GATE Ecology and Evolution

Sample Paper – 8

Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Ecology and Evolution** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise, take $\ln 2 = 0.693$, and assume large, randomly mating populations for all Hardy–Weinberg calculations.

Fundamentals of Ecology

Q1. Ecological resilience is best defined as: **[1 mark]**

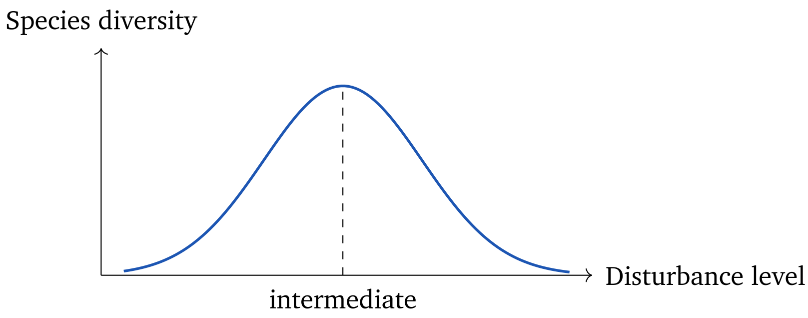
(A) the total number of species present in a community

(B) the rate at which biomass accumulates during succession

(C) the capacity of an ecosystem to absorb a disturbance and recover to its former state

(D) the permanent shift of a community into a different stable state

Q2. The intermediate disturbance hypothesis, sketched below, predicts that species diversity is highest when disturbance is: **[1 mark]**



(A) absent altogether

(B) extremely frequent and severe

(C) limited to a single event in the community's history

(D) intermediate in both frequency and intensity

Q3. A species whose removal causes a disproportionately large change in community structure relative to its own abundance is called a: **[1 mark]**

(A) keystone species

(B) dominant species by biomass

(C) indicator species

(D) invasive species

Q4. Bergmann's rule states that, within a warm-blooded species, populations living in colder climates tend to have: **[1 mark]**

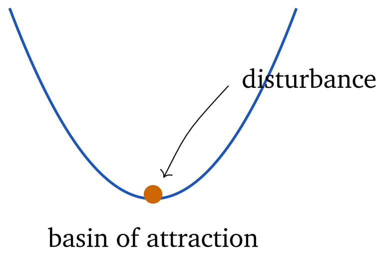
(A) smaller body size

(B) longer extremities such as ears and limbs

(C) larger body size

(D) paler coloration

Q5. In the stability landscape below, a ball resting in a deep, steep-sided valley represents an ecosystem that has: **[1 mark]**



(A) low resistance and low resilience

(B) no stable equilibrium at all

(C) an alternative stable state in a separate basin

(D) high resilience, returning quickly to its basin after a disturbance

Q6. The gradual, directional and largely predictable change in community composition that begins on a bare substrate with no pre-existing soil, such as a fresh lava flow, is called: **[1 mark]**

(A) secondary succession

(B) eutrophication

(C) a stable climax community

(D) primary succession

Population and Community Ecology

Q7. In a mark–recapture study, 40 animals are captured, marked and released. Later a sample of 50 animals is taken, of which 10 carry marks. The Lincoln–Petersen estimate of population size $\hat{N} = \dfrac{MC}{R}$ is: **[1 mark]**

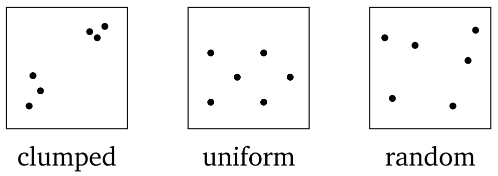
(A) 200

(B) 100

(C) 250

(D) 500

Q8. The three spatial patterns below show individuals within equal quadrats. The pattern in which individuals are spaced more evenly than random, often due to territoriality or competition, is: **[1 mark]**



(A) clumped (aggregated)

(B) uniform (regular)

(C) random

(D) exponential

Q9. The finite (geometric) rate of increase λ for a population that is neither growing nor declining from one year to the next equals: **[1 mark]**

(A) 0

(B) 2.0

(C) 1.0

(D) 0.5

Q10. The relationship between a fig tree and its species-specific pollinating fig wasp, in which the tree is pollinated and the wasp's larvae feed inside the fig, so that both partners benefit, is an example of: **[1 mark]**

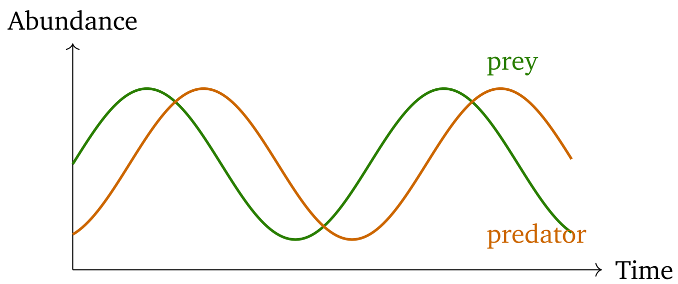
(A) mutualism

(B) commensalism

(C) parasitism

(D) amensalism

Q11. In the Lotka–Volterra predator–prey cycles shown, the predator population typically peaks: **[1 mark]**



(A) exactly in phase with the prey peak

(B) shortly before the prey peak

(C) shortly after the prey peak, lagging behind it

(D) independently of the prey abundance

Q12. Two warbler species feeding in different vertical zones of the same spruce tree, thereby reducing the overlap of their niches, illustrate: **[1 mark]**

