

Real Test

Biotechnology

- Q1** The function x^x increases in the interval
 (A) $(0, e)$ (B) $(0, 1)$
 (C) $(\frac{1}{e}, 1)$ (D) None of these
- Q2** In logistic population growth, the maximum growth rate occurs when the population size is at:
 (A) K (B) $K/2$
 (C) $2K$ (D) 0
- Q3** Which of the following diatomic molecules is paramagnetic?
 (A) B_2 (B) C_2
 (C) N_2 (D) F_2
- Q4** During bacterial cell wall remodeling, which enzyme does not participate in peptide cross-linking or cleavage?
 (A) DD-carboxypeptidases
 (B) Transpeptidases
 (C) Transaminases
 (D) Lytic transglycosylases
- Q5** Erythromycin inhibits translation by:
 (A) Causing misreading of mRNA.
 (B) Blocking polypeptide exit tunnel of 50S.
 (C) Preventing ribosome assembly.
 (D) Inhibiting aminoacyl-tRNA synthetase.
- Q6** The physical quantity *moment of force* (torque) has a dimension equal to that of:
 (A) ML^2T^{-2}
 (B) MLT^{-2}
 (C) ML^2T^{-1}
 (D) MT^{-2}
- Q7** A fungus shows cell walls rich in β -glucans but lacks ergosterol in its membrane. Which taxonomic group is this organism MOST likely to belong to?
 (A) Zygomycetes (B) Microsporidia
 (C) Ascomycetes (D) Basidiomycetes
- Q8** Four potential drug molecules show the following binding free energies toward an enzyme:
 Drug A: $-6.5 \text{ kcal mol}^{-1}$
 Drug B: $-4.8 \text{ kcal mol}^{-1}$
 Drug C: $-9.2 \text{ kcal mol}^{-1}$
 Drug D: $-7.0 \text{ kcal mol}^{-1}$
 Which drug is predicted to be most potent?
 (A) A (B) B
 (C) C (D) D
- Q9** A population of moths initially has mostly light-colored individuals. During the Industrial Revolution, soot darkened the environment, and dark-colored moths became more common over generations. Which evolutionary forces are primarily responsible for this change?
 (A) Natural selection
 (B) Genetic drift
 (C) Mutation
 (D) Gene flow
- Q10** The specific rate constant of a first-order reaction depends on the
 (A) Concentration of the reactant
 (B) Concentration of the product
 (C) Time
 (D) Temperature
- Q11** For an enzyme following Michaelis–Menten kinetics, at substrate concentration $[S] = 0.1 K_M$, the velocity v is approximately:
 (A) $0.5 V_{max}$ (B) $0.09 V_{max}$
 (C) V_{max} (D) $K_M \times V_{max}$
- Q12** A population suddenly goes through a bottleneck. Which evolutionary force becomes strongest immediately after?
 (A) Mutation



- (B) Gene flow
(C) Genetic drift
(D) Stabilizing selection
- Q13** Which structure in mammals prevents polyspermy after the first sperm enters the egg?
(A) Zona pellucida
(B) Cortical granules
(C) Vitelline membrane
(D) Nucleus
- Q14** During mismatch repair in *E. coli*, the parental strand is distinguished from the newly synthesized strand by:
(A) Presence of uracil
(B) 5'-phosphate group
(C) DNA methylation at GATC sites
(D) Presence of nicks
- Q15** An ideal gas undergoes a process in which the pressure and volume are related by $PV^2 = \text{constant}$. If the initial temperature of the gas is T_1 and the volume is doubled during this process, what will be the final temperature T_2 of the gas?
(A) $T_2 = \frac{T_1}{4}$ (B) $T_2 = \frac{T_1}{2}$
(C) $T_2 = 2T_1$ (D) $T_2 = 4T_1$
- Q16** Which of the following contributes most to rapid saltatory conduction in myelinated axons?
(A) High density of voltage-gated Na^+ channels at nodes of Ranvier
(B) Continuous distribution of Na^+ channels along the axon
(C) Large axon diameter only
(D) Increased neurotransmitter release
- Q17** Two genes, P and Q, are linked and 10 cM apart. If a heterozygous plant PpQq is testcrossed with ppqq, what is the expected proportion of recombinant offspring?
(A) 5% (B) 10%
(C) 15% (D) 50%
- Q18** Consider two matrices A and B such that

$$A = \begin{bmatrix} 1 & -1 & 1 \\ 2 & 1 & -3 \\ 1 & 1 & 1 \end{bmatrix} \text{ and}$$

$$10B = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix}$$

If B is the inverse of the matrix A , then α is

- (A) -2 (B) -1
(C) 2 (D) 5
- Q19** A population has $r = 0.1$ per year and $N = 200$. Under exponential growth, what is the increase in population (ΔN) in one year?
(A) 20 (B) 40
(C) 60 (D) 2
- Q20** Which of the following statements is TRUE about Cyclin B-CDK1?
(A) Active during S phase
(B) Drives $G_2 \rightarrow M$ transition
(C) Inhibited by p21 during G1
(D) Directly triggers DNA replication
- Q21** Which concept explains why closely related species share many similar traits?
(A) Convergent evolution
(B) Common ancestry
(C) Artificial selection
(D) Genetic drift
- Q22** Among the following which option is incorrect regarding size –
(A) $B > Al > Ga > In$
(B) $C < Si < Ge < Sn$
(C) $B < Ga < Al < In$
(D) $Na < K < Rb < Cs$
- Q23** In the pressure-flow hypothesis, the movement of sucrose in phloem occurs due to:
(A) Cohesion and adhesion of water
(B) Hydrostatic pressure difference between source and sink
(C) Root pressure
(D) Transpiration pull

Q24



In angiosperms, the male gametophyte develops from:

- (A) Microsporocyte (2n) → microspore (n) → pollen grain (n)
- (B) Microsporocyte (2n) → pollen grain (2n)
- (C) Megasporeocyte (2n) → pollen grain (n)
- (D) Microspore (n) → zygote (2n)

- Q25** In a gametophytic self-incompatibility system, pollen fails to fertilize if:
- (A) Its diploid genotype matches that of the pistil
 - (B) Pollen S-allele matches pistil S-allele
 - (C) Its haploid S-allele differs from the pistil
 - (D) Environmental conditions are unfavorable

- Q26** A block of mass m is placed on a smooth horizontal surface. A force F is applied on the block such that the force always remains directed toward a fixed point O . The magnitude of the force remains constant. When the block is at a distance r from point O , its acceleration is: (Here, θ is the angle between the force direction (toward O) and the block's instantaneous velocity).
- (A) $\frac{F}{m} \cdot \sin(\theta)$
 - (B) $\frac{F}{m} \cdot \cos(\theta)$
 - (C) $\frac{F}{m}$
 - (D) $\frac{F}{m} \cdot r$

- Q27** A child has cystic fibrosis (autosomal recessive disorder). Both parents are phenotypically normal. What is the probability that the next child will also have cystic fibrosis?
- (A) 0%
 - (B) 25%
 - (C) 50%
 - (D) 75%

- Q28** In *Agrobacterium tumefaciens*-mediated transformation, the selectable marker for plant transformants is usually:
- (A) Located within the T-DNA segment
 - (B) Located outside the T-DNA segment
 - (C) Only used for bacterial selection
 - (D) Not required

- Q29** A newly discovered bacterium grows in complete darkness. It oxidizes H_2S to obtain energy and uses CO_2 as its only carbon source. However,

when placed in organic-rich medium, it switches to using acetate as both carbon and energy source. Which option correctly identifies its nutritional modes in the two conditions?

- (A) Photoautotroph → Photoheterotroph
- (B) Chemoautotroph → Chemoheterotroph
- (C) Chemoheterotroph → Chemoautotroph
- (D) Photoautotroph → Chemoheterotroph

- Q30** A defective phage accidentally packages host DNA instead of its own genome. When it infects another bacterium, the transferred DNA may recombine with the recipient genome. This refers to:
- (A) Specialized transduction
 - (B) Generalized transduction
 - (C) Transposition
 - (D) Cotransduction

- Q31** Which enzyme pairs can catalyze opposing reactions in futile cycles?
- (A) Phosphofructokinase-1 ↔ Fructose-1,6-bisphosphatase
 - (B) Hexokinase ↔ Glucose-6-phosphatase
 - (C) Pyruvate kinase ↔ Pyruvate carboxylase + PEP carboxykinase
 - (D) Citrate synthase ↔ Aconitase

- Q32** Which of the following statements about the ER are correct?
- (A) Rough ER is the site of protein synthesis
 - (B) Smooth ER is involved in lipid synthesis and detoxification
 - (C) ER is continuous with the plasma membrane
 - (D) ER lumen is topologically equivalent to the extracellular space

- Q33** Which of the following are TRUE for eukaryotic transcription factors?
- (A) TFIID = TBP + TAFs
 - (B) TFIIE is required to recruit TFIIH
 - (C) Mediator complex helps activate Pol II transcription via enhancers
 - (D) TFIIIS catalyzes polyadenylation of pre-mRNA

Q34



Regarding speciation, which of the following statements are correct?

