

Grade 11 Biology

Evolution

Class 7

Overall Expectations

- Analyse the economic and environmental advantages and disadvantages of an artificial selection technology, and evaluate the impact of environmental changes on natural selection and endangered species
- Investigate evolutionary processes, and analyse scientific evidence that supports the theory of evolution
- Demonstrate an understanding of the theory of evolution, the evidence that supports it, and some of the mechanisms by which it occurs

Scientific Theory

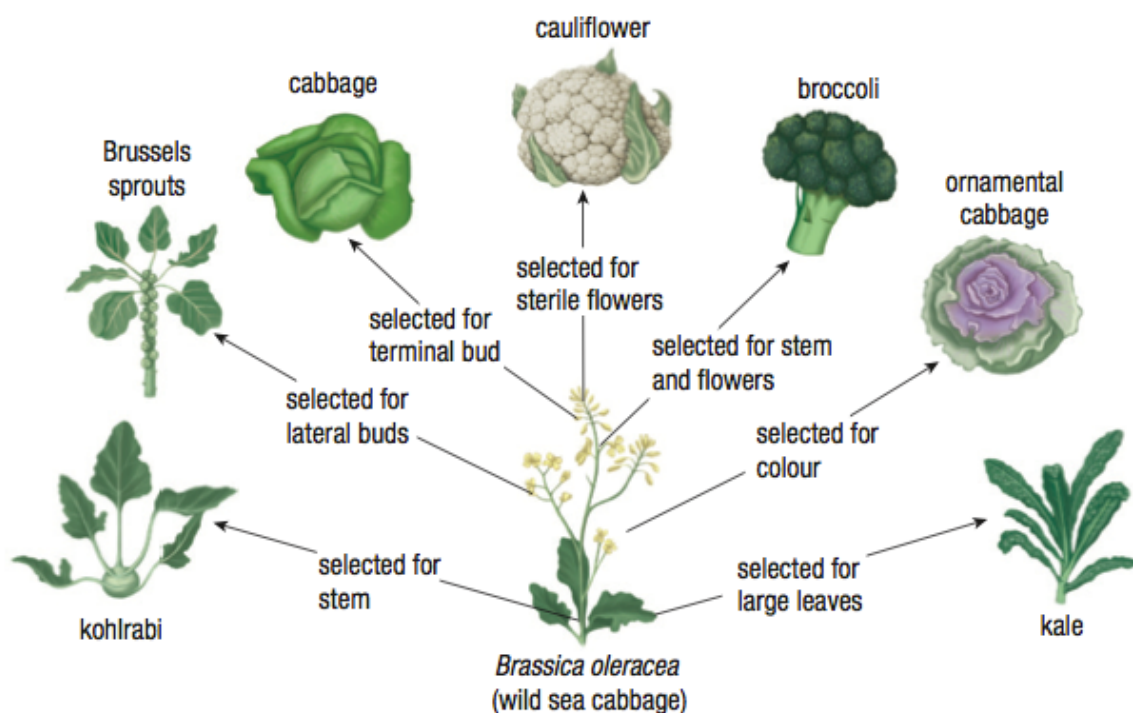
- Explanatory model that accounts for a large body of evidence
- Provides a basis for explaining observations of the natural world and for making testable predictions
- Open for revision and refinement as new evidence is gathered

Mutations: The Source of Genetic Variation

- **Neutral mutations** – a mutation that does not result in any selective advantage or disadvantage to the individual
- **Harmful mutations** – a mutations that reduces the reproductive success of an individual and is therefore selected against
- **Beneficial mutations** – a mutation that increases the reproductive success of an organism

Selective Breeding

- **Artificial Selection** – directed breeding in which individuals that exhibit a particular trait are chosen as parents of the next generation
- Produces new breeds or varieties of plants and animals



- Breeders have a particular feature in mind and select the seeds from the best plants to sow the next season
- Modern breeding involves using genetic engineering techniques to transfer the beneficial genes from an individual to another species