(A) resource partitioning (niche differentiation)

(B) competitive exclusion

(C) obligate mutualism

(D) predation

Ecosystems and Biogeochemical Cycles

Q13. In the aquatic food chain shown, the tissue concentration of the persistent pollutant DDT rises from 0.02 ppm in phytoplankton to 25 ppm in the osprey. This progressive increase in concentration along successive trophic levels is called: **[1 mark]**

phytoplankton →	zooplankton →	small fish →	osprey
0.02	0.2	2	25 ppm

(A) bioremediation

(B) eutrophication

(C) biomagnification

(D) bioaccumulation confined to a single organism

Q14. Energy is transferred with an efficiency of 10% at each step of a food chain. If a heron at the fourth trophic level obtains 5 kJ, the energy originally fixed by the producers was: **[1 mark]**

(A) 500 kJ

(B) 50 kJ

(C) 5000 kJ

(D) 50000 kJ

Q15. In the carbon cycle, the process by which atmospheric CO_2 is converted into organic carbon compounds by green plants is: **[1 mark]**

(A) photosynthesis

(B) cellular respiration

(C) combustion

(D) decomposition

Q16. The excessive enrichment of a lake with nutrients such as nitrates and phosphates, leading to dense algal blooms and subsequent oxygen depletion, is called: **[1 mark]**

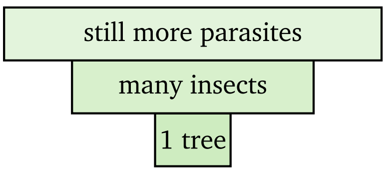
(A) acidification

(B) eutrophication

(C) biomagnification

(D) desertification

Q17. The inverted pyramid of numbers shown, in which a few producers support many more consumers, is most typical of: **[1 mark]**



(A) a temperate grassland

(B) a single large tree supporting many insect herbivores and their parasites

(C) an open-ocean phytoplankton-based community

(D) a sandy desert

Q18. Over long geological timescales, the largest reservoir of carbon on Earth is held in: [1 mark]

(A) the atmosphere

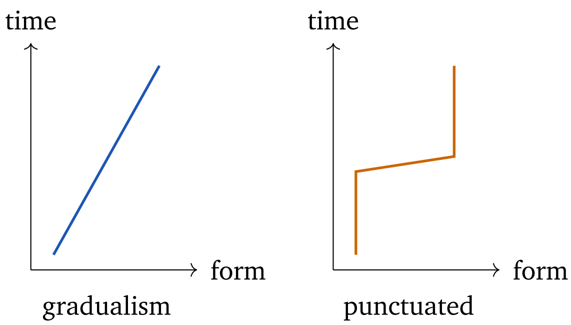
(B) living biomass

(C) the surface ocean

(D) sedimentary rocks and fossil fuel deposits

Mechanisms of Evolution

Q19. The two macroevolutionary patterns are contrasted below. The model in which species remain morphologically stable for long periods (stasis), interrupted by brief episodes of rapid change usually associated with speciation, is called: [1 mark]



(A) punctuated equilibrium

(B) phyletic gradualism

(C) orthogenesis

(D) Lamarckian inheritance

Q20. The differential survival and reproduction of individuals that carry different heritable traits, leading to adaptation, is Darwin's mechanism of: [1 mark]

(A) genetic drift

(B) natural selection

(C) gene flow

(D) mutation pressure

Q21. A recessive lethal allele a has frequency $q = 0.1$. Homozygous recessives (aa) die before reproducing (selection coefficient $s = 1$). Using $q' = \dfrac{q}{1+q}$, the allele frequency after one generation of selection is: **[2 marks]**

(A) 0.091

(B) 0.100

(C) 0.010

(D) 0.050

Q22. In a population the genotypes AA, Aa and aa have relative fitnesses 1.0, 1.0 and 0 (recessive lethal). If the recessive allele frequency is $q = 0.2$, the mean fitness of the population, $\bar{w} = 1 - q^2$, is: **[2 marks]**

(A) 0.96

(B) 1.00

(C) 0.80

(D) 0.04

Q23. A single-base substitution in a protein-coding gene that is synonymous (it does not change the encoded amino acid) is, in the great majority of cases, expected to be: **[2 marks]**

(A) strongly deleterious

(B) selectively neutral

(C) invariably advantageous

(D) always lethal

Q24. In a recipient population the frequency of allele A is 0.2. In one generation a fraction $m = 0.25$ of the population is replaced by migrants from a source in which the frequency of A is 0.6. Using $p' = (1-m)p + m\,p_m$, the new frequency of A is: **[2 marks]**

(A) 0.20

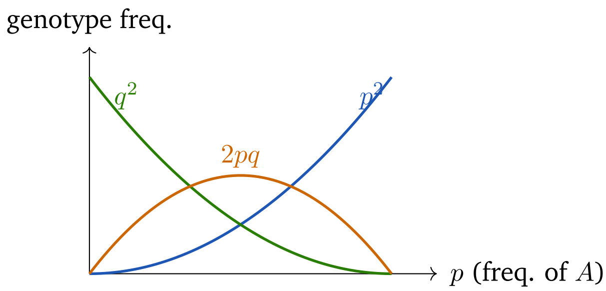
(B) 0.40

(C) 0.45

(D) 0.30

Population and Quantitative Genetics

Q25. In a Hardy–Weinberg population the dominant allele A has frequency $p = 0.7$. From the genotype-frequency curves shown, the expected frequency of homozygous dominant individuals (AA), given by p^2, is: **[2 marks]**



