



CSIR NET

Life sciences

For June 2024

Shift-1

Part- A

Unit-wise Question Paper Analysis

In humans, if both parents are of blood group AB, then, there is a 1/4 probability that their offspring will be of blood group A, and 1/2 probability that the offspring will be of blood group AB. If the couple have three children, what is the probability that NONE of the children will be of blood group A or AB?

1. 1/4
2. 3/4
3. 1/64
4. 63/64

Answer-(3) Explanation

Total Probability = 1

$$P(A) + P(AB) + P(\text{rest}) = 1$$

$$\frac{1}{4} + \frac{1}{2} + P(\text{rest}) = 1$$

$$P(\text{rest}) = 1 - \frac{1}{4} - \frac{1}{2}$$

$$= \frac{1}{4}$$

Probability of having blood group other than AA or AB for any child is $\frac{1}{4}$

So, probability that None of their children will be of blood group A or AB is

$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$$

The growth model for a population is

$$N_t = N_0 e^{rt}$$

where N_t is the population at time t , N_0 is the initial population and r is the per capita growth rate. How long does it take for the population numbers to double?

1. $(\ln 2)/r$
2. $2/r$
3. $1/(r \ln 2)$
4. $1/r$

Answer-(1) Explanation

$N_t = N_0 \cdot e^{rt}$
 When population gets doubled
 then $N_t = 2N_0$

$$2N_0 = N_0 \cdot e^{rt}$$

$$2 = e^{rt}$$

Taking ln on both side

$$\ln 2 = \ln(e^{rt})$$

$$\ln 2 = r \cdot t$$

$$t = \frac{\ln 2}{r}$$

doubling time

The chart shows forest cover as percentages of total areas of 6 countries over the period 1990-2022 and their land areas (in million km²).

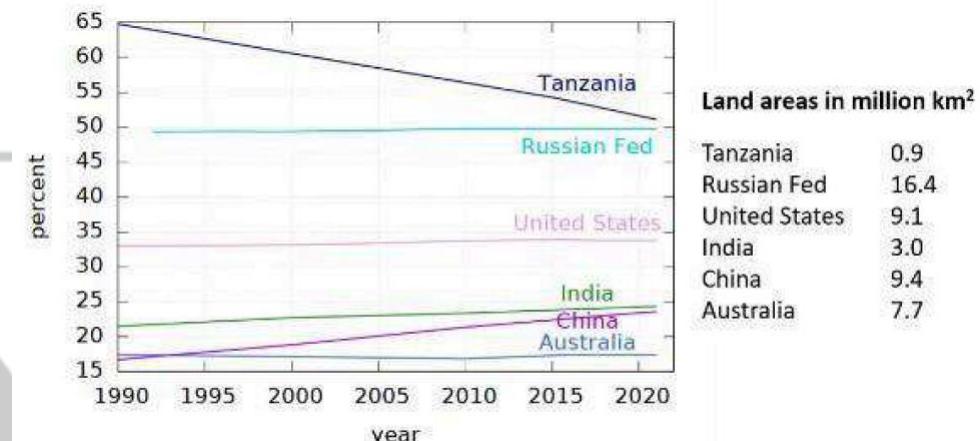
The maximum change in forest area in absolute terms among these countries took place in

1. Tanzania
2. Russian Federation
3. India
4. China

Answer-(4) Explanation

		% change (approx)	change in obs. data Trends
Tanzania	0.9	14%	0.126
Russian Federation	16.4	1%	0.164
India	3.0	3%	0.09
China	9.4	6.5%	0.611

Even though we have approximate the % change,
China's absolute change is very high.

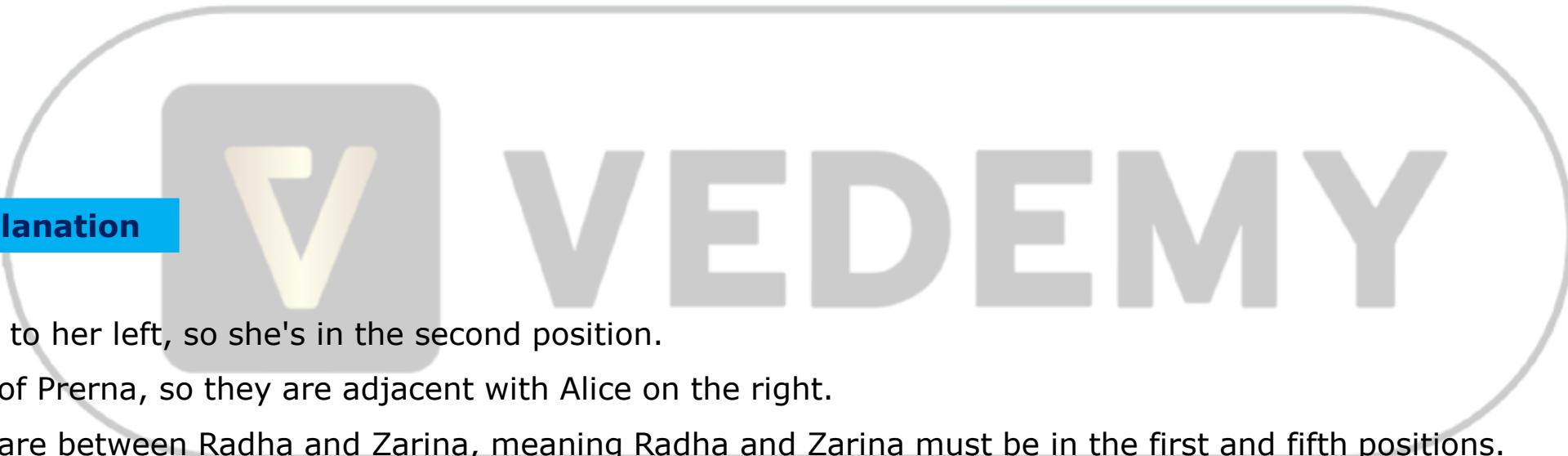


Among five girls standing side by side, Leela has exactly one girl to her left, Alice is just right of Prerna, and there are at least two girls between Radha and Zarina.

The girl in the middle is

1. Prerna
2. Alice
3. Leela
4. Zarina

Answer-(1) Explanation



Leela has one girl to her left, so she's in the second position.

Alice is just right of Prerna, so they are adjacent with Alice on the right.

At least two girls are between Radha and Zarina, meaning Radha and Zarina must be in the first and fifth positions.

The only possible arrangement is: **Radha, Leela, Prerna, Alice, Zarina**.

Correct answer: **Prerna** is in the middle.

A group of 54 boys and girls was made to stand in a queue as follows: a boy at the start was followed by a girl, then a boy followed by 2 girls, then a boy followed by 3 girls, and so on. The number of boys in the group was

1. 8
 2. 9
 3. 10
 4. 27

Answer-(2) Explanation

B G B G G B G G G B G G G G

$$1+1+1+2+1+3+1+4+1+5+1+6+1+7+1+8+1+9$$

$$2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 = 54, \text{ so there will be } 9 \text{ boys.}$$

A 1 m long rod having diameter of 12 mm weighs 880 g. What, approximately, is the density (in g/cm³) of the material of the rod?

1. 6.2
2. 6.6
3. 7.8
4. 8.8

Answer-(3) Explanation

$$1 \text{ m} = 100 \text{ cm}$$

$$12 \text{ mm} = 1.2 \text{ cm}$$

$$\text{vol of cylinder} = \pi r^2 h$$

$$= \frac{22}{7} \times (0.6 \text{ cm})^2 \times 100 \text{ cm}$$

$$\approx 113.04 \text{ cm}^3$$

$$\text{density} = \frac{\text{Weight}}{\text{Volume}} = \frac{880}{113.04} \approx 7.8 \text{ g/cm}^3$$

Suppose liars always lie and truthful persons never. In a group of 4 people A, B, C and D, A says, "We're all liars", B says, "Only one of us is a liar", C says, "No, exactly two of us are liars" and D says, "I'm truthful". Which among the following is definitely FALSE?

1. A is a liar
2. B is a liar
3. C is a liar
4. D is a liar

Answer-(4) Explanation

If A is truthful, then all are liars, which is a contradiction because a truthful person cannot be a liar.

Therefore, A must be lying. This also implies that some one is truthful.

B says only one of them is liar, but we know A is a liar and considering B is truthful, that means (B) is also truthful, which contradicts C's statement of two of them are liars, i.e B can also be lying.

Considering, C's statement, that 2 of them are liar, that means me A & B are liars that makes C & D truthful. D will be truthful in any condition.

So, option 4 will be definitely false.

Consider the first few consecutive natural numbers. The ratio of the sum of their squares to their sum can NEVER be

1. 67
2. 75
3. 91
4. 100

Answer-(4) Explanation

Sum of squares of natural numbers = $\frac{n(n+1)(2n+1)}{6}$

Sum of natural numbers = $\frac{n(n+1)}{2}$

$$\text{ratio} = \frac{\frac{n(n+1)(2n+1)}{6}}{\frac{n(n+1)}{2}}$$

2) ~~$\frac{n(n+1)(2n+1)}{6 \times n(n+1)}$~~

$\therefore \frac{2n+1}{3}$

From the options
 $2n+1 = 201$
 $2n+1 = 225$
 $2n+1 = 273$
 all of these are possible but
 $2n+1 = 300$
 is not possible

If $X > Y > 0$, then $X\%$ of Y is

1. equal to $Y\%$ of X
2. more than $Y\%$ of X
3. less than $Y\%$ of X
4. $(X + Y)\%$ of $(X + Y)$

Answer-(1) Explanation

$$X\% \text{ of } Y = \frac{X \times Y}{100} = \frac{XY}{100}$$

$$Y\% \text{ of } X = \frac{Y \times X}{100} = \frac{XY}{100}$$

It is equal.

If $16x^2 - 25y^2 + 7 = 0$, x and y being positive numbers, then which of the following may hold?

1. $4x + 5y + 1 = 0$
2. $4x - 5y - 7 = 0$
3. $4x - 5y + 1 = 0$
4. $4x - 5y - 7 = 0$

Answer-(3) Explanation

$$(4x)^2 - (5y)^2 + 7 = 0$$

$$(4x + 5y)(4x - 5y) + 7 = 0$$

$$(4x + 5y)(4x - 5y) = -7$$

Two numbers on multiplication giving (-7) .

Only possible when

∞	1×-7
-1×7	

that means $4x + 5y = -1$ or $4x + 5y = -7$
 not possible with x & y are (+ve)

$$4x + 5y = 7 \quad \text{or} \quad 4x + 5y = 1$$

$$4x - 5y = -1 \quad \text{or} \quad 4x - 5y = -7$$

↑
 so this will hold

$$4x - 5y = -1$$

$$\boxed{4x - 5y + 1 = 0}$$

↑
 This does not
 any solution for
 x & y positive

A spherical object of radius 6 cm was melted and cast into a cylindrical bar of radius 3 cm. What would be the length (in cm) of the bar?

1. 24
2. 32
3. 36
4. 42

Answer-(2) Explanation

The volume of the matter will remain same.

$$\text{Vol. of sphere} = \text{Vol. of cylinder}$$

$$\frac{4}{3}\pi R^3 = \pi r^2 h$$

$$h = \frac{\frac{4}{3}R^3}{r^2} = \frac{\frac{4}{3} \times 6 \times 6 \times 6}{3 \times 3} = 32 \text{ cm}$$

Every element in the central column of the matrix has a simple arithmetic relationship with the pairs on the left and right in the corresponding row.

What would be the value of X?

1. 2
2. 1
3. 0
4. -1

17	12	1	19	23
23	21	X	18	20
24	17	3	32	36
35	28	2	19	24

Answer-(3) Explanation

①

$$\begin{array}{ccccc} \text{I} & & \text{III} & & \text{IV} \\ 17 & +19 & & 12 & +23 \\ & 36 & - & 35 & = 1 \checkmark \end{array}$$

② $23 + 18 - 21 + 20 = 0 \checkmark$

③ $24 + 32 - 17 + 36 = 33 \checkmark$

④ $35 + 19 - 28 + 24 = 21$

The total monthly income of a family is split into expenses on food (F), house rent (H), college fees (C), entertainment (E), miscellaneous items (M), and savings (S), as shown in the pie chart.

The family transfers an amount of Rs 1000/- from the head food to the head entertainment, thereby making the expenses on the two heads equal. What is the net expenditure of the family?

1. Rs 20,000
2. Rs 50,000
3. Rs 37,500
4. Rs 17,000

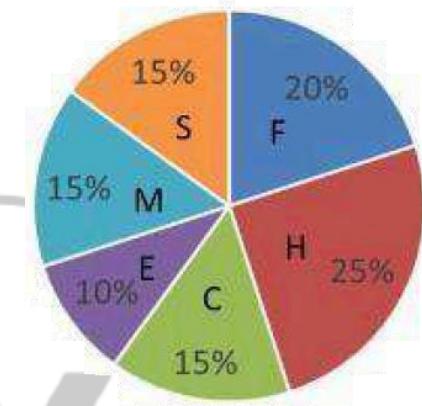
Answer-(4) Explanation

$$\text{Total expenditure} = x$$

$$\text{Food} = 0.2x$$

$$\text{Entertainment} = 0.1x$$

$$\begin{aligned} 0.2x - 1000 &= 0.1x + 1000 \\ 0.1x &= 2000 \\ x &> 20,000 \end{aligned}$$



$$\begin{aligned} 15\% \text{ of total is saving} \\ 15\% \text{ of } 20000 = 3000 \text{ is saving} \\ \text{net expenditure} &= 20000 - 3000 \\ &\approx 17000 \end{aligned}$$

A certain item of raw food contains 35% starch, 25% protein, the rest fibre. The item is cooked by boiling in water, which doubles its weight. Half of the fibre in the food becomes soluble when cooked. If the cooked item weighs 200g, the amount of soluble fibre in it is

1. 15 g
2. 30 g
3. 20 g
4. 40 g

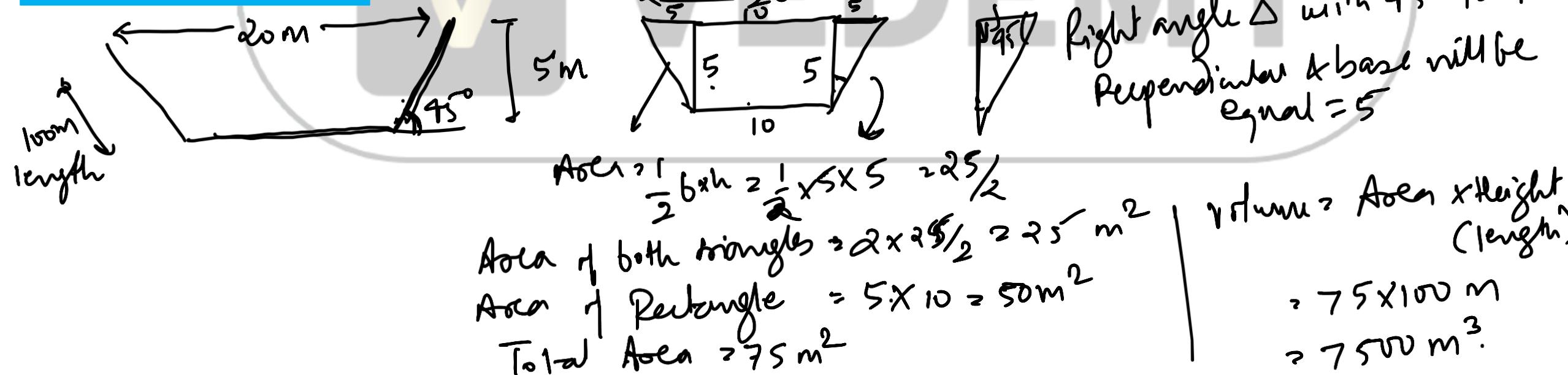
Answer-(3) Explanation

35% starch, 25% protein, that means 40% fibre
weight of cooked item = 200g
weight of uncooked item = 100g
half of fibre becomes soluble i.e. $\frac{1}{2} \times 40\% \times 100\text{gm}$
 $\therefore \frac{1}{2} \times 40 = 20\text{ gm}$

A straight irrigation canal in a plain area has a floor at a depth of 5 m from the surface. The canal is 20 m wide at the surface. The floor of the canal is flat and the embankments have a slope of 45° . When it is completely filled, what will be the volume of water (in m^3) in the canal over a length of 100m?

1. 6000
2. 7500
3. 8000
4. 9500

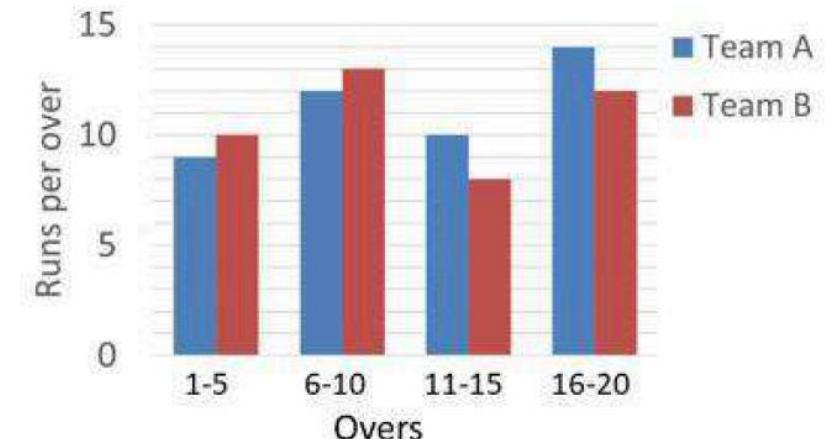
Answer-(2) Explanation



The graph shows average run rate (runs scored per over) by teams A and B in a twenty overs cricket match.

Select the INCORRECT statement.

1. Team B scored more runs than team A in the first 10 overs.
2. Team A scored more runs than team B in all.
3. Team B scored more runs in overs 1–10 than in overs 11– 20.
4. Team A has a lower overall run rate than team B.

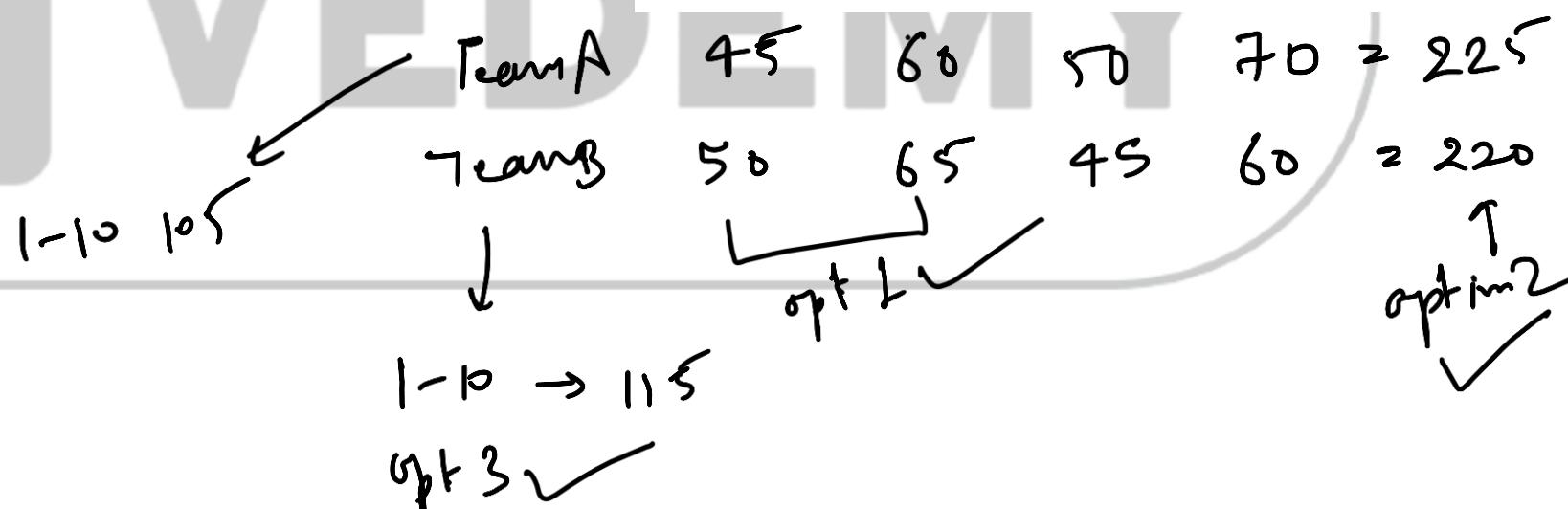


Answer-(4) Explanation

opt 1 is visibly correct.

option → 4 is false.

as Team A has scored
more runs overall.



For any four consecutive decimal digits, the largest value of the product of the sum of any two and the sum of the other two is

1. an even number and a perfect square
2. an even number, but not a perfect square
3. an odd number and a perfect square
4. an odd number, but not a perfect square

Answer-(3) Explanation

Suppose these are the four consecutive decimal digits

→ 1 2 3 4

$$\begin{array}{lll} 1+2 = 3 & 3+4 = 7 & 3 \times 7 = 21 \\ 1+3 = 4 & 2+4 = 6 & 6 \times 4 = 24 \\ 1+4 = 5 & 2+3 = 5 & 5 \times 5 = 25 \end{array}$$

$\underline{\underline{=}}$ → it is the largest
and it is odd & also perfect square.

It can also be done assuming, $a, (a+1), (a+2), (a+3)$, as well.

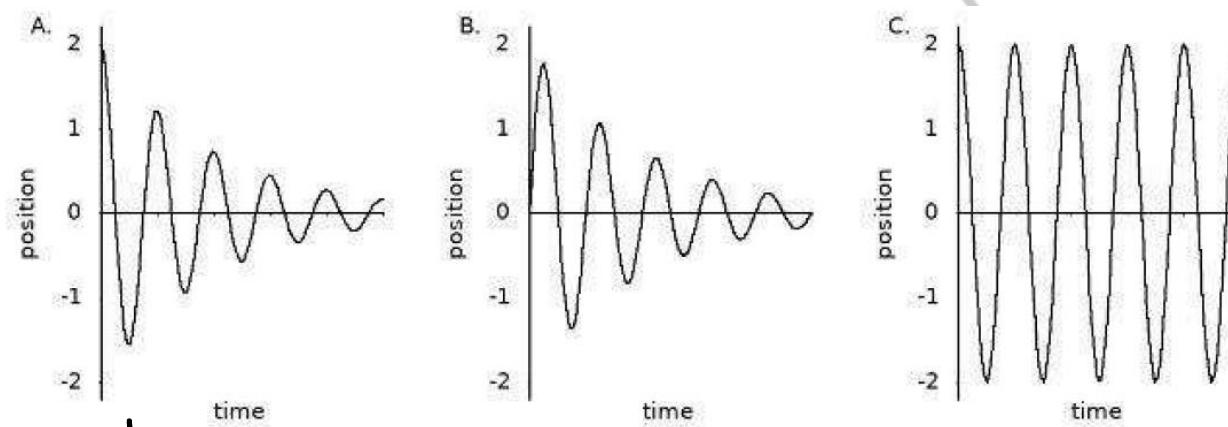
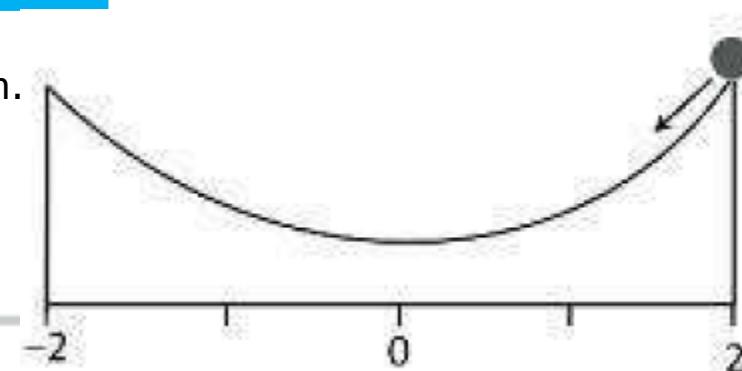
A ball starts rolling from the edge of the slope at time $t = 0$ as shown in the diagram.

Referring to the graphs A, B, C, which of the following statements is correct?

1. A depicts motion with friction while C depicts motion without friction
2. C depicts motion with friction while A depicts motion without friction
3. B depicts motion with friction while A depicts motion without friction
4. B depicts motion with friction while C depicts motion without friction

Answer-(1) Explanation

therefore only option 1 is correct.



change is decreasing over time
motion with friction
but starting point should be at 2.
↓ motion with friction
↓ motion without friction.

A record player stylus moves along a spiral groove cut on an annular portion of a disc. A record with inner radius 4 cm and outer radius 10 cm of the annulus, turning 100 times plays for 22 minutes. During this time the stylus travels at an average linear speed that is approximately equal to

1. 100 m/h
2. 120 m/h
3. 220 m/h
4. 440 m/h

Answer-(2) Explanation

$$\text{Average radius} = \frac{4+10}{2} = \frac{14}{2} = 7 \text{ cm}$$

$$\text{Circumference} = 2\pi(7) = 14\pi$$

$$\text{Distance travelled} = 14\pi \times 100 = 1400\pi \text{ cm} \\ = 14\pi \text{ m}$$

Time = 22 minutes

$$\text{So in 22 minutes} = 14\pi \text{ m} \\ \text{60 minutes} = \frac{14\pi \times 60}{22} = 119.88 \text{ m/h} \approx 120 \text{ m/h}$$

Choose the option that will make the following statement FALSE:

A CHILD COUNTED THE NUMBER OF APPEARANCES OF THE LETTER T IN THIS SENTENCE, AND REPORTED IT CORRECTLY AS

1. TEN
2. ELEVEN
3. TWELVE
4. THIRTEEN

Answer-(1) Explanation

The given line has 11 "T" in it, so writing Ten will make it 12 & the ans will be wrong.

Eleven will not change the no. of T ✓

Twelve will increase the no. of T to 12 ✓

Thirteen will increase the no. of T to 13 ✓.



