

Evolution and speciation

Definition: Is a branch of biology that deals with the origin of life and diversity among the living organisms through ages.

Evolution is the change in the inherited traits of a population of organism through successive generation.

Evolution is a fact not a theory. The fact that the earth exists with liquid water with 3.5 billion years old. It is the fact that living forms come from previous living forms.

Evolution may occur when there is a variation of inherited traits with a population.

The major sources of such variations are: *Mutation*, *genetic recombination* and *Gene flow*.

A trait is a particular characteristics of anatomical, Biochemical or behavioral that is the result of gene environment interaction.

Mutation: Is the sudden change of chromosome or traits. Mutation introduced genetic changes that can be passed to next generation through reproduction and may give all alternative traits in organisms.

Genetic Recombination: (crossing over): Shuffling the genes into new combination that can cause or result in organisms exhibiting different traits.

Gene flow: The transfer of alleles from one population to another, resulting from the movement of fertile individuals or their gametes.

Genetic drift: In small populations, frequencies of particular alleles may change drastically by chance alone. Such changes in allele frequencies occur randomly, as if the frequencies were drifting, and are thus known as **genetic drift**.

Founder Effects: Sometimes one or a few individuals disperse and become the founders of a new, isolated population at some distance from their place of origin. These pioneers are not likely to have all the alleles present in the source population.

Different types of evolution:

1. **Cosmic Evolution:** Is the scientific study of universal change that includes **Galaxies, Stars Planets and life**.
2. **Stellar Evolution:** Is the process by which a **star** undergoes a sequence of **radial** changes during its life time.
3. **Chemical evolution:** The creation of chemical elements in the universe either through big Bang or **super theory**.
4. **Micro-Evolution:** Evolutionary changes that occur within a population may eventually lead to the formation of new species, but not as a onetime event.
5. **Macro-Evolution:** Is the origin or disappearance (extinction) of taxonomy categories above the species level and the result are new genera families or phyla.
6. **Organic Evolution:** A gradual genetic difference in a set of living beings to generate new forms. It is the process made an organism's slight change from their ancestor.

Development of the evolutionary thought (a brief *historical background*)

1. Aristotle: He proposed 2 principles.

- A. **Matter:** is what the plant or animal is made of.
- B. **Form:** is what makes the development. According to his theory the center of the planet is made up of 4 elements: Earth, air, fire and water. He also studied the **soul** and the soul is responsible for the moral and intellectual aspects of human being.
2. **Democritus:** The universe is composed of small particles called the atoms.
3. **Rene Descartes:** God act of creation.
4. **Comte de Buffon:** He proposed the evolutionary chain of the living organisms. Man placed on the top and microbes on the bottom of the chain.
5. **Malthus:** he proposed theory of population growth and food supply. If population grows geometrical, it creates demand for food supply as a result famine is formed.
6. **James Hutton:** The earth is vastly old and the regular destruction and rebuilding makes the planet suitable for mankind.
7. **Lyell:** He prepared geological time scale and time table.
8. **Wallace:** He supports the theory of Natural selection proposed by Darwin.

The origin of life

1. Theory of spontaneous generation (Abiogenesis/ Autogenesis).

Life originated from non living things in a spontaneous manner. (Greek). Plato and Aristotle. Mud of the Nile gives rise to Frogs, Toads Snakes Mice and even Crocodile when warmed by the sun.(Egyptians). No scientific ground and the theory is discarded.

2. Theory of eternity of life

Life is immortal. The living substance has existed with non living matter from the very beginning.

- a. **Cosmozoic theory:**(Richer)
- b. **Cosmic panspermia theory**(Arrhenius)
- c. **Helmholtz theory**
 - a. **Cosmozoic theory** (Richer): Protoplasm reached the earth in the form of spores or germs or other simple particles from some unknown part of the universe with cosmic dust and subsequently evolved into various forms of life.
 - b. **Cosmic panspermia theory** (Arrhenius): Organisms existed throughout the universe and their spores, particles etc. could freely travel through the space from one star to the other.
 - c. **Helmholtz theory:** Speculated that the “protoplasm” in some form reached the earth with falling meteorites. The theory of eternity of life is also discarded because it does not explain the origin of life in the earth.
3. Proposed by: **Francesco Redi:** Life originated from pre existing life. Supported by **Spallanzani** and **Louis Pasteur**.
4. **Theory of Catastrophism:** After each Catastrophe there is a new creation. This theory is (believed by theory of creationism) and evolution of newer forms of life from the surviving ones. It was supported by Oparin theory of origin life and the modern theory of life or theory of origin life by chemical Evolution.
- ❖ **Oparin theory of origin:** The origin of life on earth (1936). Origin of life occurred along the origin and evolution of the earth and its atmosphere. The primordial atmosphere of the Earth had: Water, Methane, and Ammonia. And the result of series changes, a colloidal

body called Coecervate and containing Biological macromolecules (proteins, lipids and nucleic acids) etc.

