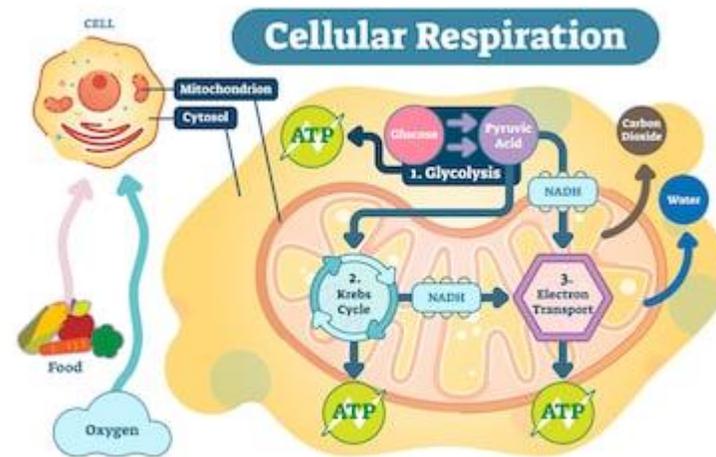
2. In physiology, respiration (often confused with breathing) is defined as the transport of oxygen from the outside air to the cells within tissues, and the transport of carbon dioxide in the opposite direction. This is in contrast to the biochemical definition of respiration, which refers to the cellular one, that is to say the metabolic process by which an organism obtains energy by making oxygen react with glucose to give water, carbon dioxide and ATP (energy). Although physiologic respiration is necessary to sustain cellular respiration and thus life, in animals the processes are distinct: cellular respiration takes place in individual cells of the organism, while physiologic respiration concerns the bulk flow and transport of metabolites between the organism and the external environment.

Physiologic and cellular respirations differ:

- A) only in terms of environment where they take place
- B) only in terms of metabolic products they result in
- C) only in terms of processes involved
- D) only in terms of transport of metabolites
- E) all of the previous terms are correct

QUESTION NO. 2

By reading the text, you can see that they happen in different environment, as CR happens in cells, while PR larger organs, have different end products (CR makes water, carbon dioxide and ATP, while PR is concerned with the transport of metabolites) and therefore involve different processes to get those. PR transports



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3. “Action has to be taken now to stop the spread of bovine tuberculosis (TB). Experts agree that reducing the number of badgers in the most heavily infected areas will help to break the cycle of infection between badgers and cattle and begin to reduce TB in both species. Although badgers can be vaccinated, there is no vaccine available to protect our cattle, and best estimates suggest it will be ten years before one is available. The only way to stop bovine TB spreading is to kill badgers.” Which one of the following, if true, most strengthens the above argument?

- A) Five annual vaccinations are necessary to fully protect a badger against bovine TB
- B) Shooting large numbers of badgers is more expensive than vaccinating them
- C) In a trial, killing ten thousand badgers reduced the TB rate in cattle by only fifteen percent
- D) When efforts are made to remove badgers, many are injured rather than outright killed
- E) Ethically, many people do not support this solution

QUESTION NO.3

If true, option A would imply that in order for the vaccine to fully work on a badger they would have to be given five annual shots, something that could be expensive, not to mention time consuming, On the other hand, killing them would solve the problem more quickly.

Option B, C and D weaken the argument. Option E is off topic.

3. “Action has to be taken now to stop the spread of bovine tuberculosis (TB). Experts agree that reducing the number of badgers in the most heavily infected areas will help to break the cycle of infection between badgers and cattle and begin to reduce TB in both species. Although badgers can be vaccinated, there is no vaccine available to protect our cattle, and best estimates suggest it will be ten years before one is available. The only way to stop bovine TB spreading is to kill badgers.” Which one of the following, if true, most strengthens the above argument?

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4. 60% of the people registered in a sports center do swimming and 70% play tennis. The total people registered in the sports center are 200; how many of them do both swimming and tennis?

- A) 30
- B) 40
- C) 80
- D) 130
- E) 60

QUESTION NO. 4

60% of 200 is 120 ($200 \cdot 0.6 = 120$) and 70% of 200 is 140 ($200 \cdot 0.7 = 140$),

afterwards we take either of the two results (as an example we'll use the number of people registered for swimming, 120)

and subtract the total students by that amount ($200 - 120 = 80$). This is the amount of students not participating in swimming,

we subtract the amount of people participating in tennis by the amount of students not participating in swimming ($140 - 80 = 60$) to find the amount of students that definitely participate in both swimming and tennis.

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- B) 40
- C) 80
- D) 130
- E) 60

5. A 400g packet of snacks has the following nutritional values: it contains 10.86g of protein per 100 g and 1.5g of protein per snack. How many snacks does the package contain?

- A) 29
- B) 30
- C) 25
- D) 13
- E) 33

QUESTION NO. 5

We can use the proportions to solve this problem.

We first have to find how many grams is a snack and then divide the value per the total weight of the packet (400g).

So $10.86:100=1.5:x$ leading to $x=13.8$ grams per snack.

By dividing the total per the result that we just got, we have that the package contains 29 snacks in total.

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6. Two runners, Liz and Rory, are training for a competition. Rory passes the start point every 9 minutes. Liz passes the start point every 15 minutes. They have just set off on their routes. How long will it be before they meet up at the start point again?

- A) 45 minutes
- B) 1 hour
- C) 30 minutes
- D) 3 hours
- E) 1 hour and a half

QUESTION NO. 6

In order to solve this problem you need to calculate the least common multiple (minimo comune multiplo in Italian) of the two numbers (9 minutes and 15 minutes).

By breaking them down into prime factors you get that the time is 45 minutes.



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7. I wish to tile an area of a wall 240cm wide by 200 cm high. Tiles are 20 cm square. I will therefore need $12 \times 10 = 120$ tiles. Which of the following uses the same method of calculation as that above?

- A) A ladder is 4m high, each step is 0.2m. Therefore there are 20 steps.
- B) A swimming pool is 5m by 4m. The cover costs £ 10.000 per square meter. Therefore it will cost £ 200 for the whole cover.
- C) A box containing sugar cubes is 10cm x 10 cm x 5 cm. A sugar cube has a side of 1 cm, therefore the box contains 500 cubes.
- D) Using square tables of 1.5 m on each side, I need to make up a dining table 6m x 3 m, therefore I will need 8 tables.
- E) I work 80 hours a week and I earn £ 7.00 an hour. Therefore in one month (considered as 4 weeks) I will earn £ 2240.

QUESTION NO. 7

This is an example of problem where you need to identify the similarities.

Answer D has the same pattern of the text:

you have a certain area that must be covered with smaller objects (tiles or dining tables)

and the calculations are the same: you find the total area and the area of the object and then you find the ratio to find out how many tables/tiles are needed.

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8. The figures below show the results of a survey of 1000 people on the sizes of their current and previous car:

		Current car			
		Large	Medium	Small	Total
Previous car	Large	100	120	20	240
	Medium	80	200	80	360
	Small	40	160	200	400
Total		220	480	300	1000

If the table is representative of those who are looking to change their car at present, what percentage of car buyers would you expect to trade up to a larger car than their present one?

- A) 12%
- B) 22%
- C) 24%
- D) 28%
- E) 70%

QUESTION NO. 8

You need to recognise which parts of the table are relevant to the question, and how to use these values to get to the correct answer. The data relates to people's last change of car, but the question is about people's intentions on buying their next car.

At face value these may seem to be two different things. However, we are told that the table is representative of those who are looking to change their car at present. This means that we could equally rewrite the table headings so that 'Current car' is on the left and 'Next car' is on the top.

Having understood the information given, be clear about what the question wants you to find - the percentage of purchasers likely to trade up to a larger car than their present model. One such group is those whose current car is medium and previous car was small. We can list all the groups which fit the requirement of the question.

On the basis of this survey, you would expect 280 people to trade up. The final step is to calculate the appropriate percentage correctly. The total number surveyed was 1000, so: $28/100 \times 100 = 28\%$. The correct answer is D.

The fact that this is one of the choices given may improve our confidence that it is correct, but we must be wary as the question setters choose the alternative options to represent easily made mistakes.

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9. A jeweller sells a watch with a 18 % reduction on the price, that is a 36 dollar reduction. What was the price of the watch?

- A) \$ 160
- B) \$ 210
- C) \$ 185
- D) \$ 200
- E) \$ 150

QUESTION NO. 9

Let's call the initial price X; the 18 % of X is 36.

Therefore, $X = (36 \times 100) : 18 = 200\$$



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10. In order to succeed in academic examinations it is necessary to study. Therefore, if a student works hard in a particular subject, he or she should do well when the time of the examination comes. Which of the following best describes the flaw in the argument?

- A) It assumes that it is necessary to study in order to succeed.
- B) It overestimates the value of studying in preparation for examinations
- C) It ignores the fact that some subjects are more academic than others
- D) It assumes that studying hard is a sufficient condition for academic success
- E) It ignores the fact that some students do not need to study very much in order to succeed

QUESTION NO. 10

When it is asked to identify the flaw of the argument, you need to explain why the conclusion does not follow the previous statements. First you need to identify which would be the proper conclusion and what reasons support your decision.

Answer D matches with our response because, in order to succeed in a subject, studying may not be the only factor to consider, but the student also needs to understand what he or she is studying, for example.



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11. Which one of the following was the author to a series of short stories, namely “Dubliners”?

- A) William Shakespeare
- B) Rudyard Kipling
- C) James Joyce
- D) Charles Baudelaire
- E) William Turner

QUESTION NO. 11

James Augustine was an Irish novelist, short story writer, poet, teacher, and literary critic. He contributed to the modernist avant-garde and is regarded as one of the most influential and important authors of the 20th century. Kipling is famous for his "The Jungle Book".

Charles Baudelaire was a French poet. William Turner was a Romantic painter. Therefore, the correct answer is C.



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12. Who produced and detected X-rays in 1895?

- A) Wilhelm Conrad Röntgen
- B) Guglielmo Marconi
- C) Albert Einstein
- D) David Hilbert
- E) Marie Curie

QUESTIO NO. 12

Marconi is known for his work on long-distance radio transmission;

Einstein theorised the relativity and won the Nobel Prize for his discovery of the law of the photoelectric effect;

David Hilbert was a mathematician;

Marie Curie was a Polish chemist.

The correct answer is A.



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- C) Albert Einstein
- D) David Hilbert
- E) Marie Curie

13. What happened on 3rd March, 1918?

- A) The end of World War I
- B) Treaty of Brest-Litovsk
- C) The end of World War II
- D) Night of the Long Knives
- E) March on Rome

QUESTION NO. 13

The Treaty of Brest-Litovsk was a peace treaty signed between the new Bolshevik government of Russia and the Central Powers, that ended Russia's participation in World War I.



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- A) The end of World War I
- B) Treaty of Brest-Litovsk
- C) The end of World War II
- D) Night of the Long Knives
- E) March on Rome

14. In which of the following States there is there an higher percentage of Christians than other religious groups?

- A) Pakistan
- B) North Korea
- C) China
- D) Sudan
- E) Ethiopia

QUESTION NO. 14

- Pakistan 1,6%;
- North Korea 1,7%;
- China 2,51 %;
- Sudan 8,2%;
- Ethiopia 62,8%

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- C) China
- D) Sudan
- E) Ethiopia

15. In which year was the independence of United States declared?

- A) 1846
- B) 1918
- C) 1687
- D) 1776
- E) 1492

QUESTION NO. 15

On July 4th 1776 the Continental Congress declared that the thirteen American colonies were no longer subject to the monarch of Britain and were now united, free and independent states. The correct answer is D.



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16. What's the capital city of New Zealand?

- A) Old Russell/Okiato
- B) Auckland
- C) Wellington
- D) Christchurch
- E) Dunedin

QUESTION NO. 16

Wellington has been the capital of New Zealand since 1865. New Zealand's first capital city was Old Russell (Okiato) in 1840–41.

Auckland was the second capital from 1841 until 1865, when Parliament was permanently moved to Wellington after an argument that persisted for a decade.

As the members of parliament could not agree on the location of a more central capital, Wellington was decided on by three Australian commissioners. The correct answer is C.



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- D) Christchurch
- E) Dunedin

17. When was the Magna Carta libertatum document agreed to?

- A) 1234
- B) 1302
- C) 1215
- D) 1198
- E) 1220

QUESTION NO. 17

Magna Carta Libertatum (Medieval Latin for "Great Charter of Freedoms"), commonly called Magna Carta, is a charter of rights agreed to by King John of England at Runnymede, near Windsor, on 15 June 1215.

First drafted by the Archbishop of Canterbury to make peace between the unpopular King and a group of rebel barons, it promised the protection of church rights, protection for the barons from illegal imprisonment, access to swift justice, and limitations on feudal payments to the Crown, to be implemented through a council of 25 barons.

The charter became part of English political life and was typically renewed by each monarch in turn, although as time went by and the fledgling Parliament of England passed new laws, it lost some of its practical significance.

Correct answer: C.



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- E) 1220

18. Which of the following branches of the European Union has Ursula von der Leyen as President?

- A) The European Commission (EC)
- B) The European Central Bank (EBC)
- C) The European Parliament
- D) The Council of the European Union
- E) The European Committee of the Regions

QUESTION NO. 18

Ursula Gertrud von der Leyen is a German politician and the President of the European Commission since 1 December 2019. She served in the federal government of Germany from 2005 to 2019 as the longest-serving member of Angela Merkel's cabinet.

She is a member of the centre-right Christian Democratic Union (CDU) and its EU counterpart, the European People's Party (EPP).

The correct answer is A.



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19. Who is the author of “The Rime of the Ancient Mariner”?

- A) W. Wordsworth
- B) S.T. Coleridge
- C) J. Keats
- D) G.G. Byron
- E) P.B. Shelley

QUESTION NO.19

The Rime of the Ancient Mariner (originally The Rime of the Ancyent Marinere) is the longest major poem by the English poet Samuel Taylor Coleridge, written in 1797–98 and published in 1798 in the first edition of Lyrical Ballads.

Correct answer: B.



19. Who is the author of “The Rime of the Ancient Mariner”?

- A) W. Wordsworth
- B) S.T. Coleridge
- C) J. Keats
- D) G.G. Byron
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20. In ancient times, the pigment "Purpura" was obtained from:

- A) A type of shellfish
- B) A Mediterranean plant
- C) The eggs of a bird living in Tunisia
- D) A mixture of different pigments coming from India
- E) Mineral sources

QUESTION NO.20

The correct answer is A. Purpura is a pigment that in the past was obtained from a particular kind of shellfish, the Murex, and made the fortune of the Phoenicians, who were the only ones to know how to obtain that precious and desired colour.



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21. Luis Sepùlveda, the famous writer that, among other novels, wrote “The story of a seagull and the cat who taught her to fly”, was born in:

- A) Peru
- B) Spain
- C) Colombia
- D) Chile
- E) Argentina

QUESTION NO. 21

Luis Sepùlveda was born in Ovalle, Chile in 1949. He recently died due to COVID-19, after being confirmed to be the first man in the Asturias to be infected by the virus. He died in Oviedo, Spain on 16 April 2020.



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- B) Spain
- C) Colombia
- D) Chile
- E) Argentina

22. The type of government that runs China at the moment is:

- A) People's Republic, governed by the Democratic Party
- B) Monarchy
- C) Federal Republic
- D) People's Republic, governed by the Communist Party
- E) Dictatorship

QUESTION NO. 22

China is officially called People's Republic of China (PRC) is governed by the Communist Party of China, with Xi Jinping as president. It is one of the few existing socialistic states and it is one of the world's only socialist states that is explicitly aiming to build communism.



