

CUET PG 2025 ZOOLOGY Question Paper with Solutions

Time Allowed :1 Hour 30 Mins	Maximum Marks :300	Total Questions :75
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General Instructions

Read the following instructions very carefully and strictly follow them:

1. The examination duration is 90 minutes. Manage your time effectively to attempt all questions within this period.
2. The total marks for this examination are 300. Aim to maximize your score by strategically answering each question.
3. There are 75 mandatory questions to be attempted in the Agro forestry paper. Ensure that all questions are answered.
4. Questions may appear in a shuffled order. Do not assume a fixed sequence and focus on each question as you proceed.
5. The marking of answers will be displayed as you answer. Use this feature to monitor your performance and adjust your strategy as needed.
6. You may mark questions for review and edit your answers later. Make sure to allocate time for reviewing marked questions before final submission.
7. Be aware of the detailed section and sub-section guidelines provided in the exam. Understanding these will aid in effectively navigating the exam.

1. What is the sequence of the template DNA for an mRNA with the sequence?
5'-CAUUGGCCAAGG-3'

- (A) 5'-CATTGGCCAAGG-3'
(B) 5'-CCTTGGCCAATG-3'
(C) 5'-GTAACCGGTTCC-3'
(D) 5'-CAUUGGCCAAGG-3'

Correct Answer: (B) 5'-CCTTGGCCAATG-3'

Solution:

Step 1: Understanding the Concept:

The process of creating an mRNA molecule from a DNA template is called transcription. During transcription, the DNA template strand is read in the 3' to 5' direction to synthesize a complementary mRNA strand in the 5' to 3' direction. The base pairing rules are: Adenine (A) in DNA pairs with Uracil (U) in RNA, Thymine (T) in DNA pairs with Adenine (A) in

RNA, Guanine (G) in DNA pairs with Cytosine (C) in RNA, and Cytosine (C) in DNA pairs with Guanine (G) in RNA.

Step 2: Detailed Explanation:

1. Identify the given mRNA sequence:

The given mRNA sequence is 5'-CAUUGGCCAAGG-3'.

2. Determine the complementary DNA sequence:

To find the template DNA strand, we need to write the complementary base sequence according to the base-pairing rules (A-T, G-C, and U in mRNA pairs with A in DNA).

mRNA: 5' - C A U U G G C C A A G
G - 3'

 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

↓

Template DNA: 3' - G T A A C C G G T T C
C - 5'

3. Write the template DNA sequence in the standard 5' to 3' direction:

By convention, DNA sequences are written in the 5' to 3' direction. To do this, we read the sequence obtained in the previous step from right to left.

The sequence is 3'-GTAACCGGTTCC-5'.

Written in the 5' to 3' direction, it becomes 5'-CCTTGGCCAATG-3'.

Step 3: Final Answer:

Comparing this result with the given options, we find that option (B) matches our derived sequence. Option (A) represents the coding (sense) strand, where T replaces U. Option (C) represents the template strand but written in the incorrect 3' to 5' direction. Option (D) is the mRNA sequence itself.

Quick Tip

To quickly find the template DNA strand (in 5' to 3' format) from an mRNA sequence, first find the sequence of the coding strand by replacing U with T in the mRNA sequence. Then, find the complementary sequence of the coding strand. For example, mRNA is 5'-CAUUGGCCAAGG-3'. The coding strand is 5'-CATTGGCCAAGG-3'. The complementary (template) strand is 5'-CCTTGGCCAATG-3'.

2. Which type of polymerase activity is shown by the enzyme telomerase?

- (A) DNA-dependent DNA polymerase
- (B) DNA-dependent RNA polymerase
- (C) RNA-dependent DNA polymerase
- (D) RNA-dependent RNA polymerase

Correct Answer: (C) RNA-dependent DNA polymerase

Solution:

Step 1: Understanding the Concept:

Telomerase is a specialized enzyme responsible for maintaining the length of telomeres, which are repetitive nucleotide sequences at the ends of linear chromosomes. Chromosomes shorten with each cell division, and telomerase counteracts this by adding telomeric repeats to the chromosome ends.

Step 2: Detailed Explanation:

Telomerase is a ribonucleoprotein, meaning it is composed of both a protein component (TERT - telomerase reverse transcriptase) and an RNA component (TERC - telomerase RNA component).

The enzyme functions by using its internal RNA component (TERC) as a template to synthesize DNA.

- It synthesizes DNA, so it is a DNA polymerase.

- It uses an RNA molecule as a template, so its activity is RNA-dependent.

Therefore, telomerase is an RNA-dependent DNA polymerase. This type of enzyme is also known as a reverse transcriptase.

Step 3: Analyzing the Options:

- (A) **DNA-dependent DNA polymerase:** An enzyme that synthesizes DNA using a DNA template (e.g., DNA polymerase during replication).

- (B) **DNA-dependent RNA polymerase:** An enzyme that synthesizes RNA using a DNA template (e.g., RNA polymerase during transcription).

- (C) **RNA-dependent DNA polymerase:** An enzyme that synthesizes DNA using an RNA template. This correctly describes telomerase.

- (D) **RNA-dependent RNA polymerase:** An enzyme that synthesizes RNA using an RNA template (e.g., found in some viruses).

Step 4: Final Answer:

The activity of telomerase is to synthesize DNA using an RNA template, which is defined as RNA-dependent DNA polymerase activity. Thus, option (C) is correct.

Quick Tip

Remember the name "reverse transcriptase" for RNA-dependent DNA polymerase. Telomerase performs reverse transcription to extend the ends of chromosomes. This is a key concept in both molecular biology and cancer studies, as telomerase is often reactivated in cancer cells.

3. If the growth medium of a bacterial strain contains both glucose and lactose, how does it affect the lac operon?

A. CAP protein binds lac promoter

- B. Repressor binds lac operator
- C. CAP protein does not bind lac promoter
- D. Repressor does not bind lac operator

Choose the most appropriate answer from the options given below:

- (A) A and B
- (B) C and D
- (C) A and D
- (D) B and C

Correct Answer: (B) C and D

Solution:

Step 1: Understanding the Concept:

The lac operon in *E. coli* is a classic model for gene regulation. Its expression is controlled by two main factors: the presence of lactose (the inducer) and the presence of glucose (the preferred energy source). This involves two regulatory mechanisms: negative control by the lac repressor and positive control by the Catabolite Activator Protein (CAP).

Step 2: Detailed Explanation:

We need to analyze the state of the lac operon when both glucose and lactose are present in the medium.

1. Effect of Lactose Presence:

- When lactose is present, it is converted into allolactose.
- Allolactose acts as an inducer by binding to the lac repressor protein.
- This binding causes a conformational change in the repressor, preventing it from binding to the operator region (lacO) of the operon.
- Therefore, **the Repressor does not bind the lac operator**. This means statement **D is correct**, and statement B is incorrect.

2. Effect of Glucose Presence (Catabolite Repression):

- The lac operon is also subject to positive control by the CAP protein. However, CAP can only bind to the promoter and activate transcription when it is complexed with cyclic AMP (cAMP).
- The level of cAMP in the cell is inversely proportional to the level of glucose.
- When glucose is present (and at a high level), the level of cAMP is low.
- Without sufficient cAMP, the CAP protein cannot bind to the CAP-binding site in the lac promoter.
- Therefore, **the CAP protein does not bind the lac promoter**. This means statement **C is correct**, and statement A is incorrect.

Step 3: Final Answer:

Based on the analysis, when both glucose and lactose are present:

- The CAP protein does not bind the promoter (Statement C).

- The repressor does not bind the operator (Statement D).

The combination of correct statements is C and D. This corresponds to option (B). The result is that transcription of the lac operon occurs, but only at a very low, basal level because the positive activation by CAP is absent.

Quick Tip

Remember the hierarchy of control for the lac operon: Glucose is the boss. If glucose is present, the operon is largely off (low transcription), regardless of lactose. For high-level transcription, two conditions must be met: glucose must be absent (so CAP binds) AND lactose must be present (so the repressor unbinds).

4. Which one of the following correctly describes the role of signal recognition particles?

- (A) Aid in the decoding of the information carried by the signal peptide for the secretory protein.
- (B) Aid in recognizing the antigen for inflammatory response.
- (C) Aid in receiving coated vesicles for exocytosis.
- (D) Aid in deciphering the genetic code for protein synthesis.

Correct Answer: (A) Aid in the decoding of the information carried by the signal peptide for the secretory protein.

Solution:

Step 1: Understanding the Concept:

The Signal Recognition Particle (SRP) is a crucial component in the cellular machinery for protein targeting. It is a ribonucleoprotein complex that recognizes and directs proteins destined for the secretory pathway (e.g., to be secreted, inserted into membranes, or targeted to certain organelles) to the endoplasmic reticulum (ER).

Step 2: Detailed Explanation:

The process, known as co-translational targeting, occurs as follows:

1. A ribosome begins translating an mRNA molecule. If the protein is destined for the secretory pathway, a specific N-terminal amino acid sequence called the 'signal peptide' emerges from the ribosome.
2. The SRP recognizes and binds to this signal peptide. This binding event causes a pause in translation.
3. The entire complex (SRP, ribosome, nascent polypeptide) is then targeted to the ER membrane, where SRP binds to an SRP receptor.
4. The ribosome docks with the translocon (a protein channel in the ER membrane), translation resumes, and the growing polypeptide chain is threaded through the channel into the ER lumen.

In essence, the SRP 'decodes' the signal peptide, interpreting it as a 'mail address' for the ER.

Step 3: Analyzing the Options:

- **(A) Aid in the decoding of the information carried by the signal peptide for the secretory protein:** This accurately describes the primary function of SRP. It recognizes the signal peptide and initiates the targeting process.
- **(B) Aid in recognizing the antigen for inflammatory response:** This is the function of immune system components like antibodies and T-cell receptors.
- **(C) Aid in receiving coated vesicles for exocytosis:** This process involves proteins like SNAREs, which mediate vesicle fusion with the plasma membrane.
- **(D) Aid in deciphering the genetic code for protein synthesis:** This is the fundamental role of the ribosome and transfer RNAs (tRNAs).

Step 4: Final Answer:

Option (A) provides the most accurate and specific description of the role of the Signal Recognition Particle.

Quick Tip

Think of the SRP as a postal worker for the cell. It reads the 'zip code' (the signal peptide) on a newly made protein and ensures it gets delivered to the correct 'address' (the endoplasmic reticulum).

5. Which of the following is the most stable DNA configuration under normal physiological conditions?

- (A) A-DNA
- (B) B-DNA
- (C) C-DNA
- (D) Z-DNA

Correct Answer: (B) B-DNA

Solution:

Step 1: Understanding the Concept:

DNA can exist in several different helical structures, known as conformations. The most common are A-DNA, B-DNA, and Z-DNA. These forms differ in their helical sense (right-handed vs. left-handed), dimensions (width, pitch), and the orientation of the bases relative to the helix axis.

Step 2: Detailed Explanation:

- **B-DNA:** This is the classic right-handed double helix structure described by Watson and Crick. It is the most common form of DNA found in cells under normal physiological conditions,

which involve a high degree of hydration and relatively low salt concentrations. Its stability under these conditions makes it the primary conformation for most DNA sequences in vivo.

- **A-DNA:** This is also a right-handed helix, but it is wider and more compact than B-DNA. It is primarily observed under dehydrating (low water) conditions. While not the dominant form for DNA in the cell, this conformation is adopted by DNA-RNA hybrids and double-stranded RNA.

- **Z-DNA:** This is a left-handed helix with a zigzagging sugar-phosphate backbone. It is less stable than B-DNA and forms only under specific conditions, such as high salt concentrations or in sequences with alternating purines and pyrimidines (e.g., GCGCGC). It is thought to play a role in gene regulation.

- **C-DNA:** This is a less common right-handed form observed under certain low-hydration and salt conditions.

Step 3: Final Answer:

The question asks for the most stable configuration under "normal physiological conditions." This directly refers to the aqueous environment inside a living cell. In this environment, the B-DNA conformation is the most stable and predominant form. Therefore, option (B) is the correct answer.

Quick Tip

Associate B-DNA with 'Biological' or 'Body' conditions. It's the standard, most common form you see in textbook diagrams. A-DNA is for 'Arid' (dry) conditions, and Z-DNA is for 'Zigzag' and is the odd one out, being left-handed.

6. Arrange the following cell cycle stages in the correct order of their occurrence:

- A. S phase**
- B. M phase**
- C. G1 phase**
- D. G2 phase**

- (A) D, B, C, A
- (B) A, C, B, D
- (C) C, A, D, B
- (D) B, C, D, A

Correct Answer: (C) C, A, D, B

Solution:

Step 1: Understanding the Concept:

The cell cycle is the ordered series of events that leads to cell division and the production of two daughter cells. It is broadly divided into two main periods: Interphase, where the cell grows

and replicates its DNA, and the Mitotic (M) phase, where the cell divides.

Step 2: Detailed Explanation:

Interphase is further subdivided into three distinct phases that occur in a specific sequence:

1. **G1 phase (Gap 1):** This is the first phase after a cell has just divided. During G1, the cell grows in size and synthesizes proteins and mRNA necessary for DNA synthesis. This corresponds to letter **C**.
2. **S phase (Synthesis):** Following G1, the cell enters the S phase. The primary event in this phase is the replication of the cell's DNA. This corresponds to letter **A**.
3. **G2 phase (Gap 2):** After DNA replication is complete, the cell enters the G2 phase. In this phase, the cell continues to grow and synthesizes proteins required for mitosis. It's a period of preparation for cell division. This corresponds to letter **D**.

After Interphase (G1, S, and G2) is complete, the cell enters the final phase of the cycle:

4. **M phase (Mitosis):** This phase involves the separation of the duplicated chromosomes (mitosis) and the division of the cytoplasm (cytokinesis) to form two identical daughter cells. This corresponds to letter **B**.

Step 3: Final Answer:

The correct sequence of the cell cycle stages is $G1 \rightarrow S \rightarrow G2 \rightarrow M$.

Using the given letters, the order is $C \rightarrow A \rightarrow D \rightarrow B$.

This sequence matches option (C).

Quick Tip

A simple mnemonic to remember the order of the cell cycle is "Go Sally Go! Make Children!". **Go** - **G1** **Sally** - **S** phase **Go** - **G2** **Make Children** - **M** phase (Cytokinesis)

7. Match LIST-I with LIST-II

LIST-I Types Cancer		LIST-II Tissues involved	
A.	Carcinoma	I.	Muscle
B.	Chondroma	II.	Cartilage
C.	Sarcoma	III.	Blood
D.	Myeloma	IV.	Epithelial Tissue

Choose the most appropriate answer from the options given below:

- (A) A - IV, B - II, C - I, D - III
(B) A - III, B - II, C - I, D - IV
(C) A - II, B - I, C - IV, D - III
(D) A - I, B - II, C - IV, D - III

Correct Answer: (A) A - IV, B - II, C - I, D - III

Solution:

Step 1: Understanding the Concept:

This question requires knowledge of cancer terminology, specifically the classification of tumors based on their tissue of origin. The suffix "-oma" generally refers to a tumor, and the prefix indicates the tissue type.

Step 2: Detailed Explanation:

Let's match each cancer type in LIST-I with its corresponding tissue in LIST-II.

- **A. Carcinoma:** Carcinomas are malignant tumors that arise from epithelial cells. Epithelial tissues line the surfaces of organs and cavities throughout the body. Therefore, Carcinoma matches with Epithelial Tissue. (**A** → **IV**).
- **B. Chondroma:** The prefix "chondro-" refers to cartilage. A chondroma is a benign tumor composed of mature cartilage. Therefore, Chondroma matches with Cartilage. (**B** → **II**).
- **C. Sarcoma:** Sarcomas are malignant tumors that arise from mesenchymal tissues, which include connective tissues like bone, fat, and muscle. Therefore, Sarcoma matches with Muscle. (**C** → **I**).
- **D. Myeloma:** The prefix "myelo-" refers to bone marrow. Myeloma (specifically multiple myeloma) is a cancer of plasma cells, which are a type of white blood cell produced in the bone marrow. Therefore, Myeloma matches with Blood (as it's a cancer of blood cells). (**D** → **III**).

Step 3: Final Answer:

The correct pairings are: A-IV, B-II, C-I, D-III. This corresponds to option (A).

Quick Tip

Memorizing common medical prefixes is key for biology exams.

- **Carcino-** = Cancer (from epithelial cells)
- **Sarco-** = Flesh (connective/mesenchymal tissue)
- **Chondro-** = Cartilage
- **Myelo-** = Marrow/Spinal cord
- **Hema-** = Blood

These prefixes can help you quickly deduce the origin of many cancer types.

8. The approximate diameter of actin filaments is:

- (A) 4 micrometer (μm)
- (B) 8 micrometer (μm)
- (C) 4 nanometer (nm)
- (D) 8 nanometer (nm)

Correct Answer: (D) 8 nanometer (nm)

Solution:

Step 1: Understanding the Concept:

The cytoskeleton of a eukaryotic cell is composed of three main types of protein filaments: microfilaments (actin filaments), intermediate filaments, and microtubules. These filaments differ in their protein composition, structure, and diameter. The question asks for the diameter of actin filaments.

Step 2: Detailed Explanation:

- **Actin Filaments (Microfilaments):** These are the thinnest of the three types. They are polymers of the protein actin and form a flexible, helical filament. Their diameter is approximately 7 to 8 nanometers (nm).
- **Intermediate Filaments:** As their name suggests, their diameter is intermediate between the other two. They are made of various proteins (like keratin, vimentin, lamin) and have a diameter of about 10 nm.
- **Microtubules:** These are the thickest cytoskeletal filaments. They are hollow tubes made of tubulin protein dimers and have an outer diameter of about 25 nm.

Step 3: Final Answer:

The options provided are in micrometers and nanometers. Micrometers are far too large for a cytoskeletal filament. The correct range is in nanometers. Between the nanometer options, 8 nm is the most accurate approximation for the diameter of an actin filament.

Therefore, option (D) is the correct answer.

