DEPARTMENT OF EDUCATION

GRADE 12

BIOLOGY

MODULE 4

EVOLUTION

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GRADE 12

BIOLOGY

MODULE 4

EVOLUTION

IN THIS MODULE YOU WILL LEARN ABOUT:

12.4.1: THEORIES AND EVIDENCE OF EVOLUTION

12.3.2: MECHANISM OF EVOLUTION

Acknowledgements

We acknowledge the contributions of all Lower and Upper Secondary teachers, who in one way or another helped to develop this Course.

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PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 - 2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD
Secretary for Education

MODULE 12.4: EVOLUTION

Introduction

In Module 3 we looked at Genetics and how certain characteristics are passed down from the parents to the children or to the offspring. These characteristics are eye, skin, hair colour, height, and hair colour. Every now and then you get an individual plant or animal that is slightly different. These variations are of particular features that are different from the parents. These variations happen very slowly. In fact these differences happen over many generations to produce an offspring that is different from the parent.

The differences also may be beneficial to the organism. The differences that are passed on come in the form of genes. Genes are passed on from the parent to the offspring. There are good genes and there are bad genes. The bad genes do not continue to the next generation because it does not allow the offspring to survive. The genes that help an organism to survive are the good genes. These are the genes that are passed down from one generation to the next.

The methods in which these beneficial genes are passed on, are mechanisms that enable an organism to evolve overtime. This is how organisms evolve to adapt to their environment. Evolution is all about surviving in an environment. If an organism is not able to survive then it is at risk of becoming extinct. One prominent scientist that significantly contributed to our understanding of evolution is **Charles Darwin**. In Module 4 we will closely look at people who contributed to the study of evolution and the mechanisms that cause it to occur.

Learning Outcomes

After going through this module, you are expected to:

- state the difference between Lamarck's Theory of Evolution and Charles Darwin's Theory of Evolution.
- explain the differences between fossil record, transitional fossils, comparative bio-chemistry, comparative anatomy, and bio-geographic distribution.
- identify evolutionary agents such as non-random mating, mutation, descent with modification (survival of the fittest), migration (gene flow), and genetic drift.
- define between immigration, emigration, and migration.
- compare and contrast homologous structures and analogous structures.
- differentiate between the four (4) types of mutation that occur in the gene sequence.
- explain the difference between spontaneous mutation and induced mutation.

Time Frame

Suggested allotment time: **10 weeks**

If you set an average of 3 hours per day, you should be able to complete the module comfortably by the end of the assigned week. Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor. Do not pass any question without solving it first.

DO NOT LEAVE ANY QUESTION UNANSWERED

Terminology

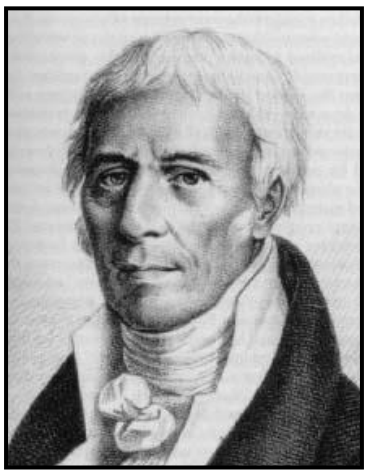
Analogous structures	A development of a certain physical structure developed by two or more organisms that enable them to perform the same function but they all descend from different ancestors. For example, a bat's wings and a bird's wings.
Bottleneck Effect	When a small number of species are able to reproduce, this may lead to a different generation of species.
Cast	The filling in of a hole to produce a three-dimensional model of an organism **.**
Emmigration	Movement of organism(s) out of one population to the next population.
Founder effect	The end result of a founder population.
Founder population	Movement or change in a population from one geographic area to another area. Where the population begins another new population. That new population can either be representative of the population or not.
Fossilisation	Step by step process, where organism's body and bones become preserved over thousands and millions of years.

Genetic drift	An event that occurs accidentally to make one gene from one population go to another population of genes.
Gene flow	The physical movement of organisms of the same species from one geographic area to another geographic area.
Gene pool	A geographic area where a group of the same species (along with their genes) are located.
Genetic variation	A small change in the physical makeup of an organism of the same species.
Homologous structure	A certain physical structure developed by two or more organisms that enable them to perform the same function and they all descend from one common ancestor.
Immigration	Movement of organism(s) outside the population and into the population.
Induced mutation	A change in the genetic code of an organism and the cause of the change is known.
Law of fossil succession	The way in which fossils are found along the soil profile from top (most recent fossils) to the bottom (most pre-historic).
Migration	The movement of organisms along with their genes from one geographic area to another.
Mould	An impression in the ground which an organism causes millions of years ago.
Mutagents	They are the agents causing mutation.
Mutation	A change in the genetic code that makes an organism a little different from others of the same species. It could be based on their physical appearance.
Natural selection	A process by which traits that help an organism to survive are passed on to the offspring.

Organelles	Tiny structures found inside a cell that plays a a certain role in the overall function of the cell.
Paleontology	The study of dead extinct animal or plant remains.
Population	A group of the same species numbering more than one, in the same area.
Species	An organism when mating with the same organisms will produce a fertile offspring.
Spontaneous mutation	A change in the genetic code but the cause is unknown.
Trace fossils	These are imprints such as footprints, teeth, hand marks and holes caused by organisms millions of years ago.
Transitional Fossils	These are fossils that link one species of organisms to another.

12.4.1 Theories and Evidence of Evolution

The theory of evolution has been long proposed and redefined until the present. One of those early scientists was a man named Jean Baptiste Lamarck. He stated that a trait can be acquired during an organism's lifetime. There were scientists before Lamarck who also stated their own theory of evolution but Lamarck was closer to the real one. Charles Darwin was a later scientist who put all other theories into one simple to understand theory that we come to know now as the "Theory of Evolution by Natural Selection".



Jean Baptiste Lamarck, who proposed the theory of evolution before Charles Darwin.

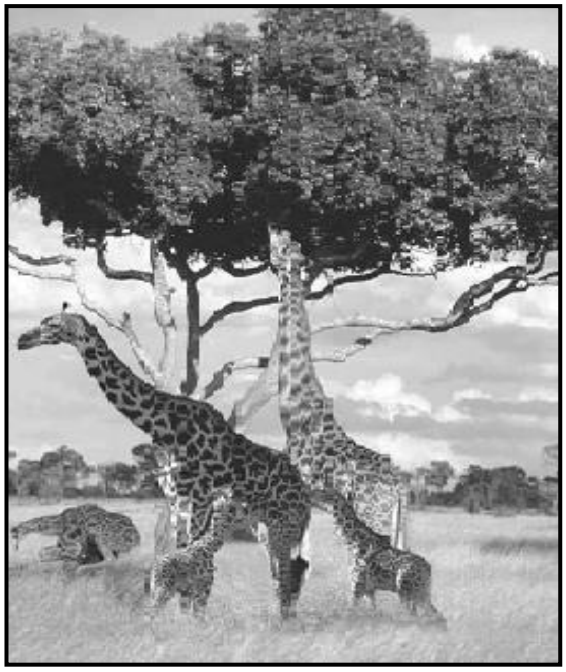
Lamarck's Theory of Evolution

In 1809, a French biologist by the name of Jean Baptiste Lamarck came up with a theory to explain how plants and animals change over time.

His theory reasonably explained why there were changes in characteristics of plants and animals.

He searched for answers to the existences of such a great diversity of characteristics and came up with two important perspectives:

- The features (traits/characteristics) of an organism can change in response to the type of environment it lives in and what it's internal body needs.
- These acquired traits are passed down from one generation to the next. For example, as giraffes feed on the leaves of trees. the act of stretching their necks will enable it to grow longer. Consequently these traits will be acquired by its genes and passed onto the next generation.



Long necked giraffes stretching their necks to eat the leaves above. Lamarck assumed that if the giraffe began stretching its' neck when it was young to adult age, it would develop a longer neck. Consequently, passing on its genes to its offspring who would also have a long neck.

