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**Biology — Class 12**

Chapter(s): Human Reproduction

**Maximum Marks: 39** **Time Allowed: 1 Hour 10 Minutes**

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**Section A — MCQ & Assertion-Reason (1 mark each)**

**Q1. A botanist finds a mature seed with (i) a persistent endosperm and (ii) an additional persistent nutritive tissue derived from nucellus. Which pair of terms correctly identifies (i) and (ii), respectively? [1 mark]**

A) (i) Ex-albuminous; (ii) Pericarp

B) (i) Albuminous; (ii) Perisperm

C) (i) Non-albuminous; (ii) Testa

D) (i) Parthenocarpic; (ii) Chalaza

**Q2. In a dicot plant, the pollen grains are shed in 2-celled stage (vegetative cell + generative cell). If 200 such pollen grains germinate successfully and each fertilises one ovule, what is the total number of male gametes formed specifically by mitosis of the generative cells during pollen tube growth? [1 mark]**

A) 200

B) 300

C) 400

D) 800

**Q3. A mutation disrupts formation of filiform apparatus in synergids, but the embryo sac otherwise becomes normal (7-celled, 8-nucleate) and viable pollen lands on the stigma. Which outcome is most likely? [1 mark]**

A) Pollen tube reaches the ovary but fails to enter the embryo sac efficiently, reducing fertilisation success.

B) Triple fusion occurs normally but syngamy fails, producing only endosperm.

C) Syngamy occurs but triple fusion fails, producing only embryo without endosperm.

D) Anther dehiscence is inhibited because filiform apparatus signals tapetum degeneration.

**Q4. A maize-like wind-pollinated plant is experimentally modified so its pollen becomes sticky and heavy, while the stigma remains large and feathery. Assuming no change in ovule number, which prediction best follows for successful pollination under natural wind conditions? [1 mark]**

A) Pollination efficiency decreases because heavy, sticky pollen is poorly transported by wind currents.

B) Pollination efficiency increases because stickiness always improves aerial dispersal.

C) Pollination efficiency is unchanged because feathery stigma alone determines wind pollination.

D) Pollination efficiency increases because heavy pollen carries more cytoplasm and germinates faster.

**Q5. In a species, the primary endosperm nucleus (PEN) undergoes 10 successive free-nuclear divisions before cellularisation. Ignoring any nuclear fusion or degeneration during this phase, how many free nuclei will be present in the endosperm just before cell wall formation begins? [1 mark]**

A) 30

B) 512

C) 1024

D) 2048

**Q6. Assertion (A): In an angiosperm embryo sac, although it is 8-nucleate at maturity, it is described as 7-celled.**
**Reason (R): Two polar nuclei remain in the central cell without being separated by cell walls. [1 mark]**

A) Both A and R are true and R is the correct explanation of A.

B) Both A and R are true but R is not the correct explanation of A.

C) A is true but R is false.

D) A is false but R is true.

**Q7. Assertion (A): In double fertilisation, the product of triple fusion is triploid.**
**Reason (R): Triple fusion involves fusion of one male gamete with two haploid polar nuclei present in the central cell. [1 mark]**

A) Both A and R are true and R is the correct explanation of A.

B) Both A and R are true but R is not the correct explanation of A.

C) A is true but R is false.

D) A is false but R is true.

**Q8. Assertion (A): Geitonogamy is genetically similar to autogamy.**
**Reason (R): In geitonogamy, pollen is transferred from the anther to the stigma of a different plant of the same species. [1 mark]**

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A) Both A and R are true and R is the correct explanation of A.
B) Both A and R are true but R is not the correct explanation of A.
C) A is true but R is false.
D) A is false but R is true.

**Q9. Assertion (A): Self-incompatibility can prevent fertilisation even when viable pollen of the same species lands on the stigma.**
**Reason (R): Self-incompatibility is a genetic mechanism that can inhibit pollen germination or pollen tube growth in the pistil. [1 mark]**

A) Both A and R are true and R is the correct explanation of A.
B) Both A and R are true but R is not the correct explanation of A.
C) A is true but R is false.
D) A is false but R is true.

