EVOLUTION

Content Statements:

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A4.1.4	Evidence for evolution from homologous structures
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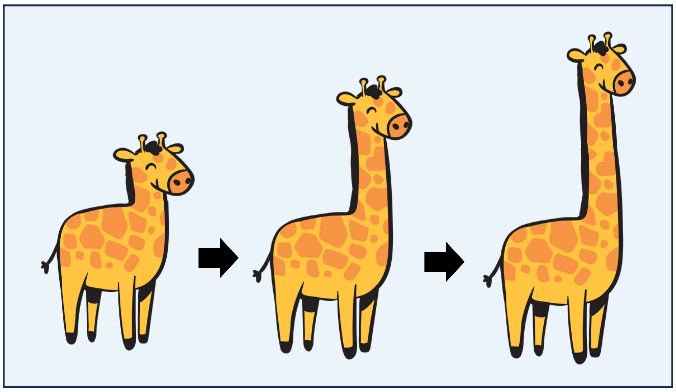
EVOLUTION

Evolution describes the changes that occur in the **heritable characteristics** of a population. These changes reflect differences in the allele frequency of a population's gene pool across successive generations. These evolutionary changes are caused by either random events (genetic drift), environmental pressures (natural selection) or human intervention (artificial selection). Evolution acts as a driving mechanism for **speciation**.

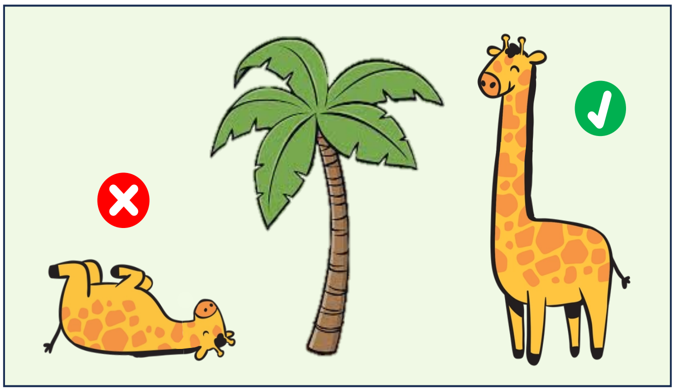
EVOLUTIONARY THEORIES

The current understanding of evolution was developed from a number of competing theories. One of the earliest proponents of evolution was **Jean Baptiste Lamarck**, who outlined a concept whereby species may change over time as a consequence of the habitual use or disuse of any given feature. Excessive use would cause a feature to strengthen, while continued disuse would cause it to begin to atrophy. Lamarck believed that these acquired characteristics could then be passed onto successive generations, changing a species over time. However, this theory was *flawed* because traits must be heritable in order for evolution to occur.

An alternate theory was proposed by **Charles Darwin**, who suggested that characteristics are not acquired but instead occur naturally and are selected for by the environment according to the capacity to provide an adaptive advantage. Organisms which possessed traits that were better suited to environmental conditions would be more likely to survive, reproduce and pass the traits on to future generations, resulting in change over time (evolution). The concept of natural selection represented a *paradigm shift* in evolutionary theory.



Lamarck: Use and disuse causes transformation



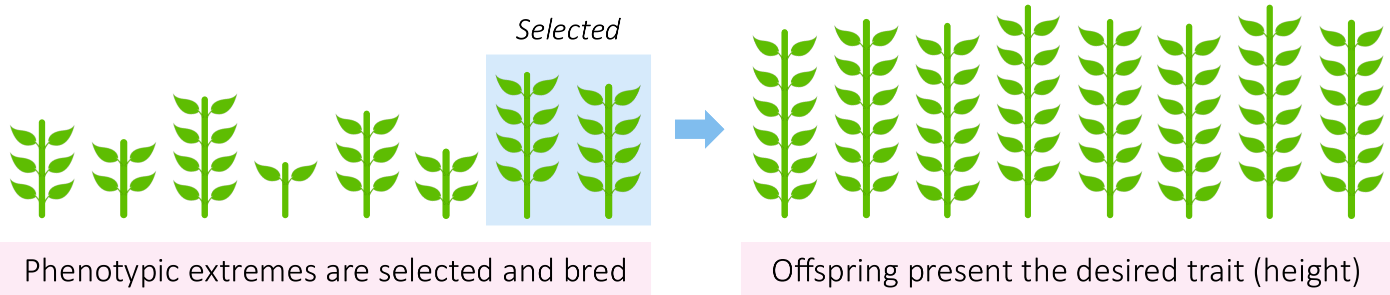
Darwin: Inherited variation will lead to selection

EVIDENCE FOR EVOLUTION

Evidence for evolutionary change can be demonstrated by either showing a change in features between a modern and ancestral species or through identifying shared characteristics in a variety of different species (indicating **common ancestry**). A progressive change in features can be seen in many examples of selective breeding, while a demonstration of common ancestry may involve either structural or molecular evidence.

1. SELECTIVE BREEDING

Selective breeding involves the intervention by humans in the reproduction of a species to produce desired traits in offspring (**artificial selection**). The systematic selection and propagation of all phenotypic extremes will result in the rapid development of pronounced variation between a domesticated species and any wild counterparts. Scientists also have the capacity to introduce targeted phenotypes via genetic modification.