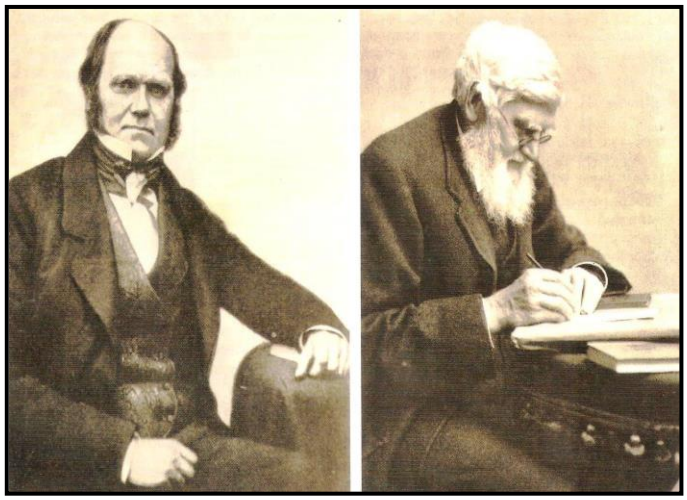
He also believed that animal organs continue to exist by being used or begin to disappear if not being used. For example, if chickens did not use their wings to fly then eventually their wings would disappear. If the wings were used then it would continue to exist.

However, the problem with Lamarck's theory is that it was based on assumption. He had no proof and did not bother to find out how it could happen.

Charles Darwin's Theory of Evolution by Natural Selection

In 1858, a British biologist, Charles Darwin and Alfred Russel Wallace independently came up with a theory that fully explained the change in characteristics and the abundance in diversity. Their theory was based on evidence and proof.

Charles Darwin was the first to come up with a credible theory of evolution. The theory he came up with is called: the **Theory of Evolution by Natural Selection**.



To the left is young Charles Darwin and on the right is Alfred Russel Wallace who both independently came up with the "the theory of evolution".

Charles Darwin's "Theory of Evolution by Natural Selection" states that: Species evolve or change their traits over many generations through a process that helps the traits to survive and continue its' traits to the next generation.

This theory explains the causes of evolution and that it could be tested by observation and experimentation. It states that change or evolution does not happen during an individual's lifetime, it occurs over several generations in **populations.**

A **population** is made out of a group of plants or animals of the **same species**. Examples include a population of ants on one tree, a herd of cows on a farm, and the Bird of Paradise in Papua New Guinea.

For example, take a group of giraffes. Giraffes naturally have a long neck. From one generation to the next you get young giraffes that have long necks.

Suddenly, the trees they like to eat start to show signs of disease. Eventually the whole species of that particular tree dies out. Now the other tree that these giraffes like to feed on is taller than the diseased trees. If a giraffe that is born has a much taller neck than normal is able to get to these taller trees then its offspring (babies) will also have the same longer necks than the parent.

Therefore, overtime the giraffe with the longer neck will be able to produce more offspring then the originally shorter necked giraffes and eventually there will no longer be any Giraffes with shorter necks. This is an example of one particular characteristic that changes overtime. There are many other examples of characteristics that change overtime that help an animal or plant survive in its environment.

It is now time for you to complete Learning Activity 1. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 1 (which you will send in for assessment).

Learning Activity 1

30 minutes

A. Choose the letter of the best answer.

1. In what year did Jean Baptiste Lamarck came up with his theory of evolution?

   a. 1808 b. 1858

   c. 1809 d. 1859

2. Charles Darwin was from:

   a. France b. Ireland

   c. Britain d. Scotland

3. Who is credited for “The Theory of Evolution by Natural Selection”.

   a. Isaac Newton
   b. Alfred Wallace
   c. Charles Darwin
   d. Jean Baptiste Lamarck

4. The same group of species that live in one area is called a _____.

   a. genus b. family

   c. species d. population

5. Who proposed the other “Theory of Evolution”?

   a. Isaac Newton
   b. Alfred Wallace
   c. Charles Darwin
   d. Jean Baptiste Lamarck

B. Write either true or false from the statements given.

1. The “Theory of Evolution by Natural Selection” occurs from one generation to the next generation.

   (True/False)

2. One individual organism is known as a population.

   (True/False)

3. The “Theory of Evolution by Natural Selection” is testable and observable.

   (True/False)

4. A group of the same species of ants that live on the same tree can be regarded as a population.

   (True/False)

5. Jean Baptiste Lamarcks theory was based on evidence and proof.

   (True/False)

Thank you for completing your Learning Activity .1 Check your work. Answers are at the end of this module.

Evidence for Evolution

Evolution is a process by which plants and animals have changed (according to their environment) so that they are able to survive and continue their existence. Before Charles Darwin's time, many scientists speculated how evolution occurred and did not have any hypothesis that can be tested.

When Charles Darwin came up with his revolutionary "Theory of Evolution by Natural Selection", there was finally a logical explanation and a theory that could be observed. Since then the branch of evolution has grown and evidence for evolution widened to encompass many other evidence.

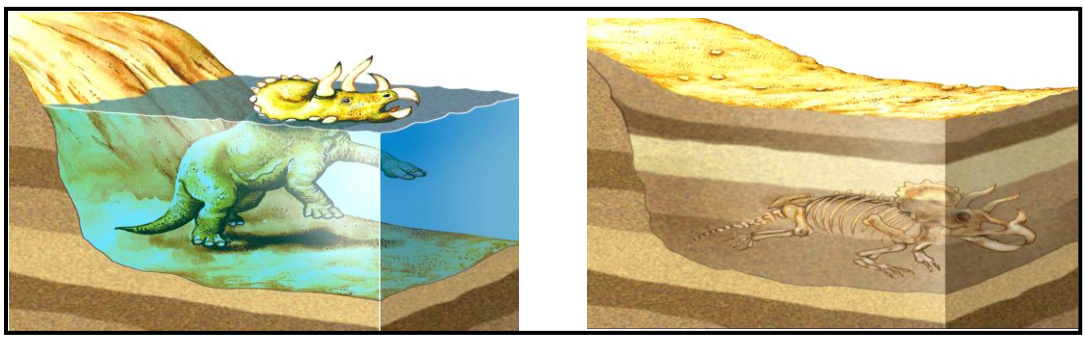
Evidence that plants and animals do change (evolve) over many generations come from several sources. These sources include:

1. Fossil Record
2. Transitional Fossils
3. Comparative Biochemistry
4. Comparative Anatomy
5. Bio-Geographic Distribution
6. Bio-Geographic Isolation
7. Hybridisation

1. The Fossil Record

Plants and animals that are buried underground without air become fossilised. Under these ideal environments bones and living tissue can become preserved for thousands and even millions of years. There are preserved remains of plants and animals (under the right condition) will become preserved or fossilised.

Fossilization is the process by which the body of the organism is preserved. People who dig up these remains and study them are called **paleontologists**. The preserved remains of organisms will give us a clue as to what plants and animals existed hundreds of millions of years ago. Below are preserved remains of a dinosaur



A dinosaur trapped in the water. Under the right conditions the skeleton of this dinosaur was preserved. This is known as fossilisation.

There are two types of evidence that comes from the fossil record.

A human body that was preserved in ice under the right conditions.

(a) Direct evidence

These are fossil evidence such as bones of animals, leaves and shells of marine dwelling creatures buried millions of years ago.

Ocean creatures that die under layers of sand and sediment can (in the right condition) become preserved.

In certain situations if air is present the remains of the organism can decay leaving an imprint or hole in the sediment.

The hole in the sediment is called a **mould**. If the mould is filled in to take shape of the mould, a three-dimensional model of the actual organism can be formed. This is called a **cast**, as shown in the picture on the right.

A natural cast that have formed when flowing water removed most of the tissue from this organism.