❖ **Colloidal:** homogeneous non-crystalline substance consisting of large molecules or ultramicroscopic particles of one substance dispersed in a second substance, as in gels, sols, and emulsions.

Lederberg has recognized the following three steps in Oparin's thesis:

1. **Chemogeny:** Chemical evolution.
2. **Biogeny:** Formation of self-reproducing biological units.
3. **Cognogeny:** Evolution of mechanism of expressions, communication, perception and feeding.

Evidences in support of Oparins Hypothesis

Stanley miller experiment: through the Spark discharge apparatus he found dark condensed liquid and he analyzed in chromatography. The liquid was a mixture of **amino acids** and a number of other **organic compounds** such as hydrogen cyanides, aldehydes and cyano compounds.

Modern view regarding the origin of life based on Oparin hypothesis

1. Origin of the earth: **Big bang hypothesis** (Gigantic explosion) as a result in the universe clouds of dusts and gases, chiefly hydrogen and Helium spread through the space. Some of the condensed particles converted to the sun, planets and the earth was formed 4600 million years ago.
2. **Prebiotic synthesis:** The core of the primitive earth melted from heat of condensation but the outer crust cooled quickly except where convection or volcanic eruption brought and masses from the molten core to the surface. The primitive atmosphere: was formed as various gases escaped from the interior of the earth (out gassing). The **earlier atmosphere** containing primarily Hydrogen, Methane, Ammonia and water.
3. **Biological Evolution:**
 - A. **Origin of Coacervates:** The large organic molecules which were synthesized abiotically on primitive earth latter came together due to intermolecular attraction, they formed large colloidal aggregates. Such water bound aggregates have been named **microspheres** by **Sidney Fox** and latter these colloidal bodies were named **Coacervates** by **Oparin**. Each Coecervate was a cluster of macromolecules surrounded by a membrane. The Coecervate was a colloidal body that contains important biological molecules, such as proteins, nucleic acids, lipids, polysaccharides etc. Much chemical reaction including the decomposition of glucose took place inside the Coecervate. According to the Oparin the Coecervate the slow living molecule which gave rise to the cell.
 - B. **Origin of Protocells (Eobionts or protobionts):** The first living form originated in the primitive ocean was cluster of nucleo-proteins. Represents in the ancient ocean the beginning of life were marked by biosynthesis, replication, nutrition and adaption. They appear in the ancient ocean about 3700 million years ago. It is estimated that life originate at least 3700 million years ago
 - C. **Origin of prokaryotes:** They are origin were from Protocells. Protocells became greater independent and occurred the capacity for better utilization of energy. Mutation might have in replication process of DNA which causes the structural changes in the protocells. These mutations provide raw materials for organic evolution. (for the evolution of prokaryotes).

The first living was the **prokaryotes** like **bacteria**. And they were single celled, with naked DNA. Nutritionally they were **Chemoheterotrophs** (They absorbed the organic materials from the outside both for body building and liberation of energy. Respiration was **anaerobic** since free oxygen was absent in the environment

Theories of Evolution

1. Lamarckism theory: is also called ‘the theory of inheritance of acquired character’. Is the first theory of evolution, which was proposed by Jean Baptist Lamarck (1744-1829). A French biologist and wrote a book called ‘Philosophie Zoologique’.

The theory of **inheritance of acquired character** states that **modification which the organism** acquires in **adaptation** to the environment which it meets during its life time is automatically handed down to its **descendants**, so become part of **heredity**.

His evolutionary ideas can be discussed in brief as follows:

A. Internal forces of life tend to increase the size of the organism. New structure appear b/c of an “inner want” of the organism, that is the internal forces of life tend to increase continuously the size of an organism and its component part.

B. Direct environmental effect over living organisms: The organs of an animal became modified in appropriate fashion indirect response to a changing environment.

C. Use and disuse: The various organs became greatly improved through use or reduced to vestiges through disuse.

D. Inheritance of acquired characteristics: Some bodily modifications, in some manner, could be transferred and impressed on the germ cells to affect future generation. Thus, inheritance was viewed by Lamarck simply as the direct transmission of those superficial bodily changes that arose within the life time of the individual owing to use or disuse.

Examples in support of Lamarckism

a. Giraffe: the ancestors of giraffe were bearing a **small neck and fore-limbs** and were like **horses**. But as they were in a place with surface no **vegetation**, they had to **stretch their neck and fore-limbs** to take the leaves for food. This resulted in the slight **elongation** of these parts. Whatever they **acquired** in **one generation** was transmitted to the **next generation** with the results that a race of **along necked** and **long fore-limbed** animals was developed

1. August Wiesmann: was the first person to make definite distinction b/n heritable changes and those which cannot be inherited. According to **Wiesmann**, the characters influencing the **germ cells** are **only inherited**. There is continuity of germplasm but the **somatoplasm** (protoplasm of somatic cells) is not **transmitted** to the **next generation** hence it does not carry **characters** to the next generation.