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For June 2024

Shift-1

Part- B

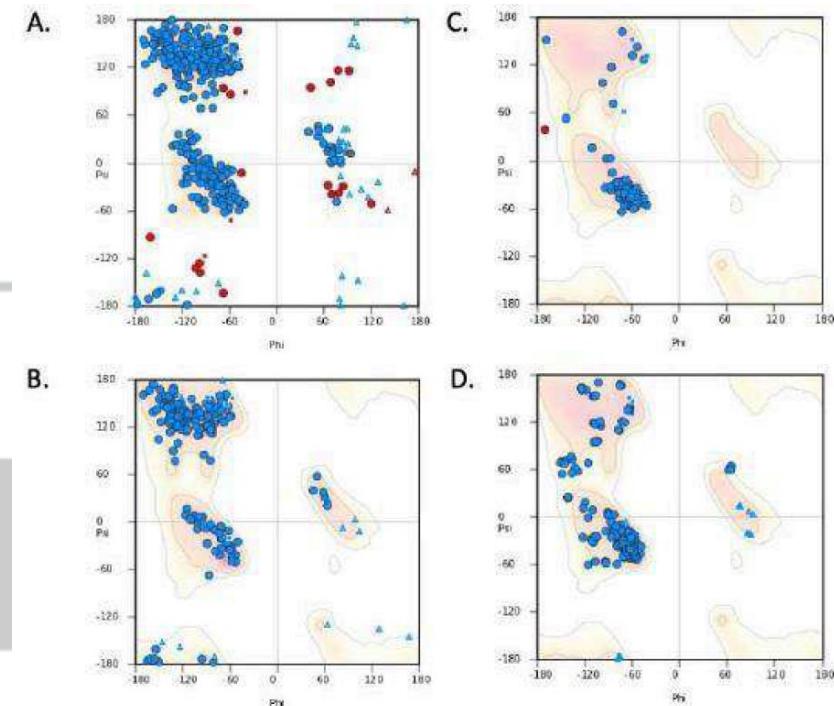
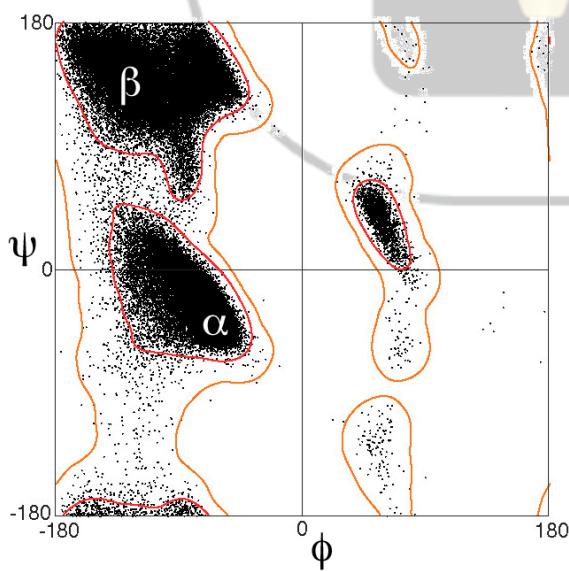
Unit-wise Question Paper Analysis

Given below are Ramachandran plots for four different proteins.

Choose the correct pair of proteins, both of which are predominantly alpha helical in nature.

1. A and B
2. A and C
3. B and D
4. C and D

Answer-(4) Explanation



Which one of the following pairs correctly matches the enzyme with its allosteric activator?

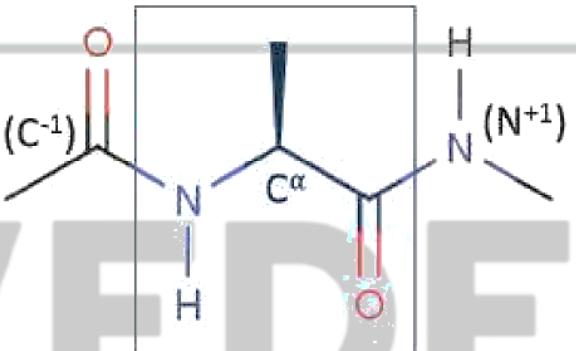
1. Phosphofructokinase : Citrate
2. Pyruvate dehydrogenase : NADH
3. Pyruvate carboxylase : ADP
4. Pyruvate kinase : Fructose-1 ,6-bisphosphate

Answer-(4) Explanation

Enzyme	Function	Positive Regulators	Negative Regulators
Hexokinase (HK)	Catalyzes the phosphorylation of glucose to glucose-6-phosphate.	Glucose, ADP	Glucose-6-phosphate
Phosphofructokinase (PFK)	Catalyzes the conversion of fructose-6-phosphate to fructose-1,6-bisphosphate; the main regulatory step in glycolysis.	AMP, fructose-2,6-bisphosphate	ATP, citrate, low pH
Pyruvate Kinase (PK)	Catalyzes the conversion of phosphoenolpyruvate to pyruvate.	Fructose-1,6-bisphosphate, AMP	ATP, alanine

In the representation of the di-peptide shown below, the superscript '-1' denotes the atom of the previous amino acid while '+1' denotes the atom of the next amino acid. The atomic coordinates of how many AND which of the following atoms are required to uniquely define the torsion angles, ϕ and ψ of the Ramachandran plot?

1. 4 atoms; C^{-1} , N, C^α , C for ϕ ; N, C^α , C, N^{+1} for ψ
2. 2 atoms; N and C^α for ϕ ; C^α and C for ψ
3. 4 atoms; H, N, C^α , C for ϕ ; N, C^α , C, O for ψ
4. 3 atoms; C^{-1} , N, C^α for ϕ ; C^α , C, N^{+1} for ψ



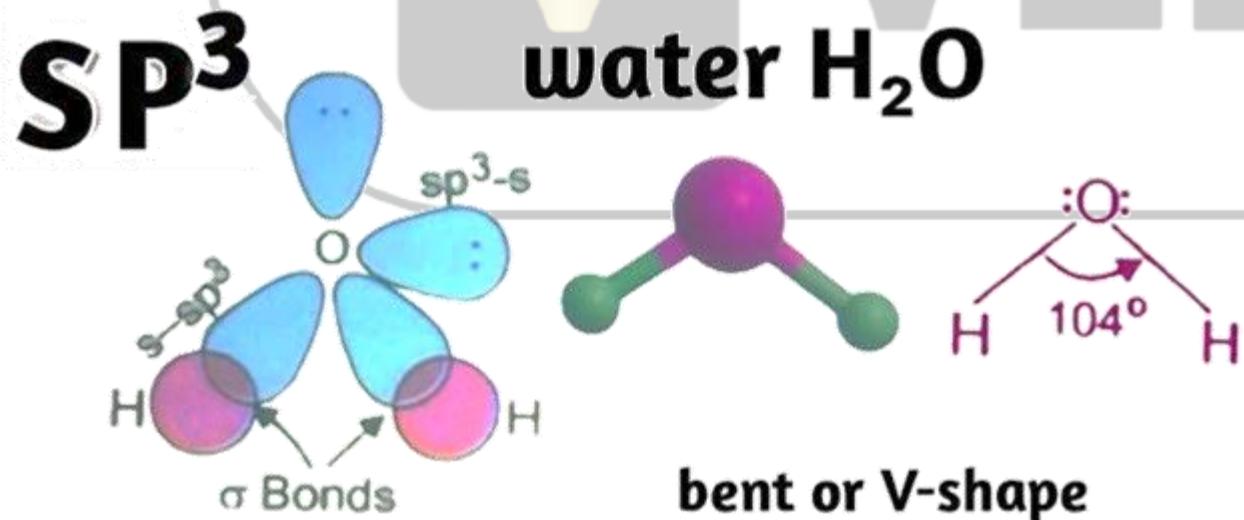
Answer-(1) Explanation

- Torsion Angle ϕ (phi): Defined by the atoms $C(i-1)$, $N(i)$, $C^\alpha(i)$, and $C(i)$. It represents the rotation around the bond between the carbonyl carbon of the previous amino acid and the nitrogen of the current amino acid.
- Torsion Angle ψ (psi): Defined by the atoms $N(i)$, $C^\alpha(i)$, $C(i)$, and $N(i+1)$. It represents the rotation around the bond between the nitrogen of the current amino acid and the carbonyl carbon of the current amino acid.
- Thus, the correct answer is that four atoms are needed: $C(i-1)$, $N(i)$, $C^\alpha(i)$, and $C(i)$ for ϕ , and $N(i)$, $C^\alpha(i)$, $C(i)$, and $N(i+1)$ for ψ .

Which one of the following statements regarding the structure of water molecule is correct?

1. The oxygen atom in water is in sp^3 hybridization, with an H-O-H angle of 109.5° .
2. The oxygen atom in water is in sp^2 hybridization, with an H-O-H angle of 120° .
3. The oxygen atom in water is in sp^3 hybridization, with an H-O-H angle of 104.5° .
4. The oxygen atom in water is in sp^2 hybridization, with an H-O-H angle of 90° .

Answer-(3) Explanation



In animal cells, typically which organelle is only provided by the sperm to the oocyte following fertilization?

1. Nucleolus
2. Peroxisomes
3. Mitochondria
4. Centrioles

Answer-(4) Explanation

During fertilization, the sperm contributes its centrioles to the zygote, which play a crucial role in cell division. The egg (oocyte), on the other hand, primarily contributes the cytoplasm and most of the organelles, including mitochondria. While both the sperm and egg contribute to the genetic material through their respective nuclei, the centrioles are specifically supplied by the sperm, facilitating the first mitotic division of the zygote post-fertilization.

In eukaryotes, nucleosome remodelers

1. methylate histone H3.
2. acetylate histone H3 and 1-44.
3. create DNaseI hypersensitive sites.
4. degrade histone subunits.

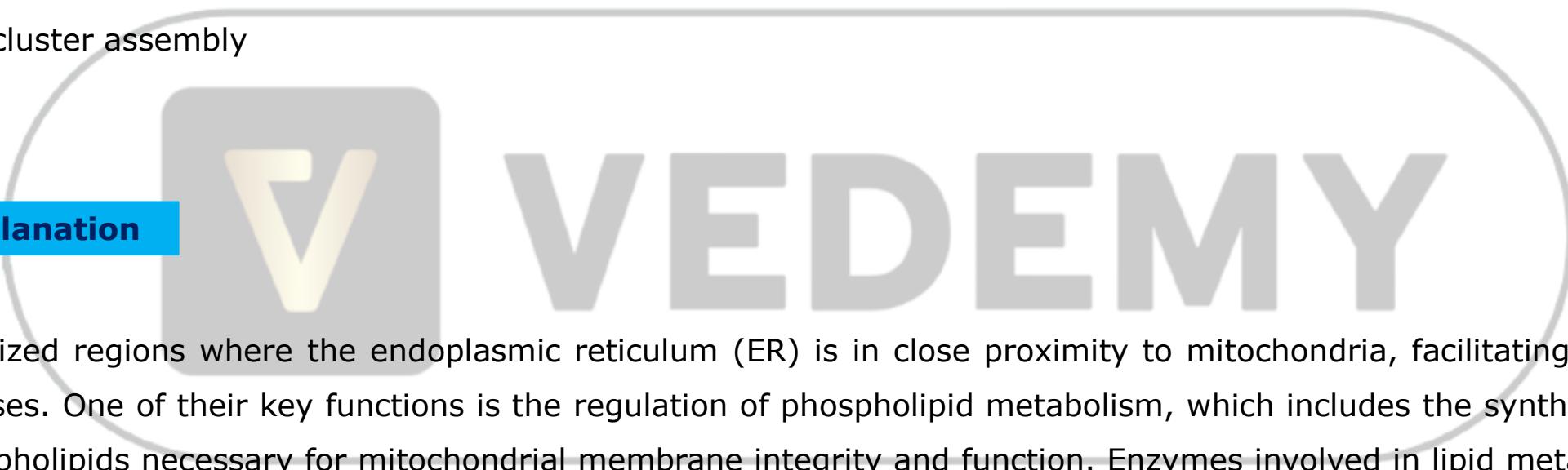
Answer-(3) Explanation

Nucleosome remodelers are ATP-dependent complexes that modify the structure of chromatin by repositioning or evicting nucleosomes. This remodeling process leads to the formation of DNase I hypersensitive sites (DHSs), which are regions of DNA that become accessible to DNase I digestion due to the loss of nucleosome occupancy. These DHSs are often associated with active regulatory elements such as promoters and enhancers, facilitating the binding of transcription factors and other proteins necessary for gene expression.

Which one of the following activities is associated with Mitochondria-associated ER membranes (MAM)?

1. Protein glycosylation
2. ATP synthesis
3. Phospholipid metabolism
4. Iron-sulphur cluster assembly

Answer-(3) Explanation



MAMs are specialized regions where the endoplasmic reticulum (ER) is in close proximity to mitochondria, facilitating various metabolic processes. One of their key functions is the regulation of phospholipid metabolism, which includes the synthesis and transport of phospholipids necessary for mitochondrial membrane integrity and function. Enzymes involved in lipid metabolism, such as those responsible for synthesizing phosphatidylserine and cholesterol, are enriched at MAMs, highlighting their crucial role in lipid homeostasis and energy metabolism within the cell.

In eukaryotic cells, DNA replication is restricted to the S phase of the cell cycle because

1. DNA polymerase is present only in the S phase of the cell cycle.
2. Origin recognition complex (ORC) recognizes origin only in the S phase.
3. MCM helicases get activated in the S phase of the cell cycle.
4. MCM helicases get activated in the G1 phase of the cell cycle.

Answer-(3) Explanation



VEDEMY

In eukaryotic cells, DNA replication is restricted to the S phase of the cell cycle primarily because:

MCM helicases get activated in the S phase of the cell cycle.

During the S phase, MCM (minichromosome maintenance) helicases are activated to unwind the DNA, allowing replication to proceed. This activation is crucial for the initiation of DNA synthesis, which does not occur in the G1 phase.

What is the correct order in which the following proteins are recruited during DNA double strand break repair in prokaryotes?

1. RecA, RecBCD, Ssb, DNA Pol III, DNA Ligase
2. ssb, RecA, RecBCD, DNA Pol III, DNA Ligase
3. RecBCD, RecA, Ssb, DNA Pol III, DNA Ligase
4. RecBCD, Ssb, RecA, DNA Pol III, DNA Ligase

Answer-(4) Explanation

Order	Protein	Function
1	RecBCD	Processes the DNA ends at the double-strand break, acting as a helicase and nuclease.
2	Ssb	Binds to single-stranded DNA (ssDNA) to stabilize it and prevent re-annealing.
3	RecA	Facilitates the search for homologous sequences and promotes strand invasion for homologous recombination.
4	DNA Pol III	Synthesizes new DNA to fill in gaps created during the repair process.
5	DNA Ligase	Seals nicks in the DNA backbone, completing the repair process.

Which one of the following statements for the lac operon in *E. coli* is **INCORRECT**?

1. The lac operon is controlled by both the Lac repressor and the activator protein, CAP.
2. The lac operon is highly expressed only when both lactose and glucose are absent.
3. The lac operon is highly expressed only when lactose is present and glucose is absent.
4. In the presence of lactose, the repressor cannot bind to the operator.

Answer-(2) Explanation

Condition	Lactose	Glucose	Lac Repressor (LacI)	CAP (cAMP-CAP Complex)	Expression of lac Operon
1. Both Present	Present	Present	Active	Inactive	Low expression (due to glucose preference)
2. Lactose Present, Glucose Absent	Present	Absent	Inactive	Active	High expression (operon activated)
3. Lactose Absent, Glucose Present	Absent	Present	Active	Inactive	No expression (repressor active)
4. Both Absent	Absent	Absent	Active	Inactive	No expression (repressor active)

Which one of the following does NOT occur during ribosome-associated quality control of damaged mRNA?

1. mRNA degradation
2. Nascent protein degradation
3. Disengagement of ribosome from mRNA
4. Ribosome-mRNA monosome degradation

Answer-(4) Explanation

The statement that does NOT occur during ribosome-associated quality control of damaged mRNA is: Ribosome-mRNA monosome degradation.

Explanation

1.mRNA degradation: This occurs as part of the quality control process when faulty mRNA is detected. The defective mRNA is targeted for degradation to prevent the synthesis of nonfunctional or toxic proteins.

2.Nascent protein degradation: This also occurs during ribosome-associated quality control. When translation stalls due to damaged mRNA, the incomplete or defective nascent polypeptides are marked for degradation.

3.Disengagement of ribosome from mRNA: This is a necessary step in ribosome-associated quality control. When a ribosome stalls on defective mRNA, it must disengage to allow for the recycling of ribosomal components and the degradation of the stalled complex.

4.Ribosome-mRNA monosome degradation: This statement is incorrect because ribosome-associated quality control does not typically involve the degradation of the ribosome-mRNA monosome as a whole. Instead, the focus is on degrading the defective mRNA and the nascent polypeptide chain, while the ribosome is recycled or disassembled.

Which one of the following statements regarding mammalian innate immunity is INCORRECT?

1. Pattern recognition receptors (PRRs) are a component of innate immunity.
2. Serum complement proteins are part of innate immunity.
3. Innate immunity has only a narrow range of specificity.
4. The outcome of innate immunity is the rapid recognition and phagocytosis or destruction of the pathogen.

Answer-(3) Explanation

Statement 1 is correct as PRRs like Toll-like receptors (TLRs), recognize pathogen-associated molecular patterns (PAMPs) and initiate immune responses and are a component of innate immunity.

Statement 2 is also correct as the complement system consists of serum proteins that enhance opsonization, promote inflammation, and directly lyse pathogens, and are a component of innate immunity.

Statement 3 is incorrect because innate immunity is the body's first line of defense against foreign substances and germs, and it responds in the same way to all of them. This is why it's sometimes called the "non-specific" immune system.

Statement 4 is correct because the primary function of innate immunity is indeed the rapid recognition and elimination of pathogens through mechanisms such as phagocytosis.

Which one of the following statements correctly explains the function of a GTPase activating protein (GAP) in the regulation of heterotrimeric G proteins in plants?

1. It activates G β protein.
2. It inactivates G α protein.
3. It directly inhibits ligand binding to GPCR.
4. It leads to the dissociation of G α from G β /G γ subunits.

Answer-(2) Explanation

GAPs increase the intrinsic rate of GTP hydrolysis, which is essential for terminating the signaling activity of G proteins. Specifically, GAPs bind to the G α subunit and promote its conversion from the active GTP-bound state back to the inactive GDP-bound state, thereby regulating the signaling pathways associated with these proteins in plants and other eukaryotic organisms.

Which one of the following statements regarding plasmodesmata in a plant cell is INCORRECT?

1. They are specialized cell-to-cell junctions.
2. They are open channels that connect the cytosol of adjacent cells.
3. The plasma membranes of the adjacent cells extend continuously through each plasmodesma.
4. Plasmodesmata are extensions of chloroplast that interconnects the cytosol of the adjacent cells.

Answer-(4) Explanation



VEDEMY

Statement 4 is Incorrect since Plasmodesmata are not extensions of chloroplasts; they are cytoplasmic strands that pass through cell walls, connecting the cytoplasm of adjacent plant cells. Chloroplasts are organelles within the cytoplasm, but they are not involved in forming plasmodesmata.

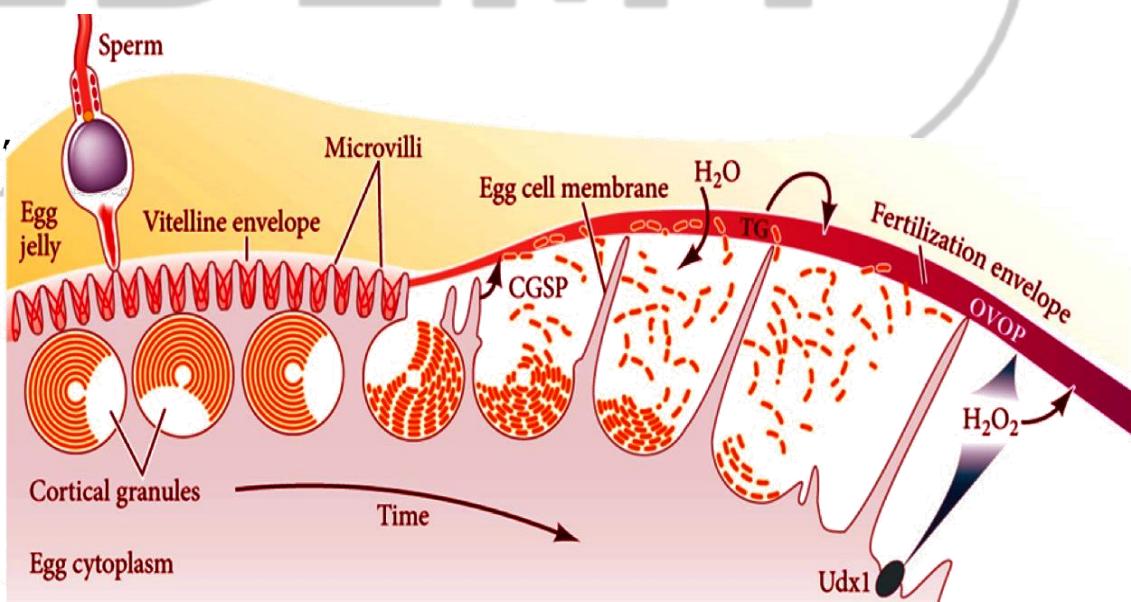
Which one of the following statements about the cortical reaction in sea urchins is correct?

1. The entry of Ca^{2+} ions into the egg initiates development.
2. The exocytosed cortical granules during egg maturation contain the components of the zona pellucida.
3. The depolarization of the plasma membrane after sperm entry helps to block polyspermy.
4. The release of the cortical granules after sperm entry converts the vitelline membrane into the fertilization membrane which blocks polyspermy.

Answer-(4) Explanation

The release of the cortical granules after sperm entry converts the vitelline membrane into the fertilization membrane which blocks polyspermy.

OVOP and transglutaminases (TG) harden the vitelline envelope, now called the fertilization envelope.



In *Caenorhabditis elegans*, blastomere identity occurs both through conditional and autonomous modes of cell specification. Which one of the following options is a correct statement in this regard?

1. If the AB and P1 blastomeres are experimentally separated, the AB cell will generate all cells it would normally make.
2. When AB divides to form daughter cells, ABp becomes different from ABa through its interaction with the P2 cell.
3. The specification of AB cell is determined by the presence of cytoplasmic determinants.
4. The P2 cell produces a morphogen for the determination of the ABp cell.

Answer-(2) Explanation

- Aba and ABp are equivalent cells (GLP-1) whose fate is determined by their positions within the embryo.
- ABp becomes different from ABa through its interaction with the P2 cell.
- Contact between ABp and P2 is essential for the specification of ABp cell fates, and the ABa cell can be made into an ABp-type cell if it is forced into contact with P2

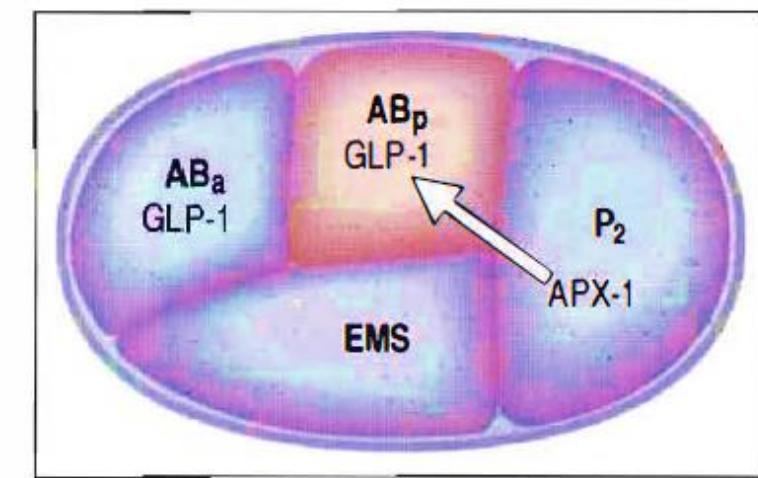
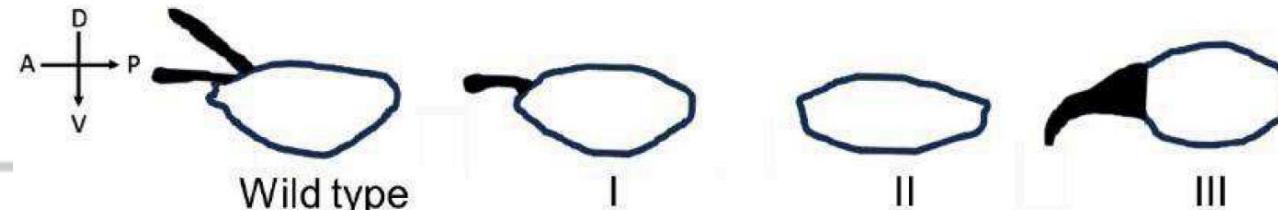


Fig. 6.6 An early inductive event specifies AB_p. AB_p becomes different from AB_a as a result of a signal emanating from the adjacent P₂ cell, thought to be the protein APX-1. This signal is received by the receptor GLP-1 on the AB_p cell.
After Mello, C.C., et al.: 1994.

The following are sketches of wild-type and mutant (I - III) embryos of *Drosophila melanogaster*.

Which one of the following options represents a correct match between the gene and its loss of function phenotype?

1. dorsal : I
2. torpedo : III
3. gurken : II
4. cactus : III



Answer-(3) Explanation

Gurken is a dorsal axis genes, hence its LOF can ventralized the embryo. From the figure only II option seems similar from both D & V axis, so it can be take as ventralized embryo

If chimeric mouse embryos were generated using GFP-expressing embryonic stem cells and RFP-expressing induced pluripotent stem cells, which one of the following tissues from any resulting embryos will not express any fluorescent protein?

1. Brain
2. Heart
3. Intestine
4. Placenta

Answer-(4) Explanation

Placenta do not form from embryonic stem cell or induced pluripotent stem cell, it is formed from trophoblast. Other body organ can be derived from embryonic stem cell.

Which one of the following is a correct combination of four carbon intermediates formed during C4 photosynthesis in plants?

1. Malate and Aspartate
2. Aspartate and Alanine
3. Phosphoenolpyruvate and Oxaloacetate
4. Alanine and Pyruvate

Answer-(1) Explanation

Malate and Aspartate are four carbon intermediates formed during C4 photosynthesis in plants

Which one of the following represents the predominant 'source organ' during phloem translocation in healthy plants?