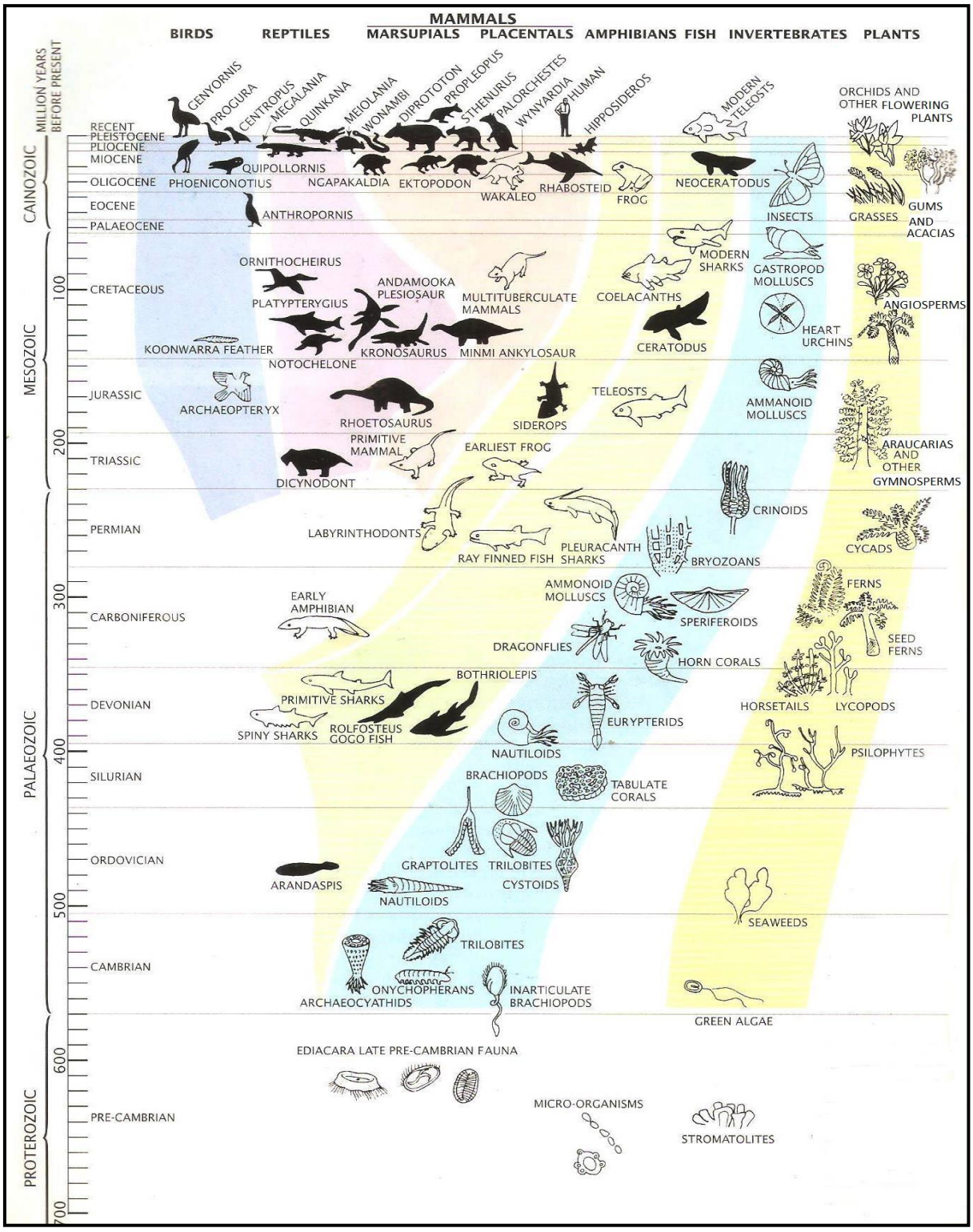
(b) Indirect evidence

These are fossil evidence such as footprints, holes, tooth and hand marks. Indirect fossils are called **trace fossils**. Examples of trace fossils include dinosaur footprints from dried river beds.

The fossil record shows that different organisms lived at different times after the formation of the Earth until present time.

Footprints of an animal millions off ago.

The diagram below is an example of different species living at certain time interval known as the **law of fossilisation**.



It consistently shows that certain organisms only appear at a certain time and not at any other time. This is known as the "**law of fossil succession".**

For example:

- Uni-cellular organisms (microbes) appeared first before multi-cellular organisms.
- Simple organisms appeared first before complex organisms.
- Marine organisms appeared first before amphibians (such as frogs).
- Amphibians appeared first before land dwelling creatures such as reptiles.
- Reptiles appeared first before birds.
- Reptiles appeared first before mammals.
- Poikilotherms (cold-blooded animals) appeared first before Homiotherms (warm-blooded animals).
- Ferns appeared first before flowering plants.

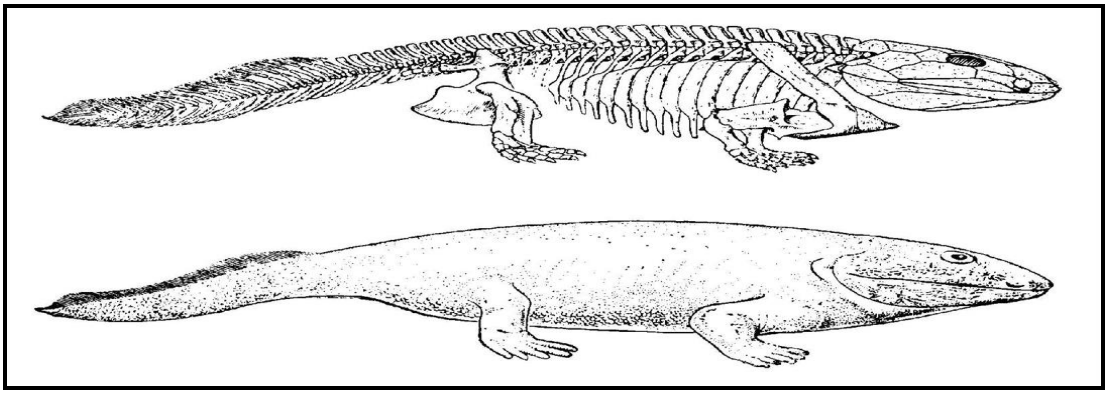
This is usually the sequence found in the fossil record. If this is the sequence then the progression is from simple organisms to complex organisms; soft body organisms to hard body organisms or small organisms to large organisms.

2. Transitional Fossils

Fossil records show a progression from simple organisms to complex organisms over millions of years. Then it should be expected that there should also be organisms (species) that would connect the gap.

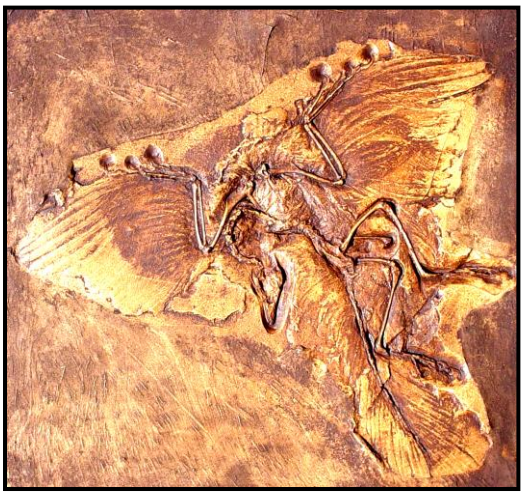
For example, there should be fossil records that connects:
(1) sea dwelling creatures to land dwelling creatures.
(2) land dwelling creatures to air dwelling creatures.
(3) uni-cellular organisms to multi-cellular organisms and so forth.

These types of fossils would be known as **transitional fossils** because they are the link. The diagram below shows a sea dwelling creature to a land dwelling creature.



An animal that existed during the times of the dinosaurs. If you look closely you can see that it has a tail of a fish and legs of an amphibian. This was a transitional fossil that linked fishes to amphibians.

The very first evidence of transition fossils came in 1861, in Germany in a place called Bavaria. In the law of fossil succession it is believed that birds evolved from reptiles. The fossil uncovered in Bavaria seemed to show a bird but had bones of a reptile. The bird was named *Archeopteryx*. Archeopteryx had teeth in its beak, claws at the end of its wings and a tail that had many joints.