22. The type of government that runs China at the moment is:

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- C) Federal Republic
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Associazione Studenti e Prof di Medicina Uniti Per

BIOLOGY



23. The extracellular matrix :

- 1. provides support and connects the cells**
- 2. is also known as a glycocalyx**
- 3. is secreted by animal cells and many bacteria**
- 4. is present only in plant cells**

Choose the correct answer:

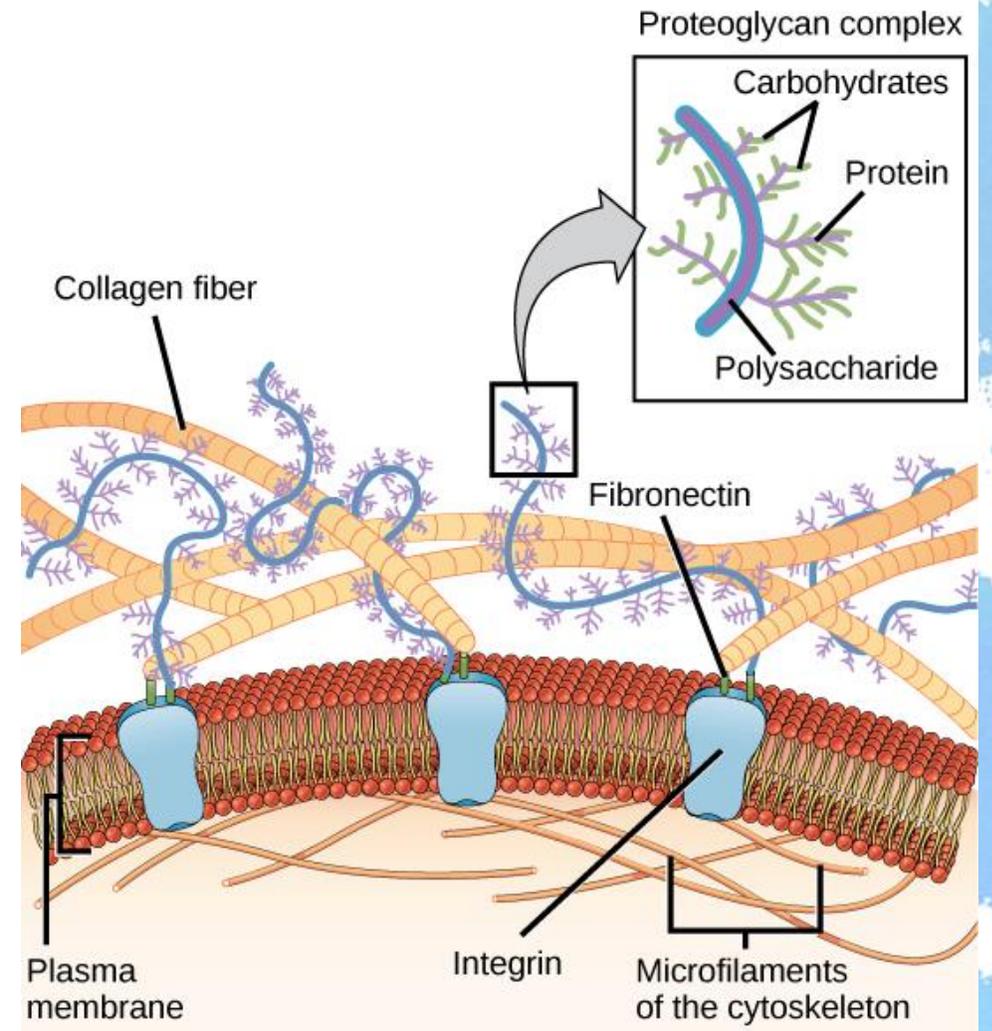
- A) All of them
- B) 1,2 and 3
- C) 1,2 and 4
- D) Only 3
- E) Only 2 and 4

Most **animal cells** release materials into the extracellular space, creating a highly-hydrated fibrous meshwork of proteins and carbohydrates called the **extracellular matrix (ECM)**.

The layer of the ECM consists of a network of **fibrous proteins** with **sugar-based side chains**, known as the **glycocalyx**, that surrounds and covers the membrane of endothelial cells, many bacteria and other cells.

Due to its diverse nature and composition, the **ECM** can serve many functions, such as **providing support, segregating tissues** from one another, and regulating intercellular **communication**.

The answer is: B



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- 1. provides support and connects the cells**
- 2. is also known as a glycocalyx**
- 3. is secreted by animal cells and many bacteria**
- 4. is present only in plant cells**

Choose the correct answer:

- A) All of them
- B) 1,2 and 3
- C) 1,2 and 4
- D) Only 3
- E) Only 2 and 4

24. Which of the following statements about DNA is false?

- A) it is a polymer
- B) two polynucleotide strands wound around each other in a double helix, held together by covalent bonds
- C) it involves 4 different bases
- D) Rosalind Franklin's work led to the discovery of the DNA double helix
- E) it contains a pentose sugar, **nitrogen-containing** bases and phosphate groups

Deoxyribonucleic acid, DNA, is a molecule composed of **two chains** that coil around each other to form a **double helix** carrying **genetic** instructions for the development, functioning, growth and **reproduction** of all known **organisms** and many **viruses**.

The two DNA strands are also known as **polynucleotides** as they are composed of simpler **monomeric** units called **nucleotides**. Each nucleotide is composed of one of **four nitrogen-containing nucleobases** (cytosine [C], **guanine** [G], **adenine** [A] or **thymine** [T]), a pentose **sugar** called **deoxyribose**, and a **phosphate group**.

The **nucleotides are joined to one another in a chain by covalent bonds** between the sugar of one nucleotide and the phosphate of the next, resulting in an alternating **sugar-phosphate backbone**. The nitrogenous bases of the two separate polynucleotide **strands are bound together**, according to **base pairing** rules (A with T and C with G), **with hydrogen bonds** to make double-stranded DNA.

Between 1951 and 1952, Rosalind Franklin managed to photograph DNA, obtaining extraordinarily clear images revealing the double helix structure of the molecule.

The answer is: B

2. Which of the following statements about DNA is false?

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25. Which of the following processes are catabolic reactions:

- 1. Photosynthesis**
- 2. Glycolysis**
- 3. Protein synthesis**
- 4. Fermentation**

Choose the correct answer:

- A) all of them
- B) 1 and 4 only
- C) 1,3 and 4
- D) 2 only
- E) 2 and 4 only

Catabolic reactions break down large organic molecules into smaller molecules, **releasing the energy** contained in the chemical bonds.

- **Glycolysis**, glyco “sweet”, and *lysis*, meaning “dissolution or breakdown”, can be defined as the sequence of enzymatic reactions that, in the cytosol, leads to the **conversion/splitting** of one molecule of glucose, a six carbon sugar, to two molecules of pyruvate, a three carbon compound, with the concomitant production of two molecules of ATP, the universal energy currency in biological systems.
- **Fermentation is an anaerobic** pathway through which the pyruvic acid can be routed into ethanol, a C-2 compound (alcohol fermentation) or into lactic acid. In fermentation the reduced NADH produced in glycolysis is converted back to oxidized NAD⁺. The net energy gain in fermentation is 2 ATP molecules/glucose molecule.
- **Photosynthesis**, the process by which green plants and certain other organisms transform light energy into chemical energy. During photosynthesis in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds.
- **Protein synthesis** is the biological process by which cells generate proteins from RNA.

The answer is : E

25. Which of the following processes are catabolic reactions:

- 1. Photosynthesis**
- 2. Glycolysis**
- 3. Protein synthesis**
- 4. Fermentation**

Choose the correct answer:

- A) all of them
- B) 1 and 4 only
- C) 1,3 and 4
- D) 2 only
- E) 2 and 4 only

26. In case of hyperglycemia, an excessive amount of glucose circulates in the blood plasma. In order to bring blood sugar back to normal:

- A) the liver converts glycogen in glucose
- B) the body needs sugar
- C) insulin stimulates the entry of glucose into the cells
- D) glucagon stimulates glycogenolysis
- E) nothing happens

Hyperglycemia is the technical term for **high blood glucose** (blood sugar), condition in which an excessive amount of **glucose** circulates in the **blood plasma**.

- If the liver converts glycogen in glucose, the quantity of glucose in the blood increases and the hyperglycaemia worsens further. Normally the opposite process occurs: **gluconeogenesis**, which converts excess glucose into glucagon, a form of energy storage, bringing blood sugar back to normal.
- The glucagon is a **peptide hormone**, produced by **alpha cells** of the **pancreas**. It works to raise the concentration of **glucose** and **fatty acids** in the bloodstream. If glucagon stimulates the glycogenolysis, the hyperglycemia increases further.
- The amount of glucose in your bloodstream is tightly regulated by the **hormone insulin**. **Insulin** is always being released in small amounts by the pancreas. When the amount of glucose in your blood rises to a certain level, the pancreas will release more insulin to **push** more **glucose into the cells**. This causes the glucose levels in your blood to drop.

The answer is: C

26. In case of hyperglycemia, an excessive amount of glucose circulates in the blood plasma. In order to bring blood sugar back to normal:

- A) the liver converts glycogen in glucose
- B) the body needs sugar
- C) insulin stimulates the entry of glucose into the cells
- D) glucagon stimulates glycogenolysis
- E) nothing happens

27. In which of the following cells the number of chromosomes is equal or less than than a female haploid cell:

- 1. hepatocytes**
- 2. erythrocytes**
- 3. sperm**

Choose the correct answer:

- A) 1 only
- B) 1,2 and 3
- C) 1 and 3 only
- D) 3 only
- E) none of them

- **Haploid cells** are the result of diploid cells replicating and dividing twice through **meiosis**. Haploid means "half." Each daughter cell produced from this division is haploid, meaning that it contains half the number of **chromosomes** as its parent cell. Female gametes are called **ova** or egg cells, and male gametes are called **sperm**. Gametes are **haploid cells**, and each cell carries only one copy of each chromosome. In humans, the haploid number is expressed as **$n = 23$** because haploid human cells have one set of 23 chromosomes. There are 22 sets of autosomal chromosomes (or non-sex chromosomes) and one set of sex chromosomes.
- **Erythrocytes** lack of nucleus and therefore of genetic material (no chromosomes).
- **Hepatocytes** are **diploid cells** and contain two complete sets of chromosomes. **$2n = 46$** This is double the haploid chromosome number. Humans have 23 sets of homologous chromosomes for a total of 46 chromosomes. Paired **sex chromosomes** are the X and Y homologs in males and the X and X homologs in females.

The answer is: D

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- 1. hepatocytes**
- 2. erythrocytes**
- 3. sperm**

Choose the correct answer:

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- B) 1,2 and 3
- C) 1 and 3 only
- D) 3 only
- E) none of them

28. Four medical students, Clara, Giacomo, Valentina and Filippo, recorded different structures that they thought were found in a healthy animal red blood cell, a liver cell and a typical maple leaf cell.

Med Students	red blood cell (RBC)	maple leaf cell	liver cell
Clara	Centrioles	80s ribosomes	Well-defined core
Giacomo	Hemoglobin	70s ribosomes	Vacuole
Valentina	Dna strands	Chloroplasts	Cell wall
Filippo	Hemoglobin	Plasmodesmata	Mitochondria

Which students gave totally correct answers?

- A) Clara and Filippo
- B) Giacomo only
- C) Filippo only
- D) Valentina and Giacomo
- E) None of them

Red blood cells (erythrocytes or **RBC**) **lack a cell nucleus** (and consequently the DNA) and most **organelles**, in order to **accommodate** maximum space for a protein called **hemoglobin**, which carries oxygen from the lungs to all parts of the body. RBC can be viewed as sacks of hemoglobin, with a **plasma membrane** as the sack.

Liver cells, hepatocytes, are the most abundant type of cell in the human liver. Like a typical animal eukaryotic cell it has a well-defined nucleus, a cell membrane and several organelles such as mitochondria and **80S** vedberg **ribosomes**. It **does not have a vacuole**.

Maple leaf cell, a plant cell, have features that animal cells do not have: a **cell wall**, a large **central vacuole**, plastids such as **chloroplasts**, **plasmodesmata**, small channels that directly connect the cytoplasm of neighboring plant cells to each other, establishing living bridges between cells and **70S** vedberg **ribosomes**.

Clara was right only about the liver cell. Giacomo was right about RBC and maple leaf cell but not about the liver cell. Valentina was right only about the maple leaf cell. Filippo was right about everything.

The answer is: C

28. Four medical students, Clara, Giacomo, Valentina and Filippo, recorded different structures that they thought were found in a healthy animal red blood cell, a liver cell and a typical maple leaf cell.

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Which students gave totally correct answers?

- A) Clara and Filippo
- B) Giacomo only
- C) Filippo only
- D) Valentina and Giacomo
- E) None of them

29. Which of the following hereditary diseases is autosomal recessive:

- 1. Albinism**
- 2. Achondroplasia or dwarfism**
- 3. Huntington disease**
- 4. Sickle cell anemia**

Choose the correct answer:

- A) none of them
- B) 1 and 2
- C) 3 and 4
- D) 2 only
- E) 1 and 4

IMAT simulation

- **Albinism** is a **congenital disorder** characterized in humans by the complete or partial absence of **pigment** in the skin, hair and eyes. Albinism results from inheritance of **recessive gene alleles**.
- **Achondroplasia** is a **genetic disorder** that results in **dwarfism**. In those with the condition, the arms and legs are short, while the **torso** is typically of normal length. The disorder has an **autosomal dominant** mode of inheritance, meaning only one mutated copy of the gene is required for the condition to occur.
- **Sickle cell anaemia (SCA)** is one of a group of disorders known as sickle cell disease. Sickle cell anemia is an inherited red blood cell disorder in which there aren't enough healthy red blood cells to carry oxygen throughout your body. Normally, the flexible, round red blood cells move easily through blood vessels. In sickle cell anemia, the red blood are shaped like sickles or crescent moons. These rigid, sticky cells can get stuck in small blood vessels, which can slow or block blood flow and oxygen to parts of the body. Sickle cell conditions have an **autosomal recessive** pattern of inheritance from parents.
- **Huntington disease** is a progressive **brain** disorder that causes uncontrolled movements, emotional problems, and loss of thinking ability (cognition). The disease is caused by an **autosomal dominant** mutation of a gene.

The answer is: E

29. Which of the following hereditary diseases is autosomal recessive:

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- 3. Huntington disease**
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Choose the correct answer:

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- C) 3 and 4
- D) 2 only
- E) 1 and 4

30. The first metabolic intermediate that is common to the aerobic metabolism of glucose and fatty acids is:

- A) acetyl CoA
- B) beta-hydroxybutyrate
- C) pyruvate
- D) citrate
- E) glyceraldehyde 3-phosphate

Once inside the cell **long-chain-fatty-acid—CoA ligase** catalyzes the reaction between a fatty acid molecule with **ATP** (which is broken down to **AMP** and inorganic pyrophosphate) to give a fatty acyl-adenylate, which then reacts with free **coenzyme A** to **give a fatty acyl-CoA molecule**.

In glucose metabolism when oxygen is present, the mitochondria will undergo aerobic respiration which leads to the Krebs cycle. However, if oxygen is not present, fermentation of the pyruvate molecule will occur.

In the presence of oxygen, when acetyl-CoA is produced, the molecule then enters the citric acid cycle (Krebs cycle)

The answer is A

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- B) beta-hydroxybutyrate
- C) pyruvate
- D) citrate
- E) glyceraldehyde 3-phosphate

31. The Duchenne muscular dystrophy is caused by a mutation of the dystrophin gene located on the short arm of the X chromosome. Which of the following statements are false?

- A) Females typically are **carriers** of the genetic trait while males are affected.
- B) The daughter of a carrier mother has a 50% chance of being a carrier
- C) The DMD is a degenerative neuromuscular pathology
- D) The son of a carrier mother has a 50% chance of inheriting the defective gene from his mother.
- E) The son has a 25% chance of inheriting the disease from his father

The **Duchenne Muscular Dystrophy** is a neuromuscular disease characterized by rapidly progressing muscle atrophy and weakness, by degeneration of skeletal, smooth and cardiac muscles.

DMD has an **X-linked recessive** inheritance pattern and is passed on by the mother, who is referred to as a *carrier*. Every boy inherits an X chromosome from his mother and a Y chromosome from his father, which is what makes him male. Girls get two X chromosomes, one from each parent.

Each son born to a woman with a dystrophin mutation on one of her two X chromosomes has a 50 % chance of inheriting the flawed gene and having DMD. Each of her daughters has a 50 % chance of inheriting the mutation and being a *carrier*. Carriers may not have any disease symptoms but can have a child with the mutation or the disease.

The answer is: E

31. The Duchenne muscular dystrophy is caused by a mutation of the dystrophin gene located on the short arm of the X chromosome. Which of the following statements are false?

- A) Females typically are **carriers** of the genetic trait while males are affected.
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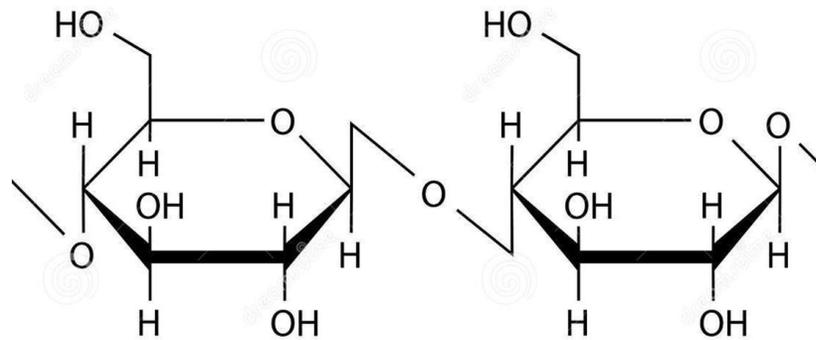
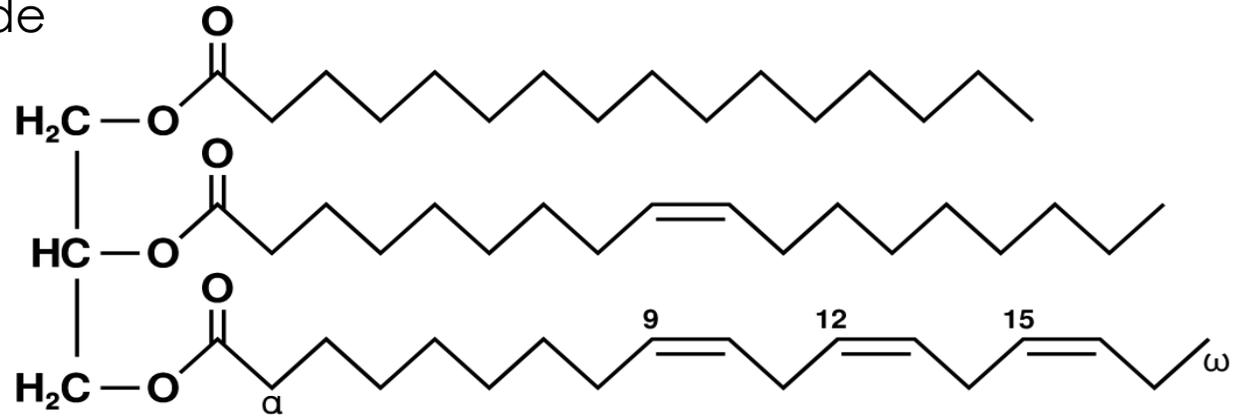
32. Which of the following molecules contain only carbon, hydrogen and oxygen?

