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SUBJECT CONTENT – 10 TOUGHEST PYQ

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Q-1 During the cell cycle, _____.

[OAVS PGT BIOLOGY 2021]

- (A) the levels of cyclins remain mostly constant but levels of CDKs oscillate
- (B) the levels of cyclins and levels of CDKs both oscillate
- (C) the levels of CDKs remain mostly constant but levels of cyclins oscillate
- (D) the levels of cyclins and CDKs remain mostly constant but levels of inhibitors of CDKs oscillate

ANS- (C) the levels of CDKs remain mostly constant but levels of cyclins oscillate

Explanation: Cyclin-dependent kinases (CDKs) are present at nearly **constant levels** throughout the cell cycle, but they are active only when bound to **cyclins**. Cyclin levels **rise and fall** because they are synthesised in a specific phase and then destroyed by **ubiquitin-mediated proteolysis** (via the **APC/C** and **SCF** complexes). This oscillation drives the cell through **G₁, S, G₂ and M**. The discovery earned **Hartwell, Hunt and Nurse** the **Nobel Prize in 2001**.

Key Points:

- ✦ *Cyclin discovered by:* **Tim Hunt** in **1982** (sea urchin eggs)
- ✦ **MPF: Maturation/M-phase Promoting Factor = Cyclin B + CDK1**
- ✦ **G₁/S transition:** Controlled by **Cyclin D–CDK4/6** and **Cyclin E–CDK2**
- ✦ **Key checkpoints:** **G₁/S, G₂/M** and the **spindle (metaphase) checkpoint**

Other Options:

- (A) **the levels of cyclins remain mostly constant but levels of CDKs oscillate** — CDKs are serine/threonine kinases whose activity is controlled by binding partners, phosphorylation by **CAK** and dephosphorylation by **Cdc25**.
- (B) **the levels of cyclins and levels of CDKs both oscillate** — The cell cycle was mapped in **yeast** by Paul Nurse using **cdc** (cell division cycle) mutants such as **cdc2** in fission yeast.
- (D) **the levels of cyclins and CDKs remain mostly constant but levels of inhibitors of CDKs oscillate** — CDK inhibitors (**CKIs**) such as **p21, p27** and **p16** block cyclin–CDK complexes; **p21** is induced by the tumour suppressor **p53** after DNA damage.

Q-2 A vascular bundle can never be _____.

[OAVS PGT BIOLOGY 2021]

- (A) concentric and amphivasal
- (B) bicollateral and endarch
- (C) radial as well as open
- (D) conjoint as well as closed



ANS- (C) radial as well as open

Explanation: In a **radial vascular bundle**, **xylem** and **phloem** lie on different **radii** alternating with each other, as in **roots**. Such bundles have **no cambium between xylem and phloem**, so they cannot be **open** in the sense used for conjoint bundles. An **open** bundle is a **conjoint collateral** bundle with a strip of **cambium** between xylem and phloem, as in **dicot stems**. In dicot roots, secondary growth needs cambium formed later from **conjunctive tissue** and **pericycle**.

Key Points:

- ✦ *Radial bundles found in:* **Roots** (dicot and monocot)
- ✦ *Dicot root xylem groups:* **2–6** (diarch to hexarch); monocot root: **polyarch** (more than 6)
- ✦ *Xylem in roots:* **Exarch** (protoxylem towards periphery)
- ✦ *Closed bundles:* No cambium, e.g. **monocot stems** (scattered bundles)

Other Options:

(A) **concentric and amphivasal** — This is a concentric bundle where **xylem** surrounds **phloem** (leptocentric), found in **Dracaena** and **Yucca**; the reverse (amphicribal) occurs in **ferns**.

(B) **bicollateral and endarch** — This bundle has **phloem on both sides of xylem**, with outer and inner cambium, and is typical of the family **Cucurbitaceae** (e.g. **Cucurbita**); stem xylem is **endarch**.

