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Evolution: Selection, Drift, and Speciation

Study Guide — Natural Selection

Comprehensive Pre-med style evolution questions on terminology, natural selection, genetic drift, speciation, and sources of variation

40 items — Study Guide with Answers

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1 In modern biology, which definition best describes evolution at the population level?

- A Change in an individual's traits during its lifetime
- B Change in the number of individuals in a population over time
- C Change in allele frequencies in a population across generations ✓**
- D Development of new organs in response to environmental demands
- E Any change in the DNA of a single individual

► **Explanation:** Evolution is defined as a heritable change in allele frequencies in a population from one generation to the next.



2 What is the gene pool of a population?

- A All the genes present in a single individual
- B All the phenotypes that appear in a population
- C The total collection of different species that live in a habitat
- D The total set of all alleles at all loci in all individuals of a population ✓**
- E The subset of alleles that are dominant in a population

► **Explanation:** The gene pool includes every allele for every gene in all individuals of the population.



3 Which statement correctly distinguishes microevolution from macroevolution?

- A Microevolution involves changes in single genes, macroevolution involves changes in non-genetic traits only
- B Microevolution occurs in prokaryotes, macroevolution occurs only in eukaryotes





C Microevolution refers to changes in allele frequencies within populations; macroevolution refers to larger-scale patterns such as speciation and extinction ✓

D Microevolution occurs by mutation, macroevolution occurs by natural selection

E Microevolution is random, macroevolution is directed

► **Explanation:** Microevolution is small-scale evolution within populations; macroevolution is the accumulation of changes leading to new species and higher taxa.

4 Which statement best describes natural selection?



A Random changes in allele frequencies due to chance events

B Non-random differential survival and reproduction of individuals with different heritable traits ✓

C The ability of individuals to change their traits in response to need

D The deliberate breeding of organisms by humans

E Random mating between all individuals in a population

► **Explanation:** Natural selection is a non-random process where individuals with advantageous heritable traits leave more offspring, changing allele frequencies.

5 In evolutionary biology, fitness is best defined as:



A The physical strength and health of an individual

B The ability of an individual to survive relative to others, regardless of reproduction

C The contribution an individual makes to the gene pool of the next generation relative to others ✓

D The total number of genes an individual carries

E The genetic similarity between parents and offspring





► **Explanation:** Evolutionary fitness is measured by reproductive success: how many viable, fertile offspring an individual leaves compared with others.

6 Which process is the ultimate source of **NEW** alleles in a population?



- A Natural selection
- B Genetic drift
- C Gene flow
- D Mutation ✓**
- E Non-random mating

► **Explanation:** Mutation creates new alleles; selection, drift, and gene flow only change the frequencies of existing alleles.

7 Which of the following is a **RANDOM** evolutionary process?



- A Natural selection favouring a particular phenotype
- B Non-random mating where females choose certain males
- C Genetic drift changing allele frequencies after a storm randomly kills individuals ✓**
- D Directionally increased survival of antibiotic-resistant bacteria
- E Artificial selection by breeders

► **Explanation:** Genetic drift is change in allele frequencies due to chance events (e.g. random deaths), not due to the traits of individuals.





8 Which scenario is the **BEST** example of genetic drift?

- A Predators preferentially catch slower animals, reducing frequency of slow-running alleles
- B A drought favours plants with deeper roots that access water more effectively
- C A hurricane randomly kills most individuals in a population, leaving survivors that are not genetically representative of the original population ✓**
- D Farmers repeatedly breed cows that produce more milk
- E Females prefer males with bright plumage, increasing those alleles

► **Explanation:** Genetic drift is strongest when random events (like a hurricane) drastically reduce population size regardless of genotype.



9 In which situation is genetic drift expected to have the **STRONGEST** effect on allele frequencies?

- A A very large population (millions of individuals)
- B A small isolated population founded by a few individuals ✓**
- C A population experiencing strong directional selection
- D A population with extremely high mutation rates
- E A population with strictly random mating

► **Explanation:** Drift is most powerful in small populations, especially after founder events or bottlenecks.



10 The founder effect is best described as:

- A Increased mutation rate in the founding generation





B A few individuals establishing a new population whose allele frequencies differ from the original population by chance ✓

- C** Selection for traits that improve colonisation ability
- D** Introduction of new alleles to a population by migration
- E** The first appearance of a new allele by mutation

► **Explanation:** The founder effect is a type of genetic drift in which a new population founded by a small number of individuals has allele frequencies that are random samples of the source population.