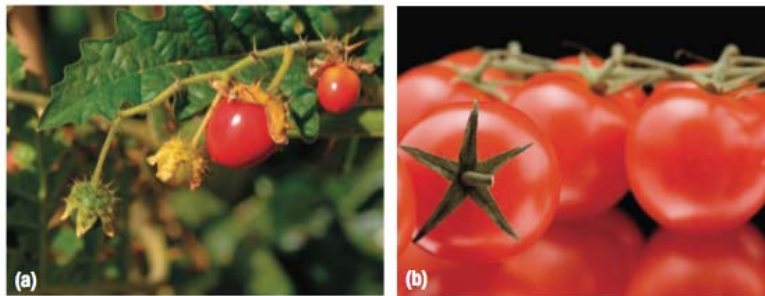


Figure 7 Beginning with (a) a wild species of tomato, farmers chose only those plants that exhibited the most desirable traits as a source of seeds for the next generation of planting. The result of thousands of generations is (b) the modern tomato.

Limitations of Artificial Selection

- Reduces genetic diversity within a population making the species vulnerable to disease
- Some favoured traits are linked to alleles that are detrimental
- Breeders cannot create traits that do not already exist within the population
- An undesirable trait may accompany a beneficial one



Implications for Natural Populations

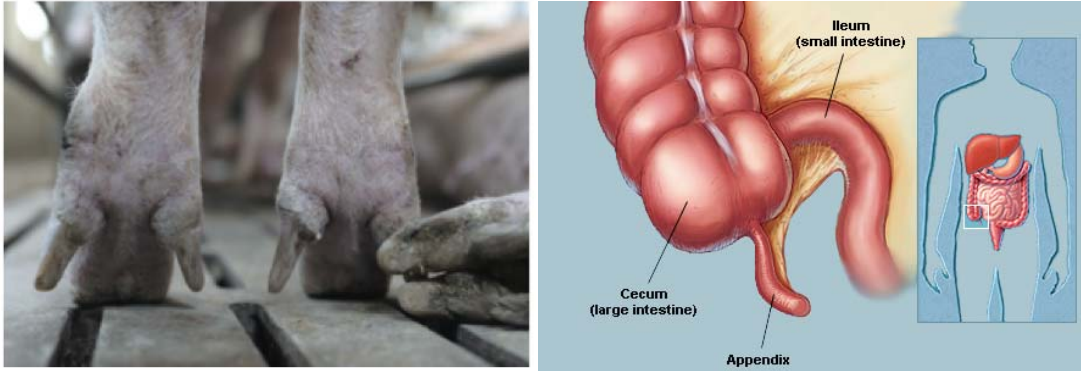
- All species exhibit genetic variation
- Mutations produce heritable changes in individuals, and these changes may be beneficial, harmful or neutral
- Some species, such as bacteria and insects, can change over relatively short periods of time
- Some domesticated species have changed dramatically under the influence of artificial selection

The Evolution of an Idea



- Most people believed that all living things had been created in their present forms and were **immutable**
- Immutable – they could not change and had not changed

- Buffon studied anatomy and animal structures and was puzzled by anatomical features that seemed to serve no purpose



Lamarck

- Proposed two principles:
 - **Use and Disuse** – structures that an individual use become larger and stronger while structures that were not used become smaller and weaker
 - **Inheritance of Acquired Characteristics** – individuals could pass on to their offspring characteristics that were acquired during their lives



