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2019/20 Academic Year 3nd Quarter Biology **Handout on Evolution** for Grade 12 students.

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Unit 4: EVOLUTION

Introduction to Evolution

Evolution:

It is the slow change and gradual development of living things from simple ancestral forms through a long period of time. It does not refer to changes that occur in an individual within its lifetime. Instead, it refers to changes in the characteristics of populations over the course of generations.

Evolution - is the gradual and heritable change of population through time.

- is the most comprehensive science in biology.
- may be defined as the development of differentiated organisms from pre-existing, less differentiated organisms over the course of time.
- defined as the accumulation of inherited changes within populations over time.
- describes how life originates and develops into various forms
- the process of evolution is illustrated by two theories namely: chemical evolution and organic evolution. The five main evolutionary mechanisms are:



a. The ultimate source of variation. Individual mutations occur so rarely that mutation alone usually does not change allele frequency much.

b. A very potent agent of change. Individuals or gametes move from one population to another.

c. Inbreeding is the most common form. It does not alter allele frequency but reduces the proportion of heterozygotes.

d. Statistical accidents. The random fluctuation in allele frequencies increases as population size decreases.

e. The only agent that produces *adaptive* evolutionary changes.

Figure 20.4 Five agents of evolutionary change. *a.* Mutation, *(b)* gene flow, *(c)* nonrandom mating, *(d)* genetic drift, and *(e)* selection.

Chemical evolution: explains the formation of complex organic compounds from simpler chemical elements or compounds. This principle attributes the origin of life on earth to the formation of complex organic compounds such as the DNA molecules that are capable of producing themselves.

Organic evolution: is concerned with the evolution of populations of living organisms by way of a continuous and irreversible process of change. The change takes place in the heritable characters of organisms through successive generations.

Micro- evolution: - occurs on small scale within a single population.
- is the change in the relative frequencies of alleles in the gene pool of a population.
- is changes in gene frequencies within a population.

Macro – evolution: - large evolutionary change such as the evolution of one species into two.
- brings phenotypic changes at species and higher levels of taxonomy.
- **punctuated equilibrium** is the most cited mode of macro – evolution.

4.1 The Origin of Life

4.1.1 Special creation theory: attributes the origin of life to a divine event that was masterminded by the supernatural being **God.**

4.1.2 The theory of spontaneous generation (Abiogenesis): states that life has originated from non- living organic matter abiogenetically. Some of the supporters of abiogenesis were Aristotle, Needham, Van Helmont etc. The theory of spontaneous generation was first disproved by **Francesco Redi**. Louis Pasteur by his advanced experimental settings disproved the theory for the last time in the way that can convince scientists to accept **biogenesis** and to reject **abiogenesis**.

4.1.3 Theory of eternity of life (Biogenesis): - regards life as eternal as matter itself.
- life only changes its form but never created from dead (non-living) substance
- has no origin and has always existed. According to this theory life comes from life never from lifeless things, and different types of organisms have always existed on earth and shall continue to exist. However, the theory **does not explain how life originated in the beginning**.

4.1.4 Cosmozoan (Panspermia) Theory: hypothesize that meteorites or dust brought microorganisms to earth which then evolved to the diversity of life we see today.
- According to Coamozoan theory, resistant spores (cosmozoa) reached from other planets. In general, this theory asserts life as an extraterrestrial origin.

4.1.5 Biochemical theory of evolution (Oparin's theory): states that the first life is the result of a set of simple chemicals existed in the primitive Earth's atmosphere. Urey and Miller's experiment generated the primitive atmosphere under laboratory condition and showed the formation of organic molecules needed for the appearance of the first life. According to these scientists' thought life originated from water body as the

simple form of life. Fish → Amphibians → Reptiles → Birds → Mammals (when we consider the specific evolution of vertebrates according to this theory). The first life on earth is assumed to be heterotrophic and prokaryotic organism.

Summary of main steps in the origin of life according to Modern theory of Origin of life

1. Free Atoms	Hydrogen, Carbon, Nitrogen, Oxygen etc.
2. Formation of inorganic molecules	H_2, H_2O, NH_3, CO_2
3. Formation of simple organic molecules	CH_4, HCN, simple sugars, fatty acids, glycerol, amino acids, nitrogen bases (purines and pyrimidines)
4. Formation of complex organic molecules	Polysaccharides, fats, proteins, nucleotides, nucleic acids
5. Formation of protocell or protobiont	Coacervates and microspheres
6. Heterotrophic prokaryotes	Non photosynthetic and without organised nucleus
7. Autotrophic prokaryotes	Photosynthetic and without organised nucleus
8. Eukaryotes	With well organised nucleus