11 The bottleneck effect occurs when:



- A** A population size sharply increases, reducing genetic variation
- B A large population is dramatically reduced in size, and the surviving gene pool is unrepresentative of the original population ✓**
- C** Selection strongly favours individuals at both extremes of a trait
- D** Mutations occur at a single locus
- E** Gene flow is blocked between populations

► **Explanation:** A bottleneck is a drastic reduction in population size where random survival alters allele frequencies and reduces genetic variation.

12 Which is the best example of gene flow?



- A** Random changes in allele frequencies in a small isolated population
- B Individuals migrating into a population and successfully breeding with residents ✓**
- C** Mutations introducing new alleles within a population
- D** Natural selection eliminating maladaptive alleles within a population
- E** Random mating within a population





► **Explanation:** Gene flow is the transfer of alleles between populations due to movement of individuals or gametes followed by reproduction.

13 Which combination correctly matches evolutionary processes with **RANDOM** vs **NON-RANDOM** effects on allele frequencies?



- A Mutation (non-random), natural selection (random)
- B Genetic drift (random), natural selection (non-random) ✓
- C Gene flow (random), genetic drift (non-random)
- D Mutation (non-random), genetic drift (non-random)
- E Natural selection (random), non-random mating (random)

► **Explanation:** Drift is random with respect to fitness; natural selection is non-random differential success of genotypes.

14 Which form of natural selection tends to reduce variation by favouring intermediate phenotypes and selecting against extremes?



- A Directional selection
- B Disruptive selection
- C Stabilising selection ✓
- D Balancing selection
- E Frequency-dependent selection

► **Explanation:** Stabilising selection trims the extremes and maintains an optimal intermediate phenotype, reducing phenotypic variation.





15 In a population of birds, only those with the longest beaks can access a new food source, and they leave significantly more offspring. Over time, the average beak length increases. Which type of selection is this?

- A Stabilising selection
- B Directional selection ✓
- C Disruptive selection
- D Balancing selection
- E Artificial selection

► **Explanation:** Directional selection favours one extreme phenotype, shifting the population mean in that direction.



16 A population of fish lives in a lake with two distinct habitats: dark, vegetated areas and bright, sandy areas. Very light and very dark colour morphs are well camouflaged and survive better, while intermediate-colour fish suffer higher predation. Which type of selection is occurring?

- A Directional selection
- B Stabilising selection
- C Disruptive selection ✓
- D Sexual selection
- E Purifying selection

► **Explanation:** Disruptive selection favours both extremes over the intermediate phenotype, potentially leading to polymorphism or even speciation.



17 What is an adaptation in evolutionary terms?





- A Any trait that appeared recently in a lineage
- B A heritable trait that increases an individual's fitness in a specific environment ✓**
- C Any behavioural response to the environment, whether inherited or learned
- D A trait that arose only by genetic drift
- E A trait that an individual acquires during its lifetime through use and disuse

► **Explanation:** Adaptations are heritable features shaped by natural selection because they increase survival or reproductive success.

18 Which situation best illustrates sexual selection rather than natural selection in general?



- A Brightly coloured males have reduced survival but attract far more mates ✓**
- B Individuals with thicker fur survive better in cold climates
- C Individuals with better camouflage are less likely to be eaten
- D Random storms kill individuals regardless of their traits
- E Humans breed dogs with certain temperaments

► **Explanation:** Sexual selection specifically involves traits that increase mating success, even if they reduce survival.

19 Kin selection explains the evolution of behaviours that:



- A Benefit unrelated members of the population equally
- B Increase an individual's own survival but never its reproduction
- C Reduce an individual's direct fitness but increase the reproductive success of relatives sharing its genes ✓**
- D Only occur in species with no parental care





- E Are entirely random in occurrence

► **Explanation:** Kin selection favours behaviours that increase inclusive fitness by helping relatives who share many of the same alleles.

20 Which statement best describes a species according to the biological species concept?



- A A group of organisms that look identical
- B A group of populations whose members can interbreed in nature and produce viable, fertile offspring ✓**
- C A group of organisms that occupy the same habitat
- D A group of organisms that share a recent common ancestor
- E A group of organisms with identical DNA sequences

► **Explanation:** The biological species concept focuses on reproductive compatibility and gene flow, not just similarity of appearance or shared ancestry.

