GATE Ecology and Evolution

Sample Paper – 1

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. According to Liebig's law of the minimum, the growth of an organism or population is controlled by: **[1 mark]**

(A) the resource that is present in the greatest abundance

(B) the simple average of all the resources available

(C) the single essential resource that is in shortest supply relative to need

(D) the total sum of all nutrients available in the environment

Q2. The full range of environmental conditions and resources under which a species can survive and reproduce *in the absence of competitors and predators* is called its: **[1 mark]**

(A) realized niche

(B) habitat

(C) guild

(D) fundamental niche

Q3. Shelford's law of tolerance states that the distribution and abundance of a species is governed by environmental factors for which the organism has: **[1 mark]**

(A) only an upper lethal limit

(B) both a lower and an upper limit of tolerance

(C) no limits provided food remains abundant

(D) only a lower lethal limit

Q4. For an ectothermic (poikilothermic) animal the metabolic rate has a temperature coefficient $Q_{10} = 2$. If its metabolic rate is 8 units at $20°$C, its rate at $30°$C is: **[1 mark]**

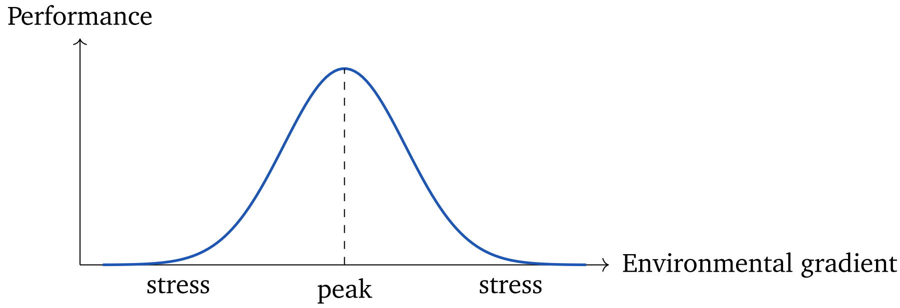
(A) 16 units

(B) 4 units

(C) 8 units

(D) 32 units

Q5. The bell-shaped curve below plots the performance of a species against an environmental gradient such as temperature. The region marked at the peak of the curve corresponds to the: **[1 mark]**



(A) zone of intolerance

(B) optimum range

(C) upper lethal limit

(D) lower limit of tolerance

Q6. An organism that can tolerate and survive across a wide range of environmental salinity is described as: **[1 mark]**

(A) stenohaline

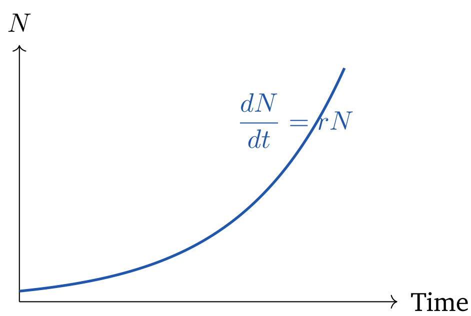
(B) euryhaline

(C) stenothermal

(D) eurythermal

Population and Community Ecology

Q7. In the exponential (geometric) growth model $\frac{dN}{dt} = rN$ the per-capita growth rate r is constant. The population size N then grows, as sketched below: **[1 mark]**



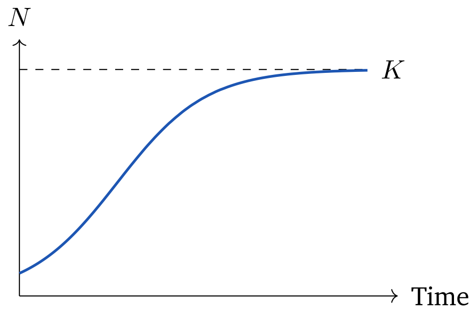
(A) exponentially without bound (a J-shaped curve)

(B) toward a fixed carrying capacity (an S-shaped curve)

(C) linearly with time

(D) not at all, remaining constant

Q8. In the logistic growth model $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$, whose growth curve is shown, the population growth rate $\frac{dN}{dt}$ is maximum when N equals: **[1 mark]**



(A) K

(B) $K/2$

(C) $K/4$

(D) 0

Q9. A population grows logistically with intrinsic rate $r = 0.5$ yr^{-1} and carrying capacity $K = 1000$. When the current size is $N = 500$, the instantaneous growth rate $\frac{dN}{dt}$ is: **[1 mark]**

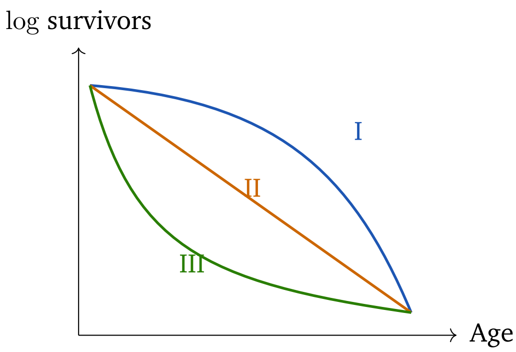
(A) 125 individuals/year

(B) 250 individuals/year

(C) 0 individuals/year

(D) 500 individuals/year

Q10. The three survivorship curves below are plotted as $\log(\text{survivors})$ against age. A species with very high mortality early in life and only a few individuals reaching old age (as in many marine fish and invertebrates) follows: **[1 mark]**



