CSIR NET Life Science Questions Answers With Solutions

Q1. Extracellular matrix comprises various proteins and polysaccharides that assemble into an organized meshwork. This associates with the cells that produce them. Given below are a few statements regarding different components of the matrix:

A. Collagen is the major protein of the extracellular matrix and is a long, triple-stranded helical structure.

B. Hyaluronan, which is produced in large quantities during wound healing, is a type of glycosaminoglycan (GAG) that contains sulfated sugar and is covalently linked to the core protein.

C. Syndecans are plasma membrane proteoglycans that interact with the actin cytoskeleton and signaling molecules of the cell cortex.

D. Decorin is a small proteoglycan secreted by fibroblasts and contains 1-10 GAG chains.

Which one of the following options represents INCORRECT statement/s?

(a) C and D only

(b) B, C, and D

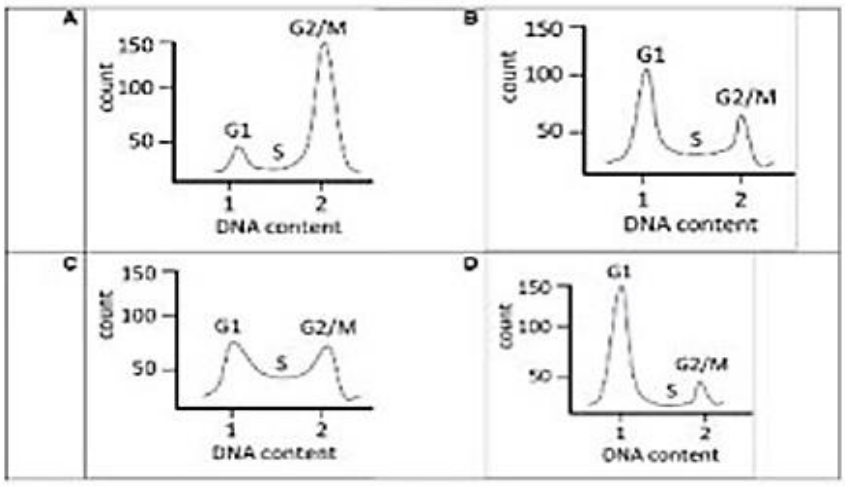
(c) A and B

(d) B only

Q2. Synchronous cultures of MCF7 breast cancer cells were grown and treated with the following:

1. MCF7 → Treated with buffer (Control group).
2. MCF7.1 → Treated with an inhibitor of Cyclin D.
3. MCF7.2 → Treated with siRNA designed against Cyclin B1.

After treatment, the cells were stained and sorted using flow cytometry. The relative amount of DNA in each of the three phases of the cell cycle (G1, S, G2/M) was plotted against the number of cells, as shown in the provided graphs (A, B, C, D).



Which one of the following options correctly represents the cell cycle states of MCF7, MCF7.1, and MCF7.2?

(a) MCF7-C; MCF7.1-D; MCF7.2-A

(b) MCF7-C; MCF7.1-A; MCF7.2-D

(c) MCF7-B; MCF7.1-D; MCF7.2-A

(d) MCF7-B; MCF7.1-A; MCF7.2-D

Q3. Apoptosis refers to programmed cell death that is triggered by specialized intracellular proteases called caspases. The intrinsic pathway of apoptosis:

A. depends on the activation of the Fas domain by the Fas ligand, which activates the DISC.

B. is regulated by the Bcl2 family of proteins.

C. consists of a key regulatory protein Apaf1, which is a water-soluble component of the electron transport chain.

D. recruits procaspase-9 into the apoptosome, and once activated, caspase-9 cleaves and activates downstream executioner caspases.

Which of the following combinations represents all correct statements?

(a) A, B, and D

(b) B, C, and D

(c) C and D only

(d) B and D only

Q4. In an experiment using nude mice, the population is divided into two groups, A and B.

- Group A mice are injected with T cells from normal mice.
- Group B mice are left untreated.
- Both groups are then immunized with LPS (Lipopolysaccharide).

Which one of the following statements regarding antibody production in groups A and B is most likely to be true?

(a) Both groups of mice will have very similar levels of antibody against LPS as it is a thymus-independent antigen.

(b) No immune response will be generated in both groups of mice as they lack thymus.

(c) Only Group A mice will have antibodies as T-independent antigens are dependent on T-cell activation.

(d) Only Group B mice will have antibodies because in Group A mice, the presence of T cells will interfere with the production of antibodies against the T-independent antigen.

Q5. Several extracellular mechanisms lead to intracellular changes to regulate stem cell behavior during development. Based on this, which one of the following statements is NOT true?

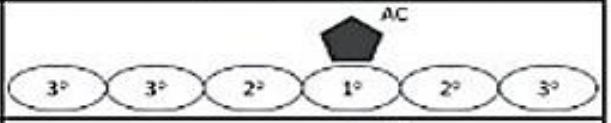
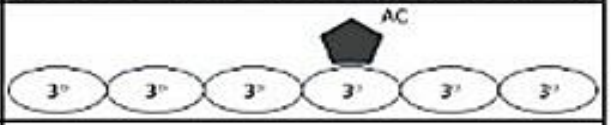
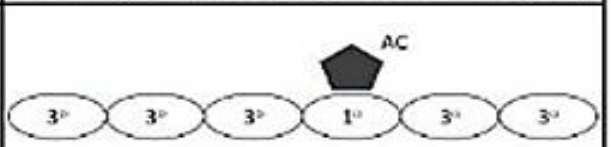
(a) Structural and adhesion factors in the extracellular matrix support cellular architecture of the stem cell niche.

(b) Different patterns of chromatin accessibility influence gene expression related to stem cell behavior.

(c) Partitioning of cytoplasmic determinants distributes factors determining cell fate evenly into daughter cells during asymmetric division.

(d) Secreted proteins from surrounding cells by autocrine, paracrine, or juxtacrine mechanisms often maintain stem cells in an uncommitted state.

Q6. By expressing the EGF-like ligand LIN-3, the *C. elegans* anchor cell (AC) directly triggers vulval development. LIN-3 acts at a distance and has a graded action. The levels of LIN-3 can be controlled by using various genetic techniques.

Strain/condition (I)		VPC cell fate (II)	
A.	Wild type worms grown on empty vector RNAi	I.	
B.	*lin*-3 mutant with a stop codon in exon 3	II.	
C.	Wild type worms grown on *lin*-3 RNAi	III.	
D.	Wild type worms expressing a multi-copy extrachromosomal array of *lin*-3 gene	IV.	