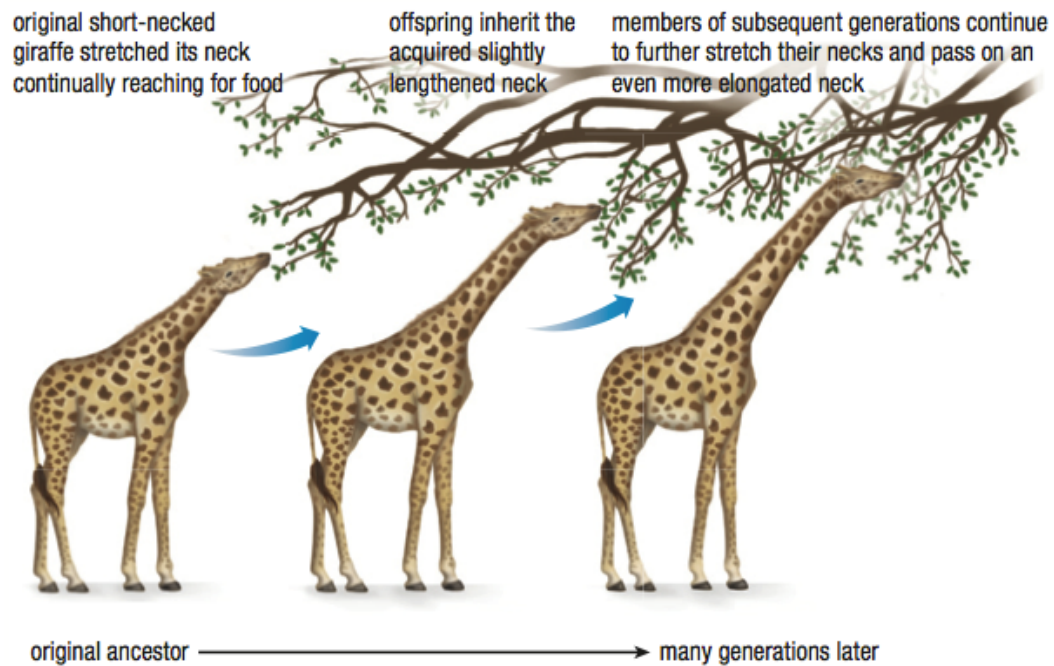


Figure 3 Lamarck's theory of evolution by the inheritance of acquired characteristics

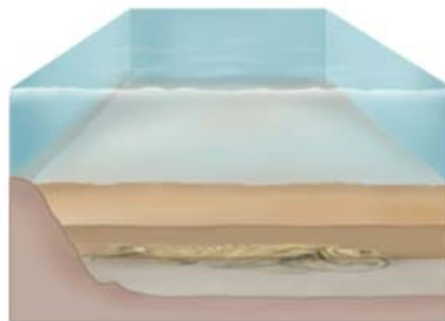
- Lamarck's theory is flawed
 - Many features do not respond to use
 - Features that do change are not normally heritable
- Lamarck proposed the following:
 - All species evolve over time
 - A species evolves in response to its environment and becomes better adapted to that environment
 - Changes are passed on from generation to generation

Fossil Formation

- Fossil – any ancient remains, impressions or traces of an organism or traces of its activity that have been preserved in rocks or other mineral deposits in Earth's crust



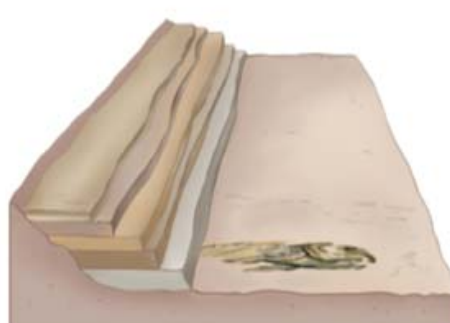
(a) dead organism



(b) organism is buried and compressed under many layers of sediment

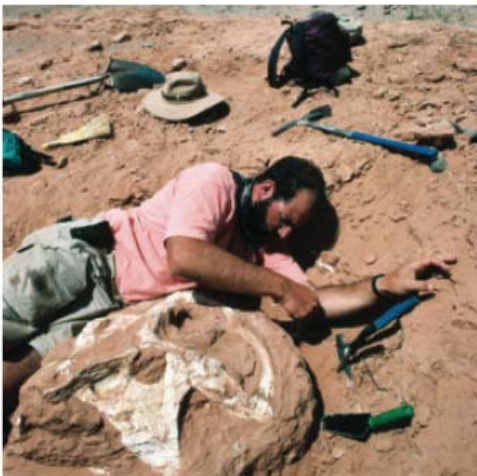


(c) under high pressure deposits harden to form sedimentary rock and the fossil remains become mineralized



