GATE Ecology and Evolution

Sample Paper – 10

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. The regulation of climate, the pollination of crops, the purification of water and the control of floods provided free of charge by functioning natural ecosystems are collectively termed: **[1 mark]**

(A) ecosystem services

(B) trophic cascades

(C) ecological footprints

(D) biogeochemical sinks

Q2. An aquatic organism that can survive only within a narrow band of temperature and dies if the temperature moves much above or below that band is described as: **[1 mark]**

(A) eurythermal

(B) euryhaline

(C) stenohaline

(D) stenothermal

Q3. An animal that keeps its internal body temperature nearly constant by physiological means despite changes in the surrounding air temperature is best described as a: **[1 mark]**

(A) thermoregulator (homeotherm)

(B) thermoconformer

(C) strict poikilotherm

(D) obligate ectotherm

Q4. The largest population size of a species that a given environment can support indefinitely, given its resources and conditions, is called the: **[1 mark]**

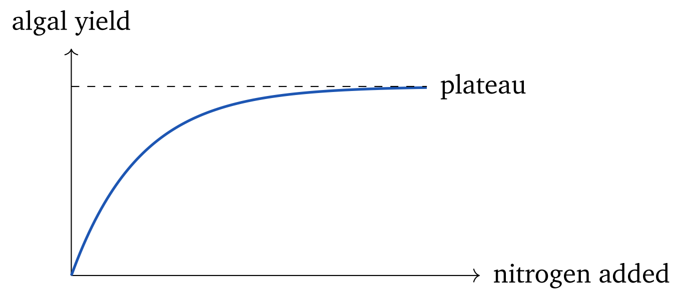
(A) biotic potential

(B) intrinsic rate of increase

(C) environmental resistance

(D) carrying capacity

Q5. The curve below shows the yield of an algal culture as increasing amounts of nitrogen are added while all other nutrients are held fixed. Beyond a point, adding more nitrogen gives no further yield because a different nutrient now sets the ceiling. The plateau illustrates: **[1 mark]**



(A) unlimited exponential growth

(B) Liebig's law of the minimum (a single limiting nutrient)

(C) the ten-percent law of energy transfer

(D) competitive exclusion between algae

Q6. A species carried by human activity into a new region where it lacks natural enemies, then multiplies rapidly and displaces native species, is best described as: **[1 mark]**

(A) an invasive species

(B) a keystone species

(C) an endemic species

(D) a foundation species

Population and Community Ecology

Q7. A bacterial culture grows exponentially with a constant per-capita growth rate $r = 0.1\ \text{h}^{-1}$. Its doubling time, $t_d = \dfrac{\ln 2}{r}$, is approximately: **[1 mark]**

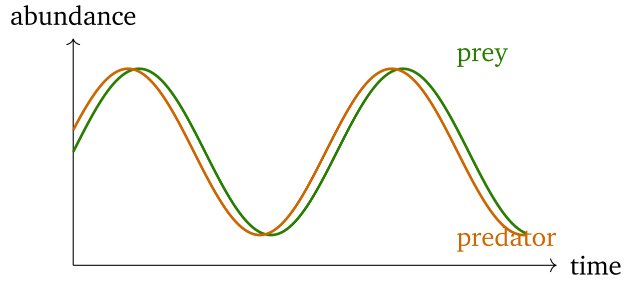
(A) 0.693 h

(B) 6.93 h

(C) 69.3 h

(D) 0.0693 h

Q8. The two curves below show the coupled abundances of a predator and its prey over time in a Lotka–Volterra system. A characteristic feature of such cycles is that the predator peak: **[1 mark]**



(A) coincides exactly with the prey peak

(B) comes before the prey peak

(C) lags behind (follows) the prey peak

(D) is completely unrelated to the prey cycle

Q9. In an interaction between two species one partner benefits while the other is neither helped nor harmed. This type of biotic interaction is called: **[1 mark]**

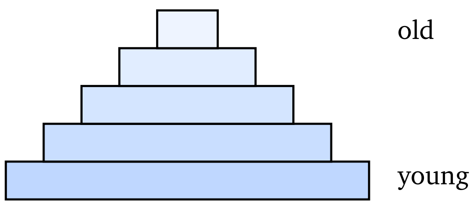
(A) mutualism

(B) commensalism

(C) parasitism

(D) interspecific competition

Q10. The age-structure diagram below is very broad at the base and narrows sharply toward the top. A population with this age structure is: **[1 mark]**



(A) rapidly growing (expanding)

(B) stable in size

(C) slowly declining

(D) already extinct

Q11. Fast-spreading invasive weeds that mature quickly, produce enormous numbers of small seeds and colonise disturbed ground are best described in life-history terms as: **[1 mark]**

(A) r-selected species

(B) K-selected species

(C) climax (equilibrium) species

(D) strictly semelparous predators

Q12. Experimental removal of a predatory sea star from a rocky shore allowed mussels to overgrow the space and caused the number of other species to collapse. A species whose effect on community structure is far larger than its abundance would suggest is called a: **[1 mark]**

(A) invasive species

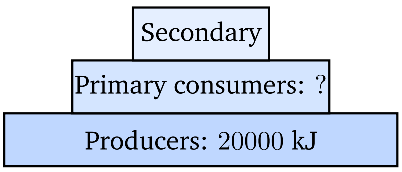
(B) foundation species

(C) ecosystem engineer

(D) keystone species

Ecosystems and Biogeochemical Cycles

Q13. Using Lindeman's ten-percent law and the energy pyramid shown, if the producers fix 20000 kJ of energy, the amount transferred to the primary consumers (herbivores) is about: **[1 mark]**