Which one of the following options correctly matches Column I and Column II?
(a) a-ii, b-iii, c- iv, d- i
(b) a-ii, b-iv, c-i ,d-iii
(c) a-iv, b-i, c-ii, d- iii
(d) a-iii, b-iv, c-i, d-ii

Q7. Given below are statements about development in different model organisms:
A. *Xenopus* egg has yolk and hence undergoes meroblastic cleavage.
B. Embryonically transcribed β-catenin in the blastomeres of sea urchin embryos regulates the autonomous specification of micromeres.
C. The sodium pump activity in the trophoblast helps in the formation of the blastocoel of a mammalian blastocyst.
D. Prevention of tubal pregnancy is one of the major functions of the zona pellucida in humans.
Which combination of the statements is true?
(a) A and B
(b) A and C
(c) B and D
(d) C and D

Q8. The following statements pertain to limb development in chick. Each statement describes an experiment and the expected outcome.
A. Targeted loss of retinoic acid synthesis in the forelimb causes a reduction of Tbx4 expression and the failure to form forelimbs.
B. When Fgf10-secreting beads are placed at a somite level that induces a limb bud expressing Tbx5 in the anterior and Tbx4 in the posterior part, a chimeric limb can be formed.
C. Constitutive activation of FGF receptors results in the loss of the forelimb field, demonstrating that expression of Fgf8 functions to inhibit forelimb development.
Which one of the following option(s) is/are correct?
(a) A only
(b) B only
(c) A and B
(d) B and C

Q9. The mechanism of primary sex determination is best known in Drosophila and mammals. Given below are statements regarding sex determination in these two model systems:
A. In *Drosophila*, if Sry gene product is present, it may block β-catenin signaling and, along with SF1, activate the Sox9 gene.
B. In mammals, alternate splicing of Sxl transcript that removes a stop codon and allows the formation of a functional protein is responsible for initiating female sex determination.
C. A trans-splicing event in Tra transcript results in the formation of functional Tra protein in *Drosophila*.
D. XO individuals in *Drosophila* are males, while XXY individuals are females.
Which of the above statements are correct?
(a) A, B, and C
(b) D only
(c) C and D
(d) B only

Q10. The following statements describe the developmental processes during different modes of reproduction in angiosperms:
A. In double fertilization, one sperm fuses with the egg and the other with the central cell to form the zygote and endosperm, respectively.
B. In sporophytic apomixis, a diploid cell gives rise to the next generation, thereby maintaining the maternal genotype.
C. In gametophytic apomixis, a reduced egg cell forms an apomictic embryo through parthenogenesis.
D. In pseudogamy, the functional endosperm is formed without fertilization.
Which one of the following represents the combinations of CORRECT statements?
(a) A and B
(b) B and C
(c) B and D
(d) C and D

Q11. Given below are certain statements regarding light absorption by the chlorophyll pigment molecule in a green leaf:
A. The absorption of a photon by a pigment molecule converts it from its lower state to an excited state.
B. Internal conversions or relaxations of pigments convert higher excited states to the lowest excited state, with a concomitant loss of energy as heat.
C. The light re-emitted from the lowest excited state of the chlorophyll molecule is fluorescence.
D. Red light absorption by the chlorophyll molecule results in a higher excitation state relative to blue light absorption.
Which one of the following combinations is correct?
(a) A, B, and C
(b) A, B, and D
(c) B, C, and D
(d) A, C, and D

Q12. Photorespiration or the C2 cycle takes place in three distinct organelles in plant cells: the chloroplast, peroxisome, and mitochondrion. The following statements relate to the C2 cycle:
A. Reduced ferredoxin and ATP are required for photorespiration and assimilation of the resulting NH_3.
B. Photosynthetic electron transport provides energy-rich ATP and NADPH for photorespiration.
C. Glutamate is translocated from the chloroplast to the peroxisome, while α-ketoglutarate is translocated from the peroxisome to the chloroplast.
D. The action of the enzyme serine hydroxymethyltransferase takes place in the peroxisome.
Which one of the following combinations contains all correct statements?
(a) A and B
(b) A and C
(c) B and C
(d) B and D

Q13. Stomata detached from the epidermis of common dayflower (*Commelina communis*) were treated with saturating photon fluxes of red light. After 2 hours, the same stomata, under the background of red light, were also illuminated with blue light.
Which one of the following statements regarding opening of stomatal apertures is true?
(a) The red light illumination will saturate stomatal opening, and blue light illumination will have no effect on it.
(b) The red light illumination will not result in the opening of stomata, and they will open only upon perceiving blue light.
(c) The blue light illumination will increase the level of stomatal opening above the saturation level of stomatal opening by red light illumination.
(d) The blue light illumination will result in closing of the stomata opened due to red light illumination.

Q14. Apoplast phloem loading is determined by the cellular location and transport function of membrane-bound proteins. The following statements describe these proteins:
A. SWEETs are the sugar transporter proteins and are capable of transporting only sucrose and not glucose.
B. Double mutants of Arabidopsis SWEET11 and SWEET12 result in carbohydrate accumulation in the source leaves and slower export of photoassimilates.
C. H^+-symport mechanism loads sucrose or polyols into Sieve Element (SE)/Companion Cell (CC) complexes.
D. Several clades of sucrose/H^+ symporters (SUTs or SUCs) are localized to plasma membranes of minor vein SE/CCs and participate in apoplastic loading.
Which one of the following combinations is correct?
(a) A, B, and C
(b) A, B, and D
(c) B, C, and D
(d) A, C, and D

Q15. A researcher had inoculated the bottom leaves of a wild-type tobacco plant with tobacco ringspot virus (TRSV) and made the following statements regarding the disease after 23 days post-inoculation.
A. Strong ringspot symptoms develop on the lower leaves.
B. The ringspot symptoms are higher on the upper leaves.
C. The top leaves have no viral symptoms.
D. The top leaves are immune to secondary infection by the same virus.
Choose the option with all correct statements:
(a) A, C, and D
(b) B and D only
(c) A and B only
(d) C and D only

Q16. Given below are the list of plant hormones (Column X) and their biosynthesis precursors (Column Y).

