GATE Ecology and Evolution

Sample Paper – 5

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 specific physical location or type of place where an organism naturally lives, feeds and breeds is called its: **[1 mark]**

(A) niche

(B) habitat

(C) guild

(D) biome

Q2. Robert MacArthur's warblers feed in different vertical zones of the same spruce tree, so that each species uses a distinct portion of a shared resource. This division of a resource that lowers competition is called: **[1 mark]**

(A) competitive exclusion

(B) resource (niche) partitioning

(C) mutualism

(D) predation

Q3. An organism that can survive only within a narrow band of temperature is described as: **[1 mark]**

(A) eurythermal

(B) euryhaline

(C) stenohaline

(D) stenothermal

Q4. The subset of environmental conditions and resources that a species actually occupies once competitors and predators are present is its: **[1 mark]**

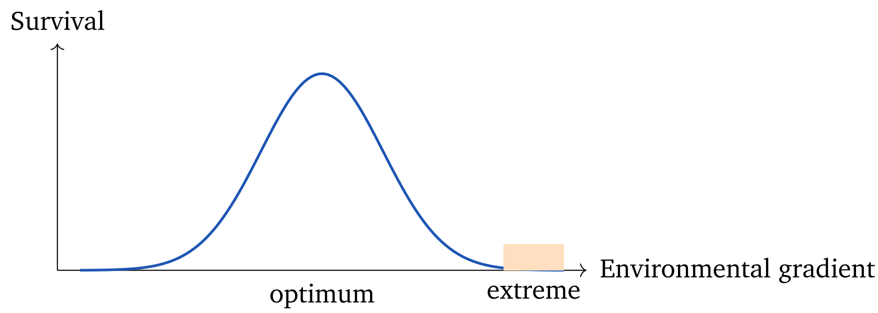
(A) realized niche

(B) fundamental niche

(C) habitat

(D) guild

Q5. The tolerance curve below plots survival against an environmental gradient. The shaded region at the far tail, where the factor is so extreme that no individual can survive, is the: **[1 mark]**



(A) optimum range

(B) zone of physiological stress

(C) zone of intolerance

(D) preferred zone

Q6. The transition band between two adjacent communities, such as the strip between a forest and a grassland, which often holds species from both sides plus some of its own, is called an: **[1 mark]**

(A) ecocline

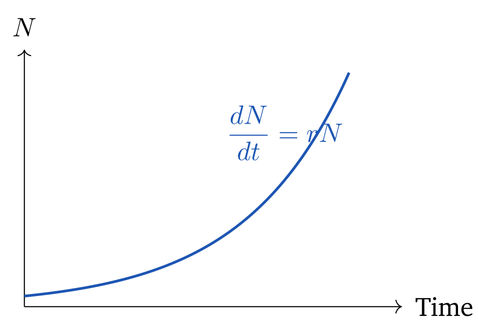
(B) ecotone

(C) ecotype

(D) biome

Population and Community Ecology

Q7. A population grows exponentially with intrinsic rate $r = 0.1$ yr^{-1}, as sketched by the J-shaped curve below. Using $t_2 = \dfrac{\ln 2}{r}$, the time taken for the population to double is: **[1 mark]**



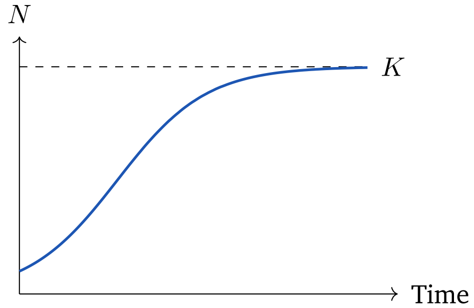
(A) 0.693 years

(B) 10 years

(C) 6.93 years

(D) 69.3 years

Q8. A population grows logistically with $\dfrac{dN}{dt} = rN\left(1 - \dfrac{N}{K}\right)$, where $r = 1.0$ yr^{-1} and $K = 800$, following the S-shaped curve shown. When the current size is $N = 200$, the instantaneous growth rate is: **[1 mark]**



(A) 150 individuals/year

(B) 200 individuals/year

(C) 100 individuals/year

(D) 0 individuals/year

Q9. In the Lotka–Volterra model of interspecific competition, two species achieve stable coexistence only when: **[1 mark]**

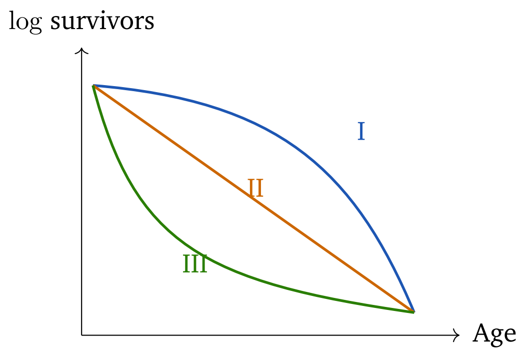
(A) interspecific competition is stronger than intraspecific competition for both species

(B) the two species occupy exactly the same niche

(C) one of the species has a carrying capacity of zero

(D) each species limits its own growth more strongly than it limits the growth of its competitor

Q10. The three survivorship curves below are plotted as $\log(\text{survivors})$ against age. Large mammals such as humans and elephants, with low juvenile mortality and most deaths concentrated in old age, follow: **[1 mark]**



