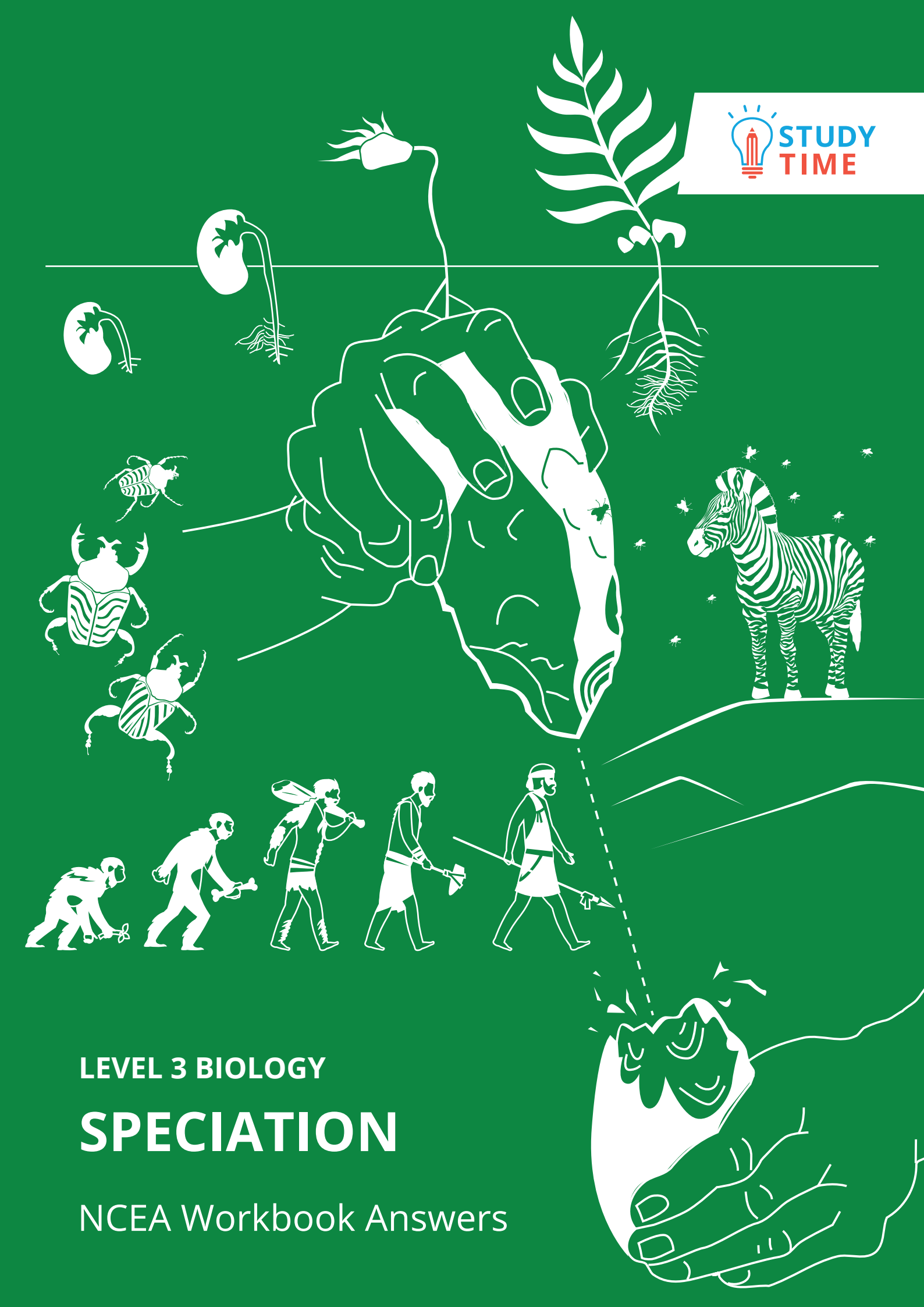


LEVEL 3 BIOLOGY

SPECIATION

NCEA Workbook Answers

Section One
The Basic Skills

Part One

The Basic Skills

1. Evolutionary Processes

a. *i.* Evolution is a change in the gene pool of a species over many generations, driven by the process of natural selection.

ii. The gene pool is the total set of alleles that are present within a population.

iii. The relative frequency of an allele within a population.

iv. Natural selection refers to the incremental selection of better-adapted phenotypes which provide a reproductive advantage to the species.