1. Roots
2. Developing fruits
3. Immature leaves
4. Mature leaves

Answer-(4) Explanation

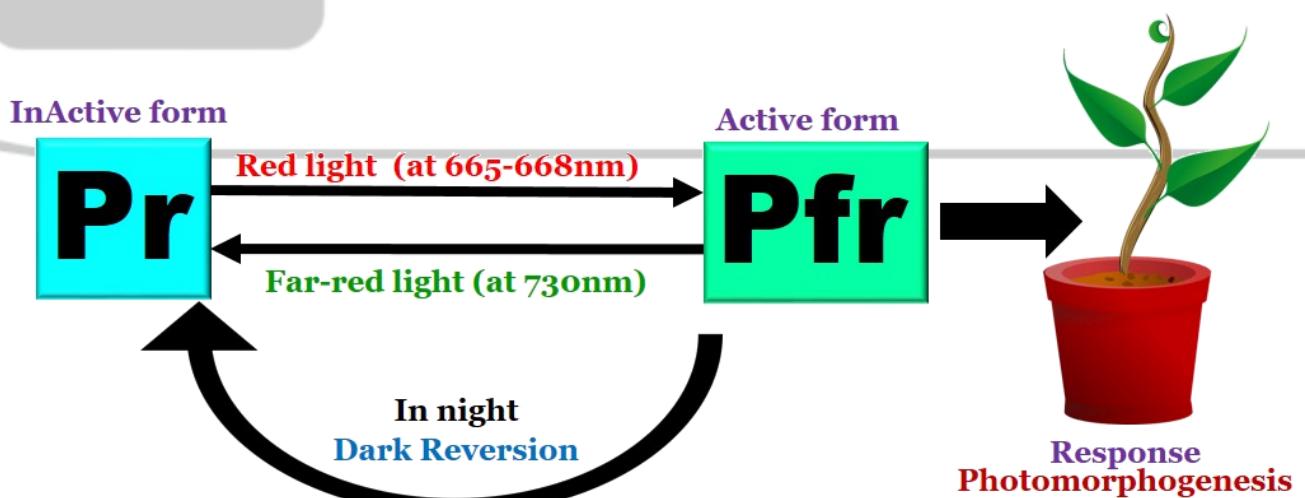
Mature leaves can act as source organ ' during phloem translocation in healthy plants

Which one of the following correctly describes 'Dark Reversion' of phytochromes?

1. Conversion of P_R to P_{FR}
2. Conversion of P_{FR} to P_R
3. Export of P_{FR} from cytosol to nucleus
4. Export of P_R from cytosol to nucleus

Answer-(2) Explanation

Conversion of P_{FR} to P_R in Night is known as dark reversion



Which of the following is LEAST suited for long-distance phloem transport of photo-assimilated carbon in plants?

1. Reducing sugars
2. Mannitol
3. Galactosyl-sucrose oligosaccharides
4. Non-reducing sugars

Answer-(1) Explanation

- Sugars are translocated in a nonreducing form .
- Results from many analyses of collected sap indicate that the translocated carbohydrates are nonreducing sugars.
- Reducing sugars, such as the hexoses glucose and fructose, contain an exposed aldehyde or ketone group. In a nonreducing sugar, such as sucrose, the ketone or aldehyde group is reduced to an alcohol or combined with a similar group on another sugar.
- Most researchers believe that the nonreducing sugars are the major compounds translocated in the phloem because they are less reactive than their reducing counterparts.
- In fact, reducing sugars such as hexoses are quite reactive and may be as much of a threat as reactive oxygen and nitrogen species.
- Sucrose is the most commonly translocated sugar.

How many amino acids are present in calcitonin, a calcium lowering hormone synthesized from C-cells of the human thyroid gland?

1. 42
2. 32
3. 22
4. 12

Answer-(2) Explanation

Calcitonin is a polypeptide hormone that plays a crucial role in regulating calcium levels in the blood. The human form of calcitonin is specifically made up of 32 amino acids, which is essential for its biological function in lowering serum calcium concentrations by inhibiting osteoclast activity and reducing renal calcium reabsorption

H₂N-Cys-Ser-Asn-Leu-Ser-Thr-Cys-Val-Leu-Gly-Lys-Leu-

1 2 3 4 5 6 7 8 9 10 11 12

Ser-Gln-Glu-Leu-His-Lys-Leu-Gln-Thr-Tyr-Pro-Arg-Thr-Asn-

13 14 15 16 17 18 19 20 21 22 23 24 25 26

Thr-Gly-Ser-Gly-Thr-Pro-NH₂

27 28 29 30 31 32

Retinal rod cell cGMP-phosphodiesterase is an enzyme with subunit structure as:

1. $\alpha\beta\gamma$
2. $\alpha\beta\gamma_2$
3. $\alpha\beta_2\gamma$
4. $\alpha_2\beta\gamma$

Answer-(2) Explanation

Retinal rod cGMP-phosphodiesterase (PDE6) is an enzyme crucial for phototransduction, consisting of a specific subunit structure: $\alpha\beta\gamma_2$. This means it has two catalytic subunits (α and β) and two inhibitory subunits (γ), forming a tetrameric complex that regulates the levels of cyclic guanosine monophosphate (cGMP) in photoreceptor cells, which is essential for vision in low light conditions.

The presence of two γ subunits allows for fine-tuning of the enzyme's activity and its interaction with other proteins in the phototransduction pathway.

How many times are sound waves amplified in the middle ear of a human?

1. 16-18
2. 6-8
3. 9-12
4. 2-4

Answer-(1) Explanation

The amplification occurs primarily due to the action of the three tiny bones in the middle ear known as the ossicles (malleus, incus, and stapes). The tympanic membrane (eardrum) vibrates in response to sound waves, and these vibrations are transferred through the ossicles to the stapes, which then transmits the sound to the inner ear. The area difference between the tympanic membrane and the stapes footplate, combined with the mechanical advantage provided by the lever action of the ossicles, results in a significant increase in pressure, estimated to be around 17 times under optimal conditions, thus falling within the range of 16-18 times amplification.

Which one of the following neurotransmitters is synthesized in synaptic vesicles instead of being transported to the vesicle after its synthesis in the cytoplasm?

1. Norepinephrine
2. Epinephrine
3. Acetylcholine
4. Serotonin

Answer-(1) Explanation

Norepinephrine is unique among the listed neurotransmitters because its final synthesis steps occur within the synaptic vesicles. While most neurotransmitters, such as acetylcholine, serotonin, and epinephrine, are synthesized in the cytoplasm and then transported into vesicles, norepinephrine is produced from dopamine inside the vesicles themselves. This process allows for more efficient regulation of its release and activity within the synapse, as it can be synthesized and stored in close proximity to its release site.

Which one of the following statements regarding principles of linkage mapping in plants is correct?

1. Genetic markers would always show higher recombination frequencies when they are closer to each other than if they are far apart.
2. The genetic distance between two markers is a true representation of the physical distance between them.
3. An ideal mapping population for a self-pollinating species is generated using polymorphic parents that are inbred lines.
4. An F_2 mapping population would segregate in a 1:2:1 ratio for a dominant marker.

Answer-(3) Explanation

1. This statement is incorrect. Generally, genetic markers that are closer together on a chromosome exhibit lower recombination frequencies due to the reduced likelihood of crossover events occurring between them. As distance increases, recombination frequencies approach 50%, indicating independent assortment.
2. This statement is also incorrect. The genetic distance, measured in centimorgans (cM), reflects the probability of recombination between markers rather than their actual physical distance on the chromosome. Recombination events are not uniformly distributed, which can lead to discrepancies between genetic and physical distances.
3. This statement is correct. In self-pollinating species, using polymorphic inbred lines as parents is ideal for generating mapping populations. This approach ensures a higher level of homozygosity and allows for clearer segregation patterns, which are essential for accurate mapping.
4. This statement is incorrect. An F_2 population typically segregates in a 3:1 ratio for a dominant marker, not 1:2:1. The 1:2:1 ratio applies to a scenario involving two alleles, where one is dominant and the other is recessive, and pertains to a single locus.

Who experimentally demonstrated "Mutations occur randomly"?

1. Alfred Hershey and Martha Chase
2. Matthew Meselson and Franklin Stahl
3. Salvador Luria and Max Delbrück
4. Francois Jacob and Jacques Monod

Answer-(3) Explanation

The statement regarding who experimentally demonstrated that "mutations occur randomly" is attributed to Salvador Luria and Max Delbrück. They conducted a pivotal experiment known as the Luria-Delbrück experiment in 1943, which provided evidence for the random nature of mutations. Their work involved studying the resistance of bacteria to phage infection and showed that mutations occurred in the absence of selective pressure, supporting the idea that mutations arise randomly rather than being directed by environmental factors. This experiment significantly contributed to the understanding of genetic variation and the mechanisms of evolution.

A DNA molecule is completely transcribed into messenger RNA by an RNA polymerase. The base composition of the DNA template strand is G = 24.1%; C=18.5%; A = 24.6%; T = 32.8%. The base composition of the newly synthesized RNA molecule is:

1. G = 24.1%, C = 18.5%, A = 24.6%, U = 32.8%
2. G = 24.6%, C = 24.1%, A = 18.5%, U = 32.8%
3. G = 18.5%, C = 24.1%, A = 32.8%, U = 24.6%
4. G = 32.8%, C = 24.6%, A = 18.5%, U = 24.1%

Answer-(3) Explanation

Transcription Process

Using the base pairing rules, we can deduce the composition of the mRNA synthesized from the DNA template:

For G (24.1%) in DNA, the corresponding base in RNA will be C (24.1%).

For C (18.5%) in DNA, the corresponding base in RNA will be G (18.5%).

For A (24.6%) in DNA, the corresponding base in RNA will be U (24.6%).

For T (32.8%) in DNA, the corresponding base in RNA will be A (32.8%).

Brassica juncea has bisexual flowers. A mutation in the mitochondria leads to cytoplasmic male sterility (CMS). CMS can be restored by a restorer of fertility gene (Rf) which is a nuclear gene. Fertility restoration is a dominant phenotype.

A CMS line is crossed to a homozygous Rf line. The obtained F_1 progeny is self- pollinated. What percentage of F_2 progeny will be male sterile?

1. 0
2. 25
3. 75
4. 100

Answer-(2) Explanation

- In the cross between a cytoplasmic male sterile (CMS) line (cms/cms) and a homozygous restorer of fertility line (Rf/Rf), the F_1 progeny will all be heterozygous (Rf/cms) and fertile due to the dominant Rf allele. When the F_1 progeny (Rf/cms) are self-pollinated, the F_2 generation will have the following genotypes: Rf/Rf: Fertile
- Rf/cms: Fertile
- cms/cms: Male sterile
- Using a Punnett square, the genotypic ratio is 1 Rf/Rf : 2 Rf/cms : 1 cms/cms. This means that 1 out of 4 (or 25%) of the F_2 progeny will be male sterile.

For maintaining hydraulic conductance, tree stems appear to trade-off vessel diameter with

1. strength of the stem.
2. stem length.
3. heartwood volume.
4. vessel length.

Answer-(1) Explanation

Tradeoff between Stem Hydraulic Efficiency and Mechanical Strength. there is a trade-off between hydraulic and mechanical function of stems, and this trade-off has compensated effect on the twig–leaf size allometric relationship.

A plant is NOT watered for seven days (day 1 — day 7). Leaf and root water potential are measured every two hours starting from day 1 till day 7. Which one of the following is LEAST LIKELY to happen?

1. Pre-dawn leaf water potential declines over the 7 days.
2. Leaf water potential shows a diurnal cycle of highs and lows.
3. Root water potential falls below leaf water potential at night.
4. Root water potential fluctuates between day and night.

Answer-(3) Explanation

Pre-dawn leaf water potential declines over the 7 days. Leaf water potential shows a diurnal cycle of highs and lows. Root water potential are least likely to falls below leaf water potential at night, as root is absorptive organ but Root water potential fluctuates between day and night.

Which one of the following options includes all plants that are major non-native invaders of aquatic ecosystems in India?

1. *Parthenium hysterophorus, Pontederia crassipes, Lantana camara*
2. *Salvinia molesta, Prosopis juliflora, Mikania micrantha*
3. *Nelumbo nucifera, Pogostemon erectus, Hygrophila serpyllum*
4. *Pontederia crassipes, Salvinia molesta, Alternanthera philoxeroides*

Answer-(4) Explanation

Pontederia crassipes, Salvinia molesta, Alternanthera philoxeroides

Select the geological time where some of the major events, like an increase in marine diversity, dominance of gymnosperms, diversification of synapsids (including the emergence of first dinosaurs), and first mammal-like forms, occurred.

1. Cretaceous
2. Jurassic
3. Triassic
4. Carboniferous

Answer-(3) Explanation

In Triassic geological time some of the major events, like an increase in marine diversity, dominance of gymnosperms, diversification of synapsids (including the emergence of first dinosaurs), and first mammal-like forms, occurred.

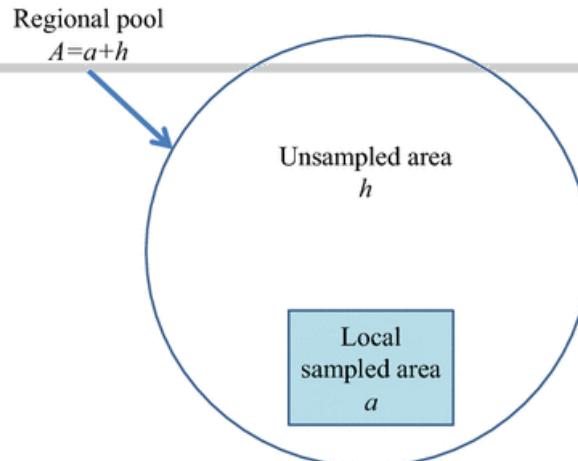
A community of woody plants is being shaped by environmental filtering. What will be the likely local species pool of this community, if the regional species pool comprises 60 species?

1. 100
2. 80
3. 120
4. 30

Answer-(4) Explanation

A regional species pool comprises all species available to colonize a focal site.

And local special pool is a part of regional pool, so it will be less than regional pool i.e. less than 60. so only option which is possible is 30.



Andaman and Nicobar archipelago are part of which biodiversity hotspots?

1. Andaman - Indo-Burma; Nicobar - Sundaland
2. Andaman - Sundaland; Nicobar - Indo-Burma
3. Andaman - Indo-Burma; Nicobar - Indo-Burma
4. Andaman - Sundaland; Nicobar - Sundaland

Answer-(1) Explanation

According to Conservation International, a region must fulfil the following two criteria to qualify as a hotspot:

1. The region should have at least 1500 species of vascular plants i.e., it should have a high degree of endemism.
2. It must contain 30% (or less) of its original habitat, i.e. it must be threatened.

Following the criteria for an area to be declared as a Biodiversity Hotspot, there are major four biodiversity hotspots in India:

1. The Himalayas
2. Indo-Burma Region (Andaman)
3. The Western Ghats
4. Sundaland (Nicobar)

Select the correct combination of terms from plant breeding systems that represents selfing or promote selfing.

1. Autogamy and allogamy
2. Cleistogamy and geitonogamy
3. Geitonogamy and allogamy
4. Autogamy and herkogamy

Answer-(2) Explanation



VEDEMY

Cleistogamy and geitonogamy

- Cleistogamy refers to flowers that self-pollinate without opening, ensuring self-fertilization.
- Geitonogamy involves the transfer of pollen from one flower to another flower on the same plant, which is technically a form of selfing since it involves the same genetic individual.

Which of these traits is NOT characteristic of r-selected tree species?

1. Mortality and reproduction are strongly dependent on population density.
2. Tend to occupy habitats that are unpredictable and/or ephemeral.
3. Thrive in habitats where resource competition is low.
4. Have superior capabilities to colonize new habitats.

Answer-(1) Explanation



VEDEMY

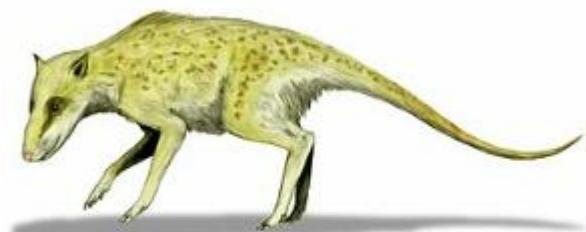
Mortality and reproduction are strongly independent on population density as r selected. Tend to occupy habitats that are unpredictable and/or ephemeral. Thrive in habitats where resource competition is low & Have superior capabilities to colonize new habitats.

In 2007, scientists reported the fossil of a deer-like animal in Kashmir, India which is considered the most recent terrestrial ancestor of whales. The name of this fossil is

1. Jainosaurus.
2. Indohyus.
3. Rajasaurus.
4. Indosuchus.

Answer-(2) Explanation

Indohyus (meaning "India's pig") is a small deer-like creature, which lived about 49 or 48 million years ago in Kashmir, India. It belongs to the artiodactyls family *Raoellidae*, and is believed to be the closest sister group of Cetacea. It lived during the same time as the related *Pakicetus*. The two may have coexisted.



Indohyus major

Which one of the following concepts can explain host-parasite co-evolution?

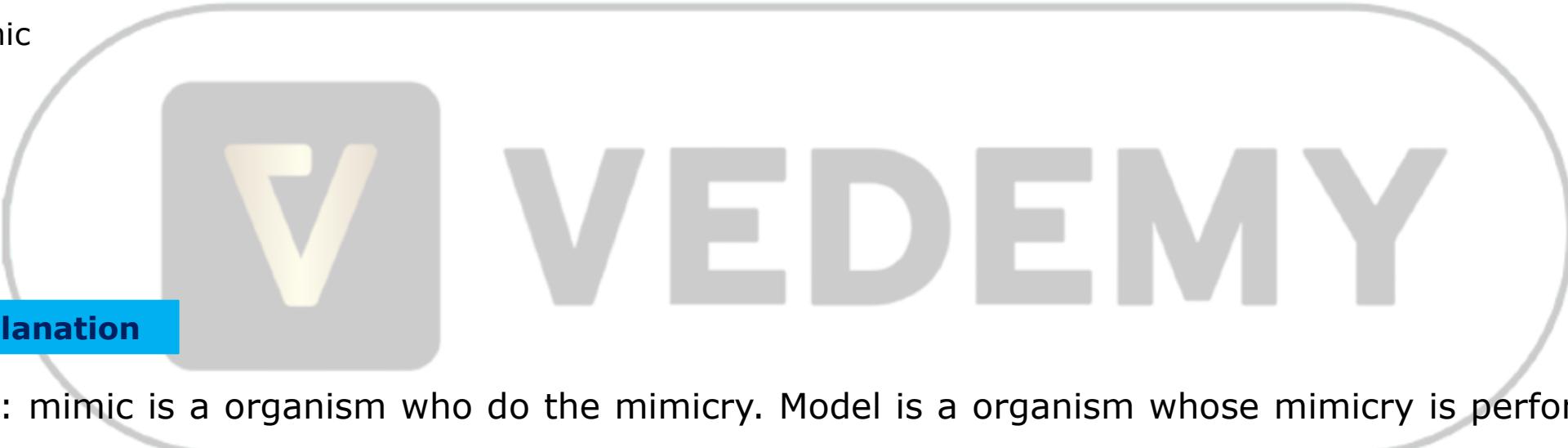
1. Kin selection
2. Red Queen hypothesis
3. Runaway selection
4. Handicap principle

Answer-(2) Explanation

Red Queen hypothesis: It's a coevolutionary "arms race" hypothesis. Van Valen named the idea "the Red Queen hypothesis," because, under this view, species had to "run" (evolve) in order to stay in the same place (extant).

Which one of the following is an example of dishonest signaling?

1. Batesian model
2. Batesian mimic
3. Mullerian model
4. Mullerian mimic



Answer-(2) Explanation

Batesian mimic: mimic is a organism who do the mimicry. Model is a organism whose mimicry is performed by mimic

Batesian mimicry, where a harmless mimic poses as harmful, but in actual it is not harmful, so it represent dishonest signaling for predators.

Select the statement that describes guild coevolution, also known as diffuse coevolution.

1. One species uses the other as a resource.
2. Two species coevolve reciprocally, but only to each other.
3. Several species are involved in coevolutionary interactions.
4. A species escapes association from a predator and diversifies. Later, a different predator adapts to the host and diversifies.

Answer-(3) Explanation

When Several species are involved in coevolutionary interactions at that time it is considered to be diffuse coevolution.

A researcher overexpresses the full-length genomic sequence of rice *GAPDH* gene under a CaMV35S promoter in transgenic rice. Which one of the following options can be used to confirm transgenic lines using PCR?

1. Using exon-specific primers of the *GAPDH* gene.
2. Using intron-specific primers of the *GAPDH* gene.
3. Amplification of the promoter region of the *GAPDH* gene.
4. Using CaMV35S promoter-specific forward and *GAPDH*-specific reverse primer.

Answer-(4) Explanation

The correct option to confirm transgenic lines using PCR is:

Using CaMV35S promoter-specific forward and *GAPDH*-specific reverse primer

This approach allows the researcher to confirm that the transgene (*GAPDH* gene) is integrated and being expressed under the control of the CaMV35S promoter. The PCR product would only be obtained if the transgene is present and correctly integrated into the genome of the transgenic rice.

A pulse oximeter measures the ratio between oxyhemoglobin and hemoglobin in the pulsating condition on the finger. Which combination of wavelengths can obtain a differential absorption to measure blood oxygen saturation?

1. Ultraviolet and Infrared
2. Visible and Infrared
3. Far-ultraviolet and visible
4. Ultraviolet and far-ultraviolet

Answer-(2) Explanation

To measure blood oxygen saturation using a pulse oximeter, the combination of wavelengths that provides differential absorption is visible and infrared. Specifically, pulse oximeters commonly use light wavelengths of 660 nm (red, in the visible spectrum) and 940 nm (near-infrared). This combination allows the device to differentiate between oxygenated hemoglobin (O_2Hb) and deoxygenated hemoglobin (Hb), as they absorb light differently at these wavelengths. Oxygenated hemoglobin absorbs more infrared light and less red light, while deoxygenated hemoglobin does the opposite. Therefore, the correct answer is visible and infrared.

It was found that most people who were vaccinated with the ancestral strain of Covid-19 (Wuhan strain) were protected against the Delta variant but not against the Omicron variant. PBMCs (peripheral blood mononuclear cells) and serum were obtained from five successfully vaccinated individuals with good neutralizing antibody titres and cytotoxic (CTL) activity against the Wuhan strain- infected targets. Pooled serum was transferred into unrelated recipient "A" and pooled purified T cells were transferred into unrelated recipient "B". Which one of the following is likely to be observed?

1. 'A' will be protected against both the ancestral strain and the Delta variant.
2. 'B' will be protected against ancestral strain but not against the Delta variant.
3. 'A' will be protected against infection with the Omicron variant.
4. 'A' will make antibodies against interferon gamma present in the donor serum.

Answer-(1) Explanation

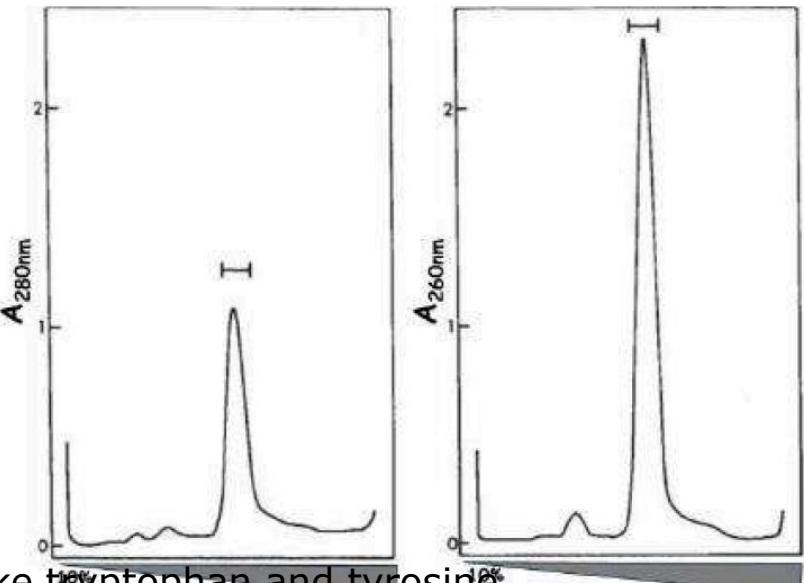
- when a pooled serum from vaccinated individuals is transferred to recipient "A" and pooled purified T cells are transferred to recipient "B," the following outcomes can be expected:
- Recipient "A" receives serum containing antibodies from the vaccinated individuals. Since these antibodies are effective against the ancestral strain and the Delta variant, "A" will be protected against both the ancestral strain and the Delta variant.
- Recipient "B" receives T cells, which can provide cellular immunity but not immediate antibody protection. The T cells may recognize and respond to the ancestral strain but will not be effective against the Delta variant due to the reduced neutralization observed with the Delta variant in individuals vaccinated with the ancestral strain. Thus, "B" will be protected against the ancestral strain but not against the Delta variant.
- Neither "A" nor "B" will be protected against the Omicron variant, as the Omicron variant has shown significant immune evasion against antibodies generated from the ancestral strain vaccination.
- There is no indication that "A" will make antibodies against interferon gamma present in the donor serum, as this is not a typical immune response.

Cell lysate in 1% TX100 was purified over an affinity column to isolate a complex with certain enzymatic activity. The purified enzyme complex was separated on a 10-50% continuous sucrose gradient. Shown below are the UV spectra using an absorbance filter at 280nm or 260nm.

Which one of the following combinations of molecules would generate the spectra shown above?

1. Protein-Protein
2. Protein-RNA
3. Protein-Lipid
4. Protein-Cholesterol

Answer-(2) Explanation



- Proteins absorb strongly at 280 nm due to the presence of aromatic amino acids like tryptophan and tyrosine.
- Nucleic acids (DNA and RNA) absorb strongly at 260 nm because of the aromatic bases (adenine, guanine, cytosine, thymine/uracil).
- Given this information, the combinations can be evaluated:
Protein-Protein: Would primarily absorb at 280 nm, with no significant signal at 260 nm.
Protein-RNA: This combination would show strong absorption at both 260 nm (from RNA) and 280 nm (from protein), leading to a characteristic spectrum that reflects both components.
Protein-Lipid: Lipids do not have significant absorbance at either 260 nm or 280 nm, so this combination would not generate a strong signal in either range.
Protein-Cholesterol: Similar to lipids, cholesterol does not absorb significantly at either wavelength, leading to minimal absorbance.

Which one of the following options has the correct set of components for assaying reverse transcriptase activity?

