GATE Ecology and Evolution

Sample Paper – 6

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. An r-selected species, adapted to unstable or unpredictable environments, is typically characterized by: **[1 mark]**

(A) few large offspring with heavy parental care and a long lifespan

(B) many small offspring, little or no parental care, and early maturity

(C) a large body size and a population held near carrying capacity

(D) strong competitive ability in crowded, saturated habitats

Q2. A group of individuals of the *same* species living together in a defined area and able to interbreed is called a: **[1 mark]**

(A) community

(B) ecosystem

(C) population

(D) biome

Q3. An ecotone is best described as: **[1 mark]**

(A) a transition zone between two adjacent communities, often showing an edge effect of high species richness

(B) the innermost, most uniform core of a single habitat

(C) a species restricted to one small geographic locality

(D) the maximum number of individuals an area can support

Q4. The photosynthetic rate of an aquatic plant doubles for every $10°$C rise in temperature, so its $Q_{10} = 2$. If the rate is 5 units at $15°$C, then at $35°$C the rate is: **[1 mark]**

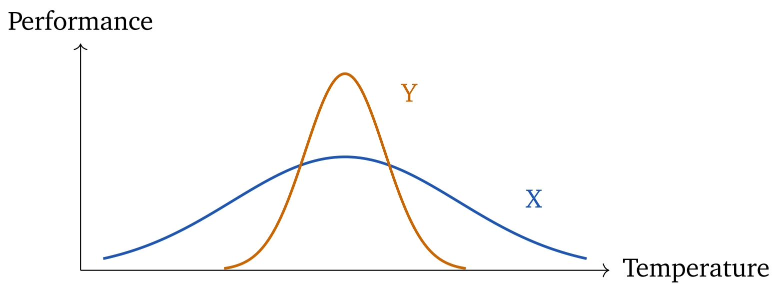
(A) 10 units

(B) 5 units

(C) 40 units

(D) 20 units

Q5. The two performance curves below plot two species against environmental temperature. The broad, low, flat curve (species X) describes a species that is: **[1 mark]**



(A) stenothermal

(B) stenohaline

(C) strictly an endotherm

(D) eurythermal

Q6. An animal that maintains a nearly constant internal body temperature by internal metabolic heat, largely independent of the surrounding temperature, is called a: **[1 mark]**

(A) homeotherm (endotherm)

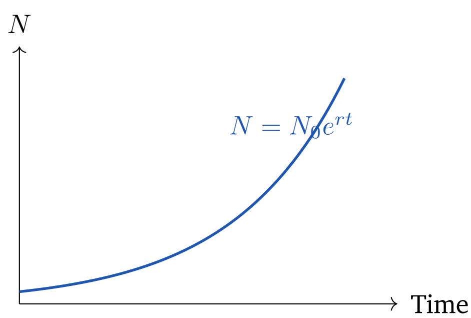
(B) poikilotherm

(C) ectotherm

(D) stenotherm

Population and Community Ecology

Q7. A population grows exponentially at a constant per-capita rate $r = 0.0693\ \text{yr}^{-1}$, as sketched below. Using the doubling time $t_d = \dfrac{\ln 2}{r}$, the population doubles in about: **[1 mark]**



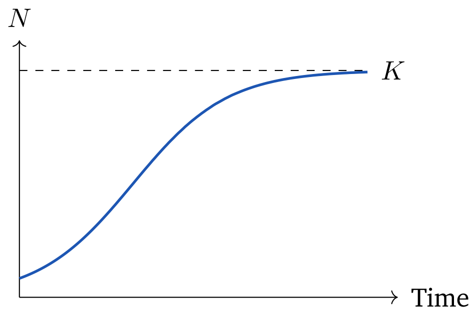
(A) 5 years

(B) 10 years

(C) 20 years

(D) 100 years

Q8. A population follows the logistic model $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$ with $r = 0.8\ \text{yr}^{-1}$ and $K = 500$, whose growth curve is shown. When the current size is $N = 100$, the instantaneous growth rate $\frac{dN}{dt}$ is: **[1 mark]**



(A) 64 individuals/year

(B) 80 individuals/year

(C) 100 individuals/year

(D) 16 individuals/year

Q9. A K-selected species, adapted to stable, predictable environments, is best characterized by: **[1 mark]**

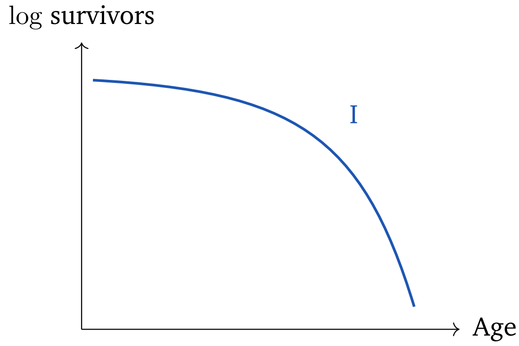
(A) a very high intrinsic rate of increase r

(B) producing enormous numbers of tiny offspring in a single reproductive event

(C) few, large offspring with high parental investment and a long lifespan

(D) a strongly concave Type III survivorship curve

Q10. The convex survivorship curve below (plotted as $\log$ survivors against age) shows very low mortality until late in life, when death is concentrated. Such a Type I curve is typical of: **[1 mark]**