**Q10. Assertion (A): Cleistogamous flowers guarantee seed set even in the absence of pollinators.**
**Reason (R): Cleistogamous flowers never open, so there is no chance of cross-pollen landing on the stigma and autogamy occurs within the closed bud. [1 mark]**

A) Both A and R are true and R is the correct explanation of A.
B) Both A and R are true but R is not the correct explanation of A.
C) A is true but R is false.
D) A is false but R is true.

## Section B — Very Short Answer (2 marks each)

**Q11. In an angiosperm, 120 pollen grains are shed at the 2-celled stage and all successfully effect fertilisation (each pollen grain fertilises one ovule). Calculate:**
**(a) the total number of male gametes delivered into embryo sacs, and**
**(b) the total number of fertilisation events (syngamy + triple fusion) that occur.**
**Answer in exactly 2 sentences with appropriate units where relevant. [2 marks]**

**Q12. A student claims: "Geitonogamy always increases genetic variation because it is functionally cross-pollination." Correct the statement by writing exactly 2 sentences: Sentence 1 must give the correct conclusion, and Sentence 2 must justify it using a principle from pollination types. [2 marks]**

**Q13. During ovule examination, a botanist finds that integuments encircle the nucellus but leave a small opening at the tip, and identifies the basal region opposite to this opening. Name (i) the opening and (ii) the basal region, and state one functional significance of the opening.**
**Answer in exactly 2 sentences. [2 marks]**

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## Section C — Short Answer (3 marks each)

**Q14. An angiosperm embryo sac at maturity is '8-nucleate but 7-celled'. Explain this by describing the organisation of nuclei into cells.**
**Write the answer in exactly 3 numbered points with headings (total 130-160 words). [3 marks]**

**Q15. A breeder wants to ensure that only the desired pollen reaches the stigma during hybridisation in a bisexual-flowered plant.**
**Explain the steps of emasculation and bagging and include the critical timing point for pollination.**
**Write the answer in exactly 3 numbered points with headings (total 130-160 words). [3 marks]**

**Q16. Wind pollination is described as a chance event with high pollen loss. Using this idea, justify why many wind-pollinated plants show (i) well-exposed stamens, (ii) large feathery stigmas, and (iii) production of enormous pollen.**
**Write the answer in exactly 3 numbered points with headings (total 130-160 words). [3 marks]**

## Section D — Long Answer (5 marks each)

**Q17. A couple reports inability to conceive after 2 years of unprotected intercourse. Semen analysis shows: sperm concentration = 10 million $mL^{1}$, total semen volume = 2.5 mL, 60% sperms are motile. (a) Calculate the total number of sperms ejaculated and the number of motile sperms. Show steps and use SI units. (b) Using human reproduction concepts, explain in exactly five numbered headed points (two sentences each) how sperm formation, maturation, transport and capacitation-related events together could explain reduced fertility in such a case. Conclude with one sentence. [5 marks]**

**Q18. During counselling, a student claims: "Menstruation happens because the ovary stops making estrogen; therefore the uterine lining simply peels off, and fertilisation timing is unrelated." Write a hard, exam-style rebuttal as a 5-mark long answer: Explain in five numbered headed points (two sentences each) the integrated sequence linking ovarian events (follicular phase, ovulation, luteal phase), endometrial changes, and the fertile window. Include one brief calculation: If ovulation is on Day 14 of a 28-day cycle, and the ovum remains viable for 24 h while sperms remain viable for 72 h in the female tract, compute the fertile window in days (Day numbers) and state it clearly with correct time units. Conclude in one sentence. [5 marks]**

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## Section E — Case Study (4 marks each)

**Q19. Read the following passage and answer the questions that follow: [4 marks]**

A reproductive health lab tracked a volunteer's 28-day menstrual cycle alongside a home ovulation predictor kit (OPK) that detects the LH surge. The volunteer recorded: Day 5-12: watery cervical mucus increasing; Day 13 evening: OPK turns positive; Day 14 morning: mild lower abdominal pain; Day 21: basal body temperature remains elevated compared to Days 6-12; Day 27: temperature begins to fall; Day 28: menstrual bleeding starts. The lab notes that sperm can remain viable in the female tract for up to 72 h, while the ovum remains viable for about 24 h after ovulation. The volunteer asks two practical questions: (1) why the OPK positive on Day 13 does not mean fertilisation already happened, and (2) which days would have the highest probability of fertilisation if unprotected intercourse occurs only once. The counsellor also explains that failure to conceive despite correct timing can occur if fertilisation is blocked at the level of sperm-oocyte interaction or if the fallopian tubes are blocked, even when cycles appear normal.

