CSIR NET Life Sciences Top 100 Questions

Q.1 **In Xenopus, different morphogens act in a concentration-dependent manner. Activin is one such morphogen. The cell receiving the highest concentration of Activin will activate which of the following?**

A. organizer
B. xbra gene
C. heart cells
D. limb

Answer: A

Sol: **Correct Answer:** (a) organizer

Explanation

Activin acts as a morphogen in Xenopus mesoderm induction: high concentrations of Activin induce dorsal mesoderm fates, including the Spemann organizer (the signalling center that patterns the embryo). Lower concentrations produce more ventral mesodermal fates (e.g., muscle precursors and genes like xbra), while very low levels may induce other cell types. Limb induction is not relevant in early Xenopus embryonic patterning; heart specification requires distinct signals and positional context.

Information Booster

-Activin gradient → concentration-dependent induction: high → organizer (dorsal mesoderm); intermediate → notochord/muscle (xbra); low → lateral/ventral mesoderm.

-The organizer secretes antagonists (e.g., Chordin, Noggin) that help establish dorsal structures.

-Morphogen thresholds are a classic way embryos translate graded signals into discrete cell fates.

Additional Knowledge (Incorrect options explained)

(b) xbra gene: xbra (Brachyury) is induced at intermediate Activin concentrations (posterior/ventral mesodermal fate), not the highest.

(c) heart cells: Cardiac induction involves later, tissue-specific interactions (e.g., endoderm/mesoderm signals), not direct activation by the highest Activin in early Xenopus.

(d) limb: Limb formation is a later morphological event in tetrapods and not a direct outcome of early Activin concentration in Xenopus embryos.

Q.2 **The general increase in surface area of an animal due to large external organs so that heat loss will be maximum in a hot climate is indicated towards:**

A. allee effect
B. allen's rule
C. bergmann's rule
D. hamilton rule

Answer: B

Sol: **Correct Answer:** (b) allen's rule

Explanation

Allen's rule states that animals living in hot climates tend to have larger external appendages (ears, limbs, tails) to increase surface area and promote heat dissipation.

This adaptation helps prevent overheating.

Information Booster

-Desert animals like jackrabbits have long ears to radiate heat.

-Cold-climate animals have shorter extremities (e.g., Arctic fox) to reduce heat loss.

Additional Information (Incorrect Options Explained)

(a) allee effect: Describes reduced population fitness at low population size; unrelated to morphology.

(c) bergmann's rule: States that warm-blooded animals in cold climates are larger in size.

(d) hamilton rule: Explains evolution of altruism (kin selection), unrelated to thermoregulation.

Q.3 **Which one of the following options related to plant growth and development is matched INCORRECTLY?**

A. leafy: floral meristem identity genes
B. xylogenesis: wood formation
C. met1: inflorescence architecture
D. caspases: enhancer of apoptosis

Answer: D

Sol: **Correct Answer:** (d) caspases: enhancer of apoptosis

Explanation

Caspases are animal proteases involved in apoptosis.

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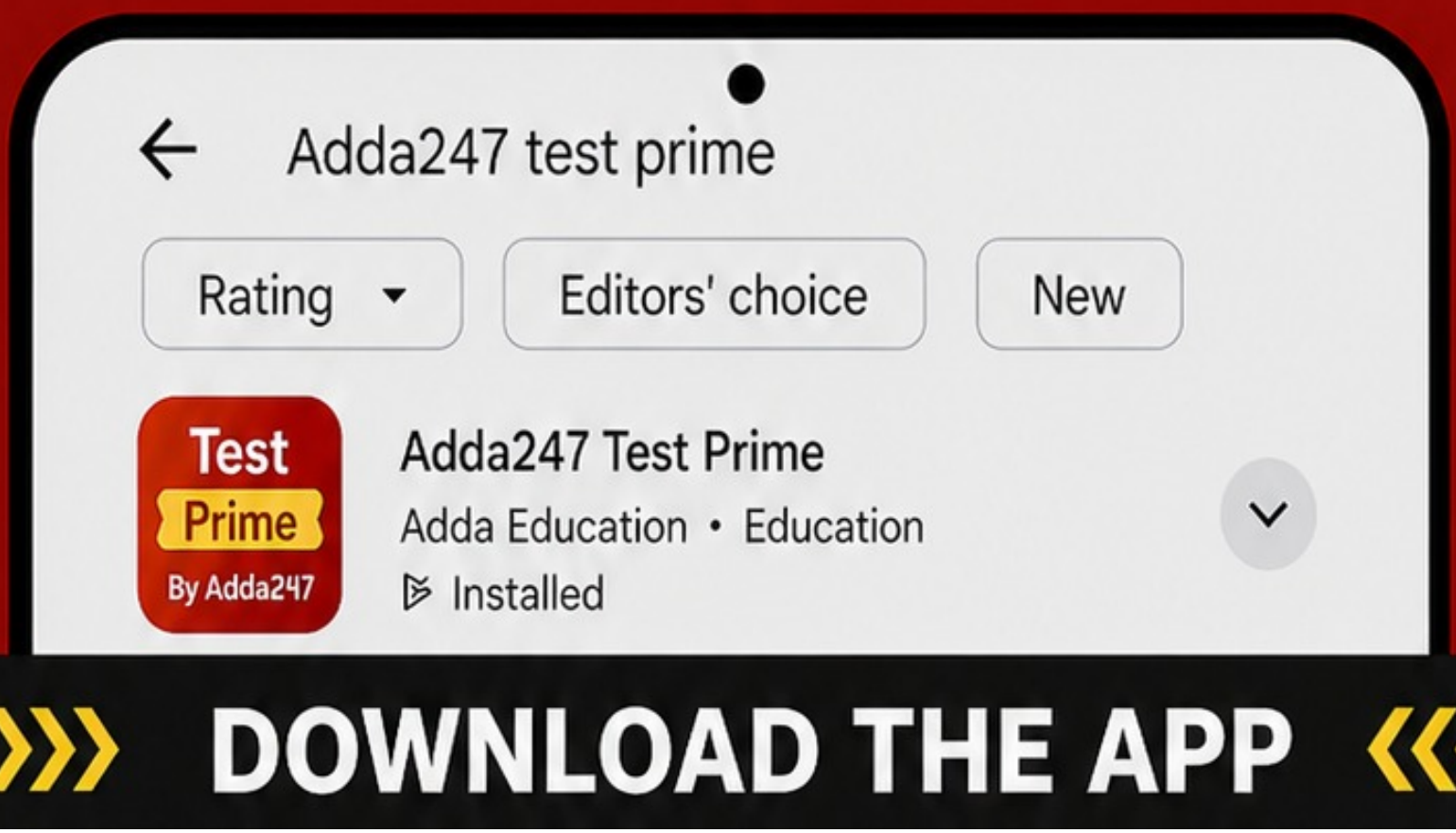

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Plants do not have classical caspases. Instead, they have metacaspases and other proteases that function differently.
Thus, the pairing "caspases: enhancer of apoptosis" is incorrect in the context of plants.

Information Booster

-LEAFY (LFY) is a master regulator controlling floral meristem identity.
-Xylogenesis is the correct term for wood (xylem) formation.
-MET1 is a maintenance DNA methyltransferase affecting gene regulation and developmental patterns.

Additional Information (Incorrect Options Explained)

(a) leafy: Correctly matched; LFY is essential for floral transition.
(b) xylogenesis: Correct; it refers to xylem/wood development.
(c) met1: Correct; MET1 affects developmental patterning including inflorescence traits.
(d) caspases: Wrong match because plants lack true caspases.

Q.4 **Which one of the following is correct about RNA Polymerase II transcription termination in eukaryotes?**

A. Termination occurs immediately when the polymerase encounters a GC-rich hairpin
B. Rho helicase unwinds the RNA–DNA hybrid at termination sites
C. Cleavage of the nascent transcript downstream of the AAUAAA signal precedes termination
D. Termination requires removal of RNA polymerase from DNA by TFIIH helicase

Answer: C

Sol: **Correct Answer:** C

Explanation:

Termination of Pol II transcription involves cleavage and polyadenylation factors recognizing the AAUAAA sequence. Cleavage occurs downstream, followed by release of the polymerase.

Information Booster:

• CPSF and CstF mediate cleavage and polyadenylation.
• Pol II CTD tail coordinates termination with RNA processing.
• Termination efficiency affects mRNA stability and 3′ end formation.
• Different polymerases use distinct termination mechanisms.
• Proper termination prevents transcriptional read-through.

Additional Knowledge:

A describes bacterial intrinsic termination.
B describes rho-dependent termination in bacteri(a)
D TFIIH functions in initiation, not termination.

Q.5 **The following is the inheritance pattern of the trait under observation:**
1. Affected parents having an affected child.
2. The traits don't skip a generation.
3. The number of affected males and affected females is almost equal.
4. The trait is often found in degrees with consanguineous marriages.
The trait is likely to be:

A. Autosomal dominant
B. Autosomal recessive
C. Sex-linked dominant
D. Mitochondrial inheritance

Answer: A

Sol: **Correct Answer:** Autosomal dominant

Explanation

-The trait does not skip generations, which is the hallmark of dominant inheritance.
-Equal number of males and females being affected indicates that the gene is autosomal, not sex-linked.
-Consanguinity may increase homozygosity, but autosomal dominant disorders can still appear in such populations.
-Thus, the most consistent pattern is autosomal dominant inheritance.

Information Booster

-Autosomal dominant traits typically show:
-Vertical transmission (every generation affected).
-Males = females affected.
-Affected individuals have at least one affected parent.
Additional Knowledge
b. Autosomal recessive traits often skip generations and are more common in consanguineous marriages—not observed here.
c. Sex-linked traits show sex-biased inheritance—not observed here.
d. Mitochondrial inheritance shows affected mothers passing the trait to all children—not observed here.

Q.6 **Apoptosis is a form of programmed cell death that occurs in multicellular organisms. Which of the following steps is wrong in the case of intrinsic apoptosis?**

A. severe damage leads to the activation of bax
B. bax forms a channel on the outer mitochondrial membrane and causes the release of cytochrome c
C. cytochrome c activates the effector caspase 8
D. caspase 8 activates the initiator caspase 9

Answer: C

Sol: **Correct Answer:** (c) cytochrome c activates the effector caspase 8

Explanation

In intrinsic (mitochondrial) apoptosis, the sequence of events is:

-Cellular damage → activation of Bax/Bak
-Bax/Bak oligomerize and form pores in the outer mitochondrial membrane
-Cytochrome c is released into the cytosol
-Cytochrome c binds Apaf-1 → forms the apoptosome
-Apoptosome activates initiator caspase-9
-Caspase-9 activates effector caspases-3 and -7 → apoptosis
Thus:
-Cytochrome c does NOT activate caspase-8
-Caspase-8 is part of the extrinsic pathway, activated by death receptors.

Information Booster

-Caspase-8 → extrinsic apoptosis (death receptor pathway: Fas/FasL, TNF).
-Caspase-9 → intrinsic apoptosis (mitochondria).
-Bax/Bak are pro-apoptotic Bcl-2 family proteins.

Additional Information (Incorrect Options Explained)

(a) Correct: DNA damage activates Bax.
(b) Correct: Bax forms channels that release cytochrome c.
(d) Incorrect description → in intrinsic pathway caspase-9 activates effector caspases, not caspase-8.

Q.7 **The gel-to-liquid crystalline phase transition temperature in phosphatidylserine (PS) lipids composed of dilinoleic acid (DL), dipalmitoyl (DP), dioleyl (DO), and distearyl (DS) fatty acids in decreasing order will be:**

A. dlps > dops > dpps > dsps
B. dlps > dops > dsps > dpps
C. dpps > dsps > dops > dlps
D. dsps > dpps > dops > dlps

Answer: D

Sol: **Correct Answer: (d) dsps > dpps > dops > dlps**

Explanation

Phase transition temperature (**Tm**) increases with **longer fatty acid chains** and **higher saturation**. Thus:

· **DSPS** (longest, saturated) → highest Tm
· **DPPS** (shorter but saturated) → next
· **DOPS** (monounsaturated) → lower
· **DLPS** (polyunsaturated) → lowest

So decreasing Tm order is: dsps > dpps > dops > dlps

Information Booster

· Saturated fatty acids pack tightly → high Tm
· Unsaturated chains create kinks → loose packing → low Tm
· Longer chains show stronger hydrophobic interactions → increased Tm

Additional Information (Incorrect Options Explained)

· **(a) & (b)** incorrectly place DLPS (most unsaturated) at the top.
· **(c)** incorrectly places DSPS below DPPS and DOPS despite being the longest, fully saturated chain.

Q.8 **Phosphorylation of an enzyme reduces its affinity for its substrate. A cell line expresses a kinase-inactive version of the upstream kinase that normally phosphorylates this enzyme. What are the kinetic parameters of the enzyme in this mutant cell line?**

A. Increased Km; unchanged Vmax
B. Decreased Km; unchanged Vmax
C. Unchanged Km and unchanged Vmax
D. Same Km but decreased Vmax

Answer: C

Sol: **Correct Answer:** C

Explanation:

The kinase normally phosphorylates the enzyme to reduce its affinity, meaning phosphorylation increases Km (lowers affinity). In the mutant cell line, the kinase is inactive, so phosphorylation does not occur. The enzyme therefore remains in its unphosphorylated, baseline state, meaning its normal affinity and catalytic capacity are retaine(d)Since Vmax is associated with catalytic efficiency (turnover number) and phosphorylation here mainly affects binding affinity, Vmax remains unchanged.

Information Booster:

• Km reflects substrate binding affinity (higher Km = weaker affinity).
• Vmax reflects catalytic speed at saturation and depends on active site chemistry.
• Covalent regulation (e.g., phosphorylation) can alter Km without altering Vmax.
• Interruption of signaling cascades prevents the post-translational modifications they control.
• Baseline enzyme state is the correct reference unless activation or inhibition occurs.

Additional Knowledge:

A: Km increases only if phosphorylation occurs, which it does not here.
B: Decreased Km would imply phosphorylation increases affinity, opposite of scenario.
D: Vmax changes only if catalytic residues or enzyme structure are altered, not the case here.

Q.9 **G protein–coupled receptors (GPCRs) constitute a large family that detect extracellular molecules and activate internal signals. Following statements are made regarding the termination of GPCR signaling:**

A. The termination of response is dependent upon the ligand concentration.
B. The inhibitory ligand is required for immediate termination using Gαi.
C. The termination of the response can also be done by GTPase activity of adenylate cyclase.
D. Phosphatase and phosphodiesterase can also be used for the termination of response.
Which of the following combinations is CORRECT?

A. A, B, C
B. A and D only
C. A, C, D
D. B, C and D

Answer: B

Sol: **Correct Answer:** (b) A and D only

Explanation:

Statement 1 (A) – Correct: Termination depends on ligand concentration. As ligand levels drop, receptor activation decreases.
Statement 4 (D) – Correct: Phosphatases dephosphorylate proteins and phosphodiesterases degrade second messengers (e.g., cAMP), both helping terminate GPCR signaling.
Incorrect statements:
Statement 2 (B) – Incorrect: Termination does not require an "inhibitory ligand." Instead, termination occurs via intrinsic GTPase activity of Gα, β-arrestin mediated receptor desensitization, and degradation of second messengers.
Statement 3 (C) – Incorrect: The GTPase activity is in the Gα subunit, not in adenylyl cyclase.
Information Booster
GPCR response termination involves:
• Gα-GTP hydrolysis → Gα-GDP (often accelerated by RGS proteins)
• β-arrestin binding → receptor desensitization and internalization
• PDEs lower cAMP/cGMP levels
• Phosphatases reverse phosphorylation signaling states.

Q.10 **During nutrient starvation, a GFP-tagged cytosolic protein is observed to localize into punctate vesicles. The researcher treats cells with bafilomycin A1 (a V-ATPase inhibitor) and notes that GFP signal accumulates in LC3-positive vesicles but fails to co-localize with lysosomal marker LAMP1.**
Which interpretations are CORRECT?
A. Atg8/LC3 lipidation is required for elongation of autophagosomes, consistent with observed puncta.
B. Beclin-1 functions in nucleation of autophagosomal membranes, which is unaffected by bafilomycin.
C. Fusion of autophagosomes with lysosomes is blocked due to failure of lysosomal acidification.
D. LC3 puncta indicate completed autophagolysosomes, not intermediate autophagosomes.

A. A, B, C, D
B. A, C, D
C. B, C, D
D. A, B, C

Answer: D

Sol: **Correct Answer:** (d) A, B, C

Explanation

Observation: GFP accumulates in LC3-positive compartments but does not co-localize with LAMP1 when cells are treated with bafilomycin A1.
Interpretation 1 (A) — True. LC3 (Atg8) lipidation (conjugation to PE) is required for autophagosome membrane elongation and closure; LC3 puncta therefore mark autophagosomal membranes or related intermediates.

Interpretation 2 (B) — True. Beclin-1 (part of the class III PI3K complex) is required for nucleation of the isolation membrane (phagophore). Bafilomycin, which inhibits vacuolar H^+-ATPase and affects lysosomal acidification/fusion, acts downstream and does not directly prevent nucleation.
Interpretation 3 (C) — True. Bafilomycin blocks lysosomal acidification and, in many contexts, prevents maturation/fusion of autophagosomes with lysosomes. The result—accumulation of LC3-positive autophagosomes that fail to acquire LAMP1—is consistent with fusion/maturation blockade.
Interpretation 4 (D) — False. LC3 puncta do not necessarily indicate completed autophagolysosomes; LC3 labels autophagosomes and can be present on intermediate structures. In fact, LC3 accumulation with loss of LAMP1 co-localization indicates stalled autophagosomes, not completed autophagolysosomes.
Information Booster
LC3/Atg8: conjugated LC3-II decorates autophagosomal membranes; number of LC3 puncta increases with autophagosome formation or with blocked degradation.
Beclin-1 (Vps34 complex): required early for phagophore nucleation; inhibitors of lysosomal acidification act later.
Bafilomycin A1: inhibits V-ATPase → prevents lysosomal acidification and can impair autophagosome–lysosome fusion/maturation; commonly used to measure autophagic flux (accumulation indicates blocked degradation).
LAMP1: lysosomal membrane marker; co-localization of LC3 with LAMP1 indicates autophagosome–lysosome fusion (autolysosome formation).

Q.11 **During the polyspermy slow block (cortical granule reaction) in sea urchin fertilization, the following events are proposed:**
A. Cortical granule release proteases.
B. Mucopolysaccharides released by the cortical granules produce an osmotic gradient.
C. A peroxidase enzyme hardens the fertilization envelope.
D. Hyalin forms a coating around the egg.
E. Cortical granule also releases ovastacin.
Pick the CORRECT combination of statements:

A. A and B only
B. A, C and E only
C. A, B, C and D only
D. B, C, D and E only

Answer: C

Sol: **Correct answer:** (c) — A, B, C and D only
Explanation
A. True – Proteases released.
Cortical granules release proteases that cleave sperm-binding receptors and detach any bound sperm.
B. True – Mucopolysaccharides create osmotic swelling.
These draw water into the perivitelline space → lifting and expanding the fertilization envelope.
C. True – Peroxidase hardens the fertilization envelope.
Enzyme crosslinks tyrosine residues → forms the "fertilization membrane."
D. True – Hyalin forms a protective envelope.
Forms the "hyaline layer" outside the egg membrane → important for blastomere adhesion later.
E. False – Ovastacin is NOT released by cortical granules in sea urchin.
Ovastacin is a mammalian cortical granule metalloprotease that cleaves ZP2 in mammals, not sea urchins.
Thus statements A, B, C, D are correct; E is incorrect for sea urchin fertilization.
Information Booster
· Sea urchins and mammals use different cortical granule enzymes (sea urchin: proteases + peroxidase; mammals: ovastacin).
· The slow block forms the fertilization envelope—a permanent barrier to polyspermy.
· Fast block (sea urchin) occurs via depolarization of the egg membrane within seconds.
· Hyalin layer is crucial for later embryonic cell adhesion.
· Cortical granule contents differ across species—always verify organism context.

Q.12 **Elegans embryo uses both autonomous and conditional modes of specification. Conditional specification at the 4-cell stage can be seen in the development of the endoderm cell lineage and also in establishment of dorsal–ventral axis. Following are statements regarding this:**
A. ABa and ABp are equivalent cells (GLP-1) whose fate is determined by their positions within the embryo in respect to P2.
B. If the P2 cell is killed at the early 4-cell stage, the ABp cell does not generate its normal complement of cells.
C. There is up-regulation of the expression of the pop-1 gene in the EMS daughter destined to become the E cell.
D. The expression of the pop-1 gene in the anterior daughter cell results in it becoming an MS cell.
Which of the above statements are TRUE?

A. A, B and D
B. A, B and C
C. B, C and D
D. A, C and D

Answer: A

Sol: **Correct Answer:** (a) A, B and D
Explanation
A — True. At the 4-cell stage ABa and ABp are initially equivalent in potential; their subsequent fates are influenced by cell–cell interactions and

positional cues (including Notch/GLP-1 signalling). Whether an AB daughter follows one fate or another depends on its position relative to P2 and on intercellular signalling.
B — True. P2 provides inductive signals required for correct specification of ABp derivatives. If P2 is killed early, ABp fails to receive the inductive cue and therefore does not produce its normal complement of descendants (it may adopt an alternative fate).
C — False. POP-1 (the TCF/LEF orthologue) is asymmetrically regulated by Wnt/MAPK signaling in the EMS lineage: the E daughter (posterior) has low nuclear POP-1 due to Wnt signaling, while the MS (anterior) daughter retains higher POP-1 levels. Thus POP-1 is not up-regulated in the E cell.
D — True. Higher POP-1 activity in the anterior EMS daughter promotes MS (mesoderm) fate; low POP-1 in the posterior daughter permits E (endoderm) specification. Therefore expression/activity of POP-1 in the anterior daughter leads to MS identity.

Information Booster

EMS lineage decision: The EMS blastomere divides to produce MS (anterior) and E (posterior). Wnt/MOM signalling from P2 to EMS biases POP-1 levels to specify E vs MS.
POP-1 dynamics: Wnt pathway lowers nuclear POP-1 in the posterior daughter (E), enabling endoderm-specific gene activation; high nuclear POP-1 in the anterior daughter (MS) represses endoderm genes.
GLP-1 / Notch: Notch signalling (GLP-1) mediates some early AB lineage interactions — positional signalling at the 4-cell stage is crucial for ABa/ABp fate differences.
Experimental evidence: Ablation (laser killing) or displacement of P2 at early stages is a classic way to demonstrate conditional specification in C. elegans.

