Evolution:

Theories put forward to explain the origin of life

Theory of Special Creation

This is the formation of organisms by supernatural means from nothing.
There was no definable precursor, living or non living, from which new species were made. It was short, an act of God.
This might have happen once or through a number of different occasions. However, some people believe that there may have been several successive creations.

Steady state theory

This suggests that life has no origin and it has been existing.

Spontaneous generation

This theory proposes that organisms have risen by natural means from non living matter (organic matter)
Until the early 19th century, people generally believed in the ongoing spontaneous generation of certain forms of life from non-living matter. For example aphids arise from the dew which falls on plants, fleas from decaying matter, mice from dirty hay, crocodiles from rotting logs at the bottom of bodies of water, maggots from rooting meat and so on. This was paired with heterogenesis, the belief that one form of life is derived from a different form (*e.g.* bees from flowers

The first solid evidence against spontaneous generation came in 1668 from Francesco Redi, who proved that no maggots appeared in meat when flies were prevented from laying eggs. It was gradually shown that, at least in the case of all the higher and readily visible organisms, the previous sentiment regarding spontaneous generation was false. The alternative seemed to be biogenesis: that every living thing came from a pre-existing living thing.

In 1768, Lazzaro Spallanzani demonstrated that microbes were present in the air, and could be killed by boiling. In 1861, Louis Pasteur performed a series of experiments which demonstrated that organisms such as bacteria and fungi do not spontaneously appear in sterile, nutrient-rich media.

Cosmozoan theory:

This suggests that life arrived on this planet from else where.

Organic evolution (abiogenesis)

In the natural sciences, abiogenesis or biopoesis is the study of how life on Earth could have arisen from inanimate matter. It should not be confused with evolution, which is the study of how groups of already living things change over time. Most amino acids, often called "the building blocks of life", can form via natural chemical reactions unrelated to life, as demonstrated in the Miller–Urey experiment and similar experiments, which involved simulating the conditions of the early Earth. In all living things, these amino acids are organized into proteins, and the construction of these proteins is mediated by nucleic acids. Which of these organic molecules first arose and how they formed the first life is the focus of abiogenesis?

In any theory of abiogenesis, two aspects of life have to be accounted for: replication, and metabolism. The question which came first gave rise to different types of theories. In the beginning, metabolism-first theories (Oparin coacervate) were proposed, and only later thinking gave rise to modern, replication-first approach.

In modern, still somewhat limited understanding, the first living things on Earth are thought to be single cell prokaryotes (which lack a cell nucleus), perhaps evolved from protobionts (organic molecules surrounded by a membrane-like structure). The oldest ancient fossil microbe-like objects are dated to be 3.5 billion years old, approximately one billion years after the formation of the Earth itself. By 2.4 B ya, the ratio of stable isotopes of carbon, iron and sulfur shows the action of living things on inorganic minerals and sediments and molecular biomarkers indicate photosynthesis, demonstrating that life on Earth was widespread by this time.

The sequence of chemical events that led to the first nucleic acids is not known. Several hypotheses about early life have been proposed, most notably the iron-sulfur world theory (metabolism without genetics) and the RNA world hypothesis (RNA life-forms).

Read and make notes about Biochemical theory (Miller's Experiment to demonstrate the biochemical theory/synthesis of organic molecules) (BIOLOGICAL SCIENCES)

Colonization of dry land: Changes necessary for an animal to move from water to dry land.

Studies have shown that most likely life began in the ocean. Many millions of years later, armed with appropriate adaptations, organisms began to for sake their aquatic home and move onto dry land. The best known example, well documented by fossils, is the migration onto land by a group of fishes in the Devonian times about 350mya.

Known as the crossopterygians, they and the early amphibians they gave rise to show a gradual transformation of paired fins into pentadactyl limbs typical of modern tetrapods

Anatomical and physiological changes required for any animal to move from water onto dry land

New means of movement and support: This particularly applies to Land dwelling vertebrates, where in contrast with fishes, the skeleton acts as a cantilever holding the head and the abdomen clear of the ground. New problems of stability will arise but these were solved by mechanical means in conjunction with complex reflexes.

Aquatic animals like fishes breathe by gills, but these totally unsuitable on land. Terrestrial animals have developed air breathing organs such as lungs.

Terrestrial organisms are liable to lose water by evaporation: Both active and passive mechanisms have evolved to copy with this. The Passive technique of developing an impermeable cuticle is common to plants and animal

Water especially in oceans is comparatively a stable medium not liable to wide temperature fluctuations which characterize the terrestrial environment. Terrestrial animals must have structural, behavioral and physiological means of maintaining a constant body temperature irrespective of the external temperature fluctuations.

Less resistance to movement on land than in water, so higher speeds can be achieved on land. There fore in order to survive on land, organisms have developed means of moving at a very high speed. This is exhibited by predators and preys where by the slowest prey has to be faster than the fastest predator in order to survive. Antelopes can reach 97km/hr, race horse 65km/hr and over 140km/hr in home coming pigeon as compared to aquatic animals which move at a low speed (the salmon a very fast moving fish does not exceed 40 km/hr (Terrestrial organisms like snails and worms which move at a very low speed live in highly protected habitats to avoid predators)

Copying with faster pace of living means developing an improved muscular-skeletal system and better neuro-sensory mechanisms. The evolution of elaborate sense organs and nervous system (large compound eye in insects and well developed brains in mammal) and rapid reflexes, has made it possible for animals to respond to quickly to the slightly changes in the environment. Such development is not only confined to land animals, nor do all land animals show them but are essential for thorough exploitation of the terrestrial environment.

External fertilization in most aquatic animals, eggs and sperms being shade into the surrounding water. As this would be impossible on land, terrestrial animals have means of introducing sperms into the female thereby bringing about internal fertilization. Terrestrial animal like amphibians which under go external fertilization have to go back to water for breeding. With internal fertilization comes the possibility of internal development and viviparity. This provides a very big advantage by preventing environmental hazards which attack the adult from causing devastating effects on the helpless eggs and young ones.