(A) Type I

(B) Type II

(C) Type III

(D) a horizontal straight line

Q11. In a life table the net reproductive rate is $R_0 = \sum l_x m_x$. If a population has $R_0 = 1$, it is expected to: **[1 mark]**

(A) grow exponentially

(B) decline steadily to extinction

(C) double in size every generation

(D) remain stable (exactly replace itself)

Q12. Gause's competitive exclusion principle states that two species competing for exactly the same single limiting resource cannot: **[1 mark]**

(A) coexist indefinitely at stable population sizes

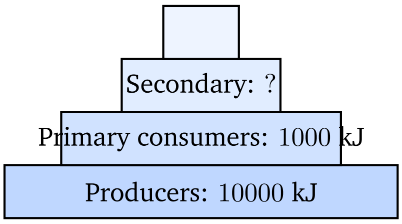
(B) ever occur on the same continent

(C) undergo character displacement

(D) share any common predator

Ecosystems and Biogeochemical Cycles

Q13. According to Lindeman's ten-percent law of energy transfer, illustrated by the pyramid below, if the producers fix 10000 kJ of energy then the energy available to the secondary consumers (carnivores) is approximately: **[1 mark]**



(A) 10000 kJ

(B) 5000 kJ

(C) 1000 kJ

(D) 100 kJ

Q14. Net primary productivity (NPP) is related to gross primary productivity (GPP) by NPP $=$ GPP $- R$, where the term R represents: **[1 mark]**

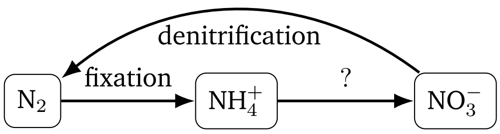
(A) the annual rainfall

(B) the incident solar radiation

(C) the reproduction rate of the producers

(D) the respiration losses of the producers

Q15. In the nitrogen cycle shown, the microbial conversion of ammonium (NH_4^+) first to nitrite and then to nitrate (NO_3^-) is called: **[1 mark]**



(A) nitrogen fixation

(B) denitrification

(C) nitrification

(D) ammonification

Q16. Which one of the following biogeochemical cycles is a purely sedimentary cycle with no significant gaseous (atmospheric) reservoir? **[1 mark]**

(A) the carbon cycle

(B) the nitrogen cycle

(C) the phosphorus cycle

(D) the water (hydrological) cycle

Q17. Organisms such as fungi and many bacteria that break down dead organic matter and return inorganic nutrients to the soil are called: [1 mark]

(A) primary producers

(B) decomposers

(C) primary consumers

(D) apex predators

Q18. In the grazing food chain shown, the hawk occupies which trophic level? [1 mark]

grass → grasshopper → frog → snake → hawk

(A) third trophic level

(B) fifth trophic level

(C) second trophic level

(D) fourth trophic level

Mechanisms of Evolution

Q19. Directional, stabilizing and disruptive selection are the three modes of natural selection. Stabilizing selection acts to: [1 mark]

(A) favour one extreme phenotype over the other

(B) favour both extreme phenotypes at the expense of the mean

(C) increase the phenotypic variance of the trait

(D) favour intermediate phenotypes and reduce the variance

Q20. The ultimate source of all new genetic (heritable) variation in a population is: [1 mark]

(A) genetic drift

(B) natural selection

(C) mutation

(D) gene flow

Q21. Genetic drift is the random change in allele frequencies from one generation to the next due to sampling error. Its effect on allele frequencies is strongest in: **[2 marks]**

(A) very large populations

(B) populations already at Hardy–Weinberg equilibrium

(C) small populations

(D) populations experiencing high gene flow

Q22. A particular genotype has relative fitness $w = 0.8$. The selection coefficient acting against it, defined as $s = 1 - w$, is: **[2 marks]**

(A) 0.2

(B) 0.8

(C) 1.8

(D) 1.0

Q23. The persistence of the sickle-cell haemoglobin allele at high frequency in malaria-endemic regions, where heterozygotes have the highest fitness, is a classic example of: **[2 marks]**

(A) directional selection

(B) genetic drift

(C) heterozygote advantage (balancing selection)

(D) disruptive selection

Q24. In a recipient population the frequency of allele A is 0.6. In one generation a fraction $m = 0.1$ of the individuals are replaced by migrants from a source population in which the frequency of A is 0.1. Using $p' = (1-m)p + m\,p_m$, the new frequency of A is: [2 marks]