(A) 0.49

(B) 0.42

(C) 0.09

(D) 0.21

Q26. In a Hardy–Weinberg population the frequency of the homozygous recessive genotype is $q^2 = 0.09$. The frequency of heterozygotes (Aa), given by $2pq$, is: **[2 marks]**

(A) 0.49

(B) 0.42

(C) 0.09

(D) 0.21

Q27. The inbreeding coefficient F of a population is a measure of: **[2 marks]**

(A) the mutation rate per generation

(B) the number of migrants exchanged per generation

(C) the reduction in heterozygosity relative to Hardy–Weinberg expectation

(D) the additive genetic variance of a trait

Q28. The narrow-sense heritability h^2 of a quantitative trait is defined as the ratio of: **[2 marks]**

(A) dominance genetic variance to phenotypic variance

(B) environmental variance to phenotypic variance

(C) total genetic variance to total phenotypic variance

(D) additive genetic variance to total phenotypic variance

Q29. Using the breeder's equation $R = h^2 S$, a selection programme achieves a response of $R = 2.0$ g when the narrow-sense heritability is $h^2 = 0.4$. The selection differential S that was applied is: **[2 marks]**

(A) 0.8 g

(B) 2.4 g

(C) 0.2 g

(D) 5.0 g

Q30. In a sample of 200 diploid individuals the genotype counts are $AA = 98$, $Aa = 84$ and $aa = 18$. The frequency of allele A in the sample is: **[2 marks]**

(A) 0.70

(B) 0.49

(C) 0.42

(D) 0.30

Speciation, Phylogeny and Macroevolution

Q31. In cladistics, a shared derived character state that is used as evidence to group two or more taxa into a single clade is called a: **[2 marks]**

(A) symplesiomorphy

(B) homoplasy

(C) synapomorphy

(D) autapomorphy

Q32. The molecular clock hypothesis, widely used to date divergence events in molecular phylogenetics, assumes that: **[2 marks]**

(A) morphological change proceeds at a constant rate through time

(B) all genes in a genome evolve at exactly the same rate

(C) mutation rates increase with the body size of the organism

(D) neutral mutations accumulate at an approximately constant rate over time

Q33. Two species are compared over 200 aligned nucleotide sites and are found to differ at 6 of them. The uncorrected proportional (p-) distance between the two sequences is: **[2 marks]**

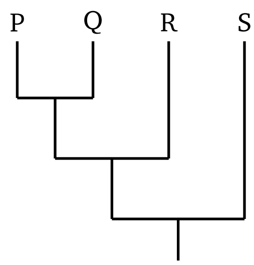
(A) 0.60

(B) 0.006

(C) 0.03

(D) 0.12

Q34. In the cladogram shown, the four taxa are P, Q, R and S. Which pair forms a monophyletic group (a clade) whose members share their most recent common ancestor? **[2 marks]**



(A) P and Q, sister taxa sharing their immediate common ancestor

(B) Q and S

(C) P and S but not Q

(D) R and S together with P but not Q

Q35. A taxonomic group that consists of a common ancestor together with only *some* of its descendants (for example, the traditional class "Reptilia" which excludes the birds) is described as: **[2 marks]**

(A) monophyletic

(B) paraphyletic

(C) polyphyletic

(D) holophyletic

Q36. The independent evolution of very similar streamlined body shapes in sharks (fish) and dolphins (mammals), producing homoplasy, is an example of: **[2 marks]**

(A) coevolution

(B) divergent evolution

(C) convergent evolution

(D) shared descent from an immediate common ancestor

Behavioural Ecology

Q37. Repeated helping between two unrelated individuals, in which a favour given now is likely to be returned by the same partner later, is best explained by: **[2 marks]**

(A) reciprocal altruism

(B) kin selection among close relatives

(C) group selection acting alone

(D) spiteful behaviour

Q38. The payoff matrix (payoffs to the row player) for one round of the Prisoner's Dilemma is shown. In the *iterated* game, the strategy that cooperates on the first move and thereafter copies the opponent's previous move is: **[2 marks]**

	Coop	Defect
Coop	3	0
Defect	5	1

(A) Always Defect

(B) Tit-for-Tat

(C) Always Cooperate

(D) purely random moves

Q39. An altruistic act gives the recipient a benefit of $B = 10$ offspring-equivalents at a cost of $C = 3$ to the actor. By Hamilton's rule, $rB > C$, the minimum coefficient of relatedness r at which the act is favoured by kin selection is: **[2 marks]**

(A) 0.10

(B) 0.30

(C) 0.50

(D) 3.33

Q40. In the Hawk–Dove game the resource value is $V = 4$ and the cost of injury from a fight is $C = 6$. The evolutionarily stable strategy is a mixed strategy that plays Hawk with probability V/C. This probability is: **[2 marks]**

(A) 0.33

(B) 1.00

(C) 0.50

(D) 0.67

Q41. In a cooperatively breeding meerkat group, a sentinel gives loud alarm calls that warn the others of an approaching predator while raising its own risk of being spotted. This behaviour is best explained by: **[2 marks]**