Q.13 **Given below are some conditions of natural selection mode:**
A. Light-colored moths got eliminated after industries establishment.
B. It was reported that sickle-shaped cells of the heterozygote kill the malaria parasite. So, the heterozygotes can resist malaria infection better than homozygotes for normal hemoglobin.
C. Robin bird lays only four eggs in her nest.
Pick the CORRECT mode of natural selection for the above cases.

A. A – stabilizing, B – disruptive, C – stabilizing
B. A – directional, B – disruptive, C – stabilizing
C. A – directional, B – stabilizing, C – stabilizing
D. A – disruptive, B – stabilizing, C – directional

Answer: C

Sol: **Correct Answer:** (c) A – directional, B – stabilizing, C – stabilizing

Explanation:

A: Industrial melanism favored dark moths after soot darkened tree bark → directional selection toward a new optimum.
B: Heterozygote advantage (HbA/HbS) has the highest fitness relative to both homozygotes → maintains an intermediate genotype → stabilizing (balancing) selection.
C: Extreme clutch sizes in robins are selected against (too few/too many reduce fitness); intermediate clutch size (~4) is favored → stabilizing selection.

Information Booster:

Directional selection: shifts the population mean toward one extreme (e.g., antibiotic resistance).
Stabilizing selection: narrows variation by favoring intermediates; maintains status quo.
Balancing selection: a broader category including heterozygote advantage and frequency-dependent selection; in phenotype terms it is stabilizing.

Additional Knowledge (Why other options are wrong):

(a): Mislabels A as stabilizing.
(b): Mislabels B as disruptive (would favor both extremes, not the heterozygote).
(d): Reverses A and C relative to correct modes.

Q.14 **DNA mismatch repair (MMR) maintains genomic stability by removing base–base mismatches and insertion/deletion mispairs produced during replication. Below are several statements about the bacterial (E. coli) MMR system. Which of the following combinations of statements is INCORRECT?**
A. In Escherichia coli, mismatches are detected by a trimer of the mismatch-repair protein MutS.
B. MutS has an ATPase activity that is required for mismatch repair.
C. The complex of MutS and the mismatch-containing DNA recruits MutL, a second protein component of the repair system.
D. MutH is an enzyme that causes an incision or nick on one strand near the site of the mismatch.
E. If the DNA is cleaved on the 5′ side of the mismatch, then exonuclease III or RecJ, which degrades DNA in a 5′ → 3′ direction, removes the stretch of DNA from the MutH-induced cut through the misincorporated nucleotide.
F. If the nick is on the 3′ side of the mismatch, then the DNA is removed by exonuclease II, which degrades DNA in a 3′ → 5′ direction.
Options

A. A and B
B. A, B, C and E
C. A, E and F
D. C, D and F

Answer: C

Sol: **Correct answer:** (c) — A, E and F

Explanation

· A is incorrect. MutS functions as a homodimer (or higher-order assemblies) in mismatch recognition — it is not described as a "trimer."

· B is correct. MutS possesses ATP-binding/ATPase activity that is essential for conformational changes and progression of repair.

· C is correct. The MutS–DNA complex recruits MutL, which coordinates downstream events.

· D is correct. MutH is an endonuclease that makes a strand-specific nick near a hemimethylated GATC site (it nicks the unmethylated, newly synthesized strand).

· E is incorrect. The directionalities stated are wrong: Exonuclease III has a 3′ → 5′ exonuclease activity (not 5′ → 3′). RecJ is a 5′ → 3′ ssDNA exonuclease. So mixing ExoIII with RecJ as both 5′→3′ is false. In practice, when the nick is 5′ to the mismatch, 5′→3′ exonucleases (e.g., RecJ, Exonuclease VII) remove DNA.

· F is incorrect. The canonical 3′→5′ exonuclease involved when the nick lies 3′ to the mismatch is Exonuclease I (3′→5′) rather than a named "exonuclease II" as stated here. The statement mislabels and misattributes the exonuclease activity.

Therefore the incorrect statements are A, E and F, matching option (c).

Information Booster

· MutS is the mismatch sensor (forms a dimer/oligomer) and binds mismatches; ATP binding/hydrolysis in MutS regulates its clamp-like conformation.

· MutL acts as a molecular matchmaker — it is recruited by MutS and stimulates MutH and downstream processing.

· MutH is a strand-specific endonuclease acting at hemimethylated GATC sites in E. coli and makes nicks in the newly synthesized (unmethylated) strand.

· Exonuclease directionality matters: if the nick is 5′ to the mismatch, a 5′→3′ exonuclease (e.g., RecJ or Exonuclease VII) removes DNA past the mismatch; if the nick is 3′ to the mismatch, a 3′→5′ exonuclease (e.g., Exonuclease I or Exonuclease III for some substrates) performs removal.

· After removal, DNA polymerase I fills the gap and DNA ligase seals the nick to complete repair.

Q.15 **The following scheme represents deletions (i–iv) in the A locus of lambda phage from a common reference point. Four point mutations (A, B, C, D) are tested against the four deletions for their ability (+) or inability (−) to give wild type (A+) recombinants. The summarized +/− pattern is shown in the image.**

	i	ii	iii	iv
A	+	+	+	+
B	-	+	-	+
C	-	+	-	+
D	-	-	+	+

Which predicted order of the point mutations along the locus is correct?

A. B–D–A–C
B. A–C–D–B
C. A–C–B–D
D. D–B–C–A

Answer: C

Sol: **Correct Answer:** (c) A–C–B–D

Explanation

A point mutation fails to give wild-type recombinants with a deletion (a "−" result) when that mutation lies within the deleted region; a "+" indicates it lies outside the deletion.

By comparing the pattern of +/− across deletions i → iv for each mutation, you can infer which deletions remove which segments and therefore deduce the relative order of the point mutations along the locus.

Applying that interval logic to the +/− table yields the linear order: A → C → B → D.

Information Booster

This is a classical deletion mapping approach: use complementation between point lesions and overlapping deletions to map gene order.

Overlapping deletions that each remove different segments let you localize point lesions to particular intervals; comparing intervals across mutations reconstructs gene order.

Q.16 **According to Kimura, "the changes at the molecular level are due to neutral mutation, not natural selection", so natural selection neither favors nor disfavors them.**

Given below are some statements regarding Neutral Mutation:

A. Non-synonymous base substitutions occur at a much higher rate than synonymous substitution.

B. Mutation occurs at a high rate in non-coding sequences as compared to coding regions.

C. Pseudogenes evolve at a high rate as compared to functional genes.

D. Maximum rate of molecular evolution is equal to the neutral mutation rate since most mutations are harmful.

Pick the INCORRECT statement(s) according to the Neutral Theory of Molecular Evolution:

A. A and C
B. B and C
C. A and D

D. B and D

Answer: C

Sol: **Correct Answer:** (c) A and D

Explanation

Neutral Theory (Kimura, 1968) states that most evolutionary changes at the molecular level are due to random fixation of selectively neutral mutations rather than adaptive changes driven by natural selection.

Hence, the rate of molecular evolution ≈ rate of neutral mutation — independent of population size.

Let's evaluate each statement:

A. Incorrect – Non-synonymous substitutions usually alter amino acids and are subject to selection pressure, so they occur slower, not faster, than synonymous substitutions (which are often neutral).

B. Correct – Non-coding regions are less constrained functionally, so mutations accumulate more freely there.

C. Correct – Pseudogenes are non-functional and evolve rapidly because there is no selection constraint.

D. Incorrect – The statement says "most mutations are harmful," which contradicts the neutral theory (which assumes that most fixed mutations are neutral, not harmful). Thus, it misrepresents the relationship between mutation rate and molecular evolution rate.

Information Booster

Neutral theory formula:

Rate of molecular evolution = neutral mutation rate = μ_0

(where μ_0 = fraction of neutral mutations × total mutation rate)

Synonymous vs Non-synonymous substitutions:

Synonymous = often neutral.

Non-synonymous = often deleterious or occasionally advantageous.

Molecular clock: The neutral theory provides a theoretical basis for the concept of a relatively constant rate of molecular evolution over time.

Nearly Neutral Theory (Ohta, 1973): Expands Kimura's model by including slightly deleterious mutations that can drift to fixation in small populations.

Q.17 **Under stressful conditions, when ACTH secretion is increased leading to elevated glucocorticoids in the bloodstream, it is highly likely that one or a combination of the following changes is occurring:**

A. Decreased circulating eosinophils and basophils.

B. Reduced IL-2 release.

C. Potentiated inflammatory response to tissue injury.

D. Increased mitotic activity of lymphocytes in lymph nodes.

Which combination is CORRECT?

A. B and C

B. A and B

C. B and D

D. C and D

Answer: B

Sol: **Correct answer:** (b) — A and B

Explanation

· Glucocorticoids (released downstream of ACTH) are broadly immunosuppressive and anti-inflammatory. Two well-established effects consistent with statements above are:

· Eosinopenia and basopenia (statement 1 / A): Glucocorticoids cause rapid redistribution and decreased circulating numbers of eosinophils and basophils (and lymphocytes), while causing neutrophilia.

· Suppression of cytokine production including IL-2 (statement 2 / B): Glucocorticoids inhibit transcription of pro-inflammatory cytokines and T-cell growth factors such as IL-2, reducing T-cell proliferation and activation.

· Statements 3 and 4 are contrary to the known effects of glucocorticoids: they dampen inflammatory responses (so 3 is false) and they suppress lymphocyte proliferation/mitotic activity (so 4 is false). Therefore the correct pair is 1 and 2 → option (b).

Information Booster

· Glucocorticoids (cortisol) act via intracellular glucocorticoid receptors to modulate gene transcription — they upregulate anti-inflammatory proteins (e.g., lipocortin) and downregulate many pro-inflammatory genes (cytokines, COX-2).

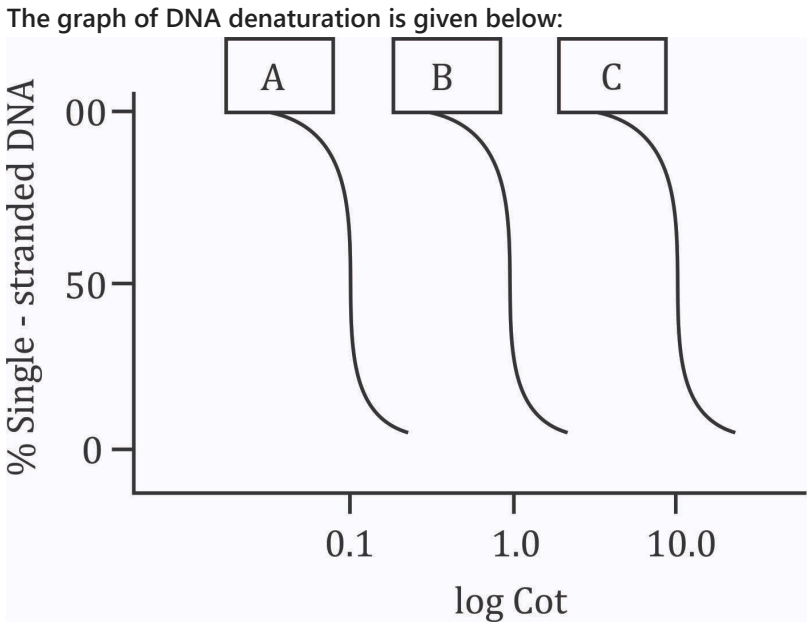
· A characteristic hematologic signature of acute glucocorticoid action is neutrophilia + lymphopenia + eosinopenia due to demargination of neutrophils and redistribution/apoptosis of lymphocytes/eosinophils.

· Glucocorticoids inhibit T-cell function by suppressing IL-2 and other interleukin production and by interfering with AP-1 and NF-κB transcriptional activity.

· Clinically, pharmacologic glucocorticoids are used to treat autoimmune and inflammatory diseases because they reduce edema, leukocyte infiltration and cytokine-mediated tissue damage.

· Chronic glucocorticoid exposure has systemic metabolic effects (gluconeogenesis, protein catabolism, fat redistribution) and predisposes to infection because of immunosuppression.

Q.18 The graph of DNA denaturation is given below:



Which of the following is CORRECT?

A. G+C content is maximum in C.

B. G+C content is minimum in A.

C. C curve is for the Bacteria.

D. C curve is for the Yeast.

A. A, C

B. A, B

C. A, B, and C

D. A, B, and D

Answer: C

Sol: **Correct Answer:** (c) A, B, and C

Explanation:

The Cot curve (DNA renaturation kinetics curve) represents how single-stranded DNA reanneals as a function of Cot value (C × t).

A lower Cot value means faster renaturation, while a higher Cot value indicates slower renaturation — typically due to increased genome complexity or higher G+C content.

From the given graph:

Curve A reanneals fastest → least complex DNA, low G+C content, likely prokaryotic or bacterial DNA.

Curve B shows intermediate complexity and G+C content — could represent yeast or lower eukaryote DNA.

Curve C reanneals slowest → highest G+C content and genome complexity (e.g., eukaryotic nuclear DNA with repetitive and unique sequences).

Thus:

G+C content maximum in C

G+C content minimum in A

C curve represents bacteria (depending on context, can represent prokaryote with high GC genome such as Pseudomonas or Mycobacterium)

Hence, statements 1, 2, and 3 are correct.

Information Booster:

Cot Value (C × t):

C = initial DNA concentration (mol/L)

t = time (sec)

$Cot_{1/2}$ is the point where half of the DNA has reannealed.

Directly proportional to genome complexity.

G+C Content:

DNA with higher GC content melts at a higher temperature and reanneals more slowly due to three hydrogen bonds between G–C pairs.

AT-rich DNA denatures at a lower temperature and reanneals faster.

DNA Types:

DNA Type Cot Value Genome Complexity Example

A Low Simple Bacterial DNA

B Intermediate Moderate Yeast DNA

C High Complex Eukaryotic DNA (Human)

Q.19 **Water potential is the potential energy of water per unit volume relative to pure water in reference conditions. It quantifies the tendency of water to move from one area to another due to osmosis, gravity, mechanical pressure, or matrix effects such as capillary action. Following are a few statements regarding water potential in plants:**

A. Only solute concentration contributes to water potential of a plant cell in a given state.

B. Water will always move from an area of higher water potential to an area of lower water potential.

C. When a flaccid cell is placed in a solution that has a water potential less negative than the intracellular water potential, water will move from solution into the cell.

D. Adding solute increases the water potential.

E. Water potential of a plant cell under severe water stress is always more negative as compared to that of unstressed cells.

Which combination of the above statements is CORRECT?

A. A, B, C

B. B, C, E
C. A, C, D
D. A, B, D

Answer: B

Sol: **Correct Answer:** (b) B, C, E

Explanation:

2 – True: Water moves from higher water potential to lower water potential.

3 – True: "Less negative" solution means higher water potential than the cell; thus water enters the cell.

5 – True: Water-stressed cells have more negative water potential than unstressed cells.

1 – False: Water potential depends on more than solute potential (also pressure, gravitational, and matric components).

4 – False: Adding solute decreases water potential (makes it more negative).

Information Booster:

Total water potential (ψw) = ψs (solute/osmotic) + ψp (pressure/turgor) + ψg (gravitational) + ψm (matric).

Pure water at standard conditions has ψw = 0; adding solute makes ψs negative.

Turgid cells have positive ψp, raising ψw; plasmolysis reduces ψp to ~0 or negative.

Additional Knowledge (Why other options are wrong):

(a) A, B, C: includes A (false).

(c) A, C, D: includes A and D (both false).

(d) A, B, D: includes A and D (both false).

Q.20 **During transgenesis, the location of the genes and their number integrated into the genome of the transgenic animal are random. It is often necessary to determine the copy number of genes and their tissue-specific expression. The following are possible methods used for this determination:**

A. Polymerase Chain Reaction (PCR)
B. Southern blot hybridization
C. Reverse Transcriptase PCR
D. Western blot
Choose the CORRECT set of combinations:

A. A and B
B. B and C
C. B and D
D. A and D

Answer: B

Sol: **Correct Answer:** (b) B and C

Explanation:

Southern blot hybridization (B) is the standard method to determine transgene copy number, because it detects the number and size of genomic DNA fragments that contain the transgene.

Reverse Transcriptase PCR (C) is used to measure gene expression, since it converts mRNA into cDNA and amplifies it, indicating whether the gene is transcriptionally active in a particular tissue.

Information Booster:

PCR (A) alone cannot reliably determine copy number, because amplification efficiency varies and does not distinguish between single vs multiple genomic insertions.

Southern blot provides information on copy number and integration pattern.

RT-PCR reveals tissue-specific gene expression, helping confirm that the transgene is functionally active.

Western blot (D) measures protein expression levels, but does not provide insertion copy number or genomic integration details.

Additional Knowledge (Incorrect Options):

A and B incorrect because PCR is not reliable for copy number.

B and D incorrect because Western blot does not measure gene integration, only protein expression.

A and D incorrect because neither PCR nor Western blot alone can confirm copy number.

Q.21 **Two different antibodies against the same protein were generated and named AB1 and AB2. While AB1 was able to detect the target protein in a western blot, it was unable to detect the protein in ELISA. The opposite was true for AB2. Which one of the following is the most likely reason?**

A. AB1 detects SDS-bound protein, whereas AB2 detects protein that is not bound to SDS.
B. AB1 is unable to cross the cell membrane, whereas AB2 is membrane permeable.
C. AB1 detects epitopes on the folded protein, whereas AB2 detects the unfolded epitopes.
D. AB1 detects linear epitopes on unfolded protein, but AB2 detects discontinuous epitopes present on the folded protein.

Answer: D

Sol: **Correct Answer: (d)**

Explanation: In western blotting, proteins are denatured due to SDS and reducing agents, exposing linear (continuous) epitopes. Antibodies recognizing these linear epitopes can bind effectively in western blot. ELISA, however, often detects proteins in a more native or folded conformation,

where discontinuous epitopes are preserved. Therefore, AB1 detects linear epitopes on unfolded protein, whereas AB2 recognizes conformational epitopes on the folded protein.

Information Booster

· Western blotting involves protein denaturation using SDS.
· Linear epitopes consist of continuous amino acid sequences.
· ELISA often preserves native protein conformation.
· Conformational (discontinuous) epitopes depend on protein folding.
· Antibody specificity depends strongly on epitope structure and protein state.

Additional Knowledge

Antibodies recognizing conformational epitopes generally fail in western blot because denaturation disrupts epitope structure. Conversely, antibodies that bind linear epitopes may not recognize the native protein structure efficiently in ELISA. Understanding epitope specificity is critical for selecting antibodies for appropriate immunodetection techniques.

Q.22 **Choose the INCORRECT statement regarding the synthesis of reactive oxygen species (ROS) upon pathogen infection in plants.**

A. Plasma membrane-spanning NADPH oxidase is involved in the synthesis of ROS.
B. NADPH oxidases are encoded by respiratory burst oxidase homolog genes in *Arabidopsis* (Atrboh).
C. Activation of NADPH oxidase does not require the action of calcium-dependent protein kinases (CDPKs).
D. Apoplastic peroxidase enzymes (PRX) are involved in ROS production.

Answer: C

Sol: **Correct Answer: (c)**

Explanation: In plant immune responses, plasma membrane NADPH oxidases (RBOHs) are key enzymes responsible for ROS generation. Their activation is tightly regulated and requires calcium binding as well as phosphorylation by calcium-dependent protein kinases (CDPKs). Therefore, the statement claiming that NADPH oxidase activation does not require CDPKs is incorrect. CDPK-mediated phosphorylation is an essential step in RBOH activation during pathogen-triggered immunity.

Information Booster

· ROS production is one of the earliest plant defense responses to pathogen attack.
· Plasma membrane NADPH oxidases (RBOHs) catalyze superoxide generation in the apoplast.
· RBOH proteins contain EF-hand motifs that bind calcium ions.
· CDPKs phosphorylate RBOHs to enhance and sustain ROS production.
· Apoplastic peroxidases also contribute to ROS accumulation during defense responses.

Additional Knowledge

Respiratory burst oxidase homologs (Atrboh genes) encode NADPH oxidases that are functionally similar to those found in animal immune systems. Upon pathogen recognition, calcium influx, CDPK activation, and phosphorylation events converge to regulate ROS bursts. This coordinated control ensures rapid defense signaling while preventing excessive oxidative damage to host tissues.

Q.23 **Assimilation Efficiency is calculated as the percentage of the ingested energy that is assimilated by an organism. Which one of the following gut architectures has the lowest assimilation efficiency?**

A. A monogastric gut with acid enzymes to break down food
B. A ruminant gut that facilitates regurgitation and chewing of cud
C. An avian gut with mechanical grinding in the gizzard
D. Cecal/Hindgut fermentation with enlarged cecum or large intestine

Answer: D

Sol: **Correct Answer: (d)**

Explanation: Hindgut fermenters rely on microbial digestion occurring after the primary site of nutrient absorption in the small intestine. As a result, microbial products such as volatile fatty acids and microbial biomass are less efficiently absorbed compared to foregut fermentation. A significant portion of energy is lost in feces, leading to lower assimilation efficiency. Therefore, cecal or hindgut fermentation shows the lowest assimilation efficiency among the given gut types.

Information Booster

· Assimilation efficiency reflects how effectively ingested food is converted into usable energy.
· In hindgut fermenters, fermentation occurs in the cecum or large intestine.
· Nutrient absorption precedes fermentation, limiting energy recovery from microbes.
· Examples include horses, rabbits, and some rodents.
· Coprophagy in some hindgut fermenters partially compensates for low efficiency.

Additional Knowledge

Ruminants exhibit high assimilation efficiency because microbial fermentation occurs in the foregut, allowing absorption of microbial proteins and fatty acids. Monogastric animals efficiently digest readily available nutrients using enzymatic digestion. Birds enhance digestion through mechanical grinding in the gizzard, improving nutrient accessibility. In contrast, hindgut fermentation limits access to microbial nutrients, making it the least efficient strategy for energy assimilation.

Q.24 **Which one of the following options is the correct sequence of gene expression for successful axis specification in *Drosophila*?**

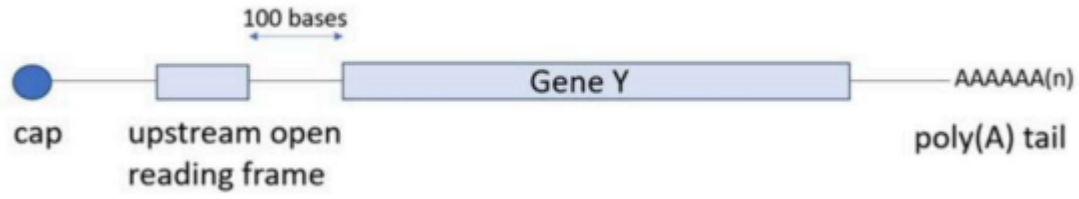
A. *Fushi tarazu → giant → hairy → gooseberry*
B. *Hedgehog → hunchback → runt → paired*
C. *Odd-skipped → knirps → hairy → armadillo*
D. *Krüppel → hairy → fushi tarazu → wingless*

Answer: D

Sol: **Correct Answer: Option 4**

Explanation: -Axis specification in *Drosophila* follows a hierarchical gene-regulation sequence: gap genes → pair-rule genes → segment-polarity genes. -*Krüppel* is a gap gene involved early in broad regional patterning. -*Hairy* and *fushi tarazu* are pair-rule genes that refine segmental boundaries. -*Wingless* is a segment-polarity gene essential for final stabilization of segments. -Hence, the correct sequential order is **Krüppel → hairy → fushi tarazu → wingless**.