(A) 0.55

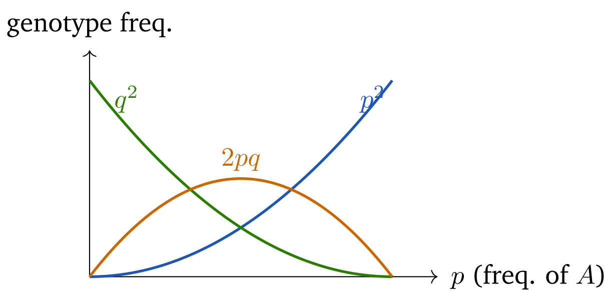
(B) 0.50

(C) 0.60

(D) 0.45

Population and Quantitative Genetics

Q25. In a population at Hardy–Weinberg equilibrium the recessive allele a has frequency $q = 0.3$. From the genotype-frequency curves sketched below, the frequency of heterozygotes (Aa), given by $2pq$, is: [2 marks]



(A) 0.42

(B) 0.09

(C) 0.49

(D) 0.21

Q26. A recessive genetic disease affects 1 in 10000 individuals, so that $q^2 = 0.0001$. Assuming Hardy–Weinberg equilibrium, the frequency of carriers (heterozygotes) in the population is approximately: [2 marks]

(A) 0.0001

(B) 0.0198

(C) 0.99

(D) 0.5

Q27. Which one of the following is *not* an assumption required for a population to remain in Hardy–Weinberg equilibrium? **[2 marks]**

(A) there is no mutation

(B) mating is random

(C) there is no natural selection

(D) the population is small

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

(A) environmental variance to phenotypic variance

(B) total genetic variance to total phenotypic variance

(C) additive genetic variance to environmental variance

(D) phenotypic variance to total genetic variance

Q29. The breeder's equation predicts the response to selection as $R = h^2 S$, where S is the selection differential. If the narrow-sense heritability is $h^2 = 0.5$ and the selection differential is $S = 4$ g, the predicted response R is: **[2 marks]**

(A) 8 g

(B) 4 g

(C) 2 g

(D) 0.5 g

Q30. In a sample of 100 diploid individuals the genotype counts are $AA = 36$, $Aa = 48$ and $aa = 16$. The frequency of allele A in the sample is: **[2 marks]**

(A) 0.36

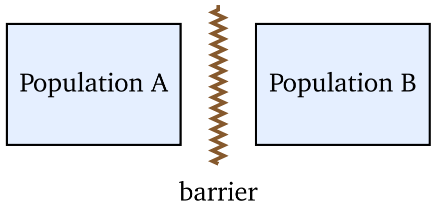
(B) 0.60

(C) 0.48

(D) 0.40

Speciation, Phylogeny and Macroevolution

Q31. Speciation that begins when a population is divided by a physical (geographic) barrier that prevents gene flow between the two parts, as shown, is called: **[2 marks]**



(A) sympatric speciation

(B) parapatric speciation

(C) speciation by polyploidy

(D) allopatric speciation

Q32. According to the biological species concept, a species is defined as a group of natural populations whose members can: **[2 marks]**

(A) merely live in the same geographic region

(B) interbreed to produce fertile offspring and are reproductively isolated from other such groups

(C) simply share a similar external morphology

(D) happen to occupy the same ecological niche

Q33. When a horse is crossed with a donkey the offspring (a mule) is viable but sterile. This type of reproductive isolation is an example of a: **[2 marks]**

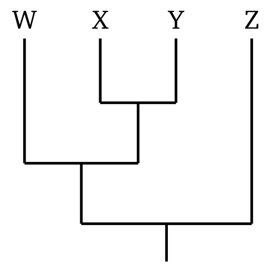
(A) prezygotic barrier

(B) temporal isolation

(C) postzygotic barrier

(D) mechanical isolation

Q34. In the phylogenetic tree shown, which two taxa are most closely related, i.e. share the most recent common ancestor? [2 marks]



(A) X and Y

(B) W and Z

(C) W and Y

(D) X and Z

Q35. A clade (a monophyletic group) is correctly defined as a group that consists of: [2 marks]

(A) an ancestor together with only some of its descendants

(B) several unrelated lineages that merely resemble one another

(C) a set of descendants excluding their common ancestor

(D) an ancestor together with all of its descendants

Q36. The wing of a bird and the wing of an insect serve the same function of flight but have entirely different evolutionary and developmental origins. Such structures are described as: [2 marks]

(A) homologous structures

(B) vestigial structures

(C) orthologous structures

(D) analogous structures (products of convergent evolution)

Behavioural Ecology

Q37. Optimal foraging theory predicts that natural selection will favour foraging behaviour that maximizes the animal's: **[2 marks]**

(A) total time spent searching for food

(B) number of different prey species encountered

(C) net rate of energy intake per unit time

(D) total distance travelled while foraging

Q38. A mating system in which a single male mates with several females during one breeding season is called: **[2 marks]**

(A) monogamy

(B) polyandry

(C) polygyny

(D) promiscuity

Q39. Hamilton's rule states that an altruistic act is favoured by kin selection when $rB > C$, where r is the coefficient of relatedness between the actor and the recipient. For full siblings (offspring of the same two parents), r equals: **[2 marks]**

(A) 0.5

(B) 0.25

(C) 0.125

(D) 1.0

Q40. The payoff matrix for the Hawk–Dove game (resource value V, cost of injury C) is shown, where each entry is the payoff to the row player. An evolutionarily stable strategy (ESS) is a strategy that, once common in a population: **[2 marks]**