The first transitional fossil (*Archeopteryx*) that showed a link between the reptiles and birds.

3. Comparative Biochemistry

Comparative biochemistry (physiology) deals with the makeup and functions of the organism's body, and similarities between different species. When comparing different species physiology, there are two (2) main points that are looked a.

(i) The makeup of their proteins

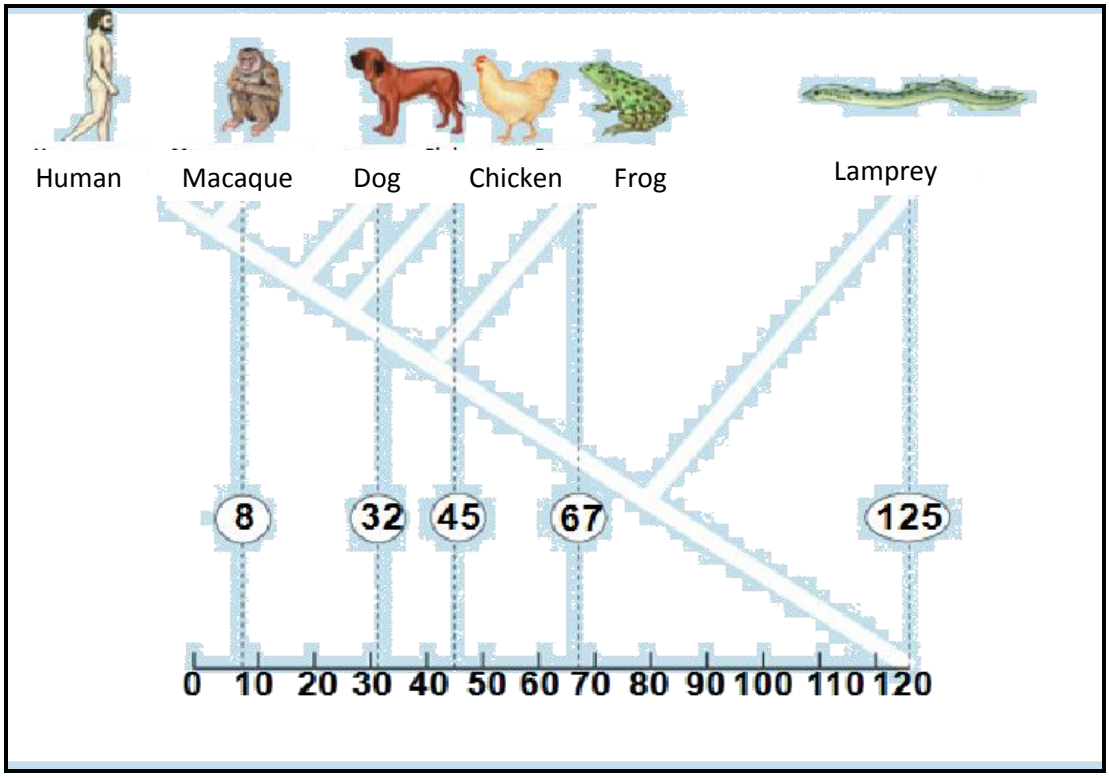
Proteins are part of the chemical composition of all living organisms. Organisms are also made up of fats (lipids), carbohydrates (sugars), and minerals such as salt (Na+), vitamins and water.

By comparing how the proteins are similar, you can tell how closely related different species really are. Thus, if the species are closely related to evolution then the makeup of proteins must be similar as well.

(ii) Composition of proteins

Proteins are made up of tiny structures called **amino acids**. There a total of 20 amino acids. Eleven (11) amino acids are produced in our own bodies so they are called **non-essential** amino acids and nine (9) amino acids are taken in by eating various foods and are called **essential** amino acids.

All organisms, whether simple or complex will have all these 20 amino acids in their bodies. For example, two species that are closely related will have very similar proteins with fewer differences, when comparing sequence of amino acids, then species that are distantly related.



The difference between a human blood pigment (haemoglobin) and five other organisms' haemoglobin. The closer the organism is to humans the less difference there is in the human protein sequence.

(ii) DNA structure

This is the structure that contains the information for the makeup of an organism. If two different species of DNA are compared the similarities will be based on the sequence of the DNA. The less differences in the DNA sequence, the more related they are.

4. Comparative Anatomy

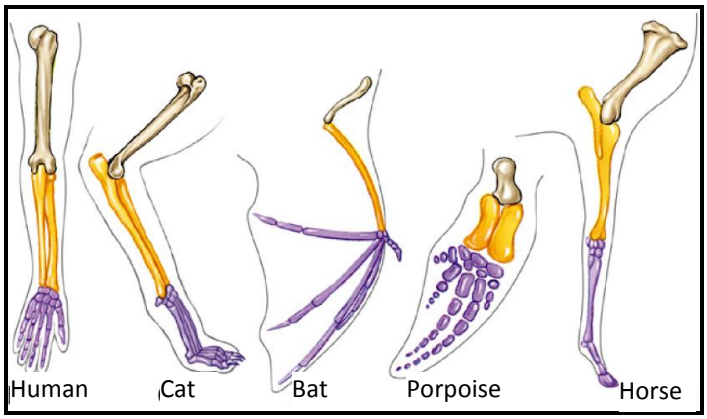
This is dealing with the structure of the body and how similar different species are. When comparing anatomy of different species there are four (4) things paleontologists look at.

- **Homology** (how similar are they in structure)

  When dealing with homology, it is the bones that are studied and how similar they are. The more similar bones two different species have in their shape the more related they are. For example;

  i) A bat.
  ii) Whale.
  iii) Cat.
  iv) Horse.
  v) Human limbs.

All these five different species have limbs for different purposes. A bat would use its' limbs for flying. A whale would use its' limbs for swimming. A horse would use its' limbs for walking or running and a human would use its' limbs for walking, running or swimming. Even though, the limbs have different functions their structures are all the same. It means they all come from one common ancestor. They all are classified as mammals. The five (5) limbs of the different species are said to be **homologous structures**. Even though they have different functions they all belong to the same common ancestor.



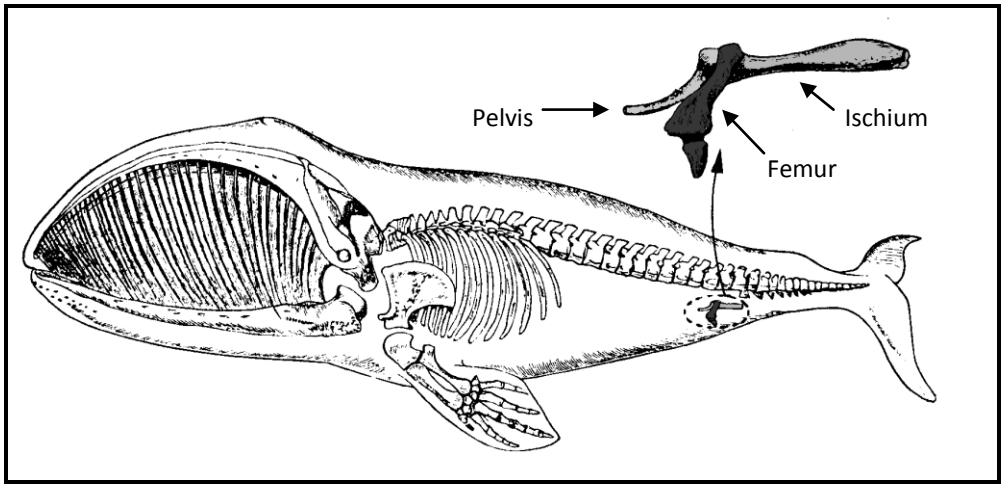
There are similarities in the limbs of these different animals. They all share one common ancestor even though the limbs are used for different purposes.

- **Analogy (similar in body function).**
  Analogy deals with how parts of the body are used between different species. For example, a bat's and bird's wings. A bat's wings and a bird's wings come from different ancestors but both use their wings for flying.