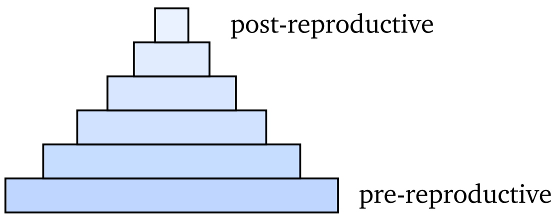
(A) marine fish that release millions of eggs

(B) most small insects

(C) species whose mortality is constant at every age

(D) large mammals such as humans and elephants

Q11. The age-structure diagram below has a very broad base of young individuals tapering to a narrow top. It represents a population that is: **[1 mark]**



(A) declining toward extinction

(B) stationary (zero growth)

(C) exactly at carrying capacity

(D) growing rapidly (expanding)

Q12. An interaction in which one species gains a benefit while the other is neither helped nor harmed is called: **[1 mark]**

(A) mutualism

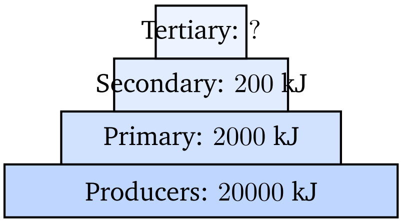
(B) commensalism

(C) parasitism

(D) interspecific competition

Ecosystems and Biogeochemical Cycles

Q13. According to Lindeman's ten-percent law, illustrated by the energy pyramid below, if the producers fix 20000 kJ then the energy available to the tertiary consumers (the fourth trophic level) is approximately: **[1 mark]**



(A) 2000 kJ

(B) 200 kJ

(C) 20 kJ

(D) 2 kJ

Q14. In the phosphorus cycle, unlike the nitrogen or carbon cycles, the largest long-term reservoir of phosphorus is: **[1 mark]**

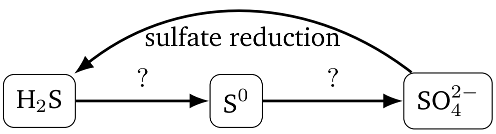
(A) the atmosphere in the form of phosphine (PH_3) gas

(B) rocks and marine sediments containing phosphate minerals

(C) the living biomass of plants and animals

(D) dissolved N_2 in ocean water

Q15. In the sulfur cycle shown, the conversion of hydrogen sulfide and elemental sulfur to sulfate (SO_4^{2-}) by chemolithotrophic bacteria is called: **[1 mark]**



(A) sulfate reduction

(B) desulfurylation

(C) sulfur oxidation

(D) assimilatory uptake

Q16. Which one of the following biogeochemical cycles has a significant gaseous phase, releasing H_2S and SO_2 to the atmosphere through volcanic activity and the burning of fossil fuels? **[1 mark]**

(A) the phosphorus cycle

(B) the calcium cycle

(C) the sulfur cycle

(D) the potassium cycle

Q17. Cultural eutrophication, the excessive growth of algae that eventually depletes dissolved oxygen in a lake, is most often triggered by the runoff input of which two limiting nutrients? **[1 mark]**

(A) carbon and oxygen

(B) nitrogen and phosphorus

(C) sulfur and iron

(D) sodium and chlorine

Q18. In the detritus-based food chain shown, the earthworm, which feeds directly on dead plant material, is functioning as a: **[1 mark]**

dead leaves → earthworm → shrew → owl

(A) primary producer

(B) detritivore

(C) apex predator

(D) photoautotroph

Mechanisms of Evolution

Q19. In an industrial region the bark of trees darkens with soot, and over successive generations a moth population shifts steadily toward darker (melanic) forms. This progressive shift of the mean phenotype in one direction is an example of: **[1 mark]**

(A) stabilizing selection

(B) disruptive selection

(C) directional selection

(D) balancing selection

Q20. Among the four evolutionary forces, the only one that reliably produces *adaptation*, a close fit between organisms and their environment, is: **[1 mark]**

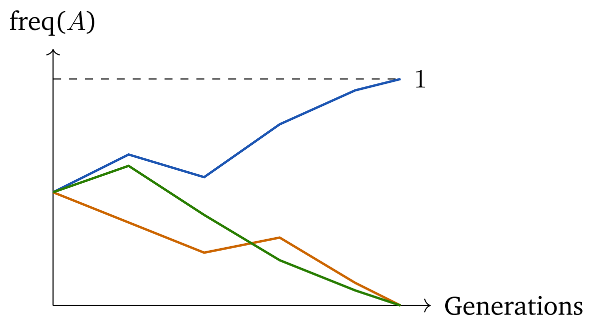
(A) natural selection

(B) genetic drift

(C) mutation

(D) gene flow

Q21. The plot below follows the frequency of allele A over generations in several small, isolated populations that started at the same frequency. Some lines wander up to fixation (1) and others down to loss (0). This behaviour illustrates that genetic drift: **[2 marks]**



(A) always increases heterozygosity within each population

(B) preserves every allele indefinitely at its starting frequency

(C) acts only upon beneficial mutations

(D) causes random loss or fixation of alleles within populations and increases divergence among them

Q22. A genotype has relative fitness $w = 0.65$. The selection coefficient acting against it, defined as $s = 1 - w$, is: **[2 marks]**

(A) 0.65

(B) 0.35

(C) 1.35

(D) 1.0

Q23. The evolutionary force that tends to make two separate populations genetically *more similar* by moving alleles between them is: **[2 marks]**

(A) genetic drift

(B) gene flow (migration)