- 1. Cellulose**
- 2. Haemoglobin**
- 3. Amylase**
- 4. Triglyceride**
- 5. DNA**

Choose the correct answer:

- A) 1 and 4 only
- B) 2 and 5 only
- C) 3 and 5 only
- D) 1 and 3 only
- E) 2 and 4 only

Triglyceride



Cellulose

The answer is: A

32. Which of the following molecules contain only carbon, hydrogen and oxygen?

- 1. Cellulose**
- 2. Haemoglobin**
- 3. Amylase**
- 4. Triglyceride**
- 5. DNA**

Choose the correct answer:

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- B) 2 and 5 only
- C) 3 and 5 only
- D) 1 and 3 only
- E) 2 and 4 only

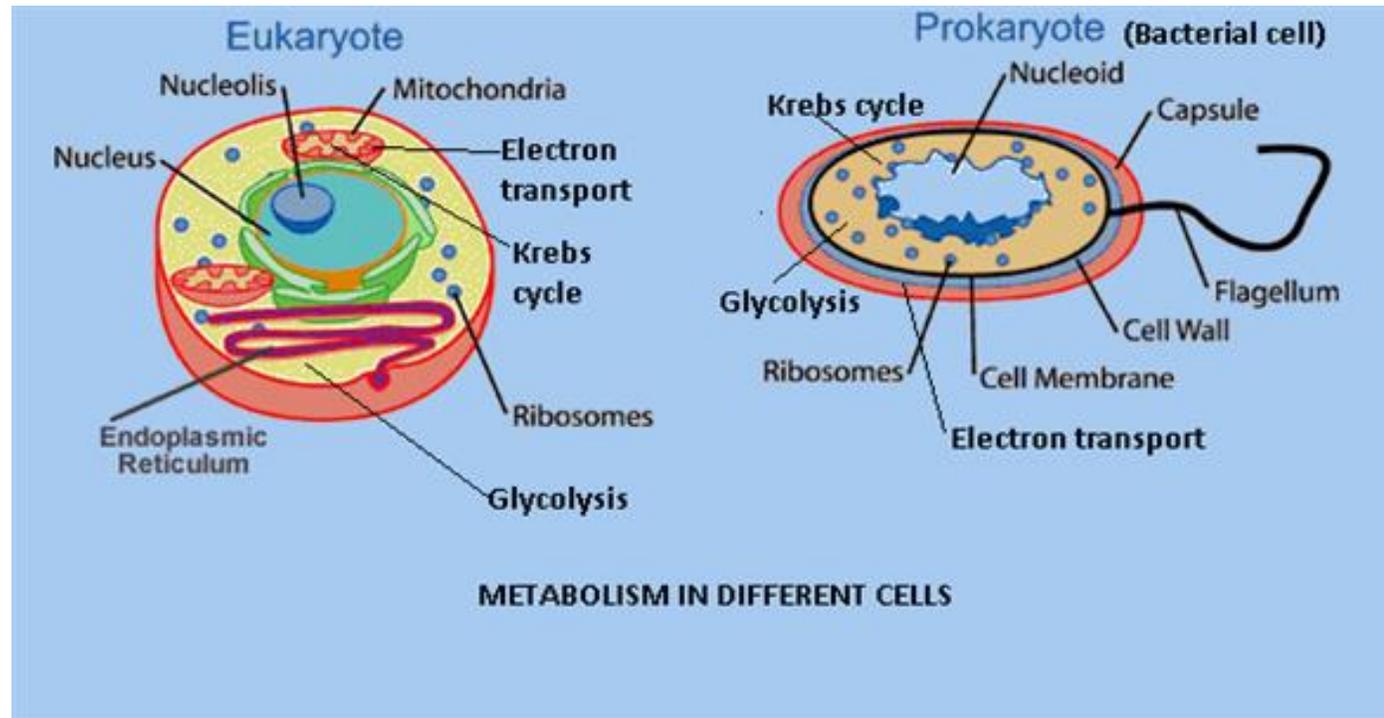
33. The Krebs Cycle is carried out:

- 1. In the mitochondrial matrix of eukaryotic cells**
- 2. In the mitochondrial matrix of prokaryotic cells**
- 3. In the cytoplasm of eukaryotic cells**
- 4. In the cytoplasm of prokaryotic cells**

Choose the correct answer:

- A) 1 and 2
- B) 3 and 4
- C) 1 and 4
- D) 1 and 3
- E) all of them

Krebs Cycle takes place in the **mitochondrial matrix** of **eukaryotic** cells, and in the **cytoplasm** of **prokaryotic** cells.



The answer is: C

33. The Krebs Cycle is carried out:

- 1. In the mitochondrial matrix of eukaryotic cells**
- 2. In the mitochondrial matrix of prokaryotic cells**
- 3. In the cytoplasm of eukaryotic cells**
- 4. In the cytoplasm of prokaryotic cells**

Choose the correct answer:

- A) 1 and 2
- B) 3 and 4
- C) 1 and 4
- D) 1 and 3
- E) all of them

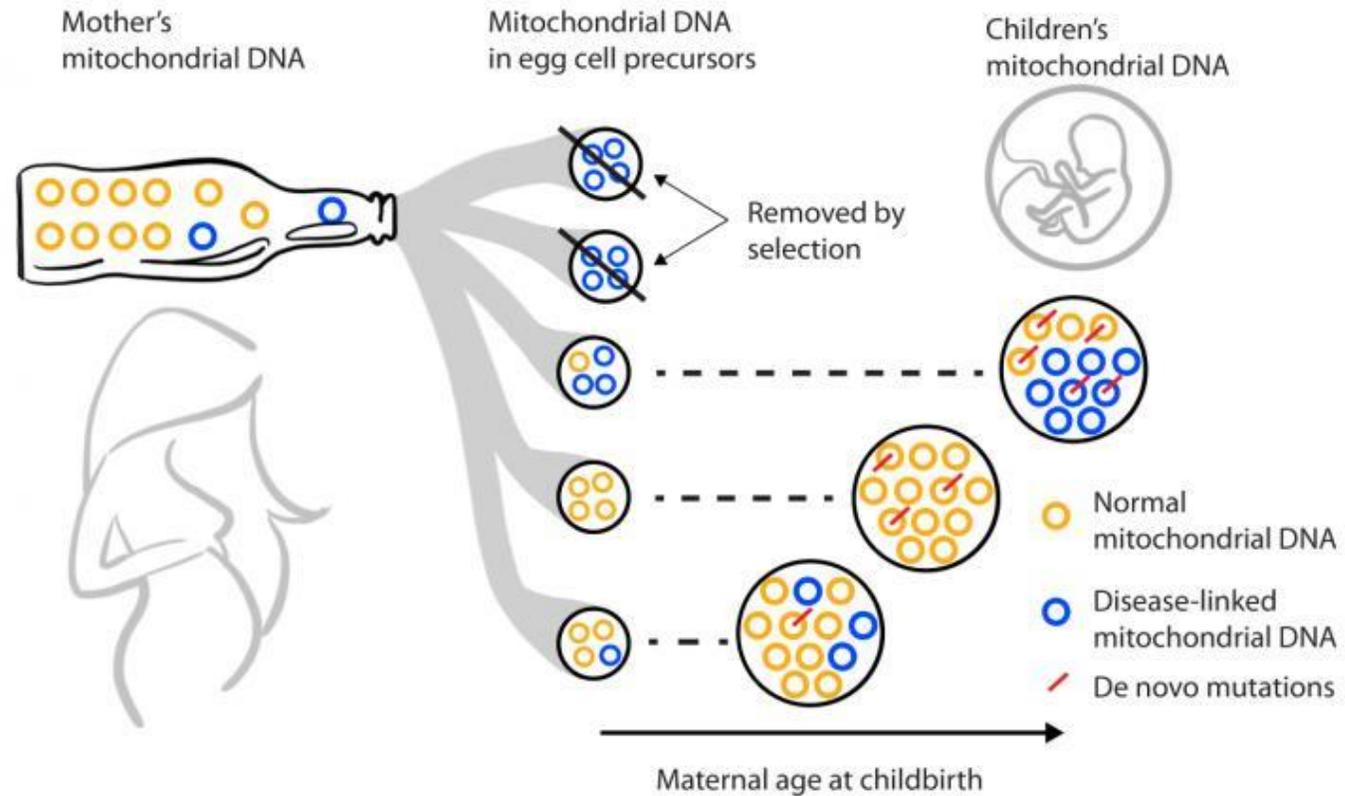
34. Which of the following options are true about mitochondrial genetic diseases?

- 1. ATP metabolism may be affected**
- 2. They can't be inherited by male sons**
- 3. They can't be inherited by female daughters**
- 4. They can't be inherited from sick fathers**
- 5. They can be inherited from sick mothers**

Choose the correct answer:

- A) 1,2 and 4
- B) 3, 4 and 5
- C) 1, 3 and 5
- D) 1, 4 and 5
- E) 1, 2, 4 and 5

Mitochondrial mutations can lead to genetic diseases that, among other symptoms, affect **ATP metabolism**. Due to fecondation mechanisms, the only mitochondria that are inherited by the zygote are those contained in the egg cell, meaning that **only mothers** can transmit this kind of genetic diseases.



The answer is: D

34. Which of the following options are true about mitochondrial genetic diseases?

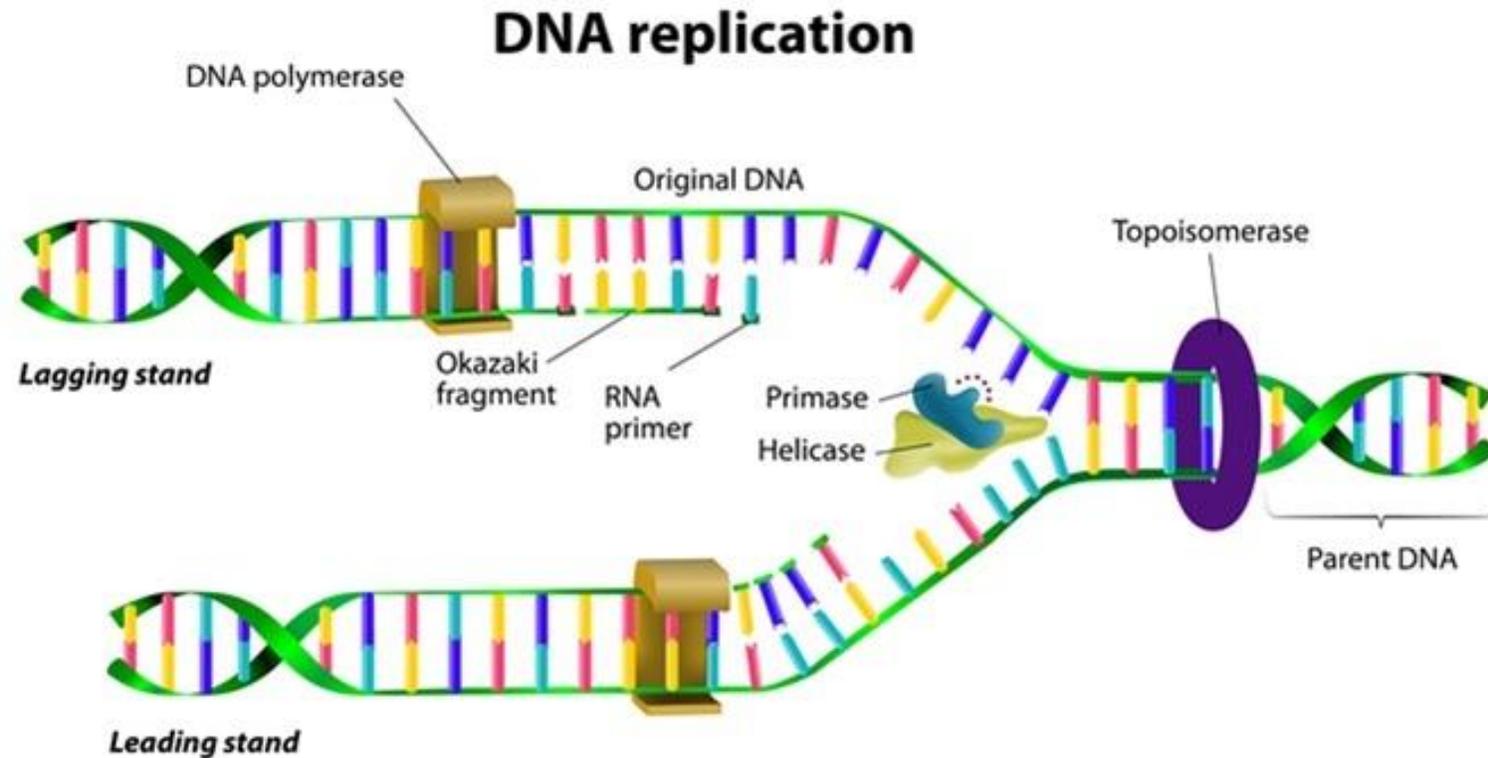
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Choose the correct answer:

- A) 1,2 and 4
- B) 3, 4 and 5
- C) 1, 3 and 5
- D) 1, 4 and 5
- E) 1, 2, 4 and 5

35. DNA replication:

- A) Is fully conservative
- B) Is absent in cells infected with viruses
- C) Happens in the first phase of mitosis
- D) Involves different enzymes, such as transferases
- E) Leads to different DNA strands



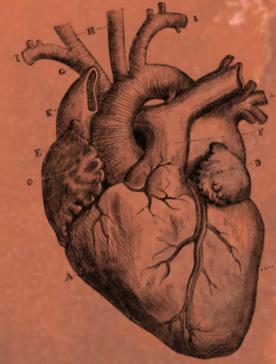
DNA replication is a semiconservative process that involves different types of enzymes, one of those is **RNA polymerase**, a particular transferencease that creates RNA primers.

The answer is: D

35. DNA replication:

- A) Is fully conservative
- B) Is absent in cells infected with viruses
- C) Happens in the first phase of mitosis
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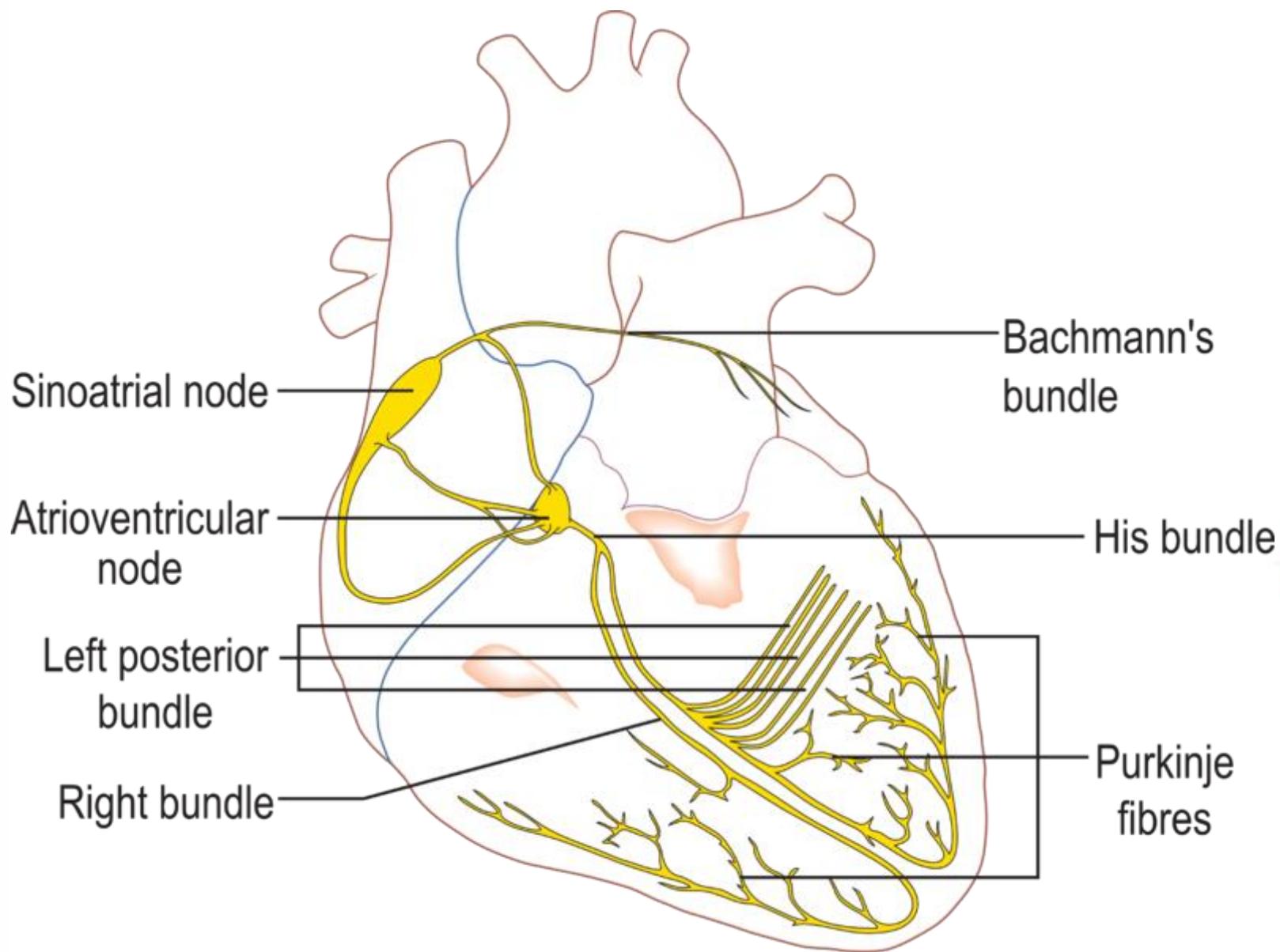