v. Sexual selection is a mode of natural selection where members of one sex choose mates of the other sex to mate with based on preferential phenotypic features.

vi. Gene flow is when individuals move into or move out of a population and their genes move with them.

vii. A group of individuals that are able to successfully interbreed under natural conditions and produce fertile offspring.

b. New alleles can only be created through mutations. A mutation is a permanent change in the base sequence of DNA which can result in a new allele. If a mutation is beneficial, it may offer the organism a selective advantage and result in an increased presence in the gene pool.

c. When the allele frequency changes in a population, it can lead to evolutionary change. If the allele frequency for an allele increases over time, it is likely that it is being selected for. This means that it is increasing the organism's chances of survival and reproduction, which can lead to an evolutionary change. Therefore, as allele frequencies change, the likelihood of evolutionary change occurring increases.

d. Genetic drift describes how the frequency of alleles can change over time due to chance events, rather than a selective pressure.

i. Genetic drift is caused by chance events, as opposed to selection pressures. Chance events occur through meiosis as each gamete ends up with a different combination of alleles. Fertilisation is also considered a chance event as it is random which particular sperm and egg fuse together. Due to these chance events, and many other chance events, the allele frequencies of the gene pool changes for no selective reasons.

ii. Genetic drift results in the allele frequency of the gene pool changing.

e. The founder effect occurs when a small group of individuals move away from the main population and establish their own gene pool.

i. After a founder effect, it is very likely that the gene pool of the smaller population will be different from that of the larger original population. This means that the founding population will also have reduced genetic diversity.

ii. It is likely that either the smaller founding population or the larger original population will lose alleles, resulting in a decrease in genetic diversity.

f. The bottleneck effect occurs when a population greatly reduces in size due to a sudden change in climate, disease, loss of habitat, or human activity.

i. A bottleneck effect can occur due to a sudden change in climate or environment, such as a volcanic eruption or other natural disasters, disease, loss of habitat or human activity such as deforestation.

ii. Genetic drift has a greater effect on smaller populations. As a bottleneck effect reduces the size of a population rapidly, genetic drift will have a great impact on the population after a bottleneck effect as opposed to before.

2. Migration

a. Migration is the movement of individuals from one population to another.

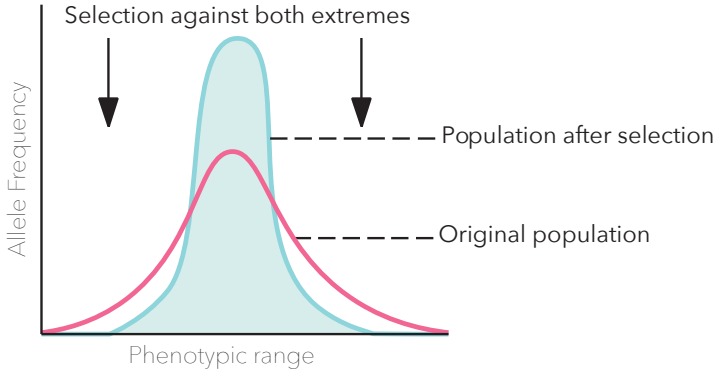
b. Immigration and emigration are types of migration. Immigration describes individuals moving into a new population, whereas emigration describes individuals leaving a population.

c. When individuals move into a population, their alleles are added to the population's gene pool. This causes the allele frequencies of their new population to change. Similarly, when individuals leave a population, they take their alleles with them, removing alleles from their original gene pool. This also results in a change in allele frequencies of the original population.

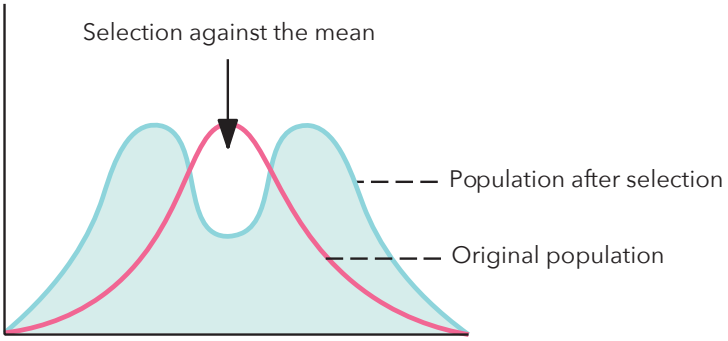
3. Types of Selection and Polyploidy

a. The phenotypic range is the complete range of phenotypes available for each gene.

b. *i.* Stabilising selection is when the two extreme phenotypes of a trait are selected against, resulting in the intermediate phenotypes becoming more common.