(A) pure selfishness at no cost to itself

(B) entirely random behaviour with no fitness consequences

(C) interspecific mutualism

(D) kin selection and reciprocity that raise the caller's inclusive fitness

Quantitative Ecology, Biostatistics and Mathematics

Q42. In a mark–recapture study of a lake fish population, 60 fish are captured, marked and released. A later independent sample of 90 fish contains 18 marked individuals. The Petersen estimate of population size $\hat{N} = \dfrac{MC}{R}$ is: **[2 marks]**

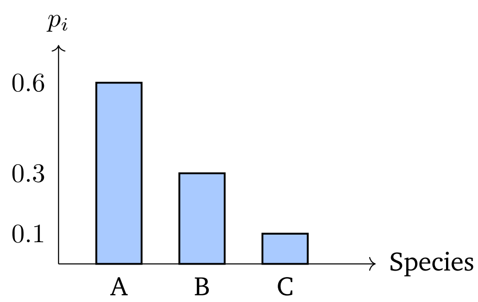
(A) 270

(B) 300

(C) 150

(D) 450

Q43. A community contains three species with proportional abundances $p_1 = 0.6$, $p_2 = 0.3$ and $p_3 = 0.1$, shown in the bar chart. Simpson's index $D = \sum_i p_i^2$ for this community is: **[2 marks]**



(A) 0.54

(B) 0.46

(C) 1.00

(D) 0.30

Q44. Counts of a plant recorded in many equal-area quadrats have a sample mean of 20 and a sample variance of 20. The variance-to-mean ratio therefore indicates that the spatial distribution of the plants is: **[2 marks]**

(A) uniform, with variance/mean < 1

(B) clumped, with variance/mean > 1

(C) random (Poisson), with variance/mean $= 1$

(D) impossible to determine from these data

Q45. A sample of $n = 100$ measurements of wing length has a standard deviation of $s = 20$ mm. The standard error of the mean, SE $= \dfrac{s}{\sqrt{n}}$, is: **[2 marks]**

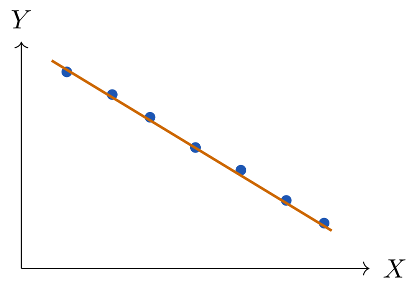
(A) 0.2 mm

(B) 2.0 mm

(C) 20 mm

(D) 200 mm

Q46. The scatter plot below shows two variables X and Y, with the points falling tightly along a straight line of negative slope. The correlation coefficient r for these data is best described as: **[2 marks]**



(A) positive and close to $+1$

(B) exactly zero

(C) positive, between 0 and $+1$

(D) negative and close to -1

Detailed Solutions

Q1.

Solution

Concept – ecological resilience: Resilience is one of two responses to disturbance. Resistance is how much a system withstands a disturbance; resilience is how well it bounces back after being displaced.

Step 1 – separate the two properties: A disturbance pushes the system away from its usual state.

Step 2 – define resilience: Resilience is the capacity to absorb that push and return to the original state.

Step 3 – test the options: Species richness and biomass accumulation rate are different quantities, and a permanent shift to a new state is the opposite of recovery.

Final Answer: the capacity to absorb disturbance and recover $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – intermediate disturbance hypothesis (IDH): Diversity is plotted as a hump against disturbance level.

Step 1 – consider very low disturbance: Competitive dominants monopolise resources and exclude weaker species, so diversity is low.

Step 2 – consider very high disturbance: Only a few disturbance-tolerant pioneers survive, so diversity is again low.

Step 3 – consider intermediate disturbance: Both good competitors and good colonisers can coexist, so diversity peaks, matching the top of the hump in the figure.

Final Answer: intermediate in both frequency and intensity $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – keystone species: A keystone species has an effect on its community that is far larger than its abundance or biomass would suggest.

Step 1 – read the description: Removal causes a disproportionately large change relative to abundance.

Step 2 – match the term: That is exactly the definition of a keystone species (as with the sea star Pisaster).

Step 3 – reject the others: A dominant species is defined by high biomass, an indicator species signals environmental conditions, and an invasive species is a non-native colonizer.

Final Answer: keystone species $\Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q3

Q4.

Solution

Concept – Bergmann's rule: Within a warm-blooded species, body size tends to increase in colder climates.

Step 1 – recall the reasoning: A larger body has a smaller surface-area-to-volume ratio.

Step 2 – link to heat loss: A smaller surface-to-volume ratio reduces heat loss, which is an advantage in the cold.

Step 3 – distinguish from Allen's rule: Shorter extremities in the cold is Allen's rule, not Bergmann's rule.

Final Answer: larger body size $\Rightarrow \boxed{\text{C}}$

$\boxed{\text{Answer: (C)}}$ Go Back to Q4

Q5.

Solution

Concept – stability landscape (ball-in-cup model): The valley is a basin of attraction and the ball is the system state; a deep, steep valley means strong pull back to the bottom.

Step 1 – read the figure: The ball sits in a deep, steep-sided valley.

Step 2 – interpret the steep walls: Any disturbance that displaces the ball is quickly reversed as it rolls back to the bottom.

Step 3 – name the property: Rapid return to the same basin is high resilience.