Q.25 **Yeast gene Y has an mRNA with an upstream open reading frame (uORF) and a downstream coding region for gene Y, both having start and stop codons.**



Which one of the following will you remove to maximize translation of gene Y?

A. Cap
B. Start codon of the uORF
C. Stop codon of the uORF
D. Poly(A) tail

Answer: B

Sol: **Correct Answer: (b)**

Explanation: Upstream open reading frames (uORFs) generally act as negative regulators of translation of the main coding sequence. Ribosomes initiate translation at the uORF start codon, terminate there, and often dissociate before reaching the main ORF. Removing the start codon of the uORF prevents ribosome initiation at the uORF, allowing efficient scanning and initiation at the start codon of gene Y. This maximizes translation of gene Y.

Information Booster

· uORFs are common regulatory elements in eukaryotic mRNAs.
· Translation of a uORF reduces ribosome availability for the downstream main ORF.
· Ribosomal reinitiation after uORF translation is usually inefficient in yeast.
· Mutation or removal of uORF start codons enhances downstream gene expression.
· uORF-mediated regulation allows fine control of protein synthesis under stress conditions.

Additional Knowledge

The 5′ cap and poly(A) tail are essential for mRNA stability, nuclear export, and efficient translation initiation, so their removal would reduce, not increase, translation. Removing the uORF stop codon would extend translation into downstream regions and likely interfere with normal gene Y translation. Therefore, specifically eliminating the start codon of the uORF is the most effective strategy to maximize translation of gene Y.

Q.26 **The cytosolic proteins, Ras and Rab, are anchored to the cytosolic face of the plasma membrane by prenylation. Prenylation typically occurs at which amino acid of the protein?**

A. Cysteine residue at or near the C-terminus
B. Cysteine residue at or near the N-terminus
C. Glycine residue at or near the C-terminus
D. Glycine residue at or near the N-terminus

Answer: A

Sol: **Correct Answer: Option 1**

Explanation: Prenylation is a lipid modification in which **isoprenoid groups (farnesyl or geranylgeranyl)** are covalently attached to proteins such as Ras and Rab. This modification typically occurs on a **cysteine residue near the C-terminus**, often within a **CAAX motif** (where C = cysteine, A = aliphatic amino acid, X = determining residue). Prenylation increases hydrophobicity, enabling these proteins to associate with the **cytosolic face of the plasma membrane**.

Q.27 **Which one of the following components of the immune system is NOT effective for the clearance of large parasites like worms?**

A. Basophils
B. Eosinophils
C. NK cells
D. Mast cells

Answer: C

Sol: **Correct Answer: (c)**

Explanation: Large parasites such as helminths are primarily eliminated through antibody-dependent, granulocyte-mediated immune responses. Eosinophils, basophils, and mast cells are specialized for anti-parasite immunity and mediate damage through degranulation. NK cells, however, are mainly involved in killing virus-infected and tumor cells via cytotoxic mechanisms. Therefore, NK cells are not effective in clearing large parasites like worms.

Information Booster

· Helminth infections induce strong **Th2-type immune responses**.
· Eosinophils release toxic granule proteins that damage parasite membranes.
· Mast cells and basophils participate in IgE-mediated responses against parasites.
· Antibody-dependent cell-mediated cytotoxicity (ADCC) is crucial for parasite clearance.
· Large parasites cannot be phagocytosed and require extracellular killing mechanisms.

Additional Knowledge

NK cells are innate lymphocytes specialized for recognizing cells with reduced MHC class I expression, such as virus-infected or malignant cells. Their cytotoxic action relies on perforin and granzymes, which are effective against single cells but not against large multicellular parasites. In contrast, granulocytes involved in Th2 immunity can attach to the surface of helminths and release toxic mediators extracellularly, making them more suitable for anti-worm defense.

Q.28 **Which one of the following statements regarding β-sheets is correct?**

A. Antiparallel β-sheets have weaker hydrogen bonds than parallel β-sheets
B. Antiparallel β-sheets have more linear and stronger hydrogen bonds than parallel β-sheets
C. β-sheets contain only hydrophobic amino acids
D. β-sheets cannot form within a single polypeptide chain

Answer: B

Sol: **Correct Answer:** B

Explanation:

In antiparallel β-sheets, hydrogen bonds form in a nearly straight (180°) arrangement, making them more stable than the slightly angled hydrogen bonds found in parallel β-sheets. Both hydrophobic and polar residues may appear, often with alternating polarity.

Information Booster:

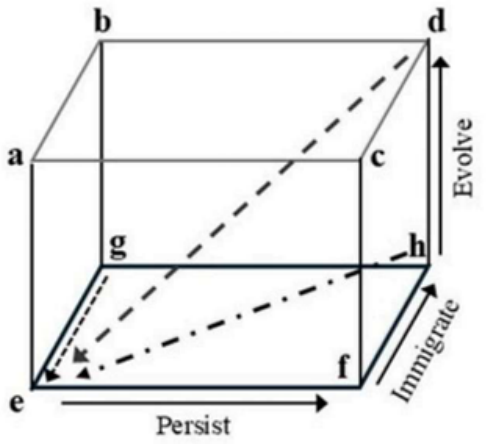
• β-sheets form via inter-strand hydrogen bonding.
• Parallel sheets: strands run same direction; antiparallel: opposite direction.
• Often found in protein cores.
• β-turns link anti-parallel strands.
• Common in amyloid fibrils.

Additional Knowledge:

A is reversed.
C β-sheets are amphipathic, not purely hydrophobi(c)
D Single chains can fold back to form antiparallel sheets.

Q.29 **The taxon cycle is the predicted, progressive ecological and evolutionary changes in the descendants of founding populations. Taking the case of insular biotas, the figure can be used to conceptualize and predict species types (a, b, c, d, e, f, g, h) based on their fundamental capacities to**

evolve, immigrate, and persist.



The table below has species types (Column X) and the possible traits (Column Y) associated with each type.

Column X		Column Y	
P.	c	i.	Ecologically naïve species, and endemics near the end of the taxon cycle (e.g., dwarfed elephants)
Q.	d	ii.	An unlikely type, because the ability to evolve on isolated islands requires relatively long persistence
R.	e	iii.	Limited dispersal abilities; unlikely to inhabit isolated oceanic islands
S.	b	iv.	Supertramps, powerful dispersers such as microsnails, ferns, and rafting rodents

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

A. P- i, Q -ii, R- iii, S- iv

B. P- iv, Q- i, R- ii, S- iii

C. P- ii, Q- iii, R- iv, S -i

D. P- iii, Q -iv, R- i, S- ii

Answer: A

Sol: Correct Answer

Option (1): P (i), Q (ii), R (iii), S (iv)

Explanation:

Species type c represents late-stage island endemics that are ecologically naïve, fitting trait (i). Type d lies at the high evolution end and represents an unlikely type because long persistence is needed to evolve on isolated islands, matching (ii). Type e corresponds to species with poor dispersal ability, unlikely to reach remote islands, matching (iii). Type b represents early colonizers with strong dispersal ability or "supertramps," matching (iv).

Information Booster

• The taxon cycle describes how species transition from widespread, highly dispersive colonizers to localized, specialized endemics over time.

• Island environments strongly filter species based on dispersal ability, persistence, and evolutionary potential.

• This framework is particularly valuable for understanding patterns in island biogeography and conservation biology.

Q.30 **Given below are the different stages of Arabidopsis embryogenesis (Column X) and their characteristic patterns of cell division (Column Y).**
Column X
A. Zygotic
B. Globular
C. Heart
D. Torpedo
Column Y
i. Formation of an 8-cell embryo, exhibiting radial symmetry and undergoing additional cell division to create the protoderm
ii. Polarized growth of cells followed by a symmetric transverse division giving rise to a small apical cell and an elongated basal cell

iii. Cell elongation and cellular differentiation processes throughout the embryonic axis with visible distinction between the adaxial and abaxial tissue of the cotyledons
iv. Focused cell division forming two cotyledons, giving bilateral symmetry to the embryo
Which one of the following options represents the correct match between Column X and Column Y?

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

Answer: B

Sol: Correct Answer: (b) A(ii) B(i) C(iv) D(iii)

Explanation:
The zygotic stage is characterized by polarization and the first asymmetric division producing apical and basal cells, matching statement (ii).
The globular stage involves formation of an 8-cell embryo with radial symmetry and protoderm initiation, matching statement (i).
The heart stage is defined by the initiation of two cotyledons, resulting in bilateral symmetry, corresponding to statement (iv).
The torpedo stage shows elongation and advanced tissue differentiation along the embryonic axis, consistent with statement (iii).

Information Booster
• Zygotic division establishes the apical–basal axis of the plant embryo
• Globular embryos show radial symmetry before cotyledon initiation
• Heart stage marks the first visible bilateral symmetry in dicot embryos
• Torpedo stage reflects rapid elongation and tissue specialization
• Protoderm formation is the earliest tissue differentiation event

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Q.31 **The following statements are made with respect to the major classes of heat shock proteins (HSPs) in plants:**
A. Cytosolic HSP100 is essential while the chloroplast HSP100 / ClpB family protein is not essential for heat stress response.
B. Proteins of the HSP90 family are exclusively localized in the nucleus.
C. Members of the HSP60 protein family (chaperonins) are abundant even at normal temperatures.
D. The C-terminal domain of small HSPs is homologous to α-crystallins, proteins found in the vertebrate eye lens.
Which one of the following options is a combination of all correct statements?

A. A and C
B. B and D
C. A and B
D. C and D

Answer: D

Sol: **Correct Answer:**
Option (4) – C and D
Explanation:
C is correct: HSP60 family proteins (chaperonins such as GroEL homologs) are housekeeping chaperones and are constitutively expressed, even under non-stress conditions.
D is correct: Small HSPs contain a conserved α-crystallin domain, homologous to vertebrate eye lens α-crystallins.
A is incorrect: Both cytosolic HSP100 and chloroplast-localized ClpB/HSP100 proteins play important roles in thermotolerance; chloroplast HSP100 is also functionally significant.
B is incorrect: HSP90 proteins are found in the cytosol, nucleus, and other compartments, not exclusively in the nucleus.
Information Booster :
· Heat shock proteins function as molecular chaperones to prevent protein aggregation.
· Small HSPs act early during stress by binding unfolded proteins.
· HSP60 and HSP70 families operate during normal cellular metabolism.
· Subcellular localization of HSPs is diverse and stress-dependent.
Additional Information (Incorrect Options):
Options 1 and 3: Include statement A, which is incorrect.
Option 2: Includes statement B, which falsely restricts HSP90 localization.

Q.32 **During development, yfg expression is regulated by proteins E, F and G, which are abundant and have long half-lives. After a specific stage of development, protein E is activated by a single short wave of phosphorylation. This leads to the following events:**
1. Phosphorylated E activates F
2. Active F activates G
3. Active G promotes yfg expression
4. Active F completely inhibits E, and active G completely inhibits F function
Which one of the following describes the expression of yfg soon after the "specific stage of development" is reached?

A. Continuously transcribing
B. One pulse of transcription
C. Transcription not initiated
D. Multiple pulses of transcription

Answer: B

Sol: **Correct Answer:**
(b) One pulse of transcription
Explanation:
The system described forms a negative feedback cascade.
A transient activation of E triggers sequential activation of F and G, leading to yfg expression.
However, once F becomes active, it shuts off E, and once G is active, it shuts off F, terminating further signaling.
Because E is activated only briefly and the downstream inhibitors are long-lived, yfg expression occurs as a single transient pulse.
Information Booster :
· Pulse generation is common in developmental gene regulatory networks.
· Negative feedback loops convert transient signals into defined expression bursts.
· Long protein half-lives help stabilize the termination of signaling.
· Such circuits ensure precise temporal control of gene expression.
Additional Information (Incorrect Options):
(a) Continuously transcribing: Ruled out due to strong negative feedback on E and F.
(c) Transcription not initiated: Incorrect since G does become active briefly.
(d) Multiple pulses: Requires repeated activation of E, which does not occur here.

Q.33 **The table below lists taxonomic groups (Column X) and their morphological features (Column Y).**
Column X
A. Crustacea
B. Chelicerata
C. Phoronida
Column Y
i. Two pairs of antennae
ii. Antennae absent
iii. Presence of lophophore
Which one of the following options represents all correct matches between Column X and Column Y?

A. A – ii; B – iii; C – i
B. A – iii; B – i; C – ii
C. A – i; B – iii; C – ii
D. A – i; B – ii; C – iii

Answer: D

Sol: **Correct Answer:**
(d) A – i; B – ii; C – iii
Explanation:
Crustacea possess two pairs of antennae, a characteristic feature of the group.
Chelicerata do not have antennae; their first appendages are chelicerae.
Phoronida are lophophorates and show a lophophore, used for suspension feeding.
Information Booster :
· Arthropods are divided based on appendage type and number.
· Chelicerates include arachnids and horseshoe crabs.
· Lophophore-bearing phyla show feeding convergence.
· Morphological markers are fundamental in taxonomy.

Q.34 **A certain trait in a species is governed by variation at the AB locus that has two alleles (A, B), giving rise to three genotypes: AA, AB, and BB. A sample of 1000 individuals was genotyped and the data are given below:**
AA = 400
AB = 400
BB = 200
Assume that each genotype is represented equally in males and females and mating is random. If the parents were randomly drawn from the given sample, which one of the following options gives all correct values of the offspring genotype frequencies?

A. AA: 0.4 ; AB: 0.4 ; BB: 0.2
B. AA: 0.6 ; AB: 0.2 ; BB: 0.2
C. AA: 0.16 ; AB: 0.16 ; BB: 0.04
D. AA: 0.36 ; AB: 0.48 ; BB: 0.16

Answer: D

Sol: **Correct Answer:**

(d) AA: 0.36 ; AB: 0.48 ; BB: 0.16

Explanation:

First, calculate allele frequencies in the parental population:

Frequency of allele A = (2×400 + 400) / (2×1000) = 1200 / 2000 = 0.6

Frequency of allele B = (2×200 + 400) / (2×1000) = 800 / 2000 = 0.4

Under random mating, offspring genotype frequencies follow Hardy–Weinberg proportions:

AA = $(0.6)^2$ = 0.36

AB = 2 × 0.6 × 0.4 = 0.48

BB = $(0.4)^2$ = 0.16

Information Booster:

· Random mating leads to Hardy–Weinberg equilibrium in one generation.

· Allele frequencies, not genotype frequencies, determine offspring outcomes.

· Equal representation of sexes ensures no bias in allele transmission.

· Population size affects sampling error, not expected frequencies.

Q.35

Given below are statements on the citric acid cycle and urea cycle, which have shared metabolic intermediates.

A. Oxaloacetate is converted to aspartate.

B. Fumarate is a citric acid cycle intermediate.

C. Argininosuccinate is cleaved to fumarate and arginine.

D. Aspartate combines with citrulline to produce argininosuccinate in the mitochondrial matrix.

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

A. A and D only

B. B and C only

C. A, C and D

D. A, B and C

Answer: D

Sol:

Correct Answer

(d) A, B and C

Explanation

Oxaloacetate undergoes transamination to form aspartate, linking the TCA cycle to the urea cycle. Fumarate is a key intermediate of the citric acid cycle and is also generated during the urea cycle. Argininosuccinate is cleaved into arginine and fumarate, confirming statements A, B, and C as correct.

Information Booster

• The urea cycle and TCA cycle are interconnected through the aspartate–argininosuccinate shunt

• Fumarate formed in the urea cycle is converted to malate and reused in the TCA cycle

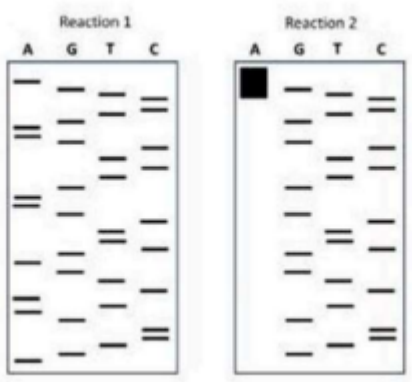
• Aspartate provides one nitrogen atom for urea synthesis

• This metabolic integration improves energy efficiency during nitrogen disposal

Additional Knowledge

Statement D is incorrect because the reaction between citrulline and aspartate occurs in the cytosol, not in the mitochondrial matrix. Only carbamoyl phosphate synthesis and citrulline formation take place in mitochondria, while argininosuccinate formation is a cytosolic step.

Q.36 **Two Sanger sequencing reactions were carried out using the same DNA template and primer. The sequencing gels are shown below.**



Lane A of reaction 2 gel shows the absence of lower bands and accumulation of higher bands (represented by a black thick band). Which of the following represents the correct reason?

Options given in the image:

A. The template DNA does not contain the base A near its 5′-region.
B. The processivity of the Sequenase enzyme is very high.
C. In the second reaction, the concentration of ddATP is very low.
D. In the second reaction, the concentration of ddTTP is very high.

Answer: C

Sol: **Correct Answer**:
(c) Only
Explanation:
In Sanger sequencing, bands in lane A arise due to incorporation of ddATP causing chain termination. A very low concentration of ddATP results in fewer termination events, allowing DNA synthesis to continue and producing longer fragments. This leads to disappearance of lower bands and accumulation of higher bands in lane A.
Information Booster:
· High processivity of DNA polymerase (option b) would lead to longer fragments, but it doesn't explain the absence of lower bands completely.
· Absence of the base A near the 5′ region (option a) would just result in missing termination at those positions but not a complete accumulation of longer products.
· High concentration of ddTTP (option d) would affect T termination, not A.
Additional Knowledge (Incorrect Options Explained):
(a) Incorrect – Even if there's no A near 5′ end, there would still be termination at other positions; lower bands would appear.
(b) Incorrect – High processivity alone doesn't prevent formation of shorter fragments; ddNTP concentration is the limiting factor.
(d) Incorrect – ddTTP affects termination at T sites; here the thick band is at A, so irrelevant.

Q.37 **The following statements are put forth about hormonal changes during normal pregnancy in humans.**
A. Pituitary secretion of FSH and LH increases.
B. Aldosterone secretion increases.
C. Glucocorticoid secretion decreases.
D. Thyroxine secretion increases.
Which one of the following options has a combination of all correct statements?

A. A and B
B. C and D
C. A and C
D. B and D

Answer: D

Sol: **Correct Answer**
(d) B and D
Explanation
During pregnancy, FSH and LH secretion is suppressed due to high estrogen and progesterone levels, so statement A is incorrect.
Aldosterone secretion increases to promote sodium and water retention, so statement B is correct.
Glucocorticoid levels rise rather than fall, making statement C incorrect.
Thyroxine secretion increases because of higher metabolic demands and increased thyroxine-binding globulin, so statement D is correct.
Information Booster
• Placental hormones regulate most endocrine changes during pregnancy.
• Progesterone and estrogen inhibit ovulation by suppressing FSH and LH.
• Expanded blood volume is supported by aldosterone action on kidneys.
• Basal metabolic rate increases, raising thyroid hormone production.
Additional Knowledge
Option (a) is incorrect because FSH and LH do not increase in pregnancy.
Option (b) is incorrect because glucocorticoids increase, not decrease.
Option (c) is incorrect because both statements are wrong.

Q.38 **Given below are a few statements about meiosis in animal cells:**
A. Failure of the chiasma formation leads to non-disjunction in meiosis I.
B. Meiotic cohesin Rec8 ensures mono-orientation of sister chromatids in meiosis II.
C. Crossover interference reduces clustering of recombination sites.
D. Residual double-strand breaks arrest meiosis at metaphase.
Which one of the following options has all the correct statements?

A. A and B only
B. A, C and D
C. A, B and C
D. B and C only

Answer: B

Sol: **Correct Answer:**

(b) A, C and D

Explanation:

A is correct: Chiasmata are essential for holding homologous chromosomes together; failure of chiasma formation leads to improper segregation and non-disjunction in meiosis I.

B is incorrect: Rec8 ensures mono-orientation in meiosis I, not meiosis II; in meiosis II, sister chromatids bi-orient like mitosis.

C is correct: Crossover interference prevents crossovers from occurring too close to each other, reducing clustering of recombination events.

D is correct: Unrepaired (residual) double-strand breaks activate meiotic DNA damage checkpoints, which can arrest meiosis before or at metaphase to prevent progression with damaged DNA.

Information Booster :

· Accurate chromosome segregation in meiosis depends on recombination and cohesion.

· Chiasmata physically link homologues until anaphase I.

· Rec8 is cleaved in a stepwise manner to allow the two meiotic divisions.

· Meiotic checkpoints ensure genome integrity by halting division when DNA damage persists.

Additional Information (Incorrect Options):

Option (a): Incorrect because Rec8 does not ensure mono-orientation in meiosis II.

Option (c): Incorrect due to inclusion of statement B.

Option (d): Incorrect because statement B is wrong and statement A (essential for non-disjunction control) is missing.

Q.39 **Antibiotic-resistant strains of various pathogenic bacteria are a serious concern for human health. The table below lists the names of important bacteria (Column X), specific strains of which can cause serious illnesses (Column Y).**

Column X

A. Specific strains of Enterobacteriaceae

B. Specific strains of Rickettsia

C. Salmonella and Klebsiella pneumoniae

D. Staphylococcus aureus

Column Y

i. Re-emerged as a significant community- and hospital-acquired infection due to methicillin resistance

ii. Multi-drug resistant strains found in humans and food, suggesting a potential for broader spread

iii. A type of bacteria that is difficult to treat due to resistance to multiple antibiotics, mainly carbapenems

iv. The causative agent of murine typhus, which has shown transmission via organ transplants

Which one of the options below is the correct match between all terms of Column X and Column Y?

A. A–iv, B–ii, C–iii, D–i

B. A–ii, B–i, C–iv, D–iii

C. A–iii, B–iv, C–ii, D–i

D. A–i, B–iii, C–i, D–ii

Answer: C

Sol: **Correct Answer:**

(c) A–iii, B–iv, C–ii, D–i

Explanation:

-Enterobacteriaceae include carbapenem-resistant strains (CRE), making them extremely difficult to treat.

-Rickettsia includes the causative agent of murine typhus, with reported cases of transmission via organ transplantation.