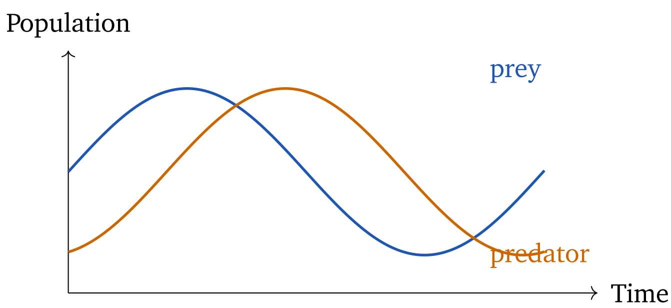
(A) Type III

(B) Type II

(C) a J-shaped curve

(D) Type I

Q11. The coupled oscillations below show a predator population (orange) and its prey population (blue) in the Lotka–Volterra predator–prey model. The predator population: **[1 mark]**



(A) peaks shortly after the prey peaks, lagging behind it

(B) peaks exactly in phase with the prey

(C) peaks shortly before the prey peaks

(D) never changes in size

Q12. Where two competing finch species live together on the same island, their beak sizes diverge more than where each lives alone, which reduces competition for seeds. This evolutionary pattern is called: **[1 mark]**

(A) competitive exclusion

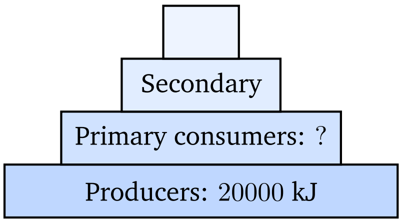
(B) ecological release

(C) mutualism

(D) character displacement

Ecosystems and Biogeochemical Cycles

Q13. In the energy pyramid below the producers fix 20000 kJ of energy. Applying Lindeman's ten-percent law, the energy available to the primary consumers (herbivores) is: **[1 mark]**



(A) 20000 kJ

(B) 2000 kJ

(C) 200 kJ

(D) 4000 kJ

Q14. The percentage of energy that is transferred from one trophic level to the next higher level in a food chain is measured by the: **[1 mark]**

(A) ecological (trophic-level transfer) efficiency

(B) assimilation efficiency

(C) net production efficiency

(D) exploitation efficiency

Q15. In a food chain the primary consumers have 1500 kJ of energy and the secondary consumers that feed on them obtain 150 kJ. The ecological efficiency of this transfer is: **[1 mark]**

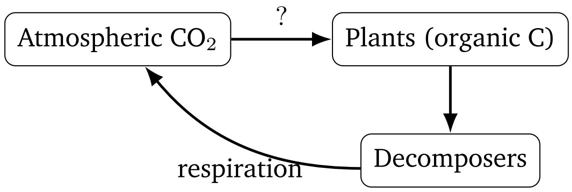
(A) 10%

(B) 1%

(C) 15%

(D) 90%

Q16. In the carbon cycle shown, the single process that removes carbon dioxide from the atmosphere and locks it into the tissues of green plants is: **[1 mark]**



(A) respiration

(B) combustion

(C) decomposition

(D) photosynthesis

Q17. Because energy is lost as heat at every transfer and can never be created within the chain, the one ecological pyramid that is always upright (never inverted) is the pyramid of: **[1 mark]**

(A) numbers

(B) energy

(C) biomass

(D) both numbers and biomass

Q18. Atmospheric nitrogen is converted to ammonia inside the root nodules of leguminous plants by a symbiotic bacterium of the genus: **[1 mark]**

(A) Nitrosomonas

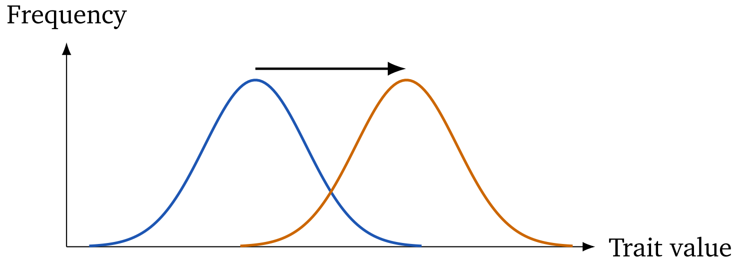
(B) Nitrobacter

(C) Rhizobium

(D) Pseudomonas

Mechanisms of Evolution

Q19. The two phenotype distributions below show a trait before selection (blue) and several generations after (orange). Because one extreme is consistently favoured, the mean shifts in that direction. This mode of selection is: **[1 mark]**



(A) stabilizing selection

(B) directional selection

(C) disruptive selection

(D) balancing selection

Q20. A mode of selection that favours both extreme phenotypes while acting against intermediate individuals, and can drive a single distribution toward a bimodal one, is: **[1 mark]**

(A) stabilizing selection

(B) directional selection

(C) disruptive selection

(D) purifying selection

Q21. A deleterious recessive allele is kept in the population by a balance between recurrent mutation and selection. If the mutation rate is $\mu = 1 \times 10^{-6}$ and the selection coefficient against the recessive homozygote is $s = 0.01$, then at mutation–selection balance the equilibrium allele frequency $\hat{q} = \sqrt{\mu/s}$ is: **[2 marks]**

