Natural selection

Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species.

According to the theory of natural selection posed by Charles Darwin and Alfred Wallace, the organism which is most responsive to change is most likely to survive.

Key components of natural selection

Inherited variation	There is genetic variation within a population that can also be inherited.
Competition	There is a struggle for survival as species tend to produce more offspring than the environment can support.
Selection	Environmental pressures lead to differential reproduction within a population.
Adaptations	Individuals with beneficial traits will be more likely to survive and pass these traits on to their offspring.
Evolution	Over time, there is a change in allele frequency within the population gene pool.

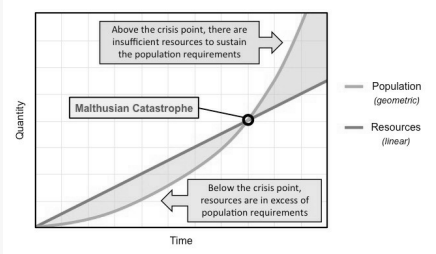
Competition

Species tend to produce more offspring than the environment can support

The Malthusian dilemma, proposed by Thomas Malthus, states that population multiply exponentially, while food resources multiple linearly. This means that a stable population will eventually outgrow its reoousrce base, leading to competition for survival.

When there is an abundance of resources, a population will grow according to its biotic potential (exponential J-curve). With more offspring, there are less resources available to other members of the population (environmental resistance). This will lead to a struggle for survival and an increase in the mortality rate (causing population growth to slow and plateau).

Malthusian dilemma



Allele frequency

Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring

The variation that exists within a population is genetic and determined by alleles.

Alleles encode for the phenotypic polymorphisms of a particular trait and may be beneficial, detrimental or neutral.

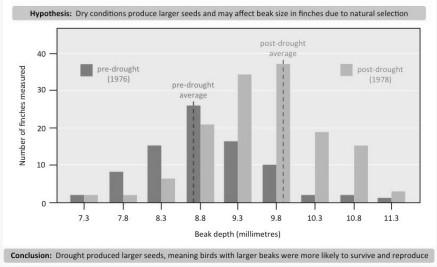
Due to natural selection, the proportion of different alleles will change across generations (evolution).

As beneficial alleles improve reproduction prospects, they are more likely to be inherited by future generations.

Detrimental allies result in fewer offspring and are less likely to be present in future generations.

If environmental conditions change, what constitutes a beneficial or detrimental trait may change, and thus allele frequencies in the population are constantly evolving.

Natural Selection on Daphne Major



Antibiotic resistance

Antibiotics are chemicals produced by microbes that either kill or inhibit the growth of bacteria (bactericidal and bacteriostatic respectively).

In a bacterial colony, over many generations, a small proportion of bacteria may develop antibiotic resistance via gene mutation.
If antibiotics are used to treat these infections, it acts as a selective pressure and causes the antibiotic resistance gene to become more prevalent.

An example of antibiotic resistance is the evolution of *Staphylococcus aureus*, which evolved to be methicillin resistant, and infections cannot be treated by that antibiotic.

Variation

Natural selection can only occur if there is variation among members of the same species

Mutation, meiosis and sexual reproduction causes variation between individuals in a species

Natural selection needs variation, as it allows for differentiation for survival.

The three main mechanisms for genetic variation in a species are mutation, meiosis and sexual reproduction.

Mutations	A gene mutation is a change in the nucleotide sequence of a section of DNA coding for a specific trait.	
Meiosis	Meiosis promotes variation by creating new gene combinations via either crossing over or independent assortment.	
	Crossing over	It involves. the exchange of segments of DNA between homologous chromosomes during Prophase I.

Variation (cont)

	Independent assortment	The orientation of each bivalent during Metaphase I occurs independently, meaning different combinations of chromosomes can be inherited when the bivalents separate in Anaphase I.
Sexual reproduction	As meiosis results in genetically distinct gametes, random fertilisation by egg and sperm will always result in different zygotes.	

For mutations and meiosis, refer to Unit 3: Genetics
For sexual reproduction, refer to Unit 11.4: Sexual reproduction

Adaptations

Adaptations are characteristics that make an individual suited to its environment and way of life

Individuals that reproduce pass on characteristics to their offspring

Adaptations are features of organisms that aid their survival by allowing them to be better suited to their environment.

Classifications of adaptations

Structural	Physical differences in biological structure.
Behavioural	Differences in patterns of of activity.
Physiological	Variations in detection and response by vital organs.
Biochemical	Differences in molecular composition of cells and enzyme functions.
Development	Variable changes that occur across the lifespan of an organism.

Biological adaptations have a genetic basis and may be passed to offspring when the parents reproduce.

Adaptive radiation

Changes in beaks of finches on Daphne Major.

Adaptive radiation is the rapid evolutionary diversification of a single ancestral line and occurs when members of a single species occupy a variety of distinct niches with different environmental conditions.

Daphne Major is a volcanic island that forms part of the Galápagos Islands and is the habitat of a variety of bird species, known as Darwin's finches, subfamily *Geospizinae*.

These finches shoed adaptive radiation and marked variation is beak size and shape according to diet. (Smaller beaks - smaller seeds, larger beaks - larger seeds).

In 1977, an extended drought changed the frequency of larger beak sizes within the population by natural selection.	The dry conditions result in plants producing larger seeds with tougher seed casings.
	Between 1976 and 1978 there was a change in average beak depth within the finch population.
	Finches with larger beaks were better equipped to feed on the seeds and this produced more offspring with larger beaks.