Column X (Plant Hormones)	Column Y (Biosynthesis Precursors)
A. Auxins	i. Geranylgeranyl diphosphate
B. Cytokinins	ii. Adenosine moiety
C. Ethylene	iii. Tryptophan
D. Gibberellins	iv. 1-aminocyclopropane 1-carboxylic acid

Which one of the following options represents the correct match between Column X and Y?
(a) A – i; B – ii; C – iii; D – iv
(b) A – iii; B – i; C – iv; D – ii
(c) A – iii; B – ii; C – iv; D – i
(d) A – iii; B – ii; C – iv; D – i

Q17. The structure and process of formation of different antigens in the blood ABO system are given in the following statements:
A. Galactose is added to the terminal of H-antigen by a transferase expressed in individuals with type A blood.
B. The B antigen is formed by a transferase expressed in individuals with type B blood, which adds a terminal N-acetylgalactosamine to H-antigen.
C. The H-antigen is formed by fucose transferase, which adds a terminal fucose to its precursor.
D. The H-antigen is the precursor of both A- and B-antigens, and it is the blood group antigen in persons of type O blood.
Which one of the following options represents the correct combination of statements?
(a) A and B
(b) B and C
(c) C and D
(d) A and D

Q18. The characteristic features and causes of different heart sounds during a cardiac cycle of humans are given in the following statements:
A. The second heart sound is loud and sharp when the diastolic pressure is decreased in the aorta or pulmonary artery.
B. Sudden closure of atrioventricular (AV) valves at the start of ventricular systole causes vibration that produces the first heart sound.
C. The second heart sound is caused by the vibration associated with the closure of aortic and pulmonary valves after the end of ventricular systole.
D. The first heart sound is soft when heart rate is low, as the ventricles are well filled with blood and the leaflets of AV valves float together before systole.
Which one of the following options represents the combination of all correct statements?
(a) A, B, and C
(b) B and C only
(c) B, C, and D
(d) A and D only

Q19. The sensory nerve fibers (Column X) and the sensory receptors connected to different sensory nerves (Column Y) are given below.

Column X (Sensory nerve fibre)	Column Y (Sensory receptor)
A. Ia	i. Muscle spindle, flower spray ending
B. Ib	ii. Pain and cold receptor
C. II	iii. Muscle spindle, annulo-spiral ending
D. III	iv. Golgi tendon organ

Which 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 - iii, C - iv, D - i**
(c) **A - iii, B - iv, C - i, D - ii**
(d) **A - iv, B - i, C - ii, D – iii**

Q20. Certain statements are put forth on the regulation of renal blood flow and are given below:
A. Norepinephrine dilates the renal vessels.
B. Dopamine causes renal vasodilation and natriuresis.
C. Angiotensin II exerts a constrictor effect.
D. Prostaglandins decrease blood flow in the renal cortex and increase it in the medulla.
E. Acetylcholine produces renal vasodilation.
Choose the option with the combination of all correct statements.
(a) A, B, and D
(b) B, C, and D
(c) B, C, and E
(d) A, C, and E

Solutions

S1. Ans.(d)
Sol. B only
Explanation:

- **Statement A (Correct)**
  - **Collagen is the most abundant structural protein in the extracellular matrix (ECM).**
  - **It forms a triple-stranded helical structure that provides mechanical strength and elasticity.**
- **Statement B (Incorrect)**
  - **Hyaluronan (Hyaluronic acid) is a glycosaminoglycan (GAG), but it is NOT sulfated and does NOT attach to a core protein like other GAGs.**
  - **Unlike other GAGs, hyaluronan is synthesized directly at the plasma membrane, instead of being synthesized in the Golgi and secreted.**
- **Statement C (Correct)**
  - **Syndecans are transmembrane proteoglycans (not just plasma membrane-associated).**
  - **They interact with the actin cytoskeleton and various signaling molecules, helping in cell adhesion, migration, and growth factor binding.**
- **Statement D (Incorrect)**
  - **Decorin is a small leucine-rich proteoglycan that plays a role in collagen fibril formation and regulation of cell growth.**
  - **However, it typically contains only one GAG chain, not 1–10.**

Since the only incorrect statement is B, the correct answer is option (d) B only.
Information Booster:

1. Collagen provides tensile strength to tissues like bones, tendons, and skin.
2. Hyaluronan is important for tissue hydration and lubrication, especially in joints.
3. Syndecans play a role in cell-matrix adhesion and signal transduction.
4. Decorin regulates collagen fibril spacing and influences cell proliferation.
5. Glycosaminoglycans (GAGs) like chondroitin sulfate and heparan sulfate attach to core proteins to form proteoglycans, except hyaluronan.
6. Proteoglycans contribute to hydration, resilience, and biochemical signaling in tissues.

S2. Ans.(b)
Sol. MCF7-C; MCF7.1-A; MCF7.2-D
Step 1: Understanding the Flow Cytometry Plots

- **G1 Phase (Low DNA content, Peak at 1 unit DNA content)**
  - Indicates cells are arrested before DNA replication.
- **S Phase (Intermediate DNA content)**
  - Represents cells actively replicating DNA.
- **G2/M Phase (High DNA content, Peak at 2 units DNA content)**
  - Indicates cells preparing for mitosis or undergoing division.

Step 2: Identifying the Control Group (MCF7 - Buffer Treated)

- MCF7 is the control group, meaning its cell cycle profile should show a normal distribution of G1, S, and G2/M phases.
- Graph C represents a normal cell cycle pattern.
- **Thus, MCF7 corresponds to Graph C.**

Step 3: Effect of Cyclin D Inhibition (MCF7.1)

- Cyclin D promotes the transition from G1 to S phase.
- Inhibiting Cyclin D should cause G1 arrest, meaning most cells accumulate in G1 with a reduction in S-phase and G2/M cells.
- Graph A shows a strong G1 arrest, which matches this expectation.
- **Thus, MCF7.1 corresponds to Graph A**.

Step 4: Effect of Cyclin B1 Knockdown (MCF7.2)

- Cyclin B1 is essential for the G2/M transition.
- Inhibiting Cyclin B1 should cause G2/M arrest, meaning cells accumulate at G2/M with fewer in G1 and S phase.
- Graph D shows a G2/M block, meaning cells are arrested in the G2/M phase.
- **Thus, MCF7.2 corresponds to Graph D**.