(A) 0.001

(B) 0.01

(C) 0.1

(D) 0.0001

Q22. For a deleterious *dominant* allele the mutation–selection balance frequency is $\hat{q} = \mu/s$. With mutation rate $\mu = 2 \times 10^{-6}$ and selection coefficient $s = 0.02$, the equilibrium frequency of the allele is: **[2 marks]**

(A) 0.02

(B) 0.01

(C) 0.0001

(D) 0.002

Q23. A genotype is subject to selection with a selection coefficient $s = 0.3$. Its relative fitness, defined as $w = 1 - s$, is: **[2 marks]**

(A) 0.7

(B) 0.3

(C) 1.3

(D) 0.35

Q24. In a recipient population the frequency of allele A is $p = 0.4$. In one generation a fraction $m = 0.2$ of individuals are replaced by migrants from a source in which the frequency of A is $p_m = 0.9$. Using $p' = (1 - m)p + m\,p_m$, the new frequency of A is: **[2 marks]**

(A) 0.40

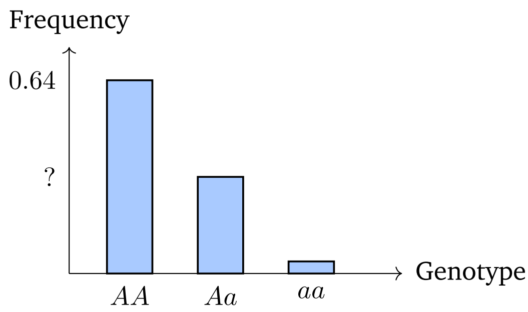
(B) 0.58

(C) 0.45

(D) 0.50

Population and Quantitative Genetics

Q25. In a population at Hardy–Weinberg equilibrium the recessive allele a has frequency $q = 0.2$. The bar chart below shows the three expected genotype frequencies. The frequency of heterozygotes (Aa), given by $2pq$, is: **[2 marks]**



(A) 0.16

(B) 0.32

(C) 0.04

(D) 0.64

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

(A) 0.0004

(B) 0.02

(C) 0.96

(D) 0.0392

Q27. In a sample of 200 diploid individuals the genotype counts are $AA = 90$, $Aa = 60$ and $aa = 50$. The frequency of allele A in the sample is: **[2 marks]**

(A) 0.60

(B) 0.45

(C) 0.40

(D) 0.55

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

(A) dominance genetic variance to phenotypic variance

(B) environmental variance to phenotypic variance

(C) additive genetic variance to total phenotypic variance

(D) total genetic variance to total phenotypic 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 $h^2 = 0.4$ and the selection differential is $S = 10$ g, the predicted response R is: **[2 marks]**

(A) 4 g

(B) 10 g

(C) 2.5 g

(D) 0.4 g

Q30. A population has observed heterozygosity $H_o = 0.3$ and expected (Hardy–Weinberg) heterozygosity $H_e = 0.5$. The inbreeding coefficient, defined as $F = \dfrac{H_e - H_o}{H_e}$, is: **[2 marks]**

(A) 0.2

(B) 0.4

(C) 0.6

(D) 0.3

Speciation, Phylogeny and Macroevolution

Q31. Speciation that occurs within a single, geographically continuous population without any physical barrier to gene flow, for example through polyploidy or a shift to a new host plant, is called: **[2 marks]**

(A) allopatric speciation

(B) peripatric speciation

(C) parapatric speciation

(D) sympatric speciation

Q32. The molecular clock hypothesis, which allows divergence times to be estimated from sequence data, rests on the assumption that: [2 marks]

(A) neutral substitutions accumulate at an approximately constant rate over time

(B) mutations occur only during speciation events

(C) molecular sequences evolve at the same rate as external morphology

(D) natural selection drives essentially all substitutions

Q33. Two lineages differ at 8% of their nucleotide sites. If substitutions accumulate at 2% per million years along each lineage (so the two lineages diverge from each other at 4% per million years), the estimated time since they shared a common ancestor is: [2 marks]

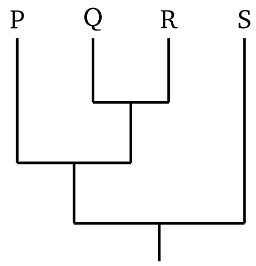
(A) 8 million years

(B) 4 million years

(C) 2 million years

(D) 1 million year

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



(A) Q and R

(B) P and S

(C) P and R

(D) Q and S

Q35. The macroevolutionary model in which most lineages stay essentially unchanged for long spans of time, with change concentrated in short bursts around speciation events, is: [2 marks]

(A) punctuated equilibrium

(B) phyletic gradualism

(C) coevolution

(D) orthogenesis

Q36. The rapid diversification of a single ancestral lineage into many descendant species that occupy a wide range of ecological niches, as seen in Darwin's finches and African cichlid fishes, is called: [2 marks]

(A) convergent evolution

(B) coevolution

(C) adaptive radiation

(D) phyletic gradualism

Behavioural Ecology

Q37. A mating system in which one female forms pair bonds with, and mates with, several males in a single breeding season, as in some jacanas and phalaropes, is called: [2 marks]