	Hawk	Dove
Hawk	$\frac{V-C}{2}$	V
Dove	0	$\frac{V}{2}$

(A) always cooperates regardless of the opponent

(B) maximizes the benefit to the group as a whole

(C) is always the pure Hawk strategy

(D) cannot be invaded by any rare alternative strategy

Q41. Zahavi's handicap principle explains that costly ornaments, such as the enormous tail of a peacock, can be favoured by sexual selection because they: **[2 marks]**

(A) are cheap and easy to produce

(B) are honest, reliable signals of the bearer's underlying genetic quality

(C) directly help the animal to escape from predators

(D) lower the metabolic cost of reproduction

Quantitative Ecology, Biostatistics and Mathematics

Q42. For the data set $\{2, 4, 4, 6, 9\}$ of counts recorded at five quadrats, the arithmetic mean is: **[2 marks]**

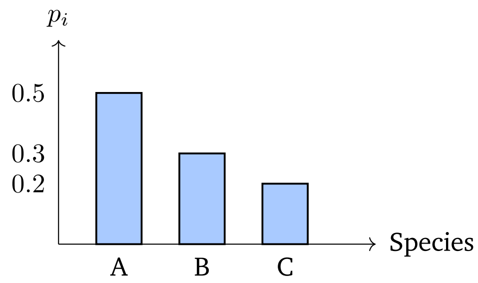
(A) 5

(B) 4

(C) 6

(D) 25

Q43. A community contains three species with proportional abundances $p_1 = 0.5$, $p_2 = 0.3$ and $p_3 = 0.2$, shown in the bar chart. Simpson's index $D = \sum_i p_i^2$ for this community equals: **[2 marks]**



(A) 0.62

(B) 0.38

(C) 1.00

(D) 0.19

Q44. For a community with two equally abundant species ($p_1 = p_2 = 0.5$), the Shannon diversity index $H' = -\sum_i p_i \ln p_i$ equals (take $\ln 2 = 0.693$): **[2 marks]**

(A) 0

(B) 1.0

(C) 0.5

(D) 0.693

Q45. In a large, randomly mating population the frequency of allele A is 0.6. The probability that a diploid individual drawn at random is homozygous AA is: **[2 marks]**

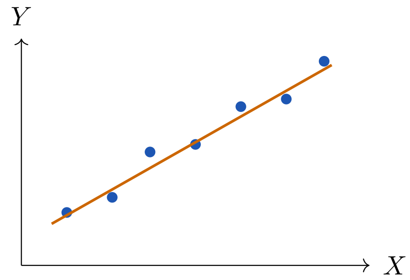
(A) 0.36

(B) 0.24

(C) 0.48

(D) 0.60

Q46. The scatter plot below shows measurements of two variables X and Y together with a fitted straight line of positive slope through the cloud of points. The correlation coefficient r for these data is best described as: **[2 marks]**



(A) positive, with $0 < r < 1$

(B) exactly zero

(C) negative, with $-1 < r < 0$

(D) exactly -1

Detailed Solutions

Q1.

Solution

Concept – Liebig's law of the minimum: Growth is limited not by the total amount of resources but by the one essential resource that is scarcest relative to what the organism needs.

Step 1 – state the idea: A chain is only as strong as its weakest link.

Step 2 – apply it to resources: The essential nutrient in shortest supply relative to demand sets the ceiling on growth.

Step 3 – test the options: Abundant resources, averages, or the total sum of nutrients do not set the limit; only the scarcest essential one does.

Final Answer: the essential resource in shortest supply $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – fundamental versus realized niche: The fundamental niche is the full set of conditions and resources a species could use with no competitors or predators; the realized niche is the smaller portion it actually occupies once biotic interactions act.

Step 1 – read the key phrase: The question specifies "in the absence of competitors and predators."

Step 2 – match the definition: That exact condition defines the fundamental niche.

Step 3 – eliminate the others: Realized niche includes competition; habitat is just the place; a guild is a set of species using resources similarly.

Final Answer: fundamental niche $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – Shelford's law of tolerance: For each environmental factor an organism has a lower limit and an upper limit; survival is possible only between them.

Step 1 – recall the tolerance curve: Performance rises from a lower limit, peaks at an optimum, and falls to an upper limit.

Step 2 – identify what bounds the range: Both a lower and an upper limit bound the tolerable range.

Step 3 – reject one-sided options: Having only an upper or only a lower limit ignores the other end of the curve.

Final Answer: both a lower and an upper limit of tolerance $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – the temperature coefficient Q_{10}: Q_{10} is the factor by which a rate changes for every $10°$C rise in temperature. Here $Q_{10} = 2$ means the rate doubles per $10°$C.

Step 1 – find the temperature change: $\Delta T = 30 - 20 = 10°\text{C}$

Step 2 – count the number of $10°$C steps: $\frac{10}{10} = 1$ step

Step 3 – apply the multiplier once: $\text{rate}_{30} = 8 \times 2^1$

Step 4 – evaluate: $\text{rate}_{30} = 8 \times 2 = 16$ units

Final Answer: 16 units $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – the tolerance (performance) curve: Performance is highest over a central band of the gradient and falls off toward both extremes.