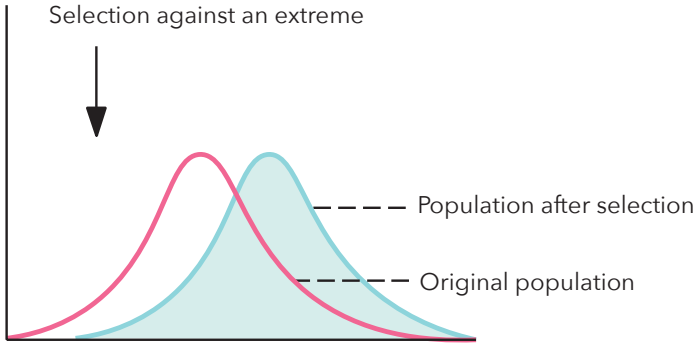


ii. Disruptive selection.



Disruptive selection is when selection pressures favour the extreme phenotypes of the trait, therefore, intermediate phenotypes are being selected against.

iii. Directional selection.



Directional selection is when one extreme phenotype of the trait is selected against, therefore, the population's trait distribution shifts towards the other extreme.

c. Polyploidy is caused by errors during cell division that results in cells with more than two copies of each chromosome. Polyploidy refers to variation in the number of chromosome sets and can lead to instant speciation.

d. The resulting organism is genetically and reproductively unique. This can cause reproductive issues in organisms that sexually reproduce. Plant species are not as affected by polyploidy as they contain both male and female sex organs and reproduce via self-fertilisation.

e.
- Autopolyploidy.
- Allopolyploidy.

f. Autopolyploidy involves the multiplication of the genome of a single species. Autopolyploidy occurs during self-fertilisation of an individual when homologous chromosomes do not separate (nondisjunction) during meiosis. This results in non-reduced, diploid gametes instead of haploid gametes. If these diploid gametes fuse with a normal haploid gamete during fertilisation, the result will be a triploid organism with three sets of chromosomes. If a diploid gamete fuses with another diploid gamete (self-fertilisation), the resulting zygote will be tetraploid. Allopolyploidy is the process whereby two different species produce an infertile offspring due to each parent having differing numbers of chromosomes. Allopolyploidy also occurs due to nondisjunction of homologous chromosomes. Since the number of chromosomes from the two parents is not identical, they typically cannot pair up during meiosis. As a result, the hybrid offspring are often sterile.

g. If the germinal cells in the hybrid offspring undergo chromosome doubling due to an autopolyploidy event, then meiosis can occur normally. If this happens, the hybrid species will be able to produce fertile gametes that contain chromosomes from both parental species.

h. When an 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 due to hybrid sterility. However, as there are many plants which can self-fertilise, the polyploid is able to be maintained in the environment and has undergone instant speciation.

4. Speciation

a. Speciation describes the formation of a new species as populations become reproductively isolated, preventing gene flow. Speciation can occur gradually as small changes accumulate over time, or it can occur instantly through changes in the chromosomes set numbers (polyploidy).

b. A group of individuals that are able to successfully interbreed under natural conditions and produce fertile offspring.

c. Hybridisation and ring species can make it hard to define a species. Hybridisation can lead to fertile offspring being produced by two different species, which does not fit with the definition of a species. Ring species is where there is a series of neighbouring populations which can interbreed, but the populations at the ends of the series are too distantly related to interbreed (a very common example of this is dog breeds). In all cases, the cut-off for defining a species becomes very hard to define.

d. Allopatric speciation occurs when two populations become geographically isolated from each other. Continued geographical isolation may lead to reproductive isolation and possibly the formation of a new species.

e. Sympatric speciation is the formation of a new species without geographical isolation. The new species become reproductively isolated even though they are surrounded by their parent population.

f. Geographical isolation can lead to allopatric speciation as separate geographical locations have different selection pressures. As the selection pressures are different in each location, over time, heritable traits will change until the populations have become so different that they are now distinct species. This indicates that speciation has occurred.

g. Speciation can occur without geographic isolation through sympatric speciation. The populations may face different selection pressures while occupying the same geographical area. The two populations may also compete for resources, leading to the populations adapting and changing their diets and resources. Lastly, two species occupying the same area may have different behaviours and breeding times which make interbreeding unlikely. These changes and different selection pressures lead to sympatric speciation.