HUMAN ANATOMY & PHYSIOLOGY

36. Which of the following structure is/are part of the electrical conduction system of the heart?

- 1. SA node**
- 2. AV node**
- 3. His bundle**
- 4. Purkinje cells**

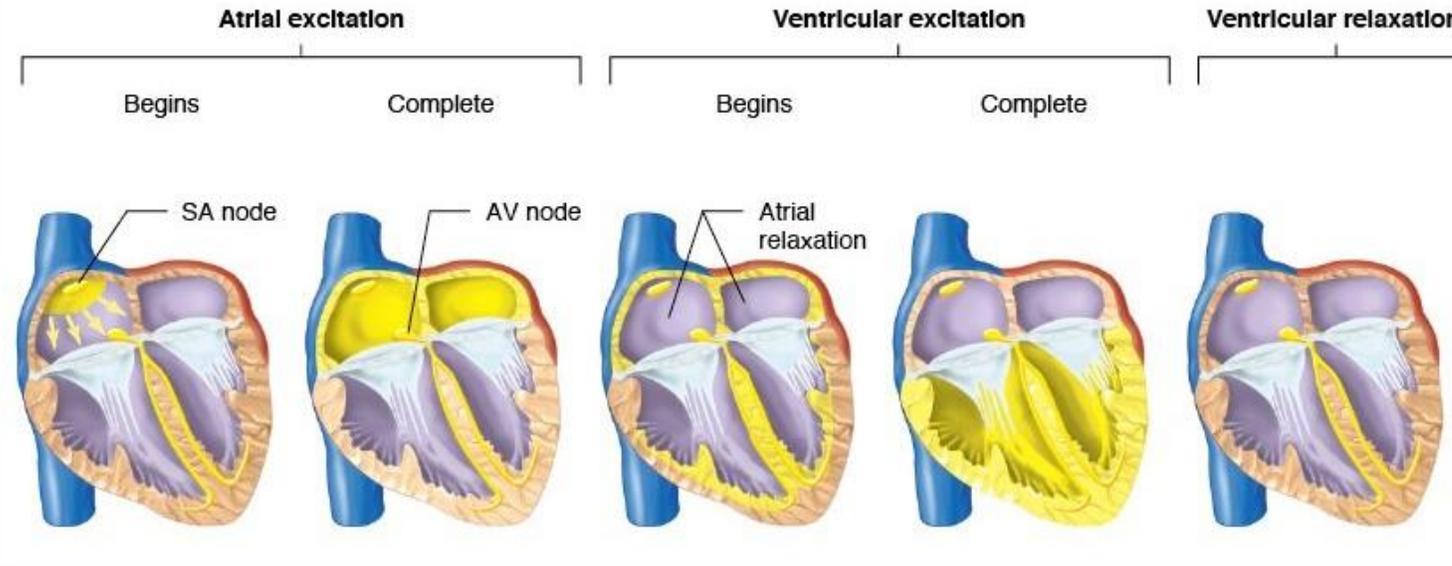
- A. 1 and 2
- B. 1,2 and 3
- C. 3 only
- D. 2 only
- E. 1,2,3 and 4



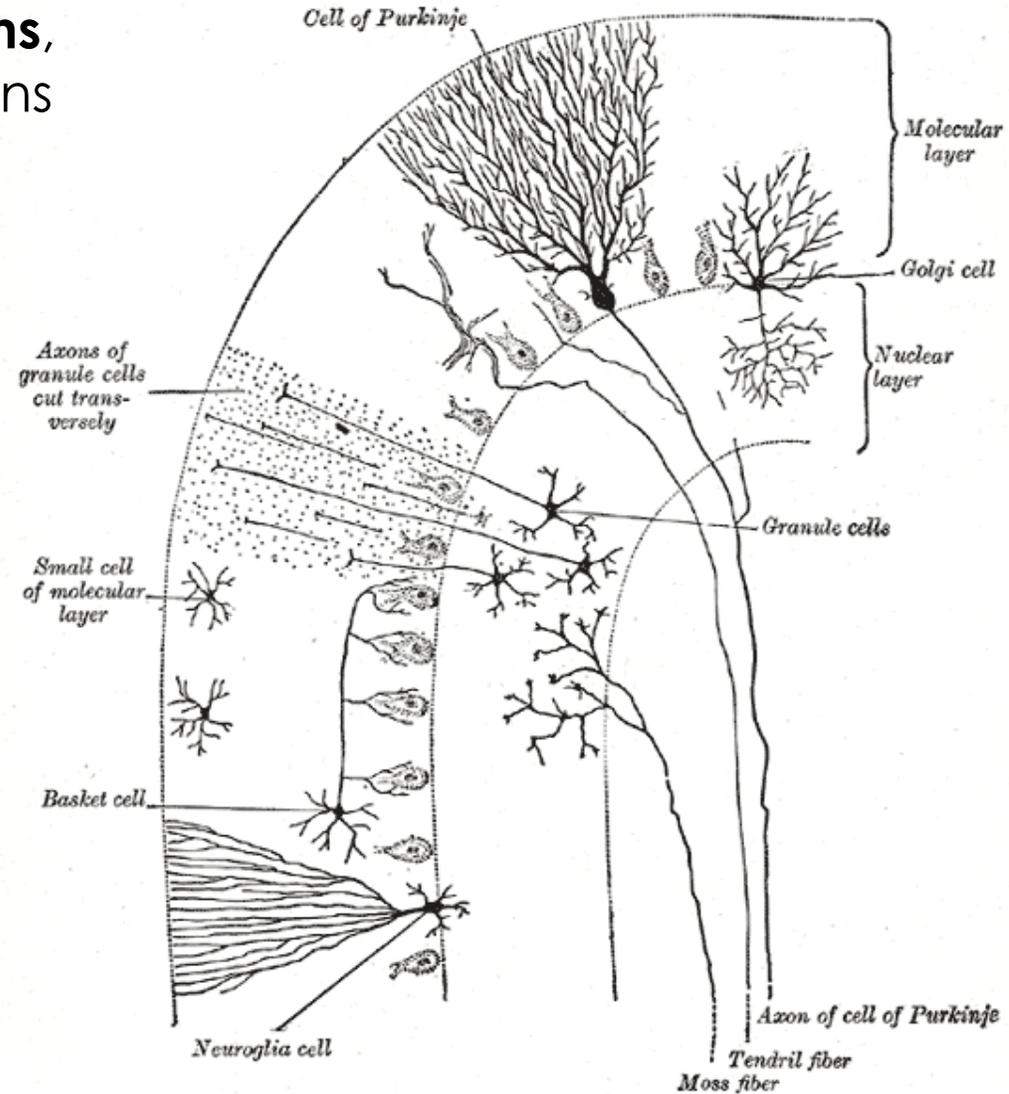
Electrical signal

1. SA node (located in the right atrium) stimulate the atria to contract.
2. AV node (located in the interatrial septum)
3. After a delay diverges and is conducted through the left and right bundle of His to the respective Purkinje fibers causing the contraction.

These signals are generated rhythmically, which in turn results in the coordinated rhythmic contraction and relaxation of the heart.



Purkinje cells, or Purkinje neurons, are a class of GABAergic neurons located in the cerebellum.



36. Which of the following structure is/are part of the electrical conduction system of the heart?

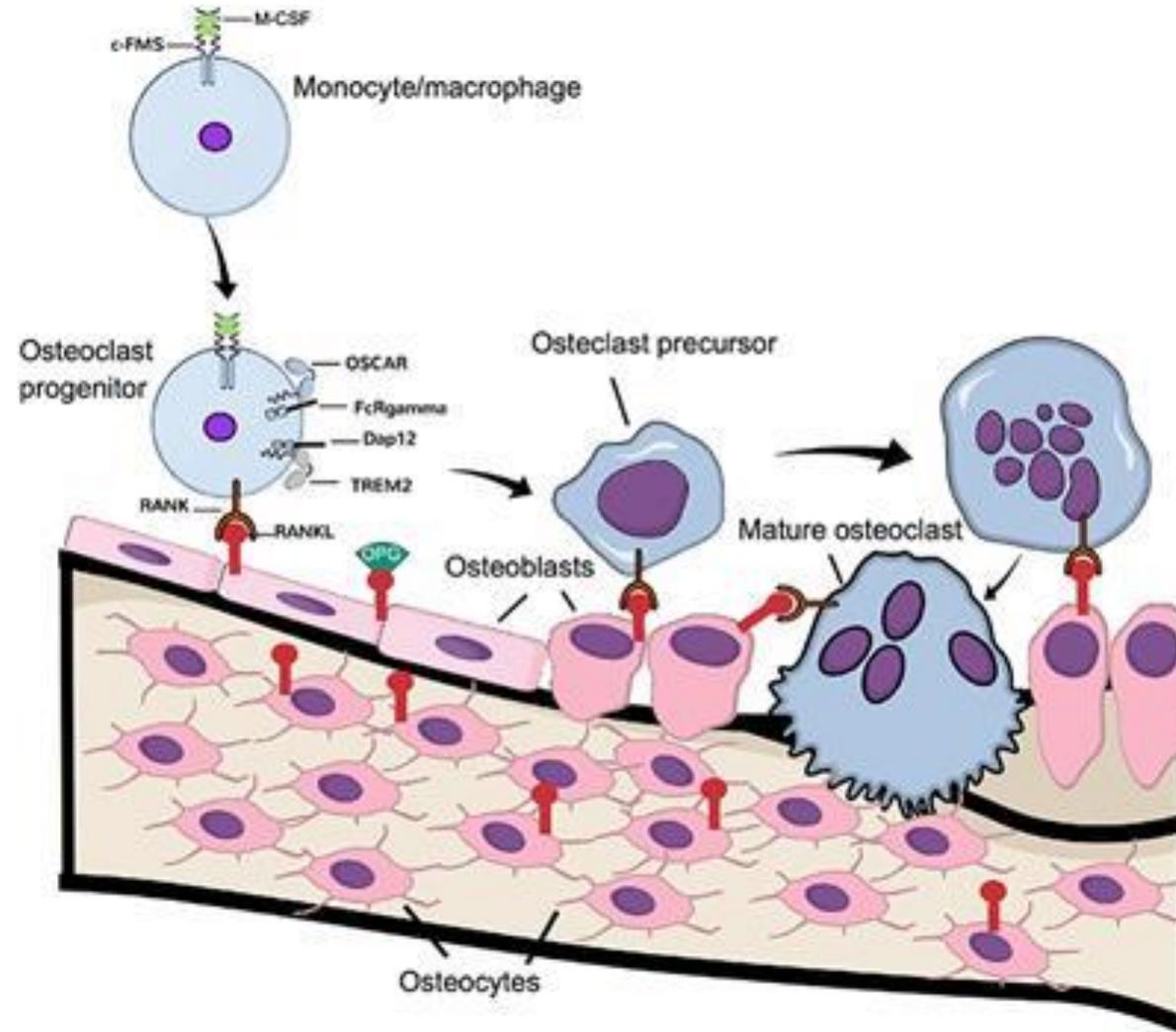
- 1. SA node**
- 2. AV node**
- 3. His bundle**
- 4. Purkinje cells**

- A. 1 and 2
- B. 1,2 and 3
- C. 3 only
- D. 2 only
- E. 1,2,3 and 4

37. Choose the right answer. The osteoclasts...

- A. Have the same cytologic origin as the osteoblasts
- B. Are a type of osteoblasts that, following an excess in bone production, enter a quiescent state
- C. Produce and secrete the unmineralized organic portion of the bone matrix, called "osteoid"
- D. Are usually more active than the osteoblasts
- E. Come from the same precursors as the macrophages

An **osteoclast** is a type of bone cell that breaks down bone tissue. This function is critical in the maintenance, repair, and remodelling of bones of the vertebral skeleton.



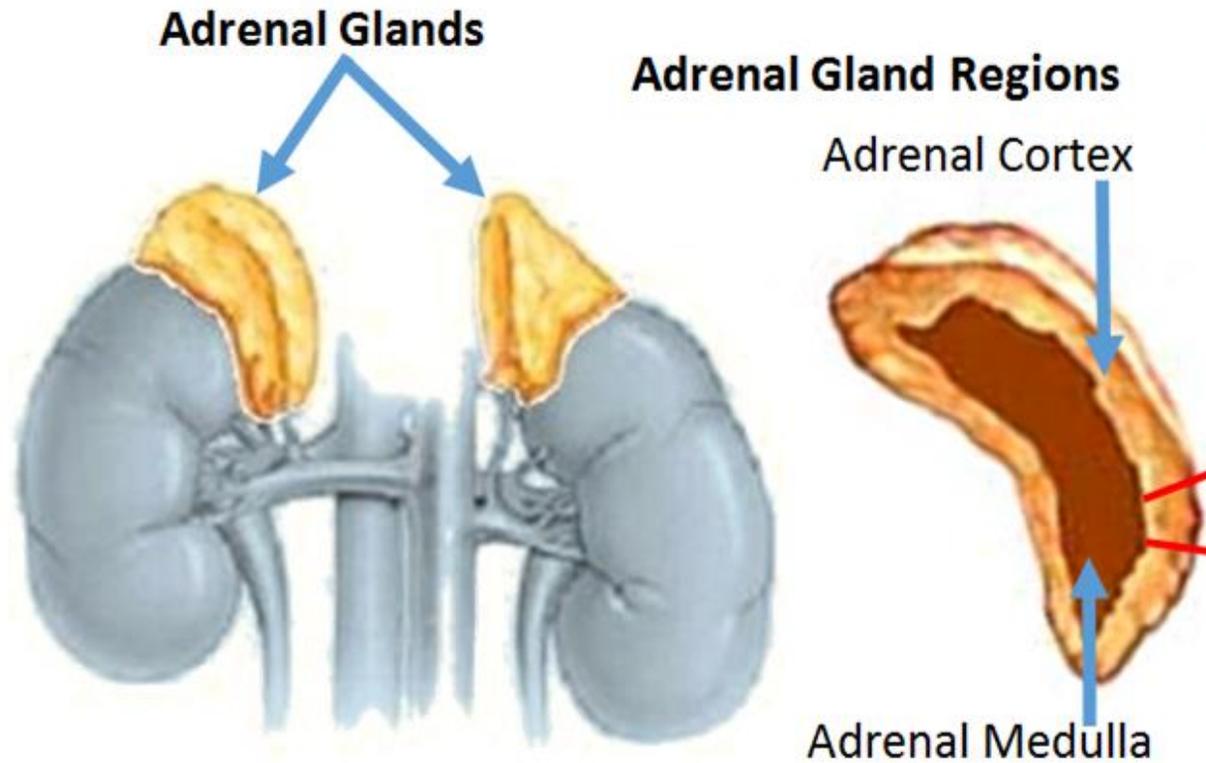
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- D. Are usually more active than the osteoblasts
- E. Come from the same precursors as the macrophages

38. Which of the following statements about the adrenal gland are correct?

- 1. It is located beneath and slightly median to the kidney**
- 2. It is divided in two sections, the cortex and the medulla**
- 3. The medulla secretes stress hormones like cortisol**
- 4. The cortex can also secrete aldosterone in response to the stimuli of the RAAS**