Evolution

What is evolution? Is the study of how groups of already living things change over time

Homologies

Evolutionary theory predicts that related organisms will share similarities that are derived from common ancestors. Similar characteristics due to relatedness are known as homologies. Homologies can be revealed by comparing the anatomies of different living things, looking at cellular similarities and differences, studying embryological development, and studying vestigial structures within individual organisms.

Evidence of Evolution:

a. **Cell Biology/molecular biology/cell biochemistry evidence.**

All living things are fundamentally alike. At the cellular and molecular level living things are remarkably similar to each other. These fundamental similarities are most easily explained by evolutionary theory which states that life shares a common ancestor.
All organisms are made of cells, which consist of membranes filled with water containing genetic material(nuclei acids), proteins, lipids, carbohydrates, salts, ATP and cytochrome. The cells of most living things use sugar for fuel while producing proteins as building blocks and messengers. Cell organelles like Mitochondria, endoplasmic reticulum and ribosomes appear to be of almost universal occurrence. This strongly supports the view that all living things have had a common ancestry. Even viruses at first sight apper very different from other organisms, possess nuclei acids. However many structures and chemical substances are not common to all organisms. Most plants contain chlorophyll, cellulose and starch which are absent in animals. Adrenaline and thyroxine are found in only vertebrates.

Read about Biochemical homology: Distribution of phosphagens, Blood pigment and Serological tests (Functional approach pg 579-580)

b. **Embryology/ developmental biology**

Studying the embryological development of living things provides clues to the evolution of present-day organisms. During some stages of development, organisms exhibit ancestral features in whole or incomplete form. **For example: the Tadpole larva of sea squirts.** An adult sea squirt has no resemblance to a chordata. It’s a sessile filter feeder, it has hardly any features found on other chordates, and there is no trace of a notochord. But a detailed examination of its larva shows that it clearly has all features of chordates. Its embryo has a notochord, pharyngeal clefts, a dorsal tubular nerve cord, segmental myotomes and a post-anal tail all characteristics of chordates. This creature is so chordate-like that it is called the tadpole larva and indeed it resembles a little tadpole. Eventually it attaches itself to rock or piece of weed by its head and undergoes metamorphosis into the sessile adult, thereby obscuring its phylogenetic relationship.

Ernst Haekel suggested that during its embryological development an organism repeats its ancestral history which is true for some organisms. For example, the presence of branchial grooves and segmental myotomes in the human embryo bears witness to a fish ancestry.

Snakes have legged ancestors.
Some species of living snakes have hind limb-buds as early embryos but rapidly lose the buds and develop into legless adults. The study of developmental stages of snakes, combined with fossil evidence of snakes with hind limbs, supports the hypothesis that snakes evolved from a limbed ancestor.

Read about the connection between Annelids and Molluscs (Comparative embryology) pg 578

c. **Geographical/distribution studies:**

Its true that continents with similar climates and conditions may have widely different animals and plants.   For example;

i. Africa and South America: Both occupy the approximately the same range of latitude and have the same variety of habitats, humid jungles, dry plains and high mountain ranges yet both support quite different faunas. The same major groups are found on both continents but most part of the individual species are different. Thus Africa has short tailed (old world) monkeys, anthropoid apes, elephants, camels, antelopes, giraffes and lions etc. South America however has none of these, instead, there are long tailed (new world) monkeys ,llamas, tapirs, pumas (mountain lions) and Jaguars

ii. Australia: despite the fact that it lies on the same latitude as South America and Africa, there is a greater difference in the fauna. In Australia we find pouched mammals or marsupials like kangaroo which are totally not found in Africa but represented by Opossum in South America. Its here we find the the spiny ant eater and the duckbilled platypus, the only living representative of the monotremes, a group of primitive egg laying mammals found no where else in the world.

iii. There fore; Africa, South America and Australia are all found in the southern Hemisphere but with different fauna. However the continents of the northern Hemisphere the differences in fauna are not much pronounced. The faunas of North America and Eurasia are strikingly similar. Elk, reindeer, Bison (buffalo), bears, beavers, lynxes, hares, mountain sheep, and goats, are all found on both continents.

There fore the continents of the northern hemisphere have a more /less uniform fauna while those of southern hemisphere have sharply contrasting faunas. Australia, Africa and South America are separated from each other by great water bodies, North America and Asia are separated from by a shallow strait (the bering strait) less than 100km wide. More over there is evidence that in the geological past a continous land bridge linked the 2 continents with one another across what is now the strait.

Its thought that main groups of modern mammals arose in the northern hemisphere and migrated to;

i. South America via the Isthnus of Panama,

ii. Africa via the strait of Gibraltar which, like the Berring strait, has been bridged in the past geological time.

iii. Australia via south East Asia to which it was at one time connected by land.

Presumably the shallowness of the Berring Strait would have made the passage of the animals between the two northern continents a relatively easy matter and it explains the present day similarities between the two faunas.

But its thought that once they got down into the southern continents, they got isolated from each other by various types of barrier. The submerging of the Isthmus of Panama is thought to have isolated the South American fauna, the Mediterranaen Sea and more recently the North Africa desert would at least partially isolate the African fauna, and the submerging of the original connection between Australia and Asia isolated the Australian fauna.

Once isolated, it is thought that the animals in each continent proceeded to evolve along their own lines. From the original stocks which invaded these continents arose many different forms filling every available habitat. This is called adaptive radiation, and it has occurred independently in each of the 3 southern continents resulting into their now possessing markedly different faunas.

Evidence for migration and isolation

Although animals of widely separated regions may be different in detail, they have many basic similarities. Continents like south America and Africa have different genera and species, but these belong to the same orders and families. When a group of animals or plants has representatives in the widely separated localities, this distribution is known as **discontinuous**.