5. Reproductive Isolating Mechanisms

a. Reproductive isolating mechanisms (RIMs) are barriers that prevent members of one species mating with members of another species. They prevent gene flow.

b. Reproductive isolating mechanisms can be prezygotic or postzygotic. Prezygotic isolating mechanisms are barriers that prevent reproduction from taking place, whereas postzygotic isolating mechanisms are barriers that occur after zygote formation.

c. Reproductive isolating mechanisms prevent gene flow between populations and species. When two populations of the same or closely related species become reproductively isolated, it can lead to speciation as gene flow is prevented between the populations. Over time, the populations will become more and more different, leading to the potential of speciation. When two species are reproductively isolated, it protects the integrity of each species as gene flow and the mixing of alleles is restricted. This means that the species remain pure and cannot produce viable offspring, preventing the existence of hybrid species.

d. Prezygotic isolating mechanisms are barriers (e.g. a mountain, the ocean) and occupy different ecological niches with no geographic overlap.

e. *i.* Geographic isolation occurs when species are separated by geographical barriers and occupy different areas with no geographical overlap.

ii. Ecological isolation occurs when species occupy or exploit different habitats within the same area.

iii. Behavioural isolation occurs when species have different courtship rituals, sounds, calls or colouration.

iv. Temporal isolation occurs when activity, mating or flowering occurs at different times of the day, month or year.

v. Mechanical isolation occurs when reproductive structures of species are incompatible and prevent the delivery and acceptance of gametes.

vi. Gametic isolation occurs when the gametes are incompatible and unable to fuse and produce a viable zygote.

f. Prezygotic isolating mechanisms stop two individuals coming together and breeding. When prezygotic isolating mechanisms restrict gene flow between two populations of the same species, the populations may face different selection pressures, and evolve into different species.

g. Allopatric speciation occurs due to geographical isolation. As the two populations are separated physically, they are prevented from mating together.

h. Sympatric speciation occurs without geographic isolation. There are other barriers that prevent gene flow between two populations. These barriers are various prezygotic reproductive isolating mechanisms such as temporal, behavioural, ecological, mechanical and gametic isolation. Any of these prezygotic reproductive isolating mechanisms can lead to sympatric speciation.

i. Postzygotic isolating mechanisms are barriers that occur after zygote formation.

j. *i.* Hybrid inviability is when the hybrid embryos are not viable as the genes of the two species are incompatible. As a result, the hybrid is likely to die before birth. If the hybrid survives, it may die before reaching reproductive age.

ii. Hybrid sterility is when the hybrid offspring that do survive birth and reach sexual maturity are sterile so they cannot produce viable gametes.

iii. Hybrid breakdown occurs when the hybrid offspring are viable, fertile and capable of producing offspring. However, these and any subsequent generations harbour detrimental genetic abnormalities, ultimately resulting in reduced fitness and fertility.

6. Patterns of Evolution

a. Divergent evolution is a pattern of evolution in which an ancestral species splits (diverges) into two or more increasingly distinct species.

i. Divergent evolution occurs when the gene flow between two distinct populations is blocked which result in differentiated accumulation of characteristics through genetic drift and natural selection.

b. Homologous structures have the same basic structure but have been adapted for different uses in different species. Homologous structures suggest that these organisms have all evolved over time from a common ancestor.

i. Homologous structures are evidence of divergent evolution. As divergent evolution occurs, structures within organisms adapt for different uses as different species emerge.

c. Convergent evolution is a pattern of evolution in which similar traits arise in two or more unrelated species.

i. Convergent evolution occurs because unrelated species are responding to similar selection pressures in different environments, and therefore, face similar selection pressures. This is because similar niches cause similar problems, leading to similar problems between unrelated species.

d. Analogous structures are features with different evolutionary origins but have similar functions. The similarities in function tell us that these unrelated species have evolved and lived in similar environments.

i. Analogous structures are evidence of convergent evolution. As convergent evolution occurs, organisms which live in similar environments face similar selection pressures. These similar selection processes mean that the same types of adaptations will be favoured and become more prevalent in the population.

e. Co-evolution occurs between two unrelated but closely interacting species, and occurs when one species develops an evolutionary advantage. This advantage then acts as a selection pressure on the other species and triggers a change in that species. This change in the second species may then cause another evolutionary change in the first species.