S3. Ans.(d)

Sol. B and D only

Explanation:

Apoptosis occurs through two main pathways:

1. **Extrinsic Pathway** (Death Receptor-Mediated)
   - Initiated by the binding of death ligands (e.g., Fas ligand) to **death receptors (Fas, TNF receptors)** on the cell surface.
   - Leads to the formation of the **Death-Inducing Signaling Complex (DISC)**, which activates **caspase-8**, triggering downstream caspase activation.
2. **Intrinsic Pathway** (Mitochondrial Pathway)
   - Regulated by **Bcl2 family proteins** (e.g., Bcl2, Bax, Bak).
   - Involves **mitochondrial outer membrane permeabilization (MOMP)**, leading to **cytochrome c release**.
   - Cytochrome c binds to **Apaf1**, forming the **apoptosome**, which **activates caspase-9**, further activating **executioner caspases (caspase-3, -7)**.

Evaluation of Statements:

- **Statement A (Incorrect)**
  - This describes the **extrinsic pathway**, where the Fas ligand binds to Fas receptors and activates **DISC (Death-Inducing Signaling Complex)**.
  - The intrinsic pathway is **not dependent** on Fas-FasL interactions.
- **Statement B (Correct)**
  - The intrinsic pathway is tightly regulated by the **Bcl2 family of proteins**.
- **Statement C (Incorrect)**
  - **Apaf1** is indeed a key regulatory protein in the apoptosome.
  - However, **it is NOT part of the electron transport chain (ETC)**; instead, **cytochrome c** is the ETC component released from mitochondria during apoptosis.
- **Statement D (Correct)**
  - Once **cytochrome c binds to Apaf1**, it forms the **apoptosome**, which recruits **procaspase-9**.
  - Activated **caspase-9** then **cleaves and activates executioner caspases** (caspase-3, -7), leading to **apoptotic cell death**.

Thus, the **correct answer is (d) B and D only.**

Information Booster:

1. **Caspases (Cysteine Aspartate Proteases)**:
   - Initiator caspases: **Caspase-8 (extrinsic), Caspase-9 (intrinsic)**
   - Executioner caspases: **Caspase-3, Caspase-7**
2. **Bcl2 Family Proteins:**
   - **Pro-apoptotic:** Bax, Bak, Bid
   - **Anti-apoptotic:** Bcl2, Bcl-xL
3. **Apoptosome Formation (Intrinsic Pathway):**
   - **Cytochrome c + Apaf1 + ATP** → Apoptosome formation
   - **Procaspase-9 activation** → **Caspase-9 activation**
   - Activation of executioner caspases → **Apoptosis**
4. **Extrinsic vs. Intrinsic Apoptosis:**
   - **Extrinsic pathway:** Death receptors (Fas, TNF) activate **caspase-8** via DISC.
   - **Intrinsic pathway:** Mitochondrial stress leads to **cytochrome c release**, activating **caspase-9**.

S4. Ans.(a)

Sol. Both groups of mice will have very similar levels of antibody against LPS as it is a thymus-independent antigen.

Explanation:

1. Nude mice lack a thymus
   - Nude mice (Foxn1^nu/nu) have a genetic mutation that causes thymic aplasia, meaning they lack mature T cells due to an absent thymus.
   - This impairs their T-dependent immune responses (B cell activation requiring T-cell help).
2. LPS (Lipopolysaccharide) is a T-independent antigen
   - Thymus-independent (TI) antigens can stimulate B cells without T-cell help.
   - LPS is a TI-1 antigen (Thymus-Independent Type 1), meaning it can directly activate B cells, even in mice lacking T cells.
3. Effect of T-cell transfer on LPS response
   - Group A (with T-cell injection): T cells are present but not required for an LPS response.
   - Group B (without T-cell injection): B cells alone are sufficient to respond to LPS.
   - Since LPS does not require T cells, both groups should show similar antibody responses.
4. Analysis of Answer Choices:
   - (a) Correct → Both groups will produce similar antibody levels since LPS is a thymus-independent antigen.
   - (b) Incorrect → Even though these mice lack a thymus, thymus-independent responses still occur.
   - (c) Incorrect → TI antigens do not require T-cell activation (contradictory statement).
   - (d) Incorrect → The presence of T cells does not interfere with the production of antibodies against a T-independent antigen.

Information Booster:

1. Thymus-Independent Antigens (TI Antigens)
   - TI-1 Antigens: Activate B cells via Toll-like receptors (TLRs), e.g., LPS (binds TLR4).
   - TI-2 Antigens: Activate B cells via cross-linking of B-cell receptors (BCRs), e.g., polysaccharides from bacterial capsules.

2. Role of B Cells in T-Independent Responses
   - Marginal zone B cells (MZ B cells) and B1 B cells respond well to TI antigens.
   - Antibody response is mainly IgM, with minimal class switching (since T-cell help is required for switching to IgG, IgA).
3. T-Dependent vs. T-Independent Responses
   - T-Dependent (TD) Antigens: Require T-cell help (e.g., proteins, vaccines).
   - T-Independent (TI) Antigens: Do not require T cells (e.g., LPS, polysaccharides).

S5. Ans.(c)

Sol. Partitioning of cytoplasmic determinants distributes factors determining cell fate evenly into daughter cells during asymmetric division.

Explanation:

1. Understanding Asymmetric Division in Stem Cells
   - Stem cells can divide asymmetrically to generate:
     - One self-renewing stem cell.
     - One differentiating daughter cell.
   - During asymmetric division, cytoplasmic determinants (mRNA, proteins, organelles) are distributed unequally, leading to different cell fates.
2. Statement (3) is Incorrect
   - It states that cytoplasmic determinants are distributed "evenly" during asymmetric division.
   - However, asymmetric division involves unequal distribution, where only one daughter cell inherits specific determinants that drive differentiation.
   - This incorrect claim contradicts the fundamental principle of asymmetric cell fate decisions in stem cells.

Evaluation of Other Statements:

- Statement (1) - Correct
  - Extracellular matrix (ECM) components (collagen, laminins, fibronectins) play a crucial role in stem cell adhesion, signaling, and niche architecture.
  - The stem cell niche provides structural support and signaling cues essential for maintaining stem cell function.
- Statement (2) - Correct
  - Chromatin accessibility determines which genes are accessible for transcription, regulating stem cell differentiation vs. self-renewal.
  - Epigenetic modifications (e.g., histone acetylation, DNA methylation) alter chromatin structure and control stem cell fate.
- Statement (4) - Correct
  - Stem cells receive signals from neighboring cells via:
    - Autocrine signaling (self-produced signals).
    - Paracrine signaling (local diffusible factors).
    - Juxtacrine signaling (direct cell-to-cell contact).
  - These signals help maintain stem cells in an undifferentiated/pluripotent state until differentiation is required.