(d) erosion or excavation of sedimentary rock exposes fossil remains

- Only organisms that die in low-oxygen locations will fossilize
- Mostly aquatic organisms, organisms with hard-body parts
- Organisms can also become trapped and preserved in amber – fossilized tree sap, or volcanic ash, ice formations or acidic bogs



- Paleontologists used fossils to study prehistoric life
 - Many fossils appear to be of unusual and unknown organisms
 - There are no fossils of most living species
 - Fossils are buried deep within rock formations
 - Fossils are often found in unexpected locations

Catastrophism

- Georges Cuvier noticed that all fossils from deeper layers were simpler than the more complex fossils above them



- Cuvier's observations supported the theory that life had evolved from simple to more complex forms over time
- Cuvier proposed the theory of catastrophism
- Catastrophism – the pattern of fossils could be accounted for by a series of global catastrophes that wiped out most species on Earth



Uniformitarianism



- Charles Lyell put forth the theory of uniformitarianism
- Uniformitarianism – geological changes are slow and gradual and that natural laws and processes have not changed over time
- Suggested that Earth was extremely old and had a long time to undergo evolutionary change

Evidence for Evolution

- Charles Darwin spent five years observing and gathering specimens on his voyage on the HMS *Beagle*
- Darwin noted that modern and extinct animals that resemble each other seemed to share geographical distributions

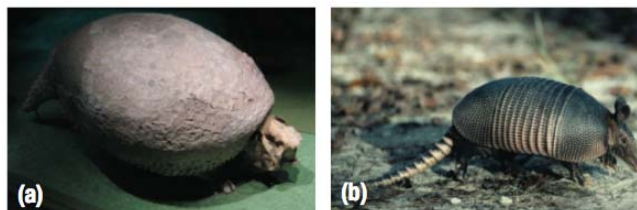


Figure 2 (a) The fossil *Glyptodon* resembled (b) the present-day armadillo, except that the *Glyptodon* was almost 200 kg heavier.

The Galapagos Islands

- These islands were formed from volcanoes 1000km off the west coast of South America
- There were no native species of amphibian or large land mammals; only species that could have arrived by air or water lived on the Galapagos



- Biogeography – the scientific study of the geographic distribution of organisms based on both living species and fossils
- There were an unusual assortment of species with unusual examples of fearlessness



Figure 1 (a) The New Zealand kakapo is a giant nocturnal parrot and the world's largest and only flightless parrot. It is critically endangered. (b) All 99 lemur species, including this sifaka, live only on the island of Madagascar, but there are lemur fossils in India.

- Darwin proposed that these species evolved in a location with no natural predators and had lost their instinctive fear



Darwin's Hypotheses

Table 1 Species on Remote Islands

Observations from the Galapagos Islands	Darwin's hypotheses regarding remote islands
many species of plants, birds, insects, and, in some cases, reptiles	Only these kinds of organisms are able to reach remote islands by crossing large expanses of open ocean.
no native amphibians and very few land mammals	Amphibians and most mammals are unable to cross open ocean and will not be found on remote islands.
many unique species found nowhere else on Earth	Over time, ancestral species have evolved into new geographically isolated species.
unique species most closely resemble species on the nearest continental land mass	Unique species are descendants of ancestral species from the nearest continental land masses and will exhibit some similarities.