f. An interspecific relationship describes the interactions between organisms from different species.

g. Mutualism can lead to co-evolution. Mutualism is an interspecific relationship between organisms that participate in a mutual interaction where both organisms benefit from each other. For example, bees and flowering plants have evolved together throughout time as they exhibit mutualistic co-evolution. The bee is provided with food and nectar by the flower, and the flower gets to disperse its pollen to other plants of the same species. Plants have developed flowers with increasingly specialised features to attract bees, who, in turn, distribute pollen grains and optimise the plant's reproductive capabilities. Simultaneously, bees underwent physiological, behavioural and structural adaptations to take advantage of the nutritional benefits offered by flowering plants.

h. Competition can lead to co-evolution. Competition is an interspecific relationship between organisms that have negative effects on each other. For example, lions prey on gazelles. Lions are known to be fast and skilful predators which will take down the slower gazelles. Faster gazelles will have differential reproductive success over slower gazelles, as they are more likely to escape. Over time, faster gazelles will be selected, as will lions. Each party in this coevolutionary relationship exerts selection pressures on the other, therefore, affecting each other's evolution.

i. Gradualism and punctuated equilibrium are two models that have been proposed for the rate at which evolution can occur. It is likely that both models operate at different times in different situations.

j. Gradualism is the accumulation of changes, due to natural selection, at fairly constant rates. The species evolves slowly, step-by-step until the organisms are so different that it is considered to be a new species.

k. Punctuated equilibrium is the hypothesis that long periods of relative stability, known as stasis, in a species are punctuated by periods of rapid evolution, followed by more stasis.

l. Gradualism describes how species can gradually transform into another, whereas, punctuated equilibrium describes how species can split into two distinct species.

m. Adaptive radiation is a type of divergent evolution which describes processes by which a large number of new species evolve over a relatively short period of time from a common ancestor.

n. Adaptive radiation and rapid speciation occurs when different groups are able to occupy a wide variety of different ecological niches that have only recently become available. Adaptive radiation often occurs following major tectonic processes, natural disasters, extinction events or during colonisation of an unexploited habitat.

7. Evidence for Evolution

a. Fossils are preserved remains of organisms and include impressions, casts and molds of their shape or marks left behind in sediment by their activities.

b. The fossil record is the totality of the fossils that have been found and analysed.

c. Fossils and the fossil record provide irrefutable evidence for evolution as it shows that very early life was simple, and that organisms change over time. This can be seen in the fossil record as more complex structures are seen more recently in the record.

d. Biogeography is the analysis of the distribution of species and ecosystems in geographical space and through geological time.

e. The geographic distribution of species across the planet and through geographical time shows a distinctive pattern. Tectonic forces have reshaped the Earth's surface and once joined landmasses are now separated by seas and oceans. Species that were once present on these ancient landmasses became geographically isolated. As there were different selection pressures on each separated landmass, the original species evolved into different, but related species.

f. Homologous structures have the same basic structures but have been adapted for different uses in different species. Homologous structures suggest that these organisms have all evolved over time from a common ancestor.

g. Analogous structures are similar structures or traits that have a similar function, even when they are not of the same evolutionary origin. These structures evolve because unrelated species live in similar environments and fill similar ecological roles. As they face similar selection pressures, the same types of adaptations are favoured. These structures indicate convergent evolution.

h. Vestigial structures are organs, tissues, bones and parts of an organism that are functionless and provide no cost or benefit. These structures are remnants of features that served an important function in the organism's ancestors. Therefore, vestigial structures provide evidence for evolution.

i. The chemistry, structure and processes of all cells are remarkably similar. For example, all animal cells contain mitochondria. Also, the codons of DNA specify the same 20 amino acids in all organisms, from bacteria to plants and animals. The conservation of structures and processes across all organisms provides evidence for a shared ancestry, and therefore, evolution.

j. Mitochondrial DNA is passed down generations by the females to both males and females, as the sperm do not pass on mitochondrial DNA, only ovum.

k. The Y chromosome is conserved and passed from father to son largely unchanged.

l. Over 95% of the Y chromosome is conserved, therefore, any changes are a result of mutation. Mutations in modern populations can be traced back to their origin. Similarly, the number of mutations on the mitochondrial DNA is proportional to the time since the divergence of a species. Therefore, the analysis of both the mitochondrial DNA and Y chromosome provide evidence for evolution.