Quick Tip

Remember the relative sizes: Actin Filaments ; Intermediate Filaments ; Microtubules. A good way to remember the approximate diameters is 7-8 nm (Actin), 10 nm (Intermediate), and 25 nm (Microtubules). Be careful with units: 1 micrometer (μm) = 1000 nanometers (nm).

9. Match LIST-I with LIST-II

LIST-I Mitochondrial Compartments		LIST-II Enzymes present	
A.	Matrix	I.	ATP synthetase
B.	Inner membrane	II.	Monoamine oxidase
C.	Space between inner and outer membranes	III.	Citrate synthetase
D.	Outer membrane	IV.	Adenylate kinase

Choose the most appropriate answer from the options given below:

- (A) A - IV, B - II, C - III, D - I
- (B) A - III, B - I, C - IV, D - II
- (C) A - II, B - I, C - IV, D - III
- (D) A - I, B - IV, C - III, D - II

Correct Answer: (B) A - III, B - I, C - IV, D - II

Solution:

Step 1: Understanding the Concept:

The mitochondrion is a double-membraned organelle with distinct compartments, each having a specific set of enzymes to carry out its functions in cellular respiration and metabolism. This question tests knowledge of the localization of specific mitochondrial enzymes.

Step 2: Detailed Explanation:

Let's match each mitochondrial compartment with its characteristic enzyme.

- **A. Matrix:** The innermost compartment, the matrix, is the site of the Krebs cycle (citric acid cycle) and fatty acid oxidation. **Citrate synthetase** is the enzyme that catalyzes the first step of the Krebs cycle. Therefore, it is located in the matrix. (**A** → **III**).
- **B. Inner membrane:** This membrane is highly folded into cristae and is the site of the electron transport chain and oxidative phosphorylation. **ATP synthetase** (also called ATP synthase or Complex V) is embedded in the inner mitochondrial membrane, where it uses the proton gradient to produce ATP. (**B** → **I**).
- **C. Space between inner and outer membranes (Intermembrane space):** This space contains several enzymes that use the ATP passing out of the matrix. **Adenylate kinase** is a phosphotransferase enzyme found here that catalyzes the reaction $2 \text{ ADP} \rightleftharpoons \text{ATP} + \text{AMP}$. (**C** → **IV**).
- **D. Outer membrane:** The outer membrane is quite permeable and contains various enzymes, including **Monoamine oxidase**, which is involved in the breakdown of neurotransmitters. (**D** → **II**).

Step 3: Final Answer:

The correct pairings are: A-III, B-I, C-IV, D-II. This combination matches option (B).

Quick Tip

Associate the main function with the compartment to remember enzyme locations:

- **Matrix** → Krebs Cycle → Citrate Synthetase.
- **Inner Membrane** → ATP Production → ATP Synthase.
- **Outer Membrane** → Acts as a boundary, has specific enzymes like Monoamine Oxidase.
- **Intermembrane Space** → "In-between" reactions → Adenylate Kinase.

10. Which of these are executioner caspases?

- A. Caspase 3
- B. Caspase 6
- C. Caspase 8
- D. Caspase 5

Choose the most appropriate answer from the options given below:

- (A) A and B only
- (B) B and C only
- (C) C and D only
- (D) A and D only

Correct Answer: (A) A and B only

Solution:

Step 1: Understanding the Concept:

Caspases (cysteine-aspartic proteases) are a family of enzymes that play essential roles in apoptosis (programmed cell death). They are broadly classified into two main groups based on their function in the apoptotic cascade: initiator caspases and executioner (or effector) caspases.

Step 2: Detailed Explanation:

- **Initiator Caspases:** These caspases (e.g., Caspase-2, -8, -9, -10) are activated at the beginning of the apoptotic pathway by specific signals. Once activated, their role is to cleave and activate the downstream executioner caspases.
- **Executioner Caspases:** These caspases (e.g., Caspase-3, -6, -7) are activated by initiator caspases. They are responsible for carrying out the "execution" phase of apoptosis by cleaving numerous cellular substrates, leading to the characteristic morphological and biochemical changes of a dying cell (e.g., DNA fragmentation, membrane blebbing).

Step 3: Classifying the Given Caspases:

- **A. Caspase 3:** This is a key **executioner** caspase, often considered the central executioner.
- **B. Caspase 6:** This is also an **executioner** caspase.
- **C. Caspase 8:** This is a primary **initiator** caspase, activated in the extrinsic (death receptor-mediated) pathway of apoptosis.
- **D. Caspase 5:** This is classified as an inflammatory caspase (along with Caspase-1 and -4 in humans), primarily involved in activating pro-inflammatory cytokines, not directly in the execution of apoptosis.

Step 4: Final Answer:

Based on the classification, Caspase 3 (A) and Caspase 6 (B) are the executioner caspases among the given options. Therefore, the correct choice is (A).

Quick Tip

A simple way to remember the main caspases:

- **Initiators:** Caspase-8 (Extrinsic path), Caspase-9 (Intrinsic path). Think of them as the "generals" giving the order.
- **Executioners:** Caspase-3, -6, -7. Think of them as the "soldiers" carrying out the order. Caspase-3 is the main soldier.

11. Which larval form of *Fasciola hepatica* has a motile tail?

- (A) Miracidium
- (B) Redia
- (C) Sporocyst
- (D) Cercaria

Correct Answer: (D) Cercaria

Solution:

Step 1: Understanding the Concept:

Fasciola hepatica, the common liver fluke, has a complex life cycle involving multiple larval stages and an intermediate host (typically a snail). The question asks to identify the specific larval stage that is characterized by the presence of a motile tail for locomotion.

Step 2: Detailed Explanation of Larval Stages:

The life cycle proceeds in the following order:

1. **Miracidium:** This is the first larval stage that hatches from the egg in freshwater. It is a free-swimming larva, but its motility is achieved through the beating of numerous cilia that cover its body, not a tail. Its goal is to find and penetrate a suitable snail host.
2. **Sporocyst:** Once inside the snail, the miracidium transforms into a sac-like sporocyst. This stage is non-motile and reproduces asexually to form either more sporocysts or the next stage, rediae.
3. **Redia:** This stage develops within the sporocyst. It has a mouth and a pharynx and is more developed than the sporocyst but is still non-motile within the snail's tissues. It also reproduces asexually to produce more rediae or cercariae.
4. **Cercaria:** This is the larval stage that emerges from the snail host back into the water. It is characterized by having a distinct body (or head) and a long, powerful tail. The tail is used for swimming, allowing the cercaria to move through the water to find and encyst on aquatic vegetation.
5. **Metacercaria:** The cercaria loses its tail and forms a protective cyst on vegetation, becoming a metacercaria, which is the infective stage for the final host (e.g., sheep, cattle, humans).

Step 3: Final Answer:

Among the options given, the **Cercaria** is the only larval form that possesses a distinct, motile

tail for swimming. Therefore, option (D) is the correct answer.

Quick Tip

Remember the motile stages in the fluke life cycle:

- **Miracidium:** Motile by **cilia**.
- **Cercaria:** Motile by a **tail**.

The stages inside the snail (Sporocyst, Redia) are non-motile sacs for asexual reproduction.

12. In the life cycle of a *Plasmodium*, once the sporozoite enters the blood of the host, it invades the hepatic portal system, resulting in occurrence of change in the host body, leading to malaria

A. Sporozoite enters the hepatocytes and divides by schizogony leading to formation of cryptomerozoites

B. Inside RBCs, the micro-metacryptozoites become rounded and modify into a young trophozoites.

C. As the trophozoite grows in size, a central vacuole is developed so that the nucleus is pushed to one side into the peripheral cytoplasm, leading to amoeboid stage.

D. In Amoeboid stage the small red eosinophils granules appear in the cytoplasm of the host corpules as Schuffner's granules

Choose the most appropriate answer from the options given below:

(A) A, B and D only

(B) A, B and C only

(C) A, B, C and D

(D) B, C and D only

Correct Answer: (C) A, B, C and D

Solution:

Step 1: Understanding the Concept:

The question asks to identify the correct statements describing the events in the life cycle of *Plasmodium* (the malaria parasite) after it enters the human host. The life cycle in humans has two main phases: the exo-erythrocytic (liver) stage and the erythrocytic (red blood cell) stage.

Step 2: Analyzing each statement:

- **Statement A: True.** When a mosquito injects sporozoites into the human bloodstream, they travel to the liver and invade liver cells (hepatocytes). Inside these cells, they undergo

asexual multiplication (schizogony) to produce thousands of merozoites (referred to as cryptomerozoites or metacryptozoites). This is the pre-erythrocytic or exo-erythrocytic cycle.

- **Statement B: True.** After the liver stage, merozoites (specifically metacryptozoites) are released into the blood and invade red blood cells (RBCs). Inside the RBC, the parasite transforms into a feeding stage called a trophozoite. This begins the erythrocytic cycle.

- **Statement C: True.** The young trophozoite develops a large food vacuole, which consumes hemoglobin. This vacuole pushes the parasite's nucleus and cytoplasm to the periphery, creating a characteristic "signet ring" appearance. As the parasite grows, it becomes larger and more irregular in shape, known as the amoeboid stage. The description is accurate.

- **Statement D: True.** In infections caused by certain species like *Plasmodium vivax* and *P. ovale*, the cytoplasm of the infected RBC develops characteristic fine, eosinophilic (reddish) dots known as Schuffner's granules or dots. This is a key diagnostic feature.

Step 3: Final Answer:

All four statements (A, B, C, and D) correctly describe different stages and events that occur during the life cycle of the malaria parasite in the human host. Therefore, the most appropriate answer includes all of them.

Quick Tip

To understand the *Plasmodium* life cycle in humans, break it down:

1. **Liver Stage (Exo-erythrocytic):** Sporozoite → Hepatocyte → Schizont → Merozoites.
2. **Blood Stage (Erythrocytic):** Merozoite → RBC → Trophozoite (ring, amoeboid) → Schizont → New Merozoites (cause fever) OR Gametocytes (infect next mosquito).

This framework helps organize the sequence of events.

13. During the process of conjugation in Paramecium, how many daughter Paramecia are formed from 2 parents?

- (A) 2
- (B) 4
- (C) 8
- (D) 16

Correct Answer: (C) 8

Solution:

Step 1: Understanding the Concept:

Conjugation in *Paramecium* is a form of sexual reproduction. It is crucial to understand that conjugation itself is the process of genetic exchange between two individuals (conjugants), not immediate cell division. The increase in population number occurs *after* the conjugants separate.

Step 2: Detailed Explanation:

1. **Pairing and Exchange:** Two parent *Paramecia* come together and exchange haploid micronuclei.
2. **Separation:** After the exchange, the two *Paramecia* separate. They are now called exconjugants. Each exconjugant contains a diploid zygote nucleus (synkaryon) which holds a new combination of genetic material.
3. **Nuclear Reorganization:** Inside each exconjugant, the old macronucleus degenerates, and the new zygote nucleus divides mitotically multiple times to form new micronuclei and macronuclei.
4. **Cell Division (Fission):** Following this reorganization, each of the two exconjugants undergoes two successive rounds of binary fission to produce four daughter cells.
5. **Calculation:** Since there are 2 exconjugants, and each produces 4 daughter cells, the total number of daughter *Paramecia* formed is:

$$\text{Total daughters} = (\text{Number of exconjugants}) \times (\text{Daughters per exconjugant})$$

$$\text{Total daughters} = 2 \times 4 = 8$$

Step 3: Final Answer:

From the initial two parent cells, a total of 8 daughter cells are produced after conjugation and subsequent fissions. Therefore, option (C) is correct.

Quick Tip

A common mistake is to confuse conjugation with binary fission. Remember, conjugation is for genetic recombination, not for reproduction. The reproduction (multiplication) happens via binary fission *after* conjugation is complete. Each of the two parents gives rise to four offspring, making a total of eight.

14. Which one of the following is a larval form of jelly fish?

- (A) Amphiblastula
- (B) Ephyra
- (C) Redia
- (D) Rhabditiform

Correct Answer: (B) Ephyra

Solution:

Step 1: Understanding the Concept:

This question requires knowledge of the life cycles of various invertebrates to identify the larva specific to jellyfish (Phylum Cnidaria, Class Scyphozoa).

Step 2: Detailed Explanation of Options:

- **Amphiblastula:** This is a free-swimming larval stage of certain sponges (Phylum Porifera).
- **Ephyra:** This is a juvenile, free-swimming medusa stage of a jellyfish. It is produced asexually by the budding (strobilation) of a polyp stage called a scyphistoma. The ephyra matures into the adult jellyfish.
- **Redia:** This is a larval stage in the life cycle of flukes (Phylum Platyhelminthes, Class Trematoda), which develops within a snail host.
- **Rhabditiform:** This is the name given to the first-stage larva of many nematodes (Phylum Nematoda), such as hookworms and roundworms.

Step 3: Final Answer:

Based on the analysis, the ephyra is the correct larval/juvenile form associated with the jellyfish life cycle. Therefore, option (B) is the correct answer.

Quick Tip

Associate key larval forms with their phyla:

- **Cnidaria (Jellyfish):** Planula, Ephyra
- **Porifera (Sponges):** Parenchymula, Amphiblastula
- **Platyhelminthes (Flukes):** Miracidium, Sporocyst, Redia, Cercaria
- **Nematoda (Roundworms):** Rhabditiform, Filariform

Knowing these associations is very helpful for matching-type questions.

15. Match LIST-I with LIST-II

LIST-I Type of cell in Porifera		LIST-II Functions	
A.	Collar cells	I.	Line the sphincters
B.	Trophocytes	II.	Special nurse cells
C.	Pinacocytes	III.	Help to form spermatocyst
D.	Thesocytes	IV.	Food storage

Choose the most appropriate answer from the options given below:

- (A) A - I, B - II, C - III, D - IV
(B) A - I, B - III, C - II, D - IV

- (C) A - I, B - II, C - IV, D - III
(D) A - III, B - II, C - I, D - IV

Correct Answer: (D) A - III, B - II, C - I, D - IV

Solution:

Step 1: Understanding the Concept:

Sponges (Phylum Porifera) have a cellular level of organization with different cell types specialized for various functions. This question tests the knowledge of these specialized cells and their roles.

Step 2: Detailed Matching:

- **A. Collar cells (Choanocytes):** These are flagellated cells that create water currents for feeding and respiration. They also play a role in reproduction; they can transform into spermatocytes or surround developing sperm to form a **spermatocyst**. So, **A matches with III**.
- **B. Trophocytes:** These are amoeboid cells that are responsible for digesting and distributing food to other cells. They function as **special nurse cells**, nourishing other cells, including developing gametes. So, **B matches with II**.
- **C. Pinacocytes:** These are flattened, epithelial-like cells that form the outer surface (pinacoderm) of the sponge. They are contractile and can regulate the size of the osculum and pores, acting like **sphincters** to control water flow. So, **C matches with I**.
- **D. Thesocytes:** These are amoeboid cells that are specialized for **food storage**. They accumulate food reserves like glycogen, lipids, and proteins. So, **D matches with IV**.

Step 3: Final Answer:

The correct set of matches is A-III, B-II, C-I, D-IV. This corresponds to option (D).

Quick Tip

Break down the names of the cells to remember their function:

- **Pinacocyte:** Think "Pin" or "Plate" - flat cells forming the outer layer.
- **Choanocyte:** Think "Collar" - collar cells.
- **Trophocyte:** Troph means "nourishment" (like in autotroph) - nurse cells.
- **Thesocyte:** Think "Thesaurus" or "Thesis" - a place for storage - food storage cells.

16. In the life history and development of sea star, numerous larval forms are formed. Arrange them in the order of their occurrence:

- A. Dipleurula
- B. Branchiolaria
- C. Bipinnaria

Choose the most appropriate answer from the options given below:

- (A) A, B, C
- (B) A, C, B
- (C) B, A, C
- (D) C, B, A

Correct Answer: (B) A, C, B

Solution:

Step 1: Understanding the Concept:

The development of sea stars (Class Asteroidea) involves indirect development with a series of distinct, free-swimming, bilaterally symmetrical larval stages before metamorphosis into a radially symmetrical adult.

Step 2: Detailed Explanation of the Order:

1. **Dipleurula (A):** The dipleurula is considered the hypothetical ancestral larva for echinoderms. The very first, early larval stage of a sea star that develops from the gastrula is a dipleurula-type larva, which then develops into the bipinnaria. So, this is the starting point.
2. **Bipinnaria (C):** This is the first well-defined larval stage of the sea star. It develops from the early larva (dipleurula concept) and is characterized by its bilaterally symmetrical body with ciliated bands used for locomotion and feeding. It does not have any attachment arms.
3. **Brachiolaria (B):** The bipinnaria larva develops into the brachiolaria larva. This is the final larval stage. It is distinguished by the growth of three additional, short, non-ciliated arms (brachiolar arms) at the anterior end, with an adhesive disc. These structures are used for attachment to a substrate before undergoing metamorphosis.

Step 3: Final Answer:

The correct chronological order of larval development is Dipleurula (early larva) → Bipinnaria → Brachiolaria. This corresponds to the sequence A, C, B. Therefore, option (B) is correct.

Quick Tip

Remember the alphabetical order trick for the main sea star larvae: **B**ipinnaria comes before **B**rachiolaria. The dipleurula is the conceptual starting form for all echinoderm larvae. So, Dipleurula → Bipinnaria → Brachiolaria.

17. Which one of the following belongs to class-Diplopoda?

- (A) Balanus
- (B) Sacculina
- (C) Scolopendra

(D) *Julus*

Correct Answer: (D) *Julus*

Solution:

Step 1: Understanding the Concept:

The question asks to identify the organism belonging to the Class Diplopoda from the given options. Class Diplopoda includes the millipedes, which are part of the Subphylum Myriapoda.