(A) Allopatric speciation occurs due to geographical isolation.

(B) Sympatric speciation requires reproductive isolation without physical separation.

(C) Hybrid sterility is an example of a prezygotic barrier.

(D) Adaptive radiation can lead to the rapid formation of multiple species from a common ancestor.

Q35 In a population showing Allee effect, which statements are true?

(A) Growth rate decreases at very low densities

(B) Cooperation among individuals may be necessary for survival

(C) Small populations always grow faster

(D) A threshold population size may be required to avoid extinction

Q36 A bacterium grows on glucose under aerobic conditions. When switched to anaerobic nitrate-respiring conditions, which of the following changes are MOST likely?

(A) ATP yield per glucose will decrease.

(B) Proton motive force will be generated.

(C) Terminal electron acceptor will have lower redox potential than O_2 .

(D) NADH will no longer be oxidized through an electron transport chain.

Q37 Select correct statements:

(A) Pleiotropy: one gene affects multiple traits

(B) Gene interaction: multiple genes affect a single trait

(C) Pleiotropy always results in epistasis

(D) Gene interaction can produce novel ratios

Q38 Which of the following statements about cardiac conduction system are correct?

(A) SA node initiates the heartbeat

(B) AV node delays the impulse to allow ventricular filling

(C)

Purkinje fibers transmit impulses to ventricular muscles

(D) Bundle of His originates in atria

Q39 In C_4 plants, which of the following statements are correct?

(A) CO_2 is initially fixed into oxaloacetate in mesophyll cells

(B) Malate transports CO_2 to bundle sheath cells

(C) Photorespiration is higher than in C_3 plants

(D) Calvin cycle occurs in bundle sheath cells

Q40 Which of the following are TRUE regarding EcoRI and HindIII?

(A) Both are Type II restriction enzymes

(B) Both generate sticky ends with 5' overhangs

(C) Both require ATP for cleavage

(D) Both recognize palindromic sequences

Q41 The value of $\lim_{x \rightarrow \infty} (\sqrt{x^2 + 5} - x)$ is equal to

Q42 Consider the differential equation $\frac{dy}{dx} + xy = 1$

If $f(x)$ denotes the integrating factor of the given differential equation. Then $f(\sqrt{2})$ is -----

(rounded off TWO decimal places)

Q43 A silicon sample is doped with 1.0×10^{16} phosphorus atoms/ cm^3 . At $300\ K$, the intrinsic carrier concentration of silicon is $n_i = 1.0 \times 10^{10}\ cm^{-3}$. Assuming complete ionization of dopants, calculate the minority carrier concentration (holes) in the semiconductor is $\dots \times 10^4\ cm^{-3}$

Q44 A single slit of width $a = 0.250\ mm$ is illuminated by monochromatic light of wavelength $\lambda = 632.8\ nm$ (He-Ne laser). A screen is placed at a distance $L = 2.00\ m$ from the slit. Find the distance y from the central maximum to the first minimum on the screen in mm.

Q45 An enzyme follows Michaelis-Menten kinetics with $K_M = 5\ \mu M$ and is competitively inhibited,



effectively doubling the apparent K_M . Find the substrate concentration that gives 50% of V_{max} under inhibition.

- Q46** How many electrons can be attributed in 5g subshell?
- Q47** In a population, allele A has a frequency of 0.6 and allele a has a frequency of 0.4. If random mating occurs, what will be the frequency of genotype Aa in the next generation?
- Q48** In a plant, commercially important traits are: dominant P, recessive q, dominant R, and recessive s. The inheritance follows Mendelian laws. Cross PpQqRrSs \times PpQqRrSs. Calculate the expected frequency of offspring showing all desired phenotypes (P-, qq, R-, ss). Round to 3 decimals.
- Q49** pK_a value of acetic acid is 4.75. If the buffer solution contains 0.125 M acetic acid and 0.25 M sodium acetate, the pH of buffer solution is _____.
- Q50** A bacterial population doubles every 30 minutes. How many hours will it take to grow from 1×10^5 to 3.2×10^6 cells?
- Q51** IgM monomer has 5 heavy chains (65 kDa each) and 5 light chains (25 kDa each). Total MW of one monomer = ?
- Q52** A eukaryotic gene is 12 kb long. RNA Pol II transcribes at 2 kb/min, but pauses for 30 seconds at each of 4 internal pause sites. Total time required to transcribe this gene (in minutes) _____
- Q53** A plane electromagnetic wave in vacuum has an electric-field amplitude $E_0 = 150 \text{ V/m}$. Calculate the time-averaged intensity (average Poynting flux) $\langle S \rangle$ in W/m^2 ..
- Q54** At 380°C, the half-life period for the first-order decomposition of H_2O_2 is 360 min. The energy of activation of the reaction is 200 kJmol^{-1} .

Calculate the time required for 75% decomposition at 450°C.

- Q55** The concentration of R in the reaction $R \rightarrow P$ was measured as a function of time and the following data is obtained.

$[R]$ (molar)	1	0.75	0.40	0.10
t (min.)	0.0	0.05	0.12	0.18

The order of the reaction is _____.

- Q56** A signal passes through three logic gates in series. The propagation delays are; Gate-1: 8 ns, Gate-2: 12 ns and Gate-3: 10 ns. The input changes at $t = 0$. What is the earliest time (in nanoseconds) at which the output can definitely produce the correct stable logic level?
- Q57** A cDNA clone of a eukaryotic gene is 850 bp long. The 5'-UTR is 130 bp, and the 3'-UTR is 100 bp. If the coding sequence includes a stop codon, how many amino acids are present in the encoded polypeptide?
- Q58** A protein solution of $1 \mu\text{M}$ shows transmission of 60% in a 1 cm cuvette. If measured in a 5 cm cuvette, what is the expected transmission? (nearest integer %)
- Q59** The value of $\int_0^{\frac{\pi}{2}} x \sin x dx$ is equal to
- Q60** A number lock has four rings, and each ring has 10 digits, 0, 1, 2, , 9. The maximum number of unsuccessful attempts that can be made while trying to open the lock without knowing the key code is _____



Answer Key

Q1	(C)	Q31	(A, B, C)
Q2	(B)	Q32	(A, B, D)
Q3	(A)	Q33	(A, B, C)
Q4	(C)	Q34	(A, B, D)
Q5	(B)	Q35	(A, B, D)
Q6	(A)	Q36	(A, B, C)
Q7	(B)	Q37	(A, B, D)
Q8	(C)	Q38	(A, B, C)
Q9	(A)	Q39	(A, B, D)
Q10	(D)	Q40	(A, B, D)
Q11	(B)	Q41	0~0
Q12	(C)	Q42	2.69~2.75
Q13	(B)	Q43	0.98~1.02
Q14	(C)	Q44	5~5.2
Q15	(B)	Q45	10~10
Q16	(A)	Q46	18~18
Q17	(B)	Q47	0.48~0.48
Q18	(D)	Q48	0.03~0.04
Q19	(A)	Q49	5~5
Q20	(B)	Q50	2.5~2.5
Q21	(B)	Q51	450~450
Q22	(A)	Q52	8~8
Q23	(B)	Q53	59~60
Q24	(A)	Q54	20~21
Q25	(B)	Q55	0~0
Q26	(C)	Q56	30~30
Q27	(B)	Q57	205~205
Q28	(A)	Q58	7~8
Q29	(B)	Q59	1~1
Q30	(B)	Q60	9999~9999



Hints & Solutions

Q1 Text Solution:

$$\text{Let } f(x) = x^x = y$$

Any function increases, then its derivative

$$f'(x) > 0$$

$$y = x^x$$

Take \log_e both sides

$$\log_e y = x \log_e x \quad [x > 0]$$

$$\Rightarrow \frac{1}{y} \frac{dy}{dx} = \frac{x}{x} + \log_e x$$

$$\Rightarrow \frac{dy}{dx} = x^x (1 + \log_e x) > 0$$

$$\Rightarrow \frac{dy}{dx} = x^x (1 + \log_e x) > 0$$

$$\Rightarrow 1 + \log_e x > 0 \quad [x^x > 0]$$

$$\Rightarrow \log_e x > -1 \text{ or } x > \frac{1}{e}$$

Hence, $f(x)$ increases for $x \in (\frac{1}{e}, 1)$

Hence, option (C) is correct.