21 Which of the following is a PREZYGOTIC reproductive barrier?



- A Hybrid embryos die before birth
- B Hybrid offspring are sterile
- C Two species of frog breed in the same pond but at different times of year ✓**
- D Hybrid offspring have reduced viability in later generations
- E Hybrid males are fertile but hybrid females are sterile

► **Explanation:** Temporal isolation (different breeding seasons) prevents mating or fertilisation and is therefore prezygotic.





22 Hybrid sterility (e.g. mules produced by horses and donkeys are sterile) is an example of:



- A Prezygotic barrier
- B Postzygotic barrier ✓
- C Temporal isolation
- D Behavioural isolation
- E Mechanical isolation

► **Explanation:** Postzygotic barriers reduce viability or fertility of hybrids after a zygote is formed, as in hybrid sterility.

23 Allopatric speciation typically occurs when:



- A A population becomes reproductively isolated without any geographic separation
- B Two species hybridise and immediately form a fertile polyploid species
- C A population is geographically divided, and gene flow between the isolated groups ceases ✓
- D Different phenotypes within the same habitat mate non-randomly
- E Mutations are completely absent in a population

► **Explanation:** Allopatric speciation involves geographic isolation, which prevents gene flow and allows genetic divergence.

24 Which scenario best illustrates sympatric speciation?





- A A river changes course and splits a population of rodents into two isolated groups
- B A small group of birds colonises a distant island and diverges from the mainland population
- C Within the same lake, a subgroup of fish begins feeding in deeper water and only mates with others using that depth ✓**
- D A new mountain range forms, separating a plant population into east and west groups
- E Two closely related species occasionally interbreed to produce hybrids

► **Explanation:** Sympatric speciation occurs without geographic separation, often through ecological niche divergence or polyploidy in plants.

25 In plants, an instantaneous mechanism of sympatric speciation is often:



- A Genetic drift in a small isolated population
- B The appearance of a new mutation in one individual
- C Polyploidy that creates reproductive isolation from the parent population ✓**
- D Gradual accumulation of small morphological changes
- E Geographical isolation by mountain formation

► **Explanation:** Polyploid individuals can be instantly reproductively isolated from diploid parents because their gametes are incompatible, leading to sympatric speciation.

26 Which term describes the evolution of many diverse species from a common ancestral species when new ecological opportunities become available, such as on an archipelago?



- A Convergent evolution
- B Adaptive radiation ✓**
- C Genetic drift





- D Stabilising selection
- E Hybrid breakdown

► **Explanation:** Adaptive radiation is the rapid evolution of many species from a common ancestor, each adapted to different ecological niches.

27 Homologous structures in different species are those that:



- A Have similar function but different evolutionary origin
- B Have different function but share a common evolutionary origin ✓**
- C Have identical function and identical DNA sequences
- D Always arise by convergent evolution
- E Are present in only one species

► **Explanation:** Homologous structures derive from a common ancestor and may have different functions, such as vertebrate forelimbs.

28 Analogous structures in different species are those that:



- A Have similar function and are inherited from a common ancestor
- B Have similar function but evolved independently in different lineages ✓**
- C Have different function but identical DNA sequences
- D Are always caused by genetic drift
- E Can only be found in closely related species

► **Explanation:** Analogous structures (e.g. wings of birds and insects) arise by convergent evolution, not by shared ancestry.





29 Which statement about natural selection and genetic drift is correct?



- A Both natural selection and drift always increase adaptation to the environment
- B Natural selection is random with respect to fitness; drift is not
- C Genetic drift can fix harmful alleles in small populations; natural selection tends to remove them ✓**
- D Only genetic drift can change allele frequencies; selection cannot
- E Natural selection always increases genetic variation

► **Explanation:** Drift is random and can fix deleterious alleles by chance in small populations; selection tends to favour beneficial alleles and remove harmful ones.

30 Which of the following is NOT an assumption of Hardy–Weinberg equilibrium?



- A No mutation
- B Random mating
- C No natural selection
- D Small population size ✓**
- E No migration (gene flow)

► **Explanation:** Hardy–Weinberg assumes a very large population (so drift is negligible), random mating, no mutation, no migration, and no selection.

31 In a large population, an allele is selectively neutral. Which statement is most accurate about its likely evolutionary fate?





- A Its frequency will never change because it is neutral
- B It will steadily increase in frequency because no selection acts against it
- C Its frequency will change over time mainly due to genetic drift ✓**
- D It will be removed immediately by natural selection
- E It will immediately fix at frequency 1

► **Explanation:** Neutral alleles are invisible to selection; their frequencies drift randomly due to sampling effects each generation.