- A. 2 only
- B. 2 and 4
- C. 2 and 3
- D. 1 and 2
- E. 3 only

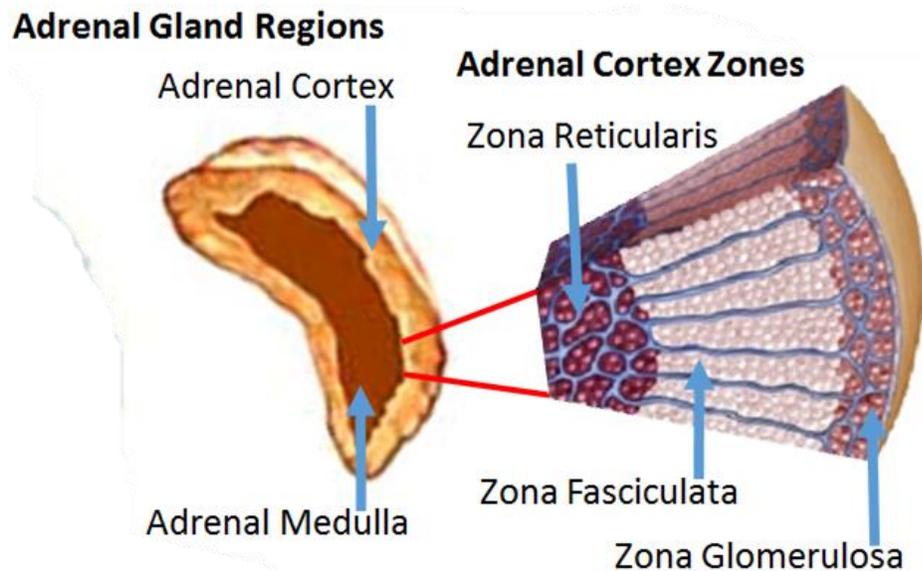


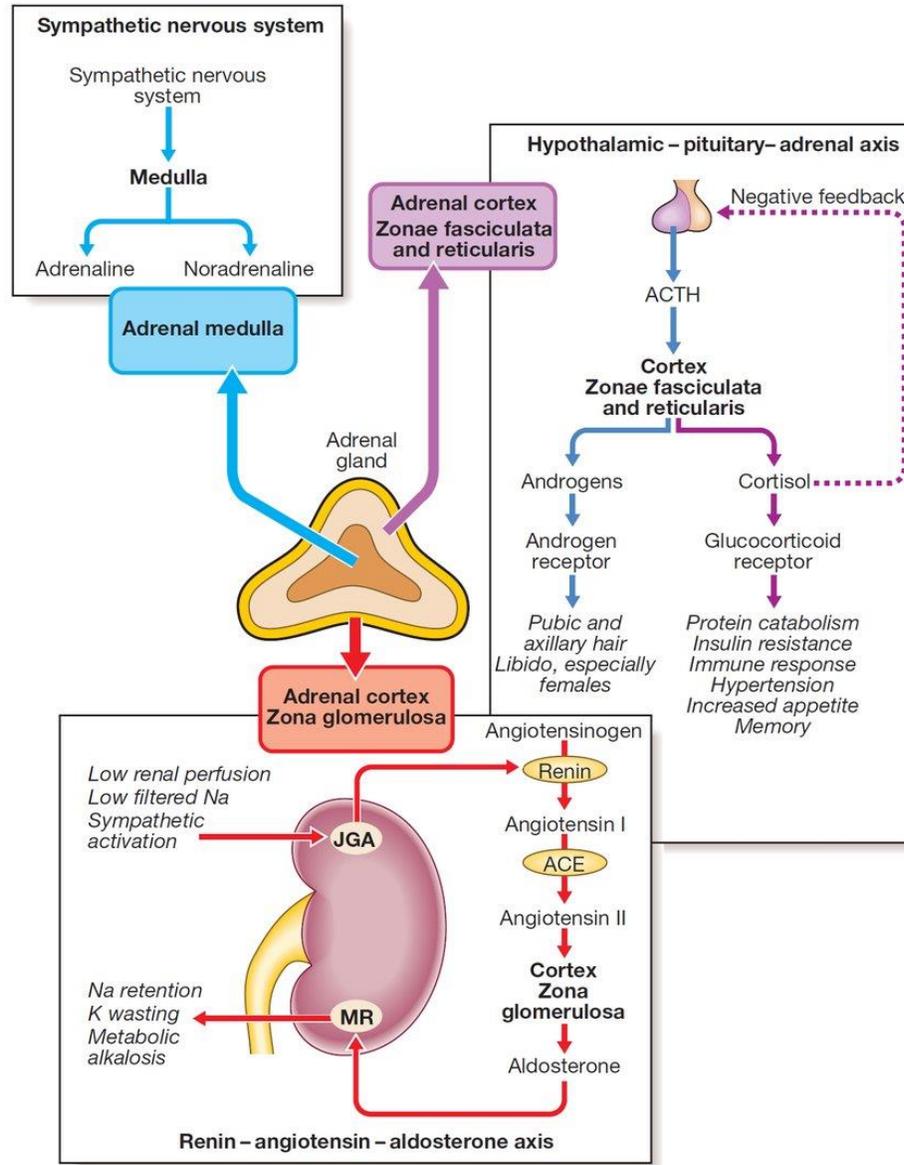
The two adrenal glands are located above the kidneys. They have a slight different size and shape depending on the side. They are divided in two parts (histologically and embryologically)

The adrenal cortex is glande-derived and is conventionally divided in three zones (from outside to inside)

- zona glomerulosa: produces aldosterone in response to AGII produced by the RAAS system.
- zona fasciculata: produces cortisol in response to stress
- zona reticularis: produces androgens (in particular DHEA) under hypophysis stimulus.

The medulla produces adrenaline (epinephrine) and noradrenaline (norepi) in response to sympathetic stimulus. It is neural-derived and actual modified nervous ganglion.





Structure and function of the adrenal glands. (ACE = angiotensin-converting enzyme; JGA = juxtaglomerular apparatus; MR = mineralocorticoid receptor)

Source : Davidsons Essentials of Medicine, 2e

38. Which of the following statements about the adrenal gland are correct?

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- 3. The medulla secretes stress hormones like cortisol**
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- A. 2 only
- B. 2 and 4
- C. 2 and 3
- D. 1 and 2
- E. 3 only

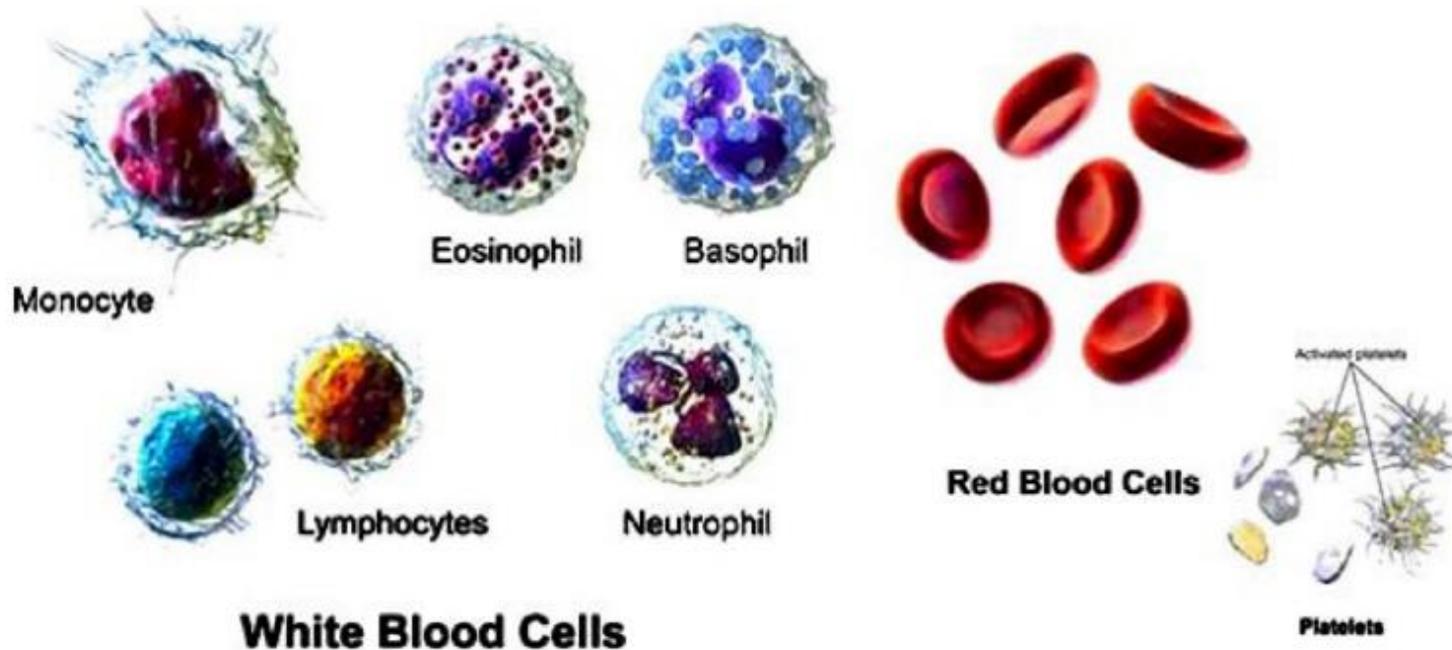
39. Which WBC are elevated during allergic reactions?

- 1. Eosinophils**
- 2. Basophils**
- 3. Neutrophils**
- 4. Lymphocytes**

- A. 1 only
- B. 1 and 2
- C. 3 only
- D. 3 and 4
- E. all

The blood is composed of:

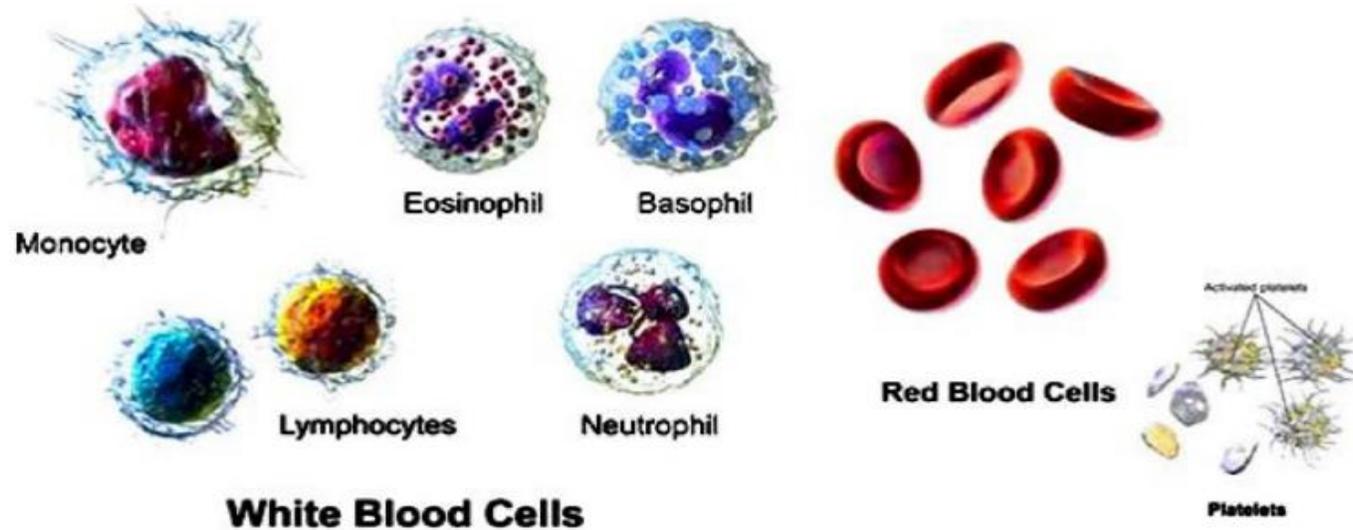
- plasma
- cells that are produced in the hematopoietic organs from the HSC. There are two lines of development:
 - The lymphoid line produces lymphocytes
 - The myeloid line produces erythrocytes, monocytes, eosinophils, neutrophils, basophils and platelets.



WBC are counted in the CBC and can be differentiated. Usually WBC are 4-11 thousands per ml of blood. In scale of frequency there are:

- Neutrophils (50-70%)
- Lymphocytes (20-40%)
- Monocytes (3-10%)
- Eosinophiles (1-3%)
- Basophiles (0-1%)

Remember: “**N**ever (5 letters->50%) **L**et (3 letters 30%) **M**onkeys (7 letters ->7%) **E**at (3 letters -> 3%) **B**ananas (if you don't let monkeys eat they have 0% bananas)”.



We can divide WBC in two main categories:

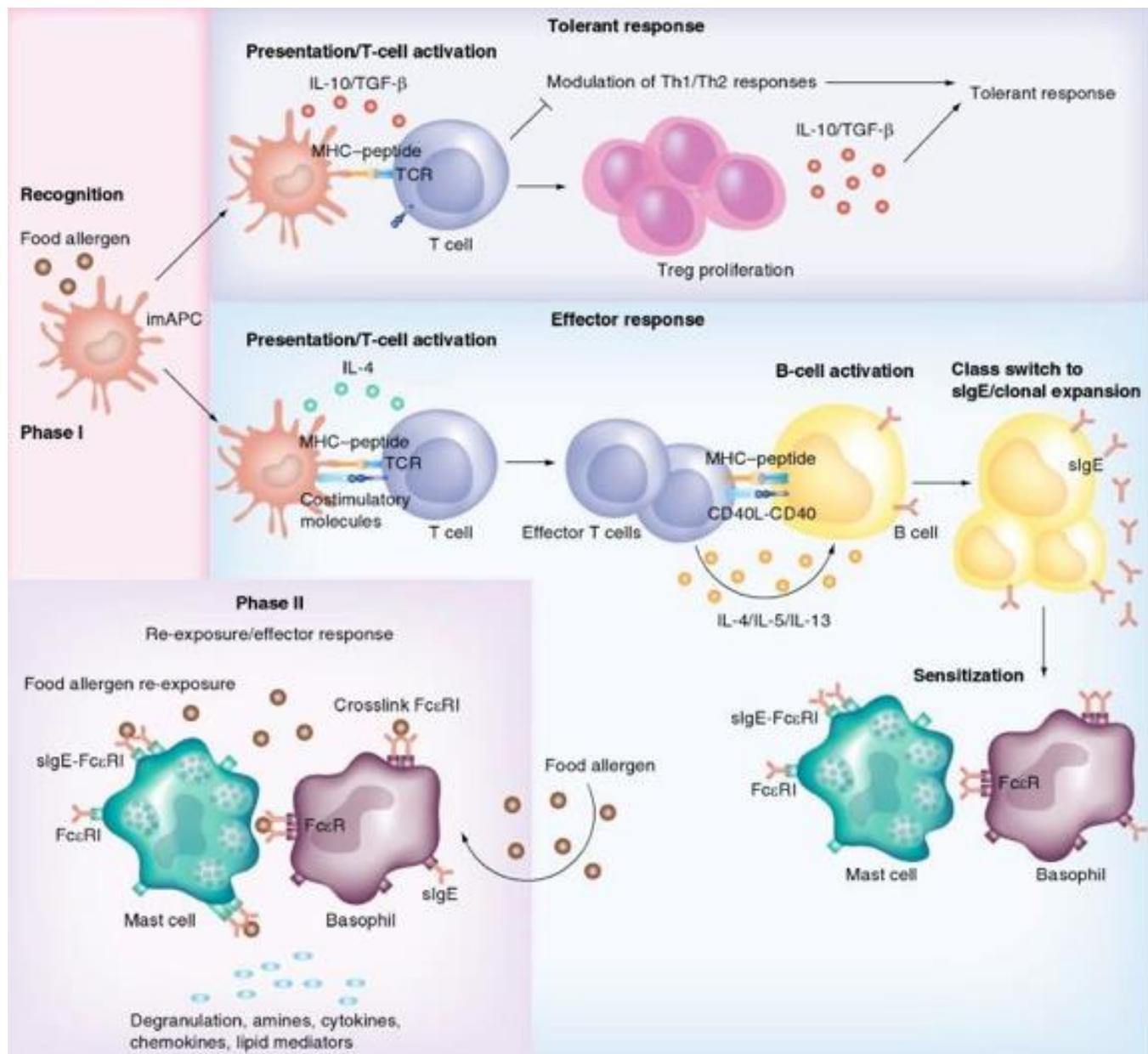
**POLYMORPHONUCLEAR
GRANULOCYTES**

- **Neutrophils:** big cells with multilobed nucleus. They are increased in number in bacterial infections. They are “professional phagocytes”.
- **Eosinophils:** big cells with multilobed nucleus, they stain red due to the color of their granules. They are increased in number in parasitic infections (mainly worms) and allergic reactions.
- **Basophils:** big cells with multilobed nucleus, they stain blue due to the color of their granules. They contain a receptor for histamine which is the main mediator (with IgE) of allergic reactions where they are increased in number.

**MONONUCLEAR
AGRANULOCYTES**

- **Monocytes:** big cells with a single nucleus. They differentiate in macrophages in the target tissue. They are increased in number in the late stage of infections.
- **Lymphocytes:** small cells with a single nucleus that fills the whole cell. They are increased in viral infections.