Q2 Text Solution:

In logistic growth, population grows fastest when resources are partly available and competition is moderate. At $K/2$, individuals have enough resources for reproduction but the population is not yet limited by carrying capacity.

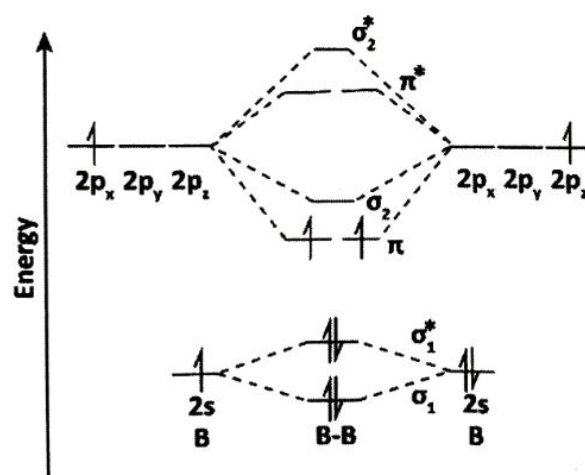
A (K): At K , growth becomes zero.

C (2K): Population cannot exceed K in logistic model.

D (0): At small size, growth rate is low due to few individuals

Q3 Text Solution:

Paramagnetic molecules have at least 1 unpaired electron in their molecular orbitals and among the given molecules only B_2 contains unpaired electron in its molecular orbital. The molecular orbital diagram of B_2 is drawn below.



Hence, the correct option is (a).

Q4 Text Solution:

A. DD-carboxypeptidases:

- Remove terminal D-Ala from peptide chains.
- Participate in peptide cross-link modification.

B. Transpeptidases

- Catalyze cross-link formation between peptide chains.
- Essential for peptidoglycan maturation.

C. Transaminases

- Catalyze amino group transfer reactions.
- Not involved in peptidoglycan cross-linking or cleavage.

D. Lytic transglycosylases

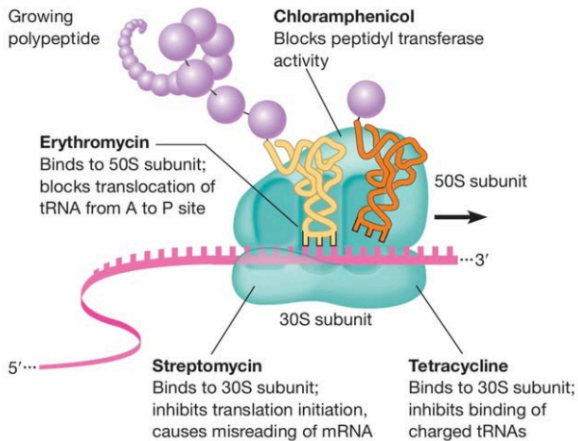
- Cleave glycosidic bonds in glycan strands.
- Play a role in cell wall remodeling.

Q5 Text Solution:

- Erythromycin is a macrolide antibiotic that binds to the 23S rRNA present in the 50S ribosomal subunit. Once bound, it blocks the polypeptide exit tunnel, the channel through which the growing peptide normally moves out of the ribosome.
- Because this tunnel is obstructed, the ribosome cannot continue elongation, and



translation stops. It does not cause misreading, does not affect tRNA charging, and does not prevent ribosome assembly.



Q6 Text Solution:

Concept:

Moment of force (torque) = Force \times Perpendicular distance $\Rightarrow \tau = F \times r$

Force has dimensions: $[F] = MLT^{-2}$

Distance has dimensions: $[r] = L$

Calculation:

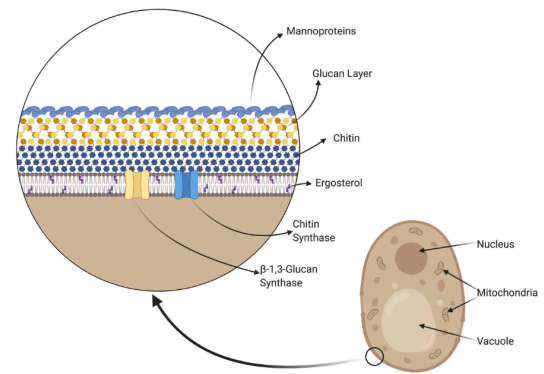
$$[\tau] = (MLT^{-2})(L) = ML^2T^{-2}$$

Q7 Text Solution:

Most true fungi have ergosterol in their cell membrane. Microsporidia are exceptional because:

- They are highly reduced, obligate intracellular parasites.
- They lack ergosterol in their membranes.
- Their cell wall is rich in chitin and β -glucans fungal traits.

So, a fungus without ergosterol but with β -glucans matches Microsporidia only.



Q8 Text Solution:

- The potency of a drug often correlates with how strongly it binds to its target, which is measured by the binding free energy (ΔG°).
- A more negative ΔG° value indicates a more favorable and stronger binding interaction between the drug and the enzyme.
- Among the given molecules, Drug C has the most negative binding free energy (-9.2 kcal/mol), meaning it binds the tightest to the enzyme.
- Stronger binding usually results in better inhibition or activation of the target, making the drug more effective at lower concentrations. Therefore, Drug C is predicted to be the most potent.

Q9 Text Solution:

During the Industrial Revolution, the environment became darker due to soot. Light-colored moths became more visible to predators, while dark-colored moths had a selective survival advantage. Over generations, the frequency of dark-colored moths increased. This change in allele frequency due to differential survival and reproduction is a classic example of directional natural selection.

- Genetic drift (B): Random changes in allele frequencies, important in small populations, not in this scenario.
- Mutation (C): Introduces new alleles but does not explain the rapid increase of dark moths.
- Gene flow (D): Movement of alleles between populations, not relevant here.



Q10 Text Solution:**Solution:**

The specific rate constant (k) of a first-order reaction is independent of the concentration of reactants or products. However, it depends on **temperature**, as given by the **Arrhenius equation**:

$$k = Ae^{-E_a/RT}$$

where:

- k is the rate constant,
- A is the pre-exponential factor,
- E_a is the activation energy,
- R is the universal gas constant, and
- T is the absolute temperature.

From this equation, it is clear that the rate constant k changes with temperature but remains unaffected by time or the concentrations of reactants and products.

Correct answer: (D) Temperature

Q11 Text Solution:

Using the Michaelis–Menten equation:

$$v = \frac{V_{max} [S]}{K_M + [S]}$$

v

Given:

$$[S] = 0.1K_M$$

$$v = \frac{V_{max} (0.1K_M)}{K_M + 0.1K_M}$$

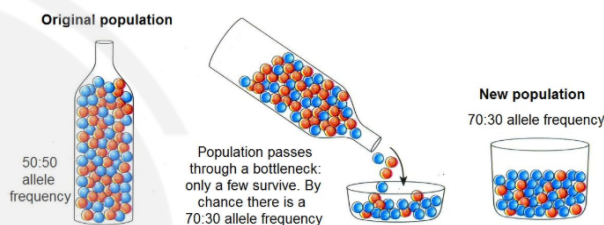
$$v = \frac{0.1V_{max} K_M}{1.1K_M}$$

$$v = \frac{0.1}{1.1} V_{max}$$

$$v \approx 0.09V_{max}$$

Q12 Text Solution:

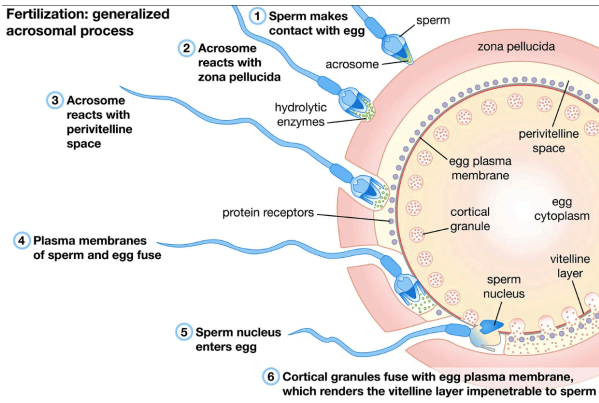
- A population bottleneck is a sharp reduction in population size due to random events like natural disasters or disease.
- In the resulting small population, chance events have a much greater impact on which alleles are passed to the next generation, a process known as genetic drift.
- This random change in allele frequencies is significantly stronger in small populations compared to large ones, making it the most potent evolutionary force immediately after a bottleneck event.