32 A cline is best described as:



- A A ring-shaped set of populations where neighbouring populations interbreed, but end populations do not
- B A gradual change in a trait or allele frequency along a geographic gradient ✓**
- C The sudden appearance of a new species in the fossil record
- D A small, isolated population with low genetic variation
- E A pair of species that occupy identical niches

► **Explanation:** Clines reflect gradual geographic variation, such as body size increasing with latitude.

33 Which statement about evolution is CORRECT?



- A Individual organisms evolve during their lifetime
- B Evolution always leads to more complex organisms
- C Evolution has no specific goal; it is the outcome of processes such as mutation, selection, drift, and gene flow ✓**
- D Evolution proceeds only when environmental conditions are stable





- E** Natural selection always produces perfectly adapted organisms

► **Explanation:** Evolution is not goal-directed and does not guarantee complexity or perfection; it results from interactions of genetic variation with chance and environment.

34 The main reason antibiotics become less effective over time against bacterial populations is that:



- A** Bacteria mutate in response to the presence of antibiotics because they need resistance
- B** Natural selection increases the frequency of pre-existing resistant mutants when antibiotics are applied ✓
- C** Antibiotics induce new beneficial mutations at a very high rate
- D** Bacteria stop reproducing in the presence of antibiotics
- E** Antibiotics cause genetic drift to favour resistance

► **Explanation:** Mutations conferring resistance occur randomly; antibiotic use kills susceptible bacteria, allowing resistant ones to survive and reproduce (selection).

35 Which is the BEST example of a non-random event in evolution?



- A** A lightning strike kills a random subset of a population
- B** A flood randomly washes away individuals from a valley
- C** Predators more often catch slower prey, allowing faster individuals to contribute disproportionately to the next generation ✓
- D** A meteor impact randomly kills many individuals
- E** Random assortment of chromosomes at meiosis I

► **Explanation:** Selection by predators is non-random with respect to phenotype and fitness, unlike environmental catastrophes.





36 In a ring species, such as some salamander or gull species, populations are distributed geographically in a ring around a barrier. Typically, neighbouring populations can interbreed, but the terminal populations where the ring meets cannot. What does this illustrate about speciation?



- A** Speciation can be a clear, instantaneous event with no intermediates
- B** Species boundaries can be gradual, and the biological species concept can be difficult to apply ✓
- C** Hybridisation cannot occur between closely related forms
- D** Allopatric speciation cannot occur in nature
- E** Natural selection does not operate when gene flow exists

► **Explanation:** Ring species highlight that reproductive isolation can evolve gradually and challenge strict application of the biological species concept.

37 Balanced polymorphism (maintenance of multiple alleles at a locus) can be promoted by which of the following mechanisms?



- A** Strong directional selection favouring a single homozygote
- B** Heterozygote advantage, where heterozygotes have higher fitness than either homozygote ✓
- C** Very strong genetic drift in a tiny population
- D** Complete dominance of one allele with no fitness differences
- E** Lethality of both heterozygotes and one homozygote

► **Explanation:** When heterozygotes are fitter than both homozygotes (e.g. sickle-cell trait vs malaria), selection maintains both alleles in the population.





38 Frequency-dependent selection occurs when:

- A The fitness of a phenotype depends on how common or rare it is in the population
- B The fitness of a phenotype is independent of its frequency
- C Allele frequencies fluctuate randomly due to chance
- D Mutations occur more often in frequent alleles than rare ones
- E Only rare phenotypes can survive

► **Explanation:** In frequency-dependent selection, a phenotype's fitness changes as its frequency changes; this can maintain diversity.



39 Which statement correctly relates natural selection and mutation?

- A Natural selection generates new mutations when they are needed
- B Mutations occur randomly with respect to fitness; natural selection then increases or decreases their frequencies
- C Natural selection prevents all harmful mutations from occurring
- D Mutations always increase fitness and are therefore selected for
- E Natural selection and mutation are identical processes

► **Explanation:** Mutations arise without regard to whether they are beneficial or harmful; selection subsequently acts on their phenotypic effects.



40 In general, natural selection is MOST efficient and powerful when:

- A Population size is very small and genetic drift is strong





- B Population size is large and there is heritable variation affecting fitness ✓**
- C There is no heritable variation in fitness-related traits
- D The environment is completely constant and mutation rate is zero
- E Individuals can direct their mutations according to need

► **Explanation:** Selection requires heritable variation in fitness; large populations reduce random drift and make selection more predictably effective.