Testing Darwin's Hypotheses

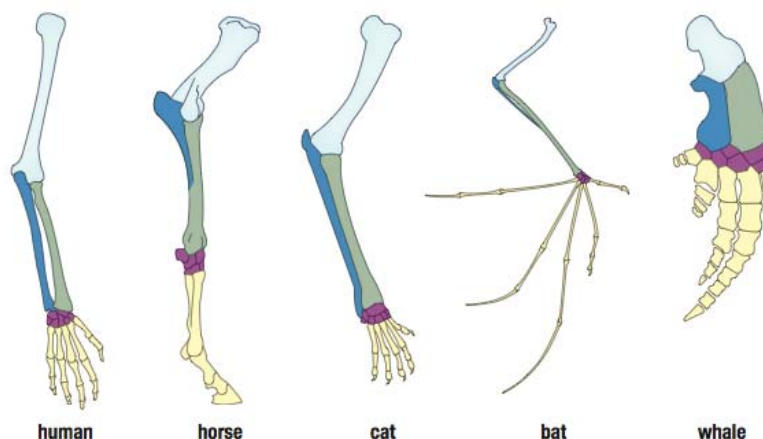


Figure 4 The black mamo was extinct by 1907.

- Examination of the native species of Hawaii supports Darwin's hypotheses
 - Unique species
 - No native terrestrial reptiles
- Introduced species thrived in the environments and had devastating impact on many native species

Homologous Features

- Homologous Features – structure with a common evolutionary origin that may serve different functions in modern species



- Closely-related species had homologous features because they share a common ancestor
- Over time original structures were modified as each species evolved

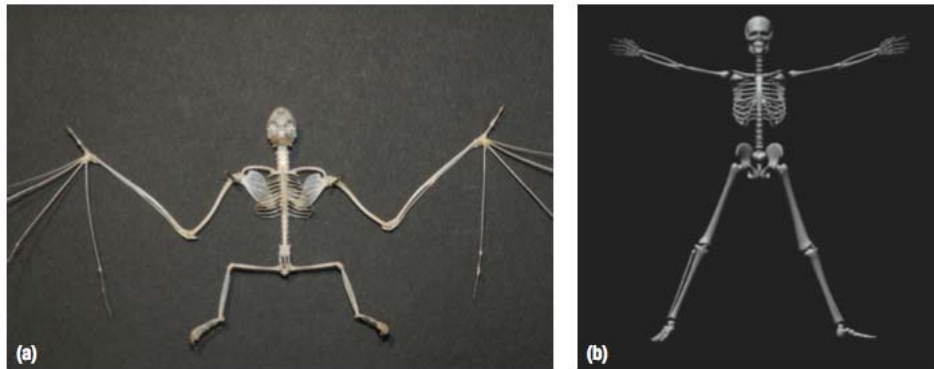


Figure 6 All mammals have an almost identical number and arrangement of bones. (a) This tiny bat skeleton is very similar in many respects to that of (b) a human.