(A) 20000 kJ

(B) 2000 kJ

(C) 200 kJ

(D) 20 kJ

Q14. The Redfield ratio describes the roughly constant atomic ratio of carbon, nitrogen and phosphorus (C:N:P) in marine phytoplankton biomass. This ratio is close to: **[1 mark]**

(A) $16 : 1 : 106$

(B) $1 : 16 : 106$

(C) $106 : 16 : 1$

(D) $106 : 1 : 16$

Q15. In the sunlit surface waters of the open ocean, the nutrient that most often limits primary production over large areas is: **[1 mark]**

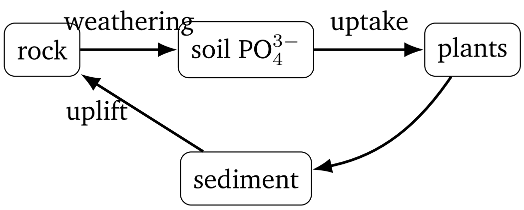
(A) dissolved carbon dioxide

(B) dissolved oxygen

(C) phosphorus

(D) nitrogen

Q16. In the phosphorus-cycle diagram shown, the long-term reservoir from which phosphorus is released into the living part of ecosystems is: **[1 mark]**



(A) the atmosphere as P_2 gas

(B) the ozone layer

(C) living biomass only

(D) weathering of phosphate-bearing rocks

Q17. The gradual, directional change in the species composition of a community after a disturbance, eventually reaching a relatively stable climax, is called: **[1 mark]**

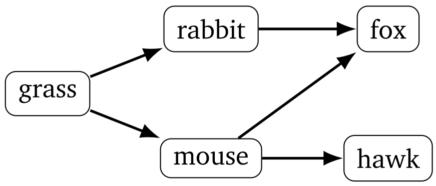
(A) eutrophication

(B) biomagnification

(C) ecological succession

(D) denitrification

Q18. In the food web shown, which organism is a primary producer, forming the base that supports every other species in the web? **[1 mark]**



(A) the grass

(B) the rabbit

(C) the fox

(D) the hawk

Mechanisms of Evolution

Q19. Disruptive (diversifying) selection favours both phenotypic extremes at the expense of intermediate forms. Over time this mode of selection tends to: **[1 mark]**

(A) collapse the population onto a single narrow phenotype

(B) reduce the phenotypic variance of the trait

(C) make all individuals identical to the mean

(D) maintain a stable polymorphism of two distinct morphs

Q20. When a phenotype enjoys higher fitness precisely because it is rare, and loses that advantage as it becomes common, the population is experiencing: **[1 mark]**

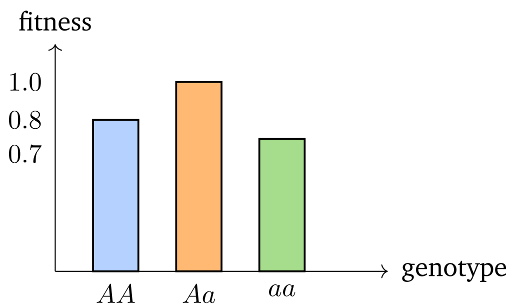
(A) negative frequency-dependent selection

(B) positive frequency-dependent selection

(C) purely directional selection

(D) stabilizing selection

Q21. The fitness bars below show overdominance: the heterozygote Aa is fitter than either homozygote. With selection coefficients $s_1 = 0.2$ against AA and $s_2 = 0.3$ against aa, the equilibrium frequency of allele a, given by $\hat{q} = \frac{s_1}{s_1 + s_2}$, is: **[2 marks]**



(A) 0.60

(B) 0.40

(C) 0.30

(D) 0.50

Q22. A particular genotype produces on average 120 surviving offspring, while the most successful genotype in the same population produces 150. The relative fitness w of the first genotype, scaled to the best, is: **[2 marks]**

(A) 0.80

(B) 1.25

(C) 0.20

(D) 1.00

Q23. The immune-system MHC (in humans, HLA) loci are famous for maintaining an extraordinarily large number of alleles at high frequencies within populations. This extreme polymorphism is best explained by: **[2 marks]**

(A) genetic drift in very small populations

(B) recurrent one-way deleterious mutation

(C) strong directional selection fixing a single allele

(D) balancing selection (heterozygote and rare-allele advantage)

Q24. In a recipient population the frequency of allele A is 0.3. In one generation a fraction $m = 0.2$ of individuals are replaced by migrants from a source population where the frequency of A is 0.8. Using $p' = (1-m)p + m\,p_m$, the new frequency of A is: **[2 marks]**

(A) 0.30

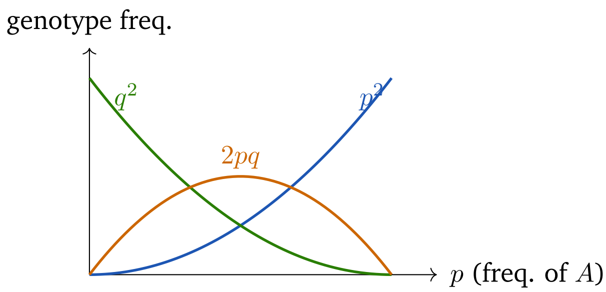
(B) 0.40

(C) 0.50

(D) 0.55

Population and Quantitative Genetics

Q25. In a population at Hardy–Weinberg equilibrium the dominant allele A has frequency $p = 0.8$. From the genotype-frequency curves sketched below, the frequency of heterozygotes (Aa), given by $2pq$, is: **[2 marks]**



(A) 0.32

(B) 0.16

(C) 0.64

(D) 0.04

Q26. A recessive genetic disorder affects 1 in 2500 individuals, so that $q^2 = \frac{1}{2500} = 0.0004$. Assuming Hardy–Weinberg equilibrium, the frequency of carriers (heterozygotes) is approximately: **[2 marks]**