(i) From the passage data, identify the most likely day of ovulation (Day number) and justify using two linked observations. (1 mark)

(ii) Explain why a positive OPK on Day 13 does not mean fertilisation has already occurred. (1 mark)

(iii) Using the viability data given, calculate the fertile window (Day numbers) for a single act of intercourse and state the best day within that window for maximum probability. (2 marks)

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**Biology — Class 12**

Chapter(s): Human Reproduction

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## Section A — MCQ & Assertion-Reason (1 mark each)

**A1.**

**Answer:**

**Correct option: (B)**

**(i) Albuminous**

**(ii) Perisperm**

**Explanation:**

Seeds retaining endosperm at maturity are albuminous, and persistent residual nucellus is termed perisperm (e.g., black pepper, beet). The

**Given:  features match these terms directly. Hence, option (B) is correct.**

**A2.**

**Answer:**

**Correct option: (C)**

400

**Explanation:**

Each 2-celled pollen grain has one generative cell that divides mitotically to form two male gametes during pollen-tube growth. Therefore, total male gametes formed = 200 × 2 = 400. Hence, option (C) is correct.

**A3.**

**Answer:**

**Correct option: (A)**

Pollen tube reaches the ovary but fails to enter the embryo sac efficiently, reducing fertilisation success.

**Explanation:**

The filiform apparatus at the micropylar end of synergids guides pollen-tube entry into a synergid; without it, tube guidance/entry becomes inefficient. Pollination and tube growth up to ovary can still occur, but fertilisation frequency falls. Hence, option (A) is correct.

**A4.**

**Answer:**

**Correct option: (A)**

Pollination efficiency decreases because heavy, sticky pollen is poorly transported by wind currents.

**Explanation:**

Wind pollination is favoured by light, non-sticky pollen that can be carried in air currents; making pollen heavy and sticky reduces its dispersal probability. A feathery stigma helps trap airborne pollen but cannot compensate for poor transport. Hence, option (A) is correct.

**A5.**

**Answer:**

**Correct option: (C)**

1024

**Explanation:**

Free-nuclear endosperm begins from the triploid PEN as a single nucleus; each division doubles the number of nuclei. After 10 divisions, nuclei = $1 \times 2^{10} = 1024$. Hence, option (C) is correct.

**A6.**

**Answer:**

**Correct option: (A)**

Both A and R are true and R is the correct explanation of A.

**Explanation:**

A typical mature embryo sac has 8 nuclei, but only six are walled off into individual cells; the remaining two polar nuclei share the central cell. This is exactly why it is 7-celled despite being 8-nucleate. Hence, option (A) is correct.

**A7.**

**Answer:**

**Correct option: (A)**

Both A and R are true and R is the correct explanation of A.

**Explanation:**

Triple fusion is the fusion of three haploid nuclei (n + n + n), producing a 3n primary endosperm nucleus. The reason correctly states the participating nuclei and thus explains the triploid outcome. Hence, option (A) is correct.

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**A8.**

**Answer:**

**Correct option: (C)**

A is true but R is false.

**Explanation:**

Geitonogamy uses pollen from another flower of the same plant, so genetically it resembles selfing like autogamy. The reason is incorrect because transfer to a different plant is xenogamy, not geitonogamy. Hence, option (C) is correct.

**A9.**

**Answer:**

**Correct option: (A)**

Both A and R are true and R is the correct explanation of A.

**Explanation:**

Self-incompatibility rejects self pollen (often from the same flower/plant) despite it being viable and of the same species. The reason correctly states the genetic basis and the mechanism of inhibition (germination/tube growth), explaining the assertion. Hence, option (A) is correct.