IMAT simulation



39. Which WBC are elevated during allergic reactions?

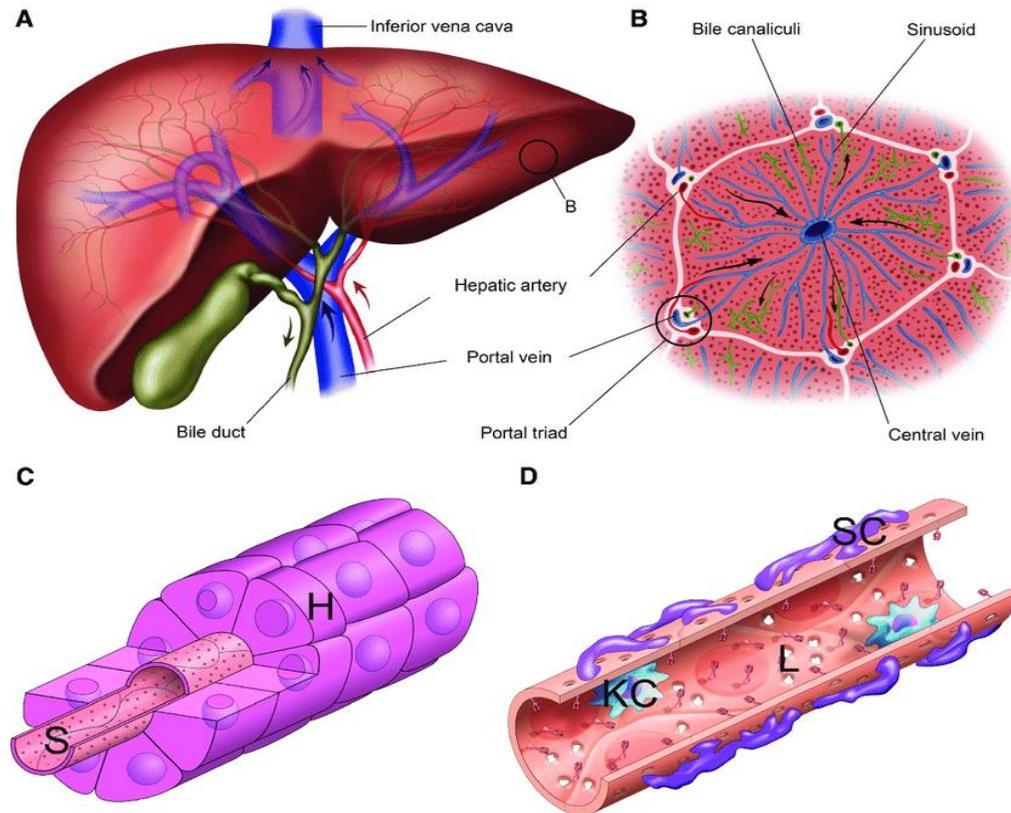
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- 2. Basophils**
- 3. Neutrophils**
- 4. Lymphocytes**

- A. 1 only
- B. 1 and 2
- C. 3 only
- D. 3 and 4
- E. all

40. Which of the following statements about the liver is/are correct?

- 1. The liver is an organ which detoxifies various metabolites**
- 2. The liver is an organ which synthesizes proteins**
- 3. The liver is an organ which produces biochemicals necessary for digestion and growth**
- 4. It is located in the right upper quadrant of the abdomen, below the diaphragm**

- A. 1 only
- B. 1 and 2
- C. 3 only
- D. 3 and 4
- E. all

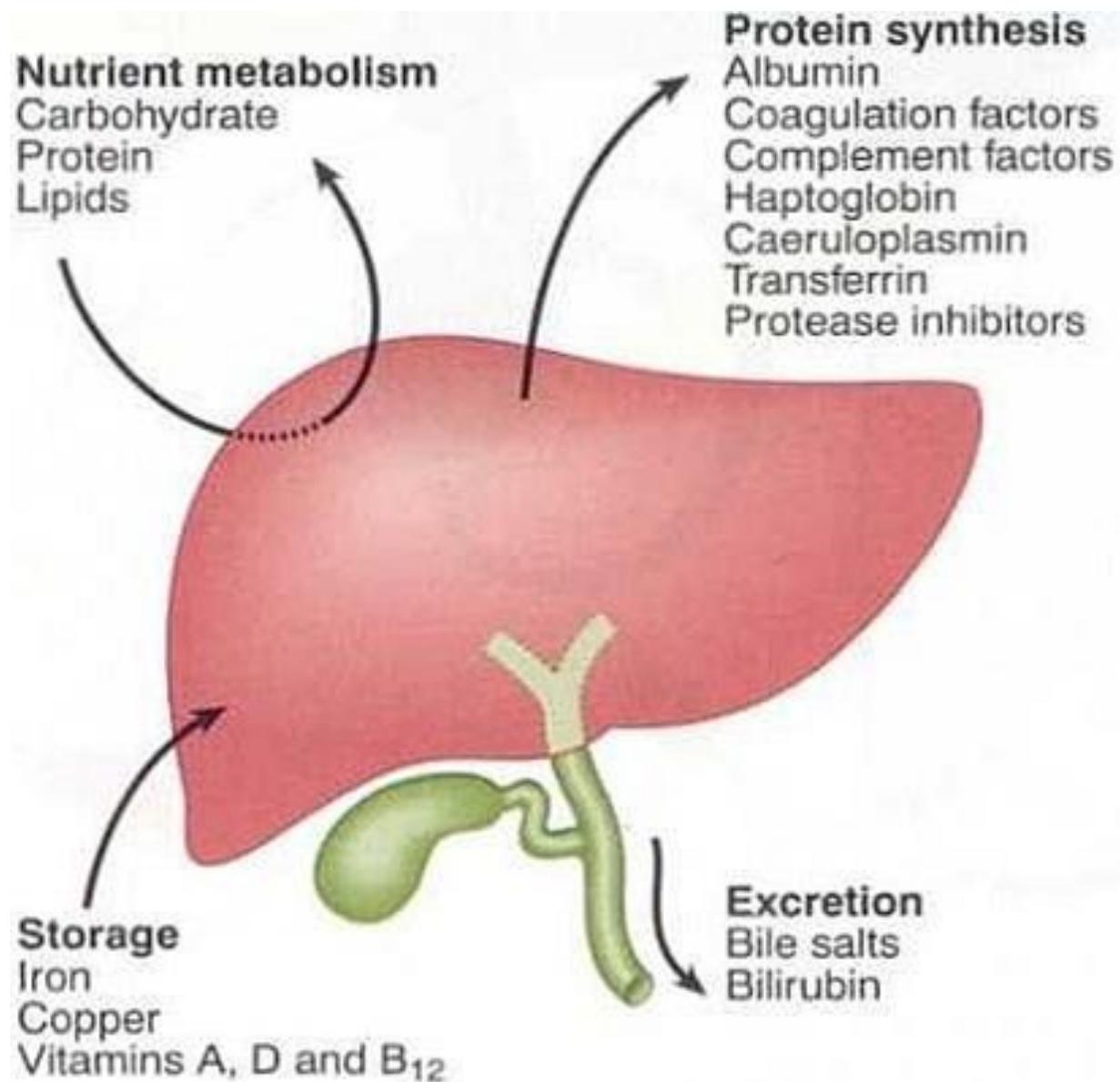


The liver is located in the right upper quadrant of the abdomen, under the diaphragm.

It's the biggest gland of the body, both endocrine and exocrine.

It's supplied by the hepatic artery and has a peculiar vascular system, the portal circulation. The liver produces bile which is excreted into the duodenum via the bile ducts. Excess bile is stored into the gallbladder.

IMAT simulation

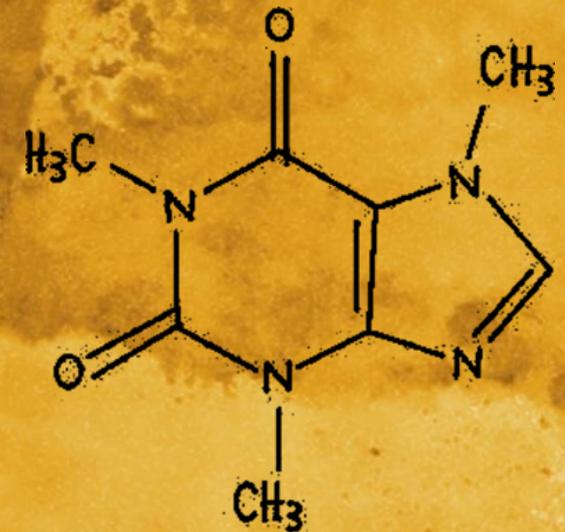
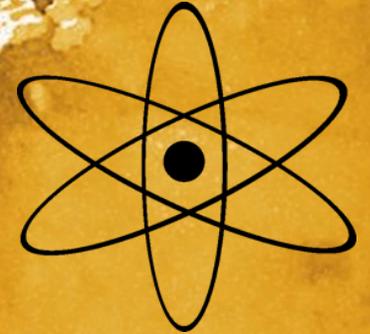
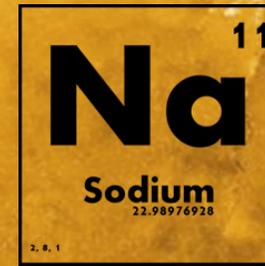


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- A. 1 only
- B. 1 and 2
- C. 3 only
- D. 3 and 4
- E. all

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CHEMISTRY

41. In an experiment 10 cm³ of carbon monoxide and 10 cm³ of oxygen are mixed. The gases react as shown in the equation below.



What will be the total volume of gas present, in cm³, at the end of the reaction?

(All gas volumes are measured at the same temperature and pressure)

- A) 10
- B) 15
- C) 20
- D) 25
- E) 30

Simulazione del Test d'ammissione

First of all you need to balance the equation: $2\text{CO (g)} + \text{O}_2 \text{(g)} \rightarrow 2\text{CO}_2 \text{(g)}$

Since the gases are kept under the same conditions for pressure and temperature, the mole ratio that exists between the species involved in the reaction becomes equivalent to the volume ratio.

2:1 mole ratio between CO and O₂. The reaction will consume a volume of CO twice as large as the volume of O₂. Carbon monoxide will act as a **limiting reagent** because it will be consumed before all the oxygen gets a chance to react.

$$2 : 1 = 10 \text{ cm}^3(\text{CO}) : x(\text{O}_2) \rightarrow x = 5 \text{ cm}^3$$

So, 10 cm³ of CO will react with 5 cm³ of O₂, leaving 5 cm³ of O₂ **in excess**.

2 : 2 mole ratio between CO and CO₂. For a given volume of CO that takes part in the reaction (10 cm³), the reaction produces an equal volume of CO₂ (10 cm³).

At the end of the reaction:

$$V_{\text{gas}} = V_{\text{O}_2 \text{ (in excess)}} + V_{\text{CO}_2 \text{ (produced)}} = 5 \text{ cm}^3 + 10 \text{ cm}^3 = 15 \text{ cm}^3$$

The correct answer is B.

41. In an experiment 10 cm³ of carbon monoxide and 10 cm³ of oxygen are mixed. The gases react as shown in the equation below.



What will be the total volume of gas present, in cm³, at the end of the reaction?

(All gas volumes are measured at the same temperature and pressure)

- A) 10
- B) 15
- C) 20
- D) 25
- E) 30

42. What is the freezing point depression of a solution of 0.16 moles of Na_2CO_3 in 100 mL of ethanol?
[$K_f = 1.99 \text{ K}\cdot\text{kg}/\text{mol}$; density of ethanol = $789 \text{ kg}/\text{m}^3$]

- A) 4 K
- B) 1.2 K
- C) 9.6 K
- D) 12 K
- E) 3.2 K

To calculate the freezing point depression: $\Delta T_f = K_f \times m$, where m = molality:

$$m \text{ (molality)} = \frac{\text{number of moles of the solute (n)}}{\text{weight of the solvent (kg)}}$$

Note that for strong electrolytes, such as Na_2CO_3 , we have to multiply per the Van't Hoff factor i , which indicates for ionic compounds the number of discrete ions in the formula. In this case $i = 3$ because, in a solvent, Na_2CO_3 dissociates in two Na^+ ions and one CO_3^{2-} (carbonate) ion.

To solve the exercise, we have to find the mass of the solvent knowing its density and its volume and remembering that $\rho = m/V$.

$$\rho \text{ of ethanol} = 789 \text{ kg/m}^3 = 789 \times 10^{-4} \text{ kg/mL}$$

$$V = 100 \text{ mL}$$

$$m = 0.0789 \text{ kg}$$

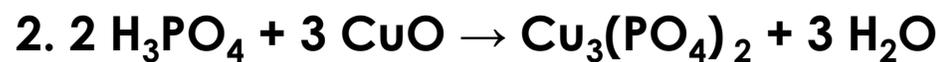
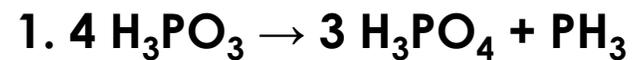
Replacing the numerical values in the formula of the freezing point depression, we obtain that its value corresponds to 12.

The correct answer is D.

42. What is the freezing point depression of a solution of 0.16 moles of Na_2CO_3 in 100 mL of ethanol?
[$K_f = 1.99 \text{ K}\times\text{kg/mol}$; density of ethanol = 789 kg/m^3]

- A) 4 K
- B) 1.2 K
- C) 9.6 K
- D) 12 K
- E) 3.2 K

43. Which of the following is/are NOT redox?



A) 1 only

B) 2 only

C) 2 and 3 only

D) 1 and 2 only

E) 1 and 3 only



This is a **disproportionation**, a redox reaction in which a substance is simultaneously oxidized and reduced.



This is **NOT** a redox reaction because the oxidation numbers are the same both in the products and in the reagents.

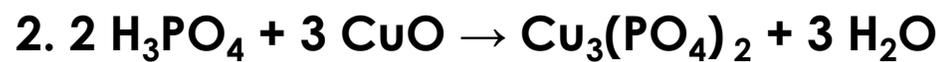
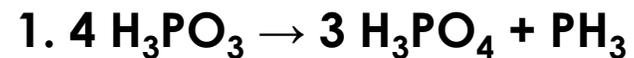


This is a redox:

- Manganese (Mn) gains electrons, so it reduces itself;
- Iodine (I) loses electrons, so it oxidizes itself.

The correct answer is B.

43. Which of the following is/are NOT redox?



A) 1 only

B) 2 only

C) 2 and 3 only

D) 1 and 2 only

E) 1 and 3 only

44. Many elements in nature can have different isotopes. Although one isotope commonly predominates due to stability, the other isotopes can affect the overall mass of the element.

Suppose a certain element has two main isotopes: isotope A has a molar mass of 128 g/mol and isotope B has a molar mass of 132 g/mol. One mole of this element, when found naturally, weighs 128.8 grams.

What are the percentages of isotopes A and B when found in nature?

- A) 50% A and 50% B
- B) 60% A and 40% B
- C) 20% A and 80% B
- D) 80% A and 20% B
- E) 30% A and 70% B

Simulazione del Test d'ammissione

If the two isotopes were equal in nature (50/50), than a mole of the element in nature would weigh 130 grams.

$$(0.5) \cdot (128\text{g}) + (0.5) \cdot (132\text{g}) = 130\text{g}$$

Since the number is less than that, we can conclude that isotope A is more dominant than isotope B, lowering the average mass.

We can exclude answers A, C and E.

Now, isotope A will make up a certain percentage of the element in nature (we will call this percentage "X"), while isotope B will make up the rest of that percentage (1-X).

$$128X + 132 \cdot (1-X) = 128.8$$

$$128X + 132 - 132X = 128.8$$

$$-4X = -3.2$$

$$X = 0.8$$

Therefore 80% of the element is composed of isotope A, and the other 20% is composed of isotope B.

The correct answer is D.

44. Many elements in nature can have different isotopes. Although one isotope commonly predominates due to stability, the other isotopes can affect the overall mass of the element.

Suppose a certain element has two main isotopes: isotope A has a molar mass of 128 g/mol and isotope B has a molar mass of 132 g/mol. One mole of this element, when found naturally, weighs 128.8 grams.

What are the percentages of isotopes A and B when found in nature?

- A) 50% A and 50% B
- B) 60% A and 40% B
- C) 20% A and 80% B
- D) 80% A and 20% B
- E) 30% A and 70% B

45. Which of the following configurations represents the correct and most stable structure of ammonia and phosphine (phosphorus trihydride)?

- A) AX_2 – linear geometry
- B) AX_4 – tetrahedral structure
- C) AX_2E_2 – bent structure
- D) AX_3E – trigonal pyramidal structure
- E) AX_3E_2 – trigonal bipyramidal structure

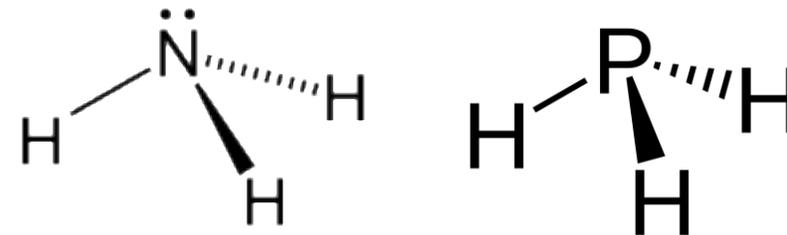
The chemical model used to determine the correct structure of every molecule is the VSEPR theory (Valence shell electron pair repulsion theory).

The most important principle of VSEPR theory is that the valence electron pairs, surrounding an atom, tend to repel each other and will, therefore, adopt an arrangement that minimizes this repulsion. This, in turn, decreases the molecule's energy and increases its stability, which determines the molecular geometry.

In our case the two molecules we have been asked to define are two hydrides, respectively, of nitrogen and phosphorus.

Nitrogen and phosphorus belong to the 5th group of the periodic table and present an electron pair and three unpaired electrons which constantly repel each other. The electron pair tends to push away the 3 hydrogen atoms thus blocking a possible tetrahedral structure.

The correct answer is D.



45. Which of the following configurations represents the correct and most stable structure of ammonia and phosphine (phosphorus trihydride)?

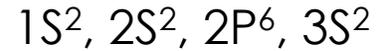
- A) AX_2 – linear geometry
- B) AX_4 – tetrahedral structure
- C) AX_2E_2 – bent structure
- D) AX_3E – trigonal pyramidal structure
- E) AX_3E_2 – trigonal bipyramidal structure

**46. Which of the elements listed has the following electron configuration:
 $1s^2 2s^2 2p^6 3s^2$**

- A) Mg
- B) Mn
- C) Cl
- D) Se
- E) Al^{-1}

Simulazione del Test d'ammissione

The question can be resolved simply by counting the number of electrons and remembering the position of the various elements on the periodic table.