An example of discontinuous distribution is the camel family; ie the family in North Africa and Asia is represented by the camel its self in south America by the llama. The fossil records show that camel family arose in the northern hemisphere and then migrated to south wards. There fore camels started in N. America then migrated to Asia through the bering strait then to Africa, and through the Isthmus of Panama into South America. Once isolated they evolved along their own lines, giving the modern camel in Asia and Africa and the llama in South America.

Read about the Australian Fauna and continental drift, the Galapagos islands) (pg564 to 568 functional approach)

d. Comparative Anatomy

If its true that widely separated groups of animals and plants share a common ancestry, as their geographical distribution suggests, they should have basic structural feature inn common. The degree of resemblance between them should indicate how closely related they are in evolution. Groups with little in common are assumed to have diverged from a common ancestor much earlier in the geological history than groups which have a lot in common. Determining the evolutionary relationship on the basis of structural similarities and differences is termed as comparative anatomy**.**

Examples include:

One of the examples of homology is shown by the **Pentadactyl limb** so called because it has five digits. This type of limb is found in the four classes of terrestrial vertebrates and can even be traced back to the fins of certain fossil fishes from which the first amphibians are thought to have evolved. The pentadactyl limb is basically built on the same plan in all vertebrates but in the course of evolution the limbs of different vertebrates have become adapted for different functions, in some cases involving severe structural modifications.

In monkeys the fingers are elongated to form a grasping hand suited for swinging from branch to branch. Several animals, including pigs, cattle, deer, and dogs have reduced, nonfunctional digits, referred to as dewclaws. The foot of the pig has lost digit 1 completely, digits 2 and 5 have been greatly reduced, and only digits 3 and 4 support the body. Evolution best explains such vestigial features. They are the remnants of ancestors with a larger number of functional digits. In horses, the limb is adapted for support and running by great elongation of the third metacarpal which becomes the cannon bone, the remaining digits are lost though the 2^{nd} and 4^{th} metacarpals, much reduced, persist as the splint bones.

Read about Vestigial structures and the vertebrate heart and arterial arches. Functional approach pg 571-574

e. Taxonomy- the Classification of Organism

A natural classification is an expression of the evolutionary relationships between different groups. Its assumed that organisms in the same group are closely related and those in separate groups are more distantly related. Revise your notes on classification (5 kingdom system, classification of chordates etc)

f. Palaeontology:

The evidence for evolution presented so far are based on studying animals and plants living to day. Further evidence comes from studying the animals and plants of the past as seen in the fossil record, a branch of biology known as palaeontology

Fossils are generally preserved in sedimentary rock, which is formed by deposition of silt, sand or calcium carbonate over thousands or millions of years. The most common method of fossilization involves conversion of hard parts of the body (bones teeth, shells) into rock.

When an animal dies, the organic material in the bones gradually decays away, resulting in the bone becoming porous. If the animal as buried in mud, mineral particles infiltrate into the bones and gradually fill up the pores. When the mud turns into rock, the bones harden and are preserved for ever.

Relative dating places fossils in a temporal sequence by noting their positions in layers of rocks, known as strata. Fossils found in lower strata were typically deposited first and are deemed to be older (this principle is known as superposition). Sometimes this method doesn't work, either because the layers weren't deposited horizontally to begin with, or because they have been overturned.
By studying and comparing strata from all over the world we can learn which came first and which came next, but we need further evidence to ascertain the specific, or numerical, ages of fossils.

Numerical dating relies on the decay of radioactive elements, such as uranium, potassium, rubidium and carbon. Very old rocks must be dated using volcanic material. By dating volcanic ash layers both above and below a fossil-bearing layer, as shown in the diagram, you can determine "older than X, but younger than Y" dates for the fossils. Sedimentary rocks less than 50,000 years old can be dated as well, using their radioactive carbon content. Geologists have assembled a geological time scale on the basis of numerical dating of rocks from around the world

Read more about palaeontology (Functional approach)

Theories of evolution

Lamarckism:

Lamarck started his scientific career as a botanist, but in 1793 he became one of the founding professors of the Musee National d'Histoire Naturelle as an expert on invertebrates. His work on classifying worms, spiders, molluscs, and other boneless creatures was far ahead of his time.

Change through use and disuse
Lamarck was struck by the similarities of many of the animals he studied, and was impressed too by the burgeoning fossil record. It led him to argue that life was not fixed. When environments changed, organisms had to change their behavior to survive. If they began to use an organ more than they had in the past, it would increase in its lifetime. If a giraffe stretched its neck for leaves, for example, a "nervous fluid" would flow into its neck and make it longer. Its offspring

would inherit the longer neck, and continued stretching would make it longer still over several generations. Meanwhile organs that organisms stopped using would shrink.

Organisms driven to greater complexity

This sort of evolution, for which Lamarck is most famous today, was only one of two mechanisms he proposed. As organisms adapted to their surroundings, nature also drove them upward from simple forms to increasingly complex ones. Like Buffon, Lamarck believed that life had begun through spontaneous generation. But he claimed that new primitive life forms sprang up throughout the history of life; today's microbes were simply "the new kids on the block."

Lamarck also proposed that organisms were driven from simple to increasingly more complex forms.

Evolution by natural processes

Lamarck was mocked and attacked by many other naturalists of his day. While they questioned him on scientific grounds, many of them were also disturbed by the theological implications of his work. Lamarck was proposing that life took on its current form through natural processes, not through miraculous interventions. For British naturalists in particular, steeped as they were in natural theology, this was appalling. They believed that nature was a reflection of God's benevolent design. To them, it seemed Lamarck was claiming that it was the result of blind primal forces. Shunned by the scientific community, Lamarck died in 1829 in poverty and obscurity.