Step 1 – read the figure: The curve peaks in the middle of the gradient.

Step 2 – name the peak region: The band around the peak, where performance is greatest, is the optimum range.

Step 3 – eliminate the others: Zones of intolerance and the lethal limits lie at the tails, not the peak.

Final Answer: optimum range $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – prefixes for breadth of tolerance: "Eury-" means broad and "steno-" means narrow; "-haline" refers to salinity and "-thermal" to temperature.

Step 1 – decode the requirement: Wide range of salinity means broad + salinity.

Step 2 – assemble the term: broad (eury) + salinity (haline) = euryhaline.

Step 3 – reject the others: Stenohaline is narrow salinity; the thermal terms refer to temperature, not salinity.

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

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – exponential growth: When r is constant the equation $\frac{dN}{dt} = rN$ has the solution $N(t) = N_0 e^{rt}$, which increases without bound.

Step 1 – note the constant per-capita rate: r does not decline as N grows, so nothing brakes the growth.

Step 2 – describe the shape: $N_0 e^{rt}$ curves upward ever more steeply, giving the J-shaped curve in the figure.

Step 3 – reject the others: An S-shape needs a carrying-capacity term; the growth is not linear and it is certainly not zero.

Final Answer: exponentially without bound (J-shaped) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – growth rate of the logistic model: The growth rate $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$ is a downward parabola in N.

Step 1 – write the rate as a function of N: $g(N) = rN - \frac{r}{K}N^2$

Step 2 – differentiate with respect to N and set to zero: $\frac{dg}{dN} = r - \frac{2r}{K}N = 0$

Step 3 – solve for N: $r = \frac{2r}{K}N$

$$N = \frac{K}{2}$$

Step 4 – interpret: The parabola peaks at $N = K/2$, so growth is fastest there.

Final Answer: $N = K/2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – evaluating the logistic rate: Substitute the given values into $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$.

Step 1 – list the data: $r = 0.5\ \text{yr}^{-1}$, $N = 500$, $K = 1000$.

Step 2 – compute the bracket: $1 - \frac{N}{K} = 1 - \frac{500}{1000} = 1 - 0.5 = 0.5$

Step 3 – multiply r and N: $rN = 0.5 \times 500 = 250$

Step 4 – multiply by the bracket: $\frac{dN}{dt} = 250 \times 0.5 = 125$

Final Answer: 125 individuals/year $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – the three survivorship curves: Type I has low early mortality and high late mortality (convex); Type II has constant mortality (straight line on a log scale); Type III has very high early mortality (concave).

Step 1 – read the requirement: High mortality early in life with few reaching old age.

Step 2 – match to the curve: A steep initial drop that then levels off is the concave Type III curve.

Step 3 – give an example: Many marine fish and invertebrates that release huge numbers of offspring follow Type III.

Final Answer: Type III $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – the net reproductive rate R_0: R_0 is the average number of offspring an individual produces over its lifetime. It compares one generation with the next.

Step 1 – interpret $R_0 = 1$: Each individual replaces itself with exactly one reproducing individual.

Step 2 – deduce the population trend: With exact replacement the size neither grows nor shrinks; it stays stable.

Step 3 – contrast the extremes: $R_0 > 1$ would mean growth and $R_0 < 1$ would mean decline.

Final Answer: the population remains stable $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – competitive exclusion (Gause's principle): Two species with identical requirements for one limiting resource cannot both persist; the better competitor drives the other out.

Step 1 – state the principle: Complete competitors cannot coexist.

Step 2 – apply it: If the niches overlap completely for the limiting resource, stable long-term coexistence is impossible.

Step 3 – reject the distractors: The principle does not forbid sharing continents or predators, and character displacement is in fact one way species avoid exclusion.

Final Answer: they cannot coexist indefinitely $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – Lindeman's ten-percent law: Only about 10% of the energy at one trophic level is passed on to the next.

Step 1 – start with the producers: Energy fixed $= 10000$ kJ.

Step 2 – transfer to primary consumers: $10\% \times 10000 = 1000$ kJ

Step 3 – transfer to secondary consumers: $10\% \times 1000 = 100$ kJ

Step 4 – state the result: The secondary consumers receive about 100 kJ.

Final Answer: 100 kJ $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept – gross versus net primary productivity: GPP is the total energy fixed by photosynthesis; part of it is spent by the plants themselves in respiration, and what remains is NPP.

Step 1 – write the balance: $\text{NPP} = \text{GPP} - R$

Step 2 – identify R: R is the energy the producers lose through their own respiration.

Step 3 – reject the others: Rainfall, radiation input and reproduction rate are not subtracted from GPP in this identity.

Final Answer: respiration by the producers $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q14

Q15.

Solution

Concept – steps of the nitrogen cycle: Fixation makes NH_4^+ from N_2; nitrification oxidises NH_4^+ to NO_3^-; denitrification returns NO_3^- to N_2; ammonification releases NH_4^+ from organic matter.

Step 1 – read the arrow in question: It runs from NH_4^+ to NO_3^-.