Step 4 – reject the others: A separate basin would be an alternative stable state, and a shallow valley would give low resilience.

Final Answer: high resilience $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – primary versus secondary succession: Primary succession starts on newly exposed substrate that has never held a community and has no soil; secondary succession starts where soil and some organisms remain after a disturbance.

Step 1 – read the key clue: Bare substrate with no pre-existing soil, such as a fresh lava flow.

Step 2 – classify it: Starting from lifeless, soil-free rock is primary succession.

Step 3 – reject the others: Secondary succession keeps its soil; eutrophication is nutrient enrichment; a climax community is the endpoint, not the process.

Final Answer: primary succession $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – Lincoln–Petersen estimator: $\hat{N} = \dfrac{M \times C}{R}$, where M is the number marked, C the size of the second sample and R the number of marked recaptures.

Step 1 – list the data: $M = 40$, $C = 50$, $R = 10$.

Step 2 – multiply M and C: $M \times C = 40 \times 50 = 2000$

Step 3 – divide by R: $\hat{N} = \dfrac{2000}{10} = 200$

Final Answer: $\hat{N} = 200 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – patterns of dispersion: Individuals may be clumped (aggregated), uniform (more even than random) or random.

Step 1 – read the requirement: Individuals spaced more evenly than random.

Step 2 – identify the cause: Territoriality and competition push neighbours apart, producing regular spacing.

Step 3 – match the middle panel: The evenly spaced panel is the uniform pattern.

Step 4 – reject the others: Clumped means aggregated, random means independent placement, and exponential is a growth form, not a dispersion pattern.

Final Answer: uniform (regular) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – the finite rate of increase λ: $\lambda = N_{t+1}/N_t$ is the multiplication factor per time step.

Step 1 – state the condition: The population neither grows nor declines, so $N_{t+1} = N_t$.

Step 2 – form the ratio: $\lambda = \dfrac{N_{t+1}}{N_t} = \dfrac{N_t}{N_t} = 1$

Step 3 – interpret: $\lambda = 1$ corresponds to a stationary population ($r = 0$).

Final Answer: $\lambda = 1.0 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – classifying interspecific interactions: An interaction in which both partners gain is denoted $(+,+)$ and is called mutualism.

Step 1 – assign the signs: The fig is pollinated (benefit) and the wasp reproduces inside the fig (benefit), so $(+,+)$.

Step 2 – name the interaction: A $(+,+)$ interaction is mutualism, and an obligate fig–wasp partnership is a textbook mutualism network.

Step 3 – reject the others: Commensalism is $(+, 0)$, parasitism is $(+, -)$, and amensalism is $(-, 0)$.

Final Answer: mutualism $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – predator–prey coupling: In the Lotka–Volterra model the predator depends on the prey for food, so its numbers respond to the prey with a delay.

Step 1 – follow the prey: When prey are abundant, predators have plenty of food and begin to increase.

Step 2 – note the delay: The predator increase takes time (reproduction and growth), so the predator peak comes after the prey peak.

Step 3 – read the figure: The orange predator curve is shifted to the right of the green prey curve, confirming the lag.

Final Answer: shortly after the prey peak, lagging behind it $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – resource partitioning: Competing species can coexist by dividing a resource so that their niches overlap less.

Step 1 – read the scenario: Two warblers feed in different vertical zones of the same tree.

Step 2 – interpret: By using different parts of the tree they reduce direct competition; this is resource partitioning (MacArthur's classic warbler study).

Step 3 – reject the others: Competitive exclusion is the loss of one species; mutualism and predation involve different sign combinations of interaction.

Final Answer: resource partitioning $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – biomagnification: A persistent, fat-soluble pollutant becomes more concentrated in body tissues at each higher trophic level.

Step 1 – read the trend: DDT rises $0.02 \to 0.2 \to 2 \to 25$ ppm from producer to top predator.

Step 2 – name the process: Increasing tissue concentration up the food chain is biomagnification.

Step 3 – distinguish from bioaccumulation: Bioaccumulation is build-up within one organism over time; biomagnification is the increase across trophic levels shown here.

Final Answer: biomagnification $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q13

Q14.

Solution

Concept – ten-percent transfer, worked backwards: Each step passes on 10%, so moving down the chain multiplies the energy by 10 per step.

Step 1 – count the steps: Producer (level 1) to heron (level 4) is 3 transfers.

Step 2 – write the relation: heron energy $=$ producer energy $\times (0.1)^3$

Step 3 – solve for the producer energy: producer energy $= \dfrac{5}{(0.1)^3} = \dfrac{5}{0.001}$

Step 4 – evaluate: producer energy $= 5000$ kJ

Final Answer: 5000 kJ $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – carbon fixation: Photosynthesis captures atmospheric CO_2 and builds it into organic molecules such as glucose.

Step 1 – identify the direction: The step converts inorganic CO_2 into organic carbon.

Step 2 – name the process: Green plants achieve this by photosynthesis.

Step 3 – reject the others: Respiration and combustion release CO_2, and decomposition returns carbon from dead matter; none of these fix atmospheric carbon into plants.

Final Answer: photosynthesis $\Rightarrow$ $\boxed{A}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q15

Q16.

Solution

Concept – eutrophication: Nutrient over-enrichment drives algal blooms; when the algae die, decomposers consume oxygen and the water becomes hypoxic.

Step 1 – read the cause: Enrichment with nitrates and phosphates.