(A) 0.0004

(B) 0.0200

(C) 0.0392

(D) 0.9800

Q27. Which one of the following forces does *not* change allele frequencies by itself, yet can still push genotype frequencies away from the Hardy–Weinberg proportions? **[2 marks]**

(A) natural selection

(B) non-random (assortative) mating

(C) gene flow (migration)

(D) genetic drift

Q28. The narrow-sense heritability h^2 of a quantitative trait, the quantity that predicts the response to selection, is defined as the ratio of: **[2 marks]**

(A) environmental variance to phenotypic variance

(B) dominance variance to phenotypic variance

(C) additive genetic variance to total phenotypic variance

(D) total phenotypic variance to additive genetic variance

Q29. Using the breeder's equation $R = h^2 S$, a breeder selects for larger seed mass with a selection differential $S = 10$ g in a population whose narrow-sense heritability is $h^2 = 0.4$. The predicted response to selection R is: **[2 marks]**

(A) 10 g

(B) 6 g

(C) 4 g

(D) 2.5 g

Q30. In a sample of 200 diploid individuals the genotype counts are $AA = 50$, $Aa = 100$ and $aa = 50$. The frequency of allele A in the sample is: **[2 marks]**

(A) 0.25

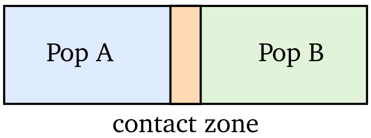
(B) 0.75

(C) 0.60

(D) 0.50

Speciation, Phylogeny and Macroevolution

Q31. Two populations that diverged in isolation meet again in the contact zone shown and produce hybrids of low fitness. Selection then strengthens prezygotic barriers to reduce this costly hybridization. This process is called: **[2 marks]**



(A) hybrid vigour

(B) introgression

(C) reinforcement

(D) genetic hitchhiking

Q32. Sudden, sympatric speciation in flowering plants, producing a new reproductively isolated species in effectively one generation, most commonly arises through: **[2 marks]**

(A) isolation by a newly formed mountain range

(B) polyploidy (whole-genome duplication)

(C) the slow accumulation of point mutations over millions of years

(D) behavioural imprinting on a host plant

Q33. Two closely related frog species live in the same pond but breed in different months of the year, so their gametes never meet. This form of reproductive isolation is an example of: **[2 marks]**

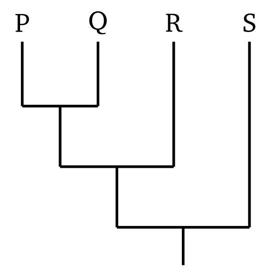
(A) mechanical isolation

(B) gametic (postmating, prezygotic) incompatibility

(C) temporal isolation

(D) a postzygotic barrier

Q34. In the cladogram shown, which taxon is the outgroup, i.e. the one that branches off earliest and is most distantly related to the remaining taxa? **[2 marks]**



(A) P

(B) Q

(C) R

(D) S

Q35. Many lineages show long spans of little morphological change interrupted by short bursts of rapid change concentrated around speciation events. This macroevolutionary tempo is called: **[2 marks]**

(A) phyletic gradualism

(B) simple anagenesis

(C) reciprocal coevolution

(D) punctuated equilibrium

Q36. The forelimb skeletons of a human arm, a whale flipper and a bat wing are built from the same set of bones inherited from a shared ancestor, even though they now serve very different functions. Such structures are: [2 marks]

(A) analogous structures

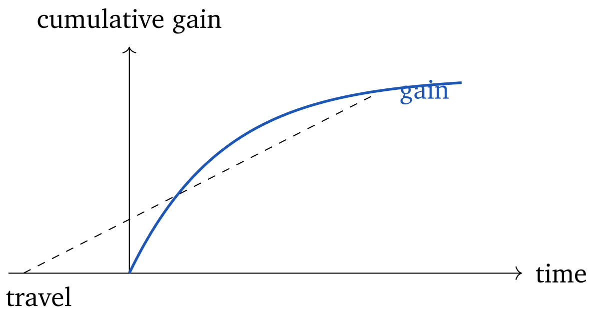
(B) vestigial structures

(C) homologous structures

(D) convergent (independently evolved) structures

Behavioural Ecology

Q37. The gain curve below shows the cumulative energy a forager collects while staying in a food patch, with travel time to the patch marked on the left. According to the marginal value theorem, the animal should leave the patch at the moment when: [2 marks]



(A) the patch has been stripped completely empty

(B) its instantaneous intake rate falls to the average intake rate for the whole habitat

(C) a fixed amount of time has passed, whatever the patch quality

(D) it meets the very first competitor

Q38. A small bird facing a cold night is near its energy threshold for survival and needs a large reward to make it through. Risk-sensitive foraging theory predicts that such a starving animal should prefer the option with: [2 marks]

(A) higher variance in reward (the risk-prone choice)

(B) lower variance in reward (the risk-averse choice)

(C) the longest handling time

(D) zero net energy content

Q39. Hamilton's rule states that an altruistic act is favoured when $rB > C$, where r is the coefficient of relatedness between actor and recipient. For two first cousins, the coefficient of relatedness r is: **[2 marks]**

(A) 0.500

(B) 0.250

(C) 0.125

(D) 0.0625

Q40. In the Hawk–Dove game whose payoff matrix is shown (resource value V, injury cost C), consider the case where the cost of injury exceeds the value of the resource, $C > V$. The evolutionarily stable outcome is then: **[2 marks]**