Step 2 – match the process: Oxidation of ammonium through nitrite to nitrate is nitrification.

Step 3 – reject the others: Fixation makes ammonium, denitrification destroys nitrate, and ammonification produces ammonium from organics.

Final Answer: nitrification ⇒ $\boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept – gaseous versus sedimentary cycles: Cycles with a large atmospheric reservoir (carbon, nitrogen, water) are gaseous; the phosphorus cycle has its main reservoir in rocks and sediments and lacks a significant gaseous phase.

Step 1 – recall the main reservoir of phosphorus: Phosphorus is stored chiefly in rock and mineral deposits.

Step 2 – note the missing atmospheric step: Phosphorus has no common gaseous form circulating in the atmosphere.

Step 3 – reject the gaseous cycles: Carbon, nitrogen and water all have major atmospheric reservoirs.

Final Answer: the phosphorus cycle ⇒ $\boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – the role of decomposers: Decomposers break down dead tissue and wastes, converting organic matter back into inorganic nutrients that plants can reuse.

Step 1 – read the description: Fungi and bacteria that break down dead matter.

Step 2 – assign the functional group: That role defines the decomposers.

Step 3 – reject the others: Producers make food, primary consumers eat plants, and apex predators sit at the top of the food chain.

Final Answer: decomposers ⇒ $\boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept – counting trophic levels: The producer is level 1, and each step along the chain adds one level.

Step 1 – number the chain: grass $= 1$, grasshopper $= 2$, frog $= 3$, snake $= 4$, hawk $= 5$.

Step 2 – read off the hawk: The hawk is at the fifth position.

Step 3 – state the level: Therefore the hawk is at the fifth trophic level.

Final Answer: fifth trophic level $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – stabilizing selection: Stabilizing selection favours phenotypes near the population mean and selects against both extremes, which narrows the variance.

Step 1 – picture the fitness curve: Fitness is highest at intermediate trait values.

Step 2 – describe the effect on the distribution: Extremes are removed, so the phenotypic variance decreases.

Step 3 – contrast the other modes: Directional selection shifts toward one extreme; disruptive selection favours both extremes and increases variance.

Final Answer: favours intermediate phenotypes and reduces variance $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – the origin of genetic variation: Mutation creates entirely new alleles; the other forces only rearrange or change the frequencies of variation that already exists.

Step 1 – ask which process makes new alleles: Only mutation introduces new DNA sequence variants.

Step 2 – examine the others: Drift and selection change frequencies of existing alleles; gene flow moves existing alleles between populations.

Step 3 – conclude: Mutation is the ultimate raw source of all new variation.

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

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – genetic drift and population size: Drift is sampling error in allele transmission. The smaller the sample of gametes, the larger the random fluctuations.

Step 1 – link sample size to error: Small samples give large sampling error; large samples average it out.

Step 2 – apply to populations: Small populations therefore show the strongest drift.

Step 3 – reject the others: Large populations resist drift, and high gene flow tends to swamp drift rather than amplify it.

Final Answer: small populations $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q21

Q22.

Solution

Concept – selection coefficient: The selection coefficient measures how much fitness falls short of the maximum: $s = 1 - w$.

Step 1 – list the data: $w = 0.8$.

Step 2 – substitute into the definition: $s = 1 - 0.8$

Step 3 – evaluate: $s = 0.2$

Final Answer: $s = 0.2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – heterozygote advantage (overdominance): When the heterozygote is fitter than either homozygote, both alleles are kept in the population; this is a form of balancing selection.

Step 1 – read the scenario: Heterozygotes have the highest fitness in malaria zones.

Step 2 – name the mechanism: Superior heterozygote fitness is heterozygote advantage, a balancing force.

Step 3 – reject the others: Directional selection would fix one allele; drift is random; disruptive selection favours both homozygotes.

Final Answer: heterozygote advantage (balancing selection) $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – change in allele frequency due to gene flow: After migration the new frequency is the weighted average $p' = (1-m)p + m\,p_m$.

Step 1 – list the data: $p = 0.6$, $m = 0.1$, $p_m = 0.1$.

Step 2 – weight the resident allele frequency: $(1-m)p = 0.9 \times 0.6 = 0.54$

Step 3 – weight the migrant allele frequency: $m\,p_m = 0.1 \times 0.1 = 0.01$

Step 4 – add the two contributions: $p' = 0.54 + 0.01 = 0.55$

Final Answer: $p' = 0.55 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q24

Q25.

Solution

Concept – Hardy–Weinberg genotype frequencies: With allele frequencies p and q, the genotype frequencies are p^2 (AA), $2pq$ (Aa) and q^2 (aa).

Step 1 – find p from q: $p = 1 - q = 1 - 0.3 = 0.7$

Step 2 – write the heterozygote frequency: $2pq = 2 \times 0.7 \times 0.3$

Step 3 – multiply step by step: $0.7 \times 0.3 = 0.21$

$2 \times 0.21 = 0.42$

Final Answer: $2pq = 0.42 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – carrier frequency under Hardy–Weinberg: Carriers are heterozygotes with frequency $2pq$; the affected are homozygous recessives with frequency q^2.