(A) monogamy

(B) polygyny

(C) promiscuity

(D) polyandry

Q38. Species that produce few offspring and invest heavily in the care and survival of each one, so that their population size tends to stay near the carrying capacity, are best described as: [2 marks]

(A) r-selected strategists

(B) K-selected strategists

(C) semelparous colonizers

(D) opportunistic breeders

Q39. Hamilton's rule states that an altruistic act spreads by kin selection when $rB > C$, where r is the coefficient of relatedness, B the benefit to the recipient and C the cost to the actor. For an act directed at a full sibling ($r = 0.5$) that costs the actor $C = 3$ offspring-equivalents, the minimum benefit B needed for the act to be favoured is: **[2 marks]**

(A) 1.5

(B) 3

(C) 6

(D) 0.5

Q40. An organism that channels all of its resources into one massive reproductive event and then dies, as in the Pacific salmon and the century plant (agave), is described as: **[2 marks]**

(A) iteroparous

(B) viviparous

(C) polygynous

(D) semelparous

Q41. According to Trivers' theory of parental investment, the sex that invests more time and resources per offspring becomes a limiting resource for the other sex and is therefore expected to be: **[2 marks]**

(A) the more ornamented sex

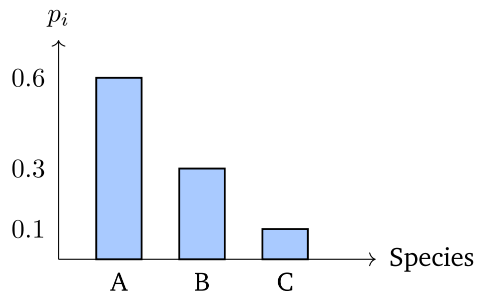
(B) the more numerous sex

(C) the choosier (more selective) sex

(D) always the male

Quantitative Ecology, Biostatistics and Mathematics

Q42. A community contains three species with proportional abundances $p_1 = 0.6$, $p_2 = 0.3$ and $p_3 = 0.1$, shown in the bar chart. Simpson's index $D = \sum_i p_i^2$ for this community equals: **[2 marks]**



(A) 0.46

(B) 0.54

(C) 1.00

(D) 0.16

Q43. A community contains four species that are all equally abundant, so each has proportional abundance $p_i = 0.25$. Using $\ln 2 = 0.693$, the Shannon diversity index $H' = -\sum_i p_i \ln p_i$ for this community equals: **[2 marks]**

(A) 0.25

(B) 0.693

(C) 4

(D) 1.386

Q44. A community of $S = 4$ species has a Shannon diversity of $H' = 1.0$. Pielou's evenness index is $J = \dfrac{H'}{\ln S}$. Taking $\ln 2 = 0.693$ (so $\ln 4 = 1.386$), the evenness J is approximately: **[2 marks]**

(A) 0.25

(B) 1.386

(C) 0.72

(D) 1.0

Q45. The quadrat counts recorded at five sampling stations are $\{1, 2, 3, 4, 20\}$. Because of the single large outlier, the measure of central tendency that best represents the typical value, the median, is: **[2 marks]**

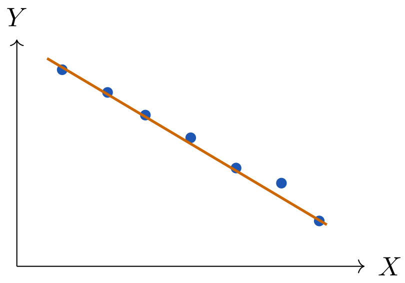
(A) 6

(B) 3

(C) 4

(D) 20

Q46. The scatter plot below shows measurements of two variables X and Y together with a fitted straight line of negative 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) negative, with $-1 < r < 0$

(C) exactly zero

(D) exactly $+1$

Detailed Solutions

Q1.

Solution

Concept – habitat versus niche: The habitat is the actual physical address of an organism, the kind of place in which it lives, feeds and breeds.

Step 1 – read the requirement: The question asks for the physical location or type of place where an organism lives.

Step 2 – match the definition: That physical "address" is precisely the habitat.

Step 3 – eliminate the others: The niche is the functional "profession" of the species (how it uses resources), a guild is a set of species using resources similarly, and a biome is a very large regional community type.

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

Answer: (B) Go Back to Q1

Q2.

Solution

Concept – resource (niche) partitioning: When competing species use different parts of a shared resource, or use it at different times, their niches overlap less and they can coexist.

Step 1 – read the scenario: Each warbler species feeds in a distinct vertical zone of the same tree.

Step 2 – name the mechanism: Dividing one resource into non-overlapping shares is resource (niche) partitioning.

Step 3 – eliminate the others: Competitive exclusion would remove one species, mutualism benefits both partners, and predation is one species eating another; none describes dividing a resource.

Final Answer: resource (niche) partitioning $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

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: Narrow range of temperature means narrow + temperature.

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

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

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

Answer: (D) Go Back to Q3

Q4.

Solution

Concept – fundamental versus realized niche: The fundamental niche is everything a species could use with no enemies present; the realized niche is the smaller part it actually holds once competitors and predators act.

Step 1 – read the key phrase: The question specifies the conditions occupied "once competitors and predators are present."

Step 2 – match the definition: The niche actually occupied under biotic pressure is the realized niche.