  A bat is a mammal and most mammals are land dwelling creatures. However, a bat is a mammal that flies. Birds fly so they are air dwelling creatures but the bat evolved to use its limbs as wings. So even though, a bat comes from land dwelling creatures because it uses its' limbs for flying, it is analogous to a bird's wings. This is known as **analogous structures**.

- **Remnant/Vestigial organs**
  They are organs that are a part of the organism that are no longer in use. That can be used to determine the relatedness of different species.

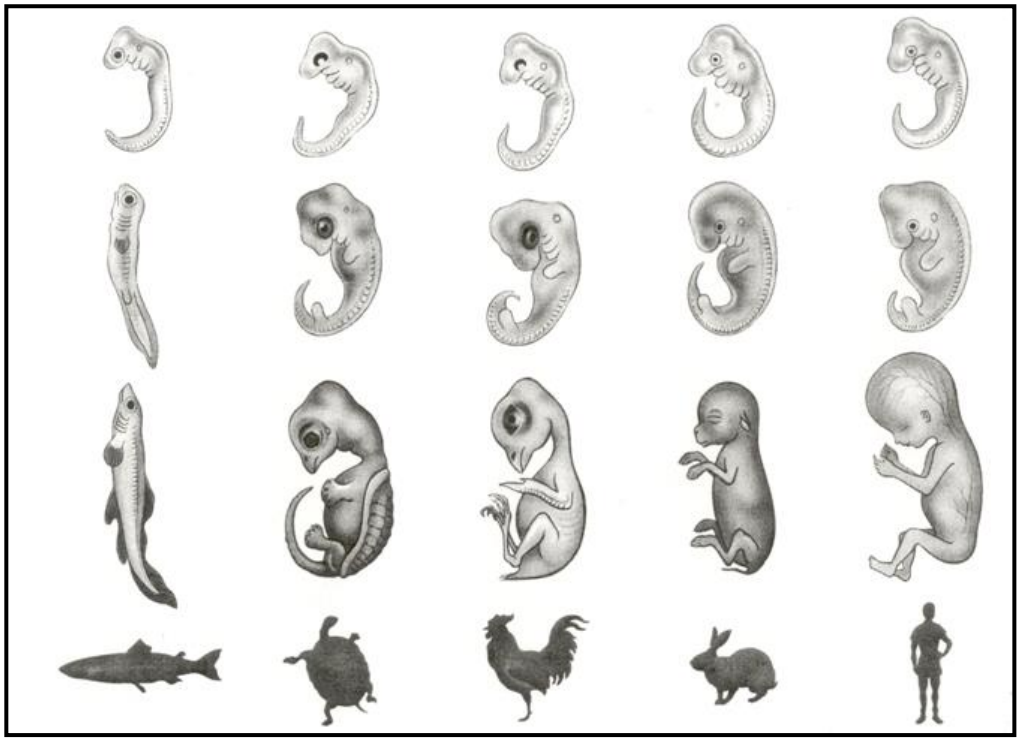
  For example, the bone structures of the front flippers of a whale contain bones of limbs that exist in mammals such as cows. The bone structure of the front flippers does indeed contain bones of limbs that exist in mammals such as cows. This shows that whales evolved from mammals to become marine dwelling creatures.



A whale with a pelvis, ischium, and femur (thigh bone) that are present in modern day mammals, but in this case are not being used. This clearly shows that whales descended or came from mammals or it has remnant organs that are not being used anymore.

- **Embryos**

  During the early development of organisms inside the womb of the mother embryos are present. Embryos are fertilized eggs that have taken the shape of the organism in its very early stages. In this case the embryos of different species can be compared to determine the relatedness of different species. The more similar in the shape the embryos are the more related two different species are. The diagram below shows examples of embryos of organisms in their early stages.



Embryos of fish, turtle, chicken, rabbit and humans.

5. Bio-Geographic Distribution/Isolation

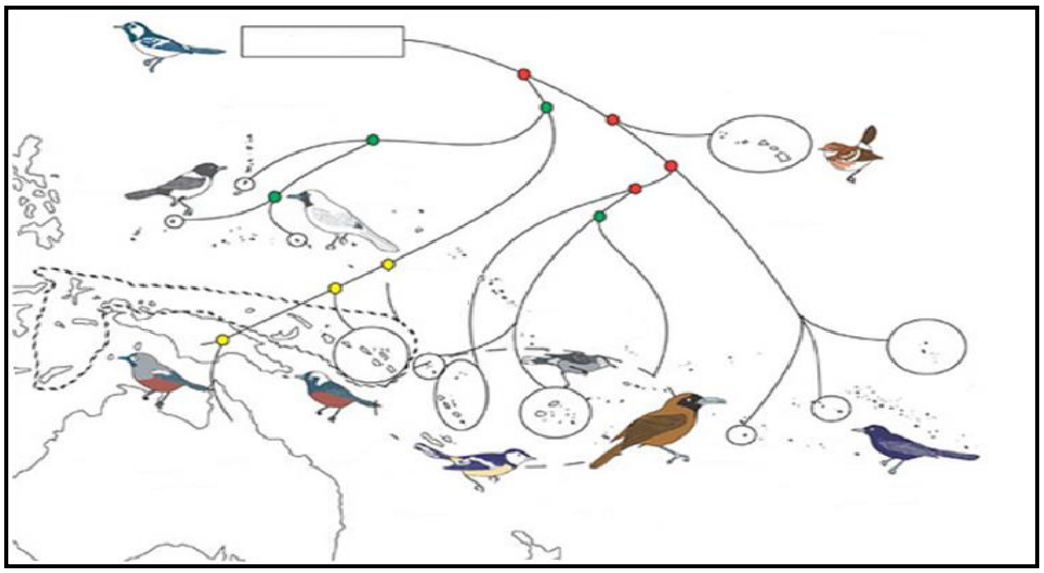
Bio-Geographical Distribution/Isolation relates to how plants and animals are located in certain geographic areas and this could lead them to become new species. They are the same species but because they are located in different regions the food they are exposed to will minutely change their feature. Over millions of years this change in features will eventually result in an entirely new species.

For example, the tawny frogmouth (Podargus *strigoides*) bird. It leaves in the woodlands of Australia. However, the northern woodland birds are small and pale in colour, than those from the south. We could assume that there is not a lot of food in the northern woodlands. This may lead to the birds in the north being smaller. Both the northern and southern birds are related but because of food availability the northern bird is smaller and paler in colour.

6. Geographic Isolation

Geographic isolation is similar to distribution however; an organism becomes a new species because it becomes isolated from the original group. This can occur when an organism travels out from where it was and is unable to return because of physical barriers such as mountains, oceans and rivers.

For example, as shown in the diagram below, a bird flying from one island to another. On the other island if it finds a lot of food, it may want to stay on this island. It may not want to travel back because of the distance and ocean isolating this island so it remains on this island.



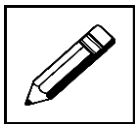
A bird species evolving over millions of years. When you study where it came from, you can see how bio-geography isolation causes variations in species.

Furthermore, because of the type of food it has to recover it may develop a different type of beak. If the food source is found in flowers the finch may develop long slender beak. If the food source is food in nuts it may develop a strong hard beak. So because of the food source it may change its variation according to its beak. This is known as **geographic isolation**.

7. Hybridisation

Hybridisation is basically the pairing of one allele from a different source and another allele from another source to create a new gene.

For example, taking an allele from a red and white colored frangipani to produce a pink one.