Step 2 – trace the effect: Blooms form, then oxygen is depleted as the bloom decomposes.

Step 3 – name it: This whole sequence is eutrophication.

Step 4 – reject the others: Acidification lowers pH, biomagnification concentrates pollutants, and desertification is land degradation.

Final Answer: eutrophication $\Rightarrow$ $\boxed{B}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q16

Q17.

Solution

Concept – inverted pyramid of numbers: A pyramid of numbers can be inverted when a single large producer supports many smaller consumers.

Step 1 – read the figure: One tree at the base supports many insects and even more parasites.

Step 2 – match the ecosystem: A single large tree supporting numerous herbivorous insects and their parasites gives exactly this inverted shape.

Step 3 – reject the others: Grasslands, plankton communities and deserts have many small producers, giving an upright pyramid of numbers.

Final Answer: a large tree supporting many insects $\Rightarrow$ $\boxed{B}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q17

Q18.

Solution

Concept – the global carbon reservoirs: Carbon is stored in the atmosphere, the ocean, living biomass and, by far the most, in rocks and fossil deposits.

Step 1 – compare the reservoirs: Sedimentary carbonate rocks and fossil fuels dwarf the atmosphere, biomass and surface ocean.

Step 2 – pick the largest: Over geological time the crustal (sedimentary) reservoir is the largest by a wide margin.

Step 3 – reject the others: The atmosphere, biomass and surface ocean are comparatively small, fast-cycling pools.

Final Answer: sedimentary rocks and fossil fuel deposits $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q18

Q19.

Solution

Concept – punctuated equilibrium versus gradualism: Gradualism predicts slow, steady morphological change; punctuated equilibrium predicts long stasis broken by short bursts of change at speciation.

Step 1 – read the right-hand pattern: Long vertical segments (form unchanged as time passes) separated by rapid horizontal jumps.

Step 2 – match the model: Stasis interrupted by rapid change is punctuated equilibrium (Eldredge and Gould).

Step 3 – reject the others: Phyletic gradualism is the smooth diagonal on the left; orthogenesis and Lamarckism are discredited directional-drive ideas.

Final Answer: punctuated equilibrium $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – natural selection: Selection is the differential reproductive success of heritable variants; favourable traits spread because their carriers leave more offspring.

Step 1 – read the definition given: Differential survival and reproduction based on heritable traits.

Step 2 – name the mechanism: This is Darwin's natural selection.

Step 3 – reject the others: Drift is random, gene flow is movement of alleles between populations, and mutation pressure is the input of new variants, none of which is defined by differential reproductive success.

Final Answer: natural selection $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept – selection against a recessive lethal: When aa is lethal ($s = 1$), the recessive allele frequency after one generation is $q' = \dfrac{q}{1+q}$.

Step 1 – list the data: $q = 0.1$.

Step 2 – compute the denominator: $1 + q = 1 + 0.1 = 1.1$

Step 3 – divide: $q' = \dfrac{0.1}{1.1} = 0.0909\ldots$

Step 4 – round: $q' \approx 0.091$

Final Answer: $q' \approx 0.091 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – mean fitness with a recessive lethal: Only the aa class (frequency q^2) has zero fitness, so $\bar{w} = 1 - q^2$.

Step 1 – list the data: $q = 0.2$, fitnesses 1.0, 1.0, 0.

Step 2 – compute q^2: $q^2 = 0.2^2 = 0.04$

Step 3 – subtract from one: $\bar{w} = 1 - 0.04 = 0.96$

Final Answer: $\bar{w} = 0.96 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – synonymous substitutions and neutral theory: A synonymous change leaves the amino acid sequence unchanged, so it usually has no effect on the protein and hence on fitness.

Step 1 – read the mutation type: The base change is synonymous (silent).

Step 2 – deduce the fitness effect: With no change in the protein there is generally no change in fitness, so the mutation is effectively neutral.

Step 3 – reject the others: Strongly deleterious, invariably advantageous or always lethal are far too strong for a silent change (Kimura's neutral theory highlights exactly such changes).

Final Answer: selectively neutral $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – allele frequency after migration: The new frequency is the weighted average $p' = (1-m)p + m\,p_m$.

Step 1 – list the data: $p = 0.2$, $m = 0.25$, $p_m = 0.6$.

Step 2 – weight the resident frequency: $(1-m)p = 0.75 \times 0.2 = 0.15$

Step 3 – weight the migrant frequency: $m\,p_m = 0.25 \times 0.6 = 0.15$

Step 4 – add the contributions: $p' = 0.15 + 0.15 = 0.30$

Final Answer: $p' = 0.30 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – Hardy–Weinberg homozygote frequency: The frequency of homozygous dominants is p^2, the rising blue curve in the figure.

Step 1 – list the data: $p = 0.7$.

Step 2 – square the allele frequency: $p^2 = 0.7 \times 0.7$

Step 3 – evaluate: $p^2 = 0.49$

Final Answer: $0.49 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – heterozygote frequency from q^2: First recover q, then $p = 1 - q$, then $2pq$.

Step 1 – take the square root of q^2: $q = \sqrt{0.09} = 0.3$

Step 2 – find p: $p = 1 - 0.3 = 0.7$

Step 3 – compute $2pq$: $2pq = 2 \times 0.7 \times 0.3$

Step 4 – evaluate: $2pq = 0.42$

Final Answer: $0.42 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – the inbreeding coefficient F: F measures the loss of heterozygosity relative to Hardy–Weinberg expectation, $F = \dfrac{H_{\exp} - H_{obs}}{H_{\exp}}$.