Step 2: Detailed Explanation of Options:

- **Balanus:** This is a genus of acorn barnacles. Barnacles belong to the Class Crustacea.
- **Sacculina:** This is a genus of parasitic barnacles. Like *Balanus*, it belongs to the Class Crustacea.
- **Scolopendra:** This is a genus of giant centipedes. Centipedes belong to the Class Chilopoda. The key difference from Diplopoda is that they have only one pair of legs per body segment.
- **Julus:** This is a genus of millipedes. Millipedes are characterized by having two pairs of legs on most of their body segments (diplosegments), which is the defining feature of Class Diplopoda.

Step 3: Final Answer:

Julus is a millipede and therefore belongs to the Class Diplopoda. Option (D) is the correct answer.

Quick Tip

To differentiate Myriapod classes:

- **Diplopoda** = **Di** (two) pods (feet) → Millipedes (two pairs of legs per segment).
- **Chilopoda** = Centipedes (one pair of legs per segment).

Remembering that "milli" means thousand (an exaggeration) and "centi" means hundred helps distinguish the two groups.

18. How many somatic cells are present in *C. elegans*?

- (A) 969
- (B) 859
- (C) 959
- (D) 979

Correct Answer: (C) 959

Solution:**Step 1: Understanding the Concept:**

Caenorhabditis elegans is a nematode (roundworm) that is a powerful model organism in developmental biology. One of its key features is eutely, which means it has a fixed number of somatic cells in the adult stage. The question asks for this specific number.

Step 2: Detailed Explanation:

The cell lineage of *C. elegans* has been completely mapped from the zygote to the adult.

- During the development of a hermaphrodite *C. elegans*, a total of 1090 somatic cells are generated.
- However, a precisely defined set of 131 of these cells undergoes programmed cell death, or apoptosis.
- This results in an adult hermaphrodite with a constant, invariant number of somatic cells.
- The final count is $1090 - 131 = 959$ somatic cells.

The adult male has a different number (1031), but 959 is the standard, widely cited number for the hermaphrodite.

Step 3: Final Answer:

The adult hermaphrodite of *C. elegans* has exactly 959 somatic cells. Therefore, option (C) is the correct answer.

Quick Tip

The number 959 is a classic factoid in molecular and developmental biology related to *C. elegans*. It's one of those specific numbers worth memorizing for competitive exams, as it highlights the concept of eutely and the precision of developmental programs.

19. How many different type of gametes can potentially be produced by an organism with the genotype aaBbccdd?

- (A) 2
- (B) 4
- (C) 8
- (D) 16

Correct Answer: (A) 2

Solution:**Step 1: Understanding the Concept:**

The number of different types of gametes an organism can produce is determined by the number of heterozygous gene pairs in its genotype. Homozygous gene pairs (e.g., aa, cc, dd) produce

only one type of allele in the gametes, so they do not contribute to the variety of gametes.

Step 2: Key Formula or Approach:

The formula to calculate the number of different gametes is:

$$\text{Number of gamete types} = 2^n$$

where n is the number of heterozygous gene pairs.

Step 3: Detailed Explanation:

1. **Identify the genotype:** The given genotype is aaBbccdd.

2. **Count the heterozygous pairs (n):** We examine each gene pair:

- aa: Homozygous
- Bb: Heterozygous
- cc: Homozygous
- dd: Homozygous

There is only one heterozygous pair (Bb). Therefore, $n = 1$.

3. **Calculate the number of gametes:**

Using the formula 2^n , with $n = 1$:

$$\text{Number of gametes} = 2^1 = 2$$

The two possible types of gametes are **aBcd** and **abcd**.

Step 4: Final Answer:

The organism can produce 2 different types of gametes. Thus, option (A) is correct.

Quick Tip

To quickly solve these problems, just scan the genotype and count how many pairs have one capital and one lowercase letter (like Bb). Ignore any pairs with two capital (BB) or two lowercase (bb) letters. Then, calculate 2 to the power of that count.

20. What is the difference between gynandromorphs and intersexes in *Drosophila*?

- (A) Intersexes are genetically similar throughout their bodies, whereas gynandromorph consists of two genetically different tissues
- (B) Intersexes are not genetically similar throughout their bodies, whereas gynandromorph genetically similar throughout their bodies
- (C) Intersexes are sterile, whereas gynandromorphs are genetically similar throughout their bodies
- (D) Intersexes are genetically similar throughout their bodies, whereas gynandromorph consists of four genetically different tissues

Correct Answer: (A) Intersexes are genetically similar throughout their bodies, whereas gynandromorph consists of two genetically different tissues

Solution:

Step 1: Understanding the Concept:

This question addresses two specific types of sexual development abnormalities in *Drosophila*, which are caused by different genetic mechanisms.

Step 2: Detailed Explanation:

- **Intersexes:** In *Drosophila*, sex is determined by the ratio of X chromosomes to sets of autosomes (X/A ratio). An intersex individual has an X/A ratio that is intermediate between that of a normal male (0.5) and a normal female (1.0), for example, a ratio of 0.67 (2X chromosomes and 3 sets of autosomes). Crucially, every cell in the body of an intersex fly has the same abnormal genetic constitution. Thus, they are **genetically similar (uniform) throughout their bodies** but display an intermediate sexual phenotype.

- **Gynandromorphs:** A gynandromorph is a genetic mosaic, meaning the organism is composed of cells with different genotypes. In *Drosophila*, this typically occurs when a female (XX) zygote loses one X chromosome from a cell during an early mitotic division. This event creates two distinct cell lines: one that is XX (female) and one that is XO (male). As these cells continue to divide, the organism develops with patches of male tissue and patches of female tissue. Therefore, a gynandromorph **consists of two genetically different tissues**.

Step 3: Analyzing the Options:

- (A) This statement correctly describes both conditions: intersexes are genetically uniform, while gynandromorphs are mosaics of two genetically different tissues.
- (B) This statement incorrectly reverses the descriptions.
- (C) While intersexes are typically sterile, the second part of the statement incorrectly claims that gynandromorphs are genetically similar.
- (D) This statement correctly describes intersexes but incorrectly states that gynandromorphs consist of four different tissues; it is typically two.

Step 4: Final Answer:

Option (A) provides the most accurate distinction between intersexes and gynandromorphs.

Quick Tip

Remember the prefixes:

- **Inter-** means "between," so intersexes have a phenotype between male and female, caused by a uniform but abnormal genetic ratio.
- **Gyn-** means female and **andro-** means male. A gynandromorph is a single organism with both male and female parts, resulting from a genetic mosaic.

21. Match LIST-I with LIST-II

LIST-I Law/Principle/Gene interaction		LIST-II Genes distribution/Ratio	
A.	Law of segregation	I.	12:3:1
B.	Principle of independent assortment	II.	Genes are distributed without mixing.
C.	Complementary gene interaction	III.	Genes on different chromosomes are distributed independently during meiosis.
D.	Dominant epistasis	IV.	9:7

Choose the most appropriate answer from the options given below:

- (A) A - II, B - III, C - IV, D - I
- (B) A - I, B - III, C - II, D - IV
- (C) A - II, B - I, C - IV, D - III
- (D) A - III, B - IV, C - I, D - II

Correct Answer: (A) A - II, B - III, C - IV, D - I

Solution:

Step 1: Understanding the Concept:

This question requires matching fundamental genetic principles and types of gene interactions with their correct descriptions or characteristic phenotypic ratios.

Step 2: Detailed Matching:

- **A. Law of Segregation:** This Mendelian law states that the two alleles of a gene segregate (separate) from each other during gamete formation, so that each gamete receives only one allele. This implies that the alleles do not blend or mix. Thus, **A matches with II.**
- **B. Principle of Independent Assortment:** This law states that alleles of genes located on different (non-homologous) chromosomes are inherited independently of one another. This is accurately described as **genes on different chromosomes are distributed independently during meiosis.** Thus, **B matches with III.**
- **C. Complementary Gene Interaction:** This is a form of non-allelic interaction where two genes work together to produce a single trait. The dominant allele of both genes is required for the expression of the dominant phenotype. A dihybrid cross involving complementary genes yields a phenotypic ratio of **9:7.** Thus, **C matches with IV.**
- **D. Dominant Epistasis:** This occurs when a dominant allele at one gene locus masks the expression of alleles at a second locus. A dihybrid cross involving dominant epistasis results in a characteristic phenotypic ratio of **12:3:1.** Thus, **D matches with I.**

Step 3: Final Answer:

The correct set of matches is A-II, B-III, C-IV, D-I. This corresponds to option (A).

Quick Tip

For matching questions involving genetic ratios, it's highly beneficial to memorize the key dihybrid cross ratios:

- **9:3:3:1** - Standard Independent Assortment
- **9:7** - Complementary Genes
- **12:3:1** - Dominant Epistasis
- **9:3:4** - Recessive Epistasis
- **15:1** - Duplicate Dominant Genes

22. Which of the following statements are true?

- A. When two or more genes co-exist on the same chromosome, they may violate the principle of independent assortment during meiosis.
 - B. Positive interference occurs when the presence of one chiasma increases the possibility of another chiasma occurring in the immediate vicinity.
 - C. The proportion of crossovers never exceeds 50%.
 - D. The Chi-square test can be used for segregation ratios and detection of linkage.
- Choose the most appropriate answer from the options given below:

- (A) A, B and D only
- (B) A, B and C only
- (C) A, B, C and D
- (D) A, C and D only

Correct Answer: (D) A, C and D only

Solution:

Step 1: Understanding the Concept:

This question assesses understanding of several key concepts in classical and statistical genetics, including linkage, interference, recombination frequency, and the Chi-square test.

Step 2: Analyzing each statement:

- **Statement A: True.** Genes located on the same chromosome are said to be linked. They tend to be inherited together and do not assort independently, which is a violation of Mendel's Principle of Independent Assortment.
- **Statement B: False.** This statement describes negative interference. **Positive interference** is the phenomenon where the occurrence of one crossover event (chiasma) *reduces* or suppresses the probability of a second crossover occurring nearby.
- **Statement C: True.** Recombination frequency is the proportion of recombinant offspring. For linked genes, it can range from 0% to 50%. A recombination frequency of 50% is the maximum possible and is equivalent to independent assortment (as occurs for genes on different

chromosomes or very far apart on the same chromosome). A frequency cannot exceed 50%.

- **Statement D: True.** The Chi-square (χ^2) test is a statistical goodness-of-fit test. It is commonly used in genetics to compare observed phenotypic ratios from a cross with the ratios expected under a certain hypothesis (e.g., Mendelian segregation ratios like 9:3:3:1). A statistically significant deviation from the expected ratio can indicate that the underlying hypothesis is incorrect, which can be used to detect linkage.

Step 3: Final Answer:

Statements A, C, and D are true, while statement B is false. Therefore, the correct option is (D).

Quick Tip

Remember the definitions of interference:

- **Positive interference:** One crossover DECREASES the chance of another nearby (the common case).
- **Negative interference:** One crossover INCREASES the chance of another nearby (rarer).

Think "positive" = inhibiting/suppressing effect.

23. Based on the threshold range, at the X/A ratio of 0.67, the sex of *Drosophila* will be:

- (A) Intersex
- (B) Superfemale
- (C) Supermale
- (D) Male

Correct Answer: (A) Intersex

Solution:

Step 1: Understanding the Concept:

The sex of a *Drosophila melanogaster* (fruit fly) is determined by the Genic Balance Theory, proposed by Calvin Bridges. According to this theory, sex is determined by the ratio of the number of X chromosomes to the number of sets of autosomes (X/A ratio).

Step 2: Key Formula or Approach:

The thresholds for the X/A ratio determine the sexual phenotype:

- **X/A Ratio ≥ 1.0 :** Female (e.g., $XX/2A = 1.0$). If $X/A > 1.0$ (e.g., $XXX/2A = 1.5$), it's a Superfemale (or metafemale), often sterile and weak.
- **X/A Ratio = 0.5:** Male (e.g., $XY/2A = 0.5$).

- **X/A Ratio ; 0.5:** Supermale (or metamale), sterile and weak.
- **X/A Ratio between 0.5 and 1.0:** Intersex. These individuals display a mixture of male and female characteristics.

Step 3: Detailed Explanation:

The question provides an X/A ratio of 0.67. We compare this value to the established thresholds:

$$0.5 < 0.67 < 1.0$$

Since the ratio falls between the value for a normal male (0.5) and a normal female (1.0), the resulting phenotype will be an Intersex. An example of a fly with this ratio would be one with two X chromosomes and three sets of autosomes ($2X/3A \approx 0.67$).

Step 4: Final Answer:

An X/A ratio of 0.67 in *Drosophila* results in an Intersex phenotype. Therefore, option (A) is correct.

Quick Tip

Memorize the key X/A ratio points for *Drosophila*: 1.0 is female, 0.5 is male. Anything between is intersex. Anything above 1.0 is superfemale, and below 0.5 is supermale. The Y chromosome in flies is important for male fertility but not for sex determination itself.

24. In a population under Hardy Weinberg Equilibrium, out of a total of 592 people, 44 people were affected by a rare autosomal recessive disorder whereas the rest of the population was normal. How many individuals in this population have the heterozygous and homozygous dominant genotypes for this trait?

- (A) 233 and 315, respectively.
- (B) 315 and 233, respectively.
- (C) 0.27 and 0.73, respectively.
- (D) 0.73 and 0.27, respectively.

Correct Answer: (A) 233 and 315, respectively.

Solution:

Step 1: Understanding the Concept:

This problem applies the principles of Hardy-Weinberg Equilibrium (HWE) to a population. HWE describes the relationship between allele frequencies and genotype frequencies in a population that is not evolving. The key equations are $p + q = 1$ and $p^2 + 2pq + q^2 = 1$.

Step 2: Key Formula or Approach:

- Let p be the frequency of the dominant allele (A) and q be the frequency of the recessive allele

(a).

- q^2 = frequency of the homozygous recessive genotype (aa), which corresponds to the affected individuals.
- p^2 = frequency of the homozygous dominant genotype (AA).
- $2pq$ = frequency of the heterozygous genotype (Aa).
- Total population size (N) = 592.
- Number of affected individuals (aa) = 44.

Step 3: Detailed Calculation:

1. Calculate the frequency of the homozygous recessive genotype (q^2):

$$q^2 = \frac{\text{Number of affected individuals}}{\text{Total population}} = \frac{44}{592} \approx 0.07432$$

2. Calculate the frequency of the recessive allele (q):

$$q = \sqrt{q^2} = \sqrt{\frac{44}{592}} \approx \sqrt{0.07432} \approx 0.2726$$

3. Calculate the frequency of the dominant allele (p):

$$p = 1 - q = 1 - 0.2726 \approx 0.7274$$

4. Calculate the expected number of heterozygous individuals (Aa):

The frequency of heterozygotes is $2pq$.

$$\text{Number of Aa} = 2pq \times N = (2 \times 0.7274 \times 0.2726) \times 592 \approx 0.3965 \times 592 \approx 234.7$$

This rounds to 235 individuals.

5. Calculate the expected number of homozygous dominant individuals (AA):

The frequency of homozygous dominants is p^2 .

$$\text{Number of AA} = p^2 \times N = (0.7274)^2 \times 592 \approx 0.5291 \times 592 \approx 313.2$$

This rounds to 313 individuals.

Step 4: Final Answer:

The calculated number of heterozygous individuals is approximately 235, and the number of homozygous dominant individuals is approximately 313. The question asks for heterozygous and homozygous dominant, respectively. The option that most closely matches our calculation is (A) 233 and 315. We can verify this option: $233(\text{Aa}) + 315(\text{AA}) + 44(\text{aa}) = 592$, which is the correct total. The minor discrepancy is likely due to rounding or the use of slightly non-ideal numbers in the problem statement. Option (A) is the intended answer.

Quick Tip

In HWE problems, always start with the information you have about the homozygous recessive group (q^2), as their genotype is unambiguously known from their phenotype. From q^2 , find q , then p , and then you can calculate all other genotype frequencies (p^2 and $2pq$).

25. Match LIST-I with LIST-II

LIST-I Period		LIST-II Genra of horse	
A.	Pleistocene	I.	Eohippus
B.	Eocene	II.	Mesohippus
C.	Miocene	III.	Equus
D.	Oligocene	IV.	Merychippus

Choose the most appropriate answer from the options given below:

- (A) A - I, B - II, C - III, D - IV
(B) A - III, B - I, C - IV, D - II
(C) A - I, B - II, C - IV, D - III
(D) A - III, B - IV, C - I, D - II

Correct Answer: (B) A - III, B - I, C - IV, D - II

Solution:

Step 1: Understanding the Concept:

This question requires knowledge of the evolutionary history of the horse, which is a classic example of evolution documented in the fossil record. The key is to match the geological epochs with the corresponding ancestral horse genera.

Step 2: Detailed Matching:

The general chronological order of horse evolution is as follows:

- **Eocene Epoch:** The earliest ancestor, *Eohippus* (also known as *Hyracotherium*), appeared. It was a small, dog-sized animal with multiple toes. So, **B matches with I.**
- **Oligocene Epoch:** *Eohippus* was followed by *Mesohippus*, which was slightly larger and had three toes on each foot, with the middle toe being more prominent. So, **D matches with II.**
- **Miocene Epoch:** *Merychippus* evolved. This was a more horse-like animal, adapted to grazing on grasslands, and it stood on its middle toe, with the side toes being reduced. So, **C matches with IV.**
- **Pleistocene Epoch:** The modern horse genus, *Equus*, evolved. This includes modern horses, donkeys, and zebras, characterized by a single hoof on each foot. So, **A matches with III.**

Step 3: Final Answer:

Combining the matches: A-III, B-I, C-IV, D-II. This corresponds to option (B).

Quick Tip

A mnemonic to remember the order of the epochs and the key genera is "Eat On My Plate".

- **E**at (**E**ocene) → **E**ohippus
- **O**n (**O**ligocene) → **M**esohippus
- **M**y (**M**iocene) → **M**erychippus
- **P**late (**P**leistocene) → **P**liohippus/**E**quus

26. Which of the following phenomena can lead to microevolution?

A. Natural Selection

B. Sexual Selection

C. Genetic Drift

Choose the most appropriate answer from the options given below:

(A) A and B only

(B) B and C only

(C) A and C only

(D) A, B and C

Correct Answer: (D) A, B and C

Solution:

Step 1: Understanding the Concept:

Microevolution is defined as the change in allele frequencies in a population over successive generations. It refers to small-scale evolutionary changes within a species. The question asks which of the given mechanisms cause these changes.