Step 3 – eliminate the others: The fundamental niche excludes competition, the habitat is just the place, and a guild is a group of species, not a niche.

Final Answer: realized niche $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – zones of a tolerance curve: Along an environmental gradient survival is highest at the optimum, falls through zones of physiological stress on either side, and reaches zero in the zones of intolerance at the extremes.

Step 1 – read the figure: The shaded band sits at the far tail of the curve, where survival has dropped to zero.

Step 2 – name the region: The extreme region where no individual can survive is the zone of intolerance.

Step 3 – eliminate the others: The optimum and preferred zone are at the peak, and the zone of physiological stress lies between the optimum and the intolerance zone, not at the very end.

Final Answer: zone of intolerance $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept – the ecotone: An ecotone is a transitional zone between two adjacent communities where the two communities meet and blend.

Step 1 – read the description: A transition band between a forest and a grassland that holds species from both.

Step 2 – match the term: A boundary community of this kind is an ecotone, and it often shows an edge effect with high species richness.

Step 3 – reject the others: An ecocline is a gradual gradient of change, an ecotype is a locally adapted genetic race, and a biome is a large regional community type.

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

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – doubling time under exponential growth: For $\frac{dN}{dt} = rN$ the size is $N(t) = N_0 e^{rt}$. Setting $N = 2N_0$ gives the doubling time $t_2 = \frac{\ln 2}{r}$.

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

Step 2 – substitute into the formula: $t_2 = \frac{0.693}{0.1}$

Step 3 – evaluate: $t_2 = 6.93$ years

Final Answer: 6.93 years $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

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: $r = 1.0\ \text{yr}^{-1}$, $N = 200$, $K = 800$.

Step 2 – compute the bracket: $1 - \frac{N}{K} = 1 - \frac{200}{800} = 1 - 0.25 = 0.75$

Step 3 – multiply r and N: $rN = 1.0 \times 200 = 200$

Step 4 – multiply by the bracket: $\frac{dN}{dt} = 200 \times 0.75 = 150$

Final Answer: 150 individuals/year $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – coexistence in Lotka–Volterra competition: Two competitors can settle at a stable equilibrium only if each species holds down its own numbers more than it holds down its rival, that is, intraspecific competition exceeds interspecific competition for both.

Step 1 – state the coexistence condition: Stable coexistence needs each population to be self-limited more strongly than it limits the other.

Step 2 – translate to the options: This is exactly "each species limits its own growth more than that of its competitor."

Step 3 – reject the others: If interspecific competition dominates the outcome is exclusion, identical niches violate coexistence, and a zero carrying capacity simply means one species cannot persist.

Final Answer: each species limits its own growth more $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

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

Step 1 – read the requirement: Low juvenile mortality with most deaths concentrated in old age.

Step 2 – match to the curve: A curve that stays high and then drops steeply at old age is the convex Type I curve.

Step 3 – give the example: Large mammals such as humans and elephants, which produce few, well-protected young, follow Type I.

Final Answer: Type I $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – predator–prey cycles: In the Lotka–Volterra predator–prey model the two populations oscillate, but the predator peak trails the prey peak by about a quarter of a cycle.

Step 1 – read the figure: The orange (predator) curve reaches its maximum a little to the right of the blue (prey) maximum.

Step 2 – interpret the lag: Predators build up only after their prey has become abundant, so the predator peak follows the prey peak.

Step 3 – reject the others: The two are not in phase, the predator does not lead the prey, and both populations clearly change over time.

Final Answer: the predator peaks shortly after the prey (it lags) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – character displacement: When two competing species co-occur, selection can push their resource-use traits apart, so that competition between them is reduced where they overlap.

Step 1 – read the scenario: Beak sizes diverge more in sympatry (where the species live together) than in allopatry.

Step 2 – name the pattern: Divergence of a trait driven by competition where species co-occur is character displacement.

Step 3 – reject the others: Competitive exclusion removes a species, ecological release is the *expansion* of a niche when a competitor is absent, and mutualism is a $+/+$ interaction.

Final Answer: character displacement $\Rightarrow \boxed{\text{D}}$

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 up to the next.

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

Step 2 – transfer to primary consumers: $10\% \times 20000 = 0.10 \times 20000 = 2000$ kJ

Step 3 – state the result: The primary consumers (herbivores) receive about 2000 kJ.

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

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – ecological (trophic-level transfer) efficiency: Ecological efficiency is the fraction of energy at one trophic level that reappears at the next level up, usually about 10%.

Step 1 – read the requirement: The measure asked for compares energy at successive trophic levels.

Step 2 – name the quantity: Energy passed from one level to the next, as a percentage, is the ecological (trophic-level transfer) efficiency.

Step 3 – reject the others: Assimilation efficiency compares assimilated to ingested energy *within* a level, net production efficiency compares production to assimilation, and exploitation efficiency is the fraction of available food actually eaten; none of these spans two trophic levels the way ecological efficiency does.

Final Answer: ecological efficiency $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept – computing ecological efficiency: Ecological efficiency $= \dfrac{\text{energy at the higher level}}{\text{energy at the lower level}} \times 100\%$.

Step 1 – list the data: Primary consumers $= 1500$ kJ; secondary consumers $= 150$ kJ.