Theory of Natural Selection (Darwin's theory of evolution)

Charles Darwin (1809 - 1882) was an English naturalist who made a study of variation in plants and animals during a five-year voyage around the world in the mid19th century. Although he was not the only scientist working on evolutionary theory - Alfred Wallace was coming to the same conclusion around the same time - it was Darwin who published his ideas first. On the Origin of Species, which came out in 1859, is possibly the most influential scientific book ever written

Darwin's drawings of variant heads and beaks among Galapagos finches

While studying wildlife on the Galapagos Islands he noticed that the Galapagos finches showed wide variations - eg in beak shape and size - from island to island. Darwin deduced that these differences made the finches better adapted to take advantage of the food in their particular local environment - thin, sharp beaks prevailing where the birds' main food was insects and grubs, and large claw-shaped beaks where their diet was buds, fruit and nuts. In each locality the finch population had somehow developed beaks which were suitable for that particular environment.

Darwin concluded that in each locality one or more individual finch happened to acquire, by random mutation, a beak shape more suitable for the food sources in that locality. These individuals then had a competitive advantage over their fellow finches, enabling them to grow and reproduce more successfully, and pass on their more specialised beaks to successive generations - until eventually the characteristic had spread throughout the finch population in that locality.

He studied hundreds more animal and plant species, and made the following key observations:

That living things tend to produce far more offspring than will survive to maturity

That within a species population numbers tend to stay more or less constant over time

That each species displays a wide variation in features

That some of these variations are passed on to the next generation

Darwin's theory explained these key facts. He inferred that living things are in continuous competition with each other - for access to space, food, and mates, for example - and that only the best suited or 'fittest' survive to reproduce and pass on their genes. Any characteristic acquired by chance mutation that gives an individual an advantage in the struggle will be naturally *selected for*.

Natural selection means the survival of organisms that are best suited to surviving and reproducing in their environment. Over millions of years, this process produces not just variations within species, but entirely new species as well. It is the engine of evolution.

Natural selection is considered to be the biggest factor resulting in the diversity of species and their genomes. The principles of Darwin's work and his theory are stated below.

One of the prime motives for all species is to reproduce and survive, passing on the genetic information of the species from *generation* to generation. When species do this they tend to produce more offspring than the *environment* can support.

The lack of resources to nourish these individuals places pressure on the size of the species *population*, and the lack of *resources* means increased competition and as a consequence, some organisms will not survive.

The organisms that die as a consequence of this competition were not totally random; Darwin found that those organisms more suited to their environment were more likely to survive.

This resulted in the well known phrase *survival of the fittest*, where the organisms most suited to their environment had more chance of survival if the species falls upon hard times.

Those organisms who are better suited to their environment exhibit desirable characteristics, which is a consequence of their genome being more suitable to begin with.

This 'weeding out' of less suited organisms and the reward of survival to those better suited led Darwin to deduce that organisms had evolved over time, where the most desirable characteristics of a species are favoured and those organisms who exhibit them survive to pass their *genes* on.

As a consequence of this, a changing environment would mean different characteristics would be favourable in a changing environment. Darwin believed that organisms had 'evolved' to suit their environments, and occupy an *ecological niche* where they would be best suited to their environment and therefore have the best chance of survival.

As the above indicates, those alleles of a species that are favoured in the environment will become more frequent in the genomes of the species, due to the organisms higher likeliness of surviving as part of the species at large.

Evolution through Natural selection by Darwin and Wallace (Mechanism of evolution) or observations and deductions on which the evidence for natural selection is based are Summarized below;

1. Over production of offspring; All organisms produce large numbers of offspring and if all survived, would lead to a geometric increase in the size of the population.

2. Constancy of numbers; Despite the tendency to increase the numbers due to over production of offspring, most populations maintain relatively constant numbers.

3. Struggle for existence; Darwin deduced on the basis of 1 and 2 that members of the same species were constantly competing with each other in an effort to survive. In this struggle for existence only a few would live long enough to breed.

4. Variation among offspring; sexually produced offspring of any species show individual variations so that no two offspring are identical.

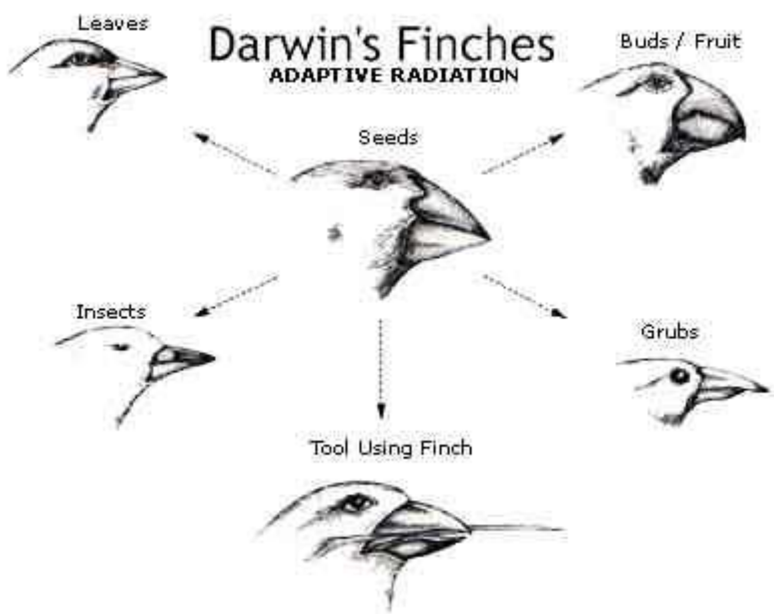
5. Survival of the fittest by natural selection; Because of variation, among the offspring there will be some better adapted to with stand the prevailing conditions. That is, some will be better adapted (fitter) to survive in the struggle for existence and therefore more likely to survive long enough to breed hence passing on their beneficial genes to their offspring.

6. Like produces like; Those that survive to breed are likely to produce offspring similar to them selves. The advantageous traits that made them to survive in the struggle for existence are likely to be passed on to the next generation.
7. Formation of new species; Over many generations, individuals with favourable traits will breed hence increase in their number. The development of a number of variations in a given direction over many generations will gradually will lead to evolution of new species.