Information Booster:

1. Stem Cell Niche:
   - The microenvironment where stem cells reside, providing physical support and regulatory signals.
   - Examples: Hematopoietic stem cell niche (bone marrow), Neural stem cell niche (brain).

2. Asymmetric vs. Symmetric Stem Cell Division:
   - Asymmetric Division: Produces one self-renewing stem cell and one committed daughter cell.
   - Symmetric Division: Produces either two stem cells or two differentiated cells.
3. Cytoplasmic Determinants in Asymmetric Division:
   - Includes mRNAs, proteins (e.g., Numb, Prospero in Drosophila), and organelles (e.g., mitochondria).
   - These factors are preferentially inherited by one daughter cell, influencing differentiation.
4. Epigenetic Regulation of Stem Cells:
   - Histone modifications: Acetylation (active genes), Methylation (silencing).
   - DNA methylation: Silences differentiation genes in pluripotent stem cells.

S6. Ans.(a)
Sol. a-ii, b-iii, c- iv, d- i
Explanation:
1. Wild-type worms grown on empty vector RNAi (A →ii)
- Normal LIN-3 levels.
- Standard vulval development pattern:
  (3° - 2° - 1° - 2° - 3°).
- Corresponds to VPC fate I.

2. *lin-3* mutant with a stop codon in exon 3 (B → iii)
- No functional LIN-3 protein → No vulval induction.
- All VPCs adopt 3° fate (remain as epidermal cells).
- Corresponds to VPC fate III (Vulvaless phenotype).

3. Wild-type worms grown on *lin-3* RNAi (C → iv)
- Reduced LIN-3 levels.
- Insufficient LIN-3 to trigger normal differentiation.
- Most VPCs remain 3° fate → Similar to LIN-3 knockout.
- Corresponds to VPC fate IV.

4. Wild-type worms expressing a multi-copy extrachromosomal array of *lin-3* gene (D → i)
- Excess LIN-3 expression → Stronger induction.
- More VPCs adopt 1° and 2° fates → Extra vulval formation.
- Corresponds to VPC fate II.

Information Booster:
Condition A - In wild-type *C. elegans* grown on empty vector RNAi, there is no knockdown or mutation affecting LIN-3 expression, meaning LIN-3 is present at normal physiological levels. This results in the standard pattern of vulval precursor cell (VPC) differentiation.
Condition B - If *C. elegans* carries a lin-3 mutant with a stop codon in exon 3, it means LIN-3 protein will not be produced due to premature translation termination. As a result, there will be no LIN-3 signaling from the anchor cell (AC), leading to a failure in vulval precursor cell (VPC) induction.
Condition C- When wild-type *C. elegans* worms are treated with LIN-3 RNAi, the expression of LIN-3 is significantly reduced due to RNA interference. This leads to a decrease in LIN-3 signaling from the anchor cell (AC), which affects vulval precursor cell (VPC) differentiation. Since RNAi decreases LIN-3 levels, VPCs do not receive sufficient signaling to differentiate properly. most VPCs remain undifferentiated as 3° cells, forming epidermal tissue instead of vulval cells .
Condition D - If wild-type *C. elegans* overexpress LIN-3 using a multi-copy extrachromosomal array, the levels of LIN-3 increase significantly. This leads to stronger signaling from the anchor cell (AC), which affects vulval precursor cell (VPC) differentiation. more VPCs adopt 1° and 2° fates, leading to excess vulval formation (Muv phenotype).

S7. Ans.(d)
Sol. C and D
Explanation:
Statement A: Incorrect

- ***Xenopus* eggs have yolk, but they undergo holoblastic (not meroblastic) cleavage.**
- Holoblastic cleavage occurs when the entire egg divides, though unevenly due to yolk presence.
- Meroblastic cleavage occurs when only part of the egg divides (e.g., in birds and fish).

Statement B: Incorrect
Embryonically transcribed β-catenin in the blastomeres of sea urchin embryos regulates the autonomous specification of micromeres.

- β-catenin itself does not directly regulate autonomous specification in sea urchin micromeres. Instead, it is a key player in conditional specification and later mesodermal and endodermal lineage specification.

Statement C: Correct
The sodium pump activity in the trophoblast helps in the formation of the blastocoel of a mammalian blastocyst.

- the formation of the blastocoel in a mammalian blastocyst is driven by sodium (Na^+) and water transport through the trophoblast (specifically, the trophectoderm layer).

Statement D: Correct

- The **zona pellucida (ZP)** prevents **polyspermy and ectopic (tubal) pregnancy**.
- The ZP hardens after fertilization to **prevent further sperm entry** (cortical reaction).
- It **keeps the fertilized egg from implanting too early**, ensuring it reaches the uterus before attachment.

Information Booster

- **Cleavage in *Xenopus*** → Holoblastic cleavage, not meroblastic, as cleavage occurs throughout the egg despite yolk presence.
- **β-Catenin in Sea Urchins** → Regulates mesoderm and endoderm fate, but micromere specification is controlled by maternal factors (Disheveled, Pmar1), not embryonically transcribed β-catenin.
- **Sodium Pump in Trophoblast** → Na^+/K^+ ATPase in the trophectoderm creates an osmotic gradient, drawing water into the blastocoel, essential for blastocyst formation.
- **Zona Pellucida in Humans** → Prevents polyspermy, regulates sperm binding, and prevents premature implantation (reducing risk of tubal pregnancy).

S8. Ans.(d)
Sol. B and C
Explanation:
Statement A- Retinoic Acid (RA) and Limb Initiation

- RA is required for forelimb formation by inducing Tbx5 expression.
- Tbx4 specifies hindlimb identity, not forelimbs → Statement A is incorrect because it links RA to Tbx4 instead of Tbx5.

Statement B- Fgf10 and Limb Bud Formation

- Fgf10 is essential for initiating limb formation by activating limb bud outgrowth.
- When Fgf10 beads are placed at an intermediate somite level, Tbx5 (forelimb) and Tbx4 (hindlimb) are co-expressed, leading to chimeric limb formation → Statement B is correct.