Step 2 – form the ratio: $\dfrac{150}{1500} = 0.10$

Step 3 – convert to a percentage: $0.10 \times 100\% = 10\%$

Final Answer: $10\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – carbon entering the biosphere: Green plants take up atmospheric CO_2 and build it into sugars during photosynthesis, which is the main pathway of carbon from the air into living tissue.

Step 1 – read the arrow in question: It runs from atmospheric CO_2 into the plants.

Step 2 – name the process: Fixing CO_2 into plant organic matter is photosynthesis.

Step 3 – reject the others: Respiration, combustion and decomposition all *release* CO_2 back to the atmosphere rather than removing it.

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

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – why the energy pyramid is always upright: Energy is lost as heat at every transfer and obeys the laws of thermodynamics, so each level must contain less usable energy than the one below it.

Step 1 – apply the one-way loss: Because roughly 90% of energy is lost at each step, the amount always decreases upward.

Step 2 – conclude the shape: A quantity that only decreases upward gives a pyramid that can never be inverted, the pyramid of energy.

Step 3 – reject the others: Pyramids of numbers and of biomass can both be inverted (for example, one large tree supporting many insects), so they are not always upright.

Final Answer: pyramid of energy $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept – symbiotic nitrogen fixation: Certain bacteria living in the root nodules of legumes reduce atmospheric N_2 to ammonia, supplying the plant with usable nitrogen.

Step 1 – read the requirement: A symbiotic bacterium inside legume root nodules that fixes nitrogen.

Step 2 – name the genus: That symbiont is Rhizobium.

Step 3 – reject the others: Nitrosomonas and Nitrobacter carry out nitrification (ammonium to nitrite to nitrate), and Pseudomonas is a denitrifier; none is the legume-nodule fixer.

Final Answer: Rhizobium $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – directional selection: Directional selection favours one extreme of a trait, so the whole distribution shifts steadily toward that extreme over generations.

Step 1 – read the figure: The orange distribution is the blue one shifted bodily to the right, with the arrow showing the mean moving.

Step 2 – match the mode: A consistent shift of the mean toward one extreme is directional selection.

Step 3 – reject the others: Stabilizing selection narrows the distribution around the mean, disruptive selection splits it toward both extremes, and balancing selection maintains variation rather than shifting the mean.

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

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – disruptive selection: Disruptive (diversifying) selection favours both extreme phenotypes and selects against the intermediates, which can split a single peak into two.

Step 1 – read the requirement: Both extremes favoured, intermediates penalized, distribution tending to become bimodal.

Step 2 – name the mode: That description is disruptive selection.

Step 3 – reject the others: Stabilizing selection favours the mean, directional selection favours only one extreme, and purifying selection simply removes deleterious variants.

Final Answer: disruptive selection $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – mutation–selection balance for a recessive allele: A harmful recessive allele is created by mutation at rate μ and removed by selection s acting on the recessive homozygote. The equilibrium is $\hat{q} = \sqrt{\mu/s}$.

Step 1 – list the data: $\mu = 1 \times 10^{-6}$ and $s = 0.01$.

Step 2 – form the ratio: $\frac{\mu}{s} = \frac{1 \times 10^{-6}}{0.01} = 1 \times 10^{-4}$

Step 3 – take the square root: $\hat{q} = \sqrt{1 \times 10^{-4}}$

Step 4 – evaluate: $\hat{q} = 0.01$

Final Answer: $\hat{q} = 0.01 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – mutation–selection balance for a dominant allele: A harmful dominant allele is exposed to selection in every carrier, so its equilibrium frequency is $\hat{q} = \mu/s$ (no square root).

Step 1 – list the data: $\mu = 2 \times 10^{-6}$ and $s = 0.02$.

Step 2 – form the ratio: $\hat{q} = \frac{\mu}{s} = \frac{2 \times 10^{-6}}{0.02}$

Step 3 – simplify the powers of ten: $\frac{2 \times 10^{-6}}{2 \times 10^{-2}} = 1 \times 10^{-4}$

Step 4 – evaluate: $\hat{q} = 0.0001$

Final Answer: $\hat{q} = 0.0001 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – relative fitness and the selection coefficient: The selection coefficient s is the fractional reduction in fitness, so the relative fitness is $w = 1 - s$.

Step 1 – list the data: $s = 0.3$.

Step 2 – substitute into the definition: $w = 1 - 0.3$

Step 3 – evaluate: $w = 0.7$

Final Answer: $w = 0.7 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

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

Step 1 – list the data: $p = 0.4$, $m = 0.2$, $p_m = 0.9$.

Step 2 – weight the resident frequency: $(1 - m)p = 0.8 \times 0.4 = 0.32$

Step 3 – weight the migrant frequency: $m\,p_m = 0.2 \times 0.9 = 0.18$

Step 4 – add the two contributions: $p' = 0.32 + 0.18 = 0.50$

Final Answer: $p' = 0.50 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – Hardy–Weinberg heterozygote frequency: With q the recessive allele frequency and $p = 1 - q$, the heterozygote frequency is $2pq$.

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

Step 2 – write the heterozygote term: $2pq = 2 \times 0.8 \times 0.2$

Step 3 – multiply step by step: $2 \times 0.8 = 1.6$

$1.6 \times 0.2 = 0.32$

Step 4 – state the result: The heterozygote frequency is 0.32.