(C) recurrent mutation

(D) inbreeding

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

(A) 0.20

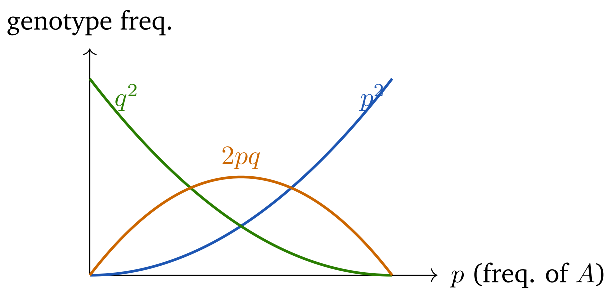
(B) 0.40

(C) 0.30

(D) 0.45

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) 0.64

(B) 0.04

(C) 0.16

(D) 0.32

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

(A) 0.0392

(B) 0.0004

(C) 0.02

(D) 0.98

Q27. Wright's fixation index F_{ST} is used in population genetics to measure: **[2 marks]**

(A) the mutation rate per locus per generation

(B) the proportion of total genetic variation that is due to differences *among* subpopulations

(C) the number of distinct alleles present at a locus

(D) the recombination frequency between two linked loci

Q28. For a subdivided population the expected heterozygosity of the whole (total) population is $H_T = 0.5$, and the average expected heterozygosity within subpopulations is $H_S = 0.4$. The fixation index $F_{ST} = \dfrac{H_T - H_S}{H_T}$ equals: **[2 marks]**

(A) 0.10

(B) 0.20

(C) 0.80

(D) 0.50

Q29. Two populations of a plant are found to have an F_{ST} value very close to 0. The most direct interpretation of this result is that the two populations experience: **[2 marks]**

(A) complete reproductive isolation from each other

(B) very strong genetic drift and rapid divergence

(C) an unusually high mutation load

(D) a high rate of gene flow that keeps them genetically homogeneous

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

(A) 0.49

(B) 0.70

(C) 0.30

(D) 0.42

Speciation, Phylogeny and Macroevolution

Q31. A well-known limitation of the *biological* species concept, which defines species by interbreeding and reproductive isolation, is that it cannot be readily applied to: **[2 marks]**

(A) sexually reproducing insects

(B) large terrestrial mammals

(C) asexually reproducing organisms and fossil forms

(D) any currently living animal species

Q32. Where two recently diverged populations meet and their hybrids have reduced fitness, natural selection may strengthen traits that reduce interbreeding, so that prezygotic barriers become stronger over time. This process is called: **[2 marks]**

(A) reinforcement

(B) introgression

(C) hybrid vigour

(D) genetic hitchhiking

Q33. Instantaneous sympatric speciation, in which a new species arises in a single step without any geographic barrier, occurs most commonly in flowering plants through: **[2 marks]**

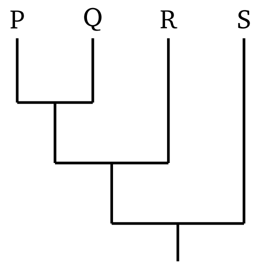
(A) long-term geographic isolation

(B) a difference in breeding season (temporal isolation)

(C) polyploidy (whole-genome duplication)

(D) genetic drift acting alone

Q34. In the cladogram shown, taxa P and Q form a clade. The taxon that is the *sister group* to the (P, Q) clade, i.e. branches off just below them, is: **[2 marks]**



(A) R

(B) S

(C) P

(D) Q

Q35. The forelimbs of a whale (flipper), a bat (wing) and a human (arm) are built on the same underlying arrangement of bones inherited from a shared ancestor, even though they now serve very different functions. Such structures are described as: **[2 marks]**

(A) analogous structures

(B) vestigial structures

(C) homologous structures

(D) purely convergent structures

Q36. In cladistics, a *shared derived* character state that is inherited from the most recent common ancestor of a group and is used to diagnose that clade is called a: **[2 marks]**

(A) plesiomorphy (shared ancestral trait)

(B) homoplasy (independently evolved similarity)

(C) autapomorphy (trait unique to one taxon)

(D) synapomorphy (shared derived trait)

Behavioural Ecology

Q37. Hamilton's rule states that an altruistic act is favoured by kin selection when $rB > C$. For an act that confers a benefit $B = 10$ on the recipient at a cost $C = 3$ to the actor, the act is favoured whenever the coefficient of relatedness r exceeds C/B, that is: **[2 marks]**

(A) 0.7

(B) 3.0

(C) 0.3

(D) 0.1

Q38. In the Hawk–Dove game shown, with resource value V and cost of injury $C > V$, the evolutionarily stable state is a mixed population in which the equilibrium proportion of Hawks equals V/C. If $V = 2$ and $C = 4$, this equilibrium proportion of Hawks is: **[2 marks]**

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

(A) 1.0

(B) 0.25

(C) 0.75

(D) 0.5

Q39. An evolutionarily stable strategy (ESS), in the sense of Maynard Smith and Price, is a strategy that: **[2 marks]**

(A) once common in a population, cannot be invaded by any rare alternative (mutant) strategy

(B) always maximizes the welfare of the group as a whole

(C) is simply the strategy with the single highest payoff, regardless of what others do

(D) requires the animal to make a conscious, rational choice

Q40. Reciprocal altruism, in which unrelated individuals help one another in the expectation of return help, can be evolutionarily stable (as in the "tit-for-tat" strategy) only when: **[2 marks]**

(A) interactions between individuals are strictly one-time events

(B) partners disperse and never encounter one another again

(C) the cost of helping always exceeds every possible future benefit

(D) the same individuals interact repeatedly and can recognize and remember their partners