Statement C- Fgf8 and Limb Field Inhibition

- Fgf8 inhibits RA signaling, which is necessary for Tbx5 expression and forelimb initiation.
- Overactivation of FGF receptors represses RA, leading to forelimb loss → Information Booster:

Information Booster:

- Retinoic Acid (RA) is essential for forelimb formation by inducing Tbx5 expression.
- Fgf10 is a key inducer of limb bud formation.
- Fgf8 inhibits forelimb development by repressing RA signaling.

S9. Ans.(b)

Sol. D only

Explanation:

Statement A: Incorrect

- **Sry (Sex-determining region Y)** is present in **mammals, not *Drosophila***.
- In **mammals**, Sry activates **Sox9**, leading to **male development**, but this pathway does not exist in *Drosophila*.

Statement B: Incorrect

- In **Drosophila**, **Sex-lethal (Sxl)** determines female sex by controlling **Transformer (Tra) splicing**.
- However, **in mammals, sex determination is driven by Sry and Sox9, not Sxl**.

Statement C: Incorrect

- In *Drosophila*, **Sex-lethal (Sxl) activates Transformer (Tra) via alternative splicing** (not by trans-splicing)
- Functional Tra activates Doublesex (Dsx), leading to female development.

Statement D: Correct

- In *Drosophila*, **sex is determined by the X-to-autosome (X:A) ratio**, not by sex chromosomes alone.
  - **XO individuals (X:A = 0.5) are males** because they have a single X chromosome.
  - **XXY individuals (X:A = 1.0) are females** because they have two X chromosomes.

Information Booster:

Sex Determination in *Drosophila*

- Based on the X-to-autosome (X:A) ratio, not sex chromosomes.
- XX (X:A = 1.0) → Female, XO (X:A = 0.5) → Male.
- Sxl (Sex-lethal) gene controls female development by activating Tra (Transformer) via alternative splicing.

Sex Determination in Mammals

- Controlled by the Sry gene on the Y chromosome, which activates Sox9, leading to testis development.
- XX → Female, XY → Male.
- Tra is activated by alternative splicing, not trans-splicing.

Trans-splicing occurs in organisms like trypanosomes, not in *Drosophila*.

S10. Ans.(a)

Sol. A and B

Explanation:

Statement A : Correct (Double Fertilization)

Double fertilization in angiosperms involves one sperm fertilizing the egg to form the zygote, while the second sperm fertilizes the central cell to form the triploid endosperm.

Statement B: Correct (Sporophytic Apomixis)

- Sporophytic apomixis (also called adventitious embryony) occurs when a diploid somatic cell in the ovule (e.g., nucellus or integuments) directly develops into an embryo.
- This results in a clone of the mother plant since there is no genetic recombination.

Statement C: Incorrect (Gametophytic Apomixis)

In gametophytic apomixis, the embryo originates from an unreduced egg cell, not a reduced egg cell.

Statement D: Incorrect (Pseudogamy Definition is Wrong)

- Pseudogamy refers to cases where fertilization is required for endosperm formation, even if the embryo itself develops apomictically.
- **Correction**: In pseudogamy, the endosperm forms after fertilization, not without fertilization.

Information Booster:

Double Fertilization -Found only in angiosperms, absent in gymnosperms. Ensures coordinated embryo and endosperm development for seed viability.

Sporophytic Apomixis-Also called adventitious embryony, occurs in Citrus, Mango, Opuntia. Embryo arises from nucellus or integument cells, bypassing gametophyte formation.

Gametophytic Apomixis -Includes diplospory (from megaspore mother cell, MMC) and apospory (from nucellar cells) Produces maternal clones, helping maintain desirable traits in plant breeding.

Example: **Taraxacum (Dandelion), Poa (Grass), Hieracium (Hawkweed)**.

Pseudogamy - Fertilization is required for endosperm activation, but not for embryo formation. Common in grasses and Rosaceae plants (e.g., blackberries, apples).

S11. Ans.(a)

Sol. A,B and C

Explanation:

Statement A: Correct

- **Absorption of light (photon) excites a pigment molecule.**
- When **chlorophyll absorbs a photon**, an **electron moves from the ground state to an excited state**.
- The energy difference between these states is **equal to the absorbed photon's energy**.
- This is the fundamental process in **photosynthesis**.

Statement B: Correct

- After excitation, **electrons return to the lowest excited state** before releasing energy.
- This process is known as **internal conversion or relaxation**.
- The **energy lost is dissipated as heat**, making it a non-radiative transition.
- It ensures that **photochemical reactions occur from the lowest excited state**.

Statement C: Correct

- When chlorophyll molecules **return to the ground state from their lowest excited state**, they emit energy as **fluorescence** (a lower-energy photon).
- Chlorophyll fluorescence occurs at a **longer wavelength** (red region) due to energy loss as heat.
- This is important in **measuring photosynthetic efficiency** in plants.

Statement D: Incorrect

- **Blue light has more energy than red light** because **energy is inversely proportional to wavelength ($E = h\nu = hc/\lambda$).**
- **Chlorophyll absorbs blue light (shorter wavelength) at a higher energy level** than red light.
- **Thus, blue light excites electrons to a higher state than red light**, making this statement incorrect.

S12. Ans.(b)
Sol. A and C
Explanation:
Statement A: Correct
- Photorespiration requires reduced ferredoxin and ATP during the recycling of NH_3 (ammonia) in the chloroplast.
- Ammonia (NH_3) is released during glycine-to-serine conversion in mitochondria and needs to be reassimilated in the chloroplast using ATP and reduced ferredoxin.
- This process ensures efficient nitrogen use and prevents nitrogen loss.

Statement B: Incorrect
- ATP and NADPH produced during photosynthetic electron transport are used in the Calvin cycle, not directly in photorespiration.
- Photorespiration does not depend on ATP and NADPH from photosynthetic electron transport but instead uses energy indirectly from other metabolic reactions.
- Thus, this statement is incorrect.

Statement C: Correct
- Glutamate (Glu) and α-ketoglutarate (α-KG) act as shuttle molecules between organelles during photorespiration.
- Glutamate moves from the chloroplast to the peroxisome, while α-ketoglutarate moves in the opposite direction.
- This exchange is crucial for nitrogen metabolism during the glycine-to-serine conversion step in mitochondria.

Statement D: Incorrect
- Serine hydroxymethyltransferase (SHMT) is primarily active in mitochondria, not in the peroxisome.
- It plays a key role in converting glycine into serine in photorespiration.
- Thus, this statement is incorrect.