Examples of Natural Selection (evidence for natural selection)

Darwin's Finches & Natural Selection

Darwin's finches are an excellent example of the way in which species' gene pools have adapted in order for long term survival via their offspring. The Darwin's Finches diagram below illustrates the way the finch has adapted to take advantage of feeding in different ecological niches.



Their beaks have evolved over time to be best suited to their function. For example, the finches that eat grubs have a thin extended beak to poke into holes in the ground and extract the grubs. Finches that eat buds and fruit would be less successful at doing this, while their claws like beaks can grind down their food and thus give them a selective advantage in circumstances where buds are the only real food source for finches.

Industrial Melanism

Polymorphism pertains to the existence of two distinctly different groups of a species that still belong to the same species. Alleles for these organisms over time are governed by the theory of natural selection, and over this time the genetic differences between groups in different environments soon become apparent, as in the case of industrial melanism.

Industrial melanism occurs in a species called the peppered moth, where the occurrence has become of more frequent occurrence since the beginning of the industrial age. The following argument elaborates the basis of principles involved in natural selection as far as industrial melanism is concerned.

Pollution, which is more common in today's world since the industrial age causes a change in environment, particularly in the 1800's when soot would collect on the sides of buildings from chimneys and industries and make them a darker colour.

The resultant effect was that the peppered moth, which had a light appearance was more visible against the darker backgrounds of sooty buildings.

This meant that *predators* of the peppered moth could find them more easily as they are more visible against a dark background.

Due to mutations, a new strain of peppered moth came to existence, where their phenotype was darker than that of the white peppered moth.

This meant that these new, darker peppered moths were once again harder to track down by their prey in environments where industry has taken its toll.

In this instance, natural selection would favour the darker moths in polluted environments and the whiter moths in the lesser polluted environments due to their ability to merge in with their environmental colours and lessen the chances of them being prone to a predator.

However, some scientists have a different view about industrial melanism and its as follows;

Peppered moths

White and black peppered moths are a classic example of natural selection in action. Before the industrial revolution in Britain most peppered moths were of the pale variety that were well camouflaged against the pale birch trees that they like to sit on. Moths with the mutant black colouring were easily spotted and eaten by birds - giving the white peppered variety an advantage.

Then the industrial revolution came along in the 19th century. Airborne pollution in industrial areas mottled the birch tree bark with soot, and now the mutant black-peppered moths blended better against the darkened bark, while the white variety became much more vulnerable to predators. Over time the mutated black peppered moths were naturally selected to survive and became far more numerous in urban areas than the pale variety.

Sickle Cell Trait

Consider this argument of natural selection in the case of sickle cell trait, a genetic defect common in Africa.

Sickle cell trait is a situation that occurs in the presence of a recessive *allele* coding for *haemoglobin*, a substance in the blood responsible for the transport of gases like oxygen. The presence of the allele is either partially expressed recessively (sickle cell), or fully expressed by a complete recessive expression which results in full blown *anaemia*. If this particular allele is dominant, no sickle cell trait is expressed in the phenotype.

The above occurrences in the case of a recessive allele result in structural defects of red blood cells, severely reducing the organism's capacity to uptake oxygen.

It was pointed out that in Africa; there is a high frequency of this mutation, where cases of *malaria* were high.

A substantiated link was made noting those who suffer sickle cell trait or anaemia were immune to the effects of malaria.

This is yet again natural selection at work. Although sickle cell trait or anaemia are not advantageous characteristics on their own, they prove to be advantageous in areas where malaria proves to be a greater threat to preserving the genome (i.e. surviving).

The *incomplete dominance* of this genetic expression proves favourable either way.

Examples of Natural selection in action today;

1. **Insecticide Resistance/ pesticide resistance**

Many new and re-emerging diseases are transmitted by arthropod vectors. Mosquitoes transmit malaria, dengue-dengue hemorrhagic fever (DHF) , yellow fever and filariasis; etc. The best way of controlling these diseases is by eliminating their vectors mainly by use of pesticides or Insecticides. But Pesticides / Insecticides resistance has been a problem in all insect groups that serve as vectors of emerging diseases. Although mechanisms by which insecticides become less effective are similar across all vector taxa, each resistance problem is potentially unique and may involve a complex pattern of resistance loci/alleles

Resistance has developed to every chemical class of insecticide, including microbial drugs and insect growth regulators. (eg, resistance to Dichlorodiphenyltrichloroethane (DDT) across the world by most insects after being applied for two years)

Pesticide resistance is the adaptation of pest species targeted by a pesticide resulting in decreased susceptibility to that chemical. In other words, pests develop a resistance to a chemical through selection; after they are exposed to a pesticide for a prolonged period it no longer kills them as effectively. The most resistant organisms are the ones to survive and pass on their genetic traits to their offspring. In many case the presence of the insecticide/pesticide activates the gene in mutant varieties. This gene initiates the synthesis of enzymes which break down the insecticide/pesticide.

2. Antibiotic resistance

Antibiotic resistance is a specific type of drug resistance when a microorganism has the ability of withstanding the effects of antibiotics. Antibiotic resistance evolves via natural selection acting upon random mutation. For example; After being exposed to drugs such as penicillin, bacterial cells have developed resistance against them. This resistance or tolerance to is not cumulative but by chance mutation. This mutation allows mutant bacteria to survive in the presence of antibiotics such as penicillin by producing an enzyme to break it down. In the presence of penicillin non resistant forms are destroyed. There fore, this selection pressure favours resistant types. Usefulness of many antibiotics has been destroyed by bacterial resistance to them. By 1950s the majority of staphylococcal infections were already penicillin resistant.

The problem has been made more acute by recent discoveries that once a resistance gene is generated, bacteria can then transfer the genetic information in a horizontal fashion (between individuals) by plasmid exchange. If a bacterium carries several resistance genes, it is called multi-resistant or, informally, a superbug. The term antimicrobial resistance is sometimes used to explicitly encompass organisms other than bacteria.