**Q13 Text Solution:**

After the first sperm fuses with the egg in mammals, cortical granules present in the egg cytoplasm release their contents into the space between the plasma membrane and the zona pellucida. This triggers biochemical changes in the zona pellucida, making it impermeable to additional sperm. This process is called the cortical (slow) block to polyspermy.

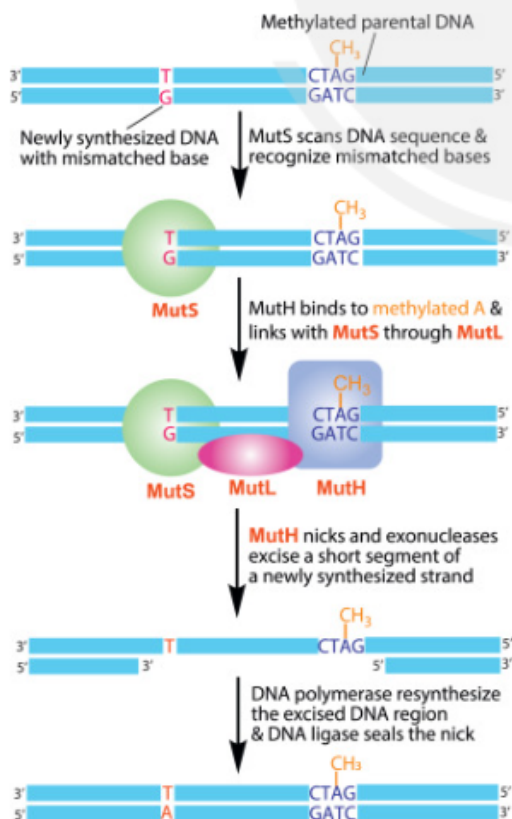
- Zona pellucida (A): While it is involved in sperm binding, it is modified by cortical granules to prevent polyspermy.
- Vitelline membrane (C): In mammals, this term is not typically used; the zona pellucida serves a similar role.
- Nucleus (D): Not involved in blocking additional sperm.





Q14 Text Solution:

- **Mismatch repair (MMR)** in *E. coli* fixes replication errors (like G–T or A–C mismatches).
- To know which strand is correct, the repair machinery must distinguish the parental (template) strand from the newly synthesized strand.
- **Key fact:** *E. coli* DNA is methylated at adenine in GATC sequences by Dam methylase.
- **Parental strand:** already methylated.
- **New strand:** initially unmethylated → recognized as the one to be corrected.



Q15 Text Solution:

Concept:

Use **ideal gas law:** $PV = nRT$

and the given process: $PV^2 = k \Rightarrow P = \frac{k}{V^2}$

Solution:

At state 1:

$$P_1 = \frac{k}{V_1^2} \Rightarrow T_1 = \frac{P_1 V_1}{R} = \frac{k}{V_1^2} \cdot \frac{V_1}{R} = \frac{k}{R V_1}$$

At state 2 (volume doubled: $V_2 = 2V_1$):

$$P_2 = \frac{k}{(2V_1)^2} = \frac{k}{4V_1^2}$$

Temperature at state 2:

$$T_2 = \frac{P_2 V_2}{R} = \frac{k}{4V_1^2} \cdot \frac{2V_1}{R} = \frac{k}{2R V_1}$$

Now divide:

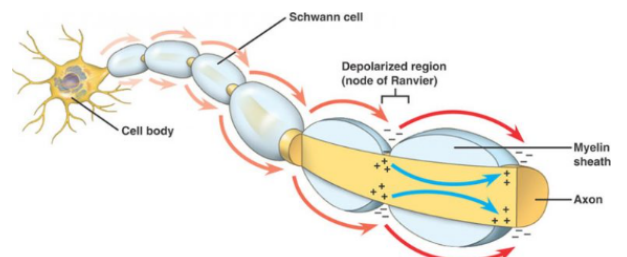
$$\frac{T_2}{T_1} = \frac{\frac{k}{2R V_1}}{\frac{k}{R V_1}} = \frac{1}{2}$$

$$T_2 = \frac{T_1}{2}$$

Correct Answer: B) $T_2 = \frac{T_1}{2}$

Q16 Text Solution:

- Saltatory conduction occurs in myelinated axons, where the action potential “jumps” from one node of Ranvier to the next.
- This rapid conduction is primarily due to the high density of voltage-gated Na^+ channels at the nodes, which allows the depolarization to regenerate only at these gaps, while the myelin sheath electrically insulates the internodal regions, preventing ion leakage.
- Axon diameter and neurotransmitter release have less influence on the speed of conduction along myelinated fibers.



Q17 Text Solution:



Given:

- Two genes, P and Q, are linked.
- Recombination frequency (distance) = 10 cM: this means 10% recombination.
- Heterozygous plant: PpQq (cis configuration assumed unless specified)
- Testcross: PpQq × ppqq

Gametes from heterozygote:

- Parental gametes: PQ, pq
- Recombinant gametes: Pq, pQ
- Recombination frequency = 10%: **10% of gametes are recombinant, 90% are parental**

Recombinant gametes: 10% total:

- Pq = 5%
- pQ = 5%

Parental gametes: 90% total:

- PQ = 45%
- pq = 45%

So recombinant gametes = 10% of total

Q18 Text Solution:

Concept: If matrix B is the inverse of the matrix A , then their product is the identity matrix, i.e., $AB = BA = I$

Solution: Given, B is the inverse of A

$$\Rightarrow AB = I$$

$$\Rightarrow B = A^{-1}$$

Given,

$$10B = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix}$$

$$\Rightarrow 10A^{-1} = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix}$$

$$\Rightarrow (10A^{-1})A = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix} A$$

$$\Rightarrow 10I = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix} \begin{bmatrix} 1 & -1 & 1 \\ 2 & 1 & -3 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 10 & 0 & 0 \\ 0 & 10 & 0 \\ 0 & 0 & 10 \end{bmatrix} = \begin{bmatrix} 10 & 0 & 0 \\ -5 + \alpha & 5 + \alpha & -5 + \alpha \\ 0 & 0 & 10 \end{bmatrix}$$

On comparing, we get $-5 + \alpha = 0$

$$\Rightarrow \alpha = 5$$

Hence, correct option is D

Q19 Text Solution:

Given: $r = 0.1$, $N = 200$

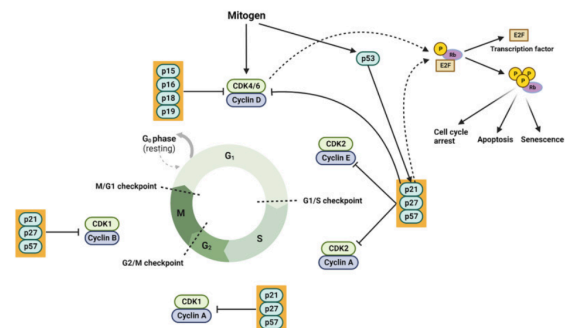
Exponential growth is calculated as: $\Delta N = r \times N$

$$= 0.1 \times 200 = 20 \text{ individuals added in one year.}$$

The growth is proportional to the current population size since each individual contributes equally to reproduction.

Q20 Text Solution:

- Cyclin B binds to CDK1 to form the M-phase promoting factor (MPF), which is essential for driving the $G_2 \rightarrow M$ transition in the eukaryotic cell cycle.
- It is not active during S phase, so it does not participate in DNA replication. While CDK inhibitors like p21 regulate G_1/S phase CDKs, Cyclin B-CDK1 is not inhibited by p21 during G_1 .
- Therefore, Cyclin B-CDK1's primary role is to trigger entry into mitosis, not DNA synthesis.