S13. Ans.(c)
Sol. The Blue light illumination will increase the level of stomatal opening above the saturation level of stomatal opening by red light illumination.
Explanation:
Stomatal Opening Mechanism: Role of Red and Blue Light
- Stomata regulate gas exchange and transpiration by adjusting their aperture size in response to environmental cues.
- Light is a key factor in stomatal opening, with both red and blue light contributing to this process through different mechanisms.

Effect of Red Light on Stomatal Opening
- Red light plays a role in stomatal opening by driving photosynthesis in guard cells, leading to ATP production.
- The increase in ATP activates proton pumps (H^+-ATPases) in the guard cell membrane, which causes K^+ ions to enter, leading to water influx and stomatal opening.
- However, red light alone reaches a saturation level, beyond which further red light does not increase stomatal aperture.

Effect of Blue Light on Stomatal Opening

- Blue light directly stimulates phototropins (Phot1 and Phot2), which are blue light receptors in guard cells.
- Activation of phototropins leads to a stronger activation of H^+-ATPases, allowing greater ion uptake (K^+, Cl^-) into guard cells.
- This results in a larger stomatal opening than red light alone.

Statement C is correct Since the stomata were already exposed to saturating red light, they were partially open. Adding blue light further increases the aperture due to its independent mechanism via phototropins.

S14. Ans.(c)
Sol. B, C, and D
Explanation:
Statement A: Incorrect

- SWEET transporters facilitate the movement of both sucrose and glucose.
- SWEET proteins function as passive uniporters, meaning they allow sugars to move along their concentration gradient.
- Since SWEETs transport both sucrose and glucose, the statement is incorrect.

Statement B: Correct

- In Arabidopsis, SWEET11 and SWEET12 function as sucrose efflux transporters that move sucrose out of mesophyll cells into the apoplast.
- Double mutants of SWEET11 and SWEET12 cause carbohydrate accumulation in source leaves, leading to reduced sucrose export.
- This proves their essential role in phloem loading.

Statement C: Correct

- Sucrose and polyols enter SE/CC complexes via a proton-symport mechanism.
- H^+-ATPase pumps protons into the apoplast, generating a proton gradient.
- Sucrose/H^+ symporters (SUTs or SUCs) use this gradient to actively transport sucrose into SE/CCs.

Statement D: Correct

- Sucrose/H^+ symporters (SUTs or SUCs) are located in the plasma membranes of minor vein sieve elements (SE) and companion cells (CCs).
- These transporters participate in apoplastic phloem loading by actively bringing sucrose into SE/CC complexes.

S15. Ans.(a)
Sol. A,C, and D
Explanation:

- **A. Strong ringspot symptoms develop on the lower leaves** (Correct)
  - Since the virus was initially introduced to the lower leaves, these areas exhibit stronger symptoms compared to the upper regions.
- **B. The ringspot symptoms are higher on the upper leaves** (Incorrect)
  - Typically, viral symptoms reduce as the infection moves upwards. The upper leaves may have mild symptoms, but the highest severity is observed in the lower leaves.
- **C. The top leaves have no viral symptoms** (Correct)
  - In many cases, the virus does not reach the topmost leaves, or plant defense mechanisms prevent visible symptoms from appearing.

- **D. The top leaves are immune to secondary infection by the same virus** (Correct)
  - This phenomenon is called **Systemic Acquired Resistance (SAR)**, where plants develop resistance to further infections after an initial viral attack.

Information Booster:

1. **Tobacco Ringspot Virus (TRSV)** is a plant pathogenic virus belonging to the Nepovirus group.
2. It primarily affects **tobacco, soybean, and various other crop species**.
3. The virus is transmitted by **nematodes** (Xiphinema spp.), infected seeds, and mechanical means.
4. **Symptoms include necrotic rings, stunting, and leaf malformations**, primarily in lower leaves.
5. **Systemic Acquired Resistance (SAR)** provides immunity to secondary infections.
6. TRSV control methods include **vector control, crop rotation, and resistant cultivars**.

Additional Knowledge:

- Ringspot symptoms include necrotic lesions, chlorosis, and leaf deformation.
- TRSV spreads systemically but shows its primary impact in the inoculated region.
- Some upper leaves may show **mild chlorosis or stunting**, but not severe ringspot symptoms.
- Many plant viruses show **limited systemic movement**, meaning the top leaves may remain asymptomatic.
- Some plants produce **antiviral defense compounds** to limit symptom development.
- **Systemic Acquired Resistance (SAR)** is a well-documented defense mechanism in plants.
- Once infected, plants activate defense pathways that protect against further viral attacks.
- SAR involves salicylic acid and pathogenesis-related (PR) proteins, enhancing resistance.

S16. Ans.(c)

Sol. A - iii; B - ii; C - iv; D – i

- Auxins are primarily synthesized from Tryptophan, an amino acid precursor in plants.
- Cytokinins, like **Zeatin**, are synthesized from adenine-type compounds.
- Ethylene is produced from **S-adenosyl methionine (SAM)** via **ACC**, a key precursor.
- Gibberellins are **terpenoid compounds** derived from **Geranylgeranyl diphosphate (GGPP)**.

Information Booster:

1. Auxins (IAA) are crucial for cell elongation, apical dominance, and root initiation.
2. Cytokinins regulate cell division, shoot growth, and delay senescence.
3. Ethylene influences fruit ripening, leaf abscission, and stress responses.
4. Gibberellins control stem elongation, seed germination, and flowering.
5. Each hormone is derived from a specific precursor and plays a distinct physiological role.
6. Understanding hormone biosynthesis is vital for crop improvement and plant growth regulation.

Additional Knowledge:

- **(A) Auxins (Tryptophan Precursor):**
  - Auxins regulate **apical dominance, phototropism, and root formation**.
  - **Synthetic auxins** like **2,4-D** are used as herbicides.
- **(B) Cytokinins (Adenosine Moiety Precursor):**
  - These hormones **promote shoot growth, delay leaf aging, and enhance nutrient mobilization**.
  - The ratio of **auxins to cytokinins** determines organ differentiation in tissue culture.
- **(C) Ethylene (ACC Precursor):**
  - Ethylene regulates **fruit ripening (e.g., bananas, tomatoes)** and **response to mechanical stress**.
  - Commercially, **ethylene inhibitors like 1-MCP** are used to delay ripening.