**A10.**

**Answer:**

**Correct option: (A)**

Both A and R are true and R is the correct explanation of A.

**Explanation:**

Cleistogamous flowers remain closed and the anthers dehisce near the stigma inside the bud, ensuring self-pollination. This directly explains why they can produce assured seed set without any pollinating agent. Hence, option (A) is correct.

## Section B — Very Short Answer (2 marks each)

**A11.**

**Answer:**

**(a) Each 2-celled pollen grain forms 2 male gametes, so total male gametes delivered = 120 × 2 = 240 (number of gametes). (b) Each fertilised ovule shows 2 fusion events (syngamy + triple fusion), so total fertilisation events = 120 × 2 = 240 (number of fusion events).**

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**A12.**

**Answer:**

Geitonogamy does not necessarily increase genetic variation because genetically it is equivalent to self-pollination. It uses pollen from another flower of the same plant, so the gametes usually carry alleles from the same genotype despite requiring a pollinating agent.

**A13.**

**Answer:**

**(i) The opening is the micropyle and (ii) the basal region is the chalaza. The micropyle provides an entry path for the pollen tube into the ovule (and later facilitates water/oxygen entry during seed germination).**

In a typical angiosperm ovule, integuments form a pore at the micropylar end, while chalaza marks the opposite basal end. The micropyle's role is directly tied to successful fertilisation because pollen tube entry occurs through it.

## Section C — Short Answer (3 marks each)

**A14.**

**Answer:**

1) Egg apparatus (Micropylar end): Three nuclei get partitioned by cell walls to form three cells-one egg cell and two synergids. The synergids show a filiform apparatus that helps guide pollen tube entry into one synergid.

2) Antipodals (Chalazal end): Three nuclei at the chalazal end become surrounded by cell walls to form three antipodal cells. These contribute to the typical cellular arrangement at the opposite pole of the embryo sac.

3) Central cell (Polar nuclei): The remaining two nuclei do not get separated by a cell wall; they remain together as two polar nuclei inside one large central cell. Thus, 3 (egg apparatus) + 3 (antipodals) + 1 (central cell) = 7 cells, even though the total nuclei are 8.

**A15.**

**Answer:**

1) Emasculation (Prevent self-pollen): Remove the anthers from the selected female parent at the bud stage, before anther dehiscence, using forceps. This ensures that the flower cannot release its own pollen onto its stigma.

2) Bagging (Prevent unwanted pollen): Immediately cover the emasculated flower with a suitably sized butter-paper bag and secure it. This physical barrier prevents contamination of the stigma by pollen from other plants carried by wind/insects.

3) Controlled pollination & rebagging (Correct timing): When the stigma becomes

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receptive, dust mature pollen collected from the chosen male parent onto the stigma. Rebag the flower after pollination and allow fruit and seed development to proceed under protection.

**A16.**

**Answer:**

1) Well-exposed stamens (Efficient dispersal): Stamens are positioned so anthers dehisce into air currents with minimal obstruction. This maximises the probability that pollen is picked up and carried away by wind.

2) Large/feathery stigma (Efficient trapping): A broad, feathery stigma increases surface area and creates a better 'pollen trap' for airborne grains. This compensates for the randomness of wind direction and dilution of pollen in air.

3) Enormous pollen production (Compensation for loss): Since most pollen grains are lost during transport and only a tiny fraction reaches a stigma, plants produce very large quantities of pollen. High pollen output statistically increases successful pollen-stigma contact, improving chances of fertilising available ovules.

## Section D — Long Answer (5 marks each)

**A17.**

**Answer:**

Infertility can result when sperm number and functional competence are insufficient to reach and fertilise the oocyte.

1) Numerical analysis (count and motile fraction):

**Given: concentration = 10 million $mL^{-1}$ = $1.0 \times 10^{10}$ $m^{-3}$; volume = 2.5 mL = $2.5 \times 10^{-6}$ $m^3$. Total sperms = ($1.0 \times 10^{10}$ $m^{-3}$) × ($2.5 \times 10^{-6}$ $m^3$) = $2.5 \times 10^4$ sperms; motile sperms = 0.60 × ($2.5 \times 10^4$) = $1.5 \times 10^4$ sperms.**

2) Spermatogenesis output (seminiferous tubules): Spermatogenesis in seminiferous tubules must produce huge numbers continuously; a low concentration indicates reduced production or loss. Causes within chapter-linked reasoning include impaired meiosis/spermiogenesis or inadequate support from Sertoli-cell environment.