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

(A) a stable mixture of Hawks and Doves in the population

(B) a population made entirely of Hawks

(C) a population made entirely of Doves

(D) no stable outcome at all

Q41. A ground squirrel gives a loud alarm call when a predator appears. The call warns nearby relatives but makes the caller more conspicuous and so more likely to be caught. This apparently self-sacrificing behaviour is best explained by: **[2 marks]**

(A) kin selection (inclusive fitness)

(B) group selection for the good of the species

(C) ordinary individual selection for the caller's own survival

(D) sexual selection through female choice

Quantitative Ecology, Biostatistics and Mathematics

Q42. In Whittaker's multiplicative partitioning of diversity, regional (gamma) diversity is related to mean local (alpha) diversity and turnover (beta) diversity by $\gamma = \alpha \times \beta$. If a region has $\gamma = 12$ species and the mean local richness is $\alpha = 3$ species, the beta diversity β is: **[2 marks]**

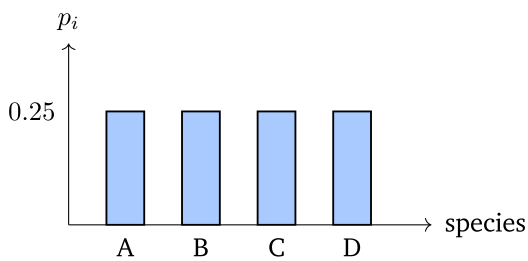
(A) 36

(B) 4

(C) 9

(D) 15

Q43. A community contains four species with equal proportional abundances, each $p_i = 0.25$, as shown in the bar chart. Simpson's index $D = \sum_i p_i^2$ for this community equals: **[2 marks]**



(A) 0.75

(B) 1.00

(C) 0.25

(D) 0.0625

Q44. For a community of four equally abundant species (each $p_i = 0.25$), the Shannon diversity index $H' = -\sum_i p_i \ln p_i$ equals (take $\ln 2 = 0.693$): **[2 marks]**

(A) 0.693

(B) 1.386

(C) 2.000

(D) 0.250

Q45. In a principal components analysis (PCA) ordination of community data, the first principal component (PC1) is the axis that: **[2 marks]**

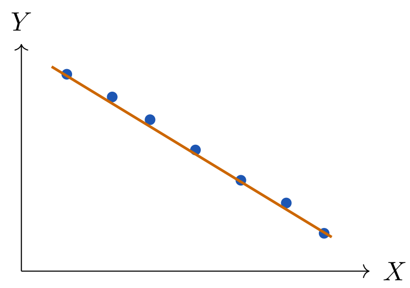
(A) always separates the data into exactly two clusters

(B) captures the largest possible share of the total variance in the data

(C) is drawn in a random direction through the cloud

(D) is always perpendicular to every environmental gradient

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



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

(B) exactly zero

(C) exactly $+1$

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

Detailed Solutions

Q1.

Solution

Concept – ecosystem services: Natural ecosystems perform work that benefits people without any human payment.

Step 1 – classify the listed benefits: Climate regulation, crop pollination, water purification and flood control are all supporting and regulating functions of nature.

Step 2 – name the collective term: Such free benefits that ecosystems provide to human society are called ecosystem services.

Step 3 – reject the others: A trophic cascade is a chain of predator effects, an ecological footprint measures human demand, and a biogeochemical sink stores a nutrient; none of these names the benefits themselves.

Final Answer: ecosystem services $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

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

Step 1 – decode the requirement: The organism tolerates only a narrow band of temperature.

Step 2 – assemble the term: narrow (steno) + temperature (thermal) = stenothermal.

Step 3 – reject the others: Eurythermal is broad temperature, while the "-haline" terms refer to salinity, not temperature.

Final Answer: stenothermal $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – regulators versus conformers: A regulator holds its internal state steady despite the external environment; a conformer lets its internal state track the outside.

Step 1 – read the description: The animal keeps body temperature nearly constant while the air temperature changes.

Step 2 – assign the category: Maintaining a constant internal temperature by physiological means is thermoregulation, and such an animal is a homeotherm.

Step 3 – reject the others: A thermoconformer, a poikilotherm and an obligate ectotherm all let body temperature follow the surroundings.

Final Answer: thermoregulator (homeotherm) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept – carrying capacity: Every environment can support only a limited population indefinitely, set by its resources and conditions.

Step 1 – read the definition asked for: The maximum size that can be sustained indefinitely.

Step 2 – match the term: That ceiling is the carrying capacity, usually written K.

Step 3 – reject the others: Biotic potential and the intrinsic rate of increase describe growth ability, and environmental resistance is the set of factors that hold a population below its potential, not the ceiling itself.

Final Answer: carrying capacity $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept – a single limiting nutrient: Growth is capped by whichever essential resource is scarcest relative to need, not by the total supply.

Step 1 – read the graph: Yield rises with added nitrogen at first, then flattens to a plateau.

Step 2 – interpret the plateau: Once nitrogen is plentiful, some other nutrient is now in shortest supply and sets the ceiling, so more nitrogen does nothing.

Step 3 – name the principle: This is Liebig's law of the minimum, the idea that a single limiting nutrient controls growth.

Step 4 – reject the others: Unlimited exponential growth has no plateau, the ten-percent law is about energy transfer, and competitive exclusion is about two species, not one culture.

Final Answer: Liebig's law of the minimum $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – invasive species: A non-native species that spreads and harms its new community, often because local predators and parasites do not control it, is called invasive.

Step 1 – read the description: Introduced by humans, lacking natural enemies, multiplying fast and displacing natives.

Step 2 – assign the term: These are exactly the hallmarks of an invasive species.

Step 3 – reject the others: A keystone species has a large stabilising role, an endemic species is native and restricted, and a foundation species builds habitat structure; none implies harmful spread.