(D) **conjoint as well as closed** — This bundle has xylem and phloem on the **same radius** without cambium, as in **monocot stems** such as **maize**, often with a **bundle sheath**.

Q-3 In a standard dihybrid cross, the F₂ genotypic ratios are **1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1** and phenotypic ratios are **9 : 3 : 3 : 1**. In a dihybrid cross where both characters show codominance but no epistatic interactions, the F₂ generation will show:

[OAVS PGT BIOLOGY 2021]

- (A) neither genotypic nor phenotypic ratios as expected
- (B) genotypic ratios as expected, but phenotypic ratios will be different
- (C) both genotypic and phenotypic ratios as expected, as there is no epistatic interaction between the two loci
- (D) phenotypic ratios as expected, but genotypic ratios will be different

ANS- (B) genotypic ratios as expected, but phenotypic ratios will be different

Given:

→ Dihybrid cross $AaBb \times AaBb$; both genes show codominance; no epistasis.

→ Standard F₂: genotypic ratio **1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1**, phenotypic ratio **9 : 3 : 3 : 1**.

Concept:



- Genotypic ratio depends only on segregation and independent assortment, so it does not change with dominance.
- In codominance, AA, Aa and aa each give a distinct phenotype, so phenotypic ratio = genotypic ratio.

Solution:

- Each gene gives 1 : 2 : 1 for both genotype and phenotype.
 $\Rightarrow F_2 \text{ ratio} = (1 : 2 : 1) \times (1 : 2 : 1) = 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1$
 $\Rightarrow \text{Phenotype classes} = 3 \times 3 = 9 \text{ (instead of 4)}$
 $\Rightarrow \text{e.g. AaBb (double codominant)} = \frac{4}{16} = \frac{1}{4}$
- Genotypic ratio stays as expected; phenotypic ratio changes from 9 : 3 : 3 : 1 to 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1.
- Ans: (B) genotypic ratios as expected, but phenotypic ratios will be different

Hint:

- With codominance or incomplete dominance, phenotype ratio = genotype ratio; only dominance and epistasis alter the phenotype ratio.

Q-4 Can glycolysis and gluconeogenesis occur simultaneously in a cell?

[OAVS PGT BIOLOGY 2021]

- (A) No, the same enzymes are involved in the two pathways, so only one is active at any given moment.
- (B) Yes, each pathway has its own enzymes and metabolites so there is no competition between the two.
- (C) Yes, both can be active in different locations of a cell depending on the metabolic need at the location.
- (D) No, they are regulated by common metabolites that inhibit one pathway and activate the other.

ANS- (D) No, they are regulated by common metabolites that inhibit one pathway and activate the other.

Explanation: Glycolysis (glucose → pyruvate) and gluconeogenesis (pyruvate → glucose) are **reciprocally regulated**, so both are not fully active at the same time in a cell; otherwise a wasteful **futile cycle** would burn ATP. The key regulator is **fructose-2,6-bisphosphate**, which **activates phosphofructokinase-1 (PFK-1)** of glycolysis and **inhibits fructose-1,6-bisphosphatase** of gluconeogenesis. Similarly, **AMP** favours glycolysis while **acetyl-CoA** and **citrate** favour gluconeogenesis. Fructose-2,6-bisphosphate was discovered by **Henri-Géry Hers** in **1980**.

Key Points:

- ✦ Glycolysis bypassed steps: **Hexokinase, PFK-1** and **pyruvate kinase** (irreversible)
- ✦ Gluconeogenesis main organ: **Liver** (about **90%**), also kidney
- ✦ Cori cycle: **Lactate** from muscle → **glucose** in liver
- ✦ Hormone activating gluconeogenesis: **Glucagon**



Other Options:

- (A) No, the same enzymes are involved in the two pathways, so only one is active at any given moment. — The two pathways share seven reversible enzymes, such as aldolase and enolase.
- (B) Yes, each pathway has its own enzymes and metabolites so there is no competition between the two. — Gluconeogenesis uses four unique enzymes: pyruvate carboxylase, PEP carboxykinase, fructose-1,6-bisphosphatase and glucose-6-phosphatase.
- (C) Yes, both can be active in different locations of a cell depending on the metabolic need at the location. — Glycolysis takes place in the **cytosol**, while gluconeogenesis starts in the **mitochondria** (pyruvate → oxaloacetate) and finishes in the cytosol and **ER**.