1. RNA primer, dNTPs, buffer, primase, DNA template
2. DNA primer, NTPs, buffer, DNA template
3. DNA primer, dNTPs, buffer, RNA template
4. RNA primer, NTPs, buffer, RNA template

Answer-(3) Explanation

- To assay reverse transcriptase activity, the correct set of components typically includes:
- RNA template: This serves as the template for reverse transcription.
- DNA primer: Required for initiating the synthesis of complementary DNA (cDNA).
- dNTPs: Deoxynucleotide triphosphates are necessary for DNA synthesis.
- Buffer: Provides the optimal pH and ionic conditions for the reaction.

In which one of the following stages pontogeniculo-occipital (PGO) spikes are found in human EEG recordings?

1. Immediately before and during REM sleep
2. Non-REM sleep stage 2
3. Awake condition
4. Non-REM sleep stage 4

Answer-(1) Explanation

Pontogeniculo-occipital (PGO) spikes are found in human EEG recordings immediately before and during REM sleep. PGO waves are phasic field potentials that originate in the pons and propagate to the lateral geniculate nucleus and occipital lobe, playing a significant role during REM sleep, which is associated with dreaming and eye movements. These waves are most prominent just before and throughout REM sleep, indicating their involvement in the neural processes related to this sleep stage.

A student counts the number of seeds produced by ten different haploid *Arabidopsis* plants and obtains the following data:
0, 5, 15, 25, 100, 150, 200, 600, 1500, 3000.

Which one of the following is the best measure of central tendency for summarizing the above data?

1. Mean
2. Median
3. Mode
4. Standard deviation

Answer-(2) Explanation

To determine the best measure of central tendency for summarizing the given data set of seeds produced by ten haploid *Arabidopsis* plants:

Data Set:

0, 5, 15, 25, 100, 150, 200, 600, 1500, 3000

Analysis:

- Mean: The mean can be heavily influenced by extreme values (outliers), such as 3000 in this case.
- Median: The median is the middle value when the data is ordered. For this data set, the median is the average of the 5th and 6th values (100 and 150), which is 125. The median is less affected by outliers.
- Mode: The mode is the most frequently occurring value. In this data set, all values are unique, so there is no mode.
- Standard Deviation: This is a measure of variability, not central tendency.

Conclusion:

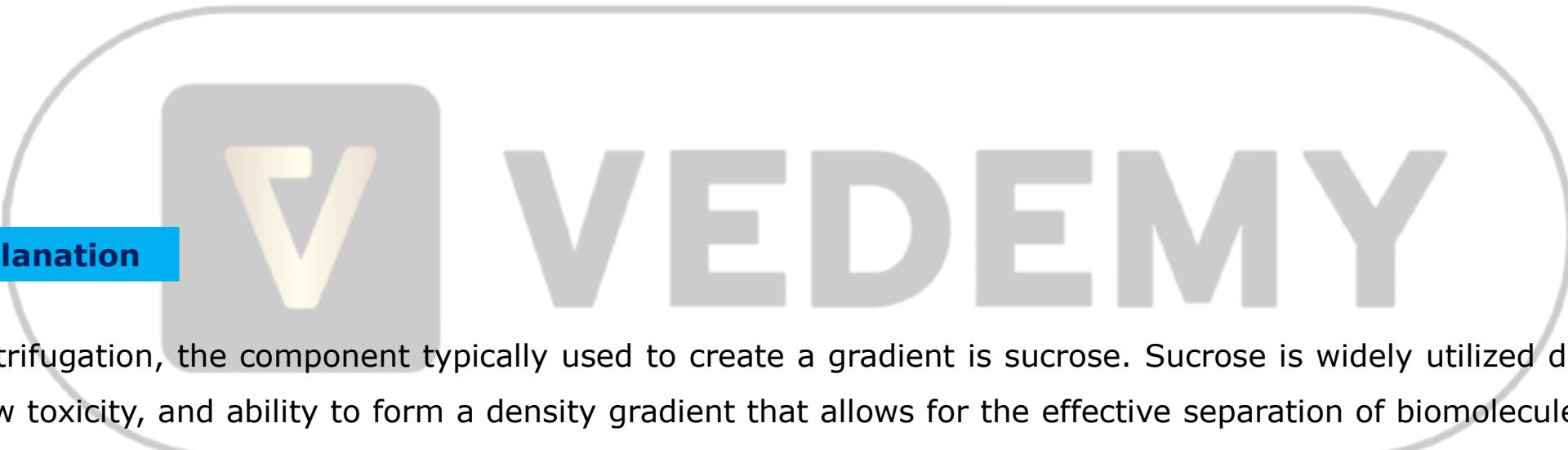
Given the presence of an outlier (3000), the median is the best measure of central tendency for summarizing this data set, as it provides a better representation of the central location of the data without being skewed by extreme values.

Best Measure: Median

In rate-zonal centrifugation, a mixture is spun just long enough to separate molecules that differ in mass but may be similar in shape and density. Which one of the following options represents the component that is typically used to create a gradient in this technique?

1. phospholipids
2. sucrose
3. KCl
4. starch

Answer-(2) Explanation



In rate-zonal centrifugation, the component typically used to create a gradient is sucrose. Sucrose is widely utilized due to its high solubility, low toxicity, and ability to form a density gradient that allows for the effective separation of biomolecules based on size and density. This is supported by the information that describes sucrose as a common density gradient medium in this technique.



CSIR NET

Life sciences

For June 2024

Shift-1

Part- C

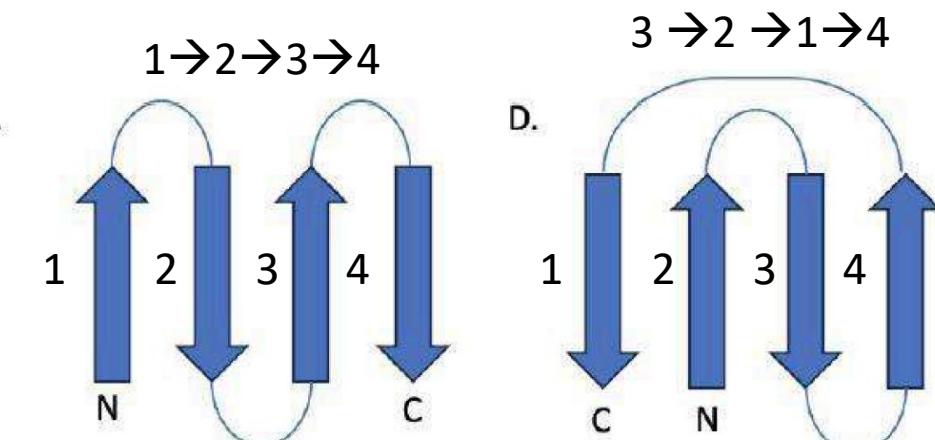
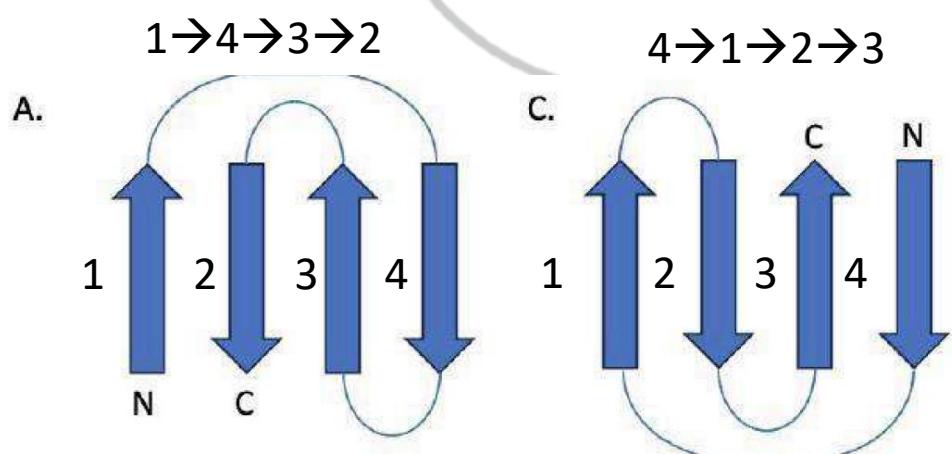
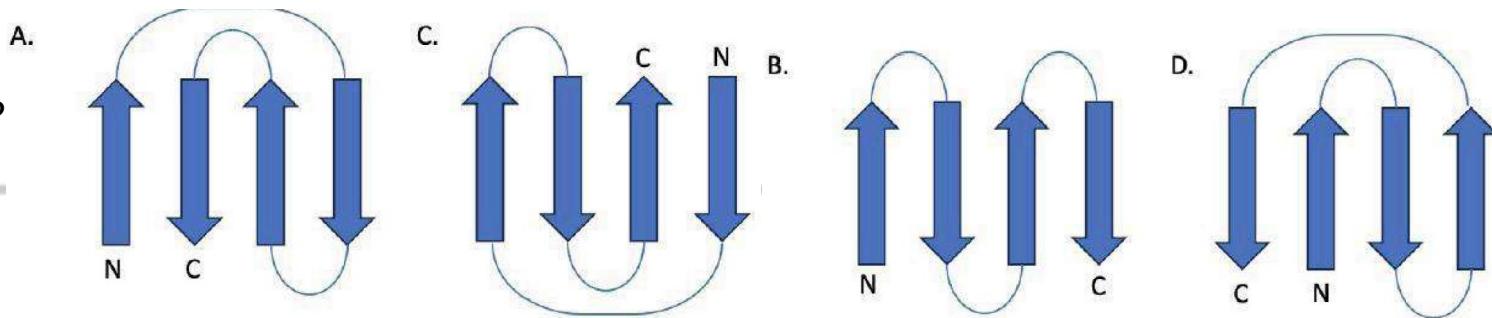
Unit-wise Question Paper Analysis

Given below are four topology diagrams corresponding to different proteins. N and C denote the N- and C-terminal ends of the protein chains.

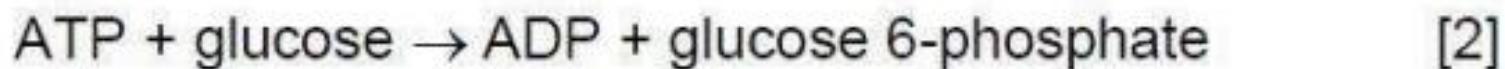
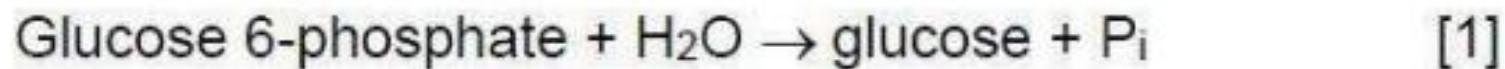
Which one of the following statements is CORRECT?

1. All four are of different folds.
2. All four are of the same fold.
3. (A), (C) and (D) are of the same fold.
4. (A) and (C) are of the same fold.

Answer-(4) Explanation



For the coupled reaction given below, the equilibrium constants (K'_{eq}) for equation [1] and equation [2] are 270 and 890, respectively.



The standard free energy of hydrolysis of ATP at 25 °C is

1. - (24 to 26) kJ / mol
2. - (18 to 20) kJ /mol
3. - (30 to 32) kJ
4. - (60 to 62) kJ / mol

Answer-(3) Explanation

The standard free energy of hydrolysis of ATP at 25 °C is typically reported to be approximately -30.5 kJ/mol (or -7.3 kcal/mol). This value indicates that the hydrolysis of ATP to ADP and inorganic phosphate (Pi) is an exergonic reaction, releasing energy that can be utilized for various cellular processes.

A propionate kinase enzyme utilizes two substrates, propionate and acetate, with K_m for propionate being half that of acetate. Which one of the following options about the rate of the reaction at very low substrate concentrations is correct?

1. The rate of propionate utilization is half that of acetate.
2. The rate of propionate utilization is double that of acetate.
3. The rate of propionate utilization is equal to that of acetate.
4. The rate of propionate utilization is four times that of acetate.

Answer-(2) Explanation

Parameter	Propionate	Acetate
K_m	Half that of acetate	Higher than propionate
Rate Equation	$v_{prop} = V_{max}/Km_{prop}[S_{prop}]$	$v_{acet} = V_{max}/Km_{acet}[S_{acet}]$
Comparison of Rates	$v_{prop} = 2 \times v_{acet}$	
Conclusion	Rate of propionate utilization is double that of acetate	

Which one of the following options represents a classical Hoogsteen base pairing?

1. anti A base-paired with anti T
2. anti G base-paired with anti C
3. syn A base-paired with anti T
4. anti G base-paired with anti U

Answer-(3) Explanation

In the context of classical Hoogsteen base pairing, the correct option is syn A base-paired with anti T.

Hoogsteen base pairing occurs when one base adopts a syn conformation while the other base remains in the anti conformation. Specifically, in the case of the A•T pair, the adenine (A) can adopt a syn orientation, allowing it to form hydrogen bonds with thymine (T) in an alternative pairing configuration. This contrasts with the typical Watson-Crick pairing, where both bases are in the anti conformation. Therefore, the combination of syn A base-paired with anti T represents a classical example of Hoogsteen base pairing.

Given below are a few statements regarding the rate of glycolysis, gluconeogenesis and glycogen metabolism.

- A. Increased blood glucose would decrease gluconeogenesis and increase glycogen synthesis.
- B. Increased levels of fructose-I 6-bisphosphate inhibits glycolysis.
- C. Increased blood glucagon inhibits glycogen synthesis and stimulates glycogen break down.
- D. Increase in AMP levels inhibits glycolysis and stimulates gluconeogenesis.

Which one of the following options represents INCORRECT statements?

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

Answer-(2) Explanation

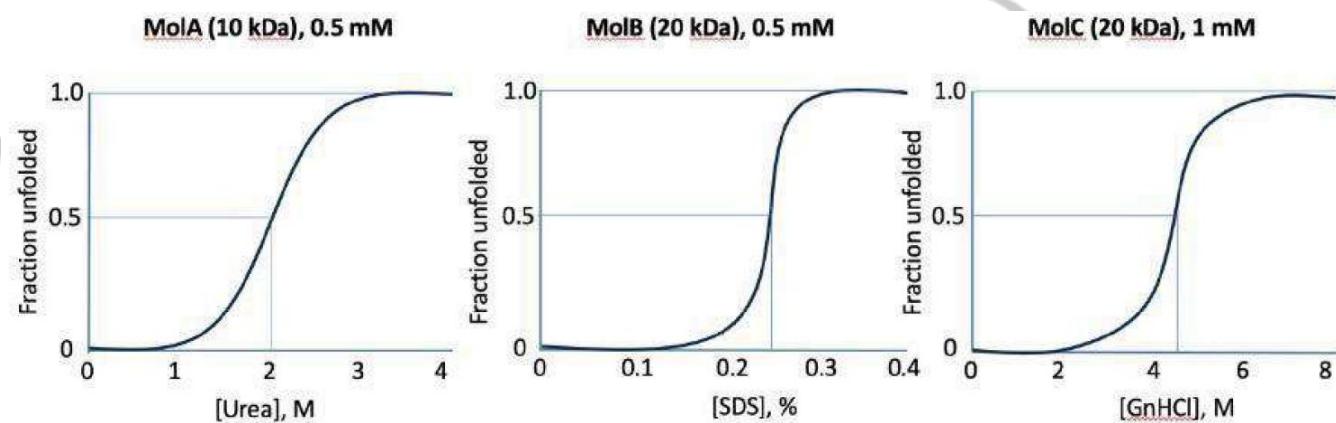
- Statement A: Correct: High blood glucose levels lead to increased insulin secretion, which promotes glycogen synthesis and inhibits gluconeogenesis.
- Statement B: Incorrect: Fructose-1,6-bisphosphate is actually an important activator of glycolysis. It stimulates phosphofructokinase, the key regulatory enzyme in glycolysis, thereby promoting the pathway rather than inhibiting it.
- Statement C: Correct: Glucagon is released when blood glucose levels are low, and it promotes glycogenolysis (the breakdown of glycogen) while inhibiting glycogenesis (the synthesis of glycogen).
- Statement D: Incorrect: Increased AMP levels indicate low energy status in the cell. AMP actually stimulates glycolysis (to generate more ATP) and inhibits gluconeogenesis (to conserve energy), making this statement incorrect.

In a protein stability study, three solutions, MolA (10 kDa) at 0.5 mM, MolB (20 kDa) at 0.5 mM, and MolC (20 kDa) at 1 mM, were subjected to denaturation by urea, SDS and guanidium hydrochloride (GnHCl), respectively. The profiles of the fraction of unfolded protein with increasing concentration of the denaturants is given below.

Which one of the following corresponds to reaction conditions at which the number of molecules of folded protein are equal, assuming the reaction volumes to be the same for all experiments?

1. 0.2 M urea; 0.05 % SDS; 4.5 M GnHCl
2. 2 M urea; 0.05 % SDS; 1 M GnHCl
3. 0.2 M urea; 0.25% SDS; 4.5 M GnHCl
4. 2 M urea; 0.25 % SDS; 1 M GnHCl

Answer-(1) Explanation



To achieve a condition where the number of molecules of folded protein is equal:
0.2 M urea for MolA: At this concentration, MolA is just beginning to unfold, meaning most of the protein remains folded.
0.05% SDS for MolB: At this concentration, MolB is also at the early stages of unfolding, with most of the protein still folded.
4.5 M GnHCl for MolC: This is around the midpoint for MolC, where 50% of the protein is unfolded, and 50% is still folded.

The Ran GTPase imposes directionality on transport through nuclear pore complexes (NPCs). Like other GTPases, Ran is a molecular switch that can exist in two conformational states, depending on whether bound to GDP or GTP. Possible reasons for compartmentalization of Ran-GTP accumulation are:

- A. Ran-GAP is enriched in the nucleus
- B. Ran-GAP is localized in the cytosol
- C. Ran-GEF is enriched in the nucleus
- D. The nuclear import receptors help in the compartmentalization of Ran-GTP

Which of the options below has all the correct statements about Ran-GTP compartmentalization?

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

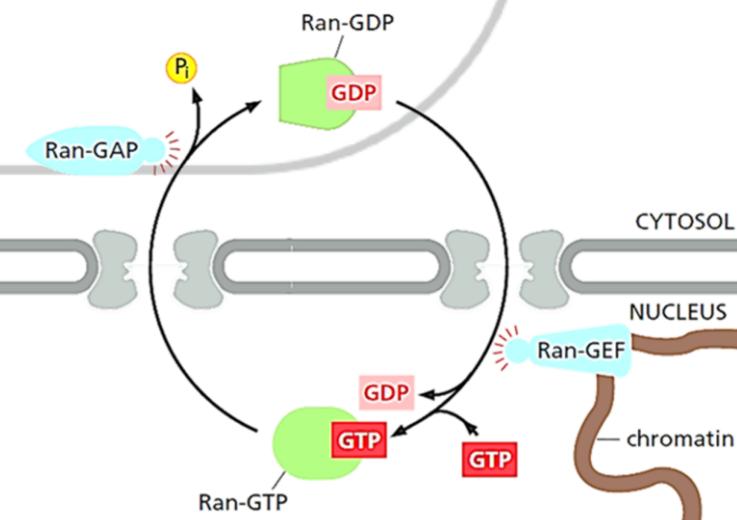
Answer-(3) Explanation

In Nucleus

- Ran-GTP.
- Ran GEF binds to chromatin and is therefore located in the nucleus.
- GEF does GDP/ GTP exchange in nucleus.

In Cytosol

- Ran-GDP.
- Ran GTPase activating protein (Ran-GAP).
- GAP does GTP hydrolysis in cytoplasm.
- Ran-GDP is imported into the nucleus by its own import receptor.



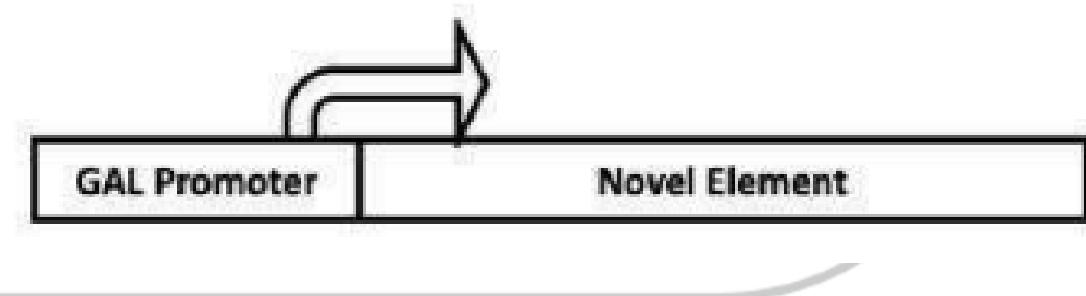
A complete retroposon was cloned under the entire galactose inducible promoter. The construct, as shown below, was inserted in the yeast genome to study the transposition event.

Some of the predicted outcomes are listed below:

- A. Cells grown in presence of glucose or galactose lead to increase in copy number of the transposon.
- B. The transposed copies will be same as the construct inserted in the genome.
- C. The transposed copies cannot transpose further.
- D. The transposed copies will not respond to either glucose or galactose in the media.

Assuming that the hypothesis is correct, choose the option that has all likely outcomes.

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



Answer-(4) Explanation

In the presence of glucose, the GAL promoter would be repressed, preventing the expression of the retroposon. Thus, no increase in copy number would occur under glucose. Under galactose, the GAL promoter would be active, leading to transcription and potential transposition, increasing the copy number. Therefore, the outcome should specify that an increase would occur only in the presence of galactose, not glucose. Hence A statement is incorrect. Since the transposed copies lack the GAL promoter, they will not be regulated by glucose or galactose, meaning they won't respond to these sugars.

Given below are some components that could potentially influence membrane fluidity.

- i. Monomeric G-proteins
- ii. Peripheral membrane proteins
- iii. Sphingolipids
- iv. Phospholipid sidechain saturation
- v. Cholesterol

Choose the option that has all the components that can influence membrane fluidity.

- 1. i, ii, v
- 2. i, ii, iv
- 3. iii, iv, v
- 4. ii, iv, v

Answer-(3) Explanation

Sphingolipids (iii): These lipids can influence membrane fluidity due to their longer fatty acid chains, which can form more ordered structures, potentially decreasing fluidity.

Phospholipid sidechain saturation (iv): The saturation of fatty acid chains in phospholipids affects fluidity. Saturated fatty acids pack tightly, reducing fluidity, while unsaturated fatty acids introduce kinks, increasing fluidity.

Cholesterol (v): Cholesterol modulates membrane fluidity by preventing fatty acid chains from packing too closely together. It enhances fluidity at lower temperatures and reduces it at higher temperatures.

URA3 gene expression allows yeast cells to grow on synthetic media lacking Uracil (SC-URA). Shown below are cell types having IJRA3 gene inserted at distinct positions of the chromosome. The ability of each cell type to grow on SC-URA in either log or stationary phase is listed on the right.

The following interpretations were made:

- A. URA3 gene in cell type 1 is probably located in a heterochromatic region.
- B. URA3 gene in cell type 2 is located in facultative heterochromatin.
- C. URA3 gene in cell type 2 is probably located in a chromosome region silenced in log phase.
- D. URA3 gene in cell type 3 is heterochromatinized in log phase.

Which one of the following options are correct interpretations?

1. A and C
2. B and D
3. A and D
4. B and C

Answer-(2) Explanation

Cell Type 1: Log Phase: Can grow (+). Stationary Phase: Can grow (+).

Interpretation: The URA3 gene is likely located in a euchromatic region, which is typically active. In the log phase, the gene is de-repressed, promoting growth. In the stationary phase, some de-repression might occur, allowing growth.

Cell Type 2: Log Phase: Can grow (+). Stationary Phase: Cannot grow (-).

Interpretation: The URA3 gene is likely in a region that is active during the log phase but becomes silenced in the stationary phase. This suggests that it is located in a region of facultative heterochromatin, which can switch between active and inactive states.

Cell Type 3: Log Phase: Cannot grow (-). Stationary Phase: Can grow (+).

Interpretation: The URA3 gene is likely silenced in the log phase, indicating that it is in a heterochromatic region during this phase. However, it becomes active in the stationary phase, suggesting a dynamic change in chromatin state.



Some features mentioned below are important for the segregation of homologous chromosomes in meiosis I.

- A. Synaptonemal complex formation between homologous chromosomes
- B. Degradation of cohesins at the chromosome arms.
- C. Retention of cohesins at the centromeres.
- D. Bi-orientation of kinetochores of sister chromatids.

Which one of the following options has all correct features?

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

Answer-(3) Explanation

Synaptonemal complex formation between homologous chromosomes:Correct: The synaptonemal complex is crucial for the pairing (synapsis) of homologous chromosomes during prophase I of meiosis. This pairing is essential for proper segregation.

Degradation of cohesins at the chromosome arms:Correct: During anaphase I of meiosis, cohesins holding the arms of homologous chromosomes degrade, allowing the homologous chromosomes to separate while sister chromatids remain attached at the centromere.

Retention of cohesins at the centromeres:Correct: Cohesins at the centromeres are retained during meiosis I, ensuring that sister chromatids do not separate prematurely. This retention is crucial for the proper segregation of homologous chromosomes.

Bi-orientation of kinetochores of sister chromatids:Incorrect for meiosis I: In meiosis I, the kinetochores of sister chromatids are not bi-oriented (attached to opposite poles). Instead, the kinetochores of sister chromatids are co-oriented (attached to the same pole), which ensures that sister chromatids do not separate and instead move together towards one pole.

Following statements are made regarding the nature of the chromosomes in bacteria.

- A. Most bacterial chromosomes are circular. However, in few bacteria, linear chromosomes exist.
- B. All the bacterial systems are known to have a single chromosome.
- C. Some bacterial chromosomes contain enhancer-like elements.
- D. Chromosomes in bacteria are stabilized by histone-like proteins

Which one of the following options represents the combination of all correct statements?