Q21 Text Solution:

Common ancestry is the evolutionary concept that explains why related species have shared



traits (homologous structures) and genetic similarities. The more recent their common ancestor, the more similarities they tend to share, both in physical features and at the molecular level (DNA and proteins).

Q22 Text Solution:

Option A: B > Al > Ga > In

- **Incorrect:** This trend is wrong.
- **Reason:**
 - Boron (B) is in Group 13, Period 2. Its size is the smallest in the group.
 - Aluminum (Al), Gallium (Ga), and Indium (In) are larger because they are further down the group.
 - The correct order should be **B < Ga < Al < In** because of the "d-block contraction" (Ga is slightly smaller than Al).

Q23 Text Solution:

The Pressure-Flow Hypothesis (also known as the mass-flow hypothesis) explains how sugars (primarily sucrose) are transported through the phloem sieve tubes from a source (where sugars are made or stored, e.g., leaves) to a sink (where sugars are used or stored, e.g., roots, fruits).

1. Loading at the Source:

- Sucrose is actively transported into the sieve tubes at the source.
- This high concentration of sucrose in the sieve tubes causes water to move into the phloem from the adjacent xylem by osmosis.

2. Generating Hydrostatic Pressure: The influx of water increases the turgor pressure (or hydrostatic pressure) within the sieve tubes at the source end. This creates a zone of high pressure.

3. Unloading at the Sink:

- Sucrose is **actively unloaded from the sieve tubes at the sink tissues.**
- The removal of sucrose causes water to leave the phloem and return to the xylem by

osmosis.

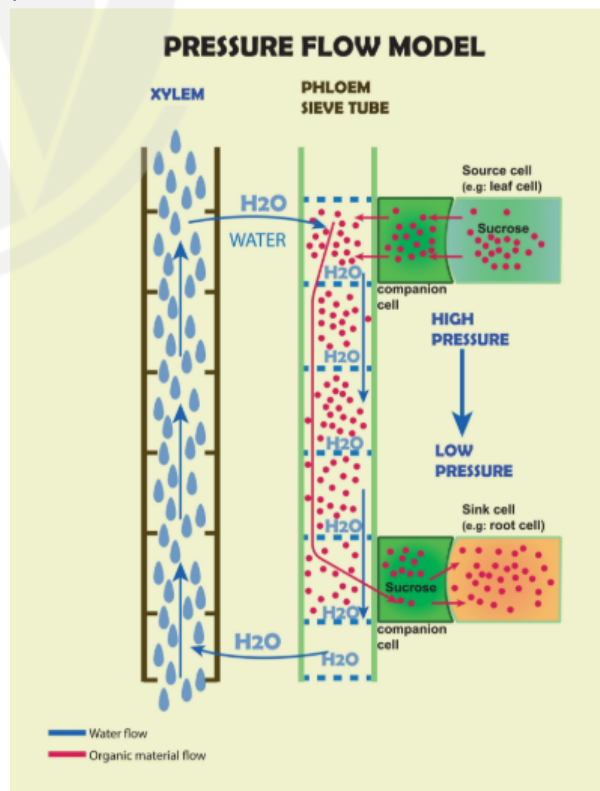
4. Pressure Gradient and Flow:

- The loss of water lowers the turgor pressure at the sink end, creating a zone of low pressure.
- The resulting hydrostatic pressure difference (high pressure at the source, low pressure at the sink) drives the bulk flow (mass flow) of the sucrose-water solution down the pressure gradient through the sieve tubes.

A) Cohesion and adhesion of water: These forces are central to water movement in the **xylem** (part of the Cohesion-Tension Theory), not sugar movement in the phloem.

C) Root pressure: This is a minor, positive pressure in the xylem that can push water up a short distance, but it is not the primary driver of sugar transport.

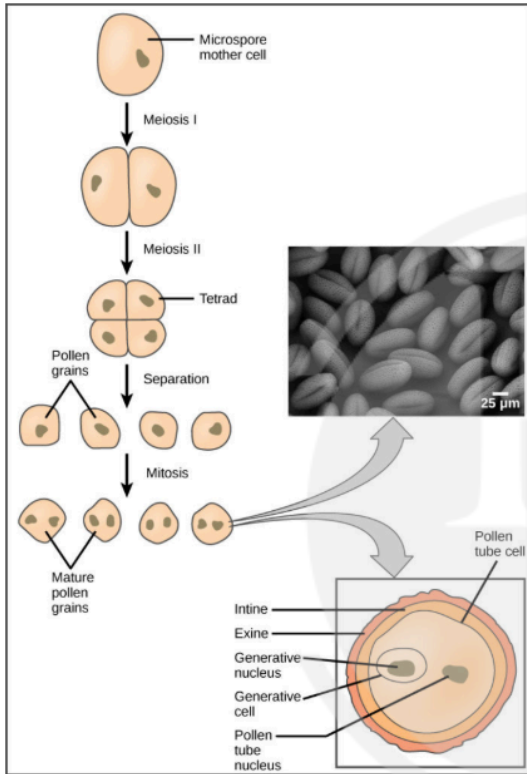
D) Transpiration pull: This is the negative pressure/tension created in the **xylem** by the evaporation of water from leaves and is the main mechanism for long-distance water transport in plants.



Q24 Text Solution:

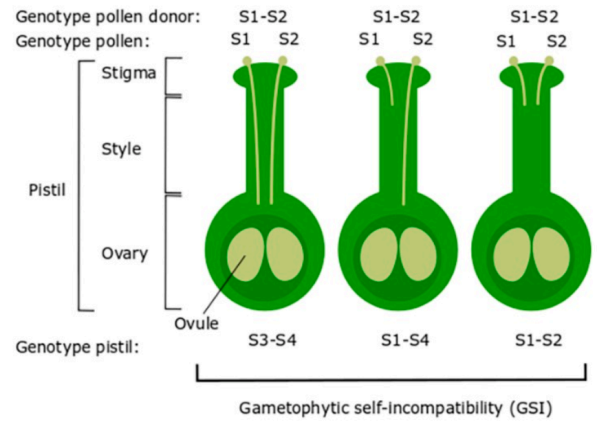


In angiosperms, the male gametophyte develops from a microsporocyte (diploid, $2n$) located in the anther. The microsporocyte undergoes meiosis to produce four haploid microspores (n). Each microspore then undergoes mitotic divisions to form a pollen grain, which represents the male gametophyte (n). The pollen grain typically contains two or three cells, including the generative cell that will give rise to sperm cells for fertilization.



Q25 Text Solution:

In a gametophytic self-incompatibility (GSI) system, the compatibility of pollen is determined by the haploid genotype of the pollen grain. Each pollen carries a single S-allele, while the pistil contains two S-alleles (diploid). Fertilization fails if the S-allele of the haploid pollen matches either of the two S-alleles in the pistil, because the pistil recognizes it as “self” and inhibits pollen tube growth. This mechanism ensures outcrossing and maintains genetic diversity in the population.



Q26 Text Solution:

Concept:

Newton’s Second Law: $\vec{F} = m\vec{a}$

Acceleration is always in the direction of force → here force points toward fixed point O.

The magnitude of acceleration depends only on the force component along the direction of motion if kinetic energy is considered.

But total acceleration is due to the full force vector. Since the entire force is toward O → no component is lost.

Solution:

$a = \frac{F}{m}$

It does not depend on:

- angle θ , or
- distance r

Only direction of acceleration changes with motion, not magnitude.

Q27 Text Solution:

Given:

- Cystic fibrosis (CF) is autosomal recessive.
- Both parents are phenotypically normal, but they have a child with CF.

For an **autosomal recessive disorder:**

- Affected child = homozygous recessive (aa)
- Both parents are normal (phenotype = dominant), but since they have an affected child, each must be **heterozygous carriers** (Aa).

So, **Parent genotypes:** $Aa \times Aa$



	A (Parent 1)	a (Parent 2)
A (Parent 1)	AA	Aa
a (Parent 1)	Aa	aa

- **AA** → normal, non-carrier
- **Aa** → normal, carrier
- **aa** → affected

Probabilities:

- AA = 25%
- Aa = 50%
- aa = 25%

Q28 Text Solution:

In *Agrobacterium tumefaciens*-mediated plant transformation, the selectable marker gene for plant transformants (e.g., antibiotic or herbicide resistance) is placed within the T-DNA segment. This ensures that when the T-DNA integrates into the plant genome, the marker gene is also incorporated, allowing researchers to select transformed plant cells. Marker genes for bacterial selection, in contrast, are located outside the T-DNA on the plasmid.