Q41. In a *lek* mating system, characteristic of some grouse and birds of paradise: **[2 marks]**

(A) males gather to display at a communal arena that females visit only to choose a mate, and the males provide no resources or parental care

(B) a single male and female form a lifelong pair bond and share the rearing of young

(C) one female mates with several males who then jointly incubate her eggs

(D) mates pair up completely at random with no display or choice

Quantitative Ecology, Biostatistics and Mathematics

Q42. For the quadrat counts $\{3, 7, 7, 8, 10, 13\}$ recorded at six sampling points, the median of the data set is: **[2 marks]**

(A) 7.5

(B) 8

(C) 7

(D) 8.5

Q43. A Leslie matrix L is used to project an age-structured population forward in time by the rule $\mathbf{N}(t+1) = L\,\mathbf{N}(t)$. The dominant eigenvalue λ of the Leslie matrix gives: **[2 marks]**

(A) the total number of individuals in the population

(B) the mean age of first reproduction

(C) the carrying capacity of the environment

(D) the asymptotic (long-term) multiplicative growth rate per time step

Q44. A stage-structured population is projected by $\mathbf{N}(t+1) = L\,\mathbf{N}(t)$, and the dominant eigenvalue of its Leslie matrix is $\lambda = 1.2$. Once the population has reached its stable stage distribution, a total size of 500 individuals will become, after one time step, about: **[2 marks]**

(A) 500 individuals

(B) 600 individuals

(C) 420 individuals

(D) 720 individuals

Q45. A community contains four species with proportional abundances $p_1 = 0.4$, $p_2 = 0.3$, $p_3 = 0.2$ and $p_4 = 0.1$. Simpson's index $D = \sum_i p_i^2$ for this community equals: **[2 marks]**

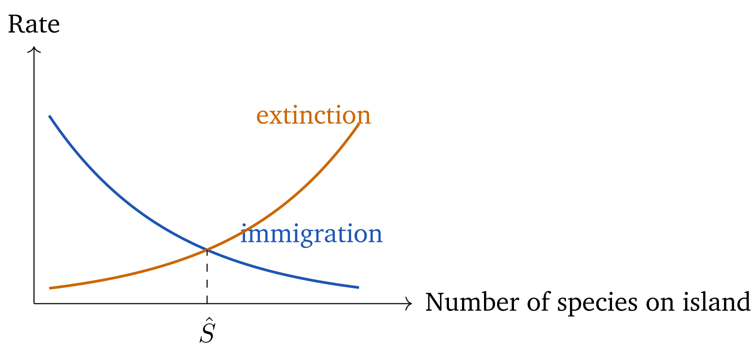
(A) 0.30

(B) 0.70

(C) 1.00

(D) 0.10

Q46. The graph below shows the MacArthur–Wilson equilibrium theory of island biogeography: a falling immigration-rate curve and a rising extinction-rate curve plotted against the number of species present. The equilibrium species number $\hat{S}$ occurs at the point where: **[2 marks]**



(A) the immigration rate of new species equals the extinction rate of resident species

(B) the immigration rate is at its maximum

(C) the extinction rate falls to zero

(D) the island holds every species present on the mainland

Detailed Solutions

Q1.

Solution

Concept – r-selection and life histories: Species are placed along a continuum from r-selected (adapted to boom-and-bust, disturbed habitats) to K-selected (adapted to stable, crowded habitats).

Step 1 – describe the r-strategist environment: Unstable or newly opened habitats reward rapid population increase over competitive staying power.

Step 2 – list the matching traits: Small body size, early maturity, a short lifespan, and many small offspring produced with little or no parental care.

Step 3 – test the options: Few large offspring, heavy parental care, large body and life near carrying capacity, and strong competitive ability are all K-selected traits, not r-selected.

Why the other options are wrong: options (A), (C) and (D) each describe the K end of the continuum.

Final Answer: many small offspring, little parental care, early maturity $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q1

Q2.

Solution

Concept – levels of ecological organization: Moving upward: organism $\rightarrow$ population $\rightarrow$ community $\rightarrow$ ecosystem $\rightarrow$ biome.

Step 1 – read the key words: The unit described is "same species," "defined area," and "able to interbreed."

Step 2 – match the definition: A set of interbreeding individuals of one species in one area is a population.

Step 3 – eliminate the others: A community includes many species; an ecosystem adds the abiotic environment; a biome is a large climatic-vegetation region.

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

Answer: (C) Go Back to Q2

Q3.

Solution

Concept – ecotone and the edge effect: An ecotone is the boundary region where two different communities meet and grade into one another.

Step 1 – identify the transition: Because species from both neighbouring communities can occur there, richness is often high.

Step 2 – name that pattern: The raised diversity at the boundary is the edge effect.

Step 3 – reject the others: The uniform core of one habitat is the opposite of a transition; a locally restricted species is an endemic; the maximum an area supports is the carrying capacity.

Final Answer: a transition zone between two communities with an edge effect $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept – the temperature coefficient Q_{10}: Q_{10} is the factor by which a rate is multiplied for each 10°C rise. Here $Q_{10} = 2$.

Step 1 – find the temperature change: $\Delta T = 35 - 15 = 20°\text{C}$

Step 2 – count the number of $10°$C steps: $\frac{20}{10} = 2$ steps

Step 3 – apply the multiplier twice: $\text{rate}_{35} = 5 \times 2^2$

Step 4 – evaluate: $\text{rate}_{35} = 5 \times 4 = 20$ units

Final Answer: 20 units $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept – breadth of thermal tolerance: The prefix “eury-” means broad and “steno-” means narrow; the suffix “-thermal” refers to temperature.