Learning Activity 2

20 minutes

A. Choose the most appropriate answer from the four (4) options.

1. Evidence of how plants and animals change over many generations comes from ____ sources.

   (a) 4 (b) 5

   (c) 6 (d) 7

2. Which evidence shows links between one species and another closely related species?

   (a) Fossil Evidence
   (b) Transitional Fossils
   (c) Comparative Anatomy
   (d) Comparative Biochemistry

3. Which evidence shows the relatedness of different species that come from one location and nowhere else in the world?

   (a) Fossil Evidence
   (b) Transitional Fossils
   (c) Bio-Geographic Distribution
   (d) Comparative Biochemistry

4. Which evidence shows the similarity in structure but difference in function?

   (a) Analogous Structure
   (b) Homologous Structure
   (c) Comparative Anatomy
   (d) Comparative Bio-chemistry

5. The process by which organism's bodies become preserved is known as _____.

   (a) moulds (b) casts
   (c) fossilisation (d) trace fossils

B. Encircle True if the statement is true and False if the statement is false..

1. A bat's and bird's wings are similar in function but come from different ancestors. This is an example of homologous structures.

   (True/False)

2. Limbs that were used before but are unused now are examples of remnant organ.

   (True/False)

3. The makeup of proteins and how two different species are related is an example of comparative anatomy.

   (True/False)

4. Archeopteryx is an example of a remnant organ.

   (True/False)

5. The makeup of DNA between two different species is an example of comparative anatomy.

   (True/False)

Thank you for completing your Learning Activity 2. Check your work. Answers are at the end of this module.

12.4.2 Mechanisms of Evolution

Evolutionary Agents: Random, Non-Random Mating and Mutation

Evolutionary agents are methods in which evolution can take place. It is the building blocks upon which organisms evolve over time.

(1) **Random Mating**

Random mating occurs without selection and many hundreds of thousands of offsprings are produced at any given time. This is done because there are predators out there that would like to feed on the offspring. If thousands are produced than the likelihood of a good number developing into adults is greater.

For example, sea anemones producing both sperm and eggs in the ocean, create many offspring's. Some of these offspring's maybe eaten but because thousands of sex cells were produced the chances are greater that a good number will develop into adults later on.

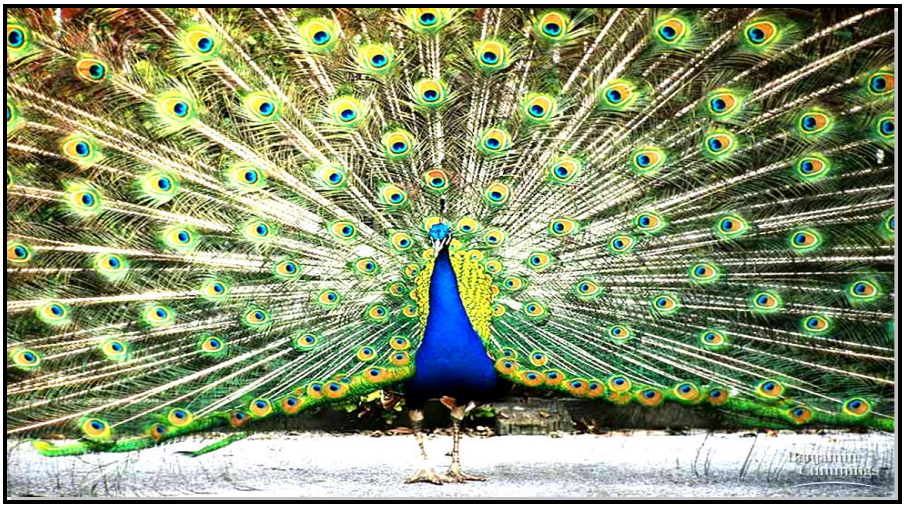
(2) **Non-Random Mating**

Non-random mating means the individual organism (specie) gets to choose which partner it wants to mate with.

For example, our Reggiana Bird of Paradise is one of the most beautiful species of birds found in the world. The brightly coloured bird that symbolises Papua New Guinea flag and many government departments is actually the male bird. The more colour the male Reggiana bird can display during mating season, the greater its chances of mating. The females get to choose which bird it mates with based upon the colours displayed.

This is an example of non-random mating because mating is based on a certain criteria. It can have an impact on evolution. The more brightly coloured the male Reggiana bird is the chances are it will pass on it's genes to the next generation. Those male Reggiana bird that are not as brightly coloured will not be successful and the likelihood of their genes being pass on to the next generation are very slim or not at all.

In three (3) or four (4) generations the less colourful male birds might disappear leaving only the most colourful of the species. Other examples are peacocks (in which the male bird also portrays its colours during mating) and humans.



A peacock displaying its colourful feathers. For peacocks it is the male that displays its colours for female to choose the most colourful partner before they mate.

(3) **Mutation**

Mutation is the change in the DNA sequence that over many millennia can cause evolution (change in an organism). Mutation is an evolutionary agent because it does determine what genes get to be passed on over many generations. It is important because a change in an organisms DNA sequence can have an impact on the organism. To understand what mutation is, let us look at what makes up all living organisms.

Organelles such as the nucleus contain structures called chromosomes. Within these structures are our genetic material called DNA. DNA is composed of structures called bases. There are a total of four bases. There is Adenine, Guanine, Cytosine and Thymine.

Remember DNA is a “double helix” so on one side of this so called ladder you will find one base and on the other side you will find the other base. The bases also combine in a particular order. Guanine always attaches itself with Cytosine while Adenine always attaches itself with Thymine. How these pairs of bases combine will also show up in the features of an organism.

Let us say in fruit flies the normal color they display is purple and the DNA sequence for that color is G-C, A-T, T-A and C-A. In the population if one individual is borne and its’ DNA sequence is changed to G-C, A-T, T-A and A-C, then as a result its’ color is orange. The last code has changed from C-A to A-C and as a result has caused this particular fruit fly to have an orange color. If this particular fruit fly mainly eats pawpaw then the purple colored fruit fly will be vulnerable to predators because predators like green frogs will be able to see them as they are feasting on pawpaw.

The purple colored fruit flies will decrease in numbers over many generations because their color makes them more susceptible to birds then the orange colored fruit flies.

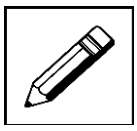
The orange colored fruit flies will increase in numbers, over many generations because they will be able to pass on their genes to the next generation. In this scenario a mutation has occurred that had a beneficial effect on the population of the species. It is beneficial for the orange colored fruit fly.

Mutation can be caused by several factors but is divided into two parts. If the agent that caused the mutation cannot be identified then it is known as a **spontaneous mutation**. If the mutation can be identified then it is called an **induced mutation**. Substances that cause mutations are radiation, x-ray, ultra-violet radiation, nuclear radiation and certain chemical substances. These agents can also be called **mutagenic agents** or **mutagens**.

In terms of mutations there are four (4) types of mutations that occur.

1. **Substitution**
   Substitution occurs when one base is replaced by another base. For example, the gene sequence TAGC and after mutation TATC. The "G" is replaced by the "T".
2. **Addition**
   Addition occurs when one base is replaced by one or more basis. For example, the gene sequence AAT and after mutation AGCAT. The "GC" were added between the two A^{s}'.
3. **Deletion**
   Deletion is the removal of one or more bases. For example, the gene sequence GCATAC and after the mutation GCAAC. The "T" is removed from the original sequence.
4. **Alteration**
   Alteration occurs when one or more bases are replaced by another base but on the same strand. For example, GCA and after the mutation GAC. The AC was swapped with CA from the original strand.

It is now time for you to complete Learning Activity 3. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 1 (which you will send in for assessment).