-Salmonella and Klebsiella pneumoniae commonly show multi-drug resistance in humans and food sources.

-Staphylococcus aureus includes methicillin-resistant strains (MRSA), a major hospital- and community-acquired pathogen.

Information Booster :

· Carbapenem resistance represents one of the gravest threats in clinical microbiology.

· MRSA is a classic example of antibiotic resistance driven by selective pressure.

· MDR food-borne pathogens pose risks beyond healthcare settings.

· Transplant-associated infections highlight emerging non-traditional transmission routes.

Q.40 **Nitrogen cycling is a critical ecosystem process. The table below lists the names of the processes (Column X) and the nature of the reactions (Column Y) in the nitrogen cycle.**

Column X

A. Ammonification

B. Nitrogen fixation

C. Nitrification

D. Denitrification

Column Y

i. Conversion of N_2 to NH_3

ii. Hydrolysis of proteins and oxidation of amino acids

iii. Reduction of NO_3^- to N_2O and N_2

iv. Oxidation of NH_3 to NO_2^- and from NO_2^- to NO_3^-

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

A. A–i, B–ii, C–iv, D–iii
B. A–ii, B–i, C–iv, D–iii
C. A–iv, B–i, C–iii, D–ii
D. A–ii, B–iv, C–iii, D–i

Answer: B

Sol: **Correct Answer:**

(b) A–(ii), B–(i), C–(iv), D–(iii)

Explanation::

Ammonification (A) converts organic nitrogen (proteins, amino acids) into ammonia via hydrolysis and deamination → (ii).

Nitrogen fixation (B) converts atmospheric N_2 to NH_3 → (i).

Nitrification (C) is the oxidation of NH_3 to NO_2^- and then to NO_3^- → (iv).

Denitrification (D) is the reduction of NO_3^- to N_2O and N_2 under anaerobic conditions → (iii).

Information Booster :

· Different microbial guilds drive distinct steps of the nitrogen cycle.

· Nitrification is aerobic, while denitrification is anaerobic.

· Ammonification links organic matter decomposition to inorganic nitrogen pools.

· Nitrogen fixation introduces new biologically available nitrogen into ecosystems.

Q.41 The protein that mediates vesicle budding from the Golgi apparatus to secretory vesicles is:

A. Clathrin
B. COPI
C. COPII
D. Dynamin

Answer: B

Sol: **Correct Answer:** B

Explanation:

COPI-coated vesicles mediate retrograde transport from Golgi compartments and also participate in intra-Golgi transport required for secretory trafficking steps. COPII forms vesicles from the ER, while clathrin mediates vesicles at the plasma membrane and TGN.

Information Booster:

• COPII: ER → Golgi
• COPI: Golgi → Golgi & Golgi → ER
• Clathrin: Endocytosis + TGN sorting
• Dynamin: Vesicle pinching (scission) during endocytosis

Additional Knowledge:

COPI dysfunction results in traffic mis-sorting and Golgi disorganization.

Q.42 Which one of the following histone marks is **NOT** an indicator of heterochromatin?

A. H3K9 trimethylation
B. MacroH2A
C. H2AX
D. H4K20 trimethylation

Answer: C

Sol: **Correct Answer: (c)**

Explanation: Heterochromatin is characterized by specific repressive histone modifications and variants that promote chromatin compaction and gene silencing. H3K9 trimethylation and H4K20 trimethylation are classic constitutive heterochromatin marks, while MacroH2A is commonly associated with facultative heterochromatin. H2AX, in contrast, is a histone H2A variant primarily involved in the DNA damage response rather than heterochromatin formation. Therefore, H2AX is not an indicator of heterochromatin.

Information Booster

· H3K9me3 is a hallmark of constitutive heterochromatin and recruits HP1 proteins.
· H4K20me3 is enriched in transcriptionally silent and compact chromatin regions.
· MacroH2A is associated with facultative heterochromatin such as the inactive X chromosome.
· Heterochromatin generally correlates with low histone acetylation and gene repression.
· Specific histone marks help distinguish euchromatin from heterochromatin.

Additional Knowledge

H2AX becomes phosphorylated to form γH2AX at sites of DNA double-strand breaks and serves as a platform for recruitment of DNA repair machinery. Its role is dynamic and damage-specific rather than structural or repressive. In contrast, heterochromatin-associated marks contribute to long-term chromatin silencing and genome stability, highlighting the functional distinction between H2AX and true heterochromatin indicators.

Q.43 **Which one of the following calcium-binding proteins, primarily detected in the photoreceptor cells of the eye and involved in inhibition of rhodopsin kinase (thereby regulating phosphorylation of rhodopsin), is it?**

A. calretinin
B. calbindin
C. recoverin
D. parvalbumin

Answer: C

Sol: **Correct Answer:** (c) recoverin

Explanation

Recoverin is a calcium-binding protein localized in photoreceptor cells (rod and cone outer segments). When Ca^{2+} levels are high, recoverin binds Ca^{2+} and inhibits rhodopsin kinase (GRK1), reducing rhodopsin phosphorylation. This modulation helps control the photoresponse recovery kinetics in photoreceptors.

Information Booster

-Recoverin is part of the neuronal calcium sensor (NCS) family and acts as a Ca^{2+}-dependent regulator of phototransduction.
-On light exposure, intracellular Ca^{2+} falls → recoverin releases inhibition on rhodopsin kinase → increased rhodopsin phosphorylation → accelerates recovery/adaptation.
-Other listed proteins (calretinin, calbindin, parvalbumin) are calcium-binding proteins with roles in neuronal Ca^{2+} buffering or signalling but are not the primary inhibitors of rhodopsin kinase.

Additional Information (Incorrect Options Explained)

(a) calretinin: neuronal Ca^{2+}-binding protein involved in buffering/signalling in certain neurons.
(b) calbindin: Ca^{2+} buffer found in various neurons; not the specific regulator of rhodopsin kinase.
(d) parvalbumin: fast Ca^{2+} buffer in some neurons and muscle; not involved in rhodopsin kinase regulation.

Q.44 **Transplantation of the dorsal lip of the blastopore to the ventral side of a gastrula embryo results in the development of a secondary embryonic axis. This demonstrates:**

A. Autonomous specification of dorsal lip cells
B. Inductive ability of organizer tissue
C. Transdetermination of ventral cells
D. Self-differentiation of donor tissue

Answer: B

Sol: **Correct Answer:** B

Explanation:

This experiment is a classical result from Spemann and Mangold (1924). The dorsal lip acts as an organizer, releasing signaling molecules (e.g., Noggin, Chordin, Follistatin) that inhibit BMP signaling in nearby ventral tissues. This induces ventral cells to change fate and participate in forming a secondary axis. Importantly, the majority of the induced axis is derived from host tissues, demonstrating induction, not autonomous development of donor tissue.

Information Booster:

• Organizer regulates dorsal–ventral patterning of embryos.
• BMP inhibition is a key mechanism for dorsal fate specification.
• Induction involves paracrine signaling, not cell replacement.
• Fate maps show minimal donor cell contribution to induced structures.
• Competence of neighboring tissues is essential for response.

Additional Knowledge:
A & D suggest donor cells alone generate the axis—wrong, host tissues form it.
C implies ventral cells change identity spontaneously, ignoring signaling role.

Q.45 **Gradualism and punctuated equilibrium represent contrasting models of evolutionary change. Which one of the following options best describes these two models?**

A. Gradualism emphasizes that evolution occurs through long periods of stasis interrupted by sudden, large-scale mutations, while punctuated equilibrium proposes continuous, slow change within species.
B. Gradualism and punctuated equilibrium both deny the role of natural selection in shaping evolutionary change.
C. Gradualism proposes that evolution proceeds through the steady accumulation of small changes, whereas punctuated equilibrium suggests long periods of evolutionary stability marked by relatively rapid bursts of speciation.
D. Both models reject the importance of the fossil record in understanding macroevolutionary patterns.

Answer: C

Sol: **Correct Answer: (c)**
Explanation: Gradualism explains evolutionary change as a slow and continuous process driven by the accumulation of small variations over long periods of time. Punctuated equilibrium, in contrast, proposes that species remain in relative morphological stasis for most of their existence, with evolutionary change occurring rapidly during brief speciation events. Thus, option (c) accurately contrasts the two models.
Information Booster
· Gradualism is closely associated with Darwin's original view of evolution.
· Punctuated equilibrium was proposed by Eldredge and Gould.
· Both models accept natural selection as a major evolutionary mechanism.
· The difference lies mainly in the tempo and pattern of evolutionary change.
· Punctuated equilibrium helps explain gaps and sudden appearances in the fossil record.

Q.46 **A polydactyly allele shows 60% penetrance and variable expressivity. What would you expect to observe in a family carrying this allele?**

A. 60% of carriers show the trait, and among those who show it, severity varies.
B. 100% of carriers show the trait but with 60% maximum severity.
C. 40% of carriers express the trait to the same degree in an identical manner.
D. 100% of carriers show the trait but the severity varies in only 40% of carriers.

Answer: A

Sol: **Correct Answer: (a)**
Explanation: Penetrance refers to the proportion of individuals carrying a particular allele who actually express the associated phenotype. A penetrance of 60% means only 60% of carriers will display polydactyly. Variable expressivity indicates that among those who do express the trait, the severity or form of the phenotype differs between individuals. Therefore, the correct expectation is that 60% of carriers show the trait with varying severity.
Information Booster
· Penetrance is an all-or-none concept describing whether a trait is expressed.
· Expressivity describes the degree or intensity of phenotypic expression.
· Variable expressivity results in differences in severity among affected individuals.
· Many autosomal dominant disorders show incomplete penetrance.
· Environmental factors and modifier genes can influence expressivity.
Additional Knowledge
Incomplete penetrance can cause a trait to appear to "skip" generations, even though the allele is present. Variable expressivity explains why individuals with the same genotype may exhibit mild to severe forms of the same condition. Polydactyly is a classic example used to illustrate both these genetic concepts in human pedigrees.

Q.47 **In the complete blood profile analysis using an automated haematology analyser, the haemoglobin concentration is measured using**

A. sedimentation analysis
B. spectrophotometric methods
C. mass spectrometry
D. NMR spectroscopy

Answer: B

Sol: **Correct Answer: (b)**

Explanation: Automated haematology analysers estimate haemoglobin concentration using spectrophotometric principles. Hemoglobin is converted into a stable coloured derivative such as cyanmethemoglobin or sodium lauryl sulfate–hemoglobin. The absorbance of this compound is measured at a specific wavelength and is directly proportional to haemoglobin concentration. Hence, spectrophotometric methods are used.

Information Booster

· Spectrophotometry is based on Beer–Lambert's law.
· Haemoglobin derivatives absorb light at characteristic wavelengths.
· Cyanmethemoglobin method is a classical reference technique.
· Modern analysers often use SLS–hemoglobin for safer analysis.
· The method is rapid, accurate, and suitable for high-throughput testing.

Additional Knowledge

Sedimentation analysis is used for measurements like erythrocyte sedimentation rate (ESR), not haemoglobin concentration. Mass spectrometry and NMR spectroscopy are advanced analytical techniques used for structural and molecular studies and are not practical for routine clinical blood profiling. Therefore, spectrophotometric estimation remains the standard method for haemoglobin measurement in automated haematology analysers.

Q.48 **Beyond its primary role in reducing atmospheric nitrogen to ammonia during symbiotic nitrogen fixation, the nitrogenase enzyme complex is also capable of catalyzing other reactions. Listed below are some reactions:**

A. Acetylene reduction ($C_2H_2 \rightarrow C_2H_4$)
B. H_2 production ($2H^+ \rightarrow H_2$)
C. ATP hydrolysis (ATP → ADP + Pi)
D. Oxidized ferredoxin to reduced ferredoxin
E. NAD reduction ($NAD^+ + H^+ \rightarrow NADH$)
Which one of the following options represents the combination of reactions that are NOT catalysed by the nitrogenase enzyme complex?

A. B and C
B. D and E
C. A and C
D. B and D

Answer: B

Sol:

Correct Answer:
(b) D and E
Explanation:
Nitrogenase can catalyze acetylene reduction (used experimentally to assay nitrogenase activity) and also produces molecular hydrogen (H_2) as a side reaction. ATP hydrolysis occurs within the nitrogenase complex to provide energy for electron transfer.
However, reduction of ferredoxin is carried out by other cellular enzymes upstream of nitrogenase, and NAD^+ reduction to NADH is not a reaction catalyzed by nitrogenase.
Information Booster:
· Nitrogenase is a multi-component enzyme requiring ATP and low-potential electrons.
· Acetylene reduction is a standard proxy for nitrogenase activity.
· Hydrogen evolution is an obligate side reaction of nitrogen fixation.
· Electron donors like ferredoxin are reduced outside the nitrogenase complex.
Additional Information (Incorrect Options):
Option (a): Incorrect because both hydrogen production and ATP hydrolysis are part of nitrogenase function.
Option (c): Incorrect since acetylene reduction is a hallmark nitrogenase reaction.
Option (d): Incorrect because hydrogen production is catalysed by nitrogenase.

Q.49 **In amphibians and fish, the cells of the organizer ultimately contribute to i) pharyngeal endoderm, ii) head mesoderm, iii) dorsal mesoderm, and iv) dorsal blastopore lip. The following statements are made about the function of the organizer and its derivatives:**
A. The pharyngeal endoderm and pre-chordal plate prevent formation of forebrain and midbrain.
B. The organizer has the ability to dorsalize the ectoderm and induce formation of the neural tube.
C. The dorsal mesoderm inhibits induction of the hindbrain and trunk.
D. The organizer tissue possesses the ability to dorsalize the surrounding mesoderm into somite-forming mesoderm.
Which one of the following options is a combination of all correct statements?

A. A and C
B. B and D only
C. A, B and D
D. B, C and D

Answer: B

Sol: **Correct Answer**

Option (b): B and D only

Explanation:

The organizer (Spemann–Mangold organizer) secretes signaling molecules that dorsalize the ectoderm, leading to neural induction and neural tube formation, making statement B correct. It also dorsalizes surrounding mesoderm to form somites, supporting statement D. Statements A and C contradict known organizer functions.

Information Booster

· The organizer functions primarily by inhibiting BMP signaling through molecules such as chordin, noggin, and follistatin.

· BMP inhibition permits ectoderm to adopt a neural fate instead of an epidermal one.

· Organizer-derived tissues are essential for body axis formation and correct nervous system regionalization.

Additional Knowledge (Incorrect Options Explained)

Statement A is incorrect because the pharyngeal endoderm and prechordal plate promote, not prevent, forebrain and midbrain development.

Statement C is incorrect because dorsal mesoderm induces the formation of hindbrain and trunk structures rather than inhibiting them.

Q.50 **Conjugation experiments were performed by mixing four different auxotrophic strains (P, Q, R, and S) of E. coli in different combinations. The generation of prototrophs on appropriate minimal selective media is shown below:**

Combination of strains No. of prototrophs obtained

P and Q - 20

S and R -1000

P and R - 0

P and S - 1000

Based on the above data, the following statements were made:

A. Strains P and R are F^- strains.

B. Strain Q is an F^+ strain.

C. Strain S is an Hfr strain.

D. Strains P and R are F^+ and F^- strains, respectively.

E. Strains P and R are both Hfr strains.

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

A. A, C and D
B. A, B and D
C. B, C and E
D. A, B and C

Answer: D

Sol: **Correct Answer:**

(d) A, B and C

Explanation:

High prototroph numbers (1000) indicate Hfr × F^- crosses (efficient recombination). Thus, S must be Hfr, and P and R must be F^- (from P–S and S–R results).

P and R = 0 prototrophs indicates F^- × F^-, confirming A.

P and Q = 20 prototrophs suggests a low-frequency transfer, characteristic of F^+ × F^-, so Q is F^+ (B).

Therefore, C is also correct, while D and E are incorrect.

Information Booster:

· Hfr strains transfer chromosomal genes at high frequency, yielding many recombinants.

· F^+ strains transfer mainly the F plasmid, producing few recombinants.

· F^- × F^- crosses produce no recombinants.

· Recombinant counts are diagnostic of mating types in conjugation.

Q.51 **In a polluted aquatic environment, bacteria are chronically exposed to low concentrations of multiple antibiotics released from pharmaceutical effluents. Over time, resistant colonies appear even when the antibiotic concentration remains constant. To determine whether resistance arises through induced mutation (a physiological response to antibiotics) or random mutation followed by selection, an ecologist performs a fluctuation test similar to that of Luria and Delbrück (1943) using replicate bacterial cultures.**

Which one of the following outcomes would best support the conclusion that antibiotic resistance arises by random mutation followed by selection, rather than by induction?

A. Each replicate culture yields nearly the same number of resistant colonies after exposure to the antibiotic.
B. Different replicate cultures show large fluctuations in the number of resistant colonies, even though each was treated identically.
C. Resistant colonies appear only after antibiotic addition.
D. The number of resistant colonies increases predictably and proportionally with exposure time in every replicate culture.

Answer: B

Sol: **Correct Answer:** (b)

Explanation:

The Luria–Delbrück fluctuation test showed that if mutations arise randomly before selection, then replicate cultures will show large variation (fluctuation) in the number of resistant colonies. Some cultures acquire mutations early and produce many resistant descendants, while others

acquire them late or not at all.

Information Booster :

· Random mutation leads to high variance in mutant numbers across identical cultures.

· Induced mutation would produce similar numbers of resistant colonies in each culture.

· Antibiotics act as selective agents, not mutagens.

· The fluctuation test was key evidence for the Darwinian model of mutation and selection.

Additional Information (Incorrect Options):

(a): Suggests induced mutation, not random mutation.

(c): Implies resistance is caused by antibiotic exposure itself.

(d): Predictable increases are inconsistent with random, pre-existing mutations.

Q.52 **The following statements are made regarding colchicine treatment in plants for inducing polyploidy.**

A. In colchicine-treated cells, sister chromatids cannot separate during anaphase, leading to chromosome doubling when the nucleus reforms.

B. Colchicine stimulates endoreduplication in the treated cells, bypassing cytokinesis to yield polyploid cells in a process called "C-mitosis".

C. In sterile interspecific hybrids, colchicine treatment may restore fertility by converting them into amphipolyploids.

D. Colchicine treatment during meiosis has no effect, as it only acts on mitotic cells.

E. Colchicine binds to tubulin and prevents spindle fibre formation during mitosis.

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

A. A, C and E only

B. B and C only

C. A, B, C and E

D. A, B, D and E

Answer: A

Sol: **Correct Answer**

(a) A, C and E only

Explanation:

Colchicine inhibits spindle fibre formation by binding to tubulin. As a result, sister chromatids fail to separate at anaphase, and when the nuclear membrane reforms, chromosome number doubles, producing polyploid cells. In sterile interspecific hybrids, chromosome doubling by colchicine allows proper pairing of homologous chromosomes, restoring fertility and forming amphipolyploids.

Information Booster

· Colchicine is widely used in plant breeding to artificially induce polyploidy

· Polyploid plants often show larger cell size, increased vigor, and improved yield

· Amphipolyploidy is important in crop evolution, such as in wheat and cotton

· Spindle inhibition is the key cellular mechanism behind colchicine action

· Colchicine-induced polyploidy occurs mainly during mitotic divisions in meristematic tissues

Additional Knowledge

Statement B is incorrect because colchicine does not stimulate true endoreduplication; "C-mitosis" refers to mitosis without spindle formation, not bypassing cytokinesis through endoreduplication.

Statement D is incorrect because colchicine can affect any dividing cell by disrupting microtubules; its action is not strictly limited to mitotic cells, and it can interfere with meiotic divisions as well.

Q.53 **In eukaryotes, many cells can assemble a spindle in the absence of centrosomes as in the case of plant cells during mitosis, and animal cells during meiosis in females. In this context, centrosome-free mitotic extracts from frog oocytes, when supplied with beads covered with DNA, are sufficient to assemble the mitotic spindle. Listed below are a few proteins that could be involved in spindle assembly in such a setting:**

A. Ran GTPase

B. Ran-GEF

C. TPX2

D. Myosin V

Which one of the following options has all proteins that are directly involved in controlling spindle assembly without centrosomes?

A. A only

B. A and B only

C. A, B, and C only

D. A, B, C, and D

Answer: C

Sol: **Correct Answer:**

(c) A, B, and C only

Explanation:

Centrosome-independent spindle assembly relies on a Ran-GTP–mediated pathway around chromatin. Ran-GEF (RCC1) generates Ran-GTP near DNA, Ran GTPase establishes a Ran-GTP gradient, and TPX2 is released from importins to promote microtubule nucleation and spindle formation. Together, A, B, and C directly regulate spindle assembly without centrosomes.

Information Booster :

· DNA-dependent spindle assembly is prominent in oocytes and plant cells.

· A high Ran-GTP concentration near chromatin promotes microtubule stabilization.
· TPX2 is a key spindle assembly factor activated by Ran-GTP signaling.
· This mechanism bypasses the need for centrosomal microtubule organizing centers.

Additional Information (Incorrect Options):

Myosin V (D): An actin-based motor protein involved in vesicle transport, not microtubule organization or spindle assembly.
Options (a) and (b): Incomplete because spindle assembly requires not just Ran signaling but also downstream effectors like TPX2.

Q.54 **The following statements are made with respect to signal transduction events in phytohormone signalling in plants:**
A. Autophosphorylation of a histidine residue in the receiver domain of the response regulator is important for signal transduction through the two-component system.
B. Phosphorylation of a conserved aspartate residue in the transmitter domain of the histidine kinase is important for the two-component system.
C. CYTOKININ RESPONSE 1 (CRE1), a cytokinin receptor, functions as an Arabidopsis histidine-containing phosphotransfer (AHP) factor.
D. In Arabidopsis, pseudo-AHP, called AHP6, acts as an inhibitor of cytokinin signalling.
E. ETR1, an ethylene receptor in Arabidopsis, has histidine kinase activity and a receiver domain.
Which one of the following options is a combination of all correct statements?

A. A and C
B. B and D
C. C and E
D. D and E

Answer: D

Sol: **Correct Answer**
(d) D and E

Explanation

Statement D is correct because AHP6 is a pseudo-histidine phosphotransfer protein that lacks the conserved histidine and negatively regulates cytokinin signalling. Statement E is correct because ETR1 is an ethylene receptor that functions as a histidine kinase and contains a receiver domain, fitting the two-component signalling framework in plants.
Information booster
• Two-component signalling in plants is adapted from bacterial systems
• Cytokinin signalling involves histidine kinase receptors, AHPs, and response regulators
• Pseudo-AHP proteins fine-tune hormone responses by inhibiting signal flow
• Ethylene receptors structurally resemble bacterial histidine kinases

Additional Knowledge

Statement A is incorrect because response regulators are phosphorylated on a conserved aspartate residue in the receiver domain, not on histidine.
Statement B is incorrect because histidine kinases autophosphorylate on a conserved histidine residue in the transmitter domain, not on aspartate.
Statement C is incorrect because CRE1 is a cytokinin receptor histidine kinase, whereas AHPs are separate soluble phosphotransfer proteins.