Step 1 – recall the effect of inbreeding: Inbreeding raises homozygosity and lowers heterozygosity.

Step 2 – match the definition: F quantifies exactly that reduction in heterozygotes compared with the random-mating expectation.

Step 3 – reject the others: Mutation rate, number of migrants and additive variance are separate parameters, not what F measures.

Final Answer: reduction in heterozygosity relative to HW expectation $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – narrow-sense heritability: $h^2 = \dfrac{V_A}{V_P}$, the fraction of phenotypic variance due to *additive* genetic effects. (Broad sense H^2 uses total genetic variance V_G.)

Step 1 – identify the numerator: Narrow sense uses only the additive genetic variance V_A.

Step 2 – identify the denominator: The denominator is the total phenotypic variance V_P.

Step 3 – reject the others: Dominance or environmental variance in the numerator, or total genetic variance (that is broad sense), are all incorrect for h^2.

Final Answer: additive genetic variance to total phenotypic variance $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept – rearranging the breeder's equation: From $R = h^2 S$ we solve $S = \dfrac{R}{h^2}$.

Step 1 – list the data: $R = 2.0$ g, $h^2 = 0.4$.

Step 2 – substitute: $S = \dfrac{2.0}{0.4}$

Step 3 – evaluate: $S = 5.0$ g

Final Answer: $S = 5.0$ g $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept – allele frequency by gene counting: $\text{freq}(A) = \dfrac{2(AA) + (Aa)}{2N}$, where N is the number of individuals.

Step 1 – list the data: $AA = 98$, $Aa = 84$, $aa = 18$, $N = 200$.

Step 2 – count the A alleles: $2 \times 98 + 84 = 196 + 84 = 280$

Step 3 – count the total alleles: $2N = 2 \times 200 = 400$

Step 4 – divide: $\text{freq}(A) = \dfrac{280}{400} = 0.70$

Final Answer: $0.70 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – characters in cladistics: A synapomorphy is a shared derived character; it is the evidence that unites a clade. A symplesiomorphy is a shared ancestral character and an autapomorphy is unique to one taxon.

Step 1 – read the requirement: A shared derived state used to group taxa into a clade.

Step 2 – name it: That is a synapomorphy.

Step 3 – reject the others: Symplesiomorphies are ancestral (not useful for defining a clade), homoplasy is convergent similarity, and an autapomorphy is confined to a single taxon.

Final Answer: synapomorphy $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – the molecular clock: Under neutral theory, neutral substitutions fix at a roughly constant rate equal to the mutation rate, so sequence divergence increases approximately linearly with time.

Step 1 – state the assumption: Neutral mutations accumulate at an approximately constant rate over time.

Step 2 – use it for dating: This lets divergence be read as elapsed time.

Step 3 – reject the others: Morphology is not clocklike, different genes tick at different rates, and mutation rate is not set by body size.

Final Answer: neutral mutations accumulate at an approximately constant rate $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – proportional (p-) distance: The p-distance is the fraction of aligned sites that differ, $p = \dfrac{\text{differences}}{\text{total sites}}$.

Step 1 – list the data: 6 differences out of 200 sites.

Step 2 – form the ratio: $p = \frac{6}{200}$

Step 3 – evaluate: $p = 0.03$

Final Answer: $p = 0.03 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – reading a cladogram: Two taxa are most closely related when they join at the same (deepest, most recent) node before connecting to anything else.

Step 1 – trace the tips: P and Q meet at the uppermost node, forming their own small clade.

Step 2 – add the outer branches: R joins the (P,Q) group next, and S is the outgroup that joins last.

Step 3 – identify the closest pair: P and Q share the most recent common ancestor, so they form a monophyletic pair.

Step 4 – reject the others: Q&S, P&S-without-Q, and R&S-with-P-but-not-Q all skip over intervening lineages and are not clades.

Final Answer: P and Q $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – mono-, para- and polyphyly: A monophyletic group is an ancestor plus all its descendants; a paraphyletic group is an ancestor plus only some descendants; a polyphyletic group leaves out the common ancestor.

Step 1 – read the definition given: An ancestor together with only some of its descendants (Reptilia excluding birds).

Step 2 – match the term: Leaving out one descendant lineage makes the group paraphyletic.

Step 3 – reject the others: Monophyletic would include the birds, polyphyletic would exclude the ancestor, and holophyletic is a synonym for monophyletic.

Final Answer: paraphyletic $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q35

Q36.

Solution

Concept – convergent evolution: Distantly related lineages under similar selection pressures can evolve similar traits independently, producing homoplasy.

Step 1 – read the example: Sharks and dolphins independently evolved streamlined bodies for fast swimming.

Step 2 – name the process: Independent evolution of similar form is convergent evolution.

Step 3 – reject the others: Coevolution is reciprocal change between interacting species, divergent evolution makes relatives less alike, and shared descent would mean the similarity is inherited (it is not).

Final Answer: convergent evolution $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – reciprocal altruism: Help exchanged between unrelated individuals is favoured when the same partners interact repeatedly and returns are likely, so cheating is punished over time.

Step 1 – read the scenario: Unrelated partners, repeated interactions, help returned later.

Step 2 – name the mechanism: This is reciprocal altruism (Trivers).