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

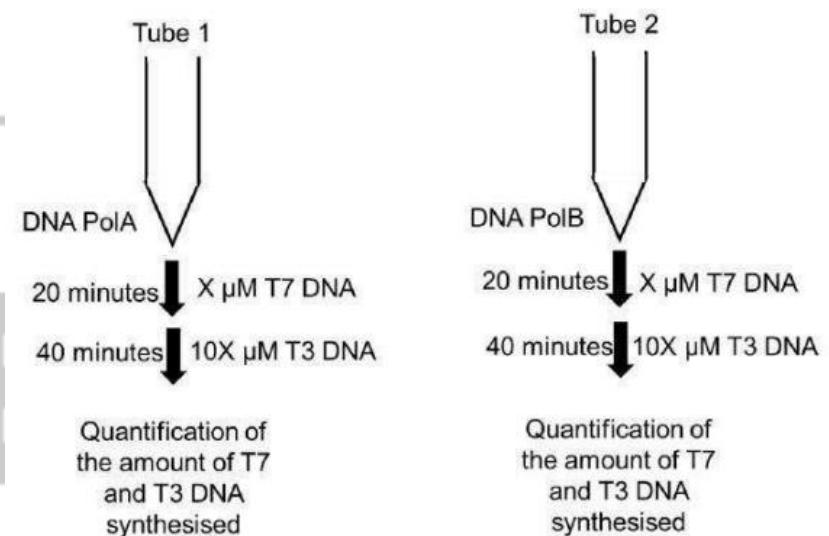
Answer-(4) Explanation

- Most bacteria have circular chromosomes, but some, like *Borrelia burgdorferi* (the causative agent of Lyme disease), have linear chromosomes.
- Bacterial chromosomes can have regulatory elements similar to enhancers found in eukaryotes.
- Bacteria have proteins known as histone-like proteins (e.g., HU, H-NS) that help in stabilizing and organizing their DNA⁵.

DNA polymerase Pol A has high fidelity but low processivity and DNA polymerase Pol B has low fidelity and high processivity. In vitro reactions for DNA synthesis using limiting amount of Pol A or Pol B were set to further characterise the enzymes according to the following scheme:

Which of the following outcome do you expect?

1. Tube 1 will have more T3 DNA and tube 2 will have more T7 DNA.
2. Tube I will have more T7 DNA and tube 2 will have more T3 DNA.
3. Both tubes will have more T3 DNA than T7 DNA.
4. Both tubes will have more T7 DNA than T3 DNA.



Answer-(1) Explanation

- Assuming that the reactions are set up in two tubes, with one tube containing Pol A and the other containing Pol B, we can predict the outcomes based on the properties of the polymerases: Tube 1 (Pol A): With Pol A's high fidelity, it will produce DNA with fewer errors, but due to its low processivity, it will likely synthesize shorter fragments of DNA. If the template is T3 DNA, Pol A may produce high-quality but shorter T3 DNA fragments.
- Tube 2 (Pol B): With Pol B's high processivity, it will synthesize longer stretches of DNA quickly, but because of its low fidelity, it may incorporate more errors. If the template is T7 DNA, Pol B may produce longer but less accurate T7 DNA fragments.

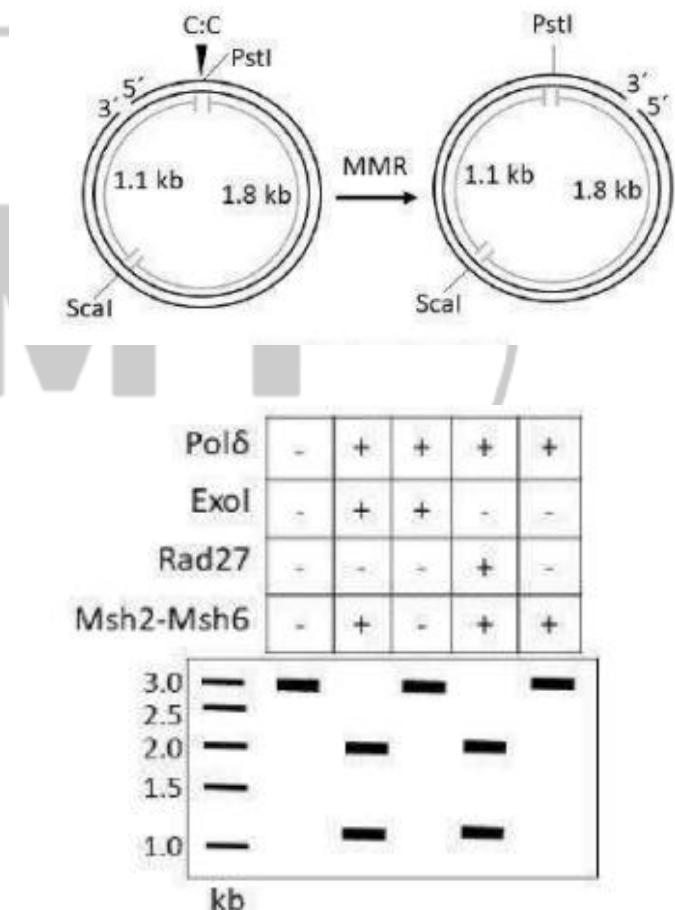
In order to investigate the involvement of the following proteins in the mismatch repair mechanism (MMR), an in vitro reconstitution experiment was performed. A 5-nicked circular DNA substrate having a C:C mismatch at the PstI site was incubated with different combination of proteins (as shown below), where upon the repair of C:C mismatch, the PstI site will be regenerated. Following the incubation, the resulting DNA were digested with PstI and Scal restriction endonucleases, and the products were electrophoresed in 0.8% agarose gel.

Based on the results obtained identify the INCORRECT statement.

1. Msh2-Msh6 complex is required for the repair of the C:C mismatched DNA.
2. Pol δ and Msh2-Msh6 complex are necessary for the repair of the C:C mismatched DNA.
3. Pol δ and Msh2-Msh6 complex are sufficient for the repair of the C:C mismatched DNA.
4. Exo1 and Rad27 are redundant to each other for the repair of the C:C mismatched DNA.

Answer-(3) Explanation

1. The Msh2-Msh6 complex is known to recognize and bind to mismatches, including C:C mismatches, and is essential for initiating the MMR process. Correct.
2. Pol δ (DNA polymerase delta) is involved in filling in the gap after the mismatch has been excised, and the Msh2-Msh6 complex is necessary for recognizing the mismatch, making both proteins necessary for the repair process. Correct.
3. While Pol δ and the Msh2-Msh6 complex are necessary for the repair, they are not sufficient on their own. Other proteins, such as exonucleases (e.g., Exo1) and ligases, are also required to complete the repair process. Therefore, this statement is incorrect.
4. Exo1 and Rad27 (also known as Fen1) can perform similar functions in the excision of mismatched bases, and they can be considered redundant in the context of mismatch repair. Correct.



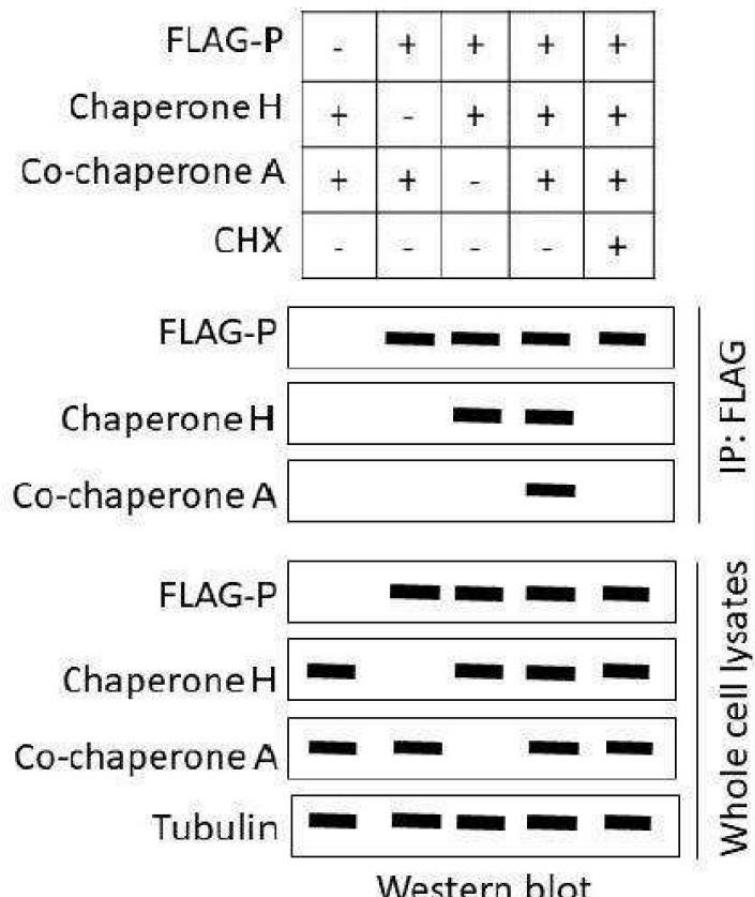
In vivo interaction between FLAG-tagged protein P and chaperone H was examined by co-immunoprecipitation (co-IP). Co-chaperone A was included and the co-IP was performed in the presence or absence of cycloheximide (CHX). The results of the co-IP experiments are shown below.

Which of the following interpretations from these experiments is INCORRECT?

1. Protein P interacts with chaperone H and co-chaperone A.
2. Chaperone H interacts only with the newly synthesized protein P.
3. Interaction between co-chaperone A and protein P is independent of chaperone H.
4. Interaction between chaperone H and protein P is independent of co-chaperone A.

Answer-(3) Explanation

Statement 1 is correct because in the presence of both chaperone H and co-chaperone A, both are pulled down with FLAG-P, showing an interaction. Statement 2 is also correct because In the presence of CHX, which blocks new protein synthesis, neither chaperone H nor co-chaperone A is pulled down. This suggests that chaperone H interacts specifically with newly synthesized FLAG-P. Statement 4 is correct as chaperone H is pulled down with FLAG-P even in the absence of co-chaperone A, showing it can interact independently of co-chaperone A. **Statement 3 is incorrect** as Co-chaperone A is pulled down with FLAG-P only when chaperone H is also present, indicating that co-chaperone A's interaction with FLAG-P depends on the presence of chaperone H.



Given below are a few statements related to enzymes and their functions in molecular reactions.

- A. Alkaline phosphatases remove 3' phosphates from DNA and RNA.
- B. S1 nuclease removes single-stranded regions from partially double- stranded DNA.
- C. 5' end-labelling of DNA molecules can be done by using polynucleotide kinase which transfers a ^{32}P -labelled phosphate group to the 5' end of dephosphorylated DNA.
- D. 3'-5' exonuclease activity of Taq polymerase releases the reporter from the 3' end of Taqman probes in qPCR.

Which one of the following options represents a combination of all correct statements?

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

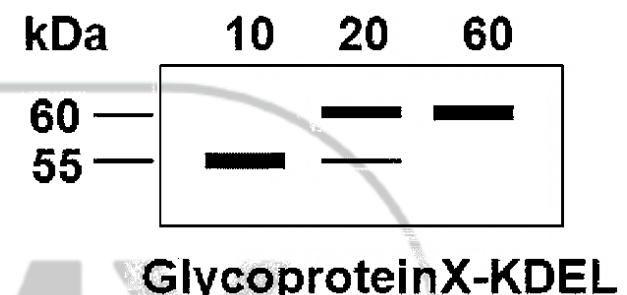
Answer-(2) Explanation

- Alkaline phosphatases primarily remove 5' phosphates from nucleotides, not 3' phosphates.
- S1 nuclease specifically degrades single-stranded regions, making this statement accurate.
- Polynucleotide kinase can indeed add a labeled phosphate group to the 5' end of dephosphorylated DNA.
- Taq polymerase possesses 5'-3' exonuclease activity, which is responsible for cleaving the reporter dye from Taqman probes during qPCR, not 3'-5' exonuclease activity.

A KDEL sequence is added at the C-terminus of a secreted glycoprotein X (500 amino acid residues) having no site for N-linked glycosylation and expressed from an inducible promoter. Following 10, 20 and 60 minutes of induction, ER are purified and probed for newly synthesized glycoprotein X-KDEL. The immunoblot obtained is shown below.

Which one of the following statements is the most likely explanation for presence of the higher molecular weight bands in lanes 20 and 60 minutes?

1. The signal sequence is not removed from some of the glycoprotein X- KDEL molecules.
2. Glycoprotein X-KDEL becomes modified in the endoplasmic reticulum after protein synthesis is completed.
3. The glycoprotein X-KDEL molecules are modified in the Golgi prior to ER retrieval.
4. The quality control mechanism in the ER recognizes a pool of glycoprotein X- KDEL as being aberrant and targets it for degradation.



Answer-(3) Explanation

KDEL Sequence: The KDEL sequence is an ER retrieval signal that causes proteins to be sent back to the ER if they escape to the Golgi. This sequence is typically recognized in the Golgi, where the retrieval process begins. **Immunoblot:** You observe two bands at different molecular weights: 60 kDa and 55 kDa. This indicates that the glycoprotein X-KDEL exists in at least two different forms, likely due to post-translational modifications.

Modification in the Golgi: Even though glycoprotein X-KDEL does not have sites for N-linked glycosylation, there can still be other types of modifications in the Golgi. These modifications can alter the molecular weight of the protein. Once the modifications occur, the protein with the KDEL sequence is recognized and retrieved back to the ER. The fact that two distinct molecular weights are observed suggests that one form of the protein is modified, likely in the Golgi, before it is retrieved back to the ER. This modification could explain the shift from 55 kDa to 60 kDa.

The ratio of total protein content to total RNA content was measured in yeast cells in log phase during growth in minimal media and in minimal media supplemented with amino acid cocktail. In the latter case, the ratio of protein to RNA increased dramatically. Which one of the following is a correct inference from the above information?

1. In minimal medium, proteins are degraded at a higher rate.
2. In amino acid-supplemented culture conditions, fewer ribosomes are simultaneously active on a single transcript.
3. In minimal medium, amino acid availability limits protein translation to a greater extent than transcription.
4. Amino acid supplementation reduces RNA synthesis by modification of RNA Pol II.

Answer-(3) Explanation

Minimal Medium: In a minimal medium without additional amino acids, the availability of amino acids is limited. This limitation primarily affects protein synthesis (translation), as amino acids are the building blocks for proteins. If amino acids are scarce, protein synthesis slows down, even if transcription (RNA synthesis) is occurring normally. This would result in a lower protein-to-RNA ratio.

Amino Acid-Supplemented Medium: When the medium is supplemented with an amino acid cocktail, the limitation on translation due to amino acid scarcity is relieved. As a result, protein synthesis can proceed more efficiently, increasing the amount of protein relative to RNA. This leads to a higher protein-to-RNA ratio.

Which one of the following options represents all correct matches between Column X and Column Y?

1. A-i, B-ii, c-iii, D-iv
2. A-ii, B-iv, c-i, D-iii
3. A-iv, B-ii, c-iii, D-i
4. A-iii, B-i, c-ii, D-iv

Column X: Microorganism		Column Y: Host receptor	
A.	Influenza virus	i.	N-acetylglucosamine
B.	<i>Entamoeba histolytica</i>	ii.	CD44
C.	<i>Streptococcus pyogenes</i>	iii.	Sialic acid residues of glycoproteins and glycolipids
D.	Human immunodeficiency virus	iv.	CD4

Answer-(4) Explanation

- The influenza virus binds to sialic acid residues on the surface of host cells to enter and infect them.
- *Entamoeba histolytica* interacts with N-acetylglucosamine on the host cells, aiding in its attachment and colonization.
- *Streptococcus pyogenes* binds to CD44, a cell surface glycoprotein, which facilitates infection.
- HIV primarily targets and binds to the CD4 receptor on T-cells, which is critical for its entry into the host cells.

The correct answer is **(A-iii, B-i, C-ii, D-iv)**.

SLN1 receptor, a part of a two-component system, is required for osmoregulation in yeast. The yeast mutant (*sln1*) lacking the SLN1 receptor protein dies. A researcher tries to rescue the mutant by expressing an *Arabidopsis* gene for the cytokinin receptor, CRE1, which like SLN1 is also a histidine kinase that acts through a two-component system.

The following statements are made regarding the outcome of the experiment.

- A. SLN1 and CRE1 proteins respond to the same external signals and therefore, CRE1 rescues the yeast mutant.
- B. As CRE1 cannot interact with the downstream signaling pathway in the yeast, it will not rescue the yeast mutant.
- C. CRE1 will rescue the yeast mutant, only if cytokinin is present.
- D. The effector domains of CRE1 and SLN1 proteins are sufficiently similar and therefore, CRE1 can induce the downstream signaling pathway and rescue the yeast mutant.

Which one of the following options represents the combination of all correct statements?

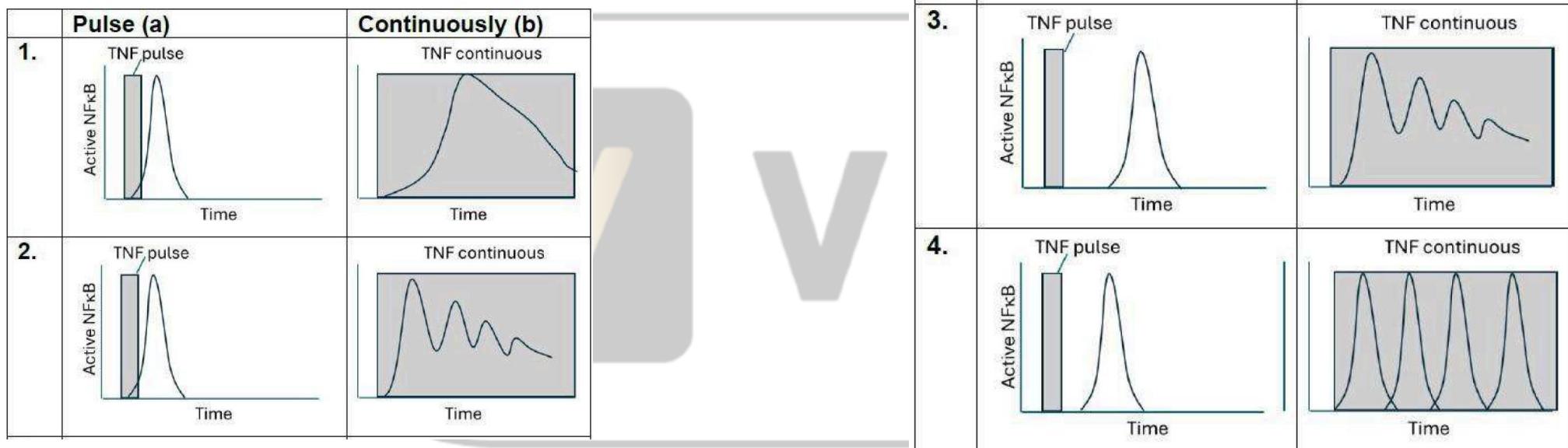
- 1. A and C
- 2. C and D
- 3. A only
- 4. B only

Answer-(2) Explanation

Plant cytokinin receptor CRE1, when activated by cytokinin, can substitute the SLN1 osmosensing function, and that its kinase activity is similarly regulated by turgor pressure. The compatibility of Cre1 with yeast hyperosmotic stress signaling pathway suggests that a mechanistically analogous osmosensing system could exist in plants.

Statement A is incorrect because SLN1 is involved in osmoregulation, whereas CRE1 is a cytokinin receptor. CRE1 only functions in response to cytokinin, not the osmoregulatory signals that SLN1 responds to. Statement B is incorrect because CRE1 can indeed interact with the downstream signaling pathway in yeast and rescue the mutant. **Statement C is correct.** CRE1, as a cytokinin receptor, requires the presence of cytokinin to be activated and to potentially rescue the yeast mutant. **Statement D is correct** because CRE1, when activated by cytokinin, can interact with the yeast's signaling pathway, substituting SLN1 to some extent.

The inhibitory I_KB_a protein binds to the NF_kB dimer and holds them in an inactive state. On TNF treatment, the I_KB_a protein is degraded and NFkB enters the nucleus to transactivate gene expression. Importantly, one of the transcriptional targets of NFkB is the I_KB_a gene itself. Together, they form a negative feedback loop. Which one of the following graphs represents the NFkB protein expression kinetics when TNF exposure is given as a pulse (a) or continuously (b)?



Answer-(2) Explanation

Option 2 is correct because, when TNF is given as a pulse, there is an immediate rise in active NFkB, leading to gene expression, followed by a decline as the feedback loop represses NFkB activity. In the case of continuous TNF presence, the feedback loop causes a delay, resulting in an oscillatory pattern where NFkB activity never fully declines, but rather fluctuates due to the ongoing TNF signaling. The active NFkB levels go up again, but not to the initial peak, following an oscillatory nature over time.

A cancer clinic is treating four unrelated patients suffering from chronic myelogenous leukemia. A researcher sequences the Philadelphia chromosome from the leukemic cells of these patients and makes the following statements:

- A. The DNA sequence was identical in the translocation breakage and rejoining (TBR) sections in all 4 patients.
- B. The DNA sequence was identical in all leukemic cells from patient I, but every patient had a different TBR sequence.
- C. All patients have translocations between long arms of chromosomes 9 and 22.
- D. All patients have translocations between long arm of chromosome 9 and short arm of chromosome 22.

Which one of the following options represents a combination of all correct statements?

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

Answer-(2) Explanation

Statement A is incorrect. While the Philadelphia chromosome results from a specific translocation ($t(9;22)$), the TBR sequences can vary among different patients. **Statement B is correct.** Within a single patient, the TBR sequences can be identical due to clonal expansion of leukemic cells, but they can differ between patients. **Statement C is correct.** The Philadelphia chromosome is characterized by a translocation between the long arms of chromosomes 9 and 22, specifically $t(9;22)(q34;q11)$. Statement D is incorrect. The translocation involves the long arm of chromosome 9 and the long arm of chromosome 22, not the short arm.

One hundred IgM+ B cells were plated at 1 cell/well and activated in vitro. This led to detectable proliferation in all wells by day four. At the end of seven days, it was found that some wells contained IgG1 antibodies, some contained both IgG1 and IgA antibodies, and some contained only IgA antibodies. The following interpretations were made:

- A. Cells that have switched to IgG1 may undergo further switching to IgA.
- B. Cells that have switched to IgA may undergo further switching to IgG1.
- C. A single cell can simultaneously secrete IgG1 and IgA.
- D. The progeny of proliferating cells may undergo independent switching events.

Which one of the following options represents the combination of all correct statements?

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

Answer-(1) Explanation

Statement A is correct. After switching to IgG1, a B cell can undergo further class switching to IgA. The process is sequential, and additional signals can induce this further switching. Statement B is incorrect. Once a B cell has switched to IgA, it generally cannot revert or switch to IgG1 because class switching typically occurs in one direction. Statement C is generally not true. A single B cell can only produce one type of antibody at a time due to the nature of the class-switching process. The presence of both IgG1 and IgA in a well likely indicates the presence of different B cells that have undergone different switching events.

Statement D is correct. As B cells proliferate, their progeny can independently undergo different class-switching events, resulting in the production of different types of antibodies (e.g., IgG1 in some cells, IgA in others).

A researcher was interested in detecting parasite-derived antigens in *Plasmodium falciparum*-infected erythrocytes. The following labelling experiments were performed, followed by immunoprecipitation with antibodies against *P. falciparum* proteins and autoradiography.

- A. Labeling with ^{32}P -ATP in the media
- B. Labeling with ^{125}I odine in the media
- C. Labeling with ^{35}S -Methionine in the media
- D. Labeling with ^3H -Hypoxanthine in the media

Which one of the following options represents labeling experiments to predominantly detect the parasite-derived antigens?

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

Answer-(2) Explanation

^{32}P -ATP would label phosphorylated proteins or nucleic acids (like DNA and RNA). However, this would label both host and parasite nucleic acids, making it less specific for detecting parasite-derived antigens. ^{125}I odine labels surface proteins but does not specifically target parasite-derived proteins, making it less effective for this purpose. ^{35}S -Methionine is an amino acid that gets incorporated into newly synthesized proteins during translation. Since it labels proteins being actively synthesized, it will predominantly label parasite proteins if the parasite is actively producing proteins in the infected erythrocytes. ^3H -Hypoxanthine is typically used to label DNA and RNA because it is incorporated into nucleic acids. Like ^{32}P -ATP, it would label nucleic acids in both the parasite and the host, making it less specific for parasite-derived antigens.

The following statements have been made regarding cell specification in an early embryo:

- A. The entire embryo rarely interacts with its environment, and its developmental trajectory cannot be guided by its immediate "ecosystem".
- B. When cells are removed, changes in cellular biochemistry and function are never preceded by a process involving the commitment of the cell to a certain fate.
- C. The fate of a cell or a tissue in the intact embryo is said to be specified when it is not capable of differentiating autonomously on being placed in a neutral environment, such as a petri dish or test tube.
- D. If cells are removed, the interactions of the remaining cells compensate the fate of the removed cells, because the fate of a cell depends upon the conditions in which the cell finds itself.

With regard to the experiment shown below, where removal of cells from an early blastula leads to normal development of the larval form, which one of the above combination of statements apply to the development of the organism?

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

Answer-(2) Explanation



With regard to the experiment shown below, where removal of cells from an early blastula leads to normal development of the larval form because If cells are removed, the interactions of the remaining cells compensate the fate of the removed cells, because the fate of a cell depends upon the conditions in which the cell finds itself.

The mouse homozygous null mutant for a gene bfg always dies mid-gestation. Chimeric mice made of bfg null cells and wild-type cells have healthy pups. When the developing brain of these pups is examined, they have more than two hippocampi. Closer examination reveals bfg null cells at the centre of these supernumerary hippocampi.

Which of the following inferences can correctly be drawn from this experiment?

1. Wild type bfg function in the developing brain induces hippocampus specification in neighbouring cells.
2. Wild type bfg function in the developing brain suppresses hippocampus specification in neighbouring cells.
3. bfg function is completely cell autonomous.
4. bfg function is hippocampus specific.

Answer-(2) Explanation

As Closer examination reveals bfg null cells at the centre of these supernumerary hippocampi, that is the indication that absence leads to supernumerary hippocampi. If a normal bfg had been there, then only one hippocampi has formed and in neighbour there should be inhibition of that hippocampi. But bfg null cells do not have that bfg, so the suppression was bypassed and supernumerary hippocampi formed.

Given below are protein domains and their binding specificities.

Which one of the following options represents all correct matches between Column X and Column Y?

1. A-iii, B-i, C-ii, D-ii
2. A-i, B-ii, C-iii, D-i
3. A-iii, B-iii, C-i, D-ii
4. A-i, B-iii, C-ii, D-i

Column X		Column Y	
Interaction domain		Binding site	
A.	SH2 domain	i.	Phosphorylated tyrosine residue on receptors
B.	SH3 domain	ii.	Charged head groups of specific phosphoinositides on plasma membrane
C.	PH domain	iii.	Short proline-rich amino acid sequence on proteins
D.	PTB domain		

Answer-(4) Explanation

SH2 (Src Homology 2) and PTB (Phosphotyrosine Binding) domains both recognize phosphorylated tyrosine residues, typically on receptor proteins.