Q29 Text Solution:

- The organism grows in darkness → so no photosynthesis, meaning it cannot be photo-anything.
- It oxidizes H_2S for energy → this is chemical energy, so it is chemo-.
- It uses CO_2 as the only carbon source → that makes it autotroph.
→ Condition 1 = Chemoautotroph
- In organic-rich medium, it uses acetate as carbon source AND energy source → organic

carbon + organic energy = chemoheterotroph.

→ Condition 2 = Chemoheterotroph

So the correct pair is: Chemoautotroph → Chemoheterotroph (Option B)

Q30 Text Solution:

- In generalized transduction, a lytic phage accidentally packages random bacterial DNA instead of its own viral DNA.
- This defective phage cannot start a normal infection but can inject the bacterial DNA into another cell.
- That DNA can then recombine with the recipient genome.

Specialized transduction is different it transfers only specific genes near the prophage integration site.

So here, since any host DNA is packaged accidentally → Generalized transduction.

Q31 Text Solution:

In a futile cycle, two enzymes catalyze opposing reactions in a metabolic pathway, often consuming ATP and generating heat without net metabolite change.

A. Phosphofructokinase-1 ↔ Fructose-1,6-bisphosphatase

- PFK-1 converts $F6P \rightarrow F1,6BP$ (glycolysis)
- FBPase converts $F1,6BP \rightarrow F6P$ (gluconeogenesis)
- It is a classic carbohydrate futile cycle.

B. Hexokinase ↔ Glucose-6-phosphatase

- Hexokinase: Glucose → Glucose-6-phosphate
- Glucose-6-phosphatase: $G6P \rightarrow$ Glucose
- It is an ATP-consuming futile cycle.

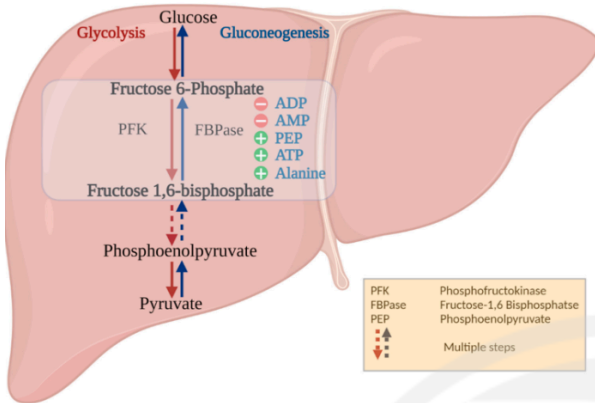
C. Pyruvate kinase ↔ Pyruvate carboxylase + PEP carboxykinase

- Pyruvate kinase: $PEP \rightarrow$ Pyruvate
- Pyruvate carboxylase + PEPCK: $Pyruvate \rightarrow PEP$
- Opposing reactions forming a gluconeogenic/glycolytic cycle.



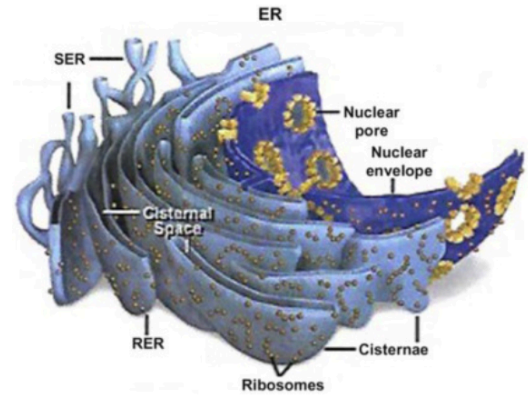
D. Citrate synthase ↔ Aconitase

- Citrate synthase: Oxaloacetate + Acetyl-CoA → Citrate
- Aconitase: Citrate ↔ Isocitrate
- These are sequential steps in TCA, not opposing reactions.



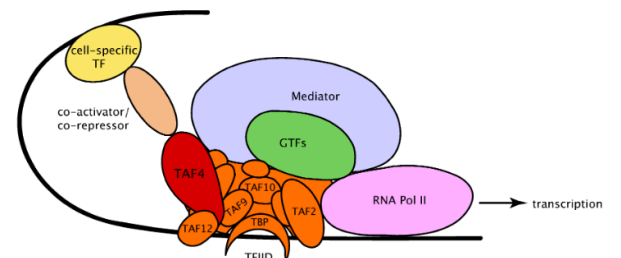
Q32 Text Solution:

- The endoplasmic reticulum (ER) is a continuous membrane system in eukaryotic cells. Rough ER, studded with ribosomes, is the primary site of protein synthesis, while smooth ER lacks ribosomes and is involved in lipid synthesis and detoxification.
- Although the ER is continuous with the nuclear envelope, it is not directly continuous with the plasma membrane.
- The ER lumen, however, is topologically equivalent to the extracellular space, meaning proteins synthesized into the lumen are sequestered from the cytoplasm and can be secreted or transported outside the cell. Therefore, statements A, B, and D are correct.



Q33 Text Solution:

- A. TFIID = TBP + TAFs — TRUE**
TFIID is a large complex made of TBP (TATA-binding protein) and TAFs (TBP-associated factors). It is the first factor that recognizes promoter elements like the TATA box.
- B. TFIIE is required to recruit TFIIH — TRUE**
TFIIE binds after TFIIF and helps recruit TFIIH, which brings helicase + kinase activities needed for promoter melting and CTD phosphorylation.
- C. Mediator complex helps activate Pol II transcription via enhancers — TRUE**
Mediator connects activator proteins at enhancers to Pol II at the promoter, stabilizing the pre-initiation complex and boosting transcription.
- D. TFIIIS catalyzes polyadenylation of pre-mRNA — FALSE**
TFIIIS has nothing to do with poly-A tail formation. It helps RNA polymerase proofread and restart after backtracking by stimulating cleavage of the nascent RNA.



Q34 Text Solution:

- A. True: Allopatric speciation occurs when populations are geographically separated,



leading to reproductive isolation and divergence into new species.

- B. True: Sympatric speciation occurs without physical separation, usually via ecological, behavioral, or genetic isolation mechanisms.
- C. False: Hybrid sterility is a postzygotic barrier, because it prevents gene flow after fertilization has occurred, not before.
- D. True: Adaptive radiation is the rapid evolution of multiple species from a common ancestor, often in response to new ecological niches.

Q35 Text Solution:

- In populations exhibiting the Allee effect, the growth rate actually declines when the population becomes very small because individuals struggle to find mates, form groups, or cooperate effectively.
- Such species often require a minimum number of individuals for survival, meaning that falling below a critical threshold population size can lead to extinction.
- This happens because cooperation such as group foraging, defense, or reproduction is essential at low densities.
- Therefore, growth rate decreases at low densities, cooperation becomes necessary, and a threshold size is required to persist, while the idea that small populations always grow faster is incorrect.

Q36 Text Solution:

Glucose metabolism changes from aerobic (O_2) to anaerobic nitrate respiration (NO_3^-).

1. ATP yield per glucose (A):

- Aerobic respiration with $O_2 \rightarrow$ maximal energy release.
- Nitrate as terminal acceptor \rightarrow lower redox potential \rightarrow less energy \rightarrow ATP yield decreases

2. Proton motive force (B):

- Nitrate respiration still uses an electron transport chain \rightarrow protons are pumped \rightarrow PMF is still generated

3. Redox potential of terminal acceptor (C):

- NO_3^-/NO_2^- redox couple $< O_2/H_2O \rightarrow$ correct

4. NADH oxidation (D):

- NADH is still oxidized via the ETC using nitrate \rightarrow incorrect

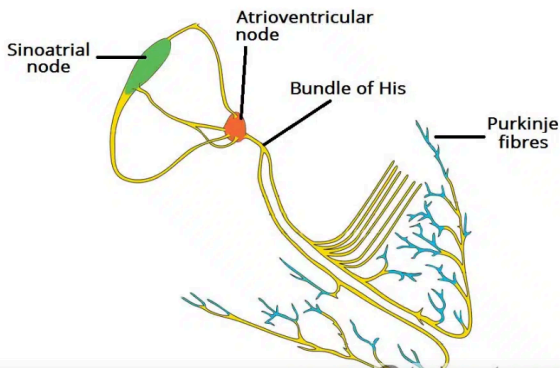
Q37 Text Solution:

- Pleiotropy occurs when a single gene influences multiple traits, so statement A is correct. Gene interaction, such as epistasis, involves two or more genes affecting a single trait, making statement B correct as well.
- However, pleiotropy does not necessarily result in epistasis, so statement C is incorrect.
- Gene interactions often produce novel F_2 phenotypic ratios that deviate from classic Mendelian ratios, such as 9:7, 12:3:1, or 15:1, which makes statement D correct. Therefore, the correct statements are A, B, and D.