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

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – carrier frequency from disease incidence: The affected are the recessive homozygotes with frequency q^2; carriers are the heterozygotes with frequency $2pq$.

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: $2 \times 0.98 = 1.96$, and $1.96 \times 0.02 = 0.0392$

Final Answer: carrier frequency $\approx 0.0392 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

Q27.

Solution

Concept – allele frequency from genotype counts: Each AA carries two A alleles and each Aa carries one, so freq$(A) = \dfrac{2(AA) + (Aa)}{2N}$.

Step 1 – list the data: $AA = 90$, $Aa = 60$, $aa = 50$, total $N = 200$.

Step 2 – count the A alleles: $2 \times 90 + 60 = 180 + 60 = 240$

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

Step 4 – form the frequency: $\text{freq}(A) = \dfrac{240}{400} = 0.60$

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

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – narrow-sense heritability: Narrow-sense heritability isolates the part of variation that parents reliably pass on, namely the additive genetic variance, as a fraction of the total phenotypic variance: $h^2 = \dfrac{V_A}{V_P}$.

Step 1 – recall the numerator: Only the additive genetic variance V_A predicts the resemblance between parents and offspring.

Step 2 – recall the denominator: It is scaled by the total phenotypic variance V_P.

Step 3 – reject the others: Dominance variance and environmental variance are not additive contributions, and the ratio of total genetic variance V_G to V_P defines the *broad*-sense heritability H^2, not h^2.

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 selection is $R = h^2S$, the product of the narrow-sense heritability and the selection differential.

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

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

Step 3 – evaluate: $R = 4$ g

Final Answer: $R = 4$ g $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – the inbreeding coefficient: F measures the shortfall of observed heterozygosity relative to the Hardy–Weinberg expectation: $F = \dfrac{H_e - H_o}{H_e}$.

Step 1 – list the data: $H_o = 0.3$ and $H_e = 0.5$.

Step 2 – compute the numerator: $H_e - H_o = 0.5 - 0.3 = 0.2$

Step 3 – divide by H_e: $F = \dfrac{0.2}{0.5}$

Step 4 – evaluate: $F = 0.4$

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

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – sympatric speciation: Sympatric speciation produces new species from a single population living in one place, with reproductive isolation arising without any geographic barrier.

Step 1 – read the scenario: Speciation happens within one continuous population, with no physical barrier, via polyploidy or a host shift.

Step 2 – match the mode: Divergence with ongoing spatial overlap is sympatric speciation.

Step 3 – reject the others: Allopatric and peripatric speciation both require geographic separation, and parapatric speciation involves a continuous cline with only partial spatial separation.

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

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – the molecular clock: The molecular clock treats neutral mutations as accumulating at a roughly steady rate, so genetic distance between lineages grows in proportion to the time since they diverged.

Step 1 – state the key assumption: Neutral substitutions build up at an approximately constant rate over time.

Step 2 – see why it enables dating: A constant rate turns the number of sequence differences into a clock that reads elapsed time.

Step 3 – reject the others: Mutations are not confined to speciation events, molecules and morphology do not evolve at the same pace, and neutral theory (not pervasive selection) underlies the clock.

Final Answer: neutral substitutions accumulate at a roughly constant rate $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – divergence dating with a molecular clock: Sequence differences accumulate independently along both lineages, so the pairwise divergence grows at twice the per-lineage rate. The time is $T = \dfrac{\text{pairwise divergence}}{\text{between-pair rate}}$.

Step 1 – list the data: Pairwise divergence $= 8\% = 0.08$; per-lineage rate $= 2\%$ per Myr.

Step 2 – find the between-pair rate: Two lineages diverge at $2 \times 2\% = 4\%$ per Myr.

Step 3 – divide divergence by rate: $T = \dfrac{0.08}{0.04} = 2$

Step 4 – attach the unit: $T = 2$ million years.

Final Answer: 2 million years $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – reading a phylogenetic tree: The two taxa that are most closely related are the ones joined by the most recent (lowest) branch point, that is, the pair whose common ancestor is nearest the tips.

Step 1 – find the shallowest node: In the tree, Q and R join at the highest (most recent) internal node.

Step 2 – read off the sister pair: That node makes Q and R sister taxa sharing the most recent common ancestor.

Step 3 – reject the others: P joins the Q–R group only at a deeper node, and S branches off deepest of all, so any pair involving P or S has an older common ancestor.

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

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – punctuated equilibrium: Punctuated equilibrium describes evolution as long stretches of stasis broken by short, rapid episodes of change that coincide with speciation.

Step 1 – read the requirement: Long periods of little change with change concentrated in brief bursts at speciation.

Step 2 – name the model: This stasis-plus-bursts pattern is punctuated equilibrium (Eldredge and Gould).

Step 3 – reject the others: Phyletic gradualism proposes slow, steady change; coevolution is reciprocal change between interacting lineages; and orthogenesis is the discredited idea of an inner drive toward a goal.

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

Answer: (A) Go Back to Q35

Q36.

Solution

Concept – adaptive radiation: Adaptive radiation is the rapid branching of one lineage into many species that specialise for different ecological roles, often after reaching new or empty habitat.

Step 1 – read the examples: Darwin's finches and African cichlids each diversified from one ancestor into many niche specialists.