Learning Activity 3

20 minutes

A. Choose the letter of the best answer.

1. Which example is NOT an agent of change (evolution)?

   (a) Mutation (b) Random Mating

   (c) Non-Random Mating (d) Survival of the Fittest

2. The Bird of Paradise mates by:

   (a) Mutation (b) Random Mating

   (c) Non-Random Mating (d) Survival of the Fittest

3. Guanine combines with _____ while Adenosine combines with _____.

   (a) Cytosine, Adenosine (b) Adenosine, Guanine

   (c) Cytosine, Thymine (d) Thymine, Guanine

4. There are a total of ___ bases in all DNA.

   (a) 3 (b) 4

   (c) 5 (d) 6

5. How many naturally occurring or unnatural mutations are there?

   (a) 1 (b) 2

   (c) 3 (d) 4

B. Encircle True if the statement is true and False if the statement is false.

1. There are four (4) types of mutations in the DNA sequence that can occur.

   (True/False)

2. Spontaneous mutation is a mutation that is caused by mutagenic agents.

   (True/False)

3. Alteration is the replacement of one or more bases by an outside base.

   (True/False)

4. DNA is a double helix ladder.

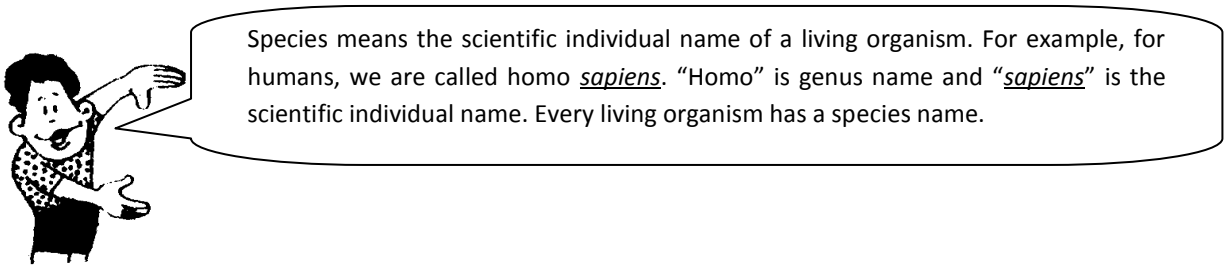
   (True/False)

5. Being exposed to an explosion by an atomic bomb is an example of a mutagenic agent that can cause mutation in the DNA sequence.
(True/False)

Thank you for completing your Learning Activity 3. Check your work. Answers are at the end of this module.

Mechanisms of Evolution

The "Theory of Evolution by Natural Selection" was proposed by Charles Darwin. The theory states that evolution or change in **species** occurs due to **Natural Selection** over many generations**.**



The phrase natural selection can also mean **survival of the fittest**. It means any species is able to reproduce to carry on its desirable traits to the next generation. This is how traits that are desirable pass on to the next generation. These traits mean any features (body parts) that help a species to survive in its environment it lives in.

For example, if two different coloured (white and black) moths (large butterflies) living next to a factory that gives off large amounts of smoke. If the smoke is black in colour it will affect the environment that the moths live in. The moths' predators are small birds that live there as well. If the environment is covered in black smoke then only the white moths are seen. The birds can easily see them.

The black moths are difficult for the birds to see. The black moths are able to pass their genes to the next generation. Most of the white moths are eaten by the birds. Less of their genes are passed onto the next generation.

Therefore, the black moths have a desirable trait that helps them to survive in the environment it lives in. They are able to pass on their genes to the next generation. The black moth has the fittest gene. This is known as the **survival of the fittest**. It is a mechanism that enables natural selection in animals.

Natural selection is only one out of several mechanisms that help evolution or change occur over generations. These other mechanisms that make change (evolution) possible are:

- Descent with modification
- Migration (gene flow)
- Genetic Drift

1. Descent with Modification

Organisms become what they are from their parents through a process known as Descent with Modification. This type of mechanism involves how genes are passed on from one generation to the next.

For example Figures A, B, C and D are of two different coloured beetles. One is green in colour and another brown in colour. The green beetles outnumber the brown beetles in this population (Figure C). The leaves they feed on become less because of a drought (Figure A).

After some generation the beetles' size begins to shrink due to a lack of leaves (Fgure B). Some more generations later the brown colored beetles outnumber the green colored beetles (Figure D). The brown coloured beetles later on were able to pass on their gene to the next generation and the generations afterwards.

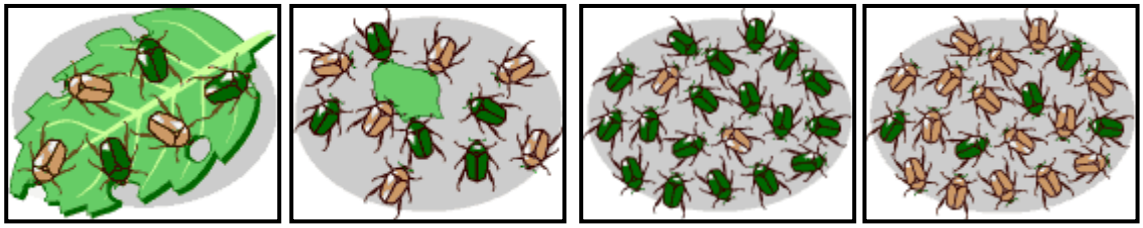
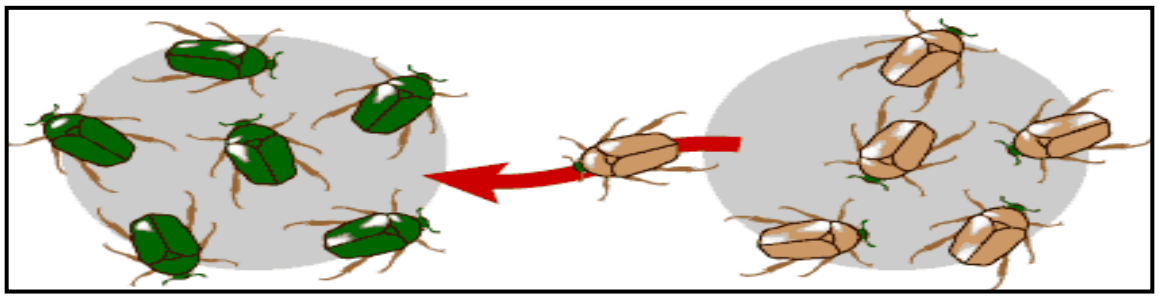


Figure A Figure B Figure C Figure D

Suppose there is group of penguins living on one island. The penguins composed of black and white penguins. The black penguins outnumbered the white penguins. If there is a snow storm most black penguins would die because they do not have the thicker layer of skin that the white penguins have. Overtime, the white penguins will outnumber the black penguins. This is an example of how genes are passed down from one generation to the next.

2. Migration (Gene Flow)

Migration is the movement of organisms from one place to another. An organism moving out of an area is called **emigration** and an organism moving into a new area is called **immigration**.



Brown coloured beetle moving from one population to the next population.

This is important to understand because of the genes that are either moving into an area or moving out of an area. An area where a population of the same species lives (and the genes they have) is called a **gene pool**. The flow of genes emigrating or immigrating is described as **gene flow**.

Gene flow creates genetic variation in species. **Genetic variation** is the small differences within the same species. It leads to changes in organisms over many generations. When it comes to genetic variation it comes down to two factors.

I. Environmental Factors

Twins may have identical genes, but if one is brought up in a different environment than the other twin then the features are different. One twin can be much slimmer than the other. The slimmer one may not be eating enough food hence is slimmer than the other.

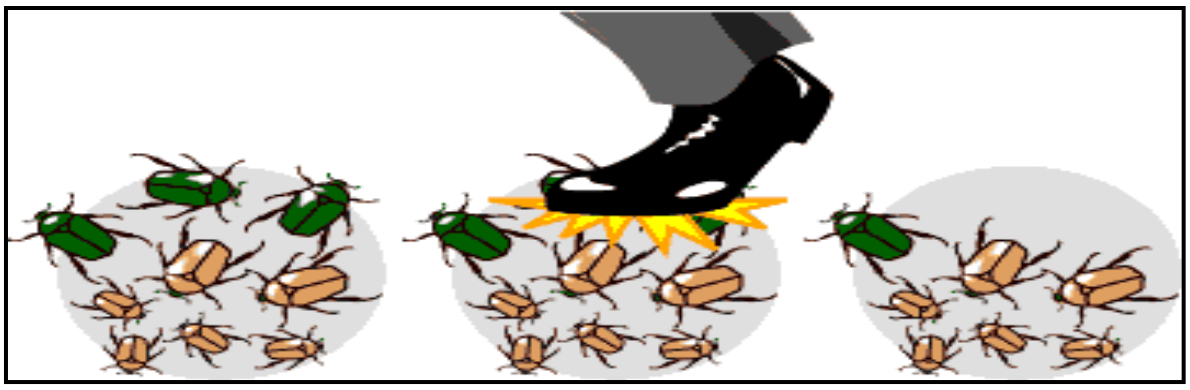
Another example would be one group of species of birds living in the Australian woodlands. The bird living up north may be smaller and paler than the one down south. This may be due to the food shortage up north so even though both birds are the same species but because of the environmental factor (which is food) the bird up north is slightly different in its' variation then the one down south.