3) Hormonal control and timing: Normal spermatogenesis requires coordinated action of hypothalamus-pituitary-testicular axis hormones to sustain germ cell divisions and differentiation. Disturbance reduces both sperm count and the proportion completing maturation.

4) Epididymal maturation and storage: Sperm leaving testes are not fully motile/fertile; they gain motility and functional maturation in epididymis. Defects in epididymal environment can reduce the motile fraction even if production is partially maintained.

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5) Transport, deposition and capacitation in female tract: After ejaculation, sperms must be transported through male ducts and deposited, then undergo capacitation in female tract to penetrate zona pellucida. A low absolute motile number drastically lowers the probability that adequate sperms reach the ampullary region of the oviduct.

**Conclusion: Here, the calculated low total and motile sperm numbers indicate that reduced sperm production/maturation and insufficient functional motile sperms can together explain subfertility.**

**A18.**

**Answer:**

Menstruation, ovulation and the fertile window are tightly coupled outcomes of coordinated ovarian and uterine cycles.

1) Follicular phase and estrogen (endometrium builds): In the follicular phase, developing ovarian follicles secrete estrogen that drives the proliferative growth of the endometrium. Hence, the uterine lining does not "simply peel off" by default; it is actively built under hormonal control.

2) Ovulation as the key timing event: Ovulation releases the secondary oocyte around mid-cycle and is the anchor for estimating the fertile window. Fertilisation is most likely when coitus occurs close to ovulation because gametes have limited viability.

3) Luteal phase and progesterone (endometrium maintained): After ovulation, the corpus luteum secretes progesterone (with some estrogen) which converts the endometrium to a secretory, implantation-ready state. If no pregnancy occurs, corpus luteum regresses, progesterone falls, and the endometrium breaks down leading to menstruation.

4) Why menstruation occurs (withdrawal bleeding): Menstruation is primarily triggered by withdrawal of progesterone and estrogen due to luteal regression, causing constriction and shedding of the functional layer of endometrium. Therefore, it is incorrect to attribute it only to "stopping estrogen" without the luteal-phase context.

5) Fertile window

**Calculation: (viability-based):**

**Given: ovulation Day = 14; ovum viable = 24 h = 1 day; sperm viable = 72 h = 3 days. Fertile window = (Day 14 - 3 days) to (Day 14 + 1 day) = Day 11 to Day 15 (inclusive), where times are in days.**

**Conclusion: Menstruation and fertility timing are consequences of cyclic ovarian hormone patterns that regulate ovulation and endometrial preparation, not independent events.**

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## Section E — Case Study (4 marks each)

**A19.**

**(i) From the passage data, identify the most likely day of ovulation (Day number) and justify using two linked observations.**

**Answer:**

Most likely ovulation is on Day 14, justified by a positive OPK (LH surge) on Day 13 evening followed by mid-cycle abdominal pain on Day 14 morning and sustained post-ovulatory rise in basal body temperature up to around Day 21.

**(ii) Explain why a positive OPK on Day 13 does not mean fertilisation has already occurred.**

**Answer:**

A positive OPK indicates the LH surge that triggers ovulation shortly after, but fertilisation can occur only after the oocyte is released and a sperm meets it in the oviduct; therefore OPK positivity is a predictor of imminent ovulation, not proof of fertilisation.

**(iii) Using the viability data given, calculate the fertile window (Day numbers) for a single act of intercourse and state the best day within that window for maximum probability.**

**Answer:**

**Given: ovulation ≈ Day 14; sperm viability = 72 h = 3 days; ovum viability = 24 h = 1 day. Fertile window = Day (14 -**

3) to Day (14 + 1) = Day 11 to Day 15; the best single day is Day 13 or Day 14 (closest to ovulation while still allowing sperm presence at release), with Day 13 often maximizing overlap if ovulation follows the LH surge.

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