Step 2: Detailed Explanation:

- **A. Natural Selection:** This is the process where individuals with certain heritable traits survive and reproduce at higher rates than other individuals because of those traits. This leads to an increase in the frequency of advantageous alleles and is a primary driver of microevolution.

- **B. Sexual Selection:** This is a specific type of natural selection in which mating success determines the passing of genes to the next generation. Traits that increase an organism's chances of securing a mate will become more common over time, thus changing allele frequencies.

- **C. Genetic Drift:** This refers to random fluctuations in allele frequencies from one generation to the next due to chance events, especially in small populations. It is a non-adaptive mechanism that can lead to the loss or fixation of alleles, causing microevolutionary change.

Step 3: Final Answer:

All three listed phenomena—Natural Selection, Sexual Selection, and Genetic Drift—are es-

established mechanisms that cause changes in allele frequencies in a population. Therefore, all three lead to microevolution. The correct answer is option (D).

Quick Tip

Remember the five main fingers of evolution that cause changes in allele frequency (microevolution):

1. Small population size (Genetic Drift)
2. Non-random mating (Sexual Selection)
3. Mutation
4. Gene Flow (Migration)
5. Natural Selection (Adaptation)

All options in the question are on this list.

27. Which of the following statements are correct about the phenomenon of genetic drift?

- A. It occurs in a small population.**
- B. It leads to the loss of genetic variation within population.**
- C. It doesn't change the allele frequency randomly.**
- D. It occurs in a large population.**

Choose the most appropriate answer from the options given below:

- (A) A and B only
- (B) A and C only
- (C) B and D only
- (D) C and D only

Correct Answer: (A) A and B only

Solution:

Step 1: Understanding the Concept:

Genetic drift is a mechanism of evolution characterized by random fluctuations in the frequencies of alleles in a population's gene pool, primarily due to chance events.

Step 2: Analyzing each statement:

- **Statement A: True.** The effects of genetic drift are most pronounced in small populations. In a small group, random events (like an individual failing to reproduce by chance) can have a disproportionately large impact on allele frequencies.
- **Statement B: True.** Genetic drift can lead to the random fixation (frequency of 100%)

or loss (frequency of 0%) of alleles. When an allele is lost, genetic variation at that locus is reduced. Over time, drift tends to decrease the genetic diversity within a population.

- **Statement C: False.** The defining feature of genetic drift is that it changes allele frequencies **randomly**. Unlike natural selection, which is directional (it selects for adaptive traits), drift is directionless and based purely on chance.

- **Statement D: False.** While genetic drift technically occurs in any finite population, its effects are negligible and insignificant in large populations. In large populations, random fluctuations tend to cancel each other out, and changes in allele frequency are primarily driven by selection.

Step 3: Final Answer:

Statements A and B are correct descriptions of genetic drift. Statements C and D are incorrect. Therefore, the correct option is (A).

Quick Tip

Think of genetic drift like flipping a coin. If you flip it 1000 times (large population), you'll get very close to 50% heads. If you only flip it 4 times (small population), it's much more likely you'll get a skewed result like 75% or 100% heads just by chance. That's genetic drift!

28. The increase in the beak depth of Galápagos finches with a relative abundance of large seeds, is an example of

- (A) Disruptive selection
- (B) Directional selection
- (C) Stabilizing selection
- (D) Balancing selection

Correct Answer: (B) Directional selection

Solution:

Step 1: Understanding the Concept:

This question describes a classic example of natural selection observed by Peter and Rosemary Grant in the Galápagos Islands. The key is to identify which mode of selection is at play when an environmental pressure favors one extreme of a phenotypic range.

Step 2: Detailed Explanation:

- The scenario states that an abundance of large seeds leads to an increase in beak depth. This means that finches with deeper, stronger beaks (one extreme of the beak depth spectrum) were better able to crack the large seeds and thus had higher survival and reproductive rates.

- This pattern, where selection favors individuals at one end of the phenotypic range, is the definition of **directional selection**. It causes the average value of the trait in the population

to shift in that direction over time.

- **Disruptive selection** would favor both extremes (e.g., very small and very large beaks) but select against the intermediate form.
- **Stabilizing selection** would favor the intermediate phenotype (e.g., average-sized beaks) and select against both extremes.
- **Balancing selection** maintains genetic diversity by keeping multiple alleles or phenotypes stable in a population.

Step 3: Final Answer:

The scenario is a textbook case of directional selection, where the population's average beak depth evolves in a specific direction in response to environmental changes. Thus, option (B) is correct.

Quick Tip

Visualize the population's trait distribution as a bell curve.

- **Directional:** The whole curve shifts to the left or right.
- **Stabilizing:** The curve becomes narrower and taller in the middle.
- **Disruptive:** The curve splits into two peaks at the ends, with a valley in the middle.

29. How many jaws are present in Aristotle's Lantern?

- (A) 3
- (B) 5
- (C) 6
- (D) 4

Correct Answer: (B) 5

Solution:

Step 1: Understanding the Concept:

Aristotle's Lantern is the complex and highly developed feeding apparatus found in sea urchins (Class Echinoidea). It is a conical structure located in the mouth that is used for scraping algae from rocks and for chewing.

Step 2: Detailed Explanation:

The structure of Aristotle's Lantern is based on the five-part (pentamerous) radial symmetry characteristic of echinoderms. It consists of a complex arrangement of muscles and calcareous plates that support five hard, pointed, tooth-like structures. These five "teeth" or "jaws" can be protruded from the mouth to scrape and chew food.

Step 3: Final Answer:

Aristotle's Lantern is composed of five jaws. Therefore, the correct option is (B).

Quick Tip

Echinoderms (like sea stars, brittle stars, and sea urchins) are famous for their five-part radial symmetry. If you see a question about the number of parts in an echinoderm structure, 5 is a very common answer. In this case, the 5 jaws of Aristotle's Lantern reflect this fundamental body plan.

30. The technique to mark, release and recapture is a practical method for

- (A) Estimating the endangered species in a population.
- (B) Estimating the population size of mobile animals
- (C) Estimating the population size of umbrella species.
- (D) Estimating the population size of indicator animals.

Correct Answer: (B) Estimating the population size of mobile animals

Solution:**Step 1: Understanding the Concept:**

The mark-release-recapture method is a widely used ecological technique to estimate the total size of a population when a direct count of all individuals is not feasible. The method involves capturing a sample of individuals, marking them in a harmless way, releasing them back into the population, and then capturing a second sample after a period of time.

Step 2: Detailed Explanation:

The core principle of this method is based on the Lincoln-Petersen index:

$$\text{Population Size (N)} = \frac{(\text{Number marked in first catch}) \times (\text{Total number in second catch})}{(\text{Number of marked recaptures in second catch})}$$

For this estimate to be accurate, several assumptions must be met, one of the most critical being that the marked individuals have had enough time to disperse and mix randomly with the unmarked population. This random mixing requires the animals to be **mobile**. The technique is not suitable for sessile (non-moving) organisms like plants or barnacles. While it can be applied to endangered, umbrella, or indicator species (options A, C, D), its fundamental requirement and most general application is for populations of **mobile animals**.

Step 3: Final Answer:

The most accurate and fundamental description of the utility of the mark-release-recapture technique is for estimating the population size of mobile animals. Option (B) is the best choice.

Quick Tip

Remember that mark-recapture relies on the "mixing bowl" assumption. You mark some, release them, and assume they mix evenly throughout the entire population. This can only happen if the animals move around. Therefore, the technique is fundamentally linked to the mobility of the species.

31. Any species that have been accidentally or deliberately transferred from their usual habitat to a new habitat whose abiotic conditions are also suitable for them are known as:

- (A) Alien or invasive species
- (B) Indicator species
- (C) Threatened species
- (D) Endangered species

Correct Answer: (A) Alien or invasive species

Solution:

Step 1: Understanding the Concept:

The question asks for the term used to describe species introduced to a new environment outside their native range.

Step 2: Detailed Explanation:

- **Alien species** (also known as exotic, non-native, or introduced species) are organisms that are moved by human activities, either intentionally or accidentally, to a new area where they are not naturally found.
- If an alien species begins to spread and cause ecological or economic harm, it is then termed an **invasive species**. The question's description fits the definition of an alien species, which is the precursor to becoming invasive. The combined term "Alien or invasive species" is the most appropriate choice.
- **Indicator species** are organisms whose presence, absence, or abundance reflects a specific environmental condition.
- **Threatened** and **Endangered species** are categories defined by the IUCN Red List based on their risk of extinction.

Step 3: Final Answer:

The definition provided in the question precisely describes an alien species, which can become invasive. Therefore, option (A) is the correct term.

Quick Tip

Remember the progression: A species introduced to a new area is **alien**. If it establishes a self-sustaining population, it is **naturalized**. If it then spreads and causes harm, it becomes **invasive**.

32. The populations, showing relatively constant density around the carrying capacity of the environment, is called

- (A) r-selected
- (B) m-selected
- (C) k-selected
- (D) p-selected

Correct Answer: (C) k-selected

Solution:

Step 1: Understanding the Concept:

This question relates to the r/K selection theory, which describes two contrasting strategies of reproduction and life history. The carrying capacity of an environment is denoted by the variable 'K'.

Step 2: Detailed Explanation:

- **K-selected species** are adapted to stable environments where population size is at or near the carrying capacity (K). They are characterized by having fewer offspring, longer lifespans, significant parental investment, and their populations tend to be relatively stable around K. Examples include elephants, whales, and humans.
- **r-selected species** are adapted to unstable environments. They prioritize high reproductive rates (r) and produce a large number of offspring with little parental care. Their populations often fluctuate significantly and are usually well below the carrying capacity. Examples include bacteria, insects, and weeds.
- The terms 'm-selected' and 'p-selected' are not standard terms in this ecological context.

Step 3: Final Answer:

The description of a population with a relatively constant density around the carrying capacity is the defining feature of a K-selected population. Thus, option (C) is correct.

Quick Tip

Associate the letters with their meaning:

- **K** → **K**arrying **K**apacity. These species are good competitors in crowded conditions.
- **r** → rate of population increase. These species are good at reproducing quickly in uncrowded conditions.

33. Which one of the following statements is correct for Mollisol?

- (A) It is the fertile soil found in low precipitation areas.
- (B) It is the infertile soil found in high precipitation areas.
- (C) It is the fertile soil found in high precipitation areas.
- (D) It is the infertile soil found in low precipitation areas

Correct Answer: (A) It is the fertile soil found in low precipitation areas.

Solution:

Step 1: Understanding the Concept:

Mollisol is one of the twelve soil orders in the USDA soil taxonomy system. The question asks for its key characteristics regarding fertility and the climate where it is found.

Step 2: Detailed Explanation:

- **Fertility:** Mollisols are among the most fertile soils in the world. Their name comes from the Latin 'mollis', meaning soft, referring to their soft, dark, humus-rich surface layer (the mollic epipedon). This high organic matter content makes them extremely productive for agriculture.
- **Climate:** These soils typically form under grassland vegetation in temperate, semi-arid to sub-humid climates. These are areas with moderate to low precipitation, not high enough to support forests but sufficient for dense grass cover. The low precipitation prevents excessive leaching of nutrients from the soil profile, contributing to their fertility.
- Therefore, Mollisols are fertile soils found in relatively low precipitation areas.

Step 3: Final Answer:

Comparing this with the options, statement (A) correctly identifies Mollisol as fertile soil found in low precipitation areas.

Quick Tip

Think of the world's great breadbaskets: the North American prairies, the Argentinian pampas, the Russian steppes. These are all grasslands with Mollisol soils, known for their incredible fertility and moderate-to-low rainfall.

34. Match LIST-I with LIST-II

LIST-I ACT		LIST-II Year of Enactment	
A.	Environmental Pollution Act	I.	1981
B.	The Air (Prevention and Control of pollution) Act	II.	1986
C.	The Water (Prevention and Control of Pollution) Act	III.	1972
D.	The Wildlife Protection and Conservation Act	IV.	1974

Choose the most appropriate answer from the options given below:

- (A) A - IV, B - III, C - II, D - I
(B) A - II, B - I, C - IV, D - III
(C) A - III, B - II, C - IV, D - I
(D) A - I, B - IV, C - III, D - II

Correct Answer: (B) A - II, B - I, C - IV, D - III

Solution:

Step 1: Understanding the Concept:

This question tests the knowledge of the years of enactment for major environmental legislation in India. "Environmental Pollution Act" is the common name for the Environment (Protection) Act.

Step 2: Detailed Matching:

- **A. The Environment (Protection) Act:** This comprehensive act was passed in the wake of the Bhopal Gas Tragedy and was enacted in **1986**. Thus, **A matches with II**.
- **B. The Air (Prevention and Control of Pollution) Act:** This act was enacted to control and prevent air pollution in **1981**. Thus, **B matches with I**.
- **C. The Water (Prevention and Control of Pollution) Act:** This was one of the earliest environmental acts in India, passed in **1974**. Thus, **C matches with IV**.
- **D. The Wildlife Protection and Conservation Act:** This act provides for the protection of wild animals, birds, and plants and was enacted in **1972**. Thus, **D matches with III**.

Step 3: Final Answer:

The correct pairings are: A-II, B-I, C-IV, D-III. This corresponds to option (B).

Quick Tip

Remember the chronological order: First protect the **wildlife** (1972), then the **water** (1974), then the **air** (1981), and finally, a comprehensive act for the entire **environment** (1986).

35. Arrange the given events to correct sequence in relation to translation:

- A. Adenylation of amino acid and aminoacyl-tRNA charging.**
- B. Formation of Peptide bond.**
- C. Recruitment of ribosome to the mRNA.**
- D. Correct positioning of charged tRNA into the P-site of the ribosome.**

Choose the most appropriate answer from the options given below:

- (A) A, B, C, D
- (B) A, C, D, B
- (C) B, A, D, C
- (D) C, B, D, A

Correct Answer: (B) A, C, D, B

Solution:

Step 1: Understanding the Concept:

The question asks for the correct chronological sequence of major events during protein synthesis (translation).

Step 2: Detailed Explanation of the Sequence:

1. **A. Adenylation of amino acid and aminoacyl-tRNA charging:** This is a prerequisite for translation. The enzyme aminoacyl-tRNA synthetase must first "charge" each tRNA molecule with its corresponding amino acid. This happens continuously in the cytoplasm. It must occur before a tRNA can be used.
2. **C. Recruitment of ribosome to the mRNA:** This is the initiation of translation. The small ribosomal subunit binds to the mRNA molecule and scans for the start codon (AUG).
3. **D. Correct positioning of charged tRNA into the P-site of the ribosome:** Once the start codon is found, the initiator tRNA (carrying methionine), which has already been charged (Step A), binds to the P-site of the ribosome. This completes the initiation complex.
4. **B. Formation of Peptide bond:** This is the first step of the elongation cycle. A second charged tRNA enters the A-site, and the ribosome catalyzes the formation of a peptide bond between the amino acid in the P-site (methionine) and the new amino acid in the A-site. This cycle of tRNA entry, peptide bond formation, and translocation repeats.

Step 3: Final Answer:

The logical sequence of events is $A \rightarrow C \rightarrow D \rightarrow B$. This corresponds to option (B).

Quick Tip

Think of translation like building with LEGOs:

- **A (Charging):** Get your specific LEGO bricks (amino acids) and attach them to the delivery trucks (tRNA).
- **C (Recruitment):** Bring the workbench (ribosome) to the blueprint (mRNA).
- **D (Positioning):** The first delivery truck (initiator tRNA) parks at the starting position (P-site).
- **B (Peptide bond):** The next truck arrives, and you connect the LEGO bricks.

36. The WBC count of a group of athletes in a team was estimated to be 7900, 9000, 7800, 8300, 2900, 4545, 5100, 3700, 9900 and 4545 per mm³ of blood. Calculate the median WBC count of this group of individuals.

- (A) 2900 per mm³
- (B) 4545 per mm³
- (C) 6369 per mm³
- (D) 6450 per mm³

Correct Answer: (D) 6450 per mm³

Solution:

Step 1: Understanding the Concept:

The median is the middle value in a dataset that has been arranged in order of magnitude. It divides the dataset into two equal halves.

Step 2: Key Formula or Approach:

1. Arrange the data in ascending or descending order.
2. Count the number of observations, N.
3. If N is odd, the median is the $(\frac{N+1}{2})$ th value.
4. If N is even, the median is the average of the $(\frac{N}{2})$ th and $(\frac{N}{2} + 1)$ th values.

Step 3: Detailed Calculation:

1. **The given dataset is:** 7900, 9000, 7800, 8300, 2900, 4545, 5100, 3700, 9900, 4545.
2. **Number of observations (N) = 10.**
3. **Arrange the data in ascending order:**
2900, 3700, 4545, 4545, **5100, 7800**, 7900, 8300, 9000, 9900
4. **Calculate the median:** Since N is even (10), the median is the average of the 5th and 6th values.
 - 5th value = 5100
 - 6th value = 7800

$$\text{Median} = \frac{5100 + 7800}{2} = \frac{12900}{2} = 6450$$

Step 4: Final Answer:

The median WBC count of the group is 6450 per mm³. Therefore, option (D) is correct.

Quick Tip

The most common mistake when calculating the median is forgetting to order the data first. Always arrange the numbers from smallest to largest before finding the middle value.

37. Which of the following statements is not applicable to the mode of a dataset?

- (A) There can be more than one mode for a particular dataset.
- (B) It is affected by extreme values in the dataset.
- (C) It represents the most frequently occurring value of the dataset.
- (D) It is calculated by inspection method and grouping method.

Correct Answer: (B) It is affected by extreme values in the dataset.

Solution:

Step 1: Understanding the Concept:

The mode is a measure of central tendency that represents the most frequently occurring value in a dataset. The question asks to identify a property that does NOT apply to the mode.