Step 1 – get q from the disease incidence: $q^2 = 0.0001$

$q = \sqrt{0.0001} = 0.01$

Step 2 – get p: $p = 1 - q = 1 - 0.01 = 0.99$

Step 3 – compute the carrier frequency: $2pq = 2 \times 0.99 \times 0.01$

Step 4 – evaluate: $2 \times 0.99 \times 0.01 = 0.0198$

Final Answer: carrier frequency ≈ 0.0198 (about 1 in 50) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – assumptions of Hardy–Weinberg equilibrium: Equilibrium requires no mutation, random mating, no selection, no gene flow, and a very large (ideally infinite) population so that drift is negligible.

Step 1 – check each listed option: No mutation, random mating and no selection are all genuine requirements.

Step 2 – test population size: A small population undergoes drift, which violates equilibrium; the model instead requires a large population.

Step 3 – pick the odd one out: "The population is small" is not an assumption of equilibrium.

Final Answer: the population is small $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

Q28.

Solution

Concept – broad-sense heritability: $H^2 = \dfrac{V_G}{V_P}$, the fraction of the total phenotypic variance that is due to all genetic differences.

Step 1 – write the definition: $H^2 = \dfrac{\text{total genetic variance}}{\text{total phenotypic variance}}$

Step 2 – identify the correct ratio: It is genetic variance over phenotypic variance, not the reverse and not an environmental ratio.

Step 3 – reject the others: Environmental-over-phenotypic gives the non-heritable fraction; the inverted and additive-over-environmental ratios are not H^2.

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

Answer: (B) Go Back to Q28

Q29.

Solution

Concept – the breeder's equation: The response to selection is $R = h^2 S$, the heritability times the selection differential.

Step 1 – list the data: $h^2 = 0.5$, $S = 4$ g.

Step 2 – substitute: $R = 0.5 \times 4$

Step 3 – evaluate: $R = 2$ g

Final Answer: $R = 2$ g $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q29

Q30.

Solution

Concept – allele frequency from genotype counts: Each individual carries two alleles; count the A alleles and divide by the total number of alleles ($2N$).

Step 1 – count the A alleles: Each AA contributes 2: $36 \times 2 = 72$

Each Aa contributes 1: $48 \times 1 = 48$

Total A alleles $= 72 + 48 = 120$

Step 2 – count the total alleles: $2N = 2 \times 100 = 200$

Step 3 – form the frequency: $\text{freq}(A) = \dfrac{120}{200}$

Step 4 – evaluate: $\text{freq}(A) = 0.60$

Final Answer: $\text{freq}(A) = 0.60 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – allopatric speciation: "Allo-" means other and "-patric" means homeland; a geographic barrier splits the range and cuts off gene flow, so the two parts diverge into separate species.

Step 1 – read the figure: A physical barrier divides one population into A and B.

Step 2 – match the mode: Divergence caused by geographic separation is allopatric speciation.

Step 3 – reject the others: Sympatric speciation needs no barrier, parapatric involves adjacent ranges, and polyploidy is an instantaneous chromosomal route.

Final Answer: allopatric speciation $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – the biological species concept: A species is a group of populations that actually or potentially interbreed to give fertile offspring and are reproductively isolated from other such groups.

Step 1 – identify the defining criterion: The criterion is reproductive: successful interbreeding plus reproductive isolation.

Step 2 – match the option: "Interbreed to produce fertile offspring and are reproductively isolated" states exactly this.

Step 3 – reject the others: Shared geography, morphology or niche are not the defining features of the biological species concept.

Final Answer: interbreed to give fertile offspring and are reproductively isolated $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – prezygotic versus postzygotic barriers: Prezygotic barriers act before fertilisation; postzygotic barriers act after the hybrid zygote forms, causing hybrid inviability or sterility.

Step 1 – note when the barrier acts: The mule is formed and lives, so a zygote did develop.

Step 2 – identify the defect: The mule is sterile, so the barrier is hybrid sterility, which is postzygotic.

Step 3 – reject the others: Temporal and mechanical isolation are prezygotic and would prevent the cross in the first place.

Final Answer: postzygotic barrier $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – reading a phylogenetic tree: The two taxa that join at the most recent (highest) internal node are the most closely related sister taxa.

Step 1 – trace the tips upward: X and Y meet at the shallowest node in the tree.

Step 2 – compare with the others: W joins the (X,Y) pair only at a deeper node, and Z joins even deeper.

Step 3 – identify the sisters: X and Y share the most recent common ancestor.

Final Answer: X and Y $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – monophyly: A monophyletic group (clade) contains a common ancestor and every one of its descendants, with none left out.

Step 1 – state the rule: Ancestor + all descendants = monophyletic.

Step 2 – compare with the wrong types: Ancestor + some descendants is paraphyletic; unrelated look-alikes or descendants without their ancestor are polyphyletic or not a clade.

Step 3 – select the correct definition: An ancestor together with all of its descendants.

Final Answer: an ancestor together with all of its descendants $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – analogy versus homology: Analogous structures share function but arose independently (convergent evolution); homologous structures share ancestry regardless of current function.