Section Two
Exam Skills & Mixed Practice

Question One

At the time of its initial release, the population of weevil would have shown a range in variation of the length of mouthparts, from smaller to longer. As the weevil larvae feed on the stems of Californian thistle, inhibiting its growth, the larvae require larger mouthparts to feed on the New Zealand population of Californian thistle due to the thicker stems. This means that overall, the newly introduced population is limited in the thistle it can graze on. As a result of this, inherited larger mouthparts provide an adaptive advantage to the weevil larvae as it means they are able to exploit and access a food source more successfully than that of the weevil with shorter mouthparts. This success in obtaining a food source means that the weevil's with a larger mouthpart were more likely to survive and reproduce, passing on their alleles. This increases the allele frequency of longer mouthparts over shorter mouthparts within the population's gene pool. Therefore, weevil larvae with longer mouthparts will become more common with the New Zealand population.

The selection pressure acting on the weevil population is the thickness of the thistle stem wall. The weevil larvae that have smaller mouthparts are less likely to be able to feed sufficiently, and therefore, are less likely to survive to reproduce and pass on their alleles. Weevil larvae that have longer mouthparts are more likely to feed sufficiently as they have an adaptive advantage, and therefore, are more likely to survive to reproduce and pass on their alleles. This changes the allele frequency in the weevil gene pool.

The thickness of the stem wall means that natural selection favours the weevil larvae with a larger mouthpart. Therefore, the selection pressure is directional. Directional selection occurs when a selective pressure selects against one extreme of a trait. In this case, the shorter mouthparts are selected against the longer mouthparts. This means that the population's trait distribution shifts towards the favoured extreme, and therefore, the New Zealand population of weevil larvae will have increasingly longer mouthparts overtime. Through this, the weevil population has evolved slightly to better fit into its environment.

Question Two

Polyploidy is where an organism has more than two homologous sets of chromosomes in their somatic cells (>2n). Polyploidy is caused by errors during cell division that result in cells with more than two copies of each chromosome. This occurs due to the homologous chromosomes not separating during meiosis, called non-disjunction. The resulting organism is genetically and reproductively unique.

Autopolyploidy is a type of polyploidy which involves the multiplication of the genome of a single species. Autopolyploidy occurs during self-fertilisation of an individual when homologous chromosomes do not separate (nondisjunction) during meiosis. This results in non-reduced, diploid gametes instead of haploid gametes. If these diploid gametes fuse with a normal haploid gamete during fertilisation, the result will be a triploid organism with three sets of chromosomes. If a diploid gamete fuses with another diploid gamete (self-fertilisation), the resulting zygote will be tetraploid.

The Coffea species are able to carry out autopolyploidy as they reproduce asexually through self-fertilisation. Therefore, the number of chromosomes in their gametes do not prevent reproduction.

Polyploidy can lead to instant speciation in plants, as autopolyploidy occurs. As plants are able to self fertilise, due to carrying both male and female sex organs, they are able to reproduce, even with a unique number of chromosomes. This leads to instant speciation. The different Coffea species have evolved through a series of polyploidy events as they have multiples of 22 chromosomes as the diploid number.

Polyploidy can lead to instant speciation in plants, as autopolyploidy occurs. As plants are able to self fertilise, due to carrying both male and female sex organs, they are able to reproduce, even with a unique number of chromosomes. This leads to instant speciation. The different Coffea species have evolved through a series of polyploidy events as they have multiples of 22 chromosomes as the diploid number.

Polyploidy plants are typically larger and more resistant to diseases than the species they originated from. This is an advantage for polyploid Coffea species as it means that the crops are more likely to survive if a disease infects the crops, as opposed to the original species. As most of the Coffea species are polyploid plants, it is also likely that the plants produce larger seeds which are held more tightly by the plant, preventing them from dropping to the ground. This makes harvesting the plants easier, as opposed to the smaller seeds that would drop to the ground on the original species. The harvest of the species would be much harder for man, as the seeds are on the ground and are smaller, meaning it is likely that not all of the seeds will be harvested.

Therefore, the polyploid Coffea species have a greater advantage over the original species as it contains a range of adaptations which have resulted from the combination of characteristics they have gotten from the original species.

Question Three

A reproductive isolating mechanism is a barrier that prevents the organisms of different species from mating and producing fertile offspring. Therefore, it prevents successful interbreeding and gene flow between the two different species.