Q.55 **Which of the following are correct statements about cell-cycle checkpoints targeted in cancer therapy?**
1. Many tumors lack a functional G1/S checkpoint due to p53 loss, making them reliant on S/G2 checkpoints.
2. Inhibiting ATR/Chk1 can sensitize tumor cells to replication stress–inducing chemotherapies.
3. Targeting spindle assembly checkpoint (SAC) kinases has no therapeutic rationale.
4. PARP inhibitors exploit defects in homologous recombination (HR) repair (e.g., BRCA mutations).

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

Answer: A

Sol: **Correct answer:** (a)

Explanation:

Statements 1, 2 and 4 are correct and reflect modern oncology strategies: p53-defective tumors depend on other checkpoints; ATR/Chk1 inhibition exacerbates replication stress; PARP inhibitors target HR-deficient cancers. Statement 3 is false—SAC inhibitors (e.g., targeting Aurora kinases) are being explored therapeutically.

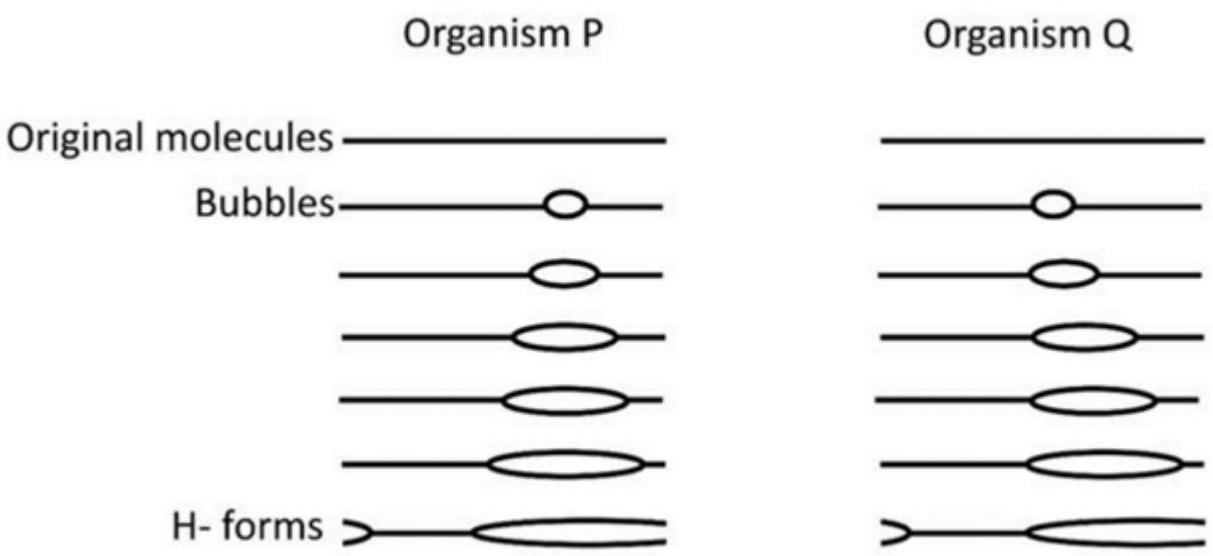
Information Booster:

· Synthetic lethality (PARP inhibitors in BRCA-mutant tumors) is a precision-medicine approach.
· ATR/Chk1 inhibitors can selectively kill tumor cells with high replication stress.
· Aurora kinase and kinesin inhibitors disrupt mitosis causing cell death—clinical trials ongoing.
· Checkpoint-targeting increases therapeutic index when combined with DNA-damaging agents.

Additional Knowledge:

Checkpoint targeting requires careful dosing due to potential toxicity in proliferative normal tissues (bone marrow, gut epithelium).

Q.56 Circular genomic DNA isolated from actively replicating stages of organisms P and Q were digested with a restriction enzyme that cuts both genomes only once. The electron micrographs of the digested DNAs are shown.



Based on these observations, the following comments are made on the number of replication origins and directionality of replication forks:
A. In organism P there are two replication origins, and replication is bidirectional.
B. In organism P there is one replication origin, and replication is bidirectional.
C. In organism Q there is one replication origin, and replication is bidirectional.
D. In organism Q there is one replication origin, and replication is unidirectional.
Which one of the following options represents the combination of all correct statements?

A. A and C
B. A and D
C. B and C
D. B and D

Answer: D

Sol: **Correct Answer:**
(d) B and D
Explanation:
After digestion at a single restriction site, circular DNA converts into a linear molecule.
In organism P, the electron micrographs show replication bubbles symmetrically positioned and H-forms consistent with two replication forks moving away from a single origin → one origin, bidirectional replication (B correct).
In organism Q, replication intermediates show asymmetric bubble growth and H-forms consistent with only one moving fork → one origin, unidirectional replication (D correct).
Information Booster :
· Bubble-shaped intermediates indicate active DNA replication.
· Symmetric bubbles arise from bidirectional fork movement.
· Asymmetric structures indicate unidirectional replication.
· Single-cut restriction digestion is a classic method to infer replication dynamics.
Additional Information (Incorrect Options):
Statement A: Incorrect—there is no evidence of two replication origins in organism P.
Statement C: Incorrect—organism Q does not show bidirectional replication patterns.
Hence, options containing A or C are incorrect.

Q.57 A B6 mouse (H-2b haplotype) was crossed with a CBA mouse (H-2k haplotype) to generate F1 progeny. The following skin transplant experiments were then performed:
A. Graft from B6 mouse to CBA mouse
B. Graft from F1 mouse to B6 parent
C. Graft from F1 mouse to CBA parent
D. Graft from F1 mouse to F1 mouse
E. Graft from B6 mouse to F1 mouse
Which one of the following options represents all recipients in which the graft is tolerated?

A. A
B. B and C
C. D
D. E

Answer: D

Sol: **Correct Answer**

(d) E

Explanation:

The F1 mouse expresses both H-2b and H-2k MHC haplotypes and is therefore immunologically tolerant to antigens from either parent. When a graft from a B6 mouse (H-2b) is transplanted into an F1 recipient, the graft is accepted because all donor MHC molecules are recognized as self by the F1 immune system. Other graft combinations involve MHC mismatch that leads to rejection.

Information Booster

· F1 hybrids express MHC molecules from both parental strains

· Parent → F1 grafts are tolerated due to shared MHC antigens

· F1 → parent grafts are rejected because the parent recognizes the non-shared haplotype as foreign

· Skin graft rejection is primarily mediated by T-cell recognition of MHC differences

· This principle is fundamental in transplantation immunology experiments

Additional Knowledge

A is incorrect because B6 (H-2b) grafts are rejected by CBA (H-2k) mice due to complete MHC mismatch.

B and C are incorrect because F1 grafts express an additional MHC haplotype not present in the parent, leading to rejection.

D represents a syngeneic (genetically identical) graft and is tolerated, but it is a trivial control and not the informative transplant outcome tested by the options.

Q.58 **Following statements are made regarding abscisic acid (ABA) signalling during water stress in plants.**

A. ABA causes membrane depolarization by decreasing cytosolic calcium levels.

B. ABA causes alkalinisation of the cytosol which stimulates opening of K^+ efflux channels.

C. ABA inhibits the activity of the plasma membrane H^+-ATPase which results in membrane depolarization.

D. During stomatal closure, ABA induces reorganization of tubulin cytoskeleton mediated by Rho GTPases.

E. ABA-induced membrane depolarization occurs by release of calcium from endoplasmic reticulum and vacuoles.

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

A. A, B, D and E

B. B, C and E

C. A, B, C and D

D. C, D and E

Answer: D

Sol: **Correct Answer:**

(d) C, D and E

Explanation:

ABA signalling during drought stress increases cytosolic Ca^{2+} levels, not decreases them, leading to membrane depolarization; hence statement A is incorrect.

ABA inhibits the plasma membrane H^+-ATPase, reducing proton extrusion and causing depolarization (C).

ABA also triggers cytoskeletal reorganization via Rho-type GTPases during stomatal closure (D).

The rise in cytosolic Ca^{2+} primarily results from release from internal stores such as ER and vacuoles, contributing to depolarization (E).

Information Booster :

· ABA is a key drought-stress hormone controlling stomatal movement.

· Elevated cytosolic Ca^{2+} acts as a second messenger in guard cells.

· Membrane depolarization favors K^+ efflux, reducing guard cell turgor.

· Cytoskeletal dynamics are crucial for stomatal aperture regulation.

Additional Information (Incorrect Options):

Statement A: Incorrect because ABA increases, not decreases, cytosolic Ca^{2+}.

Statement B: Cytosolic alkalinisation is not the primary driver of K^+ efflux during ABA-induced stomatal closure.

Therefore, options including A or B are incorrect.

Q.59 **Some features of Transcranial Direct Current Stimulation (tDCS) are stated below:**

A. The membrane potential of neurons is modulated by applying a weak electrical current between two electrodes placed on the scalp.

B. Neurons under the anode become depolarized, and neurons under the cathode become hyperpolarized during tDCS.

C. tDCS can disrupt neuronal activity and create a "virtual lesion" via anodal stimulation.

D. Neuronal activity is decreased in regions below the anode and increased in regions below the cathode.

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

A. A, B and C

B. B, C and D

C. C and D only

D. A and B only

Answer: D

Sol: **Correct Answer**

(d) A and B only

Explanation

tDCS works by applying a weak direct current through scalp electrodes, thereby modulating neuronal membrane potentials, making statement A correct. Anodal stimulation generally depolarizes neurons while cathodal stimulation hyperpolarizes them, validating statement B. Statement C is incorrect because virtual lesions are typically associated with cathodal, not anodal, stimulation. Statement D is incorrect as anodal stimulation increases, rather than decreases, neuronal excitability.

Information Booster

• tDCS alters neuronal excitability without directly triggering action potentials
• Anodal stimulation is usually excitatory, while cathodal stimulation is inhibitory
• Effects of tDCS can persist beyond the stimulation period
• Widely studied in neurorehabilitation and cognitive enhancement

Additional Knowledge

Statement C is incorrect because virtual lesion effects are produced by inhibitory (cathodal) stimulation. Statement D is incorrect since neuronal activity increases under the anode and decreases under the cathode, the opposite of what is stated.

Q.60 **An animal was found to be dorsoventrally flattened, unsegmented acoelomate, and having a gastrovascular cavity with no digestive tract. Identify the animal:**

A. hydras
B. flatworms
C. rotifera
D. brachiopoda

Answer: B

Sol: **Correct Answer:** (b) flatworms

Explanation

The key identifying features point clearly to Platyhelminthes (flatworms):
-Dorsoventrally flattened body
-Acoelomate (no body cavity)
-Unsegmented
-Gastrovascular cavity with only one opening
-Absence of a complete digestive tract
-These are classical traits of flatworms, including planarians, flukes, and tapeworms.

Information Booster

-Flatworms show bilateral symmetry and triploblastic organization.
-They use diffusion for gas exchange due to the absence of respiratory and circulatory systems.
-Hydra (Cnidaria) has a gastrovascular cavity but is not dorsoventrally flattened.
-Rotifera have a complete digestive tract (mouth and anus).
-Brachiopods are coelomate, shelled marine animals, not flat.

Additional Information (Incorrect Options Explained)

(a) Hydras → radially symmetrical, not flat.
(c) Rotifera → have pseudocoelom, corona, and complete digestive tract.
(d) Brachiopoda → bivalve-like marine coelomates.

Q.61 **The population density of butterflies increases from 80 to 86 in 1 month. If the birth rate is 0.4, what will be the death rate?**

A. 0.32
B. 0.61
C. 0.42
D. 0.9

Answer: A

Sol: **Correct Answer:** (a) 0.32

Explanation

Population change formula:

Net growth rate = Birth rate − Death rate

Initial population = 80

Final population = 86

Increase = 6

Net growth rate = 6 / 80 = 0.075

Given birth rate = 0.40

Death rate = Birth rate − Net growth rate

= 0.40 − 0.075

= 0.325 ≈ 0.32

Information Booster

-Net population growth depends on birth rate − death rate.

-If a population increases, birth rate must be greater than death rate.

-Rates are often expressed per individual per unit.

Q.62 **Extraembryonic membranes assist in the development of the embryo. They originate from the embryo but are NOT considered part of it. Among the four standard extraembryonic membranes, which one is formed from inner endoderm and outer splanchnic mesoderm?**

A. yolk sac
B. allantois
C. amnion
D. chorion

Answer: A

Sol: **Correct Answer:** (a) yolk sac

Explanation

The yolk sac is formed from:

-Inner layer: endoderm

-Outer layer: splanchnic mesoderm

This membrane plays major roles in early nutrition, blood cell formation, and primordial germ cell origin in amniotes.

Information Booster

The four extraembryonic membranes and their embryonic tissue origins:

1. Yolk sac → endoderm + splanchnic mesoderm
2. Amnion → ectoderm + somatic mesoderm
3. Chorion → ectoderm + somatic mesoderm
4. Allantois → endoderm + splanchnic mesoderm (but arises as an outgrowth of the hindgut)

Additional Information (Incorrect Options Explained)

(b) allantois: also derived from endoderm + splanchnic mesoderm but NOT primarily defined as the membrane described in the question (the classic answer is yolk sac).

(c) amnion: derived from ectoderm + somatopleure.

(d) chorion: derived from ectoderm + somatic mesoderm.

Q.63 **Some general statements are given regarding limb formation. Pick the INCORRECT statement:**

A. fgf10 becomes stabilized by wnt8c to the area where forelimbs form.
B. fgf10 becomes stabilized by wnt2b to the area where forelimbs form.
C. lateral plate of mesoderm will change into skeletal structure.
D. fgf8 secreted from the aer induces the continued mesodermal expression of fgf10.

Answer: A

Sol: **Correct Answer:** (a)

Explanation

Wnt8c stabilizes Fgf10 in the hindlimb region, not the forelimb. Forelimb Fgf10 stabilization is associated with Wnt2b (so the statement that Wnt8c stabilizes Fgf10 in the forelimb is incorrect). The other statements are correct: lateral plate mesoderm contributes to limb skeletal elements, and Fgf8 from the AER maintains mesodermal Fgf10 expression (positive feedback).

Information Booster

-Fgf10 initiates limb bud formation by inducing outgrowth from lateral plate mesoderm.
-The apical ectodermal ridge (AER) secretes Fgf8, which sustains mesenchymal Fgf10 in a feedback loop required for continued limb outgrowth.
-Limb identity cues involve Wnt family members: Wnt2b and Wnt8c have limb-region–specific roles.

Additional Information (Incorrect Options Explained)

(b) Incorrect only if interpreted as forelimb — actually Wnt2b is associated with hindlimb in some models, but in the context of this MCQ the false statement is (a) as explained.
(c) Correct — lateral plate mesoderm gives rise to limb skeletal elements (somatic lateral plate).
(d) Correct — Fgf8 from the AER helps maintain mesodermal Fgf10 expression.

Q.64 **The phosphorylation of Cdc25 phosphatase used in the cell cycle leads to which of the following phenomena in the cycle?**

A. G1 arrest
B. Stop the metaphase to anaphase transition
C. G2 arrest
D. G1 arrest and G2 arrest both

Answer: C

Sol: **Correct Answer:** (c) G2 arrest

Explanation

-Cdc25 phosphatase removes inhibitory phosphates from Cdk1–cyclin B, enabling the cell to transition from G2 → M phase.
-When Cdc25 is phosphorylated by checkpoint kinases (Chk1/Chk2), it becomes inactivated.
-Inactivation of Cdc25 means Cdk1 remains inactive, and the cell cannot enter mitosis.
Thus, the cell becomes stuck in G2, causing G2 arrest.

Information Booster

Checkpoint pathway during DNA damage:

-DNA damage activates ATM/ATR kinases
-ATM/ATR activate Chk1/Chk2
-Chk1/Chk2 phosphorylate Cdc25 → inactivation
-Cdk1–cyclin B remains inactive
-Cell is arrested in G2 phase until repair is complete

Additional Information (Incorrect Options Explained)

(a) G1 arrest → controlled mainly by Cdc25A and Cdk2/cyclin E, not this checkpoint.
(b) Metaphase → anaphase transition is controlled by APC/C, not Cdc25.
(d) Incorrect — Cdc25 inactivation specifically causes G2, not G1 arrest.

Q.65 **Chromatin remodeling adds or removes certain organic chemical groups to or from histones.**
The recruitment of CRC (chromatin-remodeling complex) during this process is carried out by which of the following enzymes?

A. histone acetylase
B. histone deacetylase
C. dna methylase
D. histone methylase

Answer: A

Sol: **Correct Answer:** (a) histone acetylase

Explanation

-Chromatin-remodeling complexes (CRCs) are often recruited to chromatin by histone acetyltransferases (HATs).

-HATs add acetyl groups to lysine residues on histone tails.

-This neutralizes the positive charge, loosens DNA–histone interaction, and opens chromatin.

-The open chromatin structure then allows CRC proteins (e.g., SWI/SNF, ISWI) to bind and remodel nucleosomes.

-Thus histone acetylases initiate recruitment of CRCs by creating the open chromatin environment they require.

Information Booster

-Histone acetylation → euchromatin → gene activation

-Histone deacetylation (HDACs) → heterochromatin → gene repression

-DNA methylation → gene silencing

-Histone methylation → context-dependent activation or repression

Additional Information (Incorrect Options Explained)

(b) HDACs remove acetyl groups → compact chromatin → inhibit CRC access

(c) DNA methyltransferases regulate cytosine methylation, not CRC recruitment

(d) Histone methylases promote activation or repression but do not primarily recruit CRCs

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Q.66 **A polypeptide segment consistently shows φ ≈ +60° and ψ ≈ −45°. This conformation most likely corresponds to a:**

A. Right-handed α-helix

B. β-strand

C. Left-handed α-helix

D. Collagen triple helix

Answer: C

Sol: **Correct Answer:** C

Explanation:

On a Ramachandran plot, left-handed α-helices are located at approximately φ ≈ +60°, ψ ≈ −45°. This region is only energetically allowed for certain residues (most notably glycine, due to low steric hindrance). Right-handed α-helices instead cluster around φ ≈ −60°, ψ ≈ −45°. The given angle values therefore clearly match the left-handed α-helix conformation.

Information Booster:

• Ramachandran plots map sterically allowed φ and ψ rotations.

• Right-handed helices dominate natural proteins due to favorable geometry.

• Left-handed helices are rare and often occur in gly-rich regions.

• Backbone sterics and side-chain bulk define allowed regions.

• Collagen uses a polyproline-like left-handed helix, not a standard α-helix.

Additional Knowledge:

A: Wrong sign for φ (should be negative).

B: β-strands occupy φ ≈ −120°, ψ ≈ +120°.

D: Collagen helices have different geometry and periodicity.

Q.67 **Which one of the following is correct regarding fructose-2,6-bisphosphate (F-2,6-BP)?**

A. It inhibits PFK-1 and activates F-1,6-BPase

B. It activates PFK-1 and inhibits F-1,6-BPase

C. It is synthesized by glucagon signaling

D. It accumulates during fasting to promote gluconeogenesis

Answer: B

Sol: **Correct Answer:** B

Explanation:

Fructose-2,6-bisphosphate is a key regulator of glycolysis and gluconeogenesis. It stimulates PFK-1, enhancing glycolysis, and inhibits F-1,6-BPase, reducing gluconeogenesis.

Information Booster:

• Insulin → F-2,6-BP increases → glycolysis ↑.

• Glucagon → F-2,6-BP decreases → gluconeogenesis ↑.

• F-2,6-BP control is mediated by PFK-2/FBPase-2 bifunctional enzyme.

• Hormonal regulation integrates blood glucose homeostasis.

• Liver uses glycolysis regulation to match metabolic state.

Additional Knowledge:

A is reversed.

C glucagon reduces F-2,6-BP.

D fasting → F-2,6-BP decreases, not increases.

Q.68 **Which statements about the spindle checkpoint (SAC) biochemical mechanism are CORRECT?**
1. Mad2 undergoes conformational activation at unattached kinetochores and participates in MCC formation.
2. Mitotic checkpoint complex (MCC) binds and inhibits APC/C–Cdc20.
3. SAC permanently prevents anaphase even after attachments form.
4. Tension across kinetochores contributes to SAC silencing.

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

Answer: A

Sol: **Correct answer:** (a)
Explanation:
Statements 1, 2 and 4 are correct: Mad2 activation and MCC formation inhibit APC/C–Cdc20 until kinetochores are properly attached and under tension, at which point SAC is silenced. Statement 3 is false—SAC inhibition is reversible.
Information Booster:
· MCC contains Mad2, BubR1 (Mad3), Bub3 and Cdc20 components.
· Kinetochore-localized Mps1 kinase initiates SAC signaling by phosphorylating targets.
· Correct attachment generates tension and recruits phosphatases to remove checkpoint signals.
· Rapid SAC silencing ensures timely anaphase onset and minimizes chromosome segregation errors.
Additional Knowledge:
Pharmacological manipulation of SAC has clinical implications—e.g., mitotic checkpoint override can sensitize tumor cells to mitotic catastrophe.

Q.69 **Which statements about meiotic recombination resolution are CORRECT?**
1. Holliday junctions are recombination intermediates that must be resolved to separate chromatids.
2. Resolution via endonuclease cleavage can yield crossover or non-crossover products depending on orientation.
3. Crossover formation is suppressed near centromeres in many organisms to prevent missegregation.
4. Recombinational repair during meiosis is independent of Spo11-initiated breaks.

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

Answer: A

Sol: **Correct answer:** (a)
Explanation:
Statements 1–3 are correct. Holliday junctions are processed by resolution yielding crossover/non-crossover outcomes; crossovers are often suppressed near centromeres to maintain segregation fidelity. Statement 4 is false—meiotic recombination is initiated by Spo11-mediated DSBs.
Information Booster:
· Resolution pathways include classical resolvases and dissolution via helicase/topoisomerase complexes.
· Crossover interference regulates distribution ensuring minimum crossover numbers per bivalent.
· Non-crossover events (gene conversions) change local allelic combinations without chiasmata formation.
· Recombination hotspots and PRDM9 role (in mammals) influence hotspot positioning.
Additional Knowledge:
Altered recombination landscapes can influence evolution and speciation patterns.

Q.70 **Which of the following describe mechanisms by which cells detect DNA damage and signal checkpoints?**
1. ATM kinase primarily responds to DNA double-strand breaks; ATR responds to replication stress and single-stranded DNA.
2. Chk1/Chk2 kinases act downstream to phosphorylate effectors like p53 and Cdc25.
3. DNA damage signaling always immediately leads to apoptosis without attempting repair.
4. Ubiquitin-mediated proteolysis and phosphorylation events modulate checkpoint protein levels/activity.