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

Answer: (A) Go Back to Q6

Q7.

Solution

Concept – doubling time in exponential growth: When a population grows as $N(t) = N_0 e^{rt}$, the time to double satisfies $2 = e^{rt_d}$, so $t_d = \dfrac{\ln 2}{r}$.

Step 1 – list the data: $r = 0.1\ \text{h}^{-1}$ and $\ln 2 = 0.693$.

Step 2 – substitute into the formula: $t_d = \dfrac{0.693}{0.1}$

Step 3 – evaluate: $t_d = 6.93\ \text{h}$

Final Answer: $t_d = 6.93\ \text{h} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q7

Q8.

Solution

Concept – predator–prey phase lag: In the Lotka–Volterra cycle the predator depends on the prey for food, so its numbers respond only after the prey have already built up.

Step 1 – read the curves: The prey (green) rises first; the predator (orange) rises a little later.

Step 2 – reason about the timing: Abundant prey feed the predators, whose population then grows and peaks a quarter-cycle after the prey.

Step 3 – state the relation: The predator peak therefore lags behind, or follows, the prey peak.

Step 4 – reject the others: The peaks are neither simultaneous nor is the predator ahead, and the two cycles are clearly linked, not independent.

Final Answer: the predator peak lags behind the prey peak $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – naming two-species interactions: Interactions are named by the sign of the effect on each partner ($+$, $-$ or 0).

Step 1 – read the signs: One species gains ($+$) and the other is unaffected (0).

Step 2 – match the $+/0$ pattern: A $+/0$ interaction is commensalism.

Step 3 – reject the others: Mutualism is $+/+$, parasitism is $+/-$, and competition is $-/-$.

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

Answer: (B) Go Back to Q9

Q10.

Solution

Concept – reading an age-structure pyramid: The shape of the pyramid shows the balance of young to old and predicts future growth.

Step 1 – read the figure: A very broad base means many pre-reproductive young; the narrow top means few old individuals.

Step 2 – project forward: The large cohort of young will soon reproduce, so numbers will climb steeply.

Step 3 – classify the population: A broad-based pyramid is the signature of a rapidly growing (expanding) population.

Step 4 – reject the others: A stable population has straighter sides, a declining one has a pinched base, and an extinct population has none.

Final Answer: rapidly growing (expanding) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – r- versus K-selection: r-selected species maximise reproductive rate in unstable, open habitats; K-selected species invest in fewer, competitive offspring near carrying capacity.

Step 1 – read the traits: Fast maturity, huge numbers of small seeds and colonisation of disturbed ground.

Step 2 – match the strategy: These are the classic traits of an r-selected (opportunistic) species.

Step 3 – reject the others: K-selected and climax species are slow, competitive equilibrium species, and semelparous predators are not what the seed traits describe.

Final Answer: r-selected species $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – keystone species: A keystone species has an effect on its community out of all proportion to its abundance, often by controlling a dominant competitor.

Step 1 – read the experiment: Removing the sea star let mussels take over and diversity collapsed.

Step 2 – interpret the outcome: By eating mussels the sea star had kept space open for many other species, so its role far exceeded its numbers.

Step 3 – assign the term: That is the defining property of a keystone species (the original Pisaster example of Paine).

Step 4 – reject the others: It is native (not invasive), it does not build the physical habitat (not a foundation species or engineer).

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

Answer: (D) Go Back to Q12

Q13.

Solution

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

Step 1 – start with the producers: Energy fixed $= 20000$ kJ.

Step 2 – transfer one level up: $10\% \times 20000 = 0.10 \times 20000$

Step 3 – evaluate: $= 2000$ kJ

Step 4 – state the result: The primary consumers receive about 2000 kJ.

Final Answer: 2000 kJ $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – the Redfield ratio: Marine phytoplankton biomass shows a remarkably constant atomic ratio of carbon to nitrogen to phosphorus.

Step 1 – recall the canonical values: The classic Redfield ratio is $C : N : P = 106 : 16 : 1$.

Step 2 – match to the options: Carbon is most abundant, nitrogen intermediate, phosphorus least, giving $106 : 16 : 1$.

Step 3 – reject the others: The reversed or reshuffled orders wrongly make phosphorus or nitrogen the most abundant element.

Final Answer: $106 : 16 : 1 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – nutrient limitation in the sea: The nutrient in shortest supply relative to phytoplankton demand limits production, and in most open-ocean surface waters that nutrient is nitrogen.

Step 1 – consider the candidates: Carbon dioxide is abundant in seawater, and oxygen is a product, not a nutrient limiting photosynthesis.

Step 2 – compare nitrogen and phosphorus: Over most of the open ocean, fixed nitrogen (nitrate, ammonium) runs out before phosphorus does, so nitrogen is the proximate limiting nutrient.

Step 3 – conclude: Nitrogen most often limits open-ocean primary production.

Final Answer: nitrogen $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – the phosphorus cycle is sedimentary: Phosphorus has no significant gaseous phase; its master reservoir is rock, and it enters ecosystems when rock weathers.

Step 1 – read the diagram: The arrow labelled “weathering” runs from rock into the soil phosphate pool that plants then take up.

Step 2 – identify the source: Therefore the ultimate reservoir feeding the living cycle is phosphate-bearing rock, released by weathering.

Step 3 – reject the others: There is no atmospheric P_2 gas, the ozone layer is irrelevant, and living biomass only recycles phosphorus rather than being its long-term source.

Final Answer: weathering of phosphate-bearing rocks $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – ecological succession: After a disturbance, communities change in a fairly predictable, directional sequence toward a stable climax.

Step 1 – read the description: Directional change in species composition ending in a stable climax.

Step 2 – name the process: That process is ecological succession.