SH3 (Src Homology 3) domains are known to bind proline-rich sequences.

PH (Pleckstrin Homology) domains typically interact with phospholipids in membranes, specifically phosphoinositides.

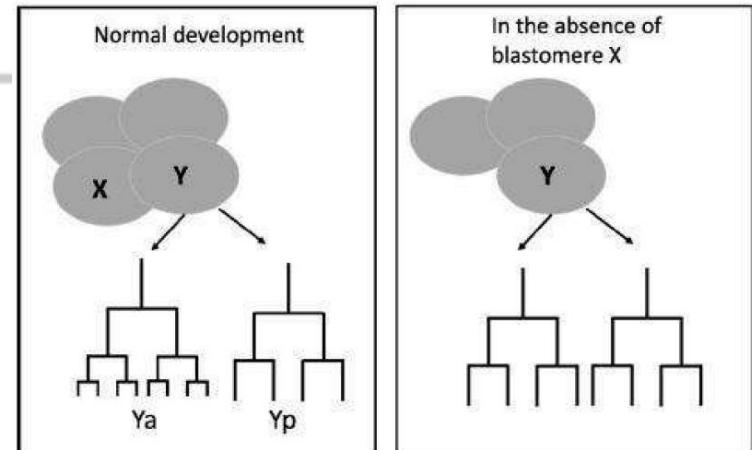
In a hypothetical organism, at a four-celled embryonic stage, blastomere 'X' instructs one of the daughter cells of an adjoining blastomere 'Y' to take the fate 'Ya'. The other daughter cell takes the fate 'Yp'. This is illustrated in the figure below as lineages for Ya and Yp. If the X blastomere is removed, both daughter cells take up the Yp fate.

This instruction is mediated by a paracrine factor, Pap2 secreted by X blastomere interacting with Pap5 present on the membrane of Y blastomere.

The following experimental manipulations were carried out, which involved creating partial genetically mosaic embryos in vitro and following the fate of the Y blastomere.

Which one of the mosaics will show a developmental pattern similar to that when blastomere X is removed?

1. X blastomere null for Pap2 and wild type Y blastomere
2. Wild type X blastomere and constitutively activated Pap5 Y blastomere
3. X blastomere null for Pap2 and constitutively activated Pap5 Y blastomere
4. X blastomere null for Pap5 and wild type Y blastomere



Answer-(1) Explanation

X blastomere null for Pap2 and wild type Y blastomere. If pap2 (which is ligand and paracrine factor) which interact with Y or WT phenotype, is got removed or mutated, then it will result in formation of 2 Yp cells

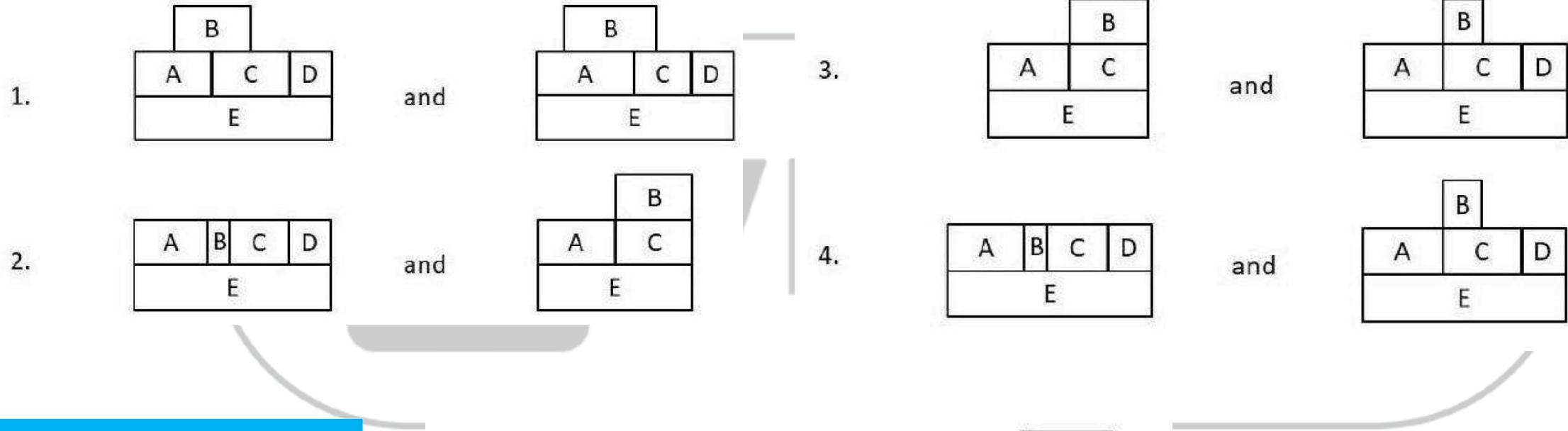
Overexpression of protein 'A' in the brain of *Drosophila melanogaster* causes the degradation of ovaries in the animal. Overexpression of a secretion-incompetent allele of 'A' does not cause this phenotype. However, downregulation of protein 'B' in ovaries concomitant with overexpression of protein 'A' in the brain prevents ovary degradation. 'A' and 'B' are found to physically interact in ovary lysates. In the light of the above experiments, which of the following inferences would be correct?

1. The protein 'A' cell autonomously influences ovary development while B is secreted to influence brain function.
2. 'A' is a ligand secreted from the brain and 'B' is a receptor in ovaries.
3. A' is a neurotransmitter secreted from the brain and 'B' is a signal transducer in the ovaries.
4. 'A' is a receptor secreted from the ovaries and 'B' is a ligand in the ovary cell membrane.

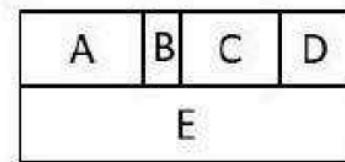
Answer-(2) Explanation

'A' is a ligand secreted from the brain and 'B' is a receptor in ovaries. As when A is less, the B is down regulated but overexpression of A (hence its binding with B), Prevent degradation of ovary. 'A' and 'B' are found to physically interact in ovary lysates. Overexpression of protein 'A' in the brain of *Drosophila melanogaster* causes the degradation of ovaries in the animal. these give a indication of A being ligand and B is receptor for A.

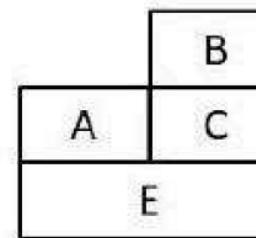
In the classic ABCDE model of flower development, different combinations of ABCDE class genes result in different whorls of organs. Which one of the following models would likely give rise to unisexual flower structures?



Answer-(2) Explanation



Se-pe-ca



Se-st

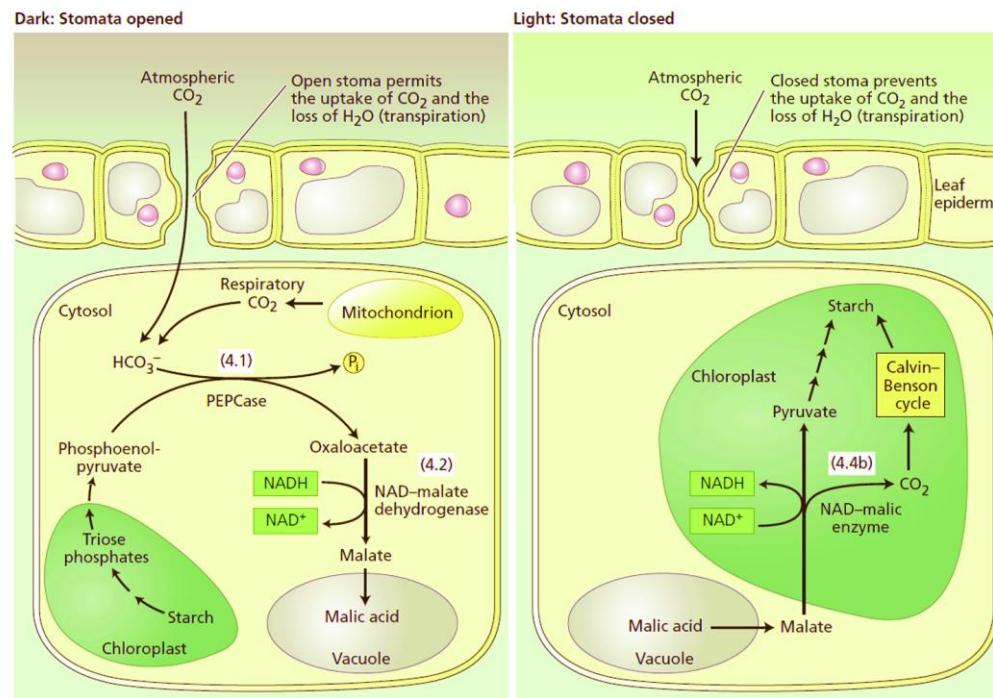
Following are certain statements regarding Crassulacean Acid Metabolism (CAM) plants:

- A. The HCO_3^- concentration is enriched in the cytosol during night by the CO_2 coming from the external atmosphere through the open stomata and the mitochondrial respiration.
- B. Oxaloacetate produced by the action of PEPCase is stored in the vacuole during dark.
- C. During light, oxaloacetate produces malate that provides CO_2 for Calvin- Benson cycle in the chloroplast.
- D. During dark, phosphoenolpyruvate is produced by the breakdown of starch present in the chloroplast.
- E. CAM is a mechanism of concentrating CO_2 around Rubisco by keeping stomata closed during day.

Which one of the following options represents the combination of all correct statements?

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

Answer-(4) Explanation



The nitrogen fixing bacterium, *Rhizobium leguminosarum*, isolated from the root nodules of garden pea (*Pisum sativum*) is cultured in a petri plate containing appropriate nutrient agar medium. A bacterial colony was picked and inoculated into a liquid growth medium to scale up the culture for the production of biofertilizer. Which one of the following statements is correct?

1. The liquid culture will be red/pink in color due to the accumulation of the pigment leghaemoglobin.
2. The rhizobial cells when reinoculated into the rhizosphere of soybean plants will effectively nodulate its roots to fix atmospheric nitrogen.
3. The rhizobial cells cannot fix nitrogen when exposed to atmospheric air.
4. The rhizobial cells get transformed into bacteroids when grown in liquid media.

Answer-(3) Explanation

Rhizobium leguminosarum fixes nitrogen only when it is in a symbiotic relationship with a legume host, inside the root nodules, where it transforms into a form called a bacteroid. This environment is low in oxygen, which is necessary because nitrogenase, the enzyme responsible for nitrogen fixation, is inactivated by high levels of oxygen. In the presence of atmospheric air, the free-living rhizobial cells cannot fix nitrogen.

Biosynthesis of glutamine and asparagine is sensitive to light and to the availability of reduced carbon. Following are a few statements regarding the same.

- A. Expression of the plastid-localized Glutamine Synthetase (GS) gene is upregulated by light.
- B. Darkness promotes the expression Of Asparagine Synthetase (AS) gene.
- C. Expression of GS is inhibited by sucrose while that of AS is upregulated by sucrose.
- D. Asparagine is a more efficient carbon source than glutamine.

Which one of the following options represents the combination of all correct statements?

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

Answer-(1) Explanation

Expression of the plastid-localized Glutamine Synthetase (GS) gene is upregulated by light. Darkness promotes the expression Of Asparagine Synthetase (AS) gene. Asparagine is a more efficient carbon source than glutamine.

Sucrose-phosphate synthase (SPS) is a key enzyme in the biosynthesis of sucrose in plants. Following are certain statements regarding SPS:

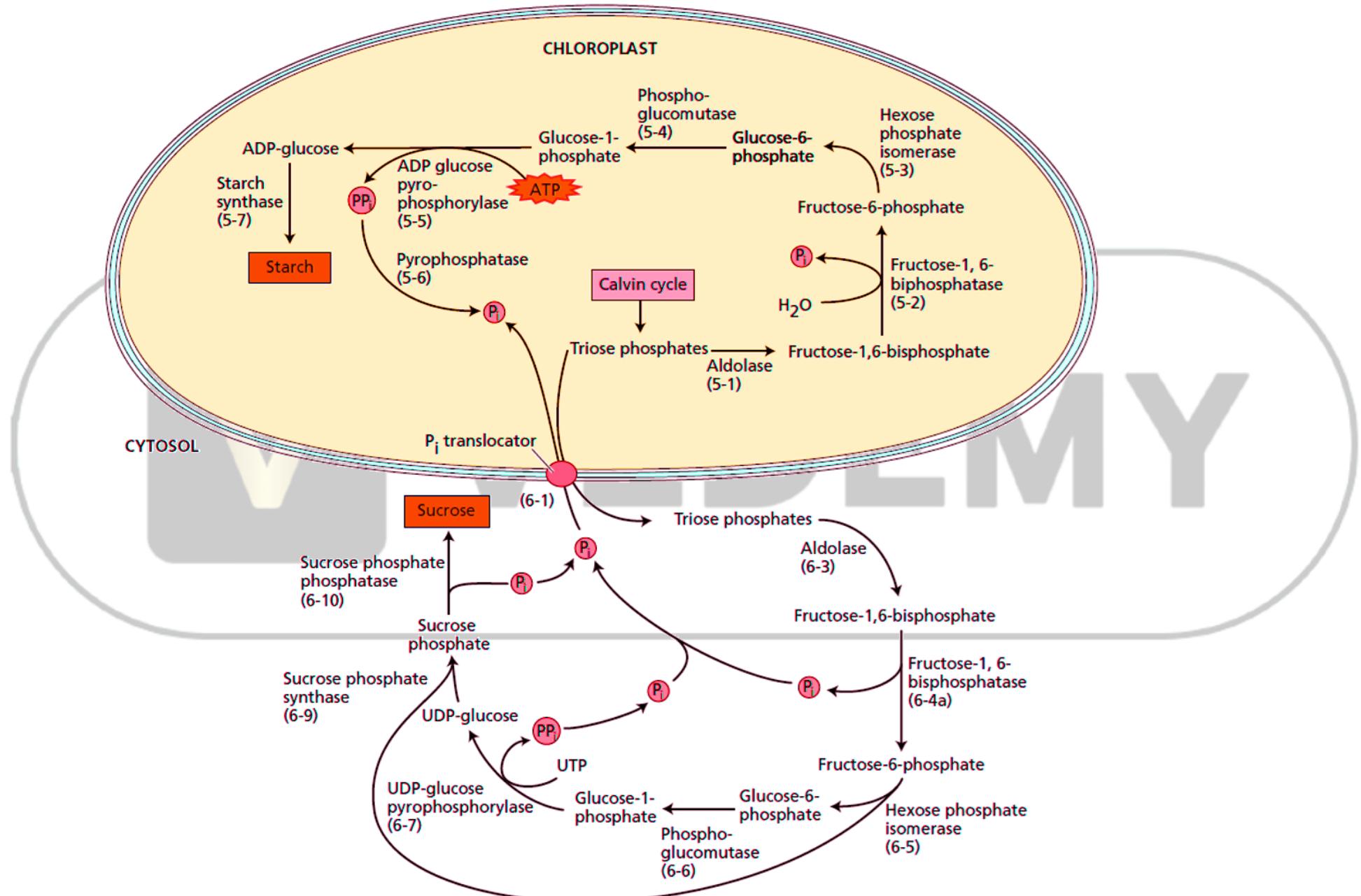
- A. Uridine-diphosphate glucose and fructose-6-phosphate are the substrates for SPS.
- B. SPS directly converts its substrate into sucrose.
- C. Phosphorylation activates while dephosphorylation inactivates SPS.
- D. SPS converts its substrate into sucrose-6-phosphate which is then converted to sucrose by the action of sucrose-phosphate phosphatase.
- E. Glucose 6-phosphate activates while Pi inactivates SPS.

Which one of the following options represents the combination of all correct statements?

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

Answer-(4) Explanation

Next Page



Following statements were made with respect to plant steroid hormones.

- A. The receptors for plant steroid hormones are found in the nucleus, similar to animal steroid hormones.
- B. There are multiple pathways for the plant steroid hormone biosynthesis involving cytochrome P450 class of enzymes.
- C. The first plant steroid hormone was isolated from male gametophytes.
- D. Plants deficient for the steroid hormone brassinosteroid show underproliferation of phloem and overproliferation of xylem cells.
- E. Castasterone is a plant steroid hormone abundant in the vegetative tissues of the plant.

Which one of the following options represents the combination of all correct statements?

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

Answer-(2) Explanation

A plant steroid receptor from *Arabidopsis thaliana* has been identified and cloned. It is a transmembrane protein which specifically recognizes plant steroids (brassinosteroids) at the cell surface and has a serine/threonine protein kinase activity.

ABA plays an important role in plant response to water stress. In the table below, column X represents some of the important enzymes in ABA biosynthesis/degradation pathways, while column Y summarizes the major function of these enzymes.

Choose the option showing the correct match between column X and column Y?

1. A-iv, B-ii, c-i, D-iii
2. A-iii, B-i, c-ii, D-iv
3. A-ii, B-iii, c-iv, D-i
4. A-i, B-iv, C-iii, D-ii



Answer-(2) Explanation

- 9-cis-epoxycarotenoid dioxygenase: This enzyme is involved in the biosynthesis of abscisic acid (ABA) and is crucial for the production of xanthoxin, a precursor in the ABA biosynthesis pathway. Correct Match: iii. Xanthoxin production
- Cytochrome P450 monooxygenase (CYP707A3): This enzyme is involved in the oxidative catabolism of ABA, which is a part of ABA degradation. Correct Match: i. Involved in the oxidative pathway of ABA catabolism
- ABA glucosyltransferase: This enzyme catalyzes the addition of glucose to ABA, producing a sugar-conjugated form of ABA, which is a storage form of ABA. Correct Match: ii. Production of a sugar-conjugated form of ABA
- β -glucosidase: This enzyme releases active ABA from its inactive, sugar-conjugated form. Correct Match: iv. Releases ABA from its sugar-conjugated form

Column X (Enzymes)		Column Y (Functions)	
A.	9-cis-epoxycarotenoid dioxygenase	i.	Involved in the oxidative pathway of ABA catabolism
B.	Cytochrome P450 monooxygenase (CYP707A3)	ii.	Production of a sugar-conjugated form of ABA
C.	ABA glucosyltransferase	iii.	Xanthoxin production
D.	β -glucosidase	iv.	Releases ABA from its sugar-conjugated form

The stimulation of sympathetic cardiac nerves increases the rate of action potential generation from the sinoatrial (SA) node of heart. The following statements suggest the mechanism of this action:

- A. The depolarizing effect of 'h' current (I_h) is decreased by sympathetic stimulation.
- B. Norepinephrine secreted by the sympathetic endings binds to β_1 adrenoceptors resulting in the increase of intracellular cAMP.
- C. The increased intracellular cAMP facilitates the opening of long-lasting (L) Ca^{++} channels.
- D. The Ca^{++} current (I_{ca}) due to the opening of voltage-gated L Ca^{++} channels is decreased.

Which one of the following options represents the correct combination of the statements?

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

Answer-(2) Explanation

Explanation given on next page.

Answer-(2) Explanation

A statement is incorrect. Sympathetic stimulation actually increases the depolarizing effect of the I_h current, which is mediated by the activation of hyperpolarization-activated cyclic nucleotide-gated (HCN) channels. This increase in I_h contributes to a faster depolarization rate and increased heart rate.

B statement is correct. Norepinephrine does bind to β_1 adrenoceptors in the SA node, leading to an increase in intracellular cAMP levels, which is a key mechanism in increasing heart rate.

C statement is correct. Increased cAMP levels lead to the activation of protein kinase A (PKA), which phosphorylates and opens L-type calcium channels, enhancing calcium influx and contributing to increased pacemaker activity.

D statement is incorrect. The Ca^{++} current (I_{Ca}) is actually increased due to the opening of L-type calcium channels in response to sympathetic stimulation. This increase in I_{Ca} further contributes to the depolarization and increased rate of action potential generation in the SA node.

During physical exercise, a large amount of oxygen is delivered to the active muscles by many physiological adjustments including a change in the P_{50} value (which is determined by Po_2 at which hemoglobin is half-saturated with oxygen). The following proposed statements explain the mechanism of change in P_{50} during exercise:

- A. P_{50} is increased during exercise as the temperature rises in active muscles.
- B. During exercise, metabolites accumulate in the active muscles resulting in higher pH that increases P_{50} .
- C. P_{50} is increased during exercise as CO_2 is decreased in active muscles.
- D. An increase in 2,3-DPG has been reported in non-trained person within 60 min of exercise resulting in higher P_{50} .

Which one of the following options represents the correct combination of the above statements?

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

Answer-(4) Explanation

Explanation given on next page.

Answer-(4) Explanation

- A statement is correct. During exercise, the temperature in active muscles increases, which leads to a rightward shift in the oxygen-hemoglobin dissociation curve, resulting in an increased P50. This means that hemoglobin's affinity for oxygen decreases, facilitating oxygen unloading in the tissues that need it most during exercise .
- B statement is incorrect. During exercise, metabolites such as lactic acid accumulate, which actually lowers the pH (causing acidosis) rather than increasing it. A lower pH increases P50, as it decreases hemoglobin's affinity for oxygen, promoting oxygen release to the tissues .
- C statement is incorrect. During exercise, the concentration of CO₂ typically increases due to enhanced metabolic activity. An increase in CO₂ levels leads to a rightward shift in the oxygen dissociation curve, thus increasing P50. Therefore, saying that P50 increases due to decreased CO₂ is not accurate .
- D statement is correct. 2,3-DPG (2,3-bisphosphoglycerate) levels can increase during exercise, especially in untrained individuals, which leads to a rightward shift in the oxygen dissociation curve, thereby increasing P50 and facilitating oxygen unloading in tissues

The types of mammalian nerve fibers (Column X) and the conduction velocity in m/s of nerve impulses (column Y) are listed below:

Which one of the following options represents correct match between

Column X and Column Y?

1. a-i, b-ii, c-iii, d-iv
2. a-ii, b-iii, c-iv, d-i
3. a-iii, b-iv, c-i, d-ii
4. a-iv, b-i, c-ii, d-iii

Column X		Column Y	
a	A α	i	12-30
b	B	ii	30-70
c	A δ	iii	70-120
d	A β	iv	3-15

Answer-(3) Explanation

Fiber Type	Function	Conduction Velocity (m/s)
A α fibers	Motor functions and proprioception	80 to 120
A β fibers	Touch and pressure sensations	33 to 75
A δ fibers	Pain and temperature sensations	10 to 30
B fibers	Autonomic functions (myelinated)	3 to 15

The following statements are made about the variety of thermoregulatory mechanisms in the body.

- A. Human voluntary activity is decreased in cold.
- B. There is a cutaneous vasodilation by heat.
- C. There is an increased secretion of epinephrine and nor-epinephrine in cold.
- D. There is a decreased heat production in cold.

Choose the combination of all correct statements about thermoregulatory mechanisms.

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

Answer-(2) Explanation

- Statement A is incorrect. In cold conditions, humans often increase voluntary activity (like shivering) to generate more heat.
- Statement B is correct. In response to heat, blood vessels near the skin surface dilate (vasodilation) to increase blood flow and release heat from the body1.
- Statement C is correct. In cold conditions, the body increases the secretion of these hormones to boost metabolism and generate more heat.
- Statement D is incorrect. In cold conditions, the body increases heat production through mechanisms like shivering and increased metabolic activity

Given below are the blood clotting factors in column X and their names in column:

Column X		Column Y	
a.	XII	i.	Fitzgerald factor
b.	HMWK	ii.	Laki-Lorand factor
c.	Pre-Ka	iii.	Stuart-Prower factor
d.	X	iv.	Fletcher factor

Which of the following combination is a correct match of the factor with its name.

1. a-iv, b-iii, c-i, d-ii
2. a-ii, b-iii, c-i, d-iv
3. a-ii, b-i, c-iv, d-iii
4. a-i, b-ii, c-iv, d-iii


Challenge

Answer-(3) Explanation

Factor	Alternative Name
Factor XII	Hageman Factor
HMWK	High-Molecular-Weight Kininogen (Fitzgerald Factor)
Prekallikrein	Fletcher Factor
Factor X	Stuart-Prower Factor
Factor XIII	Laki-Lorand Factor

The following statements are made for the effect of hormones on the glomerular filtration rate (GFR).

- A. Norepinephrine, epinephrine, and endothelin constrict renal blood vessels and decrease GFR.
- B. Endothelin dilates renal blood vessels to increase GFR.
- C. Norepinephrine and endothelin constrict renal blood vessels and decrease GFR, while epinephrine dilates renal blood vessels to increase GFR.
- D. Prostaglandin (PGE2) and bradykinin decrease renal vascular resistance and increase GFR.

Which one of the following options represents the combination of correct statements?

1. A and B
2. B and C
3. C and D
4. A and D

Answer-(4) Explanation

- Statement A is correct. Norepinephrine and endothelin are known to constrict renal blood vessels, leads to a decrease in GFR.
- Statement B is incorrect. Endothelin actually constricts renal blood vessels, leading to a decrease in GFR.
- Statement C is incorrect. While norepinephrine and endothelin do constrict renal blood vessels and decrease GFR, epinephrine typically also causes vasoconstriction, not dilation.
- Statement D is correct. Prostaglandins (like PGE2) and bradykinin are known to decrease renal vascular resistance, which increases GFR.

Given below are a few statements on concepts of molecular breeding.

- A. Correlations between quantitative traits can be because of pleiotropic effects of the same gene and/or genetic linkage of genes associated with the traits.
- B. In a Recombinant Inbred Line (RIL) population, genetic segregation of both dominant and codominant markers occurs in a 1:1 ratio.
- C. Near isogenic lines (NILS) can be produced by repeated backcrossing of the F1 to a recurrent parent.
- D. SNPs are dominant markers.

Which one of the following options represents all correct statements?