There are numerous examples of the manipulation of gene pools through selective breeding programmes:

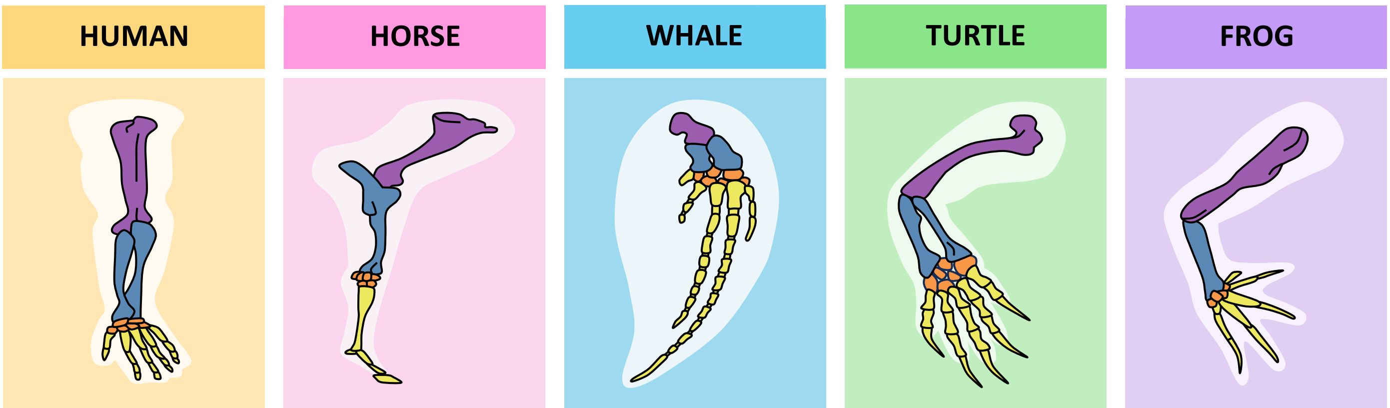
- Plants of the genus *Brassica* have been bred to produce different foods by targeting plant components, including flower buds (broccoli or cauliflower), leaf buds (cabbage or brussels sprouts) and leaves (kale)
- Dog breeds show enormous variability due to the targeted selection of certain traits – including speed (greyhounds), intelligence (sheep dogs), size (poodles), disposition (labradors) or aggression (mastiffs)

2. STRUCTURAL EVIDENCE

Anatomical structures may show evidence for evolution if they demonstrate a common ancestry, however some morphological structures that look similar might not actually reflect a shared evolutionary pathway.

Homologous Structures

Homologous structures share a common basic anatomy despite being used for different functions. These structures may appear dissimilar as they have arisen via **divergent evolution** and have become adapted to suit different environmental conditions. The more similar the homologous structures are, the more closely related two species are likely to be. A common example of a homologous structure is the **pentadactyl limb** in vertebrates. These all share a common bone arrangement in their appendages due to a shared ancestry.



Analogous Structures

Analogous structures may look morphologically similar as they share a common function however these similarities are superficial as the structures have unrelated evolutionary origins (do not share ancestry). Such structures arise via **convergent evolution** as a consequence of exposure to a shared environmental selection pressure. Examples include wings in insects and birds or the body shape of sharks and dolphins.

Analogous structures include the *wing shape* of an insect, bird and bat (but not *bone structure*)

Other Structures

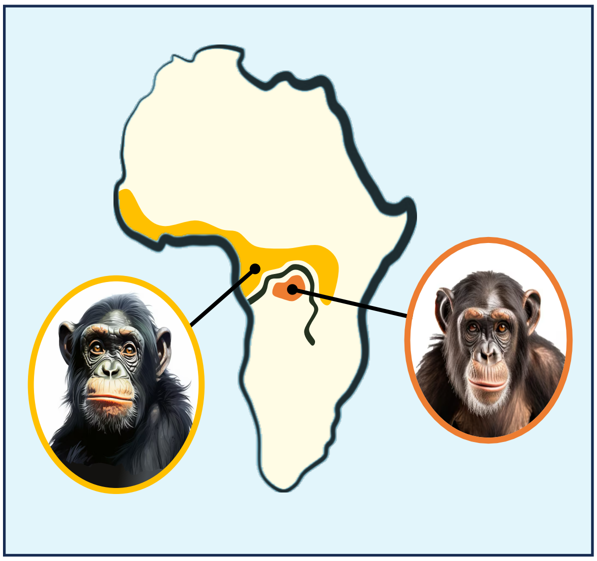
Some species retain the reduced remnants of past functional structures – these are called **vestigial organs** and demonstrate evolution. For example, whales possess the vestigial remains of a pelvic bone, indicating their ancestors once possessed hind limbs. Also, related species also undergo a similar process of biological development that can be shown via **comparative embryology** (e.g. pharyngeal slits suggest aquatic origins).

3. MOLECULAR EVIDENCE

All organisms use DNA or RNA as genetic material to produce proteins (amino acid chains). Mutations will cause differences to accumulate within gene or protein sequences, which may be inherited by offspring. Hence, the number of differences in a conserved sequence between two organisms represents the amount of time that has passed since evolutionary divergence occurred (which reflects the degree of relatedness). **Amino acid sequences** are typically used to compare distantly related species, as these sequences mutate at the slowest rate (due to codon degeneracy). **DNA sequences** are used to compare more closely related species, as these sequences mutate at a faster rate (non-coding DNA mutates faster than gene sequences as changes do not affect protein structure). Comparisons require sequences to be shared by both species.

SPECIATION

Speciation describes the formation of new species from pre-existing species. It will occur via divergent evolution, whereby two populations become separated, leading to **reproductively isolation** with no gene flow. The isolation may be *physical* (due to geographical barriers), but can also be due to *behavioural* factors (unique mating calls) or *temporal* factors (incompatible mating periods). The two populations undergo **genetically divergence** due to random mutations or exposure to different environment conditions (natural selection). When the populations can no longer interbreed and produce fertile, viable offspring then **speciation** has occurred. Chimpanzees and bonobos were separated by the Congo River and became exposed to different selection pressures (food availability and the presence of hostile gorillas), leading to their speciation.



Chimpanzees (above) and bonobos (below)