Step 3 – reject the others: Eutrophication is nutrient over-enrichment, biomagnification is the build-up of toxins up a food chain, and nitrification is a step of the nitrogen cycle.

Final Answer: ecological succession $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q17

Q18.

Solution

Concept – the base of a food web: A primary producer captures energy directly (here by photosynthesis) and supports every consumer above it.

Step 1 – read the web: All arrows begin at "grass," which is not eaten upon by anything below it.

Step 2 – identify the producer: Grass makes its own food and feeds the rabbit and mouse, so it is the primary producer.

Step 3 – reject the others: The rabbit and mouse are herbivores (primary consumers), and the fox and hawk are predators (higher consumers).

Final Answer: the grass $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – disruptive selection: Disruptive selection favours both extremes and selects against intermediates, which splits the distribution into two peaks.

Step 1 – picture the fitness curve: Fitness is high at both extreme trait values and low in the middle.

Step 2 – deduce the effect: Two divergent morphs are favoured, so a stable polymorphism of two forms can be maintained.

Step 3 – reject the others: Collapsing onto one phenotype, reducing variance, or making everyone the mean all describe stabilizing or directional selection, not disruptive.

Final Answer: maintain a stable polymorphism of two morphs $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – frequency-dependent selection: The fitness of a phenotype can depend on how common it is.

Step 1 – read the scenario: The rare form is favoured, and its advantage disappears as it becomes common.

Step 2 – fix the sign of the dependence: Fitness falls as frequency rises, so the dependence is negative.

Step 3 – name the mechanism: Rare-form advantage of this kind is negative frequency-dependent selection, a balancing force that maintains polymorphism.

Step 4 – reject the others: Positive frequency dependence favours the common form; directional and stabilizing selection do not depend on morph frequency at all.

Final Answer: negative frequency-dependent selection $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – equilibrium under overdominance: When the heterozygote is fittest, both alleles persist, and the equilibrium allele frequencies depend only on the selection coefficients against the two homozygotes.

Step 1 – list the data: $s_1 = 0.2$ (against AA), $s_2 = 0.3$ (against aa).

Step 2 – write the equilibrium formula: $\hat{q} = \dfrac{s_1}{s_1 + s_2}$

Step 3 – substitute: $\hat{q} = \dfrac{0.2}{0.2 + 0.3} = \dfrac{0.2}{0.5}$

Step 4 – evaluate: $\hat{q} = 0.4$

Final Answer: $\hat{q} = 0.4 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – relative fitness: Relative fitness scales the reproductive success of a genotype against the most successful genotype, which is set to 1.

Step 1 – list the data: The genotype yields 120 offspring; the best yields 150.

Step 2 – form the ratio: $w = \frac{120}{150}$

Step 3 – evaluate: $w = 0.8$

Step 4 – sanity check: A relative fitness must lie between 0 and 1; 0.8 does, whereas 1.25 (option B) would exceed the maximum and is impossible.

Final Answer: $w = 0.8 \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q22**

Q23.

Solution

Concept – balancing selection at MHC: Balancing selection keeps multiple alleles in a population instead of fixing one.

Step 1 – read the pattern: The MHC/HLA loci hold huge numbers of alleles at appreciable frequencies.

Step 2 – reason about immunity: Individuals carrying more MHC variants recognise more pathogens, so heterozygotes and rare variants are favoured, both forms of balancing selection.

Step 3 – conclude: Balancing selection (heterozygote and rare-allele advantage) maintains the extreme polymorphism.

Step 4 – reject the others: Drift erodes variation, one-way mutation is far too weak to build such diversity, and directional selection would fix a single allele rather than keep many.

Final Answer: balancing selection $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q23**

Q24.

Solution

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

Step 1 – list the data: $p = 0.3$, $m = 0.2$, $p_m = 0.8$.

Step 2 – weight the resident allele frequency: $(1-m)p = 0.8 \times 0.3 = 0.24$

Step 3 – weight the migrant allele frequency: $m\,p_m = 0.2 \times 0.8 = 0.16$

Step 4 – add the two contributions: $p' = 0.24 + 0.16 = 0.40$

Final Answer: $p' = 0.40 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept – Hardy–Weinberg heterozygote frequency: At equilibrium the genotype frequencies are p^2, $2pq$ and q^2, with $p + q = 1$.

Step 1 – find q: $q = 1 - p = 1 - 0.8 = 0.2$

Step 2 – write the heterozygote formula: $\text{freq}(Aa) = 2pq$

Step 3 – substitute: $2pq = 2 \times 0.8 \times 0.2$

Step 4 – evaluate: $2 \times 0.8 \times 0.2 = 0.32$

Final Answer: $2pq = 0.32 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – carrier frequency from disease incidence: Under Hardy–Weinberg the affected (recessive homozygote) frequency is q^2, and carriers are the heterozygotes $2pq$.

Step 1 – find q: $q = \sqrt{q^2} = \sqrt{0.0004} = 0.02$

Step 2 – find p: $p = 1 - q = 1 - 0.02 = 0.98$

Step 3 – compute the carrier frequency: $2pq = 2 \times 0.98 \times 0.02$

Step 4 – evaluate: $2 \times 0.98 \times 0.02 = 0.0392$

Final Answer: carriers $\approx 0.0392 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept – what changes allele versus genotype frequencies: Selection, gene flow and drift all change allele frequencies; non-random mating merely reshuffles the same alleles into different genotype combinations.

Step 1 – test each force on allele frequency: Selection removes alleles, gene flow imports them, and drift samples them randomly, so all three change allele frequencies.

Step 2 – test non-random mating: Assortative mating changes how alleles pair up but does not add, remove or import any allele, so the allele frequencies stay fixed.