4.2 Theories of Evolution

4.2.1 Lamarck's theory of evolution

- was the first scientist to propose that organisms undergo change over time as a result of some natural phenomenon rather than divine intervention.
- According to Lamarck, a changing environment caused an organism to alter its behavior, thereby using some organs or body parts more and others less.
- his theory was based on how organisms (plants, animals) change during their life time and then pass these changes onto their offspring.
- He stated that the giraffes had a long neck. Because its neck grew longer during its lifetime, as it stretched to reach leaves in high - up trees, meaning that each generation of giraffe had a longer neck than pervious generations.
- States that evolution of living things has occurred due to: use and disuse of organs or structures and inheritance of acquired characteristics.
- As to him body parts that are not being used, such as the human appendix is gradually disappearing. Eventually, people will be borne without appendix. Over several generations, a given organ or body part would increase in size if it was used a lot, or shrink and possibly disappear if it was used less.
- Animals improve themselves to the changes in their environment.
- Lamarck stated that an organism changes during its life in order to adapted to its environment. These changes are passed onto its offspring.

- However, his theory is disproved by experiments such as **cropping of dog's ears**, but their puppies are still born with normal ear.
- According to him all organisms become more complicated over time, and therefore does not account for simple organisms, such as single – celled organisms.

4.2.2 Darwin's theory of evolution

- Darwin's theory, known as natural selection believed that organisms possessed variation (each individual was slightly different from another), and these variations led to some being more likely to survive and reproduce than others. That is why features that made an organism more likely to survive more likely appear to each generation.
- Darwin's theory would state that longer necked giraffes were more likely to survive, because they could eat leaves from taller trees as a result more long neck giraffes survive and then more long necked giraffes will be born which eventually caused all giraffes to have longer necks.
- Longer necked giraffes survived because they were a better fit for their environment. It is from this idea that we get the phrase 'survival of the fittest'.
- Though Darwin didn't know what genes were he could see their effect on natural selection.
- Darwin stated that changes in an organism during its life time (acquired traits) do not affect the evolution of species.
- He stated that evolution of living things has occurred due to natural selection in the struggle for survival.
- Darwin stated that nature invites more offspring from each species and permit them to struggle and select individual best fitted or adapted to the environment to reproduce.
- Darwin believed in the theory of **pangenesis:** the concept that states every organ produce very minute structures then later release to gonads for transmission to future generations but disproved.

4.2.3 Weismann's germplasm theory: August Weismann was the first person who made a definite distinction between heritable changes and those which cannot be inherited. He disproved the use and disuse theory of Lamarck and pangenesis concept. The theory states that all the heritable variations have their origin in germ cells and a new type of organisms arise only from changed type of germ cells.

- Germplasm thought to be the actual vehicle of heredity.

4.2.4 Neo- Darwinism

- ✓ Neo – Drwinism is generally used to describe any integration of Darwin's theory of evolution by natural selection with Gregor Mendel's theory of genetics.
- ✓ It can mean any new Darwinian and Mendelian based theory such as the current evolutionary theory. The term Neo –Darwinism marks the combination of natural selection and genetics as it has been variously modified since it was first proposed.