Step 1 – read the example: Bird wing and insect wing both fly but have separate origins.

Step 2 – classify the structures: Same function, different origin means they are analogous.

Step 3 – reject the others: Homologous and orthologous imply shared ancestry, and vestigial refers to reduced remnant organs.

Final Answer: analogous structures (convergent evolution) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – optimal foraging theory: Foraging is treated as an economic problem in which selection maximises the net energy gained per unit of time spent foraging.

Step 1 – state the currency: The quantity being optimised is net energy intake rate (energy gained minus energy spent, per unit time).

Step 2 – apply it: An efficient forager chooses prey and patches that give the highest net energy rate.

Step 3 – reject the others: Maximising search time, prey diversity or distance travelled would waste, not gain, energy.

Final Answer: net rate of energy intake per unit time $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q37

Q38.

Solution

Concept – mating systems: Polygyny is one male with many females; polyandry is one female with many males; monogamy is one-to-one.

Step 1 – decode the term: “Poly-” many, “-gyny” females $\Rightarrow$ one male with many females.

Step 2 – match the description: One male mating with several females is polygyny.

Step 3 – reject the others: Monogamy is a single pair, polyandry reverses the sexes, and promiscuity has no stable pairing.

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

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – coefficient of relatedness: r is the probability that a gene in one individual is shared by descent with another. For full siblings this equals 0.5.

Step 1 – trace shared genes: Full siblings share, on average, half of their genes by descent.

Step 2 – state r: $r = 0.5$ for full siblings.

Step 3 – contrast with others: Half-siblings and grandparent–grandchild give $r = 0.25$; first cousins 0.125; an identical clone 1.0.

Final Answer: $r = 0.5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – evolutionarily stable strategy (ESS): An ESS is a strategy which, when adopted by most of the population, cannot be invaded and displaced by any rare mutant strategy.

Step 1 – state the definition: Once common, an ESS resists invasion by alternatives.

Step 2 – apply to the Hawk–Dove game: The stable mix or pure strategy is the one no rare alternative can beat, given the payoffs shown.

Step 3 – reject the others: An ESS need not be pure Hawk, need not always cooperate, and is defined by individual, not group, benefit.

Final Answer: cannot be invaded by any rare alternative strategy $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – the handicap principle: Because only high-quality individuals can bear the cost of an extravagant ornament and still survive, the ornament becomes an honest, unfakeable signal of quality.

Step 1 – note the cost: A large tail is costly and risky to carry.

Step 2 – draw the inference: Only genuinely fit males can afford the handicap, so the signal is honest.

Step 3 – reject the others: The ornament is not cheap, does not aid escape, and does not lower reproductive cost.

Final Answer: they are honest signals of genetic quality $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – arithmetic mean: The mean is the sum of the values divided by how many there are.

Step 1 – add the values: $2 + 4 + 4 + 6 + 9 = 25$

Step 2 – count the values: $n = 5$

Step 3 – divide: $\bar{x} = \dfrac{25}{5}$

Step 4 – evaluate: $\bar{x} = 5$

Final Answer: $\bar{x} = 5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – Simpson's index: $D = \sum_i p_i^2$ is the sum of the squared proportional abundances.

Step 1 – square each proportion: $p_1^2 = 0.5^2 = 0.25$

$p_2^2 = 0.3^2 = 0.09$

$p_3^2 = 0.2^2 = 0.04$

Step 2 – add the squares: $D = 0.25 + 0.09 + 0.04$

Step 3 – evaluate: $D = 0.38$

Final Answer: $D = 0.38 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – Shannon diversity index: $H' = -\sum_i p_i \ln p_i$. For two equally common species each $p_i = 0.5$.

Step 1 – write the two terms: $H' = -\big(0.5 \ln 0.5 + 0.5 \ln 0.5\big)$

Step 2 – combine the identical terms: $H' = -\big(2 \times 0.5 \times \ln 0.5\big)$

$H' = -\ln 0.5$

Step 3 – use $\ln 0.5 = -\ln 2$**:** $H' = -(-\ln 2) = \ln 2$

Step 4 – substitute the value: $H' = 0.693$

Final Answer: $H' = 0.693 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q44

Q45.

Solution

Concept – probability of a homozygous genotype: Under random mating the two alleles are drawn independently, so $P(AA) = p \times p = p^2$.

Step 1 – list the data: $p = \text{freq}(A) = 0.6$.

Step 2 – multiply the two independent draws: $P(AA) = 0.6 \times 0.6$

Step 3 – evaluate: $P(AA) = 0.36$

Final Answer: $P(AA) = 0.36 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – sign of the correlation coefficient: The correlation coefficient r lies between -1 and $+1$; its sign matches the slope of the trend and its magnitude the tightness of the cloud.

Step 1 – read the scatter: Y tends to rise as X rises, and the points cluster around a rising line.

Step 2 – fix the sign: An upward trend gives a positive r.

Step 3 – fix the magnitude: The scatter is close to but not exactly on the line, so $0 < r < 1$.

Final Answer: positive, with $0 < r < 1 \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q46**

Answer Key

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