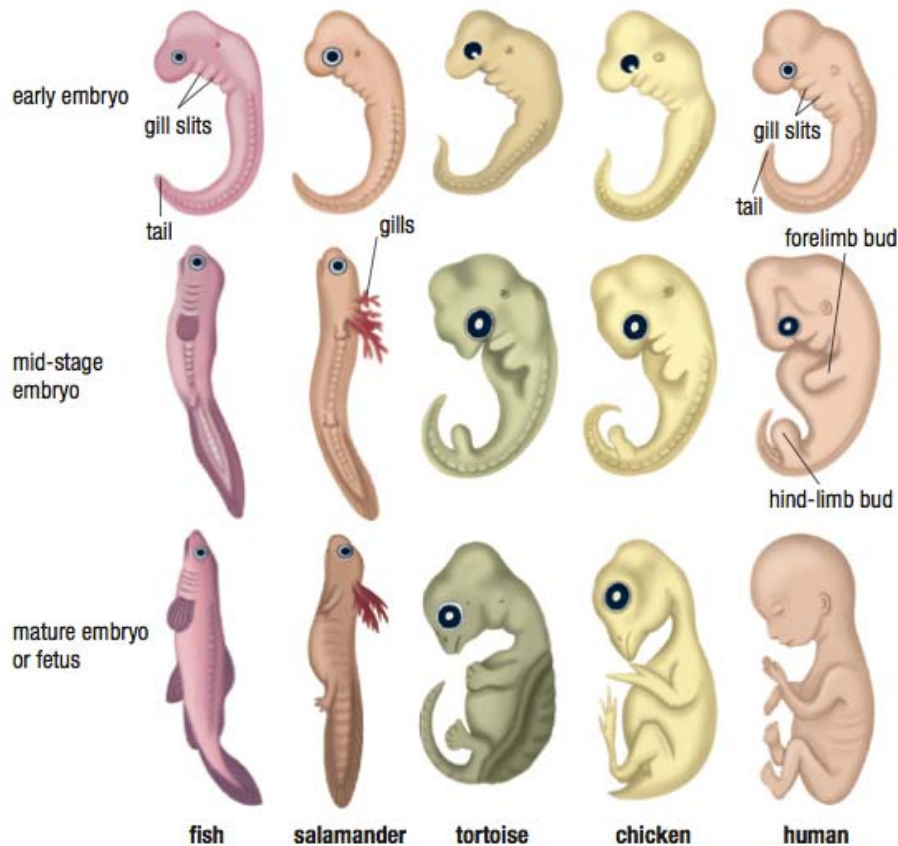


Figure 7 The early embryos of all vertebrates share many homologous features, including tails and gill slits.

Analogous Features

- Analogous Feature – a structure that performs the same function as another but is not similar in origin or anatomical structure
- Ex: Eyes and wings of flying insects have the same functions as eyes and wings of birds but they have different structures



Vestigial Features

- Vestigial Features – a rudimentary and non-functioning structure that is homologous to a fully functioning structure in a closely related species



Figure 8 Some species of cave-dwelling fish have vestigial eyes or no longer develop eyes at all.



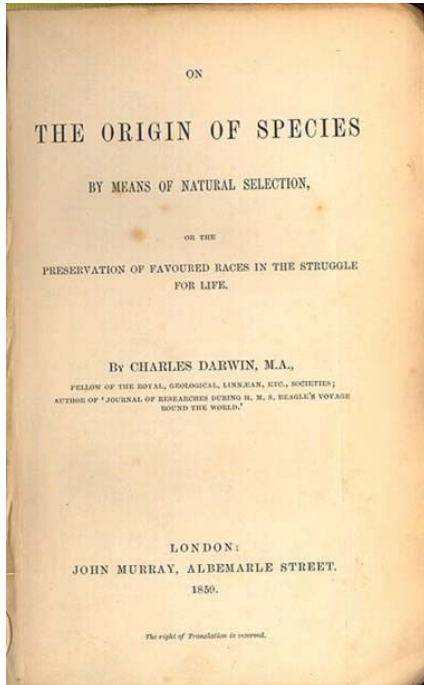
- Darwin suggested that these vestigial features were evolutionary baggage – served a function in the ancestors but became useless as the species evolved



Competition within Populations

- Malthus in his *Essay on the Principle of Population* showed that populations were limited in size by their environment
- Darwin realized that species produce large numbers of offspring but not all survive
- There is competition for survival between members of the same species for the same resources
- Darwin suggested that the environment might be favouring certain individuals in the struggle for survival

Darwin's *On the Origin of Species*



- Published in 1859, proposed that species had evolved and also how they evolve
- Natural Selection – the way in which nature favours the reproductive success of some individuals within a population over others
- Evolution is the result of natural selection occurring over many generations

