Speciation
ANSWERS

The Basics

Defining Evolution
STOP AND CHECK (PAGE 5)

- Evolution is known as a change in the gene pool (and therefore, allele frequency) of a population over time.

Processes of Evolution

Gene Pool and Allele Frequency
STOP AND CHECK (PAGE 7)

- Gene pool is the total set of alleles that are present within a population that can be passed onto the next generation.
- The total number of one allele for a particular gene divided by the total number of alleles in the gene pool for the same gene.
- Natural selection changes the allele frequency over time as advantageous alleles are selected for, while disadvantageous alleles are selected against. This results in the frequency of favourable alleles increasing, and the frequency of unfavourable alleles decreasing.

Genetic Drift

STOP AND CHECK (PAGE 9)

- Chance events lead to changes in the allele frequencies of the gene pool, for no selective reasons at all, resulting in an increase in the frequency of some alleles.
- The size of the population determines the effect genetic drift will have, as it is greatest in smaller populations.

Founder Effect

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- The founder effect involves a small group of individuals moving away from the main population, and therefore establishing their own gene pool.
- The small population is just a small sample of the original population therefore it is likely that the ratio of alleles will be different.

Bottleneck Effect

STOP AND CHECK (PAGE 11)

- A large population becomes much smaller, this could be due to a sudden change in climate, disease, loss of habitat or human interaction.
- When a population greatly reduces in size, the remaining population is often left with reduced genetic diversity. As the small population makes up just a small sample of the original population there is a change in the make-up of the gene pool.
- After a bottleneck occurs the new population is greatly reduced in size and has an allele ratio different from the original population, making it more prone to genetic drift.

Migration

STOP AND CHECK (PAGE 13)

- Migration is the movement of individuals from one population to another. Immigration is the movement of individuals into a population whereas emigration is the movement out of their original population
- When individuals move into a population, their alleles are added to the gene pool of a new population. As the allele frequency of the new population could be different, individuals could be contributing completely new alleles.

Types of Selection

STOP AND CHECK (PAGE 16)

- A phenotypic range is a distribution showing the number (or proportion) of individuals of a population with a particular phenotype.
- **Stabilising Selection:** both extremes of the phenotype are selected against while the average phenotype is selected for, over generations individuals with the middle phenotype increase.
- **Disruptive Selection:** The extremes of the phenotype are selected for, while the average is selected against so over generations individuals with the middle phenotype decreases.
- **Directional Selection:** A single phenotype is selected for over generations the number of individuals with that phenotype increases, shifting the whole phenotype range in one direction.

Polyploidy

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- Polyploidy refers to variation in the number of chromosome sets.
- Autopolyploidy is where the genome is multiplied within a single species, while allopolyploidy results from the hybridisation between species.
- Polyploidy arises from nondisjunction during cell division where chromosomes fail to separate so one daughter cell will have more chromosomes than normal.

- Instant speciation occurs when an individual (individual plant) from a particular species has a duplicated or multiplied, set of chromosomes, they can no longer breed and produce viable offspring with members of their original species, therefore creating their own species.

Processes of Evolution

QUICK QUESTIONS (PAGE 21)

- Polyploidy occurs when there is a variation in the number of chromosomes from the original number resulting from nondisjunction during cell division. As the four-wing saltbush has the ability to self-fertilise, the polyploids are able to be maintained in their respective environments.
- Random polyploidy events resulting in four-wing saltbushes that were better adapted to their respective habitats.

Speciation

Defining a Species

STOP AND CHECK (PAGE 22)

- A species refers to a group of organisms containing individuals who can produce fertile offspring.
- It is difficult to define a species in real life as hybridisation can occur between two different species to produce offspring which can sometimes be fertile.
- Speciation is the evolutionary process where populations evolve and become different distinct species.

Allopatric Speciation

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- In order for allopatric speciation to occur, the two populations must be geographically isolated and face different selection pressures.

- Geographical isolation is important as the gene pools must stay isolated, with no inbreeding between the two species throughout this time.

Sympatric Speciation

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- Allopatric speciation requires geographical isolation while sympatric speciation involves populations becoming distinct species within the same geographic location.
- In order for sympatric speciation to occur the evolving populations must occupy the same geographic location, face different selection pressures for different traits, and have a barrier that stops the different populations from interbreeding.
- Instant speciation of plant species due to polyploidy represents a new species occupying the same geographic location as the parent generation.
- Genetic mutation is the initial step of sympatric speciation.

Reproductive Isolating Mechanisms (RIMs)

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- Reproductive isolating mechanisms are barriers or factors which prevent individuals from different populations from breeding.
- Reproductive isolating mechanisms prevent gene flow between populations to enable them to form new species over time.
- The two types of mechanisms include pre-zygotic and post-zygotic reproductive isolating mechanisms.