Q-5 A mutant strain of E. coli shows constitutive expression of beta-galactosidase. The mutation is likely to be located in the:

[OAVS PGT BIOLOGY 2021]

- (A) binding domain of LacI protein
- (B) promoter region of lac operon
- (C) regulatory domain of lac permease
- (D) catalytic domain on lacZ enzyme

ANS- (A) binding domain of LacI protein

Explanation: The **lac operon** of **E. coli** is controlled by the **lac repressor (LacI)**, made by the **lacI (i) gene**. Normally the repressor binds the **operator** and blocks transcription of **lacZ (β -galactosidase)**, **lacY (permease)** and **lacA (transacetylase)** unless **lactose (allolactose)** is present. A mutation in the **DNA-binding domain** of LacI stops the repressor from binding the operator, so the genes are expressed all the time — **constitutive expression**. The operon model was proposed by **François Jacob** and **Jacques Monod** in **1961** (Nobel Prize **1965**).

Key Points:

- ✦ *Natural inducer:* **Allolactose**; artificial inducer: **IPTG**
- ✦ *Constitutive mutants:* **lacI⁻** and **O^c (operator-constitutive)**
- ✦ *Super-repressor mutant:* **lacI^s** — cannot bind inducer, operon stays **off**
- ✦ *Type of control:* **Negative** (repressor) + **positive** (CAP–cAMP)

Other Options:

- (B) **promoter region of lac operon** — The promoter is where **RNA polymerase** binds; its activity is boosted by the **CAP–cAMP complex** when **glucose is low**.
- (C) **regulatory domain of lac permease** — **Lac permease (LacY)** is a membrane protein that brings **lactose** into the cell using the **proton gradient** (**H⁺ symport**).
- (D) **catalytic domain on lacZ enzyme** — **β -galactosidase** splits lactose into **glucose and galactose** and also converts it to **allolactose**; it is a **tetramer** of about **465 kDa**.



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Q-6 Which of the following statements is INCORRECT?

[OAVS PGT BIOLOGY 2024]

- (A) Two turns of the Calvin cycle are required to make one molecule of glucose.
- (B) Ribulose 1,5-bisphosphate (RuBP) is a five-carbon ketose sugar.
- (C) Ribulose 1,5-bisphosphate (RuBP) is the principal acceptor of CO_2 in plants.
- (D) During the carboxylation stage of the Calvin cycle, two molecules of 3-phosphoglyceric acid are produced.

ANS- (A) Two turns of the Calvin cycle are required to make one molecule of glucose.

Explanation: The statement is incorrect because **six turns** of the Calvin cycle are needed to make **one molecule of glucose**. Each turn fixes only **one CO_2** , and glucose has **6 carbons**; six turns use **18 ATP** and **12 NADPH**.

Key Points:

- ♦ **Stages:** carboxylation, reduction, regeneration
- ♦ **Enzyme:** **RuBisCO**, the most abundant enzyme on Earth
- ♦ **Per CO_2 fixed:** **3 ATP + 2 NADPH**
- ♦ **Discovered by:** **Melvin Calvin** (Nobel Prize **1961**)

Other Options:

- (B) RuBP is a five-carbon ketose sugar — This is a true fact; RuBP (C_5) is regenerated at the end of each cycle.
- (C) RuBP is the principal acceptor of CO_2 — This is a true fact for **C_3 plants**; in C_4 plants the primary acceptor is **PEP**.
- (D) Two molecules of 3-PGA are produced — This is a true fact; one RuBP + one CO_2 gives **two 3-PGA (C_3)**.