Step 1 – read the figure: Species X has a wide, flat curve, so it performs across a broad span of temperatures.

Step 2 – assemble the term: broad (eury) + temperature (thermal) = eurythermal.

Step 3 – reject the others: Stenothermal describes the narrow curve (species Y); "haline" concerns salinity; being an endotherm is a physiological category, not what the tolerance curve shows.

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

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – thermoregulatory categories: A homeotherm keeps a stable internal temperature; an endotherm does so using heat from its own metabolism.

Step 1 – read the requirement: Constant body temperature, generated internally, independent of the surroundings.

Step 2 – match the term: That is precisely a homeotherm (endotherm), as in birds and mammals.

Step 3 – reject the others: Poikilotherms and ectotherms track the ambient temperature; a stenotherm merely tolerates a narrow temperature range.

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

Answer: (A) Go Back to Q6

Q7.

Solution

Concept – doubling time of exponential growth: For $N = N_0 e^{rt}$ the population doubles after a time $t_d = \dfrac{\ln 2}{r}$.

Step 1 – list the data: $r = 0.0693\ \text{yr}^{-1}$ and $\ln 2 = 0.693$.

Step 2 – write the doubling-time formula: $t_d = \dfrac{\ln 2}{r}$

Step 3 – substitute the values: $t_d = \dfrac{0.693}{0.0693}$

Step 4 – evaluate: $t_d = 10$ years

Final Answer: 10 years $\Rightarrow \boxed{\text{B}}$

Answer: (B) 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: $r = 0.8$ yr^{-1}, $N = 100$, $K = 500$.

Step 2 – compute the bracket: $1 - \frac{N}{K} = 1 - \frac{100}{500} = 1 - 0.2 = 0.8$

Step 3 – multiply r and N: $rN = 0.8 \times 100 = 80$

Step 4 – multiply by the bracket: $\frac{dN}{dt} = 80 \times 0.8 = 64$

Final Answer: 64 individuals/year $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – K-selection and life histories: K-selected species live in stable, saturated environments where competition, not sheer reproductive output, decides success.

Step 1 – describe the strategy: Invest heavily in a few high-quality offspring rather than many cheap ones.

Step 2 – list the matching traits: Few large offspring, extensive parental care, delayed maturity, large body size and a long lifespan.

Step 3 – eliminate the r-traits: A high r, single burst of tiny offspring, and Type III survivorship all belong to the r end of the continuum.

Final Answer: few large offspring with high parental investment and long lifespan $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – the three survivorship curves: Type I is convex (low early mortality, death concentrated in old age); Type II is a straight line (constant mortality); Type III is concave (very high early mortality).

Step 1 – read the figure: The curve stays high for most of life and then plunges near the end, so it is convex.

Step 2 – match the type: A convex curve is Type I.

Step 3 – give an example: Large mammals such as humans and elephants, which have few young, care for them well, and mostly die of old age, follow Type I.

Why the other options are wrong: marine fish and most insects show high early loss (Type III); constant mortality at every age would give a straight-line Type II.

Final Answer: large mammals such as humans and elephants $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – reading an age-structure pyramid: The shape of the pyramid signals the trajectory of the population.

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

Step 2 – interpret it: A large young cohort will soon enter reproduction, so births will outpace deaths.

Step 3 – name the trajectory: Such a broad-based pyramid is an expanding, rapidly growing population.

Why the other options are wrong: a declining population has a pinched base; a stationary one has roughly vertical sides; being "at carrying capacity" is not read from a broad-based pyramid.

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

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – classifying species interactions by signs: Interactions are labelled by the effect $(+, 0, -)$ on each partner.

Step 1 – read the two effects: One species gains $(+)$; the other is unaffected (0).

Step 2 – match the $(+, 0)$ combination: A $(+, 0)$ interaction is commensalism, as in a barnacle riding on a whale.

Step 3 – reject the others: Mutualism is $(+, +)$; parasitism is $(+, -)$; competition is $(-, -)$.

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

Answer: (B) Go Back to Q12

Q13.

Solution

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

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

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

Step 3 – transfer to secondary consumers: $10\% \times 2000 = 200$ kJ

Step 4 – transfer to tertiary consumers: $10\% \times 200 = 20$ kJ

Final Answer: 20 kJ $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q13

Q14.

Solution

Concept – the phosphorus cycle is sedimentary: Phosphorus lacks a stable gaseous form, so it does not build up an atmospheric pool the way carbon or nitrogen do.

Step 1 – locate the main reservoir: Phosphorus is held mainly as phosphate in rocks and in marine sediments.

Step 2 – describe its release: Weathering of rock slowly frees phosphate to soils and water, and it eventually settles again as sediment.

Step 3 – reject the others: There is no meaningful atmospheric PH_3 pool; living biomass holds only a tiny transient fraction; dissolved N_2 belongs to the nitrogen cycle.

Final Answer: rocks and marine sediments $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – steps of the sulfur cycle: Sulfur oxidation converts reduced sulfur (H_2S, S^0) to sulfate; sulfate reduction runs the reverse; assimilation builds sulfur into organic molecules; desulfurylation releases H_2S from decaying organic matter.

Step 1 – read the arrows in question: They run from H_2S to S^0 and on to SO_4^{2-}, i.e. toward the more oxidised form.