Pre-zygotic RIMs

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- Pre-zygotic reproductive isolating mechanisms prevent gene flow by stopping two individuals from coming together and breeding.
- In sympatric speciation ecological, temporal and behavioural isolations will be present as pre-zygotic reproductive isolating mechanisms.

- Structural (morphological) isolation prevents mating between individuals as their reproductive structures have become too different over time, physically preventing fertilisation. Gametic isolation is also present which prevents the eggs from one population being fertilised by the sperm of another.
- Geographical isolation such as rivers and mountain ranges can prevent individuals from different populations from coming together and mating.

Post-zygotic RIMs

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- Pre-zygotic reproductive isolating mechanisms act before fertilisation of the egg occurs, while post-zygotic mechanisms act after fertilisation has occurred.
- There are three main post-zygotic mechanisms to stop the inbreeding between species. Hybrid inviability, hybrid sterility and hybrid breakdown.

Speciation

QUICK QUESTIONS (PAGE 29)

- Sympatric speciation of the different island populations has resulted from ecological isolation. The difference in climate between habitats within the same geographical location prevents populations from coming together.
- Reproductive isolating mechanisms act to prevent different populations from breeding. As well as ecological isolation, behavioural isolation due to slight differences in appearance may prevent different species from interbreeding.
- Pre-zygotic RIMs such as structural and gametic isolation prevent the eggs and sperm of different populations from coming, as well as geographical, temporal and behavioural isolation which prevent different species from coming into contact in the first place. If the species come into contact, post-zygotic RMIs such as hybrid inviability, hybrid sterilisation and hybrid breakdown act to prevent the offspring from establishing their own population. Both pre- and post-zygotic RIM's act together to stop different species from coming together and forming a new population of hybrid species.

Patterns of Evolution

Divergent Evolution

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- Divergence (divergent evolution) occurs when two or more species are formed from a common ancestor.
- Allopatric speciation can lead to divergent evolution.
- Homologous structures are features that are similar in structure and origin but have different functions.
- Similar looking structures tell us that they likely evolved from a common ancestor, with differences in function likely resulting due to differences in environments.

Convergent Evolution

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- Divergent evolution refers to two or more species formed from a common ancestor, while convergent evolution involves two totally different species forming similar traits.
- Unrelated species have evolved from similar environments or exposed to the same selection pressures resulting in structures with similar functions but different origins.

Coevolution

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- Co-evolution occurs when an evolutionary change in one species then acts as a selection pressure on another species.
- Interspecific relationships between different species, such as mutualism, parasitism, predation and competition may involve co-evolution.

Gradualism and Punctuated Equilibrium

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- Rate of evolution refers to how quickly a species is able to undergo evolutionary changes.
- Gradualism is the gradual accumulation of continuous small changes over long periods of time, while punctuated equilibrium favours rapid burst of speciation.
- Gradualism produces divergent evolution whereas punctuated equilibrium results in adaptive radiation.

Adaptive Radiation

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- Adaptive radiation involves the rapid evolution of a number of species from a common ancestor over a shorter period of time
- Adaptive radiation occurs when different populations are able to occupy a wide variety of ecological niches resulting in the rapid speciation of the population to produce different, distinct species facing different niche selection pressures.

Patterns of Evolution

QUICK QUESTIONS (PAGE 41)

- A phylogenetic tree shows a rapid speciation event leading to a large number of new species over a short period of time.
- Gradualism refers to the gradual accumulation of continuous small changes over long periods of time, while punctuated equilibrium favours a rapid burst of speciation over a considerably shorter period of time.
- Convergent evolution has occurred between penguins and seals, this has resulted from both species facing the same selection pressures. This can be seen in the analogous structures adapted for similar environments

- The bullhorn acacia and the ant have developed a mutualistic relationship between the species leading to the co-evolution between them. Co-evolution describes the type of evolution where the evolutionary change in one species acts as a selection pressure on another and vice versa. This has developed between the species as both greatly benefit from the relationship between them, leading to the development of traits such as Betian bodies, necessary for the ant survival. If there was a gradual reduction in ant numbers the bullhorn would be unable to successfully defend itself against predators such as harmful insects and mammals, or other invasive plants, causing the number of bullhorn plants to also reduce.
- Convergent evolution is the process by which unrelated species evolve to resemble one another, compared to divergent evolution, where the species are formed from a common ancestor.
- Convergent evolution occurs when unrelated species face similar selection pressures due to them living in similar environmental conditions. Divergent evolution occurs when a group of individuals becomes isolated from their main population, and over time face different selection pressures causing the population to differ to a point where they are considered two distinct species, arising from a common ancestor.
- Convergent evolution results in unrelated species sharing analogous structures, which serve the same function but have different origins such as the wings of birds, bats and insects. Homologous structures resulting from divergent evolution are the complete opposite, they are features that look the same, but have different functions such as the pentadactyl limb.