We can calculate the total number of electrons by adding all the electrons in the different orbitals together: $2+2+6+2 = 12$ total electrons. For all the atoms that aren't ions we know the total number of protons is equal to the number of electrons. In the case of Aluminum, it has 13 protons but since it's a ion and has a negative charge the total number of electrons is 14 and not 13 (Response E is incorrect)

Manganese (Mn) has 25 electrons (Response A is incorrect), Chlorine (Cl) has 17 electrons (Response C is incorrect), Selenium (Se) has 34 electrons (Response D is incorrect)

The only one with the correct number of electrons is Magnesium (Mg) which has 12 electrons

The correct answer is A.

46. Which of the elements listed has the following electron configuration:
 $1s^2 2s^2 2p^6 3s^2$

- A) Mg
- B) Mn
- C) Cl
- D) Se
- E) Al^{-1}

47. Which one of the following molecules is a structural isomer of cycloheptane?

- A) Heptyne
- B) 2,4-dimethyl-2-pentene
- C) Methylcyclohex-2-yne
- D) Benzene
- E) 2-ethylpentane

A structural isomer is a type of isomer in which molecules with the **same molecular formula** have **different bonding patterns** and atomic organisations.

Cycloheptane molecular formula is C_7H_{14} and so the point of this question is to search the other molecule with the same molecular formula.

Heptyne: C_7H_{12}

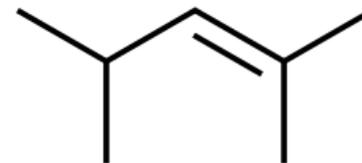
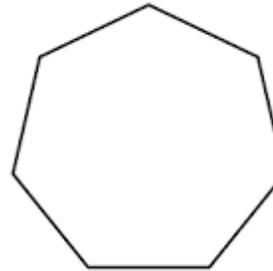
2,4-dimethyl-2-pentene: C_7H_{14}

Methylcyclohex-2-yne: C_7H_{10}

Benzene: C_6H_6

2-ethylpentane: C_7H_{16}

The correct answer is B.



47. Which one of the following molecules is a structural isomer of cycloheptane?

- A) Heptyne
- B) 2,4-dimethyl-2-pentene
- C) Methylcyclohex-2-yne
- D) Benzene
- E) 2-ethylpentane

48. Consider the redox reaction $\text{NaI} + 3 \text{HClO} \rightarrow \text{NaIO}_3 + 3\text{HCl}$.

Which of the following statements is/are correct?

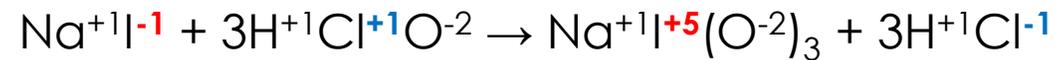
- 1. Chlorine gains electrons**
- 2. NaI is the oxydising agent**
- 3. The oxidation number of the iodine is +5 in the sodium iodate**

- A) 3 only
- B) 2 and 3 only
- C) 1 and 3 only
- D) 1 and 2 only
- E) 1, 2 and 3

In a reduction-oxidation reaction:

- **Oxidation** is the **loss of electrons** or an **increase in the oxidation number** of an atom;
- **Reduction** is the **gain of electrons** or a **decrease in the oxidation number** of an atom.
- The **oxidizing agent reduces itself**, while the **reducing agent oxidizes itself**.

The oxidation numbers in the given reaction are:



- Iodine (I) oxidizes itself, so sodium iodide (NaI) is the reducing agent
- Chlorine (Cl) reduces itself, so hypochlorous acid (HClO) is the oxidizing agent

The correct answer is C.

48. Consider the redox reaction $\text{NaI} + 3 \text{HClO} \rightarrow \text{NaIO}_3 + 3\text{HCl}$.

Which of the following statements is/are correct?

1. Chlorine gains electrons
2. NaI is the oxydising agent
3. The oxidation number of the iodine is +5 in the sodium iodate

- A) 3 only
- B) 2 and 3 only
- C) 1 and 3 only
- D) 1 and 2 only
- E) 1, 2 and 3

49. A solution of nitric acid contains 0.01 moles of HNO_3 in 100 mL of pure water. If you dilute 10 mL of this solution in enough water to make up a solution of 1L, what is the pH of the obtained solution?

- A) 11
- B) 2
- C) 0
- D) 8
- E) 3

First of all, we have to calculate the molarity of the initial solution remembering that **M (molarity) = n (number of moles of the solute) / V (volume of the solution)** and we obtain 0.1 M.

$$M (\text{molarity}) = \frac{n}{V} = \frac{0.01 \text{ mol}}{0.1 \text{ L}} = 0.1 \text{ M}$$

The number of moles contained in 10 mL is the product between the molarity and the volume, which is $0.1 \text{ M} \times 0.01 \text{ L} = 0.001 \text{ mol}$.

We can now calculate the molarity of the second solution with the previous formula obtaining 0.001M. Knowing that the nitric acid is a strong monoprotic acid, the concentration of H^+ is equal to the molarity of the solution and therefore we calculate the pH using the formula: **pH = - log₁₀[H⁺] = - log₁₀10⁻³ = 3.**

The correct answer is E.

49. A solution of nitric acid contains 0.01 moles of HNO_3 in 100 mL of pure water. If you dilute 10 mL of this solution in enough water to make up a solution of 1L, what is the pH of the obtained solution?

- A) 11
- B) 2
- C) 0
- D) 8
- E) 3

50. Which of the following molecules can have cis-trans isomerism?

1. But-2-ene
2. Butenedioic acid
3. 2-butyne

- A) 1 and 2 only
- B) 3 only
- C) 1, 2 and 3
- D) 2 only
- E) 1 and 3 only

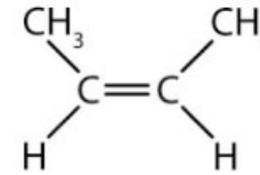
Cis-trans isomerism, also known as **geometric isomerism** or **configurational isomerism**, is a type of stereoisomer.

Cis indicates that the functional groups are on the same side of the carbon chain while *trans* conveys that functional groups are on opposing sides of the carbon chain.

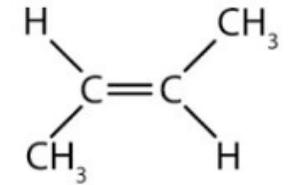
Most of the time the molecule MUST have a double bonding in order to have this isomerism, so 2-butyne can't have cis-trans isomerism.

By drawing the other two molecules, you can see that they both have cis-trans isomerism.

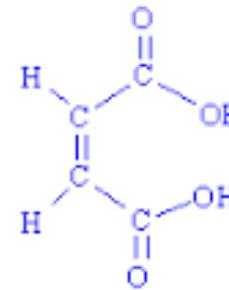
The correct answer is A.



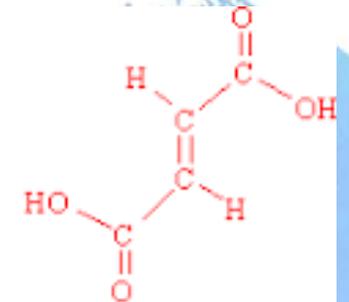
cis-2-butene



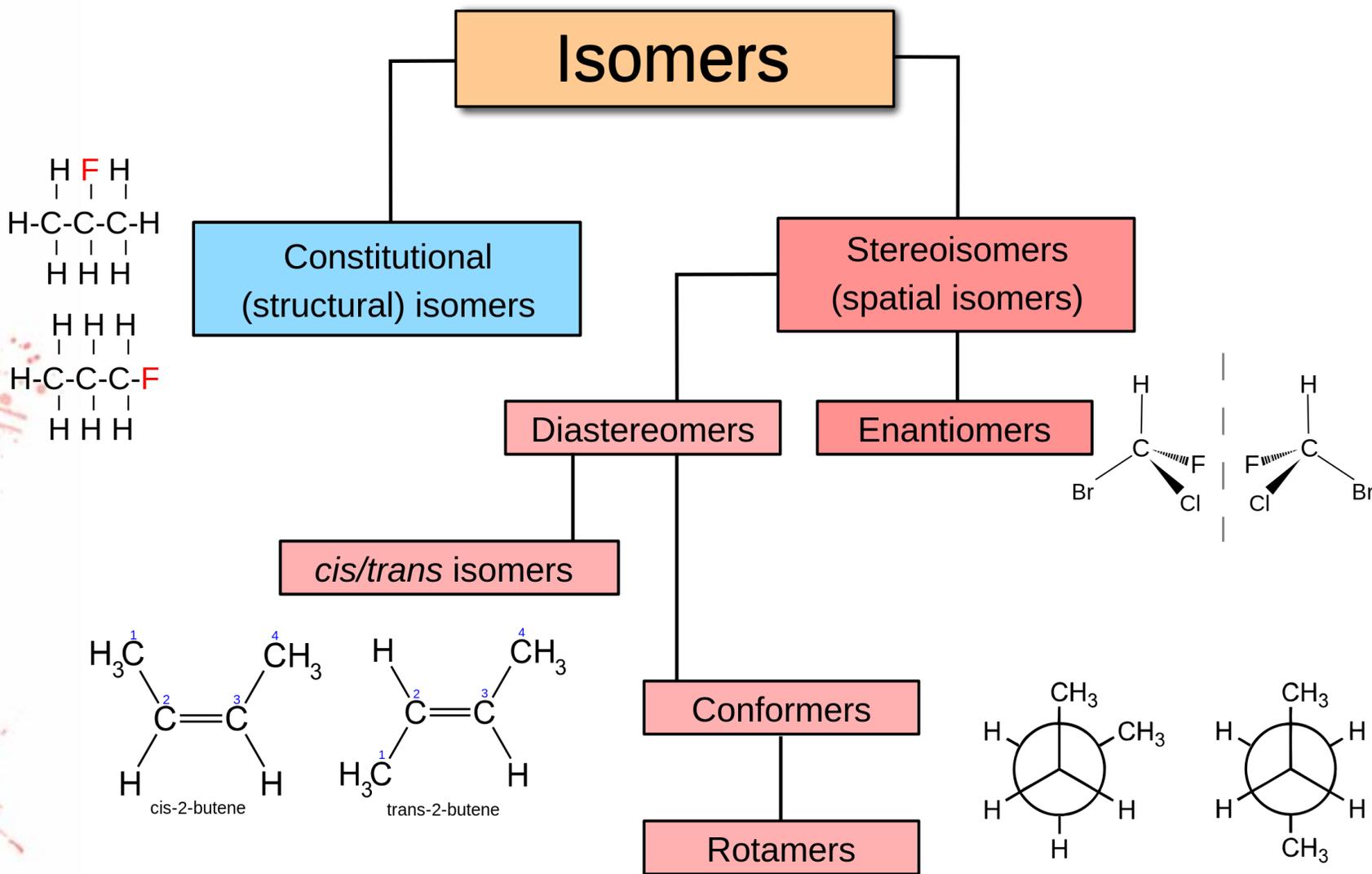
trans-2-butene



cis Butenedioic acid
("Maleic acid")



trans Butenedioic acid
("Fumaric acid")



50. Which of the following molecules can have cis-trans isomerism?

1. But-2-ene
2. Butenedioic acid
3. 2-butyne

- A) 1 and 2 only
- B) 3 only
- C) 1, 2 and 3
- D) 2 only
- E) 1 and 3 only

51. Five of the ions of vanadium are listed below:

- 1) VO_3^-
- 2) V^{3+}
- 3) V^{2+}
- 4) VO^{2-}
- 5) VO_2^+

Which two ions have vanadium in the same oxidation state?

- A) 1 and 3
- B) 2 and 5
- C) 1 and 5
- D) 3 and 4
- E) 4 and 5

Simulazione del Test d'ammissione

In all the molecules in the question where oxygen is present its oxidation number is -2, knowing this and the total charge of the molecule we can calculate the oxidation number of vanadium for all the molecules.

1. VO_3^-
2. V^{3+}
3. V^{2+}
4. VO^{2-}
5. VO_2^+

We can use a simple formula to calculate the oxidation number (X) of vanadium in the first choice: $X + 3 \cdot (-2) = -1 \rightarrow X = +5$

The oxidation number of monatomic ions equals the charge of the ion, so the oxidation number for the second and third choices is +3 and +2 respectively.

Using a similar formula we used for the first choice we can find the oxidation number for vanadium in the fourth and fifth choices:

$$X + (-2) = -2 \rightarrow X = 0$$

$$X + 2 \cdot (-2) = +1 \rightarrow X = +5$$

With this we can see that only options 1 and 5 have the same oxidation number, by default all the other choices are wrong.

The correct answer is C.

51. Five of the ions of vanadium are listed below:



Which two ions have vanadium in the same oxidation state?

A) 1 and 3

B) 2 and 5

C) 1 and 5

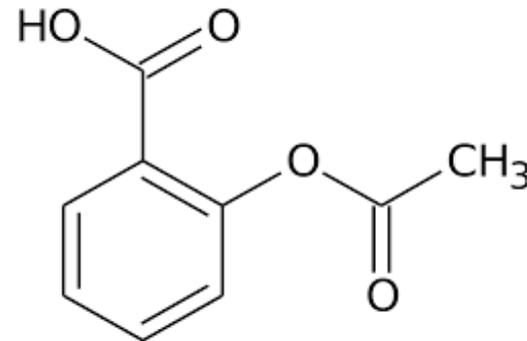
D) 3 and 4

E) 4 and 5

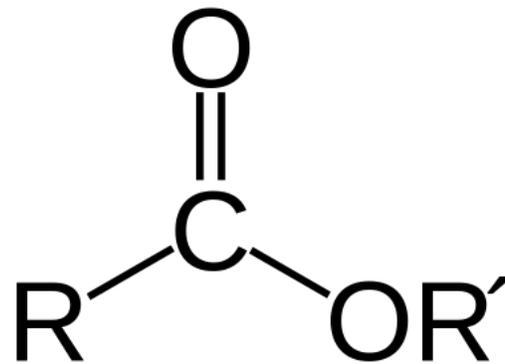
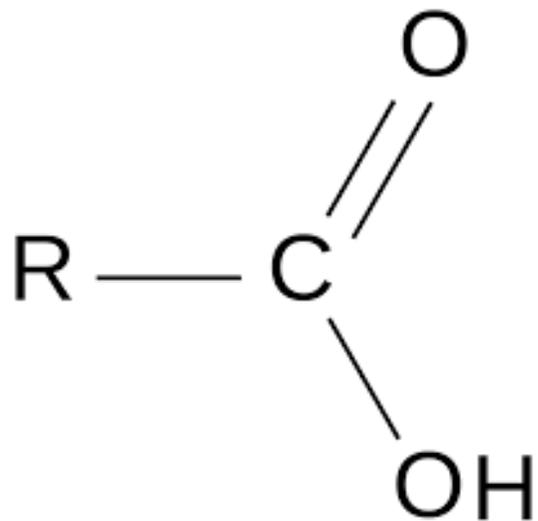
52. The acetylsalicylic acid (ASA), also known as "Aspirin", is an organic compound, belonging to the NSAID (Nonsteroidal Anti-Inflammatory Drug) family, which contains two important chemical functions.

Which option identifies these two functions?

- A. Alcohol and aldehyde
- B. Ether and ketone
- C. Ketone and acid
- D. Ester and aldehyde
- E. Ester and carboxylic acid



The acetylsalicylic acid contains the ester and acid functions which have the following structures:

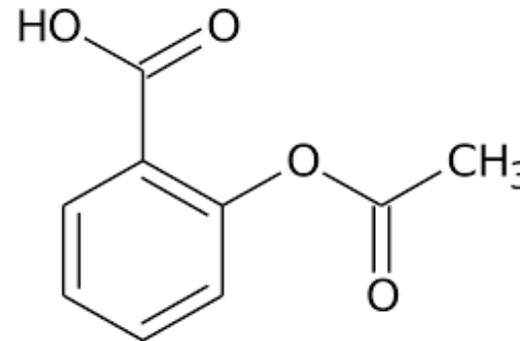


The correct answer is E.

52. The acetylsalicylic acid (ASA), also known as "Aspirin", is an organic compound, belonging to the NSAID (Nonsteroidal Anti-Inflammatory Drug) family, which contains two important chemical functions.

Which option identifies these two functions?