Q-7 If the frequency of the recessive allele (a) in a population is 0.3, what proportion of the population is expected to be heterozygous (Aa), according to the Hardy-Weinberg principle?

[OAVS PGT BIOLOGY 2024]

- (A) 0.30
- (B) 0.70
- (C) 0.42
- (D) 0.21

ANS- (C) 0.42

Given:



→ Frequency of recessive allele (a): $q = 0.3$

Concept:

→ Hardy-Weinberg: $p^2 + 2pq + q^2 = 1$, with $p + q = 1$

→ Heterozygotes (Aa) = $2pq$

Solution:

➤ $p = 1 - q = 1 - 0.3 = 0.7$

⇒ $2pq = 2 \times 0.7 \times 0.3$

⇒ $2pq = 0.42$

➤ Ans: (C) 0.42

Hint:

→ $q^2 = 0.09$ gives aa and $p^2 = 0.49$ gives AA; check $0.49 + 0.42 + 0.09 = 1$.

Q-8 If the distance between two consecutive base pairs is doubled, calculate the new total length of DNA double helix in a typical mammalian cell.

[OAVS PGT BIOLOGY 2024]

(A) 2.244 metres

(B) 4.488 metres

(C) 8.976 metres

(D) 1.122 metres

ANS- (B) 4.488 metres

Given:

→ Base pairs in a typical mammalian cell = 6.6×10^9

→ Normal distance between two consecutive bp = 0.34×10^{-9} m

→ New distance = double

Concept:

→ Length of DNA = number of bp $\times$ distance between two consecutive bp

Solution:

➤ Normal length = $6.6 \times 10^9 \times 0.34 \times 10^{-9} = 2.244$ m

⇒ New distance = $2 \times 0.34 \times 10^{-9} = 0.68 \times 10^{-9}$ m

⇒ New length = $6.6 \times 10^9 \times 0.68 \times 10^{-9} = 4.488$ m

➤ Ans: (B) 4.488 metres

Hint:

→ Length is directly proportional to bp spacing: just double 2.244 m (≈ 2.2 m in NCERT).

Q-9 If a population starts with 500 individuals and grows by 2% per month, what will be the population after 5 months?

[OAVS PGT BIOLOGY 2024]

(A) 552

(B) 550

(C) 541

(D) 510



ANS- (A) 552

Given:

→ Initial population $P_0 = 500$, growth rate $r = 2\%$ per month, $t = 5$ months

Concept:

→ Compound growth: $P = P_0 \left(1 + \frac{r}{100} \right)^t$

Solution:

➤ $P = 500 \times \left(1 + \frac{2}{100} \right)^5$

⇒ $P = 500 \times (1.02)^5$

⇒ $P = 500 \times 1.10408$

⇒ $P = 552.04 \approx 552$ individuals

➤ Ans: (A) 552

Hint:

→ Simple (non-compound) growth would give $500 + 5 \times 10 = 550$ – a common trap (option B).

Q-10 A plant cell has a solute potential of -19 bars and a pressure potential of +7 bars. Its water potential will be _____.

[OAVS PGT BIOLOGY 2024]

- (A) +26 bars
- (B) -2.71 bars
- (C) +12 bars
- (D) -12 bars

ANS- (D) -12 bars

Given:

→ Solute potential $\Psi_s = -19$ bars

→ Pressure potential $\Psi_p = +7$ bars

Concept:

→ $\Psi_w = \Psi_s + \Psi_p$

Solution:

➤ $\Psi_w = (-19) + (+7)$

⇒ $\Psi_w = -12$ bars

➤ Ans: (D) -12 bars

Hint:

→ Solute potential is always negative; pure water has $\Psi_w = 0$, so a cell's water potential is usually negative.





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