Step 2: Analyzing the statements:

- **(A) There can be more than one mode for a particular dataset.** This is true. A dataset can be bimodal (two modes), multimodal (more than two modes), or have no mode at all if all values occur with the same frequency.
- **(B) It is affected by extreme values in the dataset.** This is false. The mode is determined only by the frequency of values. Extreme values (outliers) do not affect the mode unless they happen to be the most frequent value. The mean is highly affected by extreme values, while the median is resistant.
- **(C) It represents the most frequently occurring value of the dataset.** This is true. This is the definition of the mode.
- **(D) It is calculated by inspection method and grouping method.** This is true. For simple, ungrouped data, the mode can be found by simple inspection. For grouped frequency distributions, more complex grouping methods or formulas are used to estimate the modal class.

Step 3: Final Answer:

The statement that is not applicable to the mode is that it is affected by extreme values. Therefore, option (B) is the correct answer.

Quick Tip

Remember how different measures of central tendency react to outliers:

- **Mean:** Very sensitive to outliers.
- **Median:** Not sensitive to outliers (it only cares about the middle position).
- **Mode:** Not sensitive to outliers (it only cares about frequency).

38. The number of fish caught each day by a fisherman for 10 consecutive days was reported to be 62, 58, 56, 57, 62, 59, 62, 57, 64, 63. What is the standard deviation of this dataset?

- (A) 2.9
- (B) 8.44
- (C) 3.60
- (D) 76

Correct Answer: (A) 2.9

Solution:

Step 1: Understanding the Concept:

Standard deviation is a measure of the amount of variation or dispersion of a set of values. A low standard deviation indicates that the values tend to be close to the mean, while a high standard deviation indicates that the values are spread out over a wider range.

Step 2: Key Formula or Approach:

The formula for the sample standard deviation (s) is:

$$s = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}}$$

where x_i are the individual data points, $\bar{x}$ is the mean, and N is the number of observations.

Step 3: Detailed Calculation:

1. **Data:** 62, 58, 56, 57, 62, 59, 62, 57, 64, 63. $N = 10$.
2. **Calculate the mean ($\bar{x}$):**

$$\bar{x} = \frac{62 + 58 + 56 + 57 + 62 + 59 + 62 + 57 + 64 + 63}{10} = \frac{598}{10} = 59.8$$

3. **Calculate the sum of squared deviations $\sum (x_i - \bar{x})^2$:**

$$(62 - 59.8)^2 = (2.2)^2 = 4.84$$

$$(58 - 59.8)^2 = (-1.8)^2 = 3.24$$

$$(56 - 59.8)^2 = (-3.8)^2 = 14.44$$

$$(57 - 59.8)^2 = (-2.8)^2 = 7.84$$

$$(62 - 59.8)^2 = (2.2)^2 = 4.84$$

$$(59 - 59.8)^2 = (-0.8)^2 = 0.64$$

$$(62 - 59.8)^2 = (2.2)^2 = 4.84$$

$$(57 - 59.8)^2 = (-2.8)^2 = 7.84$$

$$(64 - 59.8)^2 = (4.2)^2 = 17.64$$

$$(63 - 59.8)^2 = (3.2)^2 = 10.24$$

$$\text{Sum of squares} = 4.84 + 3.24 + 14.44 + 7.84 + 4.84 + 0.64 + 4.84 + 7.84 + 17.64 + 10.24 = 76.4$$

4. Calculate the sample variance (s^2):

$$s^2 = \frac{76.4}{10 - 1} = \frac{76.4}{9} \approx 8.489$$

5. Calculate the sample standard deviation (s):

$$s = \sqrt{8.489} \approx 2.91$$

Step 4: Final Answer:

The calculated standard deviation is approximately 2.91. This matches option (A).

Quick Tip

In competitive exams, be careful whether the question implies a "sample" or a "population". Usually, a small dataset like this is treated as a sample, so you divide the sum of squares by $N - 1$. If you divided by N (for a population), you would get $\sqrt{7.64} \approx 2.76$, which is also close but 2.9 is a better fit for the sample calculation.

39. Which one of the following animals belongs to the oviparous mammal group?

- (A) Macropus
- (B) Pteropus
- (C) Rattus
- (D) Platypus

Correct Answer: (D) Platypus

Solution:

Step 1: Understanding the Concept:

The question asks to identify an oviparous (egg-laying) mammal. Mammals are overwhelmingly viviparous (giving live birth), but there is one small, ancient group that lays eggs.

Step 2: Detailed Explanation:

- The class Mammalia is divided into three main groups based on reproductive strategy: 1. **Monotremes:** These are the only oviparous mammals. This group includes the platypus and echidnas. 2. **Marsupials:** These are viviparous mammals that give birth to a very underdeveloped (altricial) young, which then completes its development in a pouch. Examples include

kangaroos (*Macropus*), koalas, and opossums. 3. **Placental Mammals (Eutherians):** These are viviparous mammals where the fetus develops fully inside the mother's uterus, nourished by a placenta. This is the largest group of mammals, including bats (*Pteropus*), rats (*Rattus*), and humans.

- Analyzing the options: - (A) *Macropus* is a kangaroo, a marsupial. - (B) *Pteropus* is a flying fox (a type of bat), a placental mammal. - (C) *Rattus* is a rat, a placental mammal. - (D) *Platypus* is a monotreme and is famous for being an egg-laying mammal.

Step 3: Final Answer:

The platypus is the oviparous mammal among the choices. Therefore, option (D) is correct.

Quick Tip

There are only five living species of monotremes in the world: the duck-billed platypus and four species of echidna. If you see "egg-laying mammal" on an exam, the answer will almost certainly be one of these two.

40. How is the mean deviation calculated for a given dataset?

- (A) Adding all the values of the given dataset.
- (B) Dividing the sum of all the values of the given dataset by the number of observations in the dataset.
- (C) Dividing the sum of all the deviations from the mean by the number of observations in the dataset.
- (D) Dividing the sum of squares of all the deviations from mean by the number of observations in the dataset.

Correct Answer: (C) Dividing the sum of all the deviations from the mean by the number of observations in the dataset.

Solution:

Step 1: Understanding the Concept:

The question asks for the definition or method of calculating the mean deviation. Mean deviation (or mean absolute deviation) is a measure of the average distance between each data point and the mean of the dataset.

Step 2: Analyzing the options:

- (A) **Adding all the values of the given dataset.** This gives the sum of the data, not a measure of deviation.
- (B) **Dividing the sum of all the values... by the number of observations...** This is the definition of the arithmetic **mean**.
- (C) **Dividing the sum of all the deviations from the mean... by the number of observations...** This is the definition of **mean deviation**. It's important to note that "deviations" here implies the absolute values of the deviations $|x_i - \bar{x}|$, because the sum of the

simple deviations $\sum(x_i - \bar{x})$ is always zero. Given the options, this is the intended correct answer. The formula is: $MD = \frac{\sum |x_i - \bar{x}|}{N}$.

- **(D) Dividing the sum of squares of all the deviations from mean... by the number of observations...** This is the definition of the population **variance** (σ^2).

Step 3: Final Answer:

Option (C) provides the correct description for calculating the mean deviation.

Quick Tip

Keep the key statistical definitions straight:

- **Mean:** Sum of values / Number of values.
- **Mean Deviation:** Sum of absolute deviations from mean / Number of values.
- **Variance:** Sum of squared deviations from mean / Number of values (or N-1 for sample).

41. Ciliated simple columnar epithelium located at: -

A. Lining of some bronchioles of the respiratory tract

B. Cover surface of ovary

C. Larger ducts of many glands

D. Ventricles of brain

Choose the most appropriate answer from the options given below:

(A) A and D only

(B) B and C only

(C) A, B, C and D

(D) B, C and D only

Correct Answer: (A) A and D only

Solution:

Step 1: Understanding the Concept:

Ciliated simple columnar epithelium consists of a single layer of tall, column-shaped cells that have cilia on their apical surface. Cilia are motile structures that beat in a coordinated manner to move substances over the epithelial surface. We need to identify the locations where this specific tissue type is found.

Step 2: Detailed Explanation:

- **A. Lining of some bronchioles of the respiratory tract:** This is a correct location. The cilia here are part of the mucociliary escalator, which moves mucus and trapped debris up and out of the respiratory tract.

- **B. Cover surface of ovary:** This is incorrect. The surface of the ovary is covered by simple cuboidal epithelium, often referred to as germinal epithelium.
- **C. Larger ducts of many glands:** This is incorrect. While some large ducts may have columnar epithelium, it is typically non-ciliated or stratified, not ciliated simple columnar.
- **D. Ventricles of brain:** This is a correct location. The ventricles of the brain and the central canal of the spinal cord are lined by ependymal cells, which are a type of glial cell that forms a ciliated simple cuboidal to columnar epithelium. The cilia help to circulate the cerebrospinal fluid (CSF).

Step 3: Final Answer:

Based on the analysis, ciliated simple columnar epithelium is found in some bronchioles (A) and the ventricles of the brain (D). Therefore, the correct option is (A).

Quick Tip

Associate cilia with the movement of fluid or mucus. Key locations to remember are the respiratory tract (moving mucus), the fallopian tubes (moving the ovum), and the brain ventricles/spinal cord canal (moving cerebrospinal fluid).

42. Which one of the following statements is applicable to satellite cells?

- (A) These cells encircle PNS axons. They form the myelin sheath around the axons.
- (B) These are the flat cells surrounding the cell bodies of neurons in PNS ganglia.
- (C) These are cuboidal to columnar cells arranged in a single layer that possess microvilli and cilia.
- (D) These are small cells with slender processes that give off numerous spinelike projections.

Correct Answer: (B) These are the flat cells surrounding the cell bodies of neurons in PNS ganglia.

Solution:

Step 1: Understanding the Concept:

Satellite cells are a type of glial cell found in the peripheral nervous system (PNS). Glial cells are non-neuronal cells that provide support and protection for neurons. The question asks for the correct description of satellite cells.

Step 2: Detailed Explanation:

- **Statement 1:** This describes Schwann cells. Schwann cells are the glial cells in the PNS responsible for encircling axons and forming the myelin sheath.
- **Statement 2:** This is the correct definition of satellite cells. They are flat cells that surround the cell bodies (soma) of neurons located within ganglia of the PNS. They provide structural support and regulate the chemical environment of the neurons.
- **Statement 3:** This describes a type of epithelial tissue, not a glial cell.

- **Statement 4:** This is the characteristic description of microglia, which are the resident immune cells of the central nervous system (CNS).

Step 3: Final Answer:

The statement that accurately describes satellite cells is that they are flat cells surrounding neuronal cell bodies in PNS ganglia. Therefore, option (B) is correct.

Quick Tip

Remember the two main glial cells of the PNS and their primary associations:

- **Schwann Cells** → **Axons** (myelination)
- **Satellite Cells** → **Cell bodies** (support in ganglia)

43. The trigeminal nerve is the largest nerve with following branches:

- A. Olfactory**
- B. Ophthalmic**
- C. Maxillary**
- D. Mandibular**

Choose the most appropriate answer from the options given below:

- (A) A, B and D only
- (B) B, C and D only
- (C) A, B, C and D
- (D) A, C and D only

Correct Answer: (B) B, C and D only

Solution:

Step 1: Understanding the Concept:

The trigeminal nerve is the fifth cranial nerve (CN V). It is the largest cranial nerve and is a mixed nerve, meaning it has both sensory and motor functions. It is primarily responsible for sensation in the face and motor functions such as biting and chewing. The question asks to identify its main branches.

Step 2: Detailed Explanation:

The trigeminal nerve has three major branches, or divisions:

- **Ophthalmic nerve (V1):** This is a sensory nerve that supplies the skin of the forehead, scalp, upper eyelid, and the front of the nose. This corresponds to **B**.
- **Maxillary nerve (V2):** This is also a sensory nerve. It supplies the skin over the maxilla (upper jaw), the lower eyelid, and the upper lip. This corresponds to **C**.
- **Mandibular nerve (V3):** This is a mixed nerve, containing both sensory and motor fibers. It supplies sensation to the skin over the mandible (lower jaw) and side of the head. Its motor

fibers innervate the muscles of mastication. This corresponds to **D**.

- The **Olfactory** nerve (**A**) is the first cranial nerve (CN I) and is responsible for the sense of smell. It is not a branch of the trigeminal nerve.

Step 3: Final Answer:

The three branches of the trigeminal nerve are the ophthalmic, maxillary, and mandibular nerves. Therefore, B, C, and D are the correct choices. This corresponds to option (B).

Quick Tip

The name "trigeminal" itself means "three-twin," referring to its three major branches. You can remember the branches by the part of the face they serve: V1 Ophthalmic (eye area), V2 Maxillary (upper jaw), and V3 Mandibular (lower jaw).

44. What is Ferritin?

(A) It is an iron storage protein in muscle fibers, liver cells and macrophages of the spleen and liver. Iron detaches from transferrin and attaches to ferritin.

(B) It is a non-iron portion of heme which is converted to biliverdin.

(C) It is plasma protein which transfers free iron into the blood stream.

(D) It is an iron-containing molecule which transports oxygen from the blood stream to the tissues.

Correct Answer: (A) It is an iron storage protein in muscle fibers, liver cells and macrophages of the spleen and liver. Iron detaches from transferrin and attaches to ferritin.

Solution:

Step 1: Understanding the Concept:

This question asks for the definition of ferritin, a key protein involved in iron metabolism.

Step 2: Detailed Explanation of Options:

- **Statement 1:** This is the correct definition. Ferritin is the primary intracellular protein for iron storage. It is found in most tissues, but particularly in the liver, spleen, and skeletal muscle. Iron is transported in the blood by transferrin, and when it reaches a cell for storage, it is released from transferrin and taken up by ferritin.

- **Statement 2:** This describes the breakdown of the heme group from hemoglobin. The iron is removed, and the remaining porphyrin ring is converted to biliverdin, which is then reduced to bilirubin.

- **Statement 3:** This describes Transferrin, the main plasma protein that transports iron through the blood.

- **Statement 4:** This describes Hemoglobin, the protein in red blood cells that contains iron in its heme groups and is responsible for transporting oxygen.

Step 3: Final Answer:

The most accurate description of ferritin is that it is the main iron storage protein inside cells. Therefore, option (A) is correct.

Quick Tip

Remember the key proteins in iron metabolism:

- **Hemoglobin:** Oxygen **transport** in blood.
- **Transferrin:** Iron **transport** in blood.
- **Ferritin:** Iron **storage** in cells.

45. Calculate the Harmonic Mean of the following data:

10 20 40 60 120

- (A) 25
- (B) 27.5
- (C) 32.5
- (D) 50

Correct Answer: (A) 25

Solution:

Step 1: Understanding the Concept:

The harmonic mean is a type of average, calculated as the reciprocal of the arithmetic mean of the reciprocals of the observations. It is particularly useful for averaging rates.

Step 2: Key Formula or Approach:

The formula for the Harmonic Mean (HM) is:

$$HM = \frac{n}{\sum_{i=1}^n \frac{1}{x_i}}$$

where n is the number of observations and x_i are the individual values.

Step 3: Detailed Calculation:

1. **Identify the data and n:** The data points are 10, 20, 40, 60, 120. The number of observations, n , is 5.

2. **Calculate the reciprocals of each value:**

$\frac{1}{10}, \frac{1}{20}, \frac{1}{40}, \frac{1}{60}, \frac{1}{120}$

3. **Sum the reciprocals ($\sum \frac{1}{x_i}$):**

To add these fractions, we find a common denominator, which is 120.

$$\sum \frac{1}{x_i} = \frac{12}{120} + \frac{6}{120} + \frac{3}{120} + \frac{2}{120} + \frac{1}{120} = \frac{12+6+3+2+1}{120} = \frac{24}{120}$$

Simplifying the fraction: $\frac{24}{120} = \frac{1}{5}$ or 0.2.

4. **Calculate the Harmonic Mean:**

$$HM = \frac{n}{\sum \frac{1}{x_i}} = \frac{5}{\frac{1}{5}} = 5 \times 5 = 25$$

Step 4: Final Answer:

The Harmonic Mean of the given data is 25. Therefore, option (A) is correct.

Quick Tip

For any set of positive numbers, the Harmonic Mean $\leq$ Geometric Mean $\leq$ Arithmetic Mean. For this dataset, the Arithmetic Mean is $(10+20+40+60+120)/5 = 50$. The HM must be less than 50. This can help eliminate incorrect higher options.

46. What is the correct sequence of four steps of the contraction cycle in muscles?

- A. Power stroke
- B. Attachment of myosin to actin
- C. ATP hydrolysis
- D. Detachment of myosin from actin

Choose the most appropriate answer from the options given below:

- (A) A, B, C, D
- (B) A, C, B, D
- (C) C, B, A, D
- (D) C, B, D, A

Correct Answer: (C) C, B, A, D

Solution:

Step 1: Understanding the Concept:

The muscle contraction cycle, also known as the cross-bridge cycle, describes the series of molecular events that occur between actin and myosin filaments during muscle contraction.

Step 2: Detailed Explanation of the Sequence:

The cycle can be thought of as starting with the myosin head in a state ready to bind.

1. **C. ATP hydrolysis:** The myosin head has an ATP binding site and ATPase activity. It hydrolyzes ATP into ADP and inorganic phosphate (Pi). The energy released from this hydrolysis "cocks" the myosin head into a high-energy, ready position.
2. **B. Attachment of myosin to actin:** The high-energy myosin head attaches to an available binding site on the actin filament, forming a cross-bridge.

3. **A. Power stroke:** The release of the inorganic phosphate (Pi) from the myosin head triggers the power stroke. The myosin head pivots and pulls the actin filament towards the center of the sarcomere (the M line). ADP is then released.

4. **D. Detachment of myosin from actin:** A new molecule of ATP binds to the myosin head. This binding causes the myosin head to detach from the actin filament. The cycle is now ready to begin again with the hydrolysis of this new ATP molecule (back to step C).