Q38 Text Solution:

- The cardiac conduction system controls the heartbeat by generating and transmitting electrical impulses in a coordinated manner.
- The SA (sinoatrial) node, located in the right atrium, acts as the pacemaker and initiates the heartbeat.
- The AV (atrioventricular) node delays the impulse to allow complete ventricular filling before contraction.
- The Bundle of His originates from the AV node and passes the impulse to the Purkinje fibers, which then transmit the impulse to ventricular muscles, causing synchronized contraction.

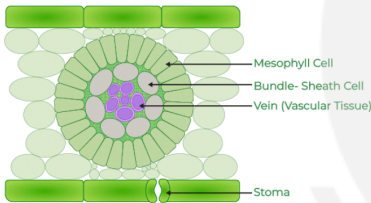




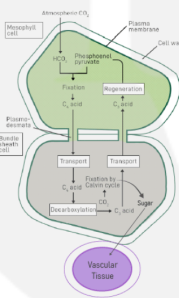
Q39 Text Solution:

In C_4 plants, carbon dioxide is first fixed in the mesophyll cells by the enzyme PEP carboxylase into a four-carbon compound, oxaloacetate. This oxaloacetate is converted into malate, which is then transported to the bundle sheath cells, where CO_2 is released for the Calvin cycle. Because CO_2 is concentrated around RuBisCO in the bundle sheath cells, photorespiration is minimized, unlike in C_3 plants.

C_4 Leaf Anatomy



The C_4 Pathway



Q40 Text Solution:

EcoRI and HindIII are classical Type II restriction enzymes widely used in molecular cloning. Both recognize specific palindromic DNA sequences and cleave within these recognition sites. They generate sticky ends with 5' overhangs, which facilitates directional ligation into vectors. Unlike Type I enzymes, Type II restriction enzymes do not require ATP for cleavage; they rely only on Mg^{2+} as a cofactor.

Q41 Text Solution:

$$\lim_{x \rightarrow \infty} (\sqrt{x^2 + 5} - x)$$

$$= \lim_{x \rightarrow \infty} (\sqrt{x^2 + 5} - x) \left(\frac{\sqrt{x^2 + 5} + x}{\sqrt{x^2 + 5} + x} \right)$$

$$= \lim_{x \rightarrow \infty} \frac{(\sqrt{x^2 + 5})^2 - x^2}{\sqrt{x^2 + 5} + x}$$

$$= \lim_{x \rightarrow \infty} \frac{x^2 + 5 - x^2}{\sqrt{x^2 + 5} + x}$$

$$= \lim_{x \rightarrow \infty} \frac{5}{\sqrt{x^2 + 5} + x}$$

$$= \lim_{x \rightarrow \infty} \frac{\frac{5}{x}}{\sqrt{1 + \frac{5}{x^2}} + 1}$$

$$= \frac{\lim_{x \rightarrow \infty} \frac{5}{x}}{\sqrt{1 + \lim_{x \rightarrow \infty} \frac{5}{x^2}} + 1}$$

$$= \frac{0}{\sqrt{1 + 0} + 1} = 0$$

Q42 Text Solution:

The given differential equation is:

$$\frac{dy}{dx} + xy = 1$$

This is a first-order linear differential equation of the form

$$\frac{dy}{dx} + P(x)y = Q(x)$$

where $P(x) = x$ and $Q(x) = 1$

The integrating factor, denoted by $f(x)$, is:

$$f(x) = e^{\int P(x)dx}$$

Substitute $P(x) = x$ into the formula:

$$f(x) = e^{\int x dx}$$

Integrate the exponent:

$$f(x) = e^{\frac{x^2}{2}}$$

(The constant of integration is omitted for the integrating factor).

Substitute $x = \sqrt{2}$ into the expression for $f(x)$:

$$f(\sqrt{2}) = e^{\frac{(\sqrt{2})^2}{2}}$$

$$f(\sqrt{2}) = e^{\frac{2}{2}}$$

$$f(\sqrt{2}) = e^1$$

$$f(\sqrt{2}) = e$$

The value of e is approximately 2.71828...

Rounding this value to two decimal places gives 2.72

The value of $f(\sqrt{2})$ rounded to two decimal places is 2.72

Q43 Text Solution:

Use the mass-action law: $np = n_i^2$

Solution:

For n-type Si: $n \approx N_D = 1.0 \times 10^{16} \text{ cm}^{-3}$

$$p = \frac{n_i^2}{n}$$



$$p = \frac{(1.0 \times 10^{10})^2}{1.0 \times 10^{16}} = \frac{1.0 \times 10^{20}}{1.0 \times 10^{16}} = 1.0 \times 10^4 \text{ cm}^{-3}$$

Final Answer:

$$p = 1.0 \times 10^4 \text{ cm}^{-3}$$

Q44 Text Solution:

Concept:

For single-slit diffraction the minima occur at angles θ satisfying

$$a \sin \theta = m\lambda, \quad m = \pm 1, \pm 2, \dots$$

For small angles ($\sin \theta \approx \tan \theta \approx y/L$),

$$y_m \approx \frac{m\lambda L}{a}$$

We need $m=1$ for the first minimum.

Calculation:

$$a = 0.250 \text{ mm} = 0.250 \times 10^{-3} \text{ m} = 2.50$$

$$\times 10^{-4} \text{ m},$$

$$\lambda = 632.8 \text{ nm} = 632.8 \times 10^{-9} \text{ m} = 6.328 \text{ L}$$

$$\times 10^{-7} \text{ m},$$

$$= 2.00 \text{ m}.$$

Distance to first minimum ($m = 1$):

$$y_1 \approx \frac{\lambda L}{a} = \frac{6.328 \times 10^{-7} \times 2.00}{2.50 \times 10^{-4}} = \frac{1.2656 \times 10^{-6}}{2.50 \times 10^{-4}}$$

$$= 5.0624 \times 10^{-3} \text{ m}.$$

So,

$$y_1 \approx 5.06 \text{ mm}.$$

Q45 Text Solution:

Given:

- $K_M = 5 \mu\text{M}$
- Competitive inhibition doubles apparent K_M :

$$K_M^{\text{app}} = 2 \times 5 = 10 \mu\text{M}$$

- Fractional velocity: $v = 0.5 V_{\text{max}}$
- Michaelis–Menten equation:

$$v = \frac{V_{\text{max}}[S]}{K_M^{\text{app}} + [S]}$$

$$0.5 V_{\text{max}} = \frac{V_{\text{max}}[S]}{10 + [S]}$$

Dividing both sides by V_{max} :

$$0.5 = \frac{[S]}{10 + [S]}$$

$$0.5(10 + [S]) = [S]$$

$$5 + 0.5[S] = [S]$$

$$5 = [S] - 0.5[S] = 0.5[S]$$

$$[S] = 10 \mu\text{M}$$

Q46 Text Solution:

The number of electrons that can be attributed to a given subshell is determined by its **orbital capacity**. For the **5g subshell**:

1. The value of **g** corresponds to an orbital quantum number ($l=4$).
2. The number of orbitals in any subshell is given by $2l+1$.
 - For $l=4$: $2(4) + 1 = 9$.
3. Each orbital can hold **2 electrons** (due to spin quantum numbers).

Thus, the **5g subshell** can hold a total of:

$$9 \times 2 = 18 \text{ electrons}.$$

Final Answer:

The **5g subshell** can accommodate **18 electrons**.