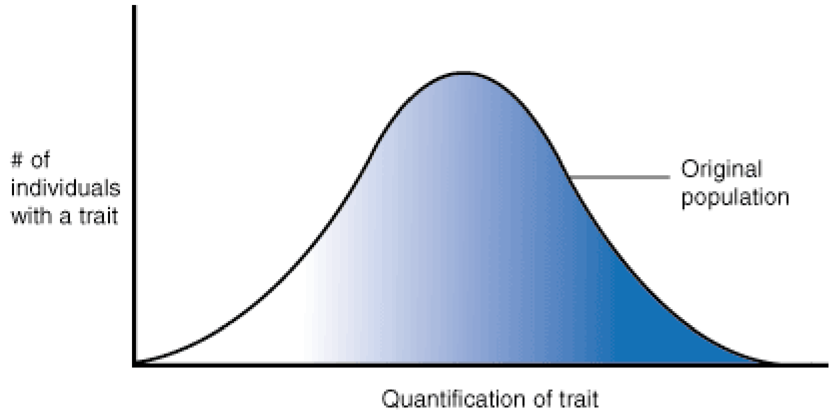
Antibiotic resistance can also be introduced artificially into a microorganism through transformation protocols. This can aid in implanting artificial genes into the microorganism. If the resistance gene is linked with the gene to be implanted, the antibiotic can be used to kill off organisms that lack the new gene.

3. Heavy metal tolerance in plants

Another example of natural selection occurs on spoil heaps containing waste materials from mining activities. Spoil heaps contain high concentrations of certain heavy matals eg tin, lead, copper and nickel. In high concentrations, these metals are toxic to most plants. Some varieties of grasses eg *Festuca ovina* and *Agrostis tenuis* have become genetically adapted to survive high levels of these metals. These plants areless competitive where the concentrations of these metals is low and they hardly survive.

Types of Natural Selection

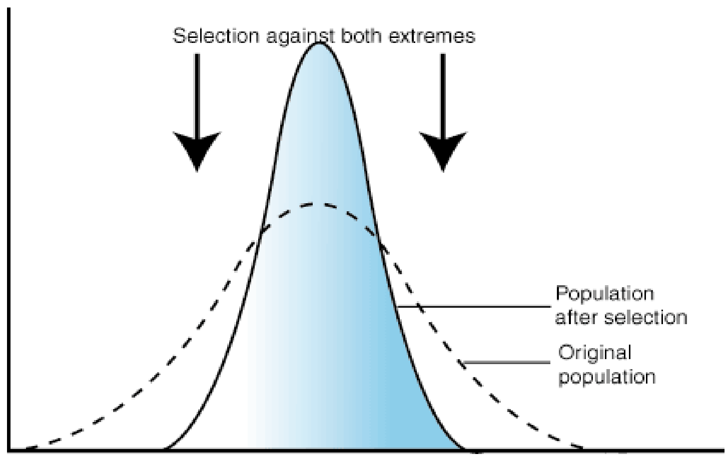
Natural selection can take many forms. To make talking about this easier, we will consider the distribution of traits across a population in graphical form. In we see the normal bell curve of trait distribution. For example, if we were talking about height as a trait, we would see that without any selection pressure on this trait, the heights of individuals in a population would vary, with most individuals being of an average height and fewer being extremely short or extremely tall. However, when selection pressures act on a trait, this distribution can be altered.



Figure%: The standard distribution of a trait across a population

Stabilizing selection

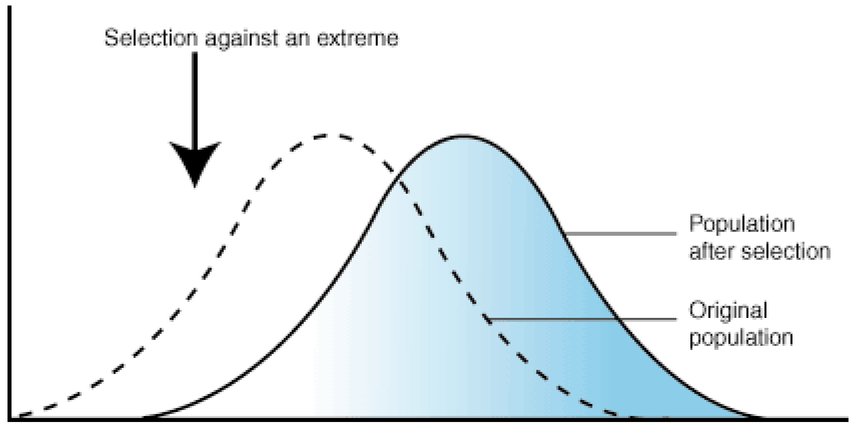
When selective pressures select against the two extremes of a trait, the population experiences stabilizing selection. For example, plant height might be acted on by stabilizing selection. A plant that is too short may not be able to compete with other plants for sunlight. However, extremely tall plants may be more susceptible to wind damage. Combined, these two selection pressures select to maintain plants of medium height. The number of plants of medium height will increase while the numbers of short and tall plants will decrease.



Figure%: The effect of stabilizing selection on trait distribution

Directional selection

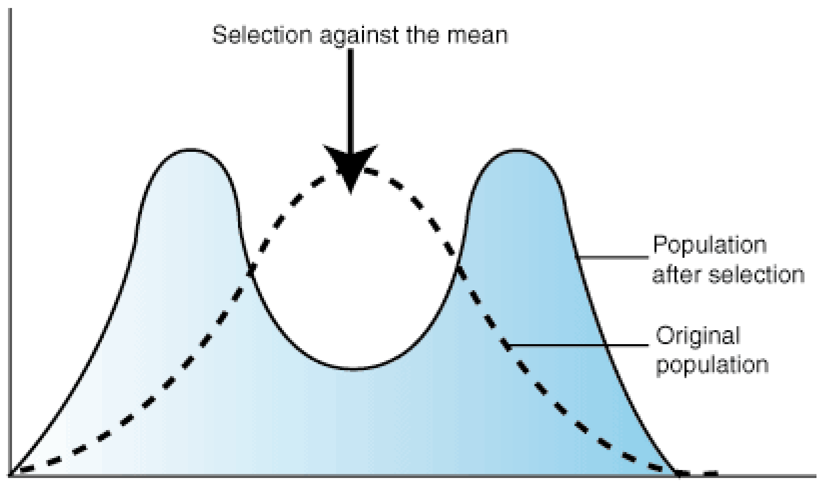
In directional selection, one extreme of the trait distribution experiences selection against it. The result is that the population's trait distribution shifts toward the other extreme. In the case of such selection, the mean of the population graph shifts. Using the familiar example of giraffe necks, there was a selection pressure against short necks, since individuals with short necks could not reach as many leaves on which to feed. As a result, the distribution of neck length shifted to favor individuals with long necks.