Step 3: Final Answer:

The correct sequence of these four events is $C \rightarrow B \rightarrow A \rightarrow D$. This corresponds to option (C).

Quick Tip

Remember the two key roles of ATP in the cycle:

- **Splitting ATP (Hydrolysis)** → Energizes/Cocks the myosin head.
- **Binding of new ATP** → Causes detachment of myosin from actin. Rigor mortis occurs after death because there is no new ATP to cause detachment.

47. Arrange the following enzymes of the citric acid cycle in the correct sequence.

A. Aconitase

B. Fumarase

C. Malate dehydrogenase

D. Isocitrate dehydrogenase

Choose the most appropriate answer from the options given below:

(A) D, A, B, C

(B) B, D, C, A

(C) C, D, A, B

(D) A, D, B, C

Correct Answer: (D) A, D, B, C

Solution:

Step 1: Understanding the Concept:

The citric acid cycle (or Krebs cycle) is a series of eight enzyme-catalyzed chemical reactions that form a key part of cellular respiration. The question asks to arrange a given subset of these enzymes in the order they appear in the cycle. Note: Option B lists the substrate "Fumarate," but it represents the enzyme "Fumarase."

Step 2: Detailed Explanation of the Sequence:

Let's place the given enzymes in the context of the full cycle:

- (Step 1: Citrate Synthase)

- **Step 2: A. Aconitase** - converts citrate to its isomer, isocitrate.

- **Step 3: D. Isocitrate dehydrogenase** - oxidizes isocitrate to α -ketoglutarate, producing NADH.
- (Step 4: α -Ketoglutarate dehydrogenase)
- (Step 5: Succinyl-CoA synthetase)
- (Step 6: Succinate dehydrogenase)
- **Step 7: B. Fumarase** - hydrates fumarate to form malate.
- **Step 8: C. Malate dehydrogenase** - oxidizes malate to oxaloacetate, producing NADH and regenerating the cycle's starting substrate.

Step 3: Final Answer:

The correct sequence of the listed enzymes as they function in the citric acid cycle is Aconitase $\rightarrow$ Isocitrate dehydrogenase $\rightarrow$ Fumarase $\rightarrow$ Malate dehydrogenase. This corresponds to the order A, D, B, C. Therefore, option (D) is correct.

Quick Tip

A helpful mnemonic for the substrates of the Krebs cycle is: "C**itrate I**s K**rebs' S**tarting S**ubstrate F**or M**aking O**xaloacetate."

- Aconitase acts on C**itrate.
- Isocitrate dehydrogenase acts on I**s
- Fumarase acts on F**or
- Malate dehydrogenase acts on M**aking

This helps confirm the sequence A, D, B, C.

48. In Glycolipids and sphingolipids, glycerol is replaced by which amino alcohol?

- (A) Sphingomyelins
- (B) Gangliosides
- (C) Sphingosine
- (D) Sulfatides

Correct Answer: (C) Sphingosine

Solution:

Step 1: Understanding the Concept:

Biological membranes are primarily composed of lipids. There are two main classes of membrane lipids based on their backbone structure: glycerophospholipids (which use a glycerol backbone) and sphingolipids. The question asks for the specific molecule that forms the backbone of sphingolipids, replacing the glycerol molecule.

Step 2: Detailed Explanation:

- **Sphingosine** is an 18-carbon amino alcohol with an unsaturated hydrocarbon chain, which forms the characteristic backbone of sphingolipids.
- A sphingolipid is formed when a fatty acid is joined to the sphingosine via an amide linkage, forming a ceramide. Various head groups can then be attached to the ceramide.
- The other options provided are all types of complex sphingolipids, not the backbone molecule itself:
- **Sphingomyelins** are ceramides with a phosphocholine or phosphoethanolamine head group.
- **Gangliosides** and **Sulfatides** are types of glycolipids (specifically glycosphingolipids), where the head group is a complex oligosaccharide.

Step 3: Final Answer:

In sphingolipids, the glycerol backbone found in glycerophospholipids is replaced by the amino alcohol sphingosine. Therefore, option (C) is the correct answer.

Quick Tip

The name of the class of lipids often gives a clue to its structure. Just as **glycerolipids** have a **glycerol** backbone, **sphingolipids** have a **sphingosine** backbone. The other options are examples of complex sphingolipids, not the fundamental building block.

49. At low substrate concentration, the initial velocity of reaction is described as _____. However, as substrate concentration increases, the reaction saturates and reaches a _____.

- (A) Hyperbola and Plateau
- (B) Plateau and Hyperbola
- (C) Straight line and Hyperbola
- (D) Straight line and straight line

Correct Answer: (A) Hyperbola and Plateau

Solution:

Step 1: Understanding the Concept:

This question describes the key features of a Michaelis-Menten plot, which graphs the initial reaction velocity (V_0) against the substrate concentration ($[S]$) for an enzyme-catalyzed reaction.

Step 2: Detailed Explanation:

The Michaelis-Menten equation is $V_0 = \frac{V_{max}[S]}{K_m + [S]}$.

- At **low substrate concentration** ($[S] \ll K_m$), the reaction is approximately first-order with respect to $[S]$, and the initial part of the graph is nearly a straight line.
- As **substrate concentration increases**, the rate of increase in velocity slows down because the enzyme's active sites are becoming occupied. The overall shape of this curve, showing the relationship between V_0 and $[S]$, is a rectangular **hyperbola**.
- At **high substrate concentration** ($[S] \gg K_m$), the enzyme's active sites are completely saturated with the substrate. The reaction rate becomes independent of $[S]$ and approaches its maximum velocity (V_{max}). On the graph, this saturation is represented by the curve leveling off, forming a **plateau**.

Step 3: Final Answer:

The question asks to describe the overall shape of the velocity curve and the state it reaches at saturation. The curve is a hyperbola, and it reaches a plateau. Therefore, option (A) is the best description. (Note: While the very initial part of the curve is a straight line, the entire curve is described as a hyperbola).

Quick Tip

Remember the two extremes of Michaelis-Menten kinetics:

- **Low $[S]$:** First-order kinetics (rate depends on $[S]$). Graph is a line.
- **High $[S]$:** Zero-order kinetics (rate is independent of $[S]$). Graph is a plateau at V_{max} .
- **Overall Shape:** A hyperbola that connects these two extremes.

50. Cellulose is a homopolymer of:

- (A) Alpha glucose
- (B) Beta glucose
- (C) Alpha fructose
- (D) Beta fructose

Correct Answer: (B) Beta glucose

Solution:

Step 1: Understanding the Concept:

A homopolymer is a polymer consisting of identical monomer units. Cellulose is a major structural polysaccharide found in the cell walls of plants. The question asks for its constituent monomer.

Step 2: Detailed Explanation:

- Polysaccharides are polymers of monosaccharides. The two most common polysaccharides

made of glucose are starch and cellulose.

- The difference between them lies in the isomeric form of the glucose monomer and the resulting glycosidic bond.
- **Starch** and **glycogen** are polymers of **alpha-glucose**, linked by α -1,4 glycosidic bonds. This linkage results in a helical polymer structure, suitable for energy storage.
- **Cellulose** is a polymer of **beta-glucose**, linked by β -1,4 glycosidic bonds. This linkage results in long, straight, unbranched chains. These chains can lie parallel to each other and form strong hydrogen bonds, creating rigid microfibrils that are ideal for structural support.
- Fructose is a different monosaccharide, a ketose, while glucose is an aldose.

Step 3: Final Answer:

Cellulose is a linear homopolymer composed of repeating units of beta-glucose. Therefore, option (B) is correct.

Quick Tip

Remember the key difference: α -glucose polymers (starch, glycogen) are for energy storage and are generally digestible by animals. β -glucose polymers (cellulose) are for structure and are generally indigestible by animals without the help of symbiotic microorganisms.

51. Match LIST-I with LIST-II

LIST-I		LIST-II	
Name of the amino acid		One letter abbreviation/name	
A.	Methionine	I.	D
B.	Aspartic acid	II.	K
C.	Lysine	III.	E
D.	Glutamine	IV.	M

Choose the correct answer from the options given below:

- (A) A - II, B - III, C - I, D - IV
- (B) A - IV, B - I, C - II, D - III
- (C) A - I, B - II, C - IV, D - III
- (D) A - III, B - IV, C - I, D - II

Correct Answer: (B) A - IV, B - I, C - II, D - III

Solution:

Step 1: Understanding the Concept:

The question requires matching standard amino acids with their universally accepted one-letter abbreviations. These are essential to know for reading protein sequences.

Step 2: Detailed Matching:

- **A. Methionine:** The one-letter code is **M**. Thus, **A matches with IV**.
- **B. Aspartic acid:** The one-letter code is **D** (from aspar**D**ic). Thus, **B matches with I**.
- **C. Lysine:** The one-letter code is **K** (as L is taken by Leucine, K is the preceding letter). Thus, **C matches with II**.
- **D. Glutamine:** The one-letter code is **Q** (pronounced 'Q-tamine'). However, Q is not in LIST-II. LIST-II has **E**, which is the code for **Glutamic acid**. There appears to be a typo in the question, with "Glutamine" in LIST-I likely intended to be "Glutamic acid". Assuming this correction, Glutamic acid's code is E (from glutam**E**c). Thus, **D matches with III**.

Step 3: Final Answer:

Based on the standard codes and correcting for the likely typo, the matches are A-IV, B-I, C-II, D-III. This combination corresponds to option (B).

Quick Tip

For amino acids whose names don't start with a unique letter, the codes can be tricky. Memorize these: Aspartic Acid (D), Glutamic Acid (E), Asparagine (N), Glutamine (Q), Phenylalanine (F), Tyrosine (Y), Tryptophan (W), Lysine (K).

52. Match LIST-I with LIST-II

LIST-I Parts of Mesoderm		LIST-II Body parts formed	
A.	Intermediate Mesoderm	I.	Notochord
B.	Chorda Mesoderm	II.	Circulatory system
C.	Paraxial Mesoderm	III.	Kidney
D.	Lateral Plate Mesoderm	IV.	Skeletal Muscle

Choose the most appropriate answer from the options given below:

- (A) A - I, B - II, C - III, D - IV
- (B) A - III, B - I, C - IV, D - II
- (C) A - II, B - IV, C - I, D - III
- (D) A - IV, B - III, C - I, D - II

Correct Answer: (B) A - III, B - I, C - IV, D - II

Solution:

Step 1: Understanding the Concept:

During embryonic development, the mesoderm, one of the three primary germ layers, differentiates into several distinct regions. Each region gives rise to specific tissues and organs in the adult body. This question tests knowledge of the derivatives of these mesodermal parts.

Step 2: Detailed Matching:

- **A. Intermediate Mesoderm:** This region is located between the paraxial and lateral plate mesoderm. It develops into the urogenital system, which includes the **kidneys** and gonads. Thus, **A matches with III**.

- **B. Chorda Mesoderm:** This is the axial mesoderm that runs along the midline of the embryo. It gives rise to the **notochord**, a key signaling center for the developing nervous system and vertebral column. Thus, **B matches with I**.

- **C. Paraxial Mesoderm:** This mesoderm is located on either side of the neural tube. It segments to form somites, which differentiate into the myotome (forming **skeletal muscle**), sclerotome (forming cartilage and bone of the vertebral column), and dermatome (forming the dermis of the skin). Thus, **C matches with IV**.

- **D. Lateral Plate Mesoderm:** This is the most lateral part of the mesoderm. It splits to form the lining of the body cavity (coelom). It gives rise to the heart, blood vessels, and blood cells of the **circulatory system**, as well as the smooth muscle of the gut and limb bones. Thus, **D matches with II**.

Step 3: Final Answer:

The correct pairings are A-III, B-I, C-IV, D-II. This corresponds to option (B).

Quick Tip

Create a mental map of the mesoderm cross-section from the center outwards:

- **Center/Axial (Chorda):** Notochord
- **Next to center (Paraxial):** Somites (muscle, vertebrae)
- **In between (Intermediate):** Kidneys/Gonads
- **Outermost (Lateral Plate):** Circulatory system, Body cavity lining

53. What is the full form of the IMZ abbreviation?

- (A) Invaginating marginal zone
- (B) Involuting marginal zone
- (C) Ingression marginal zone
- (D) Inducing marginal zone

Correct Answer: (B) Involuting marginal zone

Solution:

Step 1: Understanding the Concept:

In developmental biology, particularly during amphibian gastrulation, the embryo is divided into several zones. The marginal zone lies between the animal and vegetal poles. IMZ is an abbreviation for a specific part of this zone involved in a key gastrulation movement.

Step 2: Detailed Explanation:

- Gastrulation is the process where the single-layered blastula reorganizes into a three-layered gastrula (ectoderm, mesoderm, endoderm). This involves complex cell movements.
- **Involution** is a specific type of cell movement where a sheet of cells turns inward and spreads over an internal surface.
- The **Involuting Marginal Zone (IMZ)** is the band of cells in the amphibian embryo that rolls inward over the dorsal lip of the blastopore during gastrulation. These cells will form the future mesodermal structures like the notochord and somites.
- The other terms refer to different cell movements: *Invagination* is an infolding of a cell sheet, and *ingression* is the migration of individual cells from the surface into the embryo's interior.

Step 3: Final Answer:

The abbreviation IMZ stands for Involuting Marginal Zone, which accurately describes the function of this region during gastrulation. Therefore, option (B) is correct.

Quick Tip

Associate the key cell movements with their definitions:

- **Involute:** A sheet of cells rolls inward. (IMZ in amphibians)
- **Invaginate:** A sheet of cells folds in on itself. (Sea urchin endoderm formation)
- **Ingress:** Individual cells detach and migrate inward. (Sea urchin mesoderm formation)

54. What is the function of yolk sac?

- (A) It contains blood vessels that exchange gases with the outside environment.
- (B) It stores waste products.
- (C) It enables the embryo to float in a fluid environment that protects it from desiccation.
- (D) It enables nutrient uptake and the development of the circulatory system.

Correct Answer: (D) It enables nutrient uptake and the development of the circulatory system.

Solution:

Step 1: Understanding the Concept:

The yolk sac is one of the four extraembryonic membranes that support the developing embryo

in amniotes (reptiles, birds, mammals). Each membrane has a specialized function.

Step 2: Detailed Explanation of Functions:

- **Yolk Sac:** Its primary role is to enclose the yolk, which serves as the main source of nutrition for the embryo. It develops an extensive network of blood vessels to absorb these nutrients and transport them to the embryo. In mammals, it is the first site of blood cell formation. This matches option (D).
- **Chorion and Allantois:** The chorion lies just beneath the eggshell and, along with the allantois, forms the chorioallantoic membrane, which is the main site for gas exchange (option A).
- **Allantois:** This sac stores metabolic wastes, particularly uric acid (option B).
- **Amnion:** This membrane encloses the amniotic fluid, which provides a protective, fluid-filled cushion for the embryo, preventing mechanical shock and desiccation (option C).

Step 3: Final Answer:

The principal function of the yolk sac is to facilitate the uptake of nutrients from the yolk and to establish the initial circulatory system to transport these nutrients. Therefore, option (D) is the correct answer.

Quick Tip

Remember the 'A, B, C' of extraembryonic membranes:

- **A**mnion = **A**quatic environment (protection).
- **B**ladder (Allantois) = **B**ladder (Stores waste).
- **C**horion = **C**overing (Gas exchange).
- **Y**olk Sac = **F**ood source.

55. In Amphibia, gastrulation begins at:

- (A) The part of the egg opposite to the entry of the sperm.
- (B) Animal pole
- (C) Vegetal pole
- (D) Dorsal blastopore lip.

Correct Answer: (D) Dorsal blastopore lip.

Solution:

Step 1: Understanding the Concept:

Gastrulation is the process of forming the three primary germ layers. In amphibians, this process is initiated at a specific location on the surface of the blastula.

Step 2: Detailed Explanation:

- The initiation point of gastrulation in an amphibian embryo is marked by the formation of a slit-like invagination called the blastopore.
- The first part of this structure to form is the **dorsal blastopore lip**. This is the precise site where the first cells begin to involute (roll inward) to form the mesoderm and endoderm.
- The location of the dorsal blastopore lip is determined earlier in development. Sperm entry triggers a cortical rotation, which establishes the future dorsal-ventral axis. The dorsal blastopore lip forms in a region known as the gray crescent, which appears on the side of the egg opposite to the point of sperm entry.
- While option (A) is correct in describing where the process is located relative to sperm entry, option (D) names the specific anatomical structure where the cellular movements of gastrulation physically begin. Therefore, (D) is the more precise and direct answer. The animal and vegetal poles (B and C) are the top and bottom ends of the embryo, respectively, not the starting point of gastrulation.

Step 3: Final Answer:

Gastrulation begins at the specific structure known as the dorsal blastopore lip. This structure is also famously known as the "Spemann-Mangold organizer" because it orchestrates the development of the entire embryonic axis. Option (D) is the correct answer.

Quick Tip

The dorsal blastopore lip is the "director" of gastrulation. It's not just a location, but an active organizer that initiates and controls the complex cell movements that shape the embryo.

56. Which one of the following zones is absent in pond ecosystems?

- (A) Littoral Zone
- (B) Limnetic Zone
- (C) Profundal Zone
- (D) Euphotic Zone

Correct Answer: (C) Profundal Zone

Solution:**Step 1: Understanding the Concept:**

Lentic (standing water) ecosystems like lakes and ponds are vertically zoned based on the penetration of sunlight. The question asks which of these zones is typically absent in a pond.

Step 2: Detailed Explanation of Zones:

- **Littoral Zone:** The shallow, near-shore area where light reaches the bottom, supporting rooted aquatic plants. All ponds have a littoral zone.

- **Limnetic Zone:** The open, well-lit water surface area away from the shore, dominated by plankton. Ponds have this zone.
- **Euphotic Zone:** This is the entire upper layer of water that receives enough sunlight for photosynthesis to occur. It encompasses both the littoral and limnetic zones. Ponds are entirely within the euphotic zone.
- **Profundal Zone:** This is the deep, aphotic (non-light receiving) zone of water below the limnetic zone. It is too dark for photosynthesis. Because ponds are, by definition, shallow bodies of water, sunlight typically penetrates all the way to the bottom. Therefore, ponds lack a true, permanently dark profundal zone, which is a characteristic feature of deep lakes.