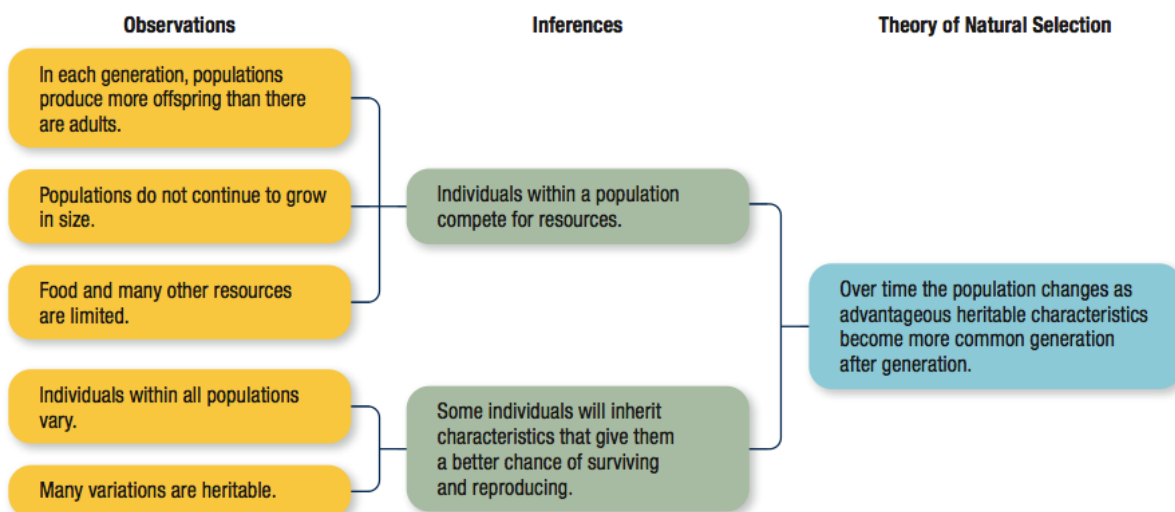
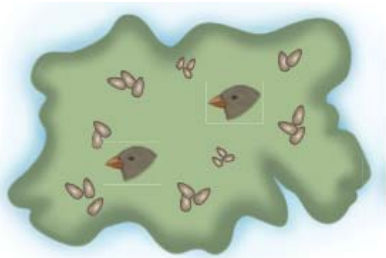


Figure 2 Darwin's theory of evolution by natural selection was powerful because it was based on five key observations that were well established and undeniable. Darwin realized that together, they gave rise to two logical inferences and provided a mechanism for evolution.

- “Survival of the Fittest” – refers to reproductive success rather than health or longevity
- Adaptation – a characteristic or feature of a species that makes it well suited for survival or reproductive success in its environment



Figure 3 All species exhibit adaptations that make them well suited to their particular environment.



(a) An ancestral population of finches with medium-sized bills are the first seed-eating birds to arrive on the Galapagos Islands. They typically eat medium-sized seeds. With no initial competition, the finches establish a growing population on a small island with a variety of plants, some with medium seeds but most with larger seeds.



(b) The finch population grows until it reaches the limit of its food supply. Each year many eggs are laid and hatched, but the island cannot support all the birds. The birds are not all alike—like any species, they exhibit variation. Some birds have slightly larger and some slightly smaller than average bills.



(c) Most of the birds must compete for the same medium-sized seeds, but any bird with an unusually large bill is able to also feed on the larger seeds. These birds have little or no competition and ample food is available to them. Darwin would say that the environment favours, or selects, these larger-billed birds. The larger-billed birds, being healthier, lay more eggs on average. Their young are more likely to be born with larger bills.



(d) As this process is repeated generation after generation, the average bill size of the birds continues to increase. This is evolution by natural selection. Had medium-sized seeds been more common than larger seeds, the advantage of the larger bill might have been offset by the energy needed to grow the bill and/or disadvantages in reaching and manipulating the medium-sized seeds.

Potential for Falsification

- The fact that we cannot find evidence to disprove the theory adds strength to the theory

Table 1 The Potential for Falsification

Hypothetical observations with the potential to falsify Darwin's theory	Actual observations and evidence
amphibians and large land mammals on remote oceanic islands	No native amphibians or large land mammals have ever been discovered on remote oceanic islands.
fossils of complex organisms found in the oldest fossil deposits	Of millions of fossils, none contradict the predicted pattern of increasing complexity over time.
complex organisms with no vestigial features	All organisms that have been studied in detail exhibit many vestigial features.
species thought to be closely related that share no homologous features with each other	All organisms that have been studied in detail exhibit many features that are homologous with other closely related species.