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

Answer-(3) Explanation

In the context of molecular breeding, several statements provide insights into genetic principles and methodologies. The first statement correctly asserts that correlations between quantitative traits can arise from pleiotropic effects of the same gene, where one gene influences multiple traits, or from genetic linkage, where genes located close to each other on a chromosome are inherited together. The second statement regarding Recombinant Inbred Lines (RILs) is also correct; RIL populations do exhibit genetic segregation, the ratios uniformly follow a 1:1 pattern for both dominant and codominant markers. The third statement is accurate, as near isogenic lines (NILs) are indeed produced through repeated backcrossing of an F1 hybrid to a recurrent parent, allowing for the retention of specific traits while maintaining the genetic background of the recurrent parent. Lastly, the claim that SNPs are dominant markers is also incorrect; SNPs are generally considered co-dominant markers because they can express both alleles in heterozygotes. Therefore, the correct interpretations of the statements identify that statements A, B and C are accurate, reflecting fundamental concepts in molecular breeding.

The plaque morphology of wild type and *rII* mutants of T4 bacteriophage following infection of different *E. coli* strains is summarized below.

The following two experiments were carried out:

Experiment I: Co-infection of two independent *rII* mutants on *E. coli* K strain resulted in several plaques, all being small and ragged.

Experiment II: *E. coli* B strain was co-infected with the *rII* mutants. T4 phages from the resulting plaques were used to infect *E. coli* K strain. Few plaques were obtained, which were all small and ragged.

Based on the observations, the following statements were made:

- A. Experiment I indicates that the two mutants are allelic.
- B. Experiment II indicates that the wild type T4 phages that infected *E. coli* K strain resulted from a recombination event.
- C. In experiment II, if the T4 phage isolated from the *E. coli* B strain was used to infect *E. coli* B strain, all plaques would be large and round.

Which one of the following options is a combination of all correct statements?

1. A only
2. B only
3. A and B
4. B and C

Answer-(2) Explanation

Explanation on Next Page.....

	<i>E. coli</i> strain	
T4 phage strain	B	K
wild type	Small and ragged	Small and ragged
<i>rII</i> mutants	Large and round	No plaques

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	<i>E. coli</i> strain	
T4 phage strain	B	K
wild type	Small and ragged	Small and ragged
<i>rII</i> mutants	Large and round	No plaques

Answer-(2) Explanation

Experiment I:

- Co-infection of two independent *rII* mutants on *E. coli* K strain resulted in several plaques, all being small and ragged.
- Interpretation: The appearance of plaques in *E. coli* K strain suggests that the two *rII* mutants complement each other, meaning they are likely not allelic (i.e., they affect different genes).
- Statement A: "Experiment I indicates that the two mutants are allelic." Incorrect: Since plaques were observed, the mutants are likely non-allelic, meaning they affect different genes. Allelic mutants would not complement each other, and no plaques would be formed on *E. coli* K.

Experiment II: *E. coli* B strain was co-infected with the *rII* mutants. T4 phages from the resulting plaques were used to infect *E. coli* K strain. Few plaques were obtained, which were all small and ragged. Interpretation: The small and ragged plaques observed on *E. coli* K indicate that some wild-type T4 phages were produced, likely due to recombination between the *rII* mutants.

Statement B: "Experiment II indicates that the wild type T4 phages that infected *E. coli* K strain resulted from a recombination event." Correct: The appearance of small and ragged plaques on *E. coli* K indicates that wild-type T4 phages were generated, likely through recombination between the two *rII* mutants.

Statement C: "In experiment II, if the T4 phage isolated from the *E. coli* B strain was used to infect *E. coli* B strain, all plaques would be large and round." Incorrect: If recombination occurred, the phage population would be a mix of wild-type and *rII* mutants. When infecting *E. coli* B, the wild-type phages would produce small and ragged plaques, while *rII* mutants would produce large and round plaques. Thus, not all plaques would be large and round.

Given below are statements on concepts of genetics.

- A. The degree to which a particular gene is expressed in a phenotype is called _____.
- B. A heritable change in gene expression that does not result from a change in the nucleotide sequence of the genome is called _____ change.
- C. The frequency with which a dominant or homozygous recessive gene is phenotypically expressed within a population is called _____.
- D. An allele that results in the death of organisms that is homozygous for the allele is _____.

Which one of the following options represents the most appropriate sequence of terms to fill all the blank spaces in the above statements?

- 1. A – expressivity B – epigenetic, C – penetrance, D – recessive lethal
- 2. A – penetrance, B – mutation, C – expressivity, D – dominant lethal
- 3. A – penetrance, B – epigenetic, C – distribution, D – conditional lethal
- 4. A – epistasis, B – mutation, C – penetrance, D – dominant lethal

Answer-(1) Explanation

In the context of genetics, several key concepts can be defined to enhance our understanding of gene expression and its implications. The degree to which a particular gene is expressed in a phenotype is referred to as **expressivity**, which indicates how variations in the same genotype can lead to different phenotypic outcomes among individuals. Additionally, a heritable change in gene expression that does not involve alterations in the nucleotide sequence of the genome is known as **epigenetic change**. This encompasses modifications that can affect gene activity, such as DNA methylation and histone modification, without changing the underlying genetic code. Furthermore, the frequency with which a dominant or homozygous recessive gene is phenotypically expressed within a population is termed **penetrance**. This concept helps in understanding how often a particular genotype manifests as a phenotype in a given population. Lastly, an allele that leads to the death of organisms that are homozygous for that allele is classified as a **recessive lethal allele**. Such alleles can significantly impact population genetics and inheritance patterns.

Recessive mutations in the human dysferlin gene lead to Limb Girdle type II muscular dystrophy. The gene is located on the second chromosome. The patient's parents do not have Limb Girdle type II dystrophy B. What is the probability that at least one of the four grandparents of this patient suffered from this disease?

1. 1/4
2. 3/10
3. 1/2
4. 7/10

- Since the gene is located on the second chromosome (an autosome), and the disease is recessive:

- Parents' genotypes: Since neither parent has the disease but the child does, both parents must be carriers (heterozygous, Aa).
- Grandparents' genotypes: Each parent inherited one allele from each of their parents (the grandparents). For the parents to be carriers (Aa), they must have received one recessive allele from one of their parents. Each grandparent has a chance of being a carrier (Aa) or being homozygous for the normal allele (AA).

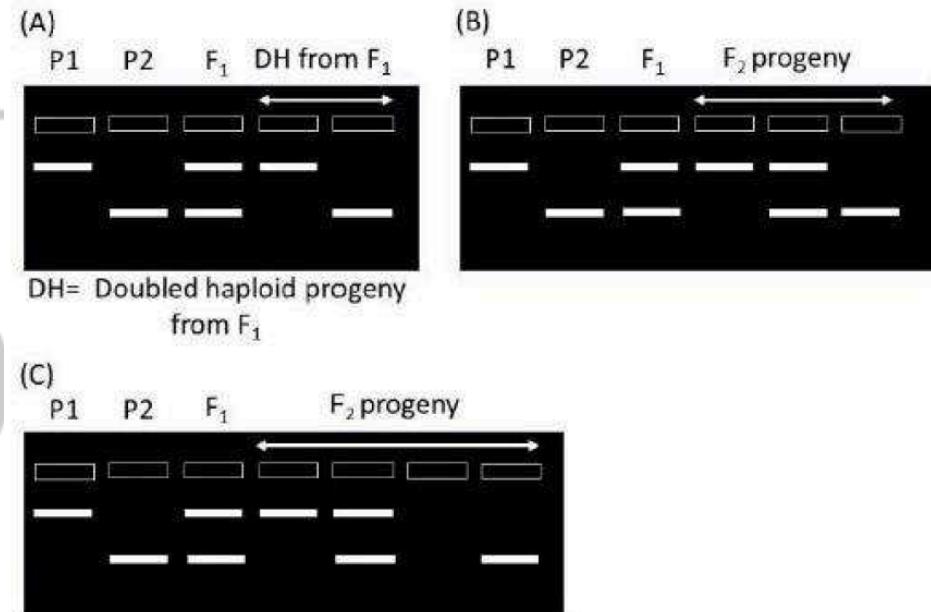
- The probability that a single grandparent is not a carrier is 3/4 (because they could be either AA or Aa, and only one out of four possibilities results in an individual with the disease, aa).
- The probability that none of the four grandparents had the disease (i.e., all four are carriers or have the normal allele) is:
 $P(\text{None affected}) = (3/4)^4 = 81/256$
- The probability that at least one grandparent had the disease is:
 $P(\text{At least one affected}) = 1 - 81/256 = 175/256 \approx 0.6836$
- value is closest to 7/10.

The following gel patterns are that of DNA markers observed in parents (P1 and P2), F₁ from a cross between them and doubled haploid progeny (panel A) or F₂ progeny, derived from selfing of F₁ (panels B and C).

A doubled haploid (DH) is a genotype formed when plants are developed from haploid cells which have undergone chromosome doubling.

Based on the pattern observed in the DH or F₂ progeny identify which of the patterns (A to C) are based on DNA markers that are allelic?

1. A only
2. B only
3. A and C
4. A and B



Answer-(4) Explanation

- Pattern A (DH from F1): In a doubled haploid (DH) population, each individual should have markers from only one of the parents, as they represent a fully homozygous state. If the markers segregate into two distinct bands corresponding to the parent alleles, these markers are allelic. Pattern A shows clear separation of alleles in a DH population, indicating allelic markers.
- Pattern B (F₂ progeny): F₂ progeny should show segregation of alleles in a Mendelian fashion (1:2:1 for co-dominant markers, 3:1 for dominant markers). If the markers segregate according to these ratios, the markers are allelic. Pattern B also shows segregation consistent with Mendelian inheritance in an F₂ population, indicating allelic markers.
- Pattern C (F₂ progeny): The F₂ progeny shows there is no clear segregation that follows Mendelian inheritance, hence the markers are not allelic.

Given below are figures representing four different situations/examples of genetic and environmental (temperature) effects on plant height in two varieties of a plant species. In figures A, C and D, solid and dashed lines represent the mean values of plant height for the two varieties G1 and G2, respectively. In figure B, the solid and dashed lines overlap.

Given below are four statements explaining the four figures.

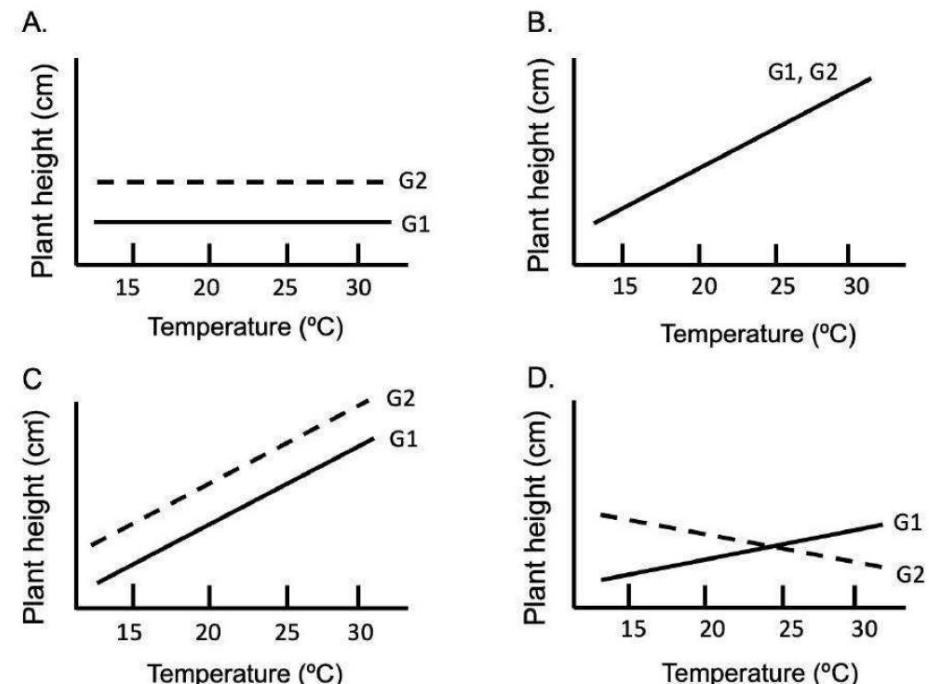
- Plant height is influenced primarily by the genotype of the two varieties.
- Variation in plant height is influenced only by the temperature and genotype has no effect.
- Genotype and temperature collectively have an additive effect on plant height.
- Both genotype and environment have an effect on plant height with the two varieties responding differently to the environment.

Which one of the following options correctly matches the figures and their corresponding explanations?

- A-i, B-ii, C-iii, D-iv
- A-i, B-iii, C-ii, D-iv
- A-iii, B-ii, C-iv, D-I
- A-iv, B-i, C-iii, D-ii

Answer-(1) Explanation

Explanation on Next Page.....



Given below are figures representing four different situations/examples of genetic and environmental (temperature) effects on plant height in two varieties of a plant species. In figures A, C and D, solid and dashed lines represent the mean values of plant height for the two varieties G1 and G2, respectively. In figure B, the solid and dashed lines overlap.

Answer-(1) Explanation

Figure A:

Both G1 and G2 lines are flat and parallel, indicating that plant height is not influenced by temperature. The height remains constant across different temperatures, suggesting that **plant height is influenced primarily by the genotype**.

Figure B:

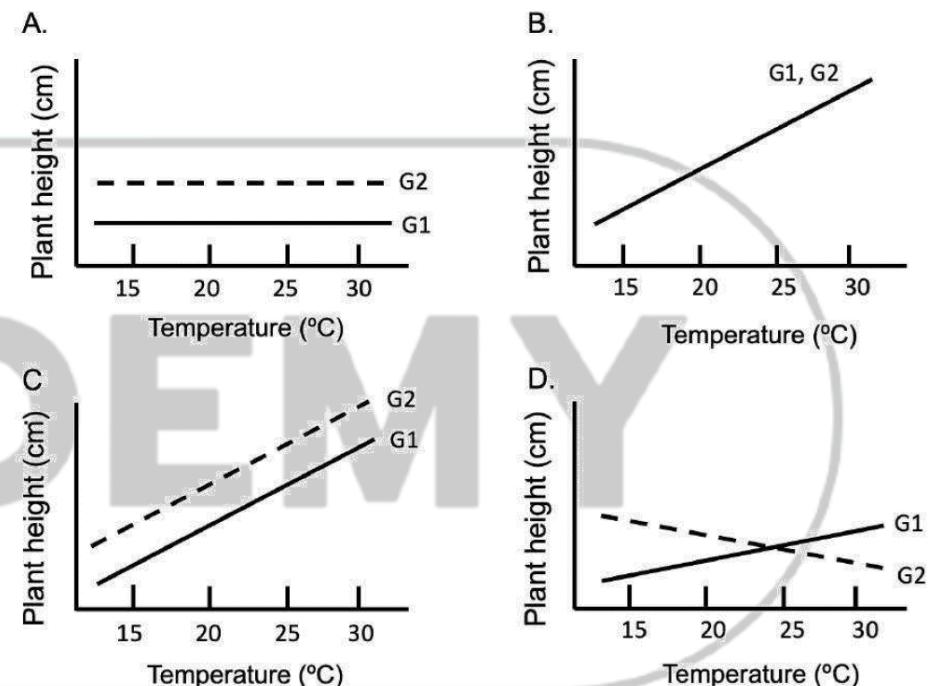
The solid and dashed lines overlap, showing that plant height is consistent for both genotypes across temperatures. This suggests that **variation in plant height is influenced only by the temperature, and genotype has no effect**.

Figure C:

Both G1 and G2 show a linear increase in plant height with increasing temperature, but they have different slopes. This indicates that **genotype and temperature collectively have an additive effect on plant height**.

Figure D:

G1 and G2 lines have different slopes and possibly different starting points, indicating that **both genotype and environment have an effect on plant height, with the two varieties responding differently to the environment**.



The table below represents a list of animals and larval stages.

Which one of the following options represents the combination of all correct matches:

1. a-ii, b-i, c-iii
2. a-i, b-iii, c-ii
3. a-ii, b-iii, c-i
4. a-iii, b-ii, c-i

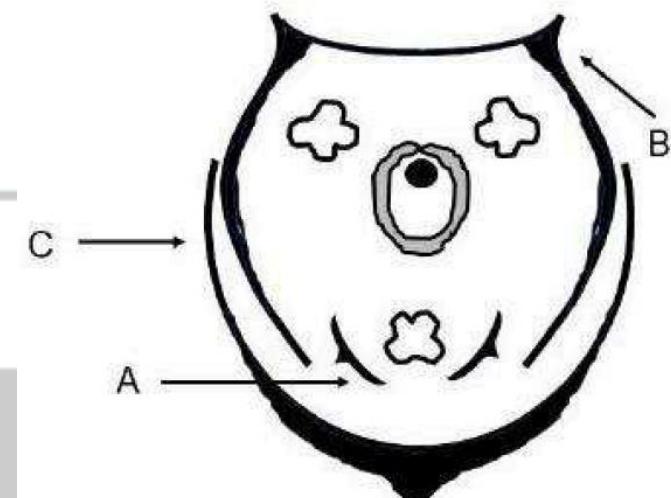
Animal		Larval stage	
a.	sponges	i.	cercariae
b.	cnidarian	ii.	amphiblastula
c.	flatworms	iii.	planula

Answer-(3) Explanation

- Sponges (Amphiblastula): A free-swimming larval stage with two cell layers that develops into an adult sponge.
- Cnidarians (Planula): A ciliated, free-swimming larva that settles to become a polyp or medusa.
- Flatworms (Cercariae): A motile larval stage of trematodes, crucial for infecting hosts in their life cycle.

Select the option that correctly identifies the three labelled floral parts in the floral diagram of a grass flower:3

1. A- palea, B- lemma, C- lodicule
2. A- lemma, B- lodicule, C- stamen
3. A- palea, B- stamen, C- lemma
4. A- lodicule, B- palea, C- lemma



Answer-(4) Explanation

In the floral diagram of a grass flower:

1.A - Palea: The palea is one of the two bracts that enclose the flower in grasses. It is the inner bract, positioned closer to the reproductive organs of the flower.

2.B - Lemma: The lemma is the outer bract that, together with the palea, forms a protective covering around the flower. It is typically larger and more robust than the palea.

3.C - Lodicule: Lodicules are small, scale-like structures found at the base of the ovary in grasses. They swell and help in the opening of the flower during pollination.

Which of the following options represents the correct order of increasing biological organisation?

1. ecosystems < communities < biomes < populations
2. populations < communities < ecosystems < biomes
3. biomes < ecosystems < communities < populations
4. populations < ecosystems < communities < biomes

Answer-(2) Explanation

populations < communities < ecosystems < biomes



VEDEMY

Which one of the options below includes habitats that are ALL found in the Indian subcontinent?

1. Boreal forest, tropical rainforest, tropical deciduous forest, alluvial grassland
2. Temperate forest, alluvial grassland, dry thorn forest, subtropical montane forest
3. Scrub forest, Chapparal vegetation, dry grasslands, riparian forest
4. Shola grasslands, alpine grasslands, tundra, warm broadleaved forest

Answer-(2) Explanation

"Temperate forest, alluvial grassland, dry thorn forest, subtropical montane forest" are all present in the diverse climates and regions of the Indian subcontinent, ranging from the Himalayas to the plains and arid zones. The other options include habitats like boreal forests, chaparral vegetation, and tundra, which are not found in India.

The names of the plant pathogens and their taxonomic groups are given in the table.

Choose the option with all the correct matches:

1. A- ii, B- iv, C-i, D-iii
2. A-iv, B- ii, C- iii, D - i
3. A- i, B - iv, C- ii, D - iii
4. A- iii, B-ii, C-iv, D-i

	Plant pathogen		Taxonomic group
A	<i>Phytophthora infestans</i>	i	Bacteria
B	<i>Cladosporium fulvum</i>	ii	Oomycetes
C	<i>Ralstonia solanacearum</i>	iii	Nematodes
D	<i>Heterodera schachtii</i>	iv	Fungi

Answer-(1) Explanation

Phytophthora infestans (Oomycetes): Causes potato late blight, not a true fungus.

Cladosporium fulvum (Fungi): Fungal pathogen causing tomato leaf mold.

Ralstonia solanacearum (Bacteria): Causes bacterial wilt in various crops.

Heterodera schachtii (Nematodes): Nematode causing sugar beet cyst nematode disease.

The table below lists nomenclatural categories in column X along with their description in column Y.

Which of the following represents the correct sequence of matches:

1. a-iv, b-iii, c-ii, d-i
2. a-i, b-iv, c-iii, d-ii
3. a-iii, b-ii, c-i, d-iv
4. a-iv, b-i, c-iii, d-ii



Answer-(4) Explanation

Column X		Column Y	
a	Homonym	i.	binomial name contains the same epithet for both the genus and species
b	Tautonym	ii.	same binominal name given to a plant and an animal
c	Basionym	iii.	original name of a taxon on which a new combination is based
d	Hemihomonym	iv.	two or more specific or subspecific scientific names with the same spelling, but for different nominal taxa

- a. Homonym → iv. Two or more specific or subspecific scientific names with the same spelling, but for different nominal taxa
- b. Tautonym → i. Binomial name contains the same epithet for both the genus and species
- c. Basionym → iii. Original name of a taxon on which a new combination is based
- d. Hemihomonym → ii. Same binominal name given to a plant and an animal

An ecological community is more than just the sum of the attributes of the constituent species. Which one of the following options is NOT an attribute of ecological communities?

1. Local extinction of a species caused by demographic stochasticity.
2. Log series species abundance distributions.
3. Stability of a food web in the face of disturbance.
4. The limits to similarity of competing species.

Answer-(1) Explanation

Demographic stochasticity is found in events within the population that are random and unpredicted and are demonstrated by individual behaviors causing immigration and emigration into or out of the population. Demographic stochasticity is the chance nature of birth and death. It causes populations to fluctuate because populations are composed of individuals that are units.

Community attributes include components that relate to individuals, or populations, as well as components that refer to habitat components that are relevant for specific species.

The following statements represent possible outcomes of competition between two species.

- A. Niche differentiation between species
- B. Expansion of fundamental niche of both species
- C. Expansion of realized niche of both species
- D. Character displacement between species

Which one of the following options represents the correct set of possible outcomes?

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

Answer-(3) Explanation

Possible outcomes of competition between two species is Niche differentiation & character displacement

For a population that grows exponentially in the time interval $(t, t+1)$, we have $N_{t+1} = R N_t$, where N denotes population size and R denotes the growth rate. Under intraspecific competition where births and deaths are density dependent, we expect the population to stabilize at carrying capacity, K . In the figure below, N_t / N_{t+1} is plotted as a linear function of N_t .

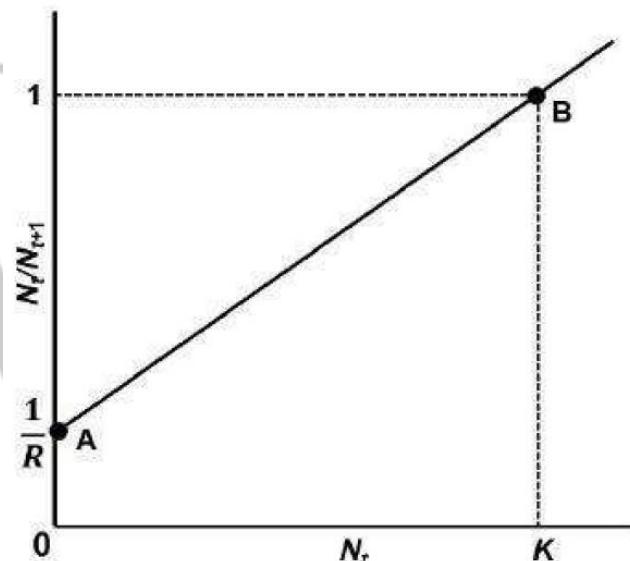
We may write down the linear equation for the line joining A with B and derive a model for density-dependent population growth under intraspecific competition.

Denoting $(R-1)/K$ as a , which of the following is the correct relationship that describes population growth?

1. $N_{t+1} = \frac{N_t R}{(1+aN_t)}$
2. $N_{t+1} = \frac{aN_t}{(1+RN_t)}$
3. $N_{t+1} = \frac{N_t R}{(a+N_t)}$
4. $N_{t+1} = \frac{aN_t R}{(1+aN_t)}$



VEDEN



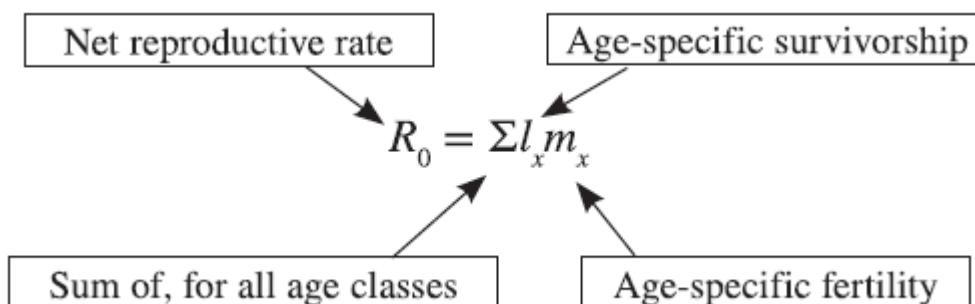
Answer-(1) Explanation

$$N_{t+1} = \frac{N_t R}{(1+aN_t)}$$

Here is some data for a cohort of 400 individuals of a species whose abundance was tracked for 6 years (its maximum lifespan). For one-year age intervals from birth to 6 years, you have the following numbers of survivors, 400, 200, 100, 40, 20, 10, and 0. The corresponding per capita birth rates are 0.1, 2.0, 3.0, 4.0, 4.0, 3.0, and 0.0. What is the basic reproductive rate R_0 ?

1. 2.52
2. 2.92
3. 2.36
4. 3.20

Answer-(1) Explanation



In a line transect of length L and half-width w, designed for estimating the density of gaur ($D=N/2Lw$), N animals were counted. The following statements represent possible assumptions about population sampling.

- A. The probability of detection is independent of distance from the transect line.
- B. The animals in question are uniformly distributed through the study area.
- C. The animals are deemed to be stationary and thus detected only once during the sampling.
- D. Animals on the line will be detected with a probability equal to 1.

Select the options that are considered as assumptions in line transect sampling.

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

Answer-(2) Explanation

The animals are deemed to be stationary and thus detected only once during the sampling

Animals on the line will be detected with a probability equal to 1.

The given table shows the annual Net Primary Productivity (NPP), season length, and Leaf Area Index (LAI) for various ecosystems.

Which one of the following options represents the correct order of decreasing per day per unit leaf area?