Step 3 – test its effect on genotypes: By pairing like with like it produces an excess of homozygotes over p^2 and q^2, pulling genotype frequencies away from Hardy–Weinberg.

Step 4 – conclude: Non-random mating fits the description: it leaves allele frequencies unchanged yet distorts genotype frequencies.

Final Answer: non-random (assortative) mating $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept – narrow-sense heritability: Only the additive part of genetic variance responds predictably to selection, so narrow-sense heritability uses additive variance.

Step 1 – recall the definition: $h^2 = \dfrac{V_A}{V_P}$, where V_A is additive genetic variance and V_P is total phenotypic variance.

Step 2 – match to the options: That is "additive genetic variance to total phenotypic variance."

Step 3 – reject the others: Environmental or dominance variance over V_P is not h^2, and the inverted ratio is meaningless.

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

Answer: (C) Go Back to Q28

Q29.

Solution

Concept – the breeder's equation: The response to one generation of selection is $R = h^2 S$.

Step 1 – list the data: $h^2 = 0.4$, $S = 10$ g.

Step 2 – substitute: $R = 0.4 \times 10$

Step 3 – evaluate: $R = 4$ g

Step 4 – interpret: The next generation's mean seed mass is expected to shift by 4 g in the selected direction.

Final Answer: $R = 4$ 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.

Step 1 – count the A alleles: Each AA has two and each Aa has one, so A alleles $= 2(50) + 100 = 100 + 100 = 200$.

Step 2 – count all alleles: 200 individuals $\times 2 = 400$ alleles.

Step 3 – form the frequency: freq$(A) = \dfrac{200}{400}$

Step 4 – evaluate: freq$(A) = 0.50$

Final Answer: freq$(A) = 0.50 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – reinforcement: When hybrids have low fitness, selection favours anything that reduces mating between the two populations, strengthening prezygotic barriers where they overlap.

Step 1 – read the scenario: Two diverged populations meet in a contact zone and make unfit hybrids.

Step 2 – reason about the cost: Individuals that avoid cross-mating waste no gametes on doomed hybrids, so mate discrimination is favoured.

Step 3 – name the process: This selective strengthening of prezygotic isolation in the contact zone is reinforcement.

Step 4 – reject the others: Hybrid vigour is high hybrid fitness, introgression is gene movement across the boundary, and hitchhiking is a linkage effect.

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

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – speciation by polyploidy: A doubling of chromosome number instantly makes the new plant reproductively incompatible with its diploid parents, all in the same location.

Step 1 – read the requirement: Sudden, sympatric, essentially one-generation origin of a new species in plants.

Step 2 – match the mechanism: Whole-genome duplication (polyploidy) creates such instant reproductive isolation and is common in plants.

Step 3 – reject the others: Mountain isolation is allopatric and gradual, point-mutation accumulation is slow, and host imprinting is a behavioural route not tied to instant plant speciation.

Final Answer: polyploidy (whole-genome duplication) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – temporal (prezygotic) isolation: A barrier that acts before fertilisation by keeping the breeding times apart is prezygotic and specifically temporal.

Step 1 – read the scenario: The two frog species share a pond but breed in different months.

Step 2 – classify the barrier: Because their breeding seasons never overlap, their gametes never meet; this is isolation by timing.

Step 3 – name it: Isolation by differing breeding times is temporal isolation.

Step 4 – reject the others: Mechanical isolation is a structural mismatch, gametic incompatibility acts at the gamete level, and a postzygotic barrier would act after a hybrid forms.

Final Answer: temporal isolation $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – the outgroup on a tree: The outgroup joins the tree at its deepest node and so is the least closely related to the rest.

Step 1 – trace the branching order: P and Q join first (sister pair), then R joins the P–Q group, and finally S joins the whole cluster at the deepest split.

Step 2 – locate the earliest branch: S diverges at the basal node, before all the others.

Step 3 – identify the outgroup: Being the earliest to branch, S is the outgroup and shares the most distant common ancestor with the rest.

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

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – punctuated equilibrium: Eldredge and Gould described a tempo of long morphological stasis broken by short bursts of change at speciation.

Step 1 – read the pattern: Long stasis interrupted by brief rapid change around speciation events.

Step 2 – name the model: That is punctuated equilibrium.

Step 3 – reject the others: Phyletic gradualism is slow steady change, anagenesis is change within a single lineage without the stasis-burst pattern, and coevolution is reciprocal change between species.

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

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – homologous structures: Structures inherited from a common ancestor share the same underlying plan even when their functions differ.

Step 1 – read the example: Human arm, whale flipper and bat wing are built from the same bones inherited from a shared ancestor.

Step 2 – apply the definition: Same ancestral structure, different functions, is the definition of homology.

Step 3 – reject the others: Analogous and convergent structures share function but not ancestry, and vestigial structures are reduced remnants, which is not what is described.

Final Answer: homologous structures $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – the marginal value theorem: A forager in a depleting patch should leave when its current intake rate drops to the average rate it could achieve across the whole habitat, including travel time.

Step 1 – read the graph: The gain curve rises steeply at first, then flattens as the patch is depleted; the tangent is drawn from the travel-time point.

Step 2 – apply the rule: The optimal leaving time is where the tangent from the travel point just touches the gain curve; the slope there is the average intake rate for the habitat.

Step 3 – interpret the slope: Instantaneous intake falls as the patch empties; when it drops to that habitat-wide average, staying longer is no longer worthwhile.

Step 4 – reject the others: Emptying the patch, using a fixed time, or leaving at the first competitor all ignore the optimal-rate condition.

Final Answer: leave when instantaneous intake equals the habitat average rate $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – risk-sensitive foraging: When an animal must reach a survival threshold, its attitude to variance depends on whether the mean falls short of that threshold.