Step 2 – match the process: Chemolithotrophs (e.g. *Thiobacillus*) gain energy by oxidising reduced sulfur to sulfate, which is sulfur oxidation.

Step 3 – reject the others: Sulfate reduction and assimilation move the opposite way; desulfurylation produces H_2S rather than sulfate.

Final Answer: sulfur oxidation $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept – cycles with a gaseous phase: The sulfur cycle, like carbon and nitrogen, has a genuine atmospheric component.

Step 1 – recall the gaseous sulfur species: H_2S and SO_2 enter the air from volcanoes, sea spray and the burning of fossil fuels.

Step 2 – confirm the atmospheric role: These gases are oxidised and returned to the surface as sulfate in rainfall, completing an atmospheric loop.

Step 3 – reject the others: Phosphorus, calcium and potassium cycles are essentially sedimentary and lack a significant gaseous phase.

Final Answer: the sulfur cycle $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – the drivers of eutrophication: Algal and cyanobacterial blooms are limited chiefly by two nutrients, and adding them fuels excess growth.

Step 1 – identify the limiting nutrients: Nitrogen and phosphorus are the two that most often limit aquatic primary production.

Step 2 – trace the consequence: Fertiliser and sewage run-off supply these nutrients; algae bloom, then die and decay, and decomposition strips oxygen from the water.

Step 3 – reject the others: Carbon and oxygen are rarely the limiting pair; sulfur, iron, sodium and chloride are not the usual triggers of eutrophication.

Final Answer: nitrogen and phosphorus $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept – detritivores in a detritus food chain: A detritus chain begins with dead organic matter rather than living plants; the animals that eat that dead matter are detritivores.

Step 1 – read the first link: The chain starts at dead leaves.

Step 2 – classify the earthworm: The earthworm feeds directly on the dead plant material, so it is a detritivore.

Step 3 – reject the others: It is not a producer or photoautotroph (it makes no food from light), and it is not the apex predator (the owl is).

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

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – directional selection: Directional selection favours one extreme of a trait, so the population mean moves steadily in that direction.

Step 1 – read the scenario: As bark darkens, darker moths survive better and their frequency rises generation after generation.

Step 2 – describe the shift: The whole distribution slides toward the dark phenotype, i.e. one extreme is favoured.

Step 3 – name the mode: A consistent shift of the mean toward one extreme is directional selection (the classic peppered-moth case).

Why the other options are wrong: stabilizing selection favours the mean, disruptive favours both extremes, and balancing selection maintains multiple alleles rather than driving a directional shift.

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

Answer: (C) Go Back to Q19

Q20.

Solution

Concept – which force produces adaptation: Of the evolutionary forces, only natural selection is systematically directed toward improving fit to the environment.

Step 1 – ask what "adaptation" requires: It requires a non-random process that consistently favours better-suited phenotypes.

Step 2 – identify that process: Natural selection preferentially preserves fitter variants, which builds adaptation.

Step 3 – reject the others: Drift is random, mutation is undirected, and gene flow simply mixes alleles between populations; none of these is aimed at fit.

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

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – consequences of genetic drift: Drift is random sampling of alleles between generations. In small isolated populations it eventually drives each allele either to fixation or to loss.

Step 1 – read the figure: Independent lines starting at the same frequency wander apart; some reach 1 (fixation), others reach 0 (loss).

Step 2 – describe the within-population effect: Fixation or loss removes the alternative allele, so heterozygosity (variation) declines within each population.

Step 3 – describe the among-population effect: Because each population drifts independently, the populations diverge from one another.

Why the other options are wrong: drift lowers, not raises, within-population heterozygosity (A); it does not preserve starting frequencies (B); and it is blind to whether a mutation is beneficial (C).

Final Answer: random loss or fixation within populations and divergence among them $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q21

Q22.

Solution

Concept – selection coefficient: The selection coefficient measures how far a genotype's fitness falls below the maximum: $s = 1 - w$.

Step 1 – list the data: $w = 0.65$.

Step 2 – substitute into the definition: $s = 1 - 0.65$

Step 3 – evaluate: $s = 0.35$

Final Answer: $s = 0.35 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept – gene flow as a homogenizing force: Gene flow is the transfer of alleles between populations through the movement of individuals or gametes.

Step 1 – ask what migration does to two populations: Each infusion of migrants makes the recipient's allele frequencies drift toward the source's.

Step 2 – state the net effect: Repeated exchange makes the populations genetically more alike, opposing divergence.

Step 3 – reject the others: Drift and inbreeding tend to increase divergence or homozygosity within populations; mutation introduces new differences rather than erasing them.

Final Answer: gene flow (migration) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

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

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

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

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

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

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

Answer: (C) 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 frequency: $2pq=2\times0.8\times0.2$

Step 3 – multiply step by step: $0.8\times0.2=0.16$, then $2\times0.16=0.32$

Step 4 – state the result: $2pq=0.32$

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

Answer: (D) Go Back to Q25

Q26.

Solution

Concept – carrier frequency from disease incidence: For a recessive disorder the affected frequency is q^2; carriers are the heterozygotes $2pq$.

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

Step 2 – find p: $p=1-q=1-0.02=0.98$

Step 3 – compute the carrier frequency: $2pq=2\times0.98\times0.02$

Step 4 – evaluate: $2\times0.98\times0.02=0.0392$

Final Answer: carrier frequency $\approx0.0392\Rightarrow\boxed{\text{A}}$

Answer: (A) Go Back to Q26

Q27.