II. Genetic Factors

A number of genetic factors can cause genetic variation. The most significant genetic factor is **mutation**. Mutation is the change in the genetic code that can cause a change in an organism's physical appearance or bodily processes (physiology). NB: Review on previous topic on mutation.

3. Genetic Drift

Is the chance event that some genes from one population continue to spread to another area. Generally, the smaller the population the greater the effects of genetic drift. If the population is small then the loss of genes that help the species continue to the next generation decreases in numbers. If there is only one or two of the species then extinction is likely.



Two coloured beetles: One green and one brown beetle. When squashed, most of the green beetles are squashed, except for one. That one green beetle moves from that population to another population. The movement of that single black beetle to another population was by chance and would have effects on the other population. This is an example of genetic drift.

If these small numbers in the population succeed in reproducing the next generation maybe very different from the previous generation. This is called the **bottleneck effect**.

For example, a small pond may hold two varieties of fish. One fish is coloured red while the other fish is coloured yellow. In this pond most of the fish is coloured yellow. When someone throws his net into the pond, most of the fish caught are red in colour. Therefore, the fish caught is not representative of the population.

If the fisherman decides to create a fish nursery with only yellow fish then obviously most of them will be yellow. The yellow fish then is called the **founder population**. After a while when this fish population increase in numbers most of them will become yellow. The unrepresentative population of mostly yellow fish that was nursed and increased in numbers is known as the **founder effect**.

It is now time for you to complete Learning Activity 4. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 1 (which you will send in for assessment).

Learning Activity 4

20 minutes

A. Choose the letter of the best answer.

1. Which example is NOT an agent of evolution (change)?

(a) Embryos

(b) Mutation

(c) Mutagens

(d) Genetic Drift

2. A population of the same species that contain different numbers of genes is known as a _____.

   (a) gene pool (b) genetic drift

   (c) genetic factors (d) genetic variation

3. The chance event that a few genes continue to pass their genes to the next generation is known as _____.

   (a) genetic drift (b) founder effect

   (c) bottleneck effect (d) founder population

4. When a few of the population's genes, after a disastrous event, pass their genes onto the next generation then this is called _____.

   (a) genetic drift (b) bottleneck effect

   (c) founder effect((d) founder population

5. The movement of genes from one population to the next population or vice versa is generally known as _____.

   (a) migration (b) emigration

   (c) immigration (d) outward and inward flow

B. Encircle True if the statement is true and False if the statement is false.

1. The general movement of animals in and out of one population and another population is called gene flow.

   (True/False)

2. The movement of a representative population to a different population is called founder population.

   (True/False)

3. The increase of an unrepresentative population in a different location is known as the founder effect.

   (True/False)

4. Environmental and genetic factors are agents of genetic variation.

   (True/False)

5. The change in organisms body make up as they pass their genes to the next generation is called genetic drift.

   (True/False)

It is now time for you to complete Assignment 4 and Practical Activity 4 in your Assessment Book 4.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

SUMMARY

You will now revise this module before doing **SUMMATIVE TEST 4**. Here are the main points to help you revise. Refer back to module topics if you need more information.

- Lamarck's theory stated that traits were acquired during the lifetime of that organism and were passed onto the next generation.
- Charles Darwin was the first to propose the "Theory of Evolution by Natural Selection". It stated that traits were acquired by certain agents. These traits are only seen after many generations.
- Charles Darwin's theory can be testable and observable.
- A population is made up of many of the same species.
- A species is an organism that can mate with itself and produce a fertile offspring.
- Evidence that organisms evolve (change) over millions of years comes from:
  - Fossil evidence
  - Transitional fossils
  - Comparative Bio-chemistry
  - Comparative Anatomy
  - Bio-Geographic Distribution
- The process by which organisms bodies become preserved over thousands and millions of years is called fossilisation.
- Two types of evidence that comes from fossils are:
  - Direct evidence
  - Indirect evidence
- A mould is a hole in sediment. It can be filled up to create a 3-dimensional model of an organism. The 3-dimensional model of the organism is called a cast.
- Footprints, tooth marks of organisms millions of years ago are examples of trace fossils.
- How fossils are arranged from simple soft bodied organisms to complex hard bodied organisms in the fossil record is known as the "Law of Fossil Succession".
- Poikilotherms are warm-blooded animals while homiotherms are cold-blooded animals.
- Fossils that show a link between closely related species are called transitional fossils.
- Comparative bio-chemistry deals with the how the organism functions and what the organism is made up of.
- Comparative bio-chemistry deals with the protein make up of organisms and the DNA make up of an organism and the similarities between species.
- Comparative anatomy looks mainly at the bone structure and the similarities between species.

- If two different species have the same common ancestor, but different function then it is known as homologous structures.
- If two different species have different ancestors, but same function in their structure then it is called analogous structure.
- Comparative anatomy deals with homology, remnant organs, analogy and embryology
- The distribution of plants and animals and how they can only be found in one place only, and nowhere else in the world can be used to determine relatedness. This is known as bio-geographic distribution.
- Non-random mating and mutation are examples of mechanisms of evolution.
- Non-random mating involves partners choosing which characteristics it wants before mating.
- Mutation is the change in DNA sequence over millions of years.
- Mutation can be forced (induced mutation) or occurs naturally (spontaneous mutation).
- Agents that cause mutation to occur are called mutagenic agents or mutagens.
- In terms of the change in the DNA sequence there are four (4) types of mutations that can occur:
  - Substitution
  - Addition
  - Deletion
  - Alteration
- Other mechanisms of change include:
  - Descent with modification
  - Migration (gene flow)
  - Genetic drift
- Descent with modification simply means the ability or fitness or survivability of an organism to pass its genes to the next generation, thus creating a small change of many generations.
- Organisms can mean both plants and animals.
- Migration is the both the coming in and going out of organisms from a population. Migration can also be known as gene flow.
- Emigration is the exit of organisms from a population.
- Immigration is the entry of organisms into a population.
- A population is made up of many of the same species. Each species contain its own genes and together it is called a gene pool.
- The small differences within the same population, like the difference in colour, are known as genetic variation.
- The chance event, after a disastrous event, that a small population is still able to pass on their genes to the next generation is called genetic drift. If this small population is unrepresentative population begins to increase in numbers then is called the bottleneck effect.

- Let us say if there were two groups of penguins white and black then the predominant population were the black penguins. If a few white penguins were to travel to a different island and started a small colony there, those white penguins would be called the founder population. The small colony that would have resulted from that founder population would be called the founder effect.

NOW DO SUMMATIVE TEST 4 IN YOUR ASSESSMENT BOOK AND SEND IN TO THE PROVINCIAL COORDINATOR FOR MARKING.

ANSWERS TO LEARNING ACTIVITIES 1-4

Learning Activity 1

A. (1) (c) (2) (c) (3) (c) (4) (d) (5) (d)

B. (1) True (2) False (3) True (4) True (5) False

Learning Activity 2

A. (1) (d) (2) (b) (3) (c) (4) (c) (5) (c)

B. (1) True (2) True (3) False (4) False (5) False

Learning Activity 3

A. (1) (b) (2) (c) (3) (c) (4) (b) (5) (d)

B. (1) True (2) False (3) False (4) True (5) True

Learning Activity 4

A. (1) (a) (2) (a) (3) (a) (4) (d) (5) (a)

B. (1) True (2) False (3) True (4) True (5) False

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21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General/Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics -General/Advance	Mathematics -General/Advance	Mathematics –General/Advance
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.