Step 3: Final Answer:

Due to their shallow depth, ponds typically lack a profundal zone. Therefore, option (C) is the correct answer.

Quick Tip

Associate the zone names with their meaning: "Littoral" relates to the shore. "Limnetic" comes from the Greek for lake. "Euphotic" means "well-lit." "Profundal" comes from "profound," meaning deep. Since ponds are not deep, they lack a profundal zone.

57. Match LIST-I with LIST-II

LIST-I Interaction Type		LIST-II Example	
A.	Mutualism	I.	Chlorella vulgaris and Diatoms
B.	Commensalism	II.	Termites and Trichonympha
C.	Proto-cooperation	III.	Intestine of Man and Entamoeba coli
D.	Antibiosis	IV.	Adamsia pallia and hermit crab

Choose the most appropriate answer from the options given below:

- (A) A - II, B - III, C - IV, D - I
- (B) A - I, B - III, C - II, D - IV
- (C) A - I, B - II, C - IV, D - III
- (D) A - III, B - IV, C - I, D - II

Correct Answer: (A) A - II, B - III, C - IV, D - I

Solution:

Step 1: Understanding the Concept:

This question requires matching different types of ecological interactions with their classic biological examples.

Step 2: Detailed Matching:

- **A. Mutualism (+/+)**: An interaction where both species benefit, and the relationship is obligatory (they cannot survive without each other). The relationship between **Termites and Trichonympha** is a perfect example. The termite provides wood and a home, while the protozoan digests the cellulose. So, **A matches II**.
- **B. Commensalism (+/0)**: An interaction where one species benefits, and the other is neither harmed nor helped. **Entamoeba coli** is a non-pathogenic amoeba living in the human intestine, feeding on gut contents without affecting the host. So, **B matches III**.
- **C. Proto-cooperation (+/+)**: A non-obligatory mutualistic relationship. Both species benefit but can survive independently. The relationship between the sea anemone **Adamsia pallia** and a **hermit crab** is a classic example. The crab gets camouflage and protection, while the anemone gets mobility and food scraps. So, **C matches IV**.
- **D. Antibiosis (-/0)**: A type of amensalism where one organism produces a chemical that inhibits or kills another. Allelopathy, where one organism secretes biochemicals that affect others, is a form of this. The relationship between certain algae like **Chlorella** and **Diatoms** can involve competition and allelopathy, where one may inhibit the other, making it a plausible (though less common) example of antibiosis in this context. So, **D matches I**.

Step 3: Final Answer:

The correct set of matches is A-II, B-III, C-IV, D-I. This corresponds to option (A).

Quick Tip

Differentiate Mutualism and Proto-cooperation by asking: "Is it required for survival?" If yes, it's Mutualism (e.g., Termite-Trichonympha). If no, it's Proto-cooperation (e.g., Hermit crab-Anemone).

58. Arrange the following stages of ecological succession in the correct sequence

- A. Ecesis
- B. Nudation
- C. Aggregation
- D. Reaction

Choose the most appropriate answer from the options given below:

- (A) A, B, C, D
- (B) A, C, B, D
- (C) B, A, C, D
- (D) C, B, D, A

Correct Answer: (C) B, A, C, D

Solution:

Step 1: Understanding the Concept:

Ecological succession is the process of change in the species structure of an ecological community over time. It follows a predictable sequence of stages.

Step 2: Detailed Explanation of the Sequence:

1. **B. Nudation:** This is the first step. It is the development of a bare area, completely devoid of life, due to factors like volcanic eruption, landslides, fire, or flooding.
2. **A. Ecesis:** This is the successful establishment of a species in a new area. It involves the germination of propagules (like seeds or spores), growth, and survival of the pioneer species that have migrated to the bare site.
3. **C. Aggregation:** Following successful establishment (ecesis), the individuals of the pioneer species reproduce and increase in number, forming groups or aggregations.
4. **D. Reaction:** As the pioneer species grow and aggregate, they begin to alter the environment. This is called reaction. They change soil composition, light availability, and moisture levels. This alteration makes the environment less suitable for themselves but more suitable for other, more competitive species to invade.

Step 3: Final Answer:

The correct chronological order of the stages of succession is Nudation → Ecesis → Aggregation → Reaction. This corresponds to the sequence B, A, C, D. Therefore, option (C) is correct.

Quick Tip

Remember the succession sequence as a story of colonization:

1. **Bare land** (Nudation)
2. **First settlers arrive and establish** (Ecesis)
3. **Settlers multiply and form a village** (Aggregation)
4. **The village changes the landscape** (Reaction)

59. Which of the following statements are correct with reference to Photochemical Smog?

- A. It is an oxidizing smog.
- B. It is formed by the reaction between NO_2 and hydrocarbons.
- C. It is a reducing smog.
- D. It is formed in the presence of UV-radiation.

Choose the most appropriate answer from the options given below:

- (A) A, B and D only
- (B) A and B only
- (C) C and D only
- (D) B, C and D only

Correct Answer: (A) A, B and D only

Solution:

Step 1: Understanding the Concept:

Photochemical smog, also known as Los Angeles-type smog, is a type of air pollution that is common in modern industrial cities with a large number of automobiles. The question asks for its defining characteristics.

Step 2: Analyzing each statement:

- **Statement A: True.** Photochemical smog is characterized by high concentrations of oxidizing agents, primarily ozone (O_3). This makes it an oxidizing smog.
- **Statement B: True.** The primary pollutants that lead to photochemical smog are nitrogen oxides (NO_x , including NO_2) and volatile organic compounds (VOCs), which are hydrocarbons. These are mainly emitted from vehicle exhaust.
- **Statement C: False.** This is the opposite of statement A. Reducing smog, also called classical or London-type smog, is characterized by high levels of sulfur dioxide (SO_2) from burning coal and has a reducing chemical nature.
- **Statement D: True.** The term "photochemical" indicates that sunlight is required. Ultra-violet (UV) radiation from the sun provides the energy to drive the chemical reactions between NO_x and VOCs, leading to the formation of secondary pollutants like ozone.

Step 3: Final Answer:

The correct statements are A, B, and D. Therefore, option (A) is the correct choice.

Quick Tip

Break down the name "Photochemical Smog":

- **Photo:** Needs sunlight (UV radiation).
- **Chemical:** Involves chemical reactions of primary pollutants ($NO_x + VOCs$).
- **Smog:** Forms a haze containing secondary pollutants, which are strong **oxidizing** agents (Ozone).

60. The Air Quality Index is measured using the Criteria Pollutants. Which one of the following is not a Criteria Pollutant?

- (A) Sulfur Dioxide
- (B) Lead
- (C) Carbon dioxide
- (D) Ozone

Correct Answer: (C) Carbon dioxide

Solution:

Step 1: Understanding the Concept:

"Criteria air pollutants" is a term used (originally by the US Environmental Protection Agency, but the concept is applied globally) for a group of six common air pollutants that are widespread and known to be harmful to public health and the environment. The Air Quality Index (AQI) is primarily based on the concentrations of these pollutants.

Step 2: Identifying the Criteria Pollutants:

The six criteria air pollutants are:

1. Ground-level Ozone (O_3)
2. Particulate Matter ($PM_{2.5}$ and PM_{10})
3. Carbon Monoxide (CO)
4. Sulfur Dioxide (SO_2)
5. Nitrogen Dioxide (NO_2)
6. Lead (Pb)

Step 3: Analyzing the Options:

- (A) **Sulfur Dioxide (SO_2)**: This is a criteria pollutant.
- (B) **Lead (Pb)**: This is a criteria pollutant.
- (C) **Carbon dioxide (CO_2)**: This is a major greenhouse gas responsible for climate change, but it is **not** classified as a criteria air pollutant because it is not directly toxic to humans at typical ambient concentrations.
- (D) **Ozone (O_3)**: Ground-level ozone is a criteria pollutant.

Step 4: Final Answer:

Carbon dioxide (CO_2) is not on the list of criteria pollutants used for calculating the AQI. Therefore, option (C) is the correct answer.

Quick Tip

Be careful to distinguish between direct air pollutants and greenhouse gases. The AQI measures pollutants that cause immediate health effects like asthma (Ozone, SO_2 , PM). Carbon Dioxide (CO_2) is the primary driver of global warming but is not an AQI component. However, Carbon *Monoxide* (CO) **is** a criteria pollutant.

61. Which of the following factors can influence the process of weathering?

- A. Rock type and structure
- B. Slope
- C. Climatic Conditions
- D. Time

Choose the most appropriate answer from the options given below:

- (A) A, C and D only
- (B) A and C only
- (C) A, B, C and D
- (D) A and D only

Correct Answer: (C) A, B, C and D

Solution:

Step 1: Understanding the Concept:

Weathering is the physical disintegration and chemical decomposition of rocks at or near the Earth's surface. It is influenced by a combination of geological, topographical, climatic, and temporal factors.

Step 2: Detailed Explanation:

- **A. Rock type and structure:** This is a critical factor. Different rocks have varying resistance to weathering based on their mineral composition (e.g., quartz is very resistant, while calcite is easily weathered by acid rain). The rock's structure, such as the presence of cracks, joints, and bedding planes, increases the surface area exposed to weathering agents, accelerating the process.
- **B. Slope:** The steepness of a slope affects weathering. On steep slopes, gravity can cause physical weathering through rockfalls. Slope also influences the amount of precipitation that can soak into the ground versus running off. Furthermore, weathered material (regolith) is removed more quickly on steep slopes, exposing fresh rock to further weathering.
- **C. Climatic Conditions:** Climate is arguably the most important factor. Temperature and moisture levels determine the dominant type and rate of weathering. For instance, cold, moist climates favor physical weathering (like frost wedging), while warm, humid climates accelerate chemical weathering.
- **D. Time:** Weathering is a slow process. The longer a rock surface is exposed to the elements, the more it will be weathered.

Step 3: Final Answer:

All four listed factors—rock type and structure, slope, climatic conditions, and time—play a significant role in influencing the process of weathering. Therefore, the correct option is (C).

Quick Tip

Think of weathering as "rock decay." Just like a wooden fence decays, the rate depends on the type of wood (rock type), whether it's on a hill (slope), the local weather (climate), and how long it's been outside (time).

62. Match LIST-I with LIST-II

LIST-I		LIST-II	
Replication Enzymes in <i>E. coli</i>		Replication Enzymes in Human	
A.	β -clamp	I.	RPA
B.	SSB	II.	PCNA
C.	Gyrase	III.	DNA polymerase alpha
D.	DnaG	IV.	Topo-I, II

Choose the most appropriate answer from the options given below:

- (A) A - I, B - II, C - III, D - IV
 (B) A - I, B - III, C - II, D - IV
 (C) A - I, B - II, C - IV, D - III
 (D) A - II, B - I, C - IV, D - III

Correct Answer: (D) A - II, B - I, C - IV, D - III

Solution:

Step 1: Understanding the Concept:

This question requires matching key DNA replication proteins from a prokaryote (*E. coli*) with their functional homologs in a eukaryote (Human). Although the specific proteins have different names, their roles in the replication process are conserved.

Step 2: Detailed Matching:

- **A. β -clamp:** In *E. coli*, this is the sliding clamp protein that encircles the DNA and holds the DNA polymerase onto the template, ensuring high processivity. Its human counterpart is **PCNA** (Proliferating Cell Nuclear Antigen). Thus, **A matches with II.**
- **B. SSB (Single-Strand Binding protein):** In *E. coli*, SSB binds to the separated single strands of DNA to prevent them from reannealing and to protect them from degradation. The human homolog is **RPA** (Replication Protein A). Thus, **B matches with I.**
- **C. Gyrase:** This is a type II topoisomerase in *E. coli* that relieves the torsional strain created by helicase unwinding. In humans, this function is performed by **Topoisomerases I and II (Topo-I, II)**. Thus, **C matches with IV.**
- **D. DnaG:** This is the primase enzyme in *E. coli* that synthesizes short RNA primers to initiate DNA synthesis. In humans, the primase is part of a complex along with **DNA polymerase alpha**, which synthesizes the primer and then extends it with a short stretch of DNA. Thus, **D matches with III.**

Step 3: Final Answer:

The correct set of matches is A-II, B-I, C-IV, D-III. This corresponds to option (D).

Quick Tip

To remember the sliding clamps: think of the Greek letter Beta (β) for **B**acteria (*E. coli*) and PCNA, which sounds like a clinical term, for more complex organisms like humans.

63. Monoclonal antibodies differ from polyclonal antibodies in their property of reacting with specific

- (A) Antigen
- (B) Clone of cell
- (C) Epitope
- (D) Antibody

Correct Answer: (C) Epitope

Solution:

Step 1: Understanding the Concept:

The question asks for the key difference in specificity between monoclonal and polyclonal antibodies. An antigen is a large molecule that can elicit an immune response, and it typically has multiple distinct recognition sites on its surface called epitopes.

Step 2: Detailed Explanation:

- **Polyclonal antibodies** are a mixture of antibodies that are secreted by different B-cell clones. As a result, this mixture recognizes and binds to *multiple different epitopes* on the surface of a single antigen.
- **Monoclonal antibodies** are a homogeneous population of antibodies produced by a single B-cell clone (via hybridoma technology). All antibodies in a monoclonal preparation are identical and bind to the *exact same, single specific epitope* on the antigen.
- Therefore, both types react with the specific **antigen**, but their difference lies in the specificity at the level of the **epitope**. Monoclonal antibodies are specific for a single epitope, whereas polyclonal antibodies are specific for the antigen as a whole, reacting with its various epitopes.

Step 3: Final Answer:

The property that distinguishes monoclonal from polyclonal antibodies is their reactivity with a specific, single epitope. Therefore, option (C) is correct.

Quick Tip

Think of it this way: An antigen is a whole car. Polyclonal antibodies are like a group of people who recognize the car by its wheels, doors, headlights, and logo. Monoclonal antibodies are like a specialist who only recognizes the car by its specific hood ornament (the epitope).

64. Which of the following diseases is not an autoimmune disease?

- (A) Rheumatoid arthritis
- (B) Lupus erythematosus
- (C) Grave's disease
- (D) Bovine spongiform encephalitis

Correct Answer: (D) Bovine spongiform encephalitis

Solution:

Step 1: Understanding the Concept:

An autoimmune disease is a condition in which the body's immune system mistakenly attacks its own healthy cells and tissues. The question asks to identify the disease from the list that does not have an autoimmune basis.

Step 2: Detailed Explanation of Options:

- **Rheumatoid arthritis:** This is a well-known autoimmune disorder where the immune system primarily attacks the synovium (the lining of the membranes that surround the joints).
- **Lupus erythematosus:** This is a systemic autoimmune disease where the immune system attacks its own tissues, causing widespread inflammation and tissue damage in affected organs.
- **Grave's disease:** This is an autoimmune disorder that causes hyperthyroidism (overactive thyroid). The immune system produces antibodies that mimic the action of thyroid-stimulating hormone (TSH), causing the thyroid gland to produce excess hormones.
- **Bovine spongiform encephalitis (BSE):** Also known as "mad cow disease," this is a transmissible spongiform encephalopathy (TSE). It is a progressive neurodegenerative disease caused by misfolded proteins called **prions**, not by an attack from the immune system.

Step 3: Final Answer:

Bovine spongiform encephalitis is a prion disease, not an autoimmune disease. Therefore, option (D) is the correct answer.

Quick Tip

Remember that autoimmune diseases involve the immune system (antibodies, T-cells) attacking "self." Diseases caused by other agents like bacteria, viruses, fungi, or prions are infectious or degenerative, not autoimmune.

65. Which of the following cells instruct the abnormal or virally infected cells to commit suicide?

- (A) Natural killer cells
- (B) B-cells
- (C) Dendritic cells
- (D) T-cells

Correct Answer: (D) T-cells

Solution:

Step 1: Understanding the Concept:

The process of instructing a cell to commit suicide is called inducing apoptosis. This is a key mechanism of the immune system to eliminate cells that are cancerous or infected with intracellular pathogens like viruses. This function is a hallmark of cell-mediated cytotoxicity.

Step 2: Detailed Explanation of Options:

- **B-cells:** Their primary function is to produce and secrete antibodies (humoral immunity), which target extracellular pathogens. They do not directly kill infected cells.
- **Dendritic cells:** These are professional antigen-presenting cells (APCs). Their main role is to process and present antigens to T-cells to initiate an adaptive immune response.
- **Natural Killer (NK) cells:** These are lymphocytes of the innate immune system. They can recognize and kill abnormal cells (like tumor cells or some virally infected cells) that have lost their self-identifying MHC class I molecules. They induce apoptosis and are a correct answer to the question in a broader sense.
- **T-cells:** Specifically, a subset called **Cytotoxic T Lymphocytes (CTLs or CD8+ T-cells)** are the primary effectors of the adaptive cell-mediated immune response. They are "instructed" to recognize a specific viral or tumor antigen presented on an MHC class I molecule on the surface of an infected cell. Upon recognition, the CTL releases molecules like perforin and granzymes that "instruct" the target cell to undergo apoptosis.
- **Comparing NK cells and T-cells:** While both can induce apoptosis, the adaptive and highly specific "instruction" via T-cell receptor binding to a specific antigen-MHC complex is a classic example of this process. In the context of the given options, "T-cells" represents this crucial arm of the specific immune response and is the most common and expected answer.

Step 3: Final Answer:

Cytotoxic T-cells are the primary immune cells that specifically recognize and instruct virally infected or abnormal cells to undergo apoptosis as part of the adaptive immune response. Therefore, option (D) is the most appropriate answer.

Quick Tip

Remember the killers of the immune system:

- **Cytotoxic T-cells (adaptive):** Specific killers. They need to be activated and recognize a specific antigen on the target cell.
- **Natural Killer (NK) cells (innate):** Non-specific killers. They are part of the first line of defense and look for cells that appear "abnormal" or are missing self-markers.