The petrel species appear to be reproductively isolated due to temporal isolation in the form of sympatric speciation. Temporal isolation is where the mating and breeding seasons of each species do not sync up. The northern giant petrels lay their eggs in late August and the southern giant petrels don't lay their eggs for another 6 weeks. Temporal isolation occurs in the form of sympatric speciation as the two species cohabit the same subantarctic islands, therefore, while they share the same ecological niche, their mating and breeding habits do not line up.

The timing of many behaviours in animals can be innate. The northern and southern species may have become reproductively isolated due to a mutation or selection pressure in an ancestral petrel species. An ancestral petrel species may have had a variation in the timing of courtship and mating. A mutation or selection pressure will have separated the parent population into two different groups. Selection pressures that may have caused this separation could have been to reduce the competition for nesting sites, mates and other resources among petrels. As there is a delay in the laying of eggs by the southern giant petrels, the northern giant petrels are able to hatch their eggs and vacate the prime nesting spots before it is time for the southern giant petrels to lay their eggs. The two distinct periods of nesting allows for less competition for food surrounding the nesting sites and gives the young birds space to learn and grow.

The northern and southern giant petrel species appear to be sympatric, however, the information provided above does not guarantee that the two species originally were separated due to sympatric speciation. Instead of being separated due to sympatric speciation, they may have been reproductively isolated from an original population due to geographical isolation, and therefore, allopatric speciation. As each population would face differing selection pressures, an accumulation of changes within each separated species would have led to the formation of the two different species.

As the northern and southern giant petrel have been known to reproduce and produce viable, fertile hybrid offspring with each other, they do not fit within the definition of separate species commonly used in biology. This example of the northern and southern giant petrel poses the question of whether these two types of petrel are different species or different populations of the same species. They could be considered to be sub-species as they can reproduce and produce fertile hybrid offspring, and therefore, are not a true case of speciation.

Section Three
Practice Exam

Question One

The pattern of evolution shown by the orchid and the moth is a mutualistic coevolutionary relationship. Mutualism is an interspecific relationship between organisms that participate in a mutual interaction where both organisms benefit from each other. This relationship is coevolutionary as both the moth and the orchid have developed an evolutionary advantage. The moth is provided with food, as nectar, by the orchid, and the orchid is able to disperse its pollen to other plants of the same species. This is more effective for the orchid than relying on wind pollination, or on insects that feed on a range of different flowers. This increases the orchids chances of reproducing.

Flowers, such as the orchid, that are pollinated by a single pollinating species can conserve energy, as all their pollen produced will be carried to only a member of its own species. Both the moth and the orchid have coevolved to fill the mutualistic relationship due to corresponding selection pressure acting on each other. Each has experienced increased survival, and therefore, reproductive success by their interaction with each other.

The selection pressures of each species have provided an adaptive advantage to the other species. The moths which feed on the nectar from the orchid are more successful and are more likely to survive and reproduce, passing on their alleles to offspring and their gene pool. Similarly, the orchids that have a longer nectary have been able to exclusively feed the moths due to its specialised mouthpart, which has increased the reproductive success of the orchid, as there is only one type of organism carrying out the pollination.

In a coevolutionary relationship, changes in one species have a direct impact on the other species. Therefore, a reduction in the number of moths will have a direct effect on the orchid. This reduction in moths would cause the orchids to be less successful in their reproduction, as there are not enough moths to pollinate them. This would likely lead to a decrease in the population of the orchids and they may even face extinction.

Question Two

A reproductive isolating mechanism is a barrier that prevents the organisms of different species from mating and producing fertile offspring. Therefore, it prevents successful interbreeding and gene flow between the two different species.

From the information above, both allopatric and sympatric speciation has occurred. Allopatric speciation has occurred to reproductively isolate the coyote, jackal and dingo from each other. Allopatric species are separated by geographical barriers, therefore, mating cannot occur. Species can become allopatric due to migration to new habitats, which is often rare, as a consequence of the natural tendency of all species to disperse to new habitats. Species can also become allopatric due to separation by geological changes. For example, the formation of new islands, continental drift and tectonic movements of the Earth's crust.

The allopatric speciation of these related dog species is also an example of adaptive radiation. This is because they have originated from a common ancestor, are isolated by geographic barriers, and divergence of the species has occurred as each population has adapted to its unique environment. This is seen specifically in the species of jackal as they have an overlapping range, however, must have three distinct niches to help reduce competition.