- **(D) Gibberellins (GGPP Precursor):**
  - They **stimulate seed germination, break dormancy, and enhance stem elongation**.
  - Farmers use **GA sprays in grapes and sugarcane** for yield improvement.

S17. Ans.(c)
Sol. C and D

A. Galactose is added to the terminal of H-antigen by a transferase expressed in individuals with type A blood. (Incorrect)
- In individuals with type A blood, a specific glycosyltransferase enzyme (A-transferase) adds N-acetylgalactosamine (not galactose) to the H-antigen.

B. The B antigen is formed by a transferase expressed in individuals with type B blood, which adds a terminal N-acetylgalactosamine to H-antigen. (Incorrect)
- In individuals with type B blood, a specific glycosyltransferase enzyme (B-transferase) adds galactose (not N-acetylgalactosamine) to the H-antigen.

C. The H-antigen is formed by fucose transferase that adds a terminal fucose to its precursor. (Correct)
- The H-antigen is the foundation for the ABO blood group antigens and is produced when the fucosyltransferase enzyme (FUT1) adds fucose to the precursor.

D. The H-antigen is the precursor of both the A- and B-antigens, and it is the blood group antigen in persons of type O blood. (Correct)
- Type O individuals do not have functional A- or B-transferases, so they retain the H-antigen as their blood group marker.
- A- and B-antigens are derived from the H-antigen by specific transferases.

Information Booster:
1. The **ABO blood group system** is determined by specific glycosyltransferase enzymes that modify the **H-antigen**.
2. **H-antigen is essential for A and B antigen formation**; without it, no ABO blood type can develop.
3. The **FUT1 gene** encodes the enzyme that synthesizes **H-antigen**, which is modified further to form A or B antigens.
4. **Type O blood** lacks the enzymes to add **extra sugars**, leaving only the **H-antigen** on red blood cells.
5. **Bombay phenotype (hh)** individuals lack the **FUT1 enzyme**, meaning they do not even have the **H-antigen**.
6. Blood transfusion compatibility depends on the presence or absence of A, B, and H antigens.

S18. Ans.(c)
Sol. B, C, and D

A. The second heart sound is loud and sharp when the diastolic pressure is decreased in the aorta or pulmonary artery. (Incorrect)
- The second heart sound (S_2) occurs due to closure of the aortic and pulmonary valves.
- A decrease in diastolic pressure actually reduces the intensity of the second heart sound, rather than making it loud and sharp.

B. Sudden closure of atrioventricular (AV) valves at the start of ventricular systole causes vibration that produces the first heart sound. (Correct)
- The first heart sound (S_1) is generated when the mitral and tricuspid valves close at the beginning of ventricular systole.
- This closure causes vibrations in surrounding structures, producing the characteristic "lub" sound.

C. **The second heart sound is caused by the vibration associated with the closure of aortic and pulmonary valves after the end of ventricular systole. (Correct)**
   - The second heart sound (S_2) is generated when the aortic and pulmonary valves close at the end of ventricular systole, leading to the "dub" sound.

D. **The first heart sound is soft when heart rate is low, as the ventricles are well filled with blood and the leaflets of AV valves float together before systole. (Correct)**
   - When heart rate is low, ventricles fill more completely, causing the AV valves to close more passively with less force, resulting in a softer first heart sound.

Information Booster:

1. **Heart sounds are produced due to the closure of heart valves** and the vibrations they generate.
2. **First heart sound (S_1) ("lub")** occurs due to **closure of mitral and tricuspid valves** at the start of **ventricular systole**.
3. **Second heart sound (S_2) ("dub")** occurs due to **closure of aortic and pulmonary valves** at the end of **ventricular systole**.
4. The **loudness of S_1 and S_2 varies** based on **heart rate, blood volume, and pressure changes**.
5. **S_2 can be split into two sounds (A_2 and P_2)** due to the slightly delayed closure of the pulmonary valve.
6. **Abnormal heart sounds (murmurs)** indicate **valvular defects** or **turbulent blood flow**.

S19. Ans.(c)

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

Explanation:

1. **Ia fibers → Muscle spindle, annulo-spiral ending**
   - Ia fibers are primary afferent fibers connected to the muscle spindle that detect rapid stretch and regulate muscle tone.
2. **Ib fibers → Golgi tendon organ**
   - Ib fibers arise from the Golgi tendon organ, which monitors muscle tension and force generation.
3. **II fibers → Muscle spindle, flower spray ending**
   - Type II fibers are secondary afferent fibers of the muscle spindle, responding to static muscle length.
4. **III fibers → Pain and cold receptor**
   - Type III fibers (A-delta fibers) are involved in pain and temperature sensation, especially for detecting cold stimuli.

Information Booster:

1. Muscle Spindles are stretch-sensitive receptors present in skeletal muscles, which help in proprioception and muscle tone regulation. They are innervated by Ia (annulo-spiral endings) and II (flower spray endings) fibers.
2. Golgi Tendon Organs (GTOs) are found in tendons and detect changes in muscle tension. They are innervated by Ib fibers and play a crucial role in preventing excessive muscle contraction.
3. Pain and Temperature Sensation is carried by Type III (A-delta) fibers, which transmit sharp, localized pain and cold temperature sensations to the central nervous system.
4. Nerve Fiber Classification: Sensory nerve fibers are classified based on their conduction velocity and diameter. Ia and Ib are the fastest, II is intermediate, and III is slower but still myelinated.

S20. Ans(c)
Sol. B, C, and E
Explanation:

1. **Statement A - Incorrect**
   - Norepinephrine primarily causes vasoconstriction of renal blood vessels by activating α1-adrenergic receptors, leading to a decrease in renal blood flow.
2. **Statement B - Correct**
   - Dopamine induces renal vasodilation and promotes natriuresis (sodium excretion) by acting on D1 receptors in renal vasculature, improving renal perfusion.
3. **Statement C - Correct**
   - Angiotensin II is a potent vasoconstrictor, primarily affecting the efferent arteriole, helping to maintain glomerular filtration rate (GFR) despite reduced renal blood flow.
4. **Statement D - Incorrect**
   - Prostaglandins (PGE2 and PGI2) usually promote renal vasodilation, counteracting the vasoconstrictive effects of norepinephrine and angiotensin II. They do not significantly decrease blood flow in the renal cortex.
5. **Statement E - Correct**
   - Acetylcholine (ACh) promotes renal vasodilation by stimulating muscarinic M3 receptors, leading to the release of nitric oxide (NO), which increases renal perfusion.