Both induce apoptosis.

66. Which one of the following immunoglobulin is responsible for atopic allergy?

- (A) IgG
- (B) IgM
- (C) IgE
- (D) IgA

Correct Answer: (C) IgE

Solution:

Step 1: Understanding the Concept:

Atopic allergy, also known as type I hypersensitivity, is an allergic reaction mediated by a specific class of antibodies (immunoglobulins). The question asks to identify this specific class.

Step 2: Detailed Explanation:

- **IgE:** This immunoglobulin is primarily responsible for allergic reactions. In an allergic individual, the immune system produces IgE antibodies in response to an allergen (e.g., pollen). These IgE antibodies then bind to the surface of mast cells and basophils. Upon subsequent exposure to the same allergen, the allergen cross-links the IgE on these cells, causing them to degranulate and release inflammatory mediators like histamine, leading to allergic symptoms.
- **IgG:** This is the most abundant immunoglobulin in the blood and is crucial for combating bacterial and viral infections.
- **IgM:** This is the first antibody produced during an initial immune response. It exists as a pentamer and is very effective at activating the complement system.
- **IgA:** This is the main immunoglobulin found in mucosal secretions like saliva, tears, and breast milk, providing the first line of defense at mucosal surfaces.

Step 3: Final Answer:

The immunoglobulin responsible for atopic allergy is IgE. Therefore, option (C) is correct.

Quick Tip

Remember the mnemonic "IgE for Emergency" or "AllergE". This helps associate the IgE isotype with immediate hypersensitivity and allergic reactions.

67. Class I MHC molecules present peptides to which of the following cell type?

- (A) CD8+ cytotoxic T-cells
- (B) CD4+ T-helper cells
- (C) Dendritic cells
- (D) Macrophages

Correct Answer: (A) CD8+ cytotoxic T-cells

Solution:

Step 1: Understanding the Concept:

Major Histocompatibility Complex (MHC) molecules are cell surface proteins that present antigenic peptides to T-cells. There are two main classes, MHC Class I and MHC Class II, which present peptides to different types of T-cells.

Step 2: Detailed Explanation:

- **MHC Class I:** These molecules are found on the surface of almost all nucleated cells in the body. Their primary function is to present *endogenous* antigens (peptides from proteins made inside the cell, such as viral proteins or abnormal tumor proteins) to **CD8+ cytotoxic T-cells**. This interaction signals the cytotoxic T-cell to kill the infected or cancerous cell.
- **MHC Class II:** These molecules are found only on the surface of professional Antigen-Presenting Cells (APCs), such as dendritic cells, macrophages, and B-cells. They present *exogenous* antigens (peptides from pathogens that have been engulfed and broken down) to **CD4+ T-helper cells**. This interaction helps to activate the T-helper cell, which then orchestrates the broader immune response.

Step 3: Final Answer:

MHC Class I molecules present peptides specifically to CD8+ cytotoxic T-cells. Therefore, option (A) is correct.

Quick Tip

Use the "rule of 8" to remember the MHC-T cell interactions:

- MHC Class **I** binds to CD8 T-cells ($1 \times 8 = 8$).
- MHC Class **II** binds to CD4 T-cells ($2 \times 4 = 8$).

68. Which one of the following best describes the innate immune response?

- (A) It is an immediate and relatively broad acting response.
- (B) It is a delayed response but highly specific.
- (C) It is acquired by vaccination.
- (D) It is acquired in life.

Correct Answer: (A) It is an immediate and relatively broad acting response.

Solution:

Step 1: Understanding the Concept:

The immune system has two main branches: the innate immune system and the adaptive immune system. They differ in their speed, specificity, and memory. The question asks for the best description of the innate response.

Step 2: Detailed Explanation:

- **Innate Immunity:** This is the body's first line of defense. It is present from birth (in-nate). Its key features are: - **Immediate:** It responds within minutes to hours of pathogen detection. - **Broad-acting (Non-specific):** It recognizes general patterns common to many pathogens (e.g., bacterial cell wall components) rather than specific antigens. - **No memory:** It responds in the same way to repeated exposures to the same pathogen. - **Adaptive Immunity:** This is the second line of defense. - **Delayed:** It takes several days to develop a response upon first exposure. - **Highly specific:** It recognizes and targets specific antigens. - **Has memory:** It mounts a faster and stronger response upon subsequent exposures to the same pathogen. This is the basis for vaccination. - **Analyzing the options:** - (A) "Immediate and relatively broad acting" perfectly describes innate immunity. - (B) "Delayed response but highly specific" describes adaptive immunity. - (C) and (D) "Acquired by vaccination" and "acquired in life" are features of adaptive immunity.

Step 3: Final Answer:

The best description for the innate immune response is that it is immediate and relatively broad acting. Therefore, option (A) is correct.

Quick Tip

Remember the key differences: **Innate** = **In**born, **I**mmEDIATE, **N**on-specific. **Adaptive** = **A**cquired, **A**ntigen-specific, has memory.

69. What are chemokines?

- (A) Cell surface receptors
- (B) Specialized chemotactic cytokine
- (C) Any foreign antigen

(D) Chemical based antibodies

Correct Answer: (B) Specialized chemotactic cytokine

Solution:

Step 1: Understanding the Concept:

Chemokines are a family of small signaling proteins that play a crucial role in the immune system by directing the movement of cells.

Step 2: Detailed Explanation:

- **Cytokines** are a broad category of proteins that act as chemical messengers between cells, particularly those of the immune system.
- **Chemokines** are a specific sub-family of cytokines. Their primary function is to induce directed cell migration, a process known as **chemotaxis**.
- Immune cells, such as neutrophils and macrophages, follow the concentration gradient of chemokines to move from the blood into tissues towards a site of infection or inflammation.
- Therefore, a chemokine is a specialized cytokine that has chemotactic (cell-attracting) activity.

Step 3: Final Answer:

The best definition for chemokines is that they are specialized chemotactic cytokines. Therefore, option (B) is correct.

Quick Tip

Break down the word "chemokine": **Chemotactic** + **cytokine**. It literally means a cytokine that causes chemical-guided movement.

70. Which one of the following best describes the application of DNA microarray?

- (A) To investigate the level of gene expression in a cancerous cell
- (B) To separate small biomolecules based on their charge.
- (C) To amplify a DNA sequence.
- (D) To study the protein synthesis in a cell.

Correct Answer: (A) To investigate the level of gene expression in a cancerous cell

Solution:

Step 1: Understanding the Concept:

A DNA microarray is a powerful molecular biology tool used for high-throughput analysis. It consists of a solid surface (like a glass slide) onto which thousands of different DNA sequences (probes) are spotted in an ordered array.

Step 2: Detailed Explanation:

- The primary application of DNA microarrays is to measure **gene expression levels** (i.e., the amount of mRNA produced from each gene) for thousands of genes simultaneously. - To do this, mRNA is extracted from two different cell populations (e.g., cancerous vs. normal cells), converted to fluorescently labeled complementary DNA (cDNA), and then hybridized to the microarray. - By analyzing the fluorescence intensity at each spot on the array, researchers can determine which genes are more active (upregulated) or less active (downregulated) in one condition compared to another. - This makes it an ideal tool for investigating the changes in gene expression that occur in diseases like cancer. - Option (B) describes electrophoresis. - Option (C) describes the Polymerase Chain Reaction (PCR). - Option (D) would typically be studied using techniques like ribosome profiling or mass spectrometry to look at proteins, not DNA microarrays.

Step 3: Final Answer:

The best description of a DNA microarray's application is to investigate the level of gene expression, for example, in a cancerous cell. Therefore, option (A) is correct.

Quick Tip

Associate "microarray" with a massive-scale analysis of gene activity. It gives a snapshot of which genes are "on" or "off" in a cell at a specific moment, making it perfect for comparing different cell states like healthy vs. diseased.

71. What is the correct sequence of steps in the genetic engineering of *E.coli* for insulin production?

- A. Obtaining a copy of the human insulin gene by isolating mRNA
- B. Switching on gene action.
- C. Identifying transformed bacteria prior to cloning
- D. Inserting the DNA into a plasmid vector and inserting the plasmid vector into the host bacterium

Choose the most appropriate answer from the options given below:

- (A) A,B,C, D
- (B) A,C,B,D
- (C) A,D,C,B
- (D) C,B,D,A

Correct Answer: The correct sequence is $A \rightarrow D \rightarrow C \rightarrow B$.

Solution:

Step 1: Understanding the Concept:

The question asks for the correct workflow for producing a human protein (insulin) in a bacte-

rial host (*E. coli*) using recombinant DNA technology.

Step 2: Detailed Explanation of the Sequence:

1. **A. Obtaining a copy of the human insulin gene by isolating mRNA:** This is the first essential step. The gene for insulin needs to be isolated from a human source. In practice, mRNA from pancreatic cells is isolated and used as a template for the enzyme reverse transcriptase to create a complementary DNA (cDNA) copy of the gene. This cDNA is used because it lacks introns, which bacteria cannot process.
2. **D. Inserting the DNA into a plasmid vector and inserting the plasmid vector into the host bacterium:** Once the insulin gene (cDNA) is obtained, it is inserted (ligated) into a plasmid vector. This recombinant plasmid is then introduced into the host bacteria (*E. coli*) through a process called transformation.
3. **C. Identifying transformed bacteria prior to cloning:** Transformation is not 100% efficient. Therefore, it is crucial to select or identify the bacteria that have successfully taken up the recombinant plasmid. This is often done using selectable markers, such as antibiotic resistance genes, that are also on the plasmid. Only the transformed bacteria will grow on a medium containing the antibiotic.
4. **B. Switching on gene action:** After selecting the transformed bacteria, they are cultured in large quantities (cloned). To produce the insulin protein, the expression of the inserted gene must be induced or "switched on." This is often controlled by an inducible promoter in the plasmid, which can be activated by adding a specific chemical (like IPTG) to the culture medium.

Step 3: Final Answer:

The logical and correct sequence of steps for producing recombinant insulin is $A \rightarrow D \rightarrow C \rightarrow B$.

Quick Tip

Think of the process like a recipe:

1. **Get the gene** (Isolate the recipe - Step A).
2. **Put the gene in a carrier and get it into the factory** (Put the recipe in a cookbook and give it to the chef - Step D).
3. **Find the factory that accepted the gene** (Make sure the chef got the right cookbook - Step C).
4. **Tell the factory to start producing** (Tell the chef to start cooking - Step B).

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72. A multiple cloning site:

- (A) Contains several copies of a cloned gene.

- (B) Allows multiple choices for choosing organisms for cloning.
- (C) Allows multiple choices for choosing restriction enzymes for cloning.
- (D) Contains multiple copies of the same restriction enzyme.

Correct Answer: (C) Allows multiple choices for choosing restriction enzymes for cloning.

Solution:

Step 1: Understanding the Concept:

A Multiple Cloning Site (MCS), also known as a polylinker, is a short segment of DNA which has been engineered into a cloning vector (like a plasmid). Its purpose is to provide convenience and flexibility for inserting a gene of interest into the vector.

Step 2: Detailed Explanation:

- The key feature of an MCS is that it contains recognition sequences for numerous different restriction enzymes, clustered together in one location.
- This design provides a researcher with a wide variety of choices for which enzyme(s) to use for cutting the plasmid and ligating the target DNA fragment. This allows for compatibility with whatever restriction sites are available on the ends of the DNA insert.
- Let's analyze the options:
- (A) is incorrect. The MCS is the site *where* a gene is cloned; it doesn't contain the gene initially.
- (B) is incorrect. The choice of organism is determined by other factors, not the MCS.
- (C) is correct. This is the primary function of the MCS – to offer a selection of unique restriction sites.
- (D) is incorrect. The MCS contains sites for many *different* enzymes, not multiple copies of the same one.

Step 3: Final Answer:

The function of a multiple cloning site is to allow multiple choices for choosing restriction enzymes for the cloning process. Therefore, option (C) is correct.

Quick Tip

Break down the name: "Multiple Cloning Site". It's a single **site** for **cloning** that offers **multiple** options. The options are the different restriction enzyme recognition sequences it contains.

73. Southern blotting procedure does not include:

- (A) Digestion and separation of DNA fragments using agarose gel electrophoresis.
- (B) Ligation of the target DNA into a cloning vector.
- (C) Transfer of DNA fragments to a nitrocellulose membrane.

(D) Hybridization of the membrane with a labelled probe.

Correct Answer: (B) Ligation of the target DNA into a cloning vector.

Solution:

Step 1: Understanding the Concept:

Southern blotting is a molecular biology technique used to detect a specific DNA sequence within a complex mixture of DNA. The question asks to identify a step that is NOT part of this analytical procedure.

Step 2: Detailed Explanation:

The standard steps of a Southern blot are:

1. **Digestion and Separation:** The DNA sample is first digested into smaller fragments using restriction enzymes. These fragments are then separated by size via agarose gel electrophoresis. (This matches option A).
 2. **Transfer (Blotting):** The separated DNA fragments are transferred from the gel to a solid membrane (like nitrocellulose or nylon). (This matches option C).
 3. **Hybridization and Probing:** The membrane is incubated with a labeled DNA probe that is complementary to the target sequence of interest. The probe will bind (hybridize) to the target fragment if it is present. (This matches option D).
 4. **Detection:** The location of the bound probe is visualized, revealing the presence and size of the target DNA fragment.
- The step described in option (B), "Ligation of the target DNA into a cloning vector," is a key step in **molecular cloning** or creating recombinant DNA. It is a constructive process, whereas Southern blotting is a purely analytical/detective process.

Step 3: Final Answer:

Ligation into a cloning vector is not part of the Southern blotting procedure. Therefore, option (B) is the correct answer.

Quick Tip

Remember the purpose of the main DNA techniques:

- **Cloning/Ligation:** To build or create new DNA molecules.
- **PCR:** To amplify or make many copies of DNA.
- **Southern Blot:** To detect or find a specific DNA sequence.

74. The brain and spinal cord develop from ectoderm arranged in a tubular structure called the neural tube. The anterior part of the neural tube expands, and constrictions appear that create multiple regions. Arrange the parts of the embryonic brain chambers in a 5 week embryo from top to bottom.

- A. Diencephalon
- B. Myelencephalon
- C. Metencephalon
- D. Mesencephalon
- E. Telencephalon

Choose the most appropriate answer from the options given below:

- (A) A, B, C, D, E
- (B) A, E, C, D, B
- (C) E, A, D, C, B
- (D) C, B, D, A, E

Correct Answer: (C) E, A, D, C, B

Solution:

Step 1: Understanding the Concept:

The development of the central nervous system begins with the formation of the neural tube. The anterior (rostral) end of this tube undergoes differentiation to form the brain. Initially, three primary brain vesicles form: the prosencephalon (forebrain), mesencephalon (midbrain), and rhombencephalon (hindbrain). By the fifth week of development, these three vesicles further differentiate into five secondary vesicles. The question asks for the correct order of these five vesicles from anterior to posterior (top to bottom).

Step 2: Detailed Explanation of the Sequence:

The development from three to five vesicles is as follows:

- The **Prosencephalon (forebrain)** divides into: 1. **E. Telencephalon** (most anterior), which will become the cerebral hemispheres. 2. **A. Diencephalon**, which will become the thalamus, hypothalamus, etc. - The **Mesencephalon (midbrain)** remains as: 3. **D. Mesencephalon**. - The **Rhombencephalon (hindbrain)** divides into: 4. **C. Metencephalon**, which will become the pons and cerebellum. 5. **B. Myelencephalon** (most posterior), which will become the medulla oblongata.

Step 3: Final Answer:

Arranging these five secondary vesicles in order from top (anterior) to bottom (posterior), we get: Telencephalon → Diencephalon → Mesencephalon → Metencephalon → Myelencephalon. This corresponds to the letter sequence E, A, D, C, B. Therefore, option (C) is correct.

Quick Tip

Remember the alphabetical and hierarchical order. The forebrain divides into T and D. The midbrain (Mesencephalon) stays the same. The hindbrain divides into Met- and Mye-. Alphabetically, Met- comes before Mye-. This gives the sequence T, D, Mes, Met, Mye.

75. Which one of the following diseases can be corrected by gene therapy?

- (A) Sleeping sickness
- (B) Measles
- (C) AIDS
- (D) Cystic fibrosis

Correct Answer: (D) Cystic fibrosis

Solution:

Step 1: Understanding the Concept:

Gene therapy is a medical approach that treats or prevents disease by correcting the underlying genetic problem. It is most directly applicable to diseases caused by a single faulty gene (monogenic disorders), where a functional copy of the gene can be introduced to replace or supplement the defective one.

Step 2: Detailed Explanation of Options:

- **Sleeping sickness:** This is an infectious disease caused by the protozoan parasite *Trypanosoma brucei*. It is treated with anti-parasitic drugs, not gene therapy.
- **Measles:** This is an infectious disease caused by the measles virus. It is preventable by vaccination.
- **AIDS (Acquired Immunodeficiency Syndrome):** This is an infectious disease caused by the Human Immunodeficiency Virus (HIV). It is managed with antiretroviral drugs. While gene therapy is being researched as a potential treatment for HIV, it is not a standard correction method.
- **Cystic fibrosis:** This is a classic example of a monogenic inherited disease. It is caused by mutations in the CFTR gene, which leads to the production of faulty protein channels. Gene therapy aims to deliver a correct copy of the CFTR gene to the cells of the patient, particularly in the lungs, to restore normal function. It is a prime candidate for correction by gene therapy.

Step 3: Final Answer:

Among the given options, cystic fibrosis is the genetic disorder that can be corrected by introducing a functional gene, which is the principle of gene therapy. Therefore, option (D) is correct.

Quick Tip

The key to this question is identifying the **genetic** disease versus the **infectious** diseases. Gene therapy is designed to fix faulty genes. Sleeping sickness, measles, and AIDS are caused by external pathogens (parasite, virus), not an inherited faulty gene from the patient's parents.