1. Desert > Tundra > Tropical Forest > Temperate Forest
2. Tropical Forest > Temperate Forest > Tundra > Desert
3. Tundra > Desert > Temperate Forest > Tropical Forest
4. Temperate Forest > Tropical Forest > Desert > Tundra

Ecosystem	Season length (days)	Annual NPP (g m^{-2})	Total LAI ($\text{m}^2 \text{m}^{-2}$)
Tropical Forest	365	2482	6.0
Temperate Forest	250	1550	6.0
Tundra	100	180	1.0
Desert	100	250	1.0

Answer-(1) Explanation

Desert > Tundra > Tropical Forest > Temperate Forest

Desert has highest per unit leaf area

NPP per unit leaf area

Desert>temperate grassland>tropical forest>temperate forest

Phylogenetic trees are used to examine

- A. relatedness among different populations, species or genera.
- B. similarity in characters among different populations, species or genera.
- C. common ancestry among different populations, species or genera.
- D. functional significance of traits in populations, species or genera.

From the above statements, select the correct combination of statements that best represent the utility of phylogenetic trees.

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

Answer-(3) Explanation

Phylogenetic trees are used to examine relatedness among different populations, species or genera. Similarity in characters among different populations, species or genera. Common ancestry among different populations, species or genera.

Cystic fibrosis is caused by a recessive allele. Roughly one out of every 500 individuals (0.20%) have this disease. Using the Hardy-Weinberg equation, the percentage of individuals who are carriers of the recessive allele for the disease is

1. 10.2
2. 1.0
3. 15.2
4. 7.6

Answer-(4) Explanation

Hardy-Weinberg Principle

The Hardy-Weinberg equation is given by:

$$p^2 + 2pq + q^2 = 1$$

Where:

- p = frequency of the dominant allele
- q = frequency of the recessive allele
- q^2 = frequency of individuals with the recessive phenotype (those with cystic fibrosis)

Given Data

1. The prevalence of cystic fibrosis is approximately 1 in 500 individuals, or $q^2 = 0.002$ (0.20%).

2. To find q , we take the square root of q^2 :

$$q = \sqrt{0.002} \approx 0.0447$$

3. Since $p + q = 1$, we can find p :

$$p = 1 - q \approx 1 - 0.0447 \approx 0.9553$$

Carrier Frequency

The carrier frequency is represented by $2pq$:

$$2pq = 2 \times p \times q \approx 2 \times 0.9553 \times 0.0447 \approx 0.0853$$

To express this as a percentage:

$$2pq \approx 0.0853 \times 100 \approx 8.53\%$$

Conclusion

The percentage of individuals who are carriers of the recessive allele for cystic fibrosis is approximately 8.5%. Among the provided options, the closest answer is 7.6%.

The statements below are about possible genetic relatedness between individuals of a monogamous, haplodiploid insect.

- A. A female is related to its son by 0.5
- B. A female is related to its brother by 0.5
- C. A male is related to its mother by 1
- D. A male is related to its daughter by 1

Which one of the following options represents the combination of all correct statements?

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

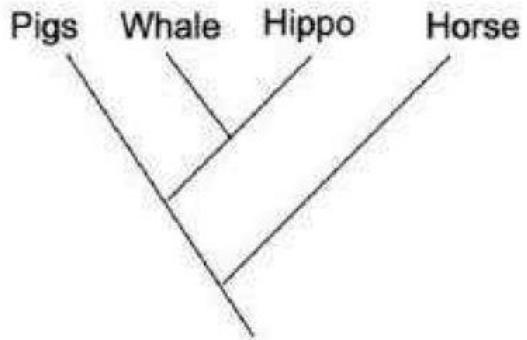
Answer-(4) Explanation

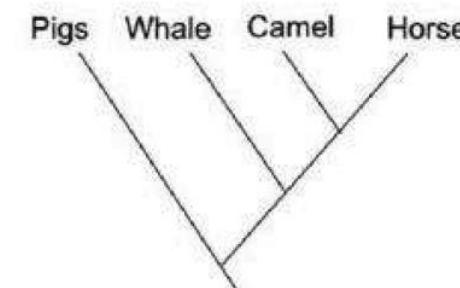
In haplodiploid insect- female is related to its son by 0.5. female is related to its brother by 0.25. male is related to its mother by 1. male is related to its daughter by 1

Shared gene proportions in haplo-diploid sex-determination system relationships

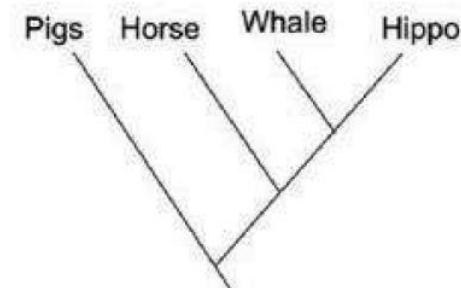
Sex	Daughter	Son	Mother	Father	Full Sister	Full Brother
Female	1/2	1/2	1/2	1/2	3/4	1/4
Male	1	N/A	1	N/A	1/2	1/2

Molecular phylogeny indicates that whales are closely related to the artiodactyls. Given this information, select the phylogenetic tree that shows the correct set of terrestrial animals with which modern whales share their most recent ancestry.

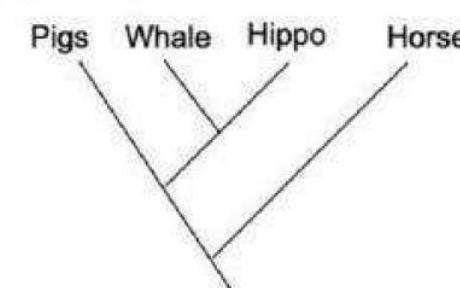
Answer-(3) Explanation

- 1 

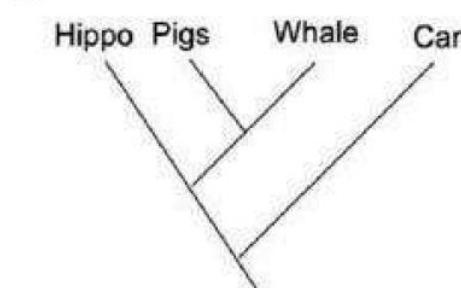
```
graph LR; P1[Pigs] --- P2[Whale]; P2 --- P3[Camel]; P2 --- P4[Horse];
```

A phylogenetic tree diagram showing the relationship between four terrestrial animals: Pigs, Whale, Camel, and Horse. The tree is rooted at the top left and branches downwards. Pigs and Whale are sister taxa, forming a clade. This clade then branches into two lines: one leading to Camel and another leading to Horse.
- 2 

```
graph LR; P1[Pigs] --- P2[Horse]; P2 --- P3[Whale]; P2 --- P4[Hippo];
```

A phylogenetic tree diagram showing the relationship between four terrestrial animals: Pigs, Horse, Whale, and Hippo. The tree is rooted at the top left and branches downwards. Pigs and Horse are sister taxa, forming a clade. This clade then branches into two lines: one leading to Whale and another leading to Hippo.
- 3 

```
graph LR; P1[Pigs] --- P2[Whale]; P2 --- P3[Hippo]; P2 --- P4[Horse];
```

A phylogenetic tree diagram showing the relationship between four terrestrial animals: Pigs, Whale, Hippo, and Horse. The tree is rooted at the top left and branches downwards. Pigs and Whale are sister taxa, forming a clade. This clade then branches into two lines: one leading to Hippo and another leading to Horse.
- 4 

```
graph LR; P1[Hippo] --- P2[Pigs]; P2 --- P3[Whale]; P2 --- P4[Camel];
```

A phylogenetic tree diagram showing the relationship between four terrestrial animals: Hippo, Pigs, Whale, and Camel. The tree is rooted at the top left and branches downwards. Hippo and Pigs are sister taxa, forming a clade. This clade then branches into two lines: one leading to Whale and another leading to Camel.

The following statements describe different patterns of sequence evolution.

- A. Most non-synonymous mutations are selected against.
- B. Synonymous mutations can accumulate.
- C. The ratio of non-synonymous to synonymous substitutions is high.
- D. Non-synonymous sites accumulate mutations at higher rates.

Which one of the options is NOT true about sequence evolution under purifying selection?

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

Answer-(2) Explanation

Most non-synonymous mutations are selected against. Synonymous mutations can accumulate. The ratio of non-synonymous to synonymous substitutions is less than 1.

In a frog species, foot webbing is controlled by a single gene where the allele for nonwebbed feet (W) is dominant and webbed feet (w) is recessive. Assume there is a population of 500 individuals, where 320 have the genotype WW, 160 have the heterozygous genotype of Ww, and 20 have the genotype ww.

What are the frequencies of the three genotypes and alleles in this population?

1. Genotype frequencies: 0.04 WW, 0.32 Ww and 0.64 ww; Allele Frequencies W - 0.5 and w - 0.5
2. Genotype frequencies: 0.32 WW 0.64 Ww and 0.04 ww; Allele Frequencies W - 0.8 and w - 0.2
3. Genotype frequencies: 0.64 WW 0.32 Ww and 0.04 ww; Allele Frequencies W - 0.8 and w - 0.2
4. Genotype frequencies: 0.34 WW, 0.34 Ww and 0.32 ww; Allele Frequencies W - 0.5 and w - 0.5

Answer-(3) Explanation

Given:

- Total population = 500 individuals
- Genotype WW = 320 individuals
- Genotype Ww = 160 individuals
- Genotype ww = 20 individuals

Genotype Frequencies:

- Frequency of WW = $\frac{320}{500} = 0.64$
- Frequency of Ww = $\frac{160}{500} = 0.32$
- Frequency of ww = $\frac{20}{500} = 0.04$

- Frequency of allele W:
 - W allele comes from both WW and Ww individuals.
 - The number of W alleles from WW = 320 individuals $\times 2 = 640$ alleles
 - The number of W alleles from Ww = 160 individuals $\times 1 = 160$ alleles
 - Total number of W alleles = $640 + 160 = 800$ alleles
- Frequency of allele w:
 - w allele comes from both Ww and ww individuals.
 - The number of w alleles from Ww = 160 individuals $\times 1 = 160$ alleles
 - The number of w alleles from ww = 20 individuals $\times 2 = 40$ alleles
 - Total number of w alleles = $160 + 40 = 200$ alleles

- Total number of alleles = $500 \text{ individuals} \times 2 \text{ alleles per individual} = 1000$ alleles
- Frequency of W = $\frac{800}{1000} = 0.8$
- Frequency of w = $\frac{200}{1000} = 0.2$

Conclusion:

The correct genotype and allele frequencies are:

- Genotype frequencies: 0.64 WW, 0.32 Ww, and 0.04 ww
- Allele frequencies: W - 0.8 and w - 0.2

RPMI and DMEM, supplemented with serum, antibiotics, glutamine and phenol red are routinely used for tissue culture of human cells in CO_2 incubators. In addition, sodium bicarbonate (NaHCO_3) and HEPES are used as buffering agents. The following statements were made about the media.

- A. While 5% CO_2 is optimal for cells cultured in RPMI, the optimal CO_2 concentration for DMEM is 7.5-10%.
- B. HEPES is necessary if cells are to be kept outside the incubator in room air for long periods.
- C. NaHCO_3 is necessary if cells are to be kept outside the incubator in room air for long periods.
- D. When cells grow rapidly in the culture medium for a few days, phenol red will turn the medium pink/red.

Which one of following options represents the correct combination of all the statements?

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

Answer-(1) Explanation

- Statement A: While 5% CO_2 is optimal for cells cultured in RPMI, the optimal CO_2 concentration for DMEM is 7.5-10%. (This statement is correct because different media formulations have different buffering capacities and CO_2 requirements.)
- Statement B: HEPES is necessary if cells are to be kept outside the incubator in room air for long periods. (HEPES is a buffering agent that maintains pH in the absence of CO_2 , making it useful for maintaining cells outside the incubator.)

Statements C and D are incorrect:

- Statement C is incorrect because NaHCO_3 alone is not sufficient to maintain pH outside of a CO_2 incubator for long periods.
- Statement D is incorrect because phenol red turns yellow when the medium becomes acidic (e.g., due to rapid cell growth and lactic acid production), not pink/red.

A plant breeder plans to introgress a gene for pathogen resistance (R) from a wild species (B) into a cultivated variety (A). Panel I in the figure shows a profile of DNA markers for A and B. Panel II shows a genetic map for the linkage group which has the gene for pathogen resistance.

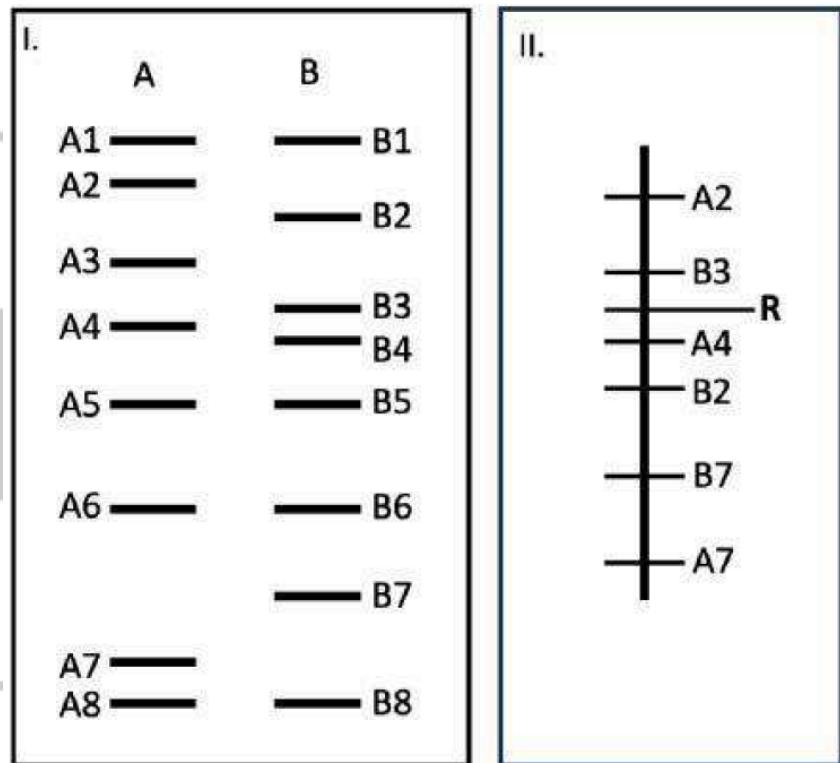
Which one of the following options has the correct choice of markers for foreground (FG) and background (BG) selection, respectively?

1. FG: B3, A4 and BG: A2, A3, A7
2. FG: B3, B2 and BG: A1, A5, A6, A8
3. FG: B3, B2 and BG: A2, A3, A4, A7
4. FG: B3, A4 and BG: A2, B2, 87 and A7

Answer-(3) Explanation

Foreground Selection (FG): Markers closely linked to the gene of interest (in this case, the pathogen resistance gene R) should be used to select individuals that carry the desired gene. The gene for pathogen resistance (R) is located on the genetic map (Panel II). The markers close to the R gene are B3, B2, and A4. For introgression, you would select for markers B3 and B2 from the **wild species (B)** that are closely linked to the R gene.

Background Selection (BG): Markers that are not linked to the gene of interest but are distributed throughout the rest of the genome should be used to recover the genetic background of the cultivated variety (A). These would be markers A2, A3, A4, A7 (as these are not close to the R gene and represent other parts of the genome of variety A).



Given below are a few statements on transgenic plants.

- A. Transgenic plants generated using a transformation vector with the CaMV35S promoter-GUS-35SpA cassette can show variations in expression levels of GUS protein in independent transgenic events due to differences in strength of promoter used to express the *GUS* gene.
- B. A transgenic plant containing two insertions of the transgene cassette as inverted repeats in tandem would segregate in a 3:1 ratio for the transgenic phenotype on backcrossing the transgenic plant with the untransformed parent.
- C. A transgene containing a potential polyadenylation signal in its coding sequence would generate full-length transgene mRNA but a truncated transgenic protein.
- D. A gene-pyramiding experiment to bring together transgenic traits by crossing independent homozygous single-copy transgenic lines for each trait would produce a plant homozygous for both the transgenes in the F₂ generation.

Which one of the following options represents a combination of only correct statements?

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

Answer-(3) Explanation

Statement A: Incorrect: Variations in expression are typically due to the position effect or copy number, not the strength of the promoter, as the promoter is consistent across events.

Statement B: Incorrect: Inverted repeats can cause gene silencing or other complex effects, not necessarily leading to a simple Mendelian 3:1 segregation pattern.

Statement C is incorrect because a transgene with a potential polyadenylation signal in its coding sequence would likely result in premature mRNA cleavage, leading to truncated mRNA and protein. It wouldn't generate full-length transgene mRNA as stated.

Statement D is correct because in a gene-pyramiding experiment, crossing independent homozygous single-copy transgenic lines can produce F₂ plants that are homozygous for both transgenes, following Mendelian inheritance patterns.

The interpretation of any clinical laboratory test is done by comparing the patient's results to the test's reference intervals. For example, the reference interval for white blood cells (WBC) in human adults is 4,500 - 11,000 cells/microlitre. Estimation of this reference interval is done by testing

1. a large number of healthy adults and estimating the range between 2.5 to 97.5 percentiles of the reference population.
2. a large number of healthy adults and estimating the range between 5 to 95 percentiles of the reference population.
3. a large number of random adults and estimating the range between 5 to 95 percentiles of the reference population.
4. a large number of random adults and estimating the range between -1.64 and +1.64 standard deviations either side of the mean of the reference population.

Answer-(1) Explanation

- Reference intervals for clinical laboratory tests are typically established by testing a large number of healthy individuals from the reference population. The goal is to determine the range of values that encompasses the central 95% of the reference population.
- Therefore, the correct answer is option a, as it accurately describes the process of estimating the reference interval using healthy adults and the 2.5th to 97.5th percentiles to establish a 95% reference interval.
- Option b is incorrect because the 5th and 95th percentiles are used to establish a 90% reference interval, not a 95% reference interval.
- Option c is incorrect because the reference population should consist of healthy individuals, not random adults.
- Option d is incorrect because the range between -1.64 and +1.64 standard deviations corresponds to the 5th and 95th percentiles, not the 2.5th to 97.5th percentiles.

Four groups of students (A – D) were asked to determine whether memory B cells generated in mice immunized with ovalbumin (OVA), in Complete Freund's adjuvant (CFA), could mount a secondary antibody response (recall response) to OVA in vitro. The groups did the following experiments:

Group A students harvested serum from the mice, loaded it on OVA-coated ELISA plates and showed that IgG and IgA anti-OVA antibodies were present.

Group B students harvested long-lived plasma cells from bone marrow of the mice, plated them in culture for 5 days and showed anti-OVA antibodies in supernatant by ELISA.

Group C students infected an epithelial cell line with the virus and showed that spleen cells from the mice could kill the infected targets.

Group D students stimulated spleen cells from the mouse with OVA for 5 days and showed anti-OVA antibodies in supernatant by ELISA.

Which one of the following options represents group(s) that did the correct experiment?

1. Group A
2. Group C
3. Groups B and C
4. Group D

Answer-(4) Explanation

Group A students This experiment demonstrates the presence of antibodies in the serum, indicating that the mice have mounted an immune response to OVA. However, it does not specifically assess the recall response of memory B cells since it is measuring antibodies in serum rather than a direct response from memory B cells.

Group B students This experiment is relevant because long-lived plasma cells are derived from memory B cells and are capable of producing antibodies. However, the presence of antibodies in the supernatant from plasma cells does not specifically demonstrate a recall response to OVA; it indicates ongoing antibody production.

Group C students This experiment assesses the cytotoxic T cell response, not the B cell recall response to OVA. Therefore, it is not relevant to the question regarding memory B cells and their ability to mount a secondary antibody response.

Group D students This experiment directly tests the ability of memory B cells to respond to OVA by stimulating them with the antigen and measuring the production of anti-OVA antibodies. This is a clear demonstration of the recall response. Group D specifically tested the ability of memory B cells to mount a secondary antibody response by stimulating spleen cells with OVA and measuring the resulting antibodies.

A researcher used CRISPR-Cas9 system and observed a different type of mutation in two alleles of a target gene in a T₀ transgenic plant. These mutations are designated as follows:

Allele 1: addition of a nucleotide

Allele 2: deletion of a nucleotide

The observed mutations can be classified as

1. monoallelic mutations.
2. biallelic heterozygous mutations.
3. biallelic homozygous mutations.
4. chimeric mutations.

Answer-(2) Explanation

- **Monoallelic mutations:** This term refers to mutations affecting only one allele of a gene, while the other allele remains wild-type or unchanged. In this case, both alleles are mutated, so this option is incorrect.
- **Biallelic heterozygous mutations:** This refers to mutations where both alleles of the gene are mutated, but the mutations are different in each allele. In this scenario, one allele has a nucleotide addition, and the other has a nucleotide deletion, making them heterozygous mutations. Therefore, this option is correct.
- **Biallelic homozygous mutations:** This would mean that both alleles have the exact same mutation. Since the mutations are different in each allele (one addition and one deletion), this option is incorrect.
- **Chimeric mutations:** Chimerism refers to the presence of two or more genetically distinct cell lines within an organism, which is not the case here. The plant in this scenario has two different mutations in the same gene but not different genetic lines, so this option is incorrect.

The theoretical resolution limit of the fluorescence microscope is about 200 nm. Super-resolution microscopy has been developed to address this limitation. Given below are super-resolution microscopy methods in column X and their principle in column Y.

Which one of the following options represents

1. A-(i), B-(ii), c-(iii)
2. A-Qi), B-(i), c-(iii)
3. A-(iii), B-(ii), c-(i)
4. A-Qi), B-(iii), c-(i)



Answer-(2) Explanation

Super-resolution microscopy (Column X)		Principle (Column Y)	
A.	Structured illumination microscopy (SIM)	(i)	focused excitation laser point is surrounded by donut-shaped depletion beam
B.	Stimulated emission depletion (STED) microscopy	(ii)	the specimen is illuminated with a pattern of light and dark stripes to generate Moiré fringes
C.	Photoactivated localization microscopy (PALM)	(iii)	utilizes variant of GFP that is activated by a wavelength different from its excitation wavelength

A. Structured illumination microscopy (SIM):

Principle: (ii) The specimen is illuminated with a pattern of light and dark stripes to generate Moiré fringes.

B. Stimulated emission depletion (STED) microscopy:

Principle: (i) Focused excitation laser point is surrounded by a donut-shaped depletion beam.

C. Photoactivated localization microscopy (PALM):

Principle: (iii) Utilizes a variant of GFP that is activated by a wavelength different from its excitation wavelength.

A student used the mark-recapture method to assess the population size of grasshopper in a field. The student was asked to repeat the recapture procedure once on three consecutive days. The procedure followed by the student and the observations made are as follows:

- On day one, 40 grasshoppers were captured, marked and released back in the field.
- On day two, 60 grasshoppers were re-caught of which, 4 were marked. He marked the unmarked ones and released all 60 in the field.
- On day three, 50 grasshoppers were re-caught of which 7 were marked. He marked the unmarked ones and released all 50 in the field.
- On day four, 25 grasshoppers were re-caught of which 6 were marked.

The student was asked to calculate the population size based on the mean of the three observations. The estimated population size is:

- 600
- ≈ 622
- ≈ 351
- ≈ 454



Answer-(2) Explanation

Recapture1)

$S_1 = 56$ UnMarked

Recapture2)

$S_1 = 56 + 40$ [All are Unmarked] = To be Considered

$S_2 = 50$ (Marked = 7)

$$; N_2 = \frac{96 \times 50}{7} = 685.7$$

UM = 43

Recapture3)

$$S_1 = 56 + 40 + 43 = 139$$

$$S_2 = 25 \quad (M = 6)$$

$$; N_3 = \frac{139 \times 25}{6} = 579.1$$

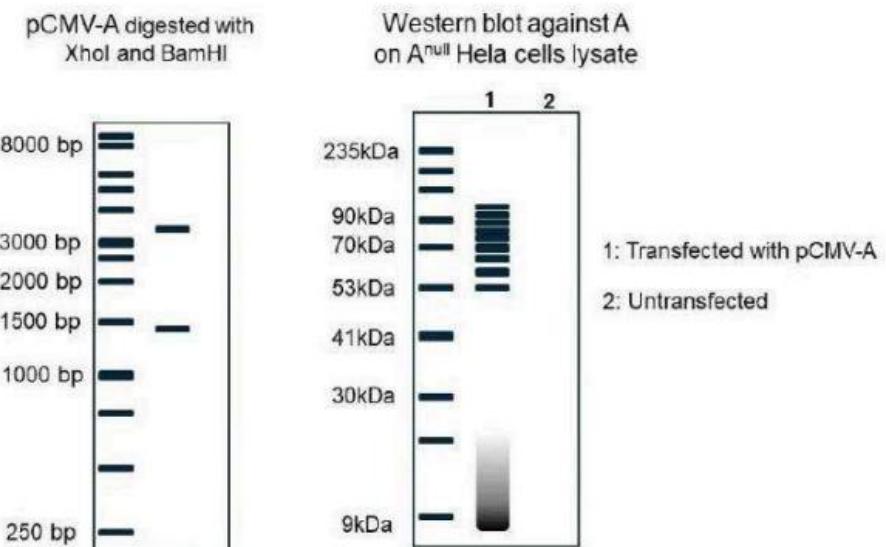
Average Value :

$$\frac{N_1 + N_2 + N_3}{3} \Rightarrow \frac{600 + 685.7 + 579.1}{3} \Rightarrow 621.6 \approx \underline{\underline{622}}$$

The CDS of the shortest isoform of human gene 'A' is cloned into a 3.3 kb vector under a CMV promoter at the BamHI and Xhol sites (pCMV-A vector).

From the agarose gel and SDS-PAGE images shown above, which one of the following is most likely true for protein A in HeLa cells:

1. Protein A forms homo-multimers.
2. Protein A is degraded by the lysosome.
3. Protein A is polyubiquitinated.
4. Protein A localizes to autophagosomes.



Answer-(3) Explanation

A. Structured illumination microscopy (SIM):

Principle: (ii) The specimen is illuminated with a pattern of light and dark stripes to generate Moiré fringes.

B. Stimulated emission depletion (STED) microscopy:

Principle: (i) Focused excitation laser point is surrounded by a donut-shaped depletion beam.

C. Photoactivated localization microscopy (PALM):

Principle: (iii) Utilizes a variant of GFP that is activated by a wavelength different from its excitation wavelength.