Sympatric speciation has also occurred, specifically within the jackal species. Sympatric species are related species whose geographical ranges overlap, which applies to the species of jackal. While the species of jackal are sympatric, it is possible that they arose allopatrically, and then became sympatric due to migration or the disappearance of a geographical barrier As there is not a geographical barrier which reproductively isolates the jackal subspecies, there must be another type of barrier to prevent gene flow between the species. Possibilities of this may include an ecological barrier, temporal isolation or behavioural isolation. As the three species live in the same geographical area, it is likely that they prefer a different habitat and do not come into contact often, therefore, do not interbreed. It is a possibility that the three species do not reproduce at the same time of the year, therefore, males and females of different species do not respond to different courtship displays. It is also a possibility that the courtship displays, rituals and pheromones of the different species are not compatible, therefore, behaviourally, members of the opposite sex from different species do not respond to each other.

It is likely that speciation has occurred due to selection pressures, which are any environmental factor that results in differential survival and reproductive success of individuals with specific characteristics. As a result, the population has a greater proportion of better-adapted individuals, and therefore, the population becomes better adapted to its environment.

When considering whether this speciation is true speciation, we have to consider the coyote, the dingo and jackal species. The coyote and dingo are geographically isolated and have diverged allopatrically. This suggests that there will be differences in their physical characteristics and behaviours as a result of their unique selection pressures in their different environments. Therefore, their status as separate species is open to interpretation as both the dingo and coyote can still interbreed with domestic dogs and produce fertile offspring. This suggests they may be subspecies of the same species. However, it can also be claimed that they are separate species as by definition, they have diverged and do not interbreed. The jackal species do not interbreed even though they presumably have the opportunity to as they are sympatric. Therefore, no hybrid offspring are produced and there is no gene flow between the gene pools of the three species. Therefore, it can be claimed that the jackal species is a true example of speciation.

Question Three

Polyploidy describes organisms whose somatic cells have more than two sets of chromosomes in their nuclei. Allopolyploidy is a type of polyploidy which results from the mating between two or in this case, three, different but closely related species. This allows a hybrid offspring to form.

Firstly, Triticum monococcum (AA) and the wild Triticum (BB) both undergo meiosis to produce their normal gametes as A and B, each with 7 chromosomes. The gametes fuse together to produce a sterile hybrid (AB) with 14 chromosomes and no matching homologous pairs as the chromosomes have come from different species. The sterile hybrid (AB) then produces Emmer wheat, T. turgidum, (AABB) as a result of self-fertilisation or meiotic error, such as non-disjunction. Non-disjunction is when homologous chromosomes do not separate during meiosis. This results in non-reduced, diploid gametes instead of haploid gametes. If a diploid gamete fuses with another diploid gamete through self-fertilisation, the resulting zygote will be tetraploid. Emmer wheat has 28 chromosomes with 14 homologous pairs of chromosomes. Emmer wheat has 28 chromosomes with 14 homologous pairs of chromosomes. Emmer wheat produces gametes (AB) with 14 chromosomes which fuse with the gametes produced by another close relative T. tauschii (DD), another infertile hybrid (ABD) is produced. This hybrid, ABD, has 14 chromosomes from the gametes of the Emmer wheat, and 7 chromosomes from the gametes of the close relative T. tauschii, and therefore, it has 21 chromosomes.

The infertile hybrid may self-fertilise again, or non-disjunction could occur and an ABD gamete could fuse with another ABD gamete producing T. aestivum, bread wheat (AA BB DD) with a total of 42 chromosomes.

Polyploidy plants are typically larger and more resistant to diseases than the species they originated from. This is an advantage for the allohexaploid bread wheat as it means that the crops are more likely to survive if a disease infects the crops, as opposed to the original three species. As the bread wheat is a polyploid plant, it is also likely that the plants produce larger seeds which are held more tightly by the plant, preventing them from dropping to the ground. This makes harvesting the plants easier, as opposed to the smaller seeds that would drop to the ground on the original three species. The harvest of the original three species would be much harder for man, as the seeds are on the ground and are smaller, meaning it is likely that not all of the seeds will be harvested. Therefore, the bread wheat has a greater advantage over the three original species as it contains a range of adaptations which have resulted from the combination of characteristics they have gotten from the original species.