Figure%: The effect of directional selection on trait distribution

Disruptive Selection

In disruptive selection, selection pressures act against individuals in the middle of the trait distribution. The result is a bimodal, or two-peaked, curve in which the two extremes of the curve create their own smaller curves. For example, imagine a plant of extremely variable height that is pollinated by three different pollinators, one that was attracted to short plants, another that preferred plants of medium height and a third that visited only the tallest plants. If the pollinator that preferred plants of medium height disappeared from an area, medium height plants would be selected against and the population would tend toward both short and tall, but not medium height plants. Such a population, in which multiple distinct forms or morphs exist is said to be polymorphic.



Figure%: The effect of disruptive selection on trait distribution

Other types of selection include; Artificial selection, kin selection, sexual selection and group selection.

Artificial selection;

Natural selection is nature's way of ensuring that the genes of those best suited to survive in a particular environment are passed on to the next generation, and it works by **random mutation**. But since humans first began domesticating plant and animal species about 15,000 years ago, man has been doing something very different - **deliberately** selecting certain characteristics for breeding purposes in order to produce species that are useful for agriculture (food production or transport). This is called **artificial selection**.

Selective breeding is when humans only breed from selected individuals in order to preserve and emphasize their desirable characteristics. Breeders, farmers, and horticulturists have used it for many centuries, in order to:

- produce new varieties of plant with higher food yields, produce new varieties of fruit with better flavor, produce new varieties of animal with higher meat, wool or milk yields, produce new varieties of animal that are faster (for transport), stronger (for pulling ploughs or carts) or otherwise more useful to us (eg as pets), produce flowers with larger blooms or more colourful blooms, produce disease-resistant or pest-resistant crops

Breeders of animals and plants in today's world are looking to produce organisms that will possess desirable characteristics, such as high crop yields, resistance to disease, high growth rate and many other phenotypical characteristics that will benefit the organism and species in the long term.

Artificial selection is divided into inbreeding and out breeding;

Inbreeding;

When a variety of plant or animal arose and possess some useful character, its bred/mated with its close relatives in order to retain the desirable character for future generations. The main problem of in breeding is that, it increases the chances of a harmful recessive gene expressing itself because there is a greater risk of a double recessive individual arising. To prevent this phenomenon, in breeding is combined with out breeding so that new genes are introduced in the stock.

Inbreeding Depression

However, while it is an advantage both to the species and to humans to produce these desirable qualities that may benefit the organisms in question, continuous in-breeding and selective breeding of particular genes runs the risk of losing some of the other genes from the gene pool altogether, which is irreversible. This is called in-breeding depression, where the preference of the advantageous genes mean that some other less desirable genes are phased out. In the long term, it is more advantageous for organisms to remain heterozygous;

Out breeding;

This is carried in order to improve existing varieties of animals and plants. This is the mating / breeding of two un related individuals of the same species where by each individual possesses its own beneficial feature and they are bred in order to combine the two. For example; A cattle breeder may cross an Ankole bull which is resistant to diseases and bad climatic conditions and a Friesian cow with a fast growth rate and gives high beef and milk yields. The most likely result will be a hybrid which grows faster, gives high beef and milk yields as well as resistant to diseases and bad climatic conditions. There for out breeding produces tougher, more fertile (etc) individuals with a better chance of survival, especially where many generations of inbreeding have taken place (hybrid have been made inferior by in breeding). This is known as hybrid vigour. **(Read more about hybrid Vigour Functional approach pg 615 and selective breeding in maize, wheat, cattle and artificial insemination, embryo transplantation Biology for advanced level pg 206)**

Extreme examples of out breeding which are very rare occur when individuals of different species are mated giving off infertile offspring.

The improvement of the human race by selection or elimination of specific characters is called eugenics

Sexual selection:

It does not depend on struggle for existence, but on struggle between the males for possession of the females; The result is not death to the unsuccessful competitor, but few or no offspring. For example brightly coloured male birds attract females as compared to dull coloured males of the same species. The result is that, its only brightly coloured male birds which will mate with the females and pass on their traits to the next generation while the dull coloured males will hardly get mates.

kin selection:

The evolution of characteristics with in organisms of the same species which favour the survival of close relatives/ enhances the fitness of relatives but lowers that of the individual displaying the behavior. And this is basis of the theory of social evolution.

Group selection: similar to kin selection

Many species have a social structure according to which individuals associate in groups such that interaction among members within each group is much more frequent than interaction of individuals across groups. Eg social insects

More complex forms of group behavior involve individuals sacrificing personal fitness on behalf of other members of the group. Eg. Sterile soldier termite self-sacrifices to protect the nest

Polymorphism;

It's the existence of two or more forms of the same species with in the same population. It can apply to biochemical, morphological and behavioural traits. Polymorphism plays a vital role in the process of natural selection. The best example is the existence of two forms of peppered moths which led to a form of natural selection termed as selective predation and the existence of different forms of land snail *Cepaea nenoralis.*

There are two types of polymorphism i.e transient polymorphism and balanced/stable polymorphism.