Solution

Concept – Wright's fixation index F_{ST}: F_{ST} partitions genetic variation, measuring how much of the total variation is explained by differences between subpopulations rather than within them.

Step 1 – recall the definition: $F_{ST}=\dfrac{H_T-H_S}{H_T}$, the share of total diversity due to population subdivision.

Step 2 – interpret the range: $F_{ST}=0$ means no differentiation; $F_{ST}=1$ means the subpopulations are fixed for different alleles.

Step 3 – reject the others: Mutation rate, allele number and recombination frequency are separate quantities that F_{ST} does not measure.

Final Answer: the proportion of total variation due to differences among subpopulations $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept – computing F_{ST} from heterozygosities: $F_{ST} = \dfrac{H_T - H_S}{H_T}$, where H_T is total expected heterozygosity and H_S the mean within-subpopulation heterozygosity.

Step 1 – list the data: $H_T = 0.5$, $H_S = 0.4$.

Step 2 – compute the numerator: $H_T - H_S = 0.5 - 0.4 = 0.1$

Step 3 – divide by H_T: $F_{ST} = \dfrac{0.1}{0.5}$

Step 4 – evaluate: $F_{ST} = 0.2$

Final Answer: $F_{ST} = 0.2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q28

Q29.

Solution

Concept – F_{ST} and gene flow: F_{ST} near 0 means the subpopulations are barely differentiated; near 1 means they are strongly differentiated.

Step 1 – read the value: $F_{ST} \approx 0$ indicates almost no genetic differentiation between the populations.

Step 2 – link it to gene flow: Frequent exchange of migrants continually mixes alleles and keeps allele frequencies nearly identical, holding F_{ST} low.

Step 3 – reject the others: Complete isolation, strong drift, or a high mutation load would each raise divergence and push F_{ST} upward, not toward 0.

Final Answer: a high rate of gene flow keeping them homogeneous $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept – allele frequency from genotype counts: Each AA carries two A alleles and each Aa carries one, out of a total of $2N$ alleles.

Step 1 – count the total alleles: $2N = 2 \times 200 = 400$

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

Step 3 – form the frequency: $\text{freq}(A) = \dfrac{280}{400}$

Step 4 – evaluate: $\text{freq}(A) = 0.70$

Final Answer: $\text{freq}(A) = 0.70 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – limits of the biological species concept: The biological species concept (BSC) rests on interbreeding and reproductive isolation, so it needs sexual reproduction and living organisms to observe.

Step 1 – ask where interbreeding cannot be assessed: In asexual organisms there is no interbreeding to test, and in fossils reproductive behaviour cannot be observed.

Step 2 – draw the conclusion: The BSC therefore cannot be applied to asexual forms or to fossil species.

Step 3 – reject the others: For sexually reproducing insects and mammals the concept works well, so those are not its weak points.

Final Answer: asexual organisms and fossils $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – reinforcement of reproductive isolation: When hybrids are less fit, selection acts against mating with the other population, strengthening prezygotic barriers.

Step 1 – read the scenario: Hybrids at the contact zone have reduced fitness, so individuals that avoid cross-mating leave more successful offspring.

Step 2 – describe the outcome: Over generations, mate-recognition and other prezygotic barriers are enhanced, completing speciation.

Step 3 – name and contrast: This selective strengthening is reinforcement. Introgression is the opposite (genes leaking across via hybrids); hybrid vigour is raised fitness; genetic hitchhiking concerns linked loci.

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

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – sympatric speciation by polyploidy: A doubling of chromosome number can create, in a single generation, individuals reproductively isolated from their parents while sharing the same location.

Step 1 – note the isolation mechanism: A tetraploid crossed with a diploid parent gives sterile triploids, so the polyploid is instantly isolated.

Step 2 – note where it happens: No geographic barrier is needed; the new species arises in place, i.e. sympatrically, which is common in plants.

Step 3 – reject the others: Geographic and temporal isolation act gradually, and drift alone does not produce instant speciation.

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

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – reading sister-group relationships on a cladogram: The sister group of a clade is the lineage that shares its most recent common ancestor and branches off immediately below it.

Step 1 – locate the (P, Q) clade: P and Q join at the highest (most recent) node.

Step 2 – move down one node: The next node down joins the (P, Q) clade with the single branch leading to R.

Step 3 – identify the sister: Therefore R is the sister group of (P, Q); S is the more distant outgroup joining still lower.

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

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – homology versus analogy: Homologous structures share a common evolutionary origin (same ancestral blueprint) even if their functions differ; analogous structures share function but arose independently.

Step 1 – read the key fact: The same bone arrangement is inherited from a shared ancestor.

Step 2 – apply the definition: Common ancestral origin, despite different present-day functions, defines homology.

Step 3 – reject the others: Analogous and purely convergent structures would share function but not ancestry; vestigial refers to reduced, functionless remnants.

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

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – character types in cladistics: A synapomorphy is a shared derived character that unites a clade; only derived states shared through common ancestry define groups.

Step 1 – read the description: "Shared derived" and "diagnoses that clade" point to a synapomorphy.

Step 2 – confirm the definition: Members of the clade share the trait because they inherited it from their most recent common ancestor.

Step 3 – reject the others: A plesiomorphy is an ancestral (shared but not derived) state; homoplasy is convergent similarity; an autapomorphy is unique to a single taxon and so cannot unite a group.

Final Answer: synapomorphy (shared derived trait) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – Hamilton's rule: Altruism is favoured when $rB > C$; rearranging, the threshold relatedness is $r > \frac{C}{B}$.