Step 2 – name the process: Rapid ecological and species diversification from a single ancestor is adaptive radiation.

Step 3 – reject the others: Convergent evolution makes unrelated lineages resemble one another, coevolution is reciprocal change between lineages, and gradualism refers to the tempo of change, not this branching pattern.

Final Answer: adaptive radiation $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – mating systems: The prefixes name who has multiple mates: "poly-andry" means one female with many males, while "poly-gyny" means one male with many females.

Step 1 – read the scenario: One female pairs with, and mates with, several males (as in jacanas and phalaropes).

Step 2 – assemble the term: one female + many males = polyandry.

Step 3 – reject the others: Monogamy is one pair bond, polygyny is one male with many females, and promiscuity involves no lasting pair bonds at all.

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

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – r- and K-selection: K-selected species live in stable, crowded environments; they produce few offspring, invest heavily in each, and hover near the carrying capacity K.

Step 1 – read the requirement: Few offspring, high parental investment, population near carrying capacity.

Step 2 – match the strategy: That life-history profile is K-selection.

Step 3 – reject the others: r-selected strategists and opportunistic breeders make many cheap offspring in unstable habitats, and semelparity refers to a single reproductive episode, a different axis of life history.

Final Answer: K-selected strategists $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – Hamilton's rule: Altruism spreads when $rB > C$. The break-even benefit is found by setting $rB = C$, giving $B = \dfrac{C}{r}$.

Step 1 – list the data: $r = 0.5$ (full siblings) and $C = 3$.

Step 2 – set the rule at threshold: $rB = C \;\Rightarrow\; 0.5 \times B = 3$

Step 3 – solve for B: $B = \frac{3}{0.5} = 6$

Step 4 – interpret: The benefit to the sibling must exceed 6 for the altruistic act to be favoured.

Final Answer: $B = 6 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – semelparity versus iteroparity: A semelparous organism reproduces in a single, all-out event and then dies; an iteroparous one breeds repeatedly over its life.

Step 1 – read the examples: Pacific salmon and the century plant each reproduce once, massively, and then die.

Step 2 – name the strategy: A single terminal bout of reproduction is semelparity.

Step 3 – reject the others: Iteroparity is repeated breeding, viviparity is giving birth to live young, and polygyny is a mating system, none of which is "breed once and die."

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

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – parental investment theory: Trivers argued that the sex investing more per offspring becomes the scarcer reproductive resource, so members of the other sex must compete for access to it, and the high-investing sex can afford to be choosy.

Step 1 – identify the high-investing sex: Greater investment per offspring makes that sex the limiting resource.

Step 2 – deduce its behaviour: Being the limiting resource, it is selected to be the choosier, more selective sex.

Step 3 – reject the others: The more ornamented and more numerous roles usually fall to the *low*-investing, competing sex, and the choosy sex is not always the male (in sex-role-reversed species it is the female).

Final Answer: the choosier (more selective) sex $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q41

Q42.

Solution

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

Step 1 – square each proportion: $p_1^2 = 0.6^2 = 0.36$

$p_2^2 = 0.3^2 = 0.09$

$p_3^2 = 0.1^2 = 0.01$

Step 2 – add the squares: $D = 0.36 + 0.09 + 0.01$

Step 3 – evaluate: $D = 0.46$

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

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – Shannon index for equal abundances: $H' = -\sum_i p_i \ln p_i$. When all S species are equally common, H' reaches its maximum value of $\ln S$.

Step 1 – note the equal proportions: Four species each have $p_i = 0.25$, so every term is identical.

Step 2 – write the sum: $H' = -4 \times \big(0.25 \ln 0.25\big)$

Step 3 – simplify using $\ln 0.25 = -\ln 4$**:** $H' = -4 \times 0.25 \times (-\ln 4) = \ln 4$

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

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

Answer: (D) Go Back to Q43

Q44.

Solution

Concept – Pielou's evenness: $J = \dfrac{H'}{\ln S}$ scales the observed Shannon diversity by its maximum possible value $\ln S$, giving a number between 0 and 1.

Step 1 – list the data: $H' = 1.0$ and $S = 4$.

Step 2 – compute the maximum diversity: $\ln S = \ln 4 = 2\ln 2 = 2{\times}0.693 = 1.386$

Step 3 – form the ratio: $J = \dfrac{1.0}{1.386}$

Step 4 – evaluate: $J \approx 0.72$

Final Answer: $J \approx 0.72 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – the median: The median is the middle value of the data once they are placed in order; unlike the mean, it is not pulled toward a single extreme outlier.

Step 1 – order the data: $1,\ 2,\ 3,\ 4,\ 20$ (already in order).

Step 2 – locate the middle position: With $n = 5$ values the middle is the 3^{rd} value.

Step 3 – read off the median: The 3^{rd} value is 3.

Step 4 – contrast with the mean: The mean is $\dfrac{1+2+3+4+20}{5} = \dfrac{30}{5} = 6$, dragged upward by the outlier 20, which is why the median better represents the typical value.

Final Answer: median $= 3 \Rightarrow \boxed{\text{B}}$

Answer: (B) 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 fall as X rises, and the points cluster around a downward-sloping line.

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

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

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

Answer: (B) Go Back to Q46

Answer Key

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