Transient polymorphism

This arises when different forms or morphs exist in a population undergoing a strong selection pressure. The frequency of each phenotypic appearance of each form is determined by the intensity of the selection pressure, such as the melanic and non melanic forms of peppered moth. Transient polymorphism usually applies in situations where one form is gradually being replaced by another.

Balanced polymorphism;

This occurs when different forms co-exist in the same population in a stable environment. The best example is the existence of two sexes in animals and plants. The genotypic frequencies of the various forms exhibit equilibrium since each form has a selective advantage. In man blood groups A, B, AB and O are examples of balanced polymorphism. Their genotypic frequencies with in different population may vary, but they remain constant from generation to generation with in that population. This is because none of them has a selective advantage over the others.

When *Charles Darwin* was in the Galapagos islands, one of the first things he noticed is the variety of

Mammals live all over the place. After the dinosaurs died out some sixty million years ago, mammals have undergone a spectacular process of expansion into different environments. Many lived on the ground; some burrowed into it. Some, like the whale, returned to the water where life had originated earlier. Others took to living in the trees; these are the primates, from which we humans recently sprang. (Our grasping hands, rotating arms, and stereoscopic vision all reveal our tree-dwelling roots.) A few mammals even took to the air, as the bats of today remind us.

When a life form expands into a new environment, any traits that happen to help individual organisms survive and reproduce there will grow more common as generations pass. Assuming the form does not die out, then, it will be modified, by natural selection, for living ever more effectively in the new environment. When a single form of life successfully expands into many environments, the process is termed "adaptive radiation."

Adaptive radiation ordinarily involves the development of new species in the new environments. That is, the cumulative effects of natural selection eventually make the populations in different environments so different from one another that interbreeding has become impossible. Mammals share a common ancestral form, but bats and whales cannot interbreed to produce, say, "whats" or "bales"!

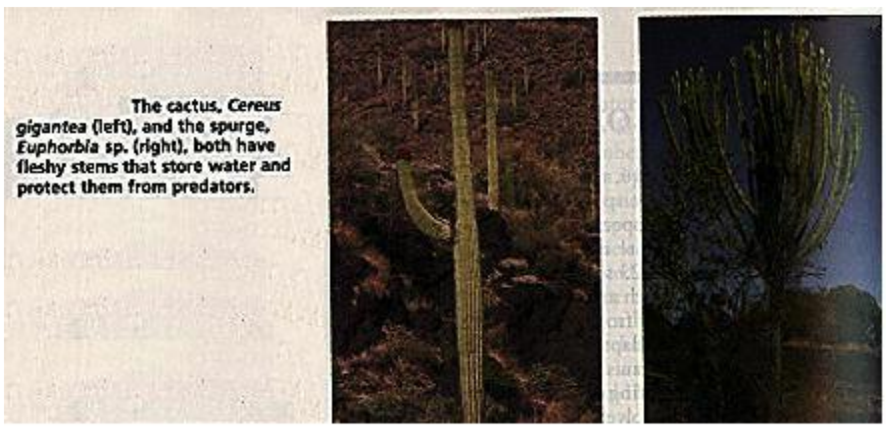
Now, a few human traits, such as skin color, do appear to reflect natural selection in different environments. Near the equator, where the sun's rays strike the earth directly year round, a dark skin aids survival and reproduction by affording protection from skin cancer; far from the equator, though, a light skin seems to offer protection against rickets, a bone disorder which can result from too little exposure to sunlight. Yet this, and other geographically based differences between human populations, are quite superficial--"skin-deep," so to speak. The ultimate biological proof of this superficiality is the fact that a healthy male and female from anywhere in the world are capable of mating to produce fertile offspring. Clearly, humans have managed to go "all over the place" *while remaining a single species*.

That a single species--especially a large-bodied one--should have done this is remarkable indeed from a zoological and ecological standpoint. Other large-bodied species remain confined to relatively narrow environmental ranges. Chimps and gorillas, our closest living kin, inhabit still the tropical forests of our early ancestors.

finches that existed on each of the islands. All in all, there were many different species of finch which differed in beak shape and overall size. This is adaptive radiation and natural selection at work.

Divergent and Convergent Evolution

Adaptive radiation is one example of divergent evolution. Divergent evolution is the process of two or more related species becoming more and more dissimilar. The red fox and the kit fox provide and example of two species that have undergone divergent evolution. The red fox lives in mixed farmlands and forests, where its red color helps it blend in with surrounding trees. The kit fox lives on the plains and in the deserts, where its sandy color helps conceal it from prey and predators. The ears of the kit fox are larger than those of the red fox. The kit fox's large ears are an adaptation to its desert environment. The enlarged surface area of its ears helps the fox get rid of excess body heat. Similarities in structure indicate that the red fox and the kit fox had a common ancestor. As they adapted to different environments, the appearance of the two species diverged.



In convergent evolution, on the other hand, unrelated species become more and more similar in appearance as they adapt to the same kind of environment. The two unrelated types of plants in the picture above have adapted to desert environments. Notice the resemblance of the cactus, which grows in the American desert, to the euphorbia, which grows in the African deserts. Both have fleshy stems armed with spines. These adaptations help the plants store water and ward off predators.

Coevolution

Coevolution is the joint change of two or more species in close interaction. Predators and their prey sometimes coevolve; parasites and their hosts often coevolve; plant-eating animals and the plants upon which they feed also coevolve. One example of coevolution is between plants and the animals that pollinate them.

In tropical regions bats visiting flowers to eat nectar. The fur on the bat's face and neck picks up pollen, which the bat transfers to the next flower it visits. Bats that feed at flowers have a slender muzzle and a long tongue with a brushed tip. These adaptations aid the bat in feeding. Flowers that have coevolved with bats are light in color. Therefore, bats, which are active at night, can easily locate them. The flowers also have a fruity odor attractive to bats.

Divergent and convergent evolution and coevolution are different ways organisms adapt to the environment. These are examples of how the diversity of life on earth is due to the ever-changing interaction between a species and its environment.