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

Answer: A

Sol: **Correct answer:** (a)
Explanation:
Statements 1, 2 and 4 are correct immunomechanistic points. Statement 3 is false—cells first attempt repair; apoptosis is a last resort if damage is

irreparable.

Information Booster:

· ATM phosphorylates H2AX (γ-H2AX) marking DSB sites for recruitment of repair factors.
· Chk kinases inhibit Cdc25 to block CDK activation and cell-cycle progression.
· Ubiquitination (e.g., MDM2 targeting p53) and deubiquitinases regulate checkpoint dynamics.
· Checkpoint activation coordinates repair pathways (HR in S/G2, NHEJ in G1).

Additional Knowledge:

Targeting DNA damage response kinases is a strategy to sensitize tumors to genotoxic therapies.

Q.71 **Given below are basic stages of Xenopus laevis development. Which one of the following options represents the CORRECT sequence?**

A. Fertilization – Cleavage – Gastrulation – Organogenesis – Neurulation – Metamorphosis.
B. Fertilization – Cleavage – Gastrulation – Neurulation – Organogenesis – Metamorphosis.
C. Fertilization – Cleavage – Gastrulation – Metamorphosis – Organogenesis – Neurulation.
D. Fertilization – Cleavage – Organogenesis – Neurulation – Gastrulation – Metamorphosis.

Answer: B

Sol: **Correct answer:** (b)

Explanation

The correct developmental sequence in Xenopus is:

· Fertilization
· Cleavage (rapid cell divisions forming a blastula)
· Gastrulation (formation of germ layers: ectoderm, mesoderm, endoderm)
· Neurulation (formation of the neural tube from ectoderm)
· Organogenesis (development of tissues and organs)
· Metamorphosis (transition from tadpole to frog)
· Option (b) matches this exact order.

Information Booster

· Cleavage in Xenopus is holoblastic but unequal due to yolk distribution.
· Gastrulation begins with dorsal lip formation and extensive cell movements (involution, epiboly, convergent extension).
· Neurulation produces the neural tube, precursor to the brain and spinal cord.
· Organogenesis includes formation of somites, notochord, heart, kidneys, and other organs.
· Metamorphosis is driven by thyroid hormones, leading to resorption of tail, limb formation, and transition to adult form.

Q.72 **Following statements were made with respect to the symbiotic association of rhizobia with legumes:**
A. Activated NodD protein binds to conserved bacterial promoters and induces expression of host-specific nod genes (nodA, nodB, nodC).
B. Nod factors are lipo-chitooligosaccharides.
C. Nod factors predominantly have β-1,6–linked N-acetyl-D-glucosamine backbone.
D. Receptors for Nod factors are protein kinases with extracellular LysM domains.
E. NodD-encoded protein is an acetyl transferase that adds a fatty acyl chain to the Nod factor.
F. NodC-encoded enzyme is a chitin oligosaccharide deacetylase that removes an acetyl group from the terminal residue.
Which combination represents ALL incorrect statements?

A. A, E and F
B. A, B and C
C. C, D and E
D. C, E and F

Answer: D

Sol: **Correct Answer:** (d) — C, E and F

Explanation

· Statement 1 (A) is correct — Activated NodD binds nod-box promoters and induces nod gene expression.
· Statement 2 (B) is correct — Nod factors are LCOs (lipo-chitooligosaccharides).
· Statement 3 (C) is incorrect — Nod backbone has β-1,4 linkages (chitin-like), not β-1,6.
· Statement 4 (D) is correct — Plants detect Nod factors using LysM receptor-like kinases.
· Statement 5 (E) is incorrect — The acyl-transferase is NodA, not NodD. NodD is a transcriptional activator.
· Statement 6 (F) is incorrect — NodB is the deacetylase; NodC polymerizes the chitin-like backbone.
· Thus, the incorrect statements are C, E and F → option (d).

Information Booster

· NodD is a transcriptional activator that responds to plant flavonoids and binds nod-box promoter sequences.
· NodA attaches the fatty acyl chain to the Nod factor backbone.
· NodB is a deacetylase that removes an acetyl group from the chitin backbone precursor.
· NodC synthesizes the β-1,4 linked N-acetylglucosamine oligomer backbone.
· Nod factor receptors in legumes are LysM-type receptor kinases that trigger downstream symbiotic signalling.

Q.73 Consider the following statements about ecological pyramids:

A. Inverted ecological pyramids can occur in ecosystems where biomass of primary producers (plants) is less than the biomass of primary consumers (herbivores).

B. Ecological pyramids can represent the flow of energy, biomass, or numbers within an ecosystem.

C. Ecological pyramids are universally applicable across all ecosystems, regardless of their complexity or biodiversity.

D. In some cases, ecological pyramids may be diamond-shaped, indicating an unusual distribution of energy or biomass among trophic levels.

E. Ecological pyramids are static structures that do not change over time, providing a fixed representation of ecosystem dynamics.

F. The shape of an ecological pyramid depends on factors such as ecosystem productivity, efficiency of energy transfer between trophic levels, and the size of organisms at each trophic level.

Which of the following combinations of statements about ecological pyramids are TRUE?

A. A, B, C, and D
B. A, B, C, and F
C. A, B, D, and F
D. B, C, E, and F

Answer: C

Sol: **Correct answer:** (c) — A, B, D, and F

Explanation

Let's evaluate each statement:

Statement 1 — TRUE.

Inverted pyramids of biomass (e.g., in aquatic ecosystems) occur when producer biomass (phytoplankton) is lower than consumer biomass (zooplankton), due to very high turnover of producers.

Statement 2 — TRUE.

Ecological pyramids can depict energy, biomass, or numbers depending on the parameter being represented.

Statement 3 — FALSE.

Ecological pyramids are not universally applicable. Some ecosystems (e.g., deep-sea vents, detritus-based systems) break simple pyramid rules and require modified representations.

Statement 4 — TRUE.

Diamond-shaped pyramids can occur when mid-trophic levels (e.g., mesopredators or herbivores) have particularly high biomass or numbers relative to lower and higher levels.

Statement 5 — FALSE.

Ecological pyramids are not static; they change over time with seasonality, disturbance, nutrient input, predator–prey dynamics, population fluctuations, etc.

Statement 6 — TRUE.

Pyramid shape reflects many ecological factors: productivity, energy transfer efficiency, organism size, lifespan, and turnover rates.

Thus the true statements are: 1 (A), 2 (B), 4 (D), and 6 (F) → option (c).

Q.74 In a transplantation experiment in a chick embryo, hindlimb mesenchyme was placed directly beneath the apical ectodermal ridge (AER) of a presumptive wing bud. The following statements were made regarding the experiment:

A. Only forelimb structures developed.

B. Hindlimb structures developed at the tip (end) of the limb.

C. There will be no development of wings in the chick (wing identity is lost).

D. Forelimb structures developed at the tip (end) of the limb.

Which of the following options lists the statements that are INCORRECT?

A. A and D
B. A, C, D
C. A, B, C
D. B, C, D

Answer: A

Sol: Correct answer :(a)

Explanation

· Limb identity (forelimb vs hindlimb) is determined primarily by the mesenchyme, not by the AER.

· When hindlimb mesenchyme is transplanted under a wing AER, the mesenchyme imposes its program: the bud will develop hindlimb-type structures at that location. Therefore:

· Statement 2 (B) is true — hindlimb structures develop at the bud tip.

· Statement 3 (C) is true — wing identity is lost at that site, so normal wing structures will not form.

· Statements 1 (A) and 4 (D) (that forelimb/wing structures develop) are false.

The only correct set of incorrect statements is A and D,

Q.75 Given below are a few statements about two models for the structure of the 30-nm fiber — the solenoid model and the zig-zag model. Identify the INCORRECT statement(s):

A. In the solenoid model, linker DNA does not pass through the central axis of the superhelix and the sides and entry/exit points of the nucleosomes are relatively accessible.
B. In the "zigzag" model, the linker DNA frequently passes through the central axis of the fiber, and the sides and even the entry and exit points are more accessible.
C. The form of the 30-nm fiber found in cells depends on the local linker DNA length.
D. The incorporation of DNA into this 30-nm fiber makes the DNA more accessible to many DNA-dependent enzymes (such as RNA polymerases).
E. In the solenoid model, the nucleosomal DNA forms a superhelix containing approximately six nucleosomes per turn.

A. A and D
B. A, B and C
C. B and E
D. D, C and E

Answer: A

Sol: **Correct answer:** (a) — Statements A and D (i.e., 1 and 4 are incorrect)

Explanation

· Statement 1 (Incorrect). In the solenoid model nucleosomes are packed into a helical array (a superhelix) with linker DNA bent so that it does not project straight through the central axis — that part is true — but the entry/exit sites and the sides are relatively buried in the compact solenoid packing (not readily accessible). So the claim that those surfaces are "relatively accessible" is wrong for the solenoid.
· Statement 2 (Correct). The zig-zag model places nucleosomes on opposite faces connected by relatively straight linker DNA that often traverses the fiber interior; this arrangement is more open and can present more accessible DNA entry/exit positions.
· Statement 3 (Correct). Whether chromatin adopts a solenoid-like or zig-zag conformation depends strongly on linker length, ionic conditions and histone H1 presence — so local linker DNA length influences the fiber form.
· Statement 4 (Incorrect). Packaging DNA into the 30-nm fiber reduces accessibility to DNA-dependent enzymes compared with the 10-nm "beads-on-a-string" form; higher-order folding is associated with transcriptional repression and restricted access.
· Statement 5 (Correct). The canonical solenoid description often describes ~6 nucleosomes per turn in the helical superstructure.
So the incorrect statements are 1 (A) and 4 (D) → option (a).

Q.76 **In Grime's classification system:**
A. Slow growth rate, low level of seed production, dense leaf canopies.
B. Small evergreen leaves, low level of seed production, long life spans, intertidal.
C. Relatively small size, rapid growth, existence in disturbed areas, annuals.
Identify the following types of plants based on the description given below.

A. A = Stress tolerators, B = Competitors, C = Ruderals.
B. A = Competitors, B = Stress tolerators, C = Ruderals.
C. A = Ruderals, B = Stress tolerators, C = Competitors.
D. A = Competitors, B = Ruderals, C = Stress tolerators.

Answer: B

Sol: **Correct Answer:** (b) — A = Competitors, B = Stress tolerators, C = Ruderals

Explanation

· Type C clearly matches Ruderals: small-sized annuals, rapid growth and occurrence in disturbed habitats.
· Type B fits Stress-tolerators: small evergreen leaves, low seed production and long life span in stressful environments (e.g., intertidal) are classic stress-tolerator traits.
· By elimination, Type A corresponds to Competitors, which are characterized by well-developed, dense canopies and high resource capture in relatively undisturbed, productive sites. (The wording about "slow growth rate" is slightly inconsistent, but dense canopy and low disturbance environment match competitors in Grime's CSR model.)
· Thus: A = Competitors, B = Stress-tolerators, C = Ruderals → option (b).

Information Booster

· Grime's CSR model classifies plants into three primary strategies: C (competitors), S (stress-tolerators), and R (ruderals).
· Competitors dominate in productive, low-disturbance habitats; they typically have tall stature, dense leaf canopies, and efficient resource capture.
· Stress-tolerators occur in environments with chronic stress (e.g., drought, nutrient-poor soils, salinity); they often have evergreen leaves, slow growth, long life spans, and low reproductive rates.
· Ruderals thrive in highly disturbed but resource-rich environments; they grow rapidly, mature early, and invest heavily in seed production, often as short-lived annuals.
· Many real species show intermediate strategies (e.g., C–S or C–R), but the three "pure" strategies help in conceptualizing plant adaptations.

Q.77 **Which one of the following set of essential components are required for running a PCR reaction?**

A. DNA template, Forward and Reverse Primer, deoxynucleotide mix, Pfu buffer, Pfu DNA Polymerase, DMSO and water.
B. DNA template, Forward and Reverse Primer, dideoxynucleotide mix, Pfu buffer, Pfu DNA Polymerase, DMSO and water.
C. DNA template, Forward and Reverse Primer, deoxynucleotide mix, Pfu buffer, Pfu DNA Polymerase, DMSO and water, DNA ligase.
D. DNA template, Forward and Reverse Primer, labelled deoxynucleotide mix, Pfu buffer, Pfu DNA Polymerase, DMSO and water.

Answer: A

Sol: **Correct answer:** (a)

Explanation

PCR requires a DNA template, a pair of primers (forward and reverse), a supply of normal deoxynucleotide triphosphates (dNTPs), a suitable buffer (including Mg^{2+}), a thermostable DNA polymerase (e.g., Pfu or Taq), and water. DMSO is optional (used to improve amplification of GC-rich templates) but is often included in reaction mixes; DNA ligase is not required for PCR, dideoxynucleotides (ddNTPs) terminate synthesis and are used for sequencing (Sanger), and labelled dNTPs are only needed for specialized detection methods.

Information Booster

· PCR core components: template DNA + forward/reverse primers + dNTPs + thermostable DNA polymerase + buffer (with Mg^{2+}) + water.
· Thermostable polymerase (Taq, Pfu, Phusion, etc.) is essential because PCR cycles include high-temperature denaturation steps.
· Dideoxynucleotides (ddNTPs) terminate chain elongation and are used in Sanger sequencing — they are inappropriate for routine PCR.
· DNA ligase joins DNA ends but is unnecessary in PCR, which synthesizes continuous strands using polymerase.
· Additives (DMSO, betaine) can improve amplification of difficult templates (high GC, secondary structure) but are not strictly essential.

Q.78 **Given below are a few statements about promiscuity (mating systems):**

A. A breeding system is considered promiscuous when both polyandry and polygyny are present simultaneously within the same population.
B. In one type of promiscuity, both males and females have multiple mating partners, and no pair bonds are established.
C. In the second type of promiscuous breeding system, known as polygynandry, multiple males form pair-bonds with multiple females at the same time.
D. Chimpanzees and bonobos exhibit a degree of promiscuity. Megapode birds, found primarily in Australia and New Guinea, are polygynandrous.
E. In promiscuous systems, parental care is predominantly provided by males, while in polygynandry it is primarily the females who take on parenting responsibility.
Which one of the following combinations of the above statements are INCORRECT?

A. A, B, C and D
B. A, B, and C
C. B and D
D. C and E

Answer: D

Sol: Correct answer :Statements 3 and 5 are incorrect (i.e., C and E).

Explanation

· Statement 1 — True. Promiscuity typically refers to a system in which both sexes mate with multiple partners and there are no lasting pair bonds; this may include cases where polyandry and polygyny occur within the same population.
· Statement 2 — True. The general, commonly used definition of promiscuity is that both males and females have multiple partners and no stable pair bonds are formed.
· Statement 3 — Incorrect. Polygynandry (a form of group mating) describes systems in which multiple males and multiple females mate with each other — it does not imply formation of multiple simultaneous pair-bonds. The phrase "form pair bonds with multiple females" is misleading because a pair bond by definition is between two individuals and implies some degree of exclusivity or at least a recognizable pair relationship; polygynandry is an interconnected mating network rather than multiple pair bonds.
· Statement 4 — Mostly True. Chimpanzees and bonobos are classic examples of promiscuous primates (both sexes mate with multiple partners). Many megapode species have communal nesting/mating systems; some populations show polygynandrous mating behaviour where multiple males and females use the same nesting mound — so the broad assertion is acceptable as a generalization (though mating systems vary among megapode species).
· Statement 5 — Incorrect/generalisation error. Parental care patterns are highly variable and cannot be generalized as "in promiscuous systems, care is predominantly provided by males." In many promiscuous systems parental care is reduced or shared or mainly by females (e.g., many mammals). Similarly, polygynandry does not systematically mean that females primarily parent — parental roles depend on the species' natural history, not the mere label "polygynandry."
Because 3 and 5 contain inaccurate or misleading claims, they are the incorrect statements.

Information Booster :

· Promiscuity (in behavioural ecology) means both sexes engage in multiple mating partners and typically no long-term pair bonds are formed.
· Polygynandry is group mating involving multiple males and multiple females mating with each other; it is a mating network rather than a set of simultaneous pair-bonds.
· Parental care patterns (male care, female care, biparental care, or no care) are determined by life history, ecological pressures and paternity certainty — they are not uniquely determined by whether a system is promiscuous or polygynandrous.
· Examples: chimpanzees and bonobos are promiscuous primates; bird mating systems vary widely — some species (including some megapodes and other communal nesters) show complex communal or polygynandrous mating behaviour, but species-level variation is large.

Q.79 **Water potential is the potential energy of water per unit volume (Ψw). Given statements:**

A. Water potential has four components to define, but only solute and pressure potential is applicable in case of plant.
B. If you add solute in pure water, the solution has fewer free water molecules and concentration of water decreases.
C. The water potential is used to describe the direction of the movement of water.
D. The positive hydrostatic pressure within cells is the pressure referred to as turgor pressure and has a positive value.
E. All solutions have higher water potential than pure water.
Pick the CORRECT statements regarding the water potential concept.

A. A, B and C only.
B. A, B, C and D only.
C. A, C and E only.

D. A, C, D and E only.

Answer: B

Sol: **Correct answer:** (b) — A, B, C and D only

Explanation

Statement 1 (A): Interpreting this in the typical plant physiology context — water potential can be decomposed into four components (solute/osmotic Ψs, pressure/turgor Ψp, matric Ψm, and gravitational Ψg). For living plant cells and most short-scale cellular water relations, the dominant, directly relevant terms are solute (Ψs) and pressure (Ψp); matric and gravitational terms are often negligible for single cells or small tissues and therefore are commonly omitted in plant-cell water relations. So in the practical plant physiology sense this statement is accepted.

Statement 2 (B): True — adding solute reduces the number of free (unbound) water molecules and lowers the water potential (and effective "concentration" of free water) relative to pure water.

Statement 3 (C): True — water moves from regions of higher water potential to regions of lower water potential; water potential therefore predicts direction of water movement.

Statement 4 (D): True — turgor pressure (positive hydrostatic pressure inside the cell) contributes positively to Ψp and is typically a positive term in living, pressurized cells.

Statement 5 (E): False — adding solute lowers water potential; thus most solutions have lower (more negative) water potential than pure water, not higher.

Because statements 1–4 are treated as correct in the standard plant physiology framing and statement 5 is false, the correct set is A, B, C and D (option b).

Q.80 **The rate constant for conversion of a substrate into the product is $10^{-4}s^{-1}$ while the reverse rate constant is $10^{-6}s^{-1}$. An enzyme enhances the rate of this reaction by 100-fold. The equilibrium constant for this enzyme-catalyzed reaction is**

A. 100
B. 10000
C. 10
D. 1000

Answer: A

Sol: Correct Answer: 1. 100

Explanation

Given:

Forward rate constant (kf) = 10^{-4} s^{-1}
Reverse rate constant (kr) = 10^{-6} s^{-1}
Step 1: Relation used

Equilibrium constant (K) = kf / kr

Step 2: Calculation

K = (10^{-4}) / (10^{-6}) = 10^{2} = 100

Step 3: Effect of enzyme

Although the enzyme increases the rate by 100 times, it increases both forward and reverse reactions equally, so the equilibrium constant remains unchanged.

Final Answer:

100

Q.81 **The mechanism of oxygen transport by hemocyanin (containing Cu) is described by**

$$\mathrm{Cu^{1+} \cdot Cu^{1+} + O_2 \rightleftharpoons Cu^{2+} \cdot O_2^{2-} \cdot Cu^{2+}}$$

Which one of the following techniques can be used to monitor the change in the oxidation state of copper?

A. Mass spectrometry
B. Circular dichroism
C. Absorption spectroscopy
D. Fluorescence spectroscopy

Answer: C

Sol: Correct Answer: 3. Absorption spectroscopy
Explanation

The question involves monitoring the change in oxidation state of copper during oxygen binding in hemocyanin:

$Cu^{+} + Cu^{+} + O_2 \rightleftharpoons Cu^{2+}–O_2^{2-}–Cu^{2+}$

Here, copper is oxidized from Cu^{+} (Cu(I)) to Cu^{2+} (Cu(II)).

Why Absorption Spectroscopy is Correct
Cu(I) is d^{10} configuration → no d–d transitions → generally colorless
Cu(II) is d^{9} configuration → shows d–d electronic transitions → absorbs visible light

Thus, when Cu(I) is converted to Cu(II), there is a change in electronic absorption spectrum, which can be easily monitored using absorption (UV-Vis) spectroscopy.

Why Other Options are Incorrect
Mass spectrometry
Detects mass, not oxidation state directly
Not suitable for tracking electronic changes
Circular dichroism
Useful for chiral molecules/protein secondary structure
Not ideal for detecting metal oxidation state changes
Fluorescence spectroscopy
Requires fluorescent species
Copper complexes typically do not give reliable fluorescence signals for oxidation state changes

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Q.82 **Which is the correct hierarchy of gene activity in early *Drosophila* segmentation?**

A. Gap, pair-rule, segment polarity, maternal
B. Maternal, gap, pair-rule, segment polarity
C. Maternal, pair-rule, gap, segment polarity
D. Segment polarity, pair-rule, gap, maternal

Answer: B

Sol: In *Drosophila*, the segmentation process is regulated by a hierarchy of genes that act in a specific order. The correct sequence of gene activity during early segmentation is:

1. **Maternal genes**: These are the first genes to be activated and set up the initial patterning of the embryo along the anterior-posterior axis. They encode proteins and RNAs deposited by the mother that establish gradients in the egg.

2. **Gap genes**: These genes are activated by maternal gene products and help subdivide the embryo into broad regions. They regulate the expression of pair-rule genes.

3. **Pair-rule genes**: These genes are responsible for creating a segmented pattern in the embryo by defining the boundaries of each segment.

4. **Segment polarity genes**: These genes refine the patterning further and establish the anterior-posterior polarity within each segment.

Information Booster:

- Maternal genes control the overall patterning of the early embryo by providing positional information.
- Gap genes break down the embryo into large segments by responding to maternal gradients.
- Pair-rule genes define the boundaries of alternating segments, and they are expressed in a repeated, periodic pattern.
- Segment polarity genes refine the segmental pattern and are involved in defining the polarity within individual segments.
- The maternal-to-gap-to-pair-rule-to-segment polarity hierarchy ensures that the segmented body plan is established correctly during early development in *Drosophila*.
- This gene hierarchy is essential for establishing the correct spatial pattern of the developing embryo, ensuring proper segmentation and body structure.