Q47 Text Solution:

Given: $A = 0.6$; $a = 0.4$

Under Hardy–Weinberg equilibrium: $p^2 + 2pq + q^2 = 1$

Aa frequency = $2pq$

$$= 2 \times 0.6 \times 0.4 = 0.48$$

Q48 Text Solution:

The desired phenotypes and their probabilities:

From Mendelian inheritance for a heterozygous cross:

1. **P- (dominant P)**

- Cross: $Pp \times Pp$



- Probability of P- = 3/4

2. qq (recessive q)

- Cross: Qq × Qq
- Probability of qq = 1/4

3. R- (dominant R)

- Cross: Rr × Rr
- Probability of R- = 3/4

4. ss (recessive s)

- Cross: Ss × Ss
- Probability of ss = 1/4

Since traits assort independently:

$$P(\text{all desired}) = P(P-) \times P(qq) \\ \times P(R-) \times P(ss)$$

$$P(\text{all desired}) = \frac{3}{4} \times \frac{1}{4} \times \frac{3}{4} \times \frac{1}{4}$$

$$P(\text{all desired}) = \frac{3 \times 1 \times 3 \times 1}{4 \times 4 \times 4 \times 4} = \frac{9}{256}$$

$$\frac{9}{256} \approx 0.035$$

Q49 Text Solution:

(5)

$$\text{pH} = \text{p}K_a + \log \frac{[\text{Salt}]}{[\text{Acid}]} \\ = 4.75 + \log \frac{0.25}{0.125} = 5.05$$

Q50 Text Solution:

Given:

- Initial population: $N_0 = 1 \times 10^5 \text{ N}$
- Final population: $N = 3.2 \times 10^6$
- Doubling time (generation time):
 $g = 30 \text{ min} = 0.5 \text{ hr}$

The population after n generations:

$$N = N_0 \cdot 2^n$$

$$3.2 \times 10^6 = 1 \times 10^5 \cdot 2^n$$

$$2^n = \frac{3.2 \times 10^6}{1 \times 10^5} = 32$$

Number of generations n :

$$2^n = 32$$

$$n = \log_2 32 = 5$$

Total time:

$$\text{Total time} = n \cdot g = 5 \cdot 0.5 \text{ hr} = 2.5 \text{ hr}$$

Q51 Text Solution:

Given:

- Heavy chain (H) = 65 kDa
- Light chain (L) = 25 kDa
- IgM monomer has **5 heavy chains + 5 light chains**

Total MW of heavy chains:

$$5 \times 65 = 325 \text{ kDa}$$

Total MW of light chains:

$$5 \times 25 = 125 \text{ kDa}$$

Total MW of IgM monomer:

$$325 + 125 = 450 \text{ kDa}$$

Q52 Text Solution:

1. Time for actual transcription (no pauses)

Gene length = 12 kb

Speed = 2 kb/min

$$\text{Transcription time} = \frac{12}{2} = 6 \text{ min}$$

2. Total pause time

Pause per site = 30 seconds = 0.5 min

Number of pauses = 4

$$\text{Pause time} = 4 \times 0.5 = 2 \text{ min}$$

3. Total time required

$$\text{Total time} = 6 + 2 = 8 \text{ min}$$

Final Answer: 8 minutes



Q53 Text Solution:**Concept:**

For an EM wave in vacuum, electric and magnetic fields carry energy. The **average intensity** (average Poynting flux) is:

$$\langle S \rangle = c \epsilon_0 E_0^2$$

where E_0 is the peak electric field amplitude.

Solution:

Given:

$$E_0 = 150 \text{ V/m}, c = 3 \times 10^8 \text{ m/s},$$

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

$$\langle S \rangle = c \epsilon_0 E_0^2 = (3 \times 10^8) (8.854$$

$$\times 10^{-12}) (150^2)$$

$$= 3 \times 10^8 \times 8.854 \times 10^{-12} \times 22500 = 5.98$$

$$\times 10^1 \text{ W/m}^2$$

$$\boxed{\langle S \rangle \approx 59.8 \text{ W/m}^2}$$

Q54 Text Solution:**Solution:**

$$\text{We know, } k = \frac{0.693}{t_{\frac{1}{2}}}$$

$$k = \frac{0.693}{360} = 0.925 \times 10^{-3} \text{ min}^{-1}$$

Value of k_2 at 450°C or 723K

$$\text{Using } \log \frac{k_2}{k_1} = \frac{E_a}{2.303R} \left[\frac{T_2 - T_1}{T_1 T_2} \right]$$

$$\log \frac{k_2}{1.925 \times 10^{-3}} = 1.5487$$

$$\frac{k_2}{1.925 \times 10^{-3}} = 35.375$$

$$k_2 = 6.81 \times 10^{-2} \text{ min}^{-1}$$

$$\text{Let } [A]_0 = 1 \text{ then } [A] = 1 - \frac{75}{100} = 0.25$$

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$$

$$\text{time} = \left(\frac{2.303}{6.81 \times 10^{-2}} \right) \log \frac{1}{0.25} = 33.82 \log 4$$

$$\Rightarrow 33.82 \times 0.6021 = 20.36 \text{ min}$$

$$t_{75\%} = 20.36 \text{ min}$$

Q55 Text Solution:

For the given reaction

$$-\frac{d[R]}{dt} = - \left(\frac{0.75 - 1}{0.05 - 0} \right) = \frac{0.25}{0.05} = 5$$

$$-\frac{d[R]}{dt} = - \left(\frac{0.40 - 0.75}{0.12 - 0.05} \right) = \frac{0.35}{0.07} = 5$$

Thus the value of $\frac{d[R]}{dt} = k$ is constant, and the reaction follows zero order kinetics.

Q56 Text Solution:**Concept:**

Propagation delay = time taken for a gate's output to correctly reflect a change in its input.

For gates in series \rightarrow total delay is the sum of individual delays.

Solution:

$$t_{\text{total}} = 8 + 12 + 10 = 30 \text{ ns}$$

So, the final output becomes stable at: 30 ns

Q57 Text Solution:**Calculating the coding sequence (CDS) length:**

- CDS length = total cDNA length
- (5'-UTR + 3'-UTR)
- CDS length = 850 - (130 + 100) = 850
- 230 = 620 bp

Calculating number of amino acids

- Each amino acid is encoded by **3 nucleotides**. The **stop codon does not code for an amino acid**, so we subtract 3 bp for the stop codon:

$$\text{CDS for amino acids} = 620 - 3 = 617 \text{ bp}$$

$$\text{Number of amino acids} = \frac{617}{3}$$

$$\approx 205 \text{ amino acids (integer)}$$

Q58 Text Solution:

Transmission T and absorbance A are related by:

$$T = 10^{-A} \times 100$$

$$A = -\log_{10}(T/100)$$

For $T = 60\%$:

$$A_1 = -\log_{10}(60/100) = -\log_{10}(0.6) \\ \approx 0.222$$

Calculating absorbance for 5 cm cuvette:



Absorbance is directly proportional to path length:

$$A_2 = A_1 \times \frac{l_2}{l_1} = 0.222 \times \frac{5}{1} = 1.11$$

$$T_2 = 10^{-A_2} \times 100 = 10^{-1.11} \times 100$$

$$10^{-1.11} \approx 0.0776$$

$$T_2 \approx 7.8\% \approx 8\% \text{ (nearest integer)}$$

Q59 Text Solution:

Concept:

$$\int_a^b f(x)g(x)dx$$

$$= [f(x) \int g(x)dx]_a^b -$$

$$\int_a^b \left[\frac{d}{dx} f(x) \int g(x)dx \right] dx$$

Solution:

Let $f(x) = x$ and $g(x) = \sin x$

$$\Rightarrow \int_0^{\pi/2} x \sin x \, dx$$

$$= [-x \cos x]_0^{\pi/2} - \int_0^{\pi/2} \frac{d}{dx} x \times [-\cos x] \, dx$$

$$= \left[-\frac{\pi}{2} \cos\left(\frac{\pi}{2}\right) - 0 \times \cos(0) \right] -$$

$$\int_0^{\pi/2} [-\cos x] \, dx$$

$$= \left[-\frac{\pi}{2} \times 0 - 0 \right] + \left[\sin\left(\frac{\pi}{2}\right) - \sin(0) \right]$$

$$= 0 + [1 - 0]$$

$$= 1$$

Q60 Text Solution:

The number of digits available on each rings is 10, ranging from 0 to 9.

Since there are 4 rings and each ring can have any of the 10 digits.

The total number of combinations is found to be $10^4 = 10 \times 10 \times 10 \times 10 = 10000$.

Since there is only one correct combination that opens the lock.

The maximum number of unsuccessful attempts is found to be

$$10000 - 1 = 9999$$