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

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

Step 3 – evaluate: $\frac{3}{10} = 0.3$

Step 4 – interpret: The act is favoured whenever relatedness r exceeds 0.3.

Final Answer: $r > 0.3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q37

Q38.

Solution

Concept – mixed ESS of the Hawk–Dove game: When $C > V$, neither pure strategy is stable; the population settles at a mix in which the proportion of Hawks is $\hat{p} = \frac{V}{C}$.

Step 1 – list the data: $V = 2$, $C = 4$.

Step 2 – write the equilibrium proportion: $\hat{p} = \frac{V}{C} = \frac{2}{4}$

Step 3 – evaluate: $\hat{p} = 0.5$

Step 4 – interpret: At equilibrium half the population plays Hawk and half plays Dove.

Final Answer: proportion of Hawks $= 0.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q38

Q39.

Solution

Concept – the evolutionarily stable strategy (ESS): An ESS is a strategy that, once adopted by most of a population, resists invasion by any rare alternative because the resident does at least as well against mutants as the mutants do.

Step 1 – read the requirement: The defining property is non-invadability by rare mutant strategies.

Step 2 – match the option: "Once common, cannot be invaded by any rare alternative strategy" is exactly this definition.

Step 3 – reject the others: An ESS need not maximize group welfare, is defined by frequency-dependent payoffs rather than a single highest payoff, and requires no conscious choice.

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

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – conditions for reciprocal altruism: Cooperation between unrelated individuals is stable only if a helper can expect to be helped in return, which requires ongoing, identifiable relationships.

Step 1 – identify the requirement for return: Individuals must meet again so that today's help can be repaid later.

Step 2 – identify the requirement for reciprocity: They must recognize and remember partners so that cheats can be detected and punished (as in tit-for-tat).

Step 3 – reject the others: One-time interactions, permanent dispersal, or costs that always exceed benefits all remove the return incentive and destabilize cooperation.

Final Answer: repeated interactions with partner recognition $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – the lek mating system: In a lek, males cluster at a traditional display ground and compete for female attention; females come only to select and mate, receiving no resources.

Step 1 – describe male behaviour: Males aggregate and display vigorously at the communal arena.

Step 2 – describe female behaviour and parental care: Females visit solely to choose a mate; there is no pair bond and no male parental care.

Step 3 – reject the others: Lifelong pair bonding with shared care is monogamy; one female with several caring males is polyandry; random pairing has no display or choice.

Final Answer: males display at a communal arena and give no parental care $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q41

Q42.

Solution

Concept – median of a data set: For an even number of ordered values the median is the mean of the two middle values.

Step 1 – order the data: $3,\ 7,\ 7,\ 8,\ 10,\ 13$ (already sorted).

Step 2 – locate the two middle values: With six values the middle pair are the 3rd and 4th: 7 and 8.

Step 3 – average them: median $= \dfrac{7+8}{2} = \dfrac{15}{2}$

Step 4 – evaluate: median $= 7.5$

Final Answer: median $= 7.5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – the Leslie matrix and its dominant eigenvalue: A Leslie matrix packages age-specific survival and fecundity so that $\mathbf{N}(t+1) = L\,\mathbf{N}(t)$. Its dominant eigenvalue λ governs long-term dynamics.

Step 1 – recall the projection behaviour: Once the population reaches the stable age distribution, total size is multiplied by λ each time step.

Step 2 – interpret λ: Thus λ is the asymptotic finite (multiplicative) rate of increase: $\lambda > 1$ growth, $\lambda < 1$ decline, $\lambda = 1$ stable.

Step 3 – reject the others: λ is not a head-count, not the age at reproduction, and not the carrying capacity (the linear Leslie model has no K).

Final Answer: the asymptotic per-step growth rate $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q43

Q44.

Solution

Concept – projecting with the dominant eigenvalue: At the stable stage distribution the total population is multiplied by λ each step: $N(t+1) = \lambda\, N(t)$.

Step 1 – list the data: $\lambda = 1.2$, $N(t) = 500$.

Step 2 – write the projection: $N(t+1) = \lambda \times N(t) = 1.2 \times 500$

Step 3 – evaluate: $N(t+1) = 600$

Final Answer: 600 individuals $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – Simpson's index: $D = \sum_i p_i^2$ sums the squared proportional abundances; it rises as one species dominates.

Step 1 – list the proportions: $p_1 = 0.4$, $p_2 = 0.3$, $p_3 = 0.2$, $p_4 = 0.1$.

Step 2 – square each term: $0.4^2 = 0.16,\ 0.3^2 = 0.09,\ 0.2^2 = 0.04,\ 0.1^2 = 0.01$

Step 3 – add the squares: $D = 0.16 + 0.09 + 0.04 + 0.01$

Step 4 – evaluate: $D = 0.30$

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

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – MacArthur–Wilson island equilibrium: The number of species on an island is a balance between immigration of new species (which falls as the island fills) and extinction of resident species (which rises as more species crowd in).

Step 1 – read the two curves: The immigration curve slopes down and the extinction curve slopes up; they cross at one point.

Step 2 – interpret the crossing: At that crossing the rate of species gained by immigration exactly equals the rate lost by extinction.

Step 3 – state the equilibrium: With gains balancing losses, species number stays at the equilibrium value $\hat{S}$ even though species turn over.

Why the other options are wrong: immigration is not maximal there, extinction is not zero, and the island holds fewer species than the whole mainland pool.

Final Answer: immigration rate equals extinction rate $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q46

Answer Key

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