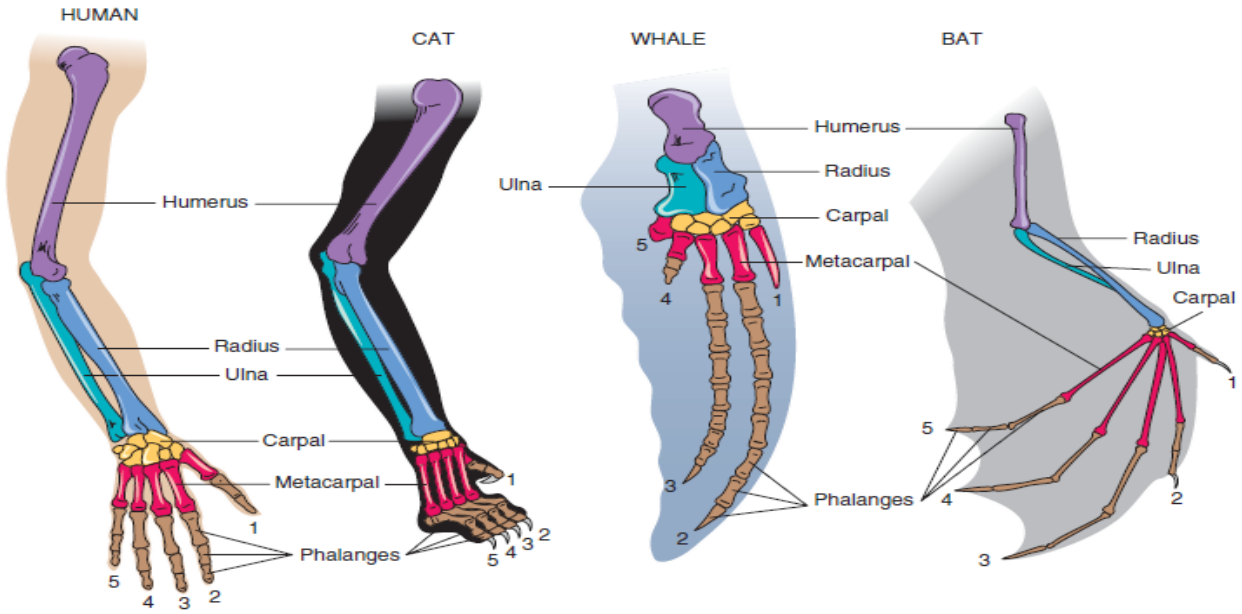
4.3 The Evidence for Evolution

A. Paleontology (Fossil record): displays that living things have different age of fossils as they appeared on earth at different times. the most direct evidence for evolution comes from the discovery, identification, and interpretation of fossils, which are the remains or traces typically left in sedimentary rock by previously existing organisms.

B. Comparative anatomy: shows that organisms may have either **homologous structure** or **analogous structure.**

Homologous structure: structures which have the same origin (common ancestor) but may or may not have the same function.

- Anatomically similar structures inherited from **a common ancestor** and have a common evolutionary origin; but may have different functions.
- have different functions because of their adaptation for different habitat (divergent evolution)
  - examples: - wings of birds and forelimbs of mammals



Analogous structure: structures those have different origin (have no common origin) but have the same function (same adaptation for similar habitat) what it is called convergent evolution.

- Examples: - wings of birds and wings of insects
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C. **Comparative embryology:** similar origin and development of embryos show common origin of vertebrates.

D. **Comparative biochemistry:** ancestrally related species show similar biochemistry and physiology because of common origin.

E. **Breeding of plants and animals:** selective breeding of domestic plants and animals shows that the characteristics of species are modifiable and changeable

4.4 The Processes of Evolution

❖ Natural selection

- is the differential survival and reproduction of individuals due to difference in **phenotype.**
- favors the survival and reproduction of individuals with the best fitted and adapted genotypes while it perishes the unfavorable genotypes in a population.
- **Gene pool**: - is the sum total of all genes in a population or species.

  It is constantly changing due to mutations, and gene recombination that introduces new genes into the population.

A. **Directional selection:** favors the phenotypes at one extreme over the others.

- - reduces variation

B. **Stabilizing selection:**

- favors individuals of a population with average values (traits).
- favors an intermediate phenotype and acts against extreme variants.
- reduces variation and improves adaptation of population to aspect of the environment that remains relatively constant.

C. **Disruptive selection:**

- favors individuals of a population with the extreme value (trait)
- intermediate phenotypes can be eliminated from the population
- may even split a population into two sub- populations

Isolation and Speciation:

Speciation: is the evolution of a new species from pre – existing one by gradual modification

Since species are reproductively isolated populations, creation of a new species demands a mechanism that will produce reproductive isolation between two populations.

The two types of speciation are: Sympatric speciation and Geographic (allopatric) speciation.

Sympatric speciation	Allopatric speciation
Occurs when populations become reproductively isolated even though they have not become geographically isolated due to **distinct microhabitat**	When a population split into two or more isolated groups by a **geographical barrier**.

Reproductive isolation mechanisms

Pre- zygotic isolation (Before formation of zygote)

Temporal (seasonal) isolation: when two individuals become sexually active at different time.

Mechanical (physical) isolation: when reproductive organs (genitalia) of opposite mates become physically unfit (incompatible)

Behavioral (ethological) isolation: when opposite mates fail to have successful **courtship display**

Gamete incompatibility (gamete isolation): though there is mating, there is no zygote formation because sperm cell nucleus unable to fuse with egg cell nucleus.

Post- mating (post- zygotic) after zygote formation

Zygote mortality: the zygote does not develop into its next stage.

Hybrid inviability: the zygote develops into individual but the individual may not successfully grow into adult.

Hybrid sterility (F_2- breakdown): though hybrid grow into adult it fail to produce its own young by sexual reproduction

Divergent evolution: a pattern of evolution in which species that were once the same diverges or become increasingly distinct.

- occurs when populations change as they adapt to different environmental conditions. The pattern of speciation and adaptive radiation are examples of divergent evolution. Adaptive radiation was noticed by Charles Darwin in different species of finches found in Galapagos Islands – finches have adapted to feeding on different kinds of food.
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Convergent evolution:

- Two completely unrelated species share similar traits. Similarity arise because each species has independently adapted to similar environmental conditions.
- in which different species appear similar due to similar adaptations (analogous structures).
- Example pectoral fins of fish and flipper-like forelimbs in dolphin.

Co- evolution: when two or more species depend heavily on each other for their survival and propagation that they constantly evolve together.

A population is a group of individuals of one species that live in the same geographic area at the same time.

Species is a group of organisms, with similar structure, function, and behavior that are capable of interbreeding with one another.