Step 1 – read the state: The bird is near starvation and the safe (low-variance) option's mean is not enough to survive the night.

Step 2 – reason about variance: Only by gambling on a high-variance option does the bird have a chance of the large reward it needs; the certain small reward guarantees death.

Step 3 – choose the strategy: So a starving animal below threshold should be risk-prone and pick the higher-variance option.

Step 4 – reject the others: The low-variance choice is for animals safely above threshold; handling time and zero-energy options are irrelevant to the risk logic.

Final Answer: higher variance (risk-prone) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – coefficient of relatedness: r is the probability that a gene in the actor is shared by descent with the recipient; it halves with each extra meiosis on the path.

Step 1 – trace the pedigree of first cousins: Their parents are full siblings, and the cousins connect through a pair of shared grandparents.

Step 2 – apply the halving rule: Full siblings have $r = \frac{1}{2}$; going one generation further down to their offspring (the cousins) halves it twice more relative to that link, giving $r = \frac{1}{8}$.

Step 3 – state the value: $r = 0.125$ for first cousins.

Step 4 – reject the others: 0.5 is for full siblings or parent-offspring, 0.25 is for half-siblings or grandparent-grandchild, and 0.0625 is for first cousins once removed.

Final Answer: $r = 0.125 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – ESS of the Hawk–Dove game when $C > V$: An evolutionarily stable strategy cannot be invaded by a rare alternative; when injury is costly, neither pure strategy is stable.

Step 1 – test pure Hawk: If all play Hawk, contests cost $\frac{V-C}{2}$, which is negative when $C > V$; a rare Dove that scores 0 does better and invades, so pure Hawk is not stable.

Step 2 – test pure Dove: If all play Dove, each shares the resource for $\frac{V}{2}$; a rare Hawk takes the whole V and invades, so pure Dove is not stable.

Step 3 – conclude the stable state: Since each pure strategy can be invaded by the other, the ESS is a stable mixture of Hawks and Doves (or a mixed strategy played by each individual).

Step 4 – reject the others: Pure Hawk and pure Dove are both invadable, and a valid ESS does exist, so "no stable outcome" is wrong.

Final Answer: a stable mixture of Hawks and Doves $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q40

Q41.

Solution

Concept – kin selection and inclusive fitness: Behaviour that lowers the actor's own survival can still spread if it raises the reproduction of relatives who carry the same genes.

Step 1 – read the behaviour: The alarm call helps nearby relatives but endangers the caller.

Step 2 – apply inclusive fitness: Because the warned neighbours are kin sharing the caller's alleles, saving them can more than repay the caller's risk (Hamilton's rule $rB > C$).

Step 3 – name the explanation: This is kin selection acting through inclusive fitness.

Step 4 – reject the others: "Good of the species" group selection is not needed and is generally weak, plain individual survival selection cannot explain a costly warning, and sexual selection is about mating, not alarm calls.

Final Answer: kin selection (inclusive fitness) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q41

Q42.

Solution

Concept – multiplicative diversity partitioning: Whittaker split regional diversity into local diversity times turnover: $\gamma = \alpha \times \beta$.

Step 1 – list the data: $\gamma = 12$ species, $\alpha = 3$ species.

Step 2 – rearrange for beta: $\beta = \dfrac{\gamma}{\alpha}$

Step 3 – substitute: $\beta = \dfrac{12}{3}$

Step 4 – evaluate: $\beta = 4$

Step 5 – interpret: The region holds about four times as many species as an average single site, reflecting turnover among sites.

Final Answer: $\beta = 4 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q42

Q43.

Solution

Concept – Simpson's index: $D = \sum_i p_i^2$ is the sum of squared proportional abundances; for S equally common species each $p_i = 1/S$.

Step 1 – square one proportion: $p_i^2 = 0.25^2 = 0.0625$

Step 2 – add over the four species: $D = 4 \times 0.0625$

Step 3 – evaluate: $D = 0.25$

Step 4 – cross-check: For S equal species $D = 1/S = 1/4 = 0.25$, which matches.

Final Answer: $D = 0.25 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – Shannon diversity index: $H' = -\sum_i p_i \ln p_i$; for S equally common species this reduces to $H' = \ln S$.

Step 1 – write the sum for four equal species: $H' = -4\,(0.25 \ln 0.25)$

Step 2 – simplify using $0.25 = 1/4$: $H' = -\ln(0.25) = \ln 4$

Step 3 – express in terms of $\ln 2$: $\ln 4 = \ln(2^2) = 2\ln 2$

Step 4 – substitute $\ln 2 = 0.693$: $H' = 2 \times 0.693 = 1.386$

Final Answer: $H' = 1.386 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – principal components analysis: PCA rotates the data to new axes ordered by how much variance each explains.

Step 1 – recall what PC1 is: The first principal component is the single direction along which the data vary the most.

Step 2 – state its property: PC1 therefore captures the largest possible share of the total variance.

Step 3 – reject the others: PCA does not force exactly two clusters, its axes are chosen to maximise variance (not at random), and PC1 is not fixed perpendicular to any environmental gradient; often it aligns with the main gradient.

Final Answer: PC1 captures the largest share of the total variance $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q45

Q46.

Solution

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

Step 1 – read the scatter: Y falls as X rises, and the points lie close to a downward line.

Step 2 – fix the sign: A downward (negative) slope gives a negative r.

Step 3 – fix the magnitude: The points are near but not exactly on the line, so $|r|$ is less than 1, giving $-1 < r < 0$.

Step 4 – reject the others: A positive or zero r contradicts the downward trend, and exactly $+1$ would need a perfect upward line.

Final Answer: negative, with $-1 < r < 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q46

Answer Key

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