Step 3 – reject the others: Kin selection needs relatedness, group selection acting alone is not required here, and spite lowers both parties' fitness.

Final Answer: reciprocal altruism $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q37

Q38.

Solution

Concept – Tit-for-Tat in the iterated Prisoner's Dilemma: Tit-for-Tat cooperates on the first move and then repeats whatever the opponent did last; it is nice, retaliatory, forgiving and clear.

Step 1 – read the requirement: Cooperate first, then copy the opponent's previous move.

Step 2 – match the strategy: That description is exactly Tit-for-Tat (Axelrod's tournament winner).

Step 3 – reject the others: Always Defect never cooperates, Always Cooperate never retaliates, and random play ignores the opponent's history.

Final Answer: Tit-for-Tat $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – Hamilton's rule: Altruism spreads when $rB > C$; the break-even relatedness is $r > \frac{C}{B}$.

Step 1 – list the data: $B = 10$, $C = 3$.

Step 2 – form the threshold ratio: $r > \frac{C}{B} = \frac{3}{10}$

Step 3 – evaluate: $r > 0.30$

Step 4 – state the minimum: The act is favoured once r reaches 0.30.

Final Answer: $r = 0.30 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – mixed ESS in the Hawk–Dove game: When $C > V$, no pure strategy is stable and the ESS is to play Hawk with probability $\frac{V}{C}$.

Step 1 – list the data: $V = 4$, $C = 6$.

Step 2 – form the ratio: $\frac{V}{C} = \frac{4}{6}$

Step 3 – evaluate: $\frac{4}{6} = 0.6667 \approx 0.67$

Final Answer: play Hawk with probability $\approx 0.67 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – alarm calling and inclusive fitness: A risky alarm call benefits nearby group members. In a cooperatively breeding group these are often relatives, so the caller gains indirect (kin-selected) fitness, and repeated turn-taking adds a reciprocity benefit.

Step 1 – note the cost and benefit: The caller takes a personal risk while warning others.

Step 2 – identify who benefits: Group-mates, many of them kin, survive to reproduce.

Step 3 – name the explanation: Kin selection plus reciprocity raise the caller's inclusive fitness.

Step 4 – reject the others: The call is costly (not cost-free selfishness), it is not random, and it is within a species (not interspecific mutualism).

Final Answer: kin selection and reciprocity raising inclusive fitness $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ Go Back to Q41

Q42.

Solution

Concept – Petersen estimator (2-mark application): $\hat{N} = \dfrac{M \times C}{R}$.

Step 1 – list the data: $M = 60$ marked, $C = 90$ in the second sample, $R = 18$ recaptured marks.

Step 2 – multiply M and C: $M \times C = 60 \times 90 = 5400$

Step 3 – divide by R: $\hat{N} = \dfrac{5400}{18} = 300$

Final Answer: $\hat{N} = 300 \Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ Go Back to Q42

Q43.

Solution

Concept – Simpson's index $D = \sum p_i^2$: Square each proportional abundance and add.

Step 1 – list the data: $p_1 = 0.6$, $p_2 = 0.3$, $p_3 = 0.1$.

Step 2 – square each term: $0.6^2 = 0.36, \quad 0.3^2 = 0.09, \quad 0.1^2 = 0.01$

Step 3 – add them: $D = 0.36 + 0.09 + 0.01 = 0.46$

Final Answer: $D = 0.46 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – variance-to-mean ratio for spatial pattern: For a Poisson (random) distribution the variance equals the mean, so the ratio is 1; a ratio below 1 signals a uniform pattern and above 1 a clumped one.

Step 1 – list the data: mean $= 20$, variance $= 20$.

Step 2 – form the ratio: $\dfrac{\text{variance}}{\text{mean}} = \dfrac{20}{20} = 1$

Step 3 – interpret: A ratio of exactly 1 indicates a random (Poisson) distribution.

Step 4 – reject the others: Uniform needs a ratio below 1 and clumped a ratio above 1.

Final Answer: random (Poisson), variance/mean $= 1 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – standard error of the mean: $\text{SE} = \dfrac{s}{\sqrt{n}}$.

Step 1 – list the data: $s = 20$ mm, $n = 100$.

Step 2 – take the square root of n: $\sqrt{100} = 10$

Step 3 – divide: $\text{SE} = \dfrac{20}{10} = 2.0$ mm

Final Answer: $\text{SE} = 2.0$ mm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q45

Q46.

Solution

Concept – sign and magnitude of r: The correlation coefficient lies in $[-1, +1]$; its sign follows the slope and its magnitude follows how tightly the points hug the line.

Step 1 – read the trend: Y falls steadily as X rises, so the slope is negative.

Step 2 – fix the sign: A downward trend gives a negative r.

Step 3 – fix the magnitude: The points lie very close to the straight line, so $|r|$ is near 1.

Step 4 – combine: r is negative and close to -1.

Final Answer: negative and close to $-1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	D	3	A	4	C	5	D
6	D	7	A	8	B	9	C	10	A
11	C	12	A	13	C	14	C	15	A
16	B	17	B	18	D	19	A	20	B
21	A	22	A	23	B	24	D	25	A
26	B	27	C	28	D	29	D	30	A
31	C	32	D	33	C	34	A	35	B
36	C	37	A	38	B	39	B	40	D
41	D	42	B	43	B	44	C	45	B
46	D								