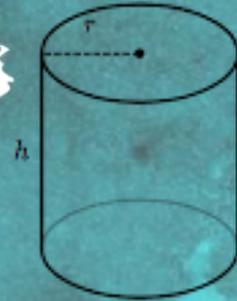
- A. Alcohol and aldehyde
- B. Ether and ketone
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- D. Ester and aldehyde
- E. Ester and carboxylic acid



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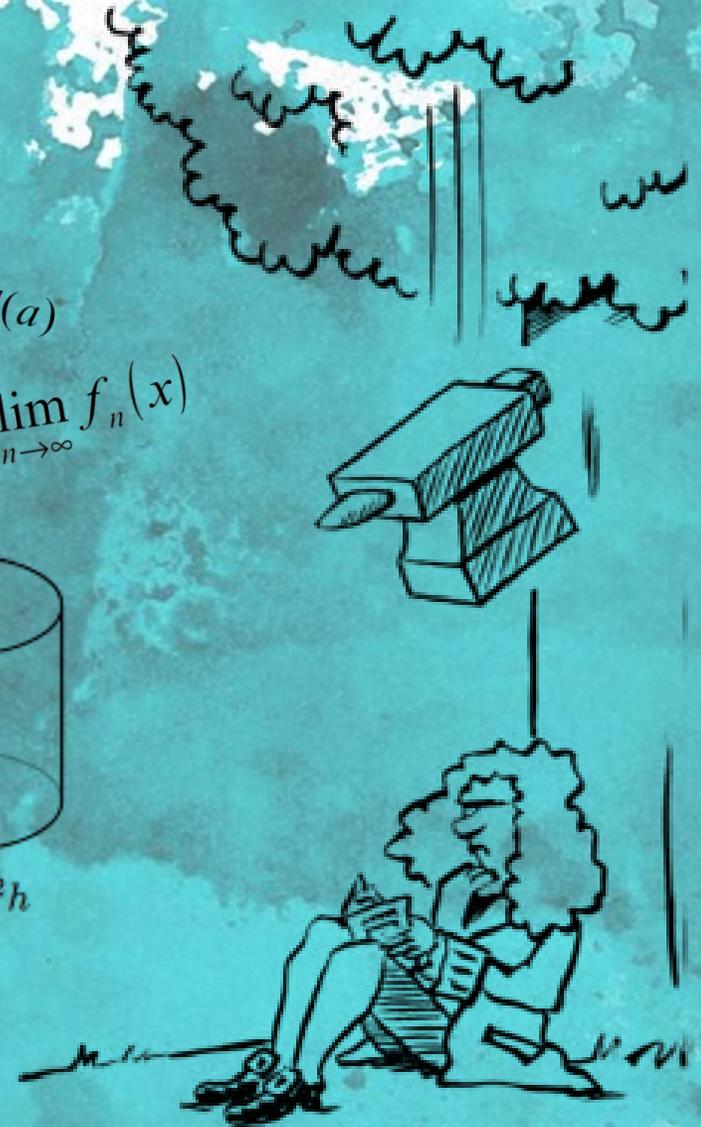
$$\int_a^b f(x) dx = F(b) - F(a)$$

$$f(x) = \lim_{n \rightarrow \infty} f_n(x)$$



$$V = \pi r^2 h$$

MATH & PHYSICS



53. Which of the following expressions is equal to $\frac{9^{2n} \cdot 27^n}{3^n}$ for all integers n ?

- A) 3^{3n+3}
- B) 3^{6n}
- C) 3^{2n+1}
- D) 3^{8n}
- E) 3^{6n+2}

First of all we must write each number as a power of 3:

$$\frac{9^{2n} \cdot 27^n}{3^n} = \frac{3^{2 \cdot 2n} \cdot 3^{3n}}{3^n}$$

A power raised to another power is a power with the same base and the product of its exponents as exponent:

$$\frac{3^{2 \cdot 2n} \cdot 3^{3n}}{3^n} = \frac{3^{4n} \cdot (3^n)^3}{3^n} = 3^{4n} \cdot 3^{2n} = 3^{6n}$$

The answer is B

53. Which of the following expressions is equal to $\frac{9^{2n} \cdot 27^n}{3^n}$ for all integers n ?

A) 3^{3n+3}

B) 3^{6n}

C) 3^{2n+1}

D) 3^{8n}

E) 3^{6n+2}

54. John bought a car for 18.000 £. After one year the car loses 10% of its original value, the second year loses further 15%. What is the price of the car after these two years?

- A) 2.430 £
- B) 13.500 £
- C) 1.800 £
- D) 243 £
- E) 13.770£

The initial price is 18.000£

First devaluation: 10%

$$18000 \cdot \frac{90}{100} = 16200$$

$$\text{or } 18000 \cdot \frac{10}{100} = 1800$$

$$18000 - 1800 = 16200$$

Second devaluation 15%

$$16200 \cdot \frac{85}{100} = 13770$$

The answer is E

54. John bought a car for 18.000 £. After one year the car loses 10% of its original value, the second year loses further 15%. What is the price of the car after these two years?

- A) 2.430 £
- B) 13.500 £
- C) 1.800 £
- D) 243 £
- E) 13.770£

55. The diameter of the wheel of a motorcycle is 63 cm. How many revolutions will it make to travel 99 km?

- A) 33,333 revolutions
- B) 50,000 revolutions
- C) 66,666 revolutions
- D) 75,000 revolutions
- E) 99,999 revolutions

The diameter of the wheel of a motorcycle = 63 cm

With this, the circumference of the wheel of motorcycle = πd
= $3,14 \times 63$
= 198 cm

Total distance travelled by the motorcycle = 99 km
= 99×1000 m
= 99×1000 m $\times 100$ cm

Therefore, number of revolutions = $(99 \times 1000 \times 100) / 198 = 50000$

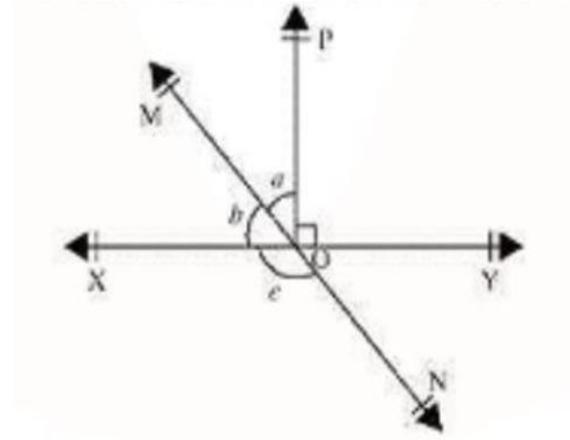
Answer: letter B

55. The diameter of the wheel of a motorcycle is 63 cm. How many revolutions will it make to travel 99 km?

- A) 33,333 revolutions
- B) 50,000 revolutions
- C) 66,666 revolutions
- D) 75,000 revolutions
- E) 99,999 revolutions

56. In the given figure, lines XY and MN intersect at O. If POY forms a 90° angle and the ratio of $a:b = 2:3$, find c:

- A) 120°
- B) 126°
- C) 132°
- D) 140°
- E) 150°



Let the common ratio between "a" and "b" be "x", so:
 $a = 2x$, and $b = 3x$

XY is a straight line, rays OM and OP stand on it, so:
 $\widehat{XOM} + \widehat{MOP} + \widehat{POY} = 180^\circ$. Since $\widehat{XOM} = a$, $\widehat{MOP} = b$ and $\widehat{POY} = 90^\circ$ we have:

$$\begin{aligned}a + b + 90^\circ &= 180^\circ \\2x + 3x + 90^\circ &= 180^\circ \\5x &= 90^\circ \\x &= 18^\circ\end{aligned}$$

So, $a = 2x = 36^\circ$ and $b = 3x = 54^\circ$

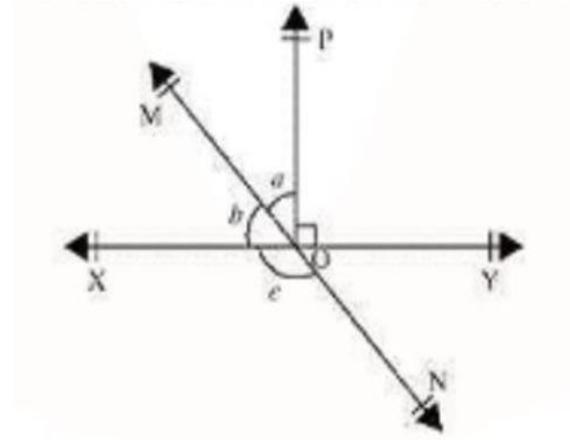
Since MN is a straight line, ray OX stands on it:

$$\begin{aligned}b + c &= 180^\circ \\54^\circ + c &= 180^\circ \\c &= 180^\circ - 54^\circ \\c &= 126^\circ\end{aligned}$$

Answer: letter B

56. In the given figure, lines XY and MN intersect at O. If POY forms a 90° angle and the ratio of $a:b = 2:3$, find c:

- A) 120°
- B) 126°
- C) 132°
- D) 140°
- E) 150°



57. The two cylinders of a hydraulic press filled with an incompressible fluid have a radius of, respectively, r and $10r$. If a force of 120 N is applied to the piston of the smaller cylinder, what is the acceleration of car with a mass of 1000 kg , placed on the plate of the bigger cylinder ($g=10.0\text{ N}\cdot\text{m}/\text{s}^2$)?

- A) The car doesn't move
- B) $10\text{ m}/\text{s}^2$
- C) $1,0\text{ m}/\text{s}^2$
- D) $2,0\text{ m}/\text{s}^2$
- E) $20\text{ m}/\text{s}^2$

We have to apply Pascal's law, which states that a pressure change at any point in a confined incompressible fluid is transmitted throughout the fluid such that the same change occurs everywhere. So, if we apply a pressure to the fluid through the piston, the same pressure is applied to the plate on the other end of the hydraulic press.

$$\frac{F_A}{S_A} = \frac{F_B}{S_B} \quad F_B = \frac{F_A S_B}{S_A} = \frac{120 \cdot 100\pi r^2}{\pi r^2} = 12000 \text{ N}$$

We use the second law of dynamics to find the car's acceleration

$$a = \frac{\sum F}{m} = \frac{12000 - 10000}{1000} = 2,0 \text{ m/s}^2$$

57. The two cylinders of a hydraulic press filled with an incompressible fluid have a radius of, respectively, r and $10r$. If a force of 120 N is applied to the piston of the smaller cylinder, what is the acceleration of car with a mass of 1000 kg , placed on the plate of the bigger cylinder ($g=10.0\text{ N}\cdot\text{m}/\text{s}^2$)?

- A) The car doesn't move
- B) $10\text{ m}/\text{s}^2$
- C) $1,0\text{ m}/\text{s}^2$
- D) $2,0\text{ m}/\text{s}^2$
- E) $20\text{ m}/\text{s}^2$

58. A capacitor with an initial capacitance of $C=C_0$ is filled by $\frac{1}{4}$ with a dielectric medium of relative permittivity $\epsilon=4$. What is the final capacitance of the device?

- A) $\frac{13}{16} C_0$
- B) $\frac{16}{13} C_0$
- C) $\frac{3}{7} C_0$
- D) $\frac{16}{13} C/V$
- E) $4 C_0$

If a capacitor is partially filled with two different dielectric medium (in this case, one is the vacuum), it can be considered as two separate capacitors in series, corresponding to the two different sections of the original capacitors.

$$C_1 = \varepsilon_1 \frac{S_1}{d_1} = 4\varepsilon \frac{S}{d/4} = 4 \cdot 4 \cdot C_0 = 16C_0 \quad C_2 = \varepsilon_2 \frac{S_2}{d_2} = \varepsilon \frac{S}{3d/4} = \frac{4}{3} \cdot C_0$$

The final capacitance of the capacitor is the equivalent capacitance of the two capacitors in series:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \quad C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2} = \frac{\frac{64}{3} C_0^2}{\frac{52}{3} C_0} = \frac{64}{52} C_0 = \frac{16}{13} C_0$$

58. A capacitor with an initial capacitance of $C=C_0$ is filled by $\frac{1}{4}$ with a dielectric medium of relative permittivity $\epsilon=4$. What is the final capacitance of the device?

- A. $\frac{13}{16} C_0$
- B. $\frac{16}{13} C_0$
- C. $\frac{3}{7} C_0$
- D. $\frac{16}{13} C/V$
- E. $4 C_0$

59. Which one of the following is NOT a fundamental physical quantity?

- A) Electric current
- B) Temperature
- C) Time
- D) Electric charge
- E) Luminous intensity

Fundamental physical quantities are quantities from which all the others are derived. They are the basis of any dimensional analysis. There are seven physical quantities that are deemed fundamental by the **International System (S.I)** and they are:

- Length (meter)
- Mass (kilogram)
- Time (second)
- Temperature (Kelvin)
- Electric Current (Ampere)
- Luminous intensity (candela)
- Amount of substance (mole)

Thus, electric charge is NOT a fundamental physical quantity as it can be derived from electric current and time.

The answer is D

59. Which one of the following is NOT a fundamental physical quantity?

- A) Electric current
- B) Temperature
- C) Time
- D) Electric charge
- E) Luminous intensity

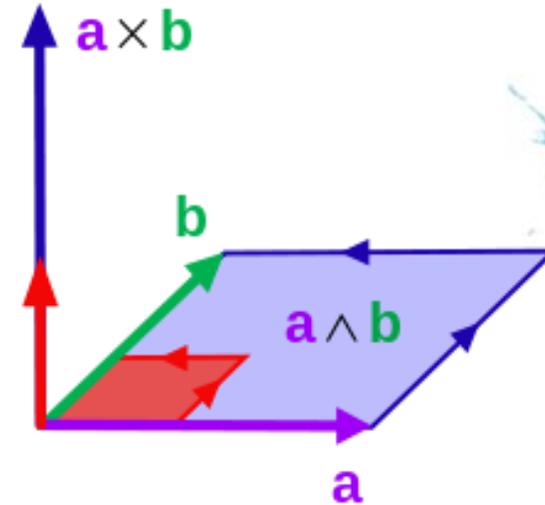
60. Given two vectors, r and s , with $|r| \neq 0$ and $|s| \neq 0$, which of the following options is/are necessarily correct?

1. $(r \times s) \perp r$
2. $(r+s) \perp s$
3. $(r+s) \cdot (r \times s) = 0$

- A) Only 1
- B) Only 2
- C) Only 3
- D) 1 and 3
- E) 1, 2 and 3

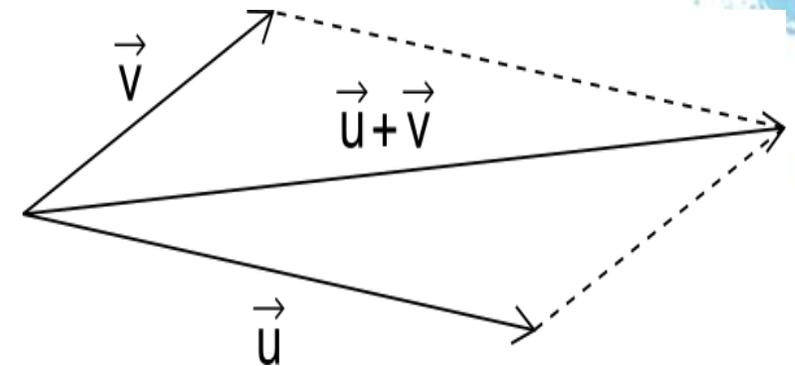
1. $(\mathbf{r} \times \mathbf{s}) \perp \mathbf{r}$

The **vector product** (\mathbf{x}) of two vectors always results in a third vector that is perpendicular to the first two. Hence, **the first option is correct**. The resulting vector (\mathbf{a}) will have a magnitude of $|\mathbf{a}| = |\mathbf{r}| \cdot |\mathbf{s}| \cdot \sin\theta$ where θ is the angle between \mathbf{r} and \mathbf{s} .



2. $(\mathbf{r} + \mathbf{s}) \perp \mathbf{s}$

The sum of two vectors results in a third vector, whose magnitude and direction both depend on the angle between the first two vectors. Therefore, the second option could be true in some cases, but is **not necessarily true**.

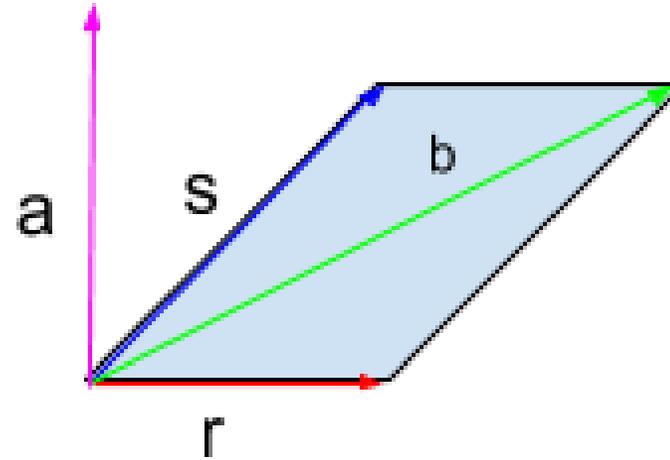


3. $(\mathbf{r}+\mathbf{s}) \cdot (\mathbf{r} \times \mathbf{s}) = 0$

As previously mentioned, the vector product of two vectors is a third vector (\mathbf{a}) that is perpendicular both to \mathbf{r} and \mathbf{s} . As a matter of fact, \mathbf{a} will be perpendicular to the plane on which \mathbf{r} and \mathbf{s} lay.

The sum of the two vectors \mathbf{r} and \mathbf{s} results into another vector (\mathbf{b}) that will necessarily lay in the same plane as \mathbf{r} and \mathbf{s} .

Thus \mathbf{b} is necessarily perpendicular to \mathbf{a} .



The **dot product**, or scalar product, of two vectors (\cdot) results into a scalar:

$$\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| \cdot |\mathbf{b}| \cdot \cos\theta$$

where θ is the angle between \mathbf{a} and \mathbf{b} .

Hence, since \mathbf{a} is perpendicular to \mathbf{b} , $\theta=90^\circ$,

$$\mathbf{a} \cdot \mathbf{b} = 0$$

so the third option is correct.

CORRECT ANSWER: D

60. Given two vectors, r and s , with $|r| \neq 0$ and $|s| \neq 0$, which of the following options is/are necessarily correct?

1. $(r \times s) \perp r$

2. $(r+s) \perp s$

3. $(r+s) \cdot (r \times s) = 0$

A) Only 1

B) Only 2

C) Only 3

D) 1 and 3

E) 1, 2 and 3

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**Thanks for
attention!**

See you soon!



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