Q.83 **The cytoplasmic domain of the receptor of which of the following proteins does NOT function as tyrosine kinase?**

A. Epidermal growth factor
B. Platelet derived growth factor
C. Insulin
D. Asialoglycoprotein

Answer: D

Sol: **Explanation-**
Asialoglycoprotein (option d) is not a growth factor. It binds to the Asialoglycoprotein receptor (ASGPR), a liver-specific receptor. ASGPR is involved in endocytosis and clearing glycoproteins, but does not have tyrosine kinase activity. So, it does not function as tyrosine kinase

Other options-

Option a - Epidermal Growth Factor (EGF)
Receptor: EGF Receptor (EGFR)
EGFR is a receptor tyrosine kinase (RTK). Upon binding EGF, it undergoes autophosphorylation on tyrosine residues, triggering downstream signaling. It **functions as tyrosine kinase**
Option b - Platelet Derived Growth Factor (PDGF)
Receptor: PDGF Receptor
It is also a receptor tyrosine kinase. Dimerization and autophosphorylation initiate multiple signaling pathways. It **functions as tyrosine kinase**
Option c - Insulin
Receptor: Insulin Receptor
Another classic receptor tyrosine kinase (RTK). Binding of insulin activates tyrosine kinase activity in the cytoplasmic domain. It functions as tyrosine kinase .

So, the correct answer is option d - Asialoglycoprotein.

Q.84 **A fly with apricot coloured eye was crossed with a sepia eyed fly of opposite sex. In F1 all flies were wild type. The genes responsible for the two phenotypes were:**

A. Allelic
B. Non-allelic
C. Pseudo-allelic
D. Paralogous genes

Answer: B

Sol: **Explanation-**

This is a classic case of complementation, where two mutations in different genes restore the wild-type phenotype in offspring. Therefore, the mutations **affect different genes and are non-allelic.**

Genetic Principle:

Complementation Test: If two recessive mutations produce a wild-type phenotype when crossed, they are in different genes → **non-allelic.**

In this case:

Apricot mutation affects one gene (e.g., white gene).

Sepia mutation affects another gene (e.g., brown gene).

When both functional copies are brought together in F1 → wild-type eye color is restored.

This confirms the genes are **non-allelic** and affect different steps in the pigment pathway.

Incorrect options-

Option a - Allelic

Allelic mutations occur at the same gene locus. If you cross two flies with different mutant alleles of the same gene, F1 offspring will still show a mutant phenotype or a partial phenotype (e.g., hypomorphic). In this case, F1 shows wild-type, which means the mutations are not allelic.

Option c - Pseudo-allelic

Pseudoalleles are closely linked genes that appear to behave like alleles of a single gene. While this seems tempting, apricot and sepia are not pseudoalleles of the same gene — they affect entirely different genes (e.g., white, scarlet, brown). Hence, the interaction here is not due to pseudoalleles, but true non-allelic complementation.

Option d- Paralogous genes

Paralogous genes are genes that evolved from a common ancestral gene through duplication, and may have similar functions. This term applies in evolutionary biology and gene family studies, not in classical genetic complementation. The concept of complementation in this question has nothing to do with paralogs.

So, the correct answer is option b - Non-allelic.

Q.85 **In *Saccharomyces cerevisiae*, DNA replication is tightly controlled, and DNA should replicate once per cell cycle. Choose the INCORRECT statement regarding why the cells do not re-replicate their DNA in the S-phase.**

A. Pre-replicative complex (Pre-RC) remains bound to the DNA in the S-phase and does not allow the re-replication.
B. Assembly of Pre-RC is inhibited by Cdk activity.
C. Assembly of Pre-RC is initiated at the end of mitosis, at the early G1 phase of the cell cycle (when the APC activity is high).
D. Cdt1 that helps in the recruitment of MCM proteins in the G1 phase is inactivated by geminin in the S-phase of the cell cycle.

Answer: A

Sol: **Explanation-**

Option A - "Pre-replicative complex (Pre-RC) remains bound to the DNA in the S-phase and does not allow the re-replication"

The Pre-RC does not remain bound to DNA in S-phase. In the G1 phase, when Cdk activity is low, the Pre-RC assembles on origins of replication. At the start of S-phase, once DNA replication begins, the Pre-RC is disassembled. This disassembly ensures that DNA replication origins fire only once, preventing re-replication. Once replication starts, Cdk activity increases, and Pre-RC components (like Cdc6, Cdt1) are inactivated or degraded. Therefore, this option is **factually incorrect**—it suggests the opposite of what actually happens.

Correct statements-

Option B - "Assembly of Pre-RC is inhibited by Cdk activity"

Cdks (cyclin-dependent kinases) play a central role in controlling Pre-RC assembly. When Cdk levels are high (during S, G2, M phases), Pre-RC assembly is inhibited. High Cdk activity phosphorylates and inactivates key Pre-RC components like Cdc6 and ORC proteins, blocking re-assembly. This prevents re-licensing of replication origins, hence avoiding re-replication. Only in G1 phase (when Cdk activity is low) can Pre-RC form again for the next cycle.

Option C - "Assembly of Pre-RC is initiated at the end of mitosis, at the early G1 phase of the cell cycle (when the APC activity is high)"

During late M phase and early G1, APC (Anaphase Promoting Complex) is highly active. APC promotes the degradation of cyclins, which causes a drop in Cdk activity. This low Cdk activity in G1 is a prerequisite for Pre-RC formation. Hence, the origins of replication are licensed (loaded with MCM helicase) during this window. As the cell enters S-phase, Cdk activity rises again and blocks further Pre-RC formation.

Option D - "Cdt1 that helps in the recruitment of MCM proteins in the G1 phase is inactivated by geminin in the S-phase of the cell cycle"

Cdt1 is a licensing factor that loads MCM helicase onto DNA during G1 phase. In higher eukaryotes, geminin binds to Cdt1 and inhibits it during S-phase to prevent re-licensing. Although budding yeast (S. cerevisiae) doesn't use geminin, the same logic applies—Cdt1 is tightly regulated (e.g., via degradation or export). This ensures that DNA replication does not restart at the same origins in the same cycle.

Since option A is the only incorrect statement among all the other options that makes it a correct answer.

Q.86 Myosin molecules that assemble into bipolar filaments in the muscle are

A. Myosin I
B. Myosin II
C. Myosin IV
D. Myosin V

Answer: B

Sol: **Correct Answer:** 2. Myosin II

Explanation

Myosin proteins are classified into different types based on their structure and function.

Key Concept: Bipolar Filaments
Bipolar filaments are thick filaments found in muscle cells
They consist of myosin molecules arranged tail-to-tail with heads projecting outward
These structures are essential for muscle contraction

Evaluation of Options

1. Myosin I
-Monomeric
-Involved in vesicle transport, not filament formation
2. Myosin II
-Forms bipolar thick filaments
-Major contractile protein in muscle
3. Myosin IV
-Not involved in muscle filament formation
4. Myosin V
-Involved in intracellular cargo transport
-Does not form bipolar filaments

Final Answer:

Myosin II

Q.87 **In the classical metapopulation model as articulated by Richard Levins (1969, 1970), the metapopulation is considered to be a collection of subpopulations occupying different patches. Which one of the following conditions should be met for a population to be considered as a metapopulation?**

A. Individual subpopulations should have realistic chances of extinction and recolonization.
B. The dynamics of the subpopulations should be dependent on each other.
C. Recolonization of a patch after extinction should be mainly through dispersal from the mainland patch.
D. Population dynamics in the various patches should be synchronous.

Answer: A

Sol: According to Levins' Metapopulation Model, the key concept is that a metapopulation is a system of spatially separated populations (subpopulations) connected by dispersal.

Conditions for a true metapopulation:

-Patches are suitable for the species but separated in space.

-Subpopulations experience local extinctions and recolonization events.

-The overall metapopulation persists because colonization rate > extinction rate.

Analysis of options:

(1) Correct. This is the defining feature of a metapopulation model.

(2) Incorrect. Subpopulations are not strongly dependent on each other; they are linked only by occasional migration.

(3) Refers to the mainland-island model, not the classical Levins model.

(4) Dynamics are not synchronous; asynchronous fluctuations stabilize the metapopulation.

Q.88 **Following statements were made about human mitochondrial genome:**

A. The replication of both the H and L strands is unidirectional and begins at specific origins.

B. Majority of the mitochondrial genes encode for protein products.

C. Though the mitochondrial genome is extremely compact, the genes never show any sequence overlap.

D. The CR/D-loop region of mitochondrial genome exhibits triple stranded structure.

E. Transcription of mtDNA starts bi-directionally from a common promoter region in the CR/D-loop region and continues round the circle.

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

A. A, B, D

B. A, D, E

C. B, D, E

D. B, C, D

Answer: A

Sol:

Evaluate each statement

A. Replication of both H and L strands is unidirectional and begins at specific origins.

Correct

Human mtDNA replication is asymmetric and unidirectional:

- H-strand begins at OH
- L-strand begins at OL

B. Majority of mitochondrial genes encode protein products.

Correct

Human mtDNA encodes:

- 13 protein-coding genes
- 22 tRNAs
- 2 rRNAs

Thus most genes are protein-coding.

C. Mitochondrial genes never show sequence overlap.

Incorrect

mtDNA is extremely compact and several genes overlap.

D. D-loop region exhibits triple-stranded structure. Correct

The D-loop contains a short third strand (7S DNA), forming a triple-stranded structure.

E. Transcription starts bi-directionally from a common promoter in D-loop and continues around circle.

Incorrect

There are separate promoters for H-strand and L-strand (HSP and LSP), not a single common bidirectional promoter.

Q.89 **Following statements were made about the characteristics of cyclin proteins:**

A. Synthesis of M-cyclin is dependent on the cyclin mRNA that is newly transcribed after every cycle.

B. Destruction of M-cyclin toward the end of mitosis is driven by ubiquitin independent proteolytic system.

C. G1 cyclins can be activated by mitogenic factors.
D. Retinoblastoma (Rb) is a key target of the activated cyclin D - Cdk 4/6 complex.
E. While cyclin A1 expression is ubiquitous, cyclin A2 expression is restricted to the germ cell lineages.
Which one of the following options contains a combination of all correct statements?

A. A, B, D
B. B, C, E
C. B, D, E
D. A, C, D

Answer: C

Sol: **Correct Answer: 3 (B, D, E)**

Evaluate each statement

A. M-cyclin synthesis depends on newly transcribed mRNA after every cycle.
Incorrect
Cyclin B (M-cyclin) levels oscillate mainly due to regulated degradation, not necessarily new transcription every cycle.

B. Destruction of M-cyclin at end of mitosis is driven by ubiquitin-dependent proteolysis.
Correct
Cyclin B is degraded via APC/C-mediated ubiquitination.

C. G1 cyclins can be activated by mitogenic factors.
Incorrect
Mitogens induce expression of G1 cyclins; they do not "activate" pre-existing ones in that way.

D. Rb is a key target of activated cyclin D–Cdk4/6 complex.
Correct
Cyclin D–Cdk4/6 phosphorylates Rb to promote G1/S transition.

E. Cyclin A1 expression is restricted to germ cell lineages.
Correct
Cyclin A1 is primarily expressed in germ cells (e.g., male meiosis).

Final Answer

Option 3 (B, D, E)

Q.90 Following statements were made about sex determination in Drosophila melanogaster:
A. It is achieved by a balance of female determinants on the X- chromosome and male determinants on the autosomes.
B. A Drosophila with 0.66 value of X:A ratio would develop intersex type.
C. Due to noninvolvement of Y chromosome in sex determination process, XO Drosophila develop as normal fertile male.
D. The high value of X:A ratio facilitates activation of feminizing switch gene Sex lethal (sxl).
E. Sex specific expression of sxl causes selective activation of dosage compensation genes in female Drosophila.
Select the option with combination of all correct statements.

A. A, B, E
B. A, B, D
C. B, C, E
D. B, C, D

Answer: B

Sol: **Correct Answer: 2 (A, B, D)**

Evaluate each statement

A. Sex determination is achieved by balance of X-linked female determinants and autosomal male determinants.
Correct
The X:A ratio determines sex in *Drosophila*.

B. X:A ratio of 0.66 produces intersex.
Correct
0.5 → male
1.0 → female
Intermediate (e.g., 0.67) → intersex.

C. XO develops into normal fertile male.
Incorrect
XO flies are sterile males (Y chromosome required for male fertility).

D. High X:A ratio activates feminizing switch gene sxl.
Correct
High X:A ratio activates Sxl, leading to female development.

E. Sex-specific sxl activates dosage compensation genes in females.
Incorrect
Dosage compensation hyperactivates the male X chromosome.
In females, Sxl represses dosage compensation machinery.

Q.91 **Colour blindness affects approximately 1 in 12 men (8%). In a population that is in Hardy-Weinberg Equilibrium (HWE) where 8% of men are colour-blind due to a sex-linked recessive gene. What proportion of women are expected to be carriers?**

A. 0.92
B. 0.85
C. 0.78
D. 0.15

Answer: D

Sol: **Explanation-**
Given:
Colour blindness is a sex-linked recessive disorder (X-linked).
8% of men are affected => = 0.08
(since males have only one X chromosome, affected males = frequency of recessive allele)
Hardy-Weinberg in Females:
For females (who have two X chromosomes):

$$\text{Carrier females (heterozygous)} = 2pq$$
$$p + q = 1 => p = 1 - q = 1 - 0.08 = 0.92$$
So,
$$2pq = 2 \times 0.92 \times 0.08 = 0.1472 \approx 0.15$$

Final Answer - Option d : 0.15

Q.92 **The largest reservoir of nitrogen in the global nitrogen cycle is the atmosphere. Options A-D below represent important pathways in the removal of nitrogen from the atmosphere at different rates.**
A. Biological fixation in oceans
B. Fixation by lightning
C. Biological fixation in natural terrestrial systems
D. Industrial nitrogen fixation

Arrange the above pathways from the lowest to the highest rate.

A. D<B<A<C
B. B<D<C<A
C. B<C<D<A
D. A<B<D<C

Answer: C

Sol: **Explanation-**
A. Biological fixation in oceans — Highest
Reason: Marine cyanobacteria (like Trichodesmium) fix large amounts of nitrogen. Oceans cover ~70% of Earth, offering vast areas for nitrogen fixation. Although individual rates are low, the global total is very high due to scale.

Highest nitrogen fixation rate

B. Fixation by lightning — Lowest
Reason: Lightning breaks N_2 into reactive nitrogen compounds (like NOx), but It's a rare, weather-dependent process and contributes less than 10 Tg N/year globally.
Lowest among the listed

C. Biological fixation in natural terrestrial systems
Reason: Includes nitrogen-fixing bacteria in root nodules of legumes (e.g., Rhizobium). More active than lightning but less than oceans and industrial processes.
Intermediate in the list

D. Industrial nitrogen fixation
Reason: Through the Haber-Bosch process, converting atmospheric N_2 to ammonia (NH_3) can be used in fertilizer production; has grown rapidly due to agriculture. It fixes over 120 Tg N/year.
Less than oceans globally, but more than natural terrestrial fixation.
Second-highest

So, the correct order should be B<C<D<A (Option c)

Q.93 Given below are the list of proteins (Column X) and their functions (Column Y) during floral induction.

Column X	Column Y
A. FLOWERING LOCUS C (FLC)	i. An activator of FLC
B. FLOWERING LOCUS D (FD)	ii. A mobile signal that induces flowering
C. FLOWERING LOCUS T (FT)	iii. Regulate target genes that mediate the reprogramming of meristem to produce flowers
D. FRIGIDA (FRI)	iv. A strong repressor of flowering

Which one of the following options represents the correct match between column X and column Y?

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

Answer: D

Sol: **Explanation-**

A. FLC (FLOWERING LOCUS C) → (iv) A strong repressor of flowering
FLC encodes a MADS-box transcription factor that represses flowering by directly inhibiting the expression of key flowering genes, such as FT and SOC1. In winter-annual accessions of Arabidopsis, FLC levels are high in young plants, preventing premature flowering. After exposure to vernalization (cold), FLC is silenced, allowing flowering to proceed in spring.

B. FD (FLOWERING LOCUS D) → (iii) Regulate target genes that mediate the reprogramming of meristem to produce flowers
FD is a transcription factor (a bZIP protein) that is expressed in the shoot apical meristem. FD partners with FT (which arrives from leaves via phloem) to form a protein complex. This complex activates target genes like APETALA1 (AP1), promoting the floral identity in the shoot apex.

C. FT (FLOWERING LOCUS T) → (ii) A mobile signal that induces flowering
FT is often referred to as "florigen", the flowering hormone. FT is produced in leaves in response to favorable photoperiods (like long days). It then travels through the phloem to the shoot apical meristem, where it interacts with FD to initiate flowering.

D. FRI (FRIGIDA) → (i) An activator of FLC
FRI functions upstream of FLC. It activates transcription of FLC. In Arabidopsis, the FRI-FLC pathway acts as a brake on flowering. In ecotypes with a functional FRI allele, FLC levels remain high, keeping the plant from flowering until vernalization occurs.

Q.94 Glycolysis and citric acid cycle contribute precursors to many biosynthetic pathways in plants. Column X lists names of the precursor and column Y lists the product synthesized.

Column X	Column Y
A. Hexose phosphate	i. Aspartate
B. Pyruvate	ii. Alanine
C. Pentose phosphate	iii. Cellulose
D. Oxaloacetate	iv. Nucleotides

Which one of the following options represents the correct match between column X and Y?

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

Answer: B

Sol: **Explanation-**

A. Hexose phosphate → (iii) Cellulose

Hexose phosphate refers to phosphorylated six-carbon sugars, such as:

1. Glucose-6-phosphate
2. Fructose-6-phosphate

These are central to carbohydrate metabolism. In plants, glucose-6-phosphate is used to form UDP-glucose, a key **precursor for Cellulose (a structural polysaccharide in plant cell walls) and Starch.**

So, Hexose phosphate is the direct precursor of Cellulose.

B. Pyruvate → (ii) Alanine

Pyruvate is the end product of glycolysis. It serves as a starting point for TCA cycle (aerobic respiration) and Amino acid biosynthesis. Through transamination, pyruvate is converted into Alanine (a non-essential amino acid)

The reaction:

Pyruvate + Glutamate → Alanine + α-ketoglutarate

(Enzyme: alanine aminotransferase)

So, Pyruvate is a direct precursor of Alanine.

C. Pentose phosphate → (iv) Nucleotides

The Pentose Phosphate Pathway (PPP) branches off glycolysis and produces NADPH (for biosynthesis) , Ribose-5-phosphate.

Ribose-5-phosphate is a pentose sugar and is the sugar backbone of RNA (ribose) and DNA (deoxyribose). It's used in synthesizing Purines and Pyrimidines and nucleotides like ATP, GTP, etc.

So, Pentose phosphate is a key precursor for Nucleotide biosynthesis.

D. Oxaloacetate → (i) Aspartate

Oxaloacetate (OAA) is a 4-carbon intermediate of the TCA cycle. Through transamination, OAA is converted into Aspartate (a key amino acid).

The reaction:

OAA + Glutamate → Aspartate + α-ketoglutarate

(Enzyme: aspartate aminotransferase)

Aspartate is also a precursor for other amino acids (e.g., lysine, threonine) and nucleotide synthesis (purine and pyrimidine rings)

So, the correct answer is b - A - iii, B - ii, C - iv, D - i

Q.95 **Young seedlings of Arabidopsis plants are exposed to the following light conditions:**

A. Far-Red light followed by Red light
B. Far-Red light followed by Red light and then Dark phase
C. Red light followed by Far-Red light
D. Dark phase followed by Far-Red light and then Red light
E. Far-Red light followed by Dark phase and then Red light
F. Red light followed by Dark phase and then Far-Red light

Which of the above conditions will lead to photomorphogenesis?

A. A, B and E
B. B and F
C. C and F
D. D, A and E

Answer: D

Sol: **Explanation-**

Photomorphogenesis - This is the light-mediated development in plants. In dark (skotomorphogenesis), seedlings are etiolated (long hypocotyl, closed cotyledons, no chlorophyll). In light (photomorphogenesis), seedlings develop short hypocotyls, open green cotyledons.
Phytochrome is a photoreversible pigment involved in red/far-red light perception It exists in two forms:

Form - Absorbs - Converts to - Function
Pr (inactive) - Red light (~660 nm) - Pfr - Accumulates in dark
Pfr (active) - Far-red light (~730 nm) - Pr - Triggers photomorphogenesis

Red light exposure converts Pr → Pfr → initiates photomorphogenesis
Far-red light exposure reverses Pfr → Pr → inhibits photomorphogenesis

Statement A - Far-Red light followed by Red light
Far-red converts all Pfr → Pr (inactive)
Then Red converts Pr → Pfr (active)
Final state = Pfr → **Photomorphogenesis occurs**

Statement B- Far-Red → Red → Dark
This results in minimal or no photomorphogenesis due to the degradation of Pfr in the dark phase following red light.
→ **No Photomorphogenesis occurs**

Statement C - Red light followed by Far-Red light
Red: Pr → Pfr (active)
Far-red: Pfr → Pr (inactive)
Final state = Pr → **No photomorphogenesis**

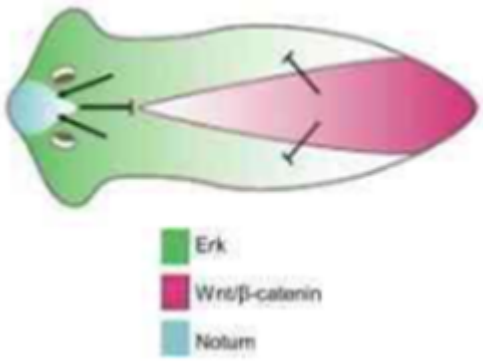
Statement D - Dark → Far-Red → Red
Initially in dark: mostly Pr
Far-red: nothing major happens (some Pfr → Pr if present)
Red: Pr → Pfr
Final state = Pfr → **Photomorphogenesis occurs**

Statement E - Far-Red → Dark → Red
Far-red: converts Pfr → Pr (inactive)
Dark: nothing changes
Red: Pr → Pfr
Final state = Pfr → **Photomorphogenesis occurs**

Statement F - Red → Dark → Far-Red
Red: Pr → Pfr
Dark: no change
Far-Red: Pfr → Pr
Final state = Pr → **No photomorphogenesis**

Correct Answer: Option d: A, D and E

Q.96 The interactions that maintain polarity during Planaria regeneration is shown in the figure below:



Following statements regarding these interactions were made:

A. When Notum expression is knocked down, the anterior facing blastema will still form a head.
B. When Notum is expressed in the posterior end, Planaria with two heads will be formed.
C. When Wnt pathway is blocked, the resulting Planaria will have heads on both the ends.
D. High levels of Erk inhibit head specification.

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

A. A and C
B. B and C
C. C and D

D. A and D

Answer: B

Sol: **Explanation-**

Planarians are flatworms with extraordinary regenerative abilities. If you cut them in half, they can regenerate both a head and a tail appropriately. This process involves polarity maintenance, meaning the body must "know" where the head and tail should be. This is regulated by interactions between three major components:

1. Wnt/β-catenin signaling – Promotes posterior (tail) fate
2. Notum – A Wnt inhibitor, allowing anterior (head) fate
3. Erk – A kinase pathway associated with regeneration onset and head formation

A. When Notum expression is knocked down, the anterior facing blastema will still form a head.

Incorrect

Notum is normally expressed at the anterior wound site. Its job is to inhibit Wnt signaling, which otherwise promotes tail identity. If Notum is knocked down, Wnt signaling remains active at the anterior, causing the blastema (regenerating tissue) to mistakenly form a tail instead of a head.

Result: Head fails to form, so this statement is false.

B. When Notum is expressed in the posterior end, Planaria with two heads will be formed.

Correct

Normally, the posterior end has active Wnt/β-catenin, leading to tail regeneration. If Notum is ectopically (artificially) expressed at the posterior, it inhibits Wnt signaling, which is necessary for tail identity. The posterior then takes on anterior identity and regenerates a head.

Results: Planarian with two heads — one at each end.

C. When Wnt pathway is blocked, the resulting Planaria will have heads on both the ends.

Correct

Wnt/β-catenin signaling is essential for tail formation. If the Wnt pathway is completely blocked (e.g., through β-catenin RNAi), the worm cannot form a tail, even at the posterior wound. In such cases, the posterior regenerates a head, just like the anterior.

Result: You get a planarian with two heads, which has been demonstrated in experiments.

D. High levels of Erk inhibit head specification.

Incorrect

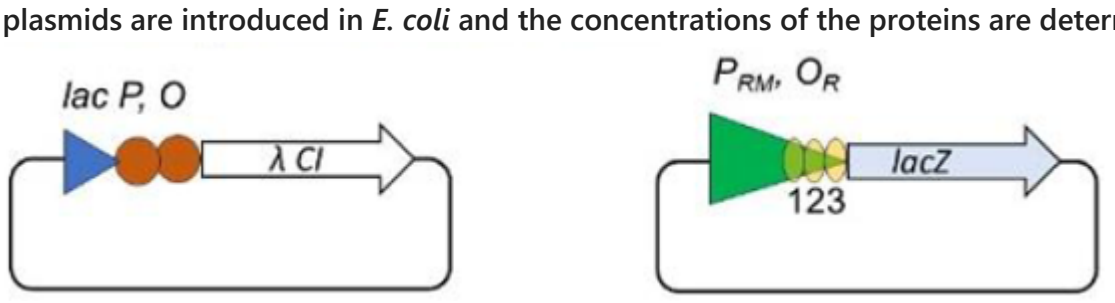
Erk (Extracellular signal-regulated kinase) is a part of the MAPK pathway, involved in wound response and regeneration. In planarians, **Erk is activated early during regeneration, particularly at the anterior wound, and is required for head formation. Blocking Erk leads to failure of head regeneration, not the other way around.

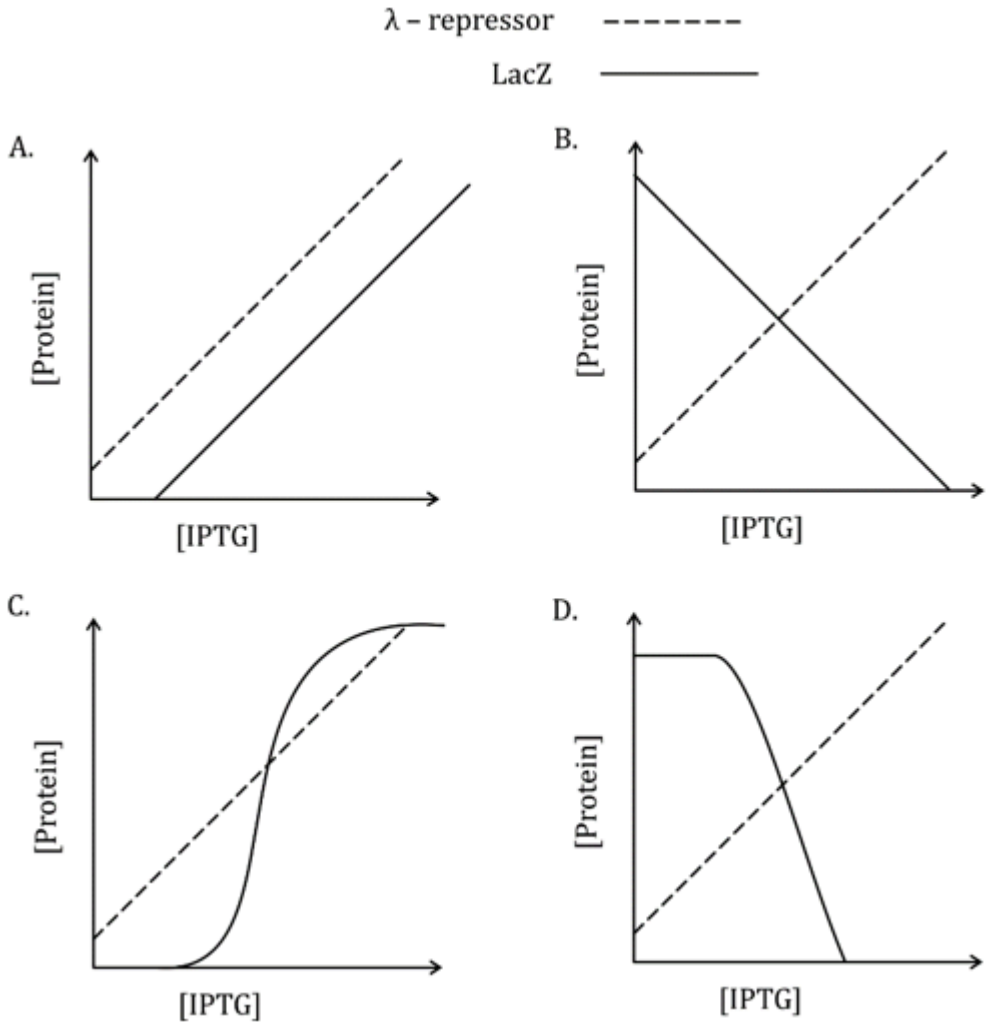
So, Erk promotes head specification, not inhibits it. Thus, this statement is false.

Statements B and C are correct.

So, the correct answer is option b - B and C

Q.97 **A lac-lambda hybrid system is developed to study the λ-repressor protein, in which the λ CI gene is under the control of *E. coli* lac promoter and operator, and the lacZ gene is under the control of λ-PRM promoter and OR operator of λ-phage. Both the plasmids are introduced in *E. coli* and the concentrations of the proteins are determined upon the addition of IPTG.**





Which graph correctly represents the expected results?

A. A
B. B
C. C
D. D

Answer: C

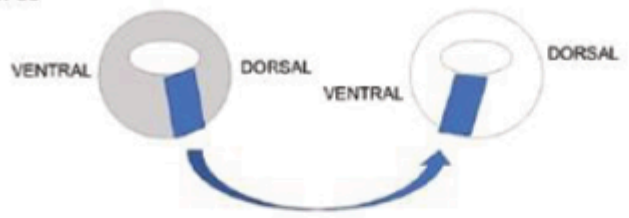
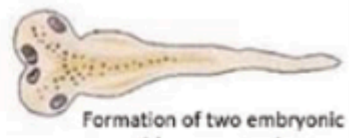
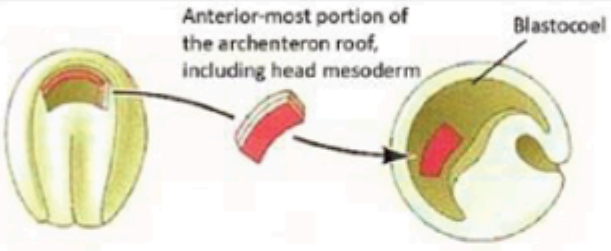
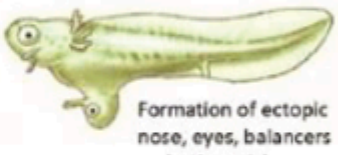
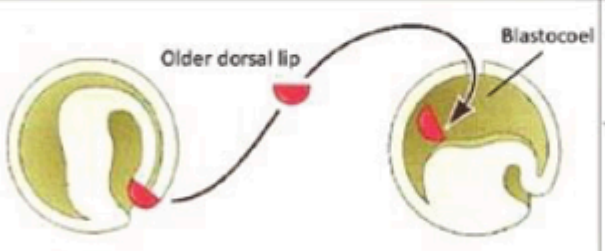
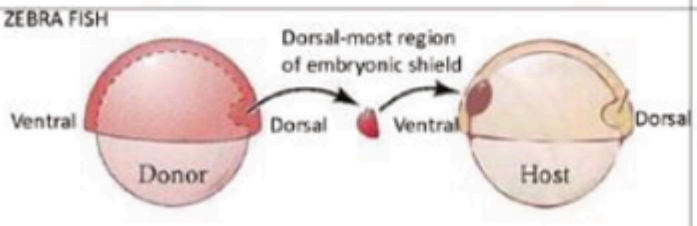
Sol: Explanation:

- **IPTG** induces the lac promoter controlling the **λ CI gene**, so **λ repressor protein levels increase** with increasing IPTG concentration (dashed line).
- As the λ repressor increases, it activates the λ-PRM promoter, increasing **lacZ expression** as well (solid line).
- This results in a **sigmoidal increase** in LacZ protein concurrent with increased λ repressor levels, depicted accurately by graph **C**.
- Graph D showing LacZ decreasing is incorrect since λ repressor here acts as an activator of the PRM promoter.

Information Booster:

- The lac promoter/operator is inducible by IPTG, which activates expression of the λ CI repressor in this system.
- The λ repressor can activate its own promoter (PRM), leading to increased lacZ expression in this hybrid construct.
- This system is used to study positive and negative regulation in gene expression.

Q.98 Given below are the outcomes of transplantation experiments.

	Transplantation experiment	Outcome
A.	XENOPUS 	 Formation of two embryonic axes with same anterior-posterior polarity
B.	NEWT 	 Formation of ectopic nose, eyes, balancers and otic vesicles
C.	NEWT 	 Formation of a secondary tail
D.	ZEBRA FISH 	 Formation of two embryonic axes with opposite anterior-posterior polarity

Which one of the following options correctly depicts the outcome of the transplantation experiments?

A. A and C
B. B and C
C. C and D
D. B and D

Answer: A

Sol: Explanation:

- **A is correct:** Transplantation of the **Xenopus dorsal lip** induces formation of **two embryonic axes with the same anterior-posterior polarity**, as the host and graft axes align.
- **C is correct:** The **older dorsal lip** in newts induces formation of a **secondary tail**, a classic developmental outcome.
- **B is incorrect:** The anterior archenteron roof does not induce ectopic head structures but contributes to early mesoderm formation.
- **D is incorrect:** Zebrafish dorsal shield transplantation results typically in two axes with **same**, not opposite, anterior-posterior polarity.

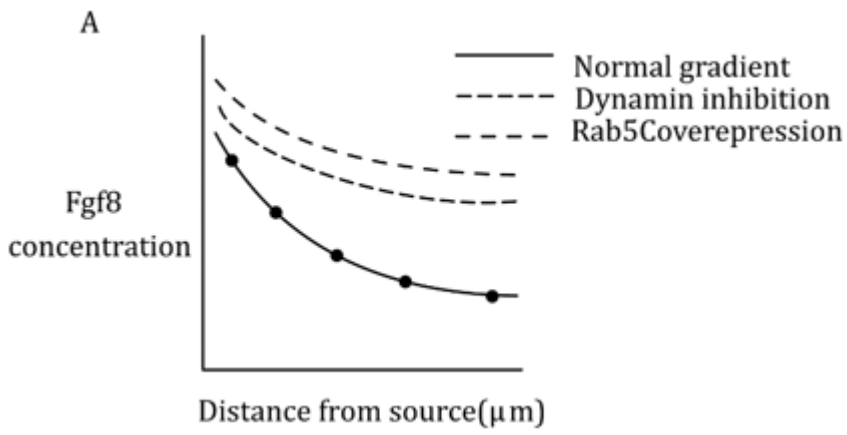
Information Booster:

- The **Spemann-Mangold organizer** in amphibians (dorsal lip) is a key structure inducing embryonic axis formation.
- Different stages of the dorsal lip have distinct inductive capacities; older dorsal lips induce tail structures.
- Zebrafish embryonic shield is functionally analogous to the amphibian organizer but experiments show polarity conservation.
- These experiments illustrate fundamental principles of embryonic induction and pattern formation.

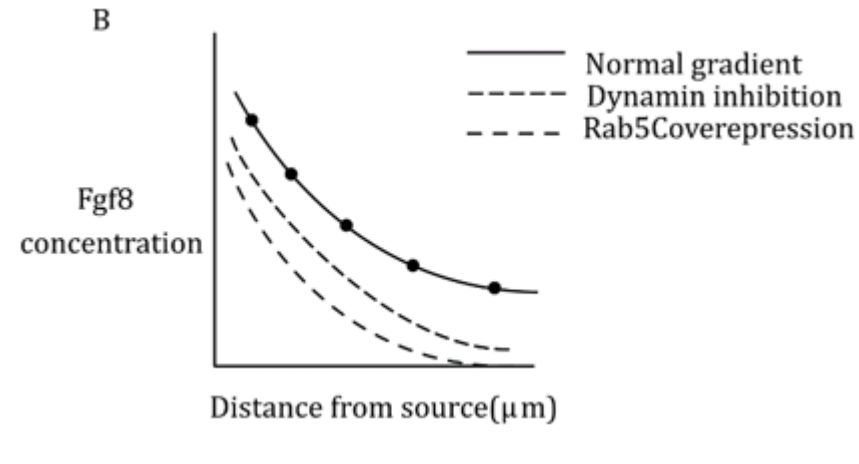
Q.99 **Gradient formation of Fgf8 is governed by both diffusion from a localized source and removal of Fgf8 ligand through endocytosis. Both Rab5C and dynamin promote endocytosis. What would happen to the Fgf8 concentration gradient when**

Rab5C is overexpressed or dynamin is inhibited?

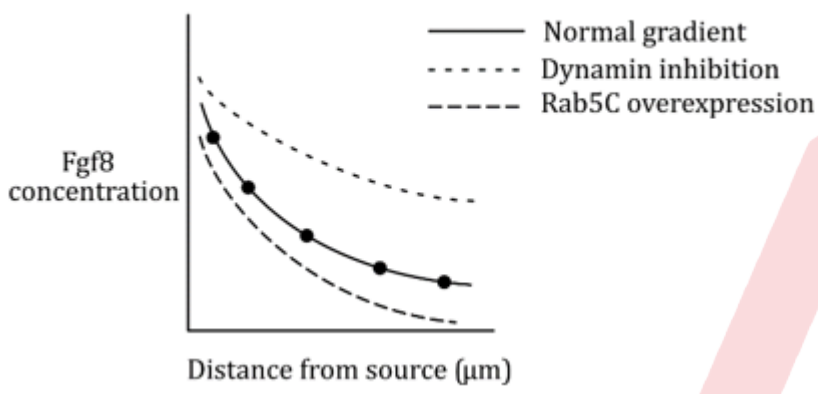
A



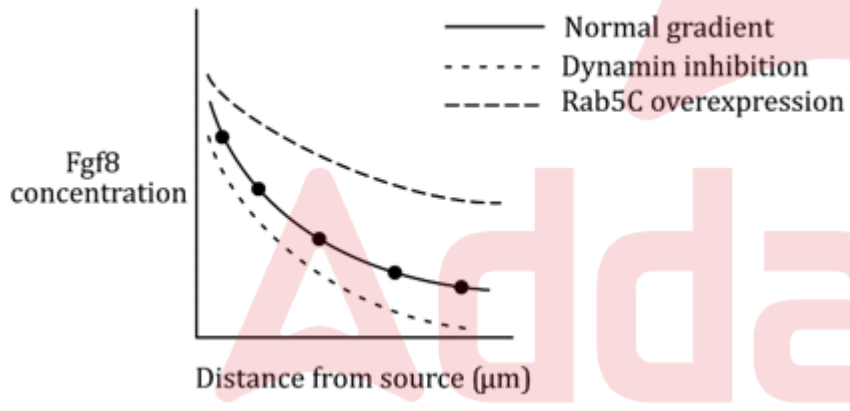
B



C



D



A. A
B. B
C. C
D. D

Answer: C

Sol: Sol.

- **Rab5C overexpression** enhances endocytosis, increasing removal of Fgf8 from the extracellular space, leading to a **steeper and lower concentration gradient**.
- **Dynamin inhibition** blocks endocytosis, reducing Fgf8 removal, resulting in a **flatter and higher concentration gradient**.
- Graph C correctly shows the **steeper gradient for Rab5C overexpression** and **flatter gradient for dynamin inhibition** compared to normal.

Information Booster:

- Fgf8 is a morphogen whose gradient is tightly regulated by synthesis, diffusion, and clearance (endocytosis).
- **Rab5C** is a small GTPase promoting endocytosis, enhancing ligand internalization and degradation.
- **Dynamin** is essential for vesicle scission during endocytosis; inhibiting dynamin decreases ligand uptake, causing accumulation.

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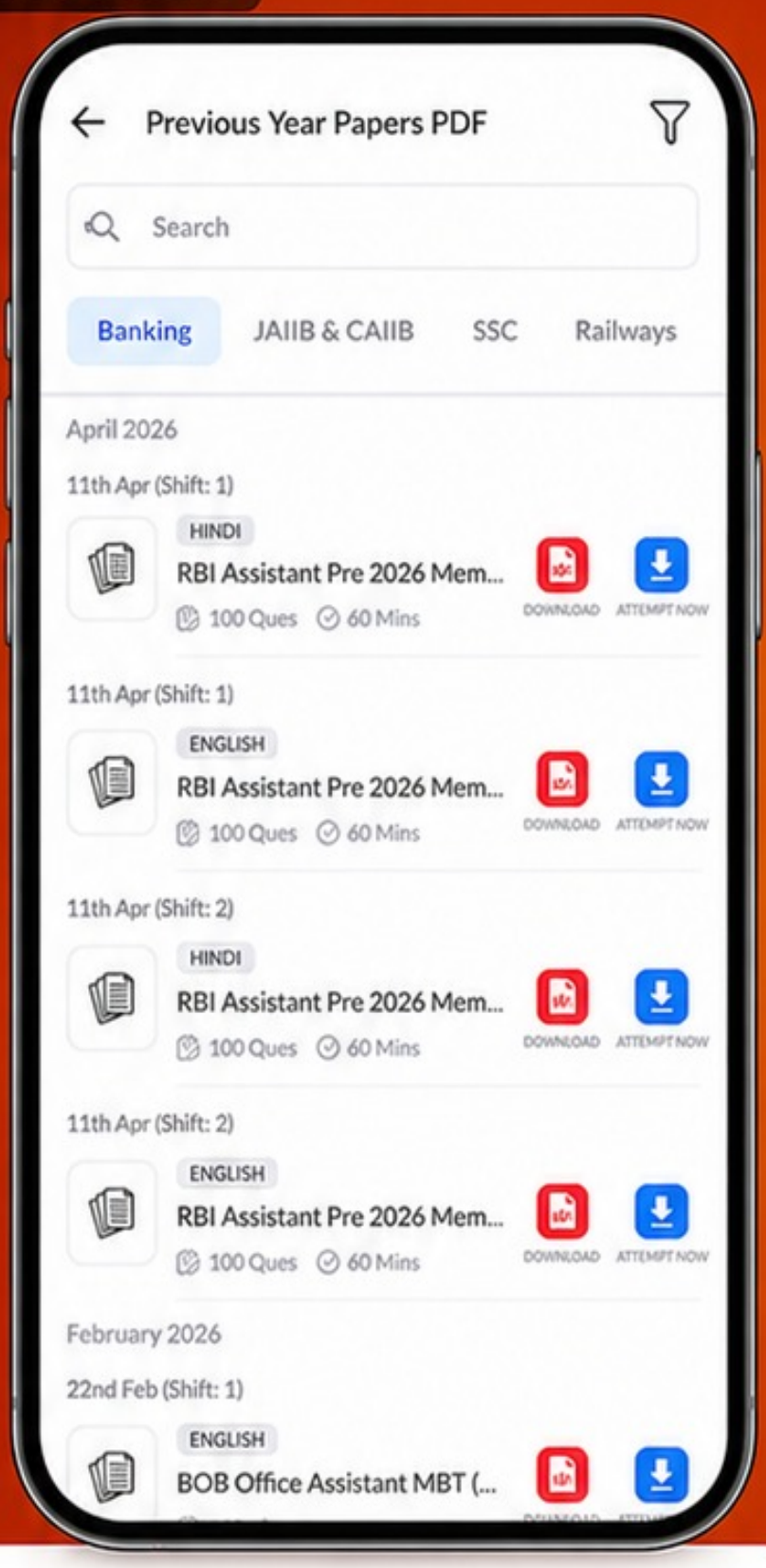

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- This regulation ensures precise spatial signaling during development.

Q.100 **ENZ function prevents premature differentiation of mouse neural stem cells. Kinase inhibitor treatment differentiates these cells prematurely. This is prevented if a specific serine-to-aspartate (S to D) mutation is introduced in ENZ. Based on this information, which one of the following statements is INCORRECT?**

A. The specific serine-to-aspartate substitution has the same effect as phosphorylation of ENZ on neural stem cell differentiation.
B. The specific serine may be the site of ENZ phosphorylation.
C. The serine-to-aspartate mutation is expected to yield the same results as an asparagine substitution.
D. The serine-to-aspartate mutation is expected to yield the same results as a glutamic acid substitution.

Answer: C

Sol: **Correct Answer**

(c) 3

Explanation:

Serine-to-aspartate substitutions are commonly used as phosphomimetic mutations because aspartate carries a negative charge similar to a phosphate group. Asparagine, however, is uncharged and cannot mimic phosphorylation. Therefore, a serine-to-asparagine substitution would not yield the same functional outcome.

Information Booster

· Phosphorylation adds negative charge that changes protein conformation and regulates activity.
· Aspartate and glutamate can partially mimic phosphorylation because of their acidic side chains.
· Neutral amino acids cannot reproduce phosphorylation-dependent signaling effects.

Additional Knowledge

(a) Correct: S→D often mimics the effect of phosphorylation on protein function.
(b) Correct: The serine residue is likely a phosphorylation site regulated by a kinase.
(d) Correct: Glutamic acid, like aspartate, is negatively charged and often behaves similarly in phosphomimetic substitutions.