Wiesmann cut off the **tails of rats** for more than **20 generation** and allow them to **breed**, and **tailless** rats were **never born**.

3 Theory of Natural selection (Charles Darwin's)

And this concept was clearly and convincingly explained on his Masterpiece “the **origin of species**” and the full title of his book was “ **The origin of species by means of natural selection or The preservation of favored race in struggle for life**” (1859). This book contains the ample evidence of the fact that evolution has and does occur and he presented logical theory regarding natural selection a major mechanism of evolution.

Its essence is that the animals and plant world came in to existence by a process of dynamic Descent. Darwin explanation of the way in which evolution occurs may be generalized as follows:

- The change in a species by survival of the organism type exhibiting a natural variation that gives it an adaptive advantage in an environment, thus leading to a new environmental equilibrium is evolution by **natural selection**.

- The natural selection is the continuous process of trial and error on a gigantic scale, for all living matter is involved. And it includes:

- The universal occurrence of variation:** The difference b/n individual with in of the population of a species constitutes Variations. A variation is the characteristics of every group of animals and plants and there are many ways in which organisms may differ. Due to the variations some individuals would be better adjusted towards the surrounding than the other.

Adaptive modifications are caused through the struggle for existence. According to Darwin, the variations are continuous and those which are helpful in adaptations of an organism towards of its surrounding would be passed on the next generation, while the others disappear.

B. Over production/ Rapid multiplication: Every species in the absence of environmental checks tends to increase in a geometrical manner. If a population of a given species doubles in one year and if there are no checks on its increase, it will quadruple in the next year, and so on. Thus more organisms of each kind are born than can possibly obtain food and survive.

Since the number of each species remains fairly constant under natural condition, it must be assumed most of the off-springs in each generation perish. If all of the off-springs of any species remained alive and reproduced they would soon crowd all other from the earth.

C. Struggle for existence: Since more individuals of each kind are born than can survive there is an **intraspecific** or **interspecific** or **environmental struggle** for survival (competition for food, mates and space.)

I. Intraspecific struggle: struggle among the members of the same species. It is the keenest form of struggle for existence b/c the requirements of life are identical for the combatants.

II. Interspecific struggle: The one waged b/n the members of different species. This best seen in a newly exposed land where to begin with might be counted the seedling of at least of 20 different species of plants but ultimately seedling of 2or 3 species grow to maturity. That is to say, these two species have survived where the others 17 or 18 could not.

III. Environmental struggle: Is the struggle b/n the organism and the environment in which it is placed. Natural catastrophes like earth quakes, tidal waves bursting of volcanoes are all causes for killing large population of many species of animal and plants.

D. Survival of the fittest: In this struggle for existence as we have seen few survive, majority die out. This is explained as being due to the fact those few which survive have necessary advantageous variation which thought small have been survive of high survival value to the individual concerned, i.e. such of them are unfit for survival have perished. This idea of “survival of the fittest” is the core of the theory of natural selection.

E. Inheritance of useful variation: The organism after getting fitted to the surroundings transmits their useful variation to the next generation, while the non useful variations are eliminated. Darwin could not differentiate b/n continuous and discontinuous variation. Hence, up to some extent, he agreed with Lamarck's views, b/c according to Darwin acquired characters which are useful to possessor could be inherited.

Darwin considered that useful variations are transmitted to the offspring and appear more prominently in succeeding generation. After some generation these continuous and gradual variation in the possessor would be so distinct that they form new species.

Neo-Darwinism

It is a modified form of Darwinism. According to the Neo-Darwinian like **T.H. Huxley**, Herbert Spencer, **D.S.Jordan**, **Asa gray**, **E. Haeckel** and **A.Weiesmann** and others. natural selection has accounted everything that is involved in evolution. Certain neo Darwinians such as A.Weiesmann and his followers rejected Darwin's theory except its principal element of natural selection. These neo Darwinian thoughts, distinguished b/n germplasm and somatoplasm of living organisms in their germplasm theory, yet they couldn't appreciate the role of mutation in evolution.

Neo Darwinians thought Adaptations result from the multiple forces and natural selection is one of these many forces in contrast to Darwin's belief who held that adaptation results mainly by a single source that is natural selection.

In conclusion, the basic ideas or points of Darwin been followed by the neo- Darwinians' are as follows:-

- a. overproduction
- b. struggle for existence
- c. variation
- d. survival of the best adapted and
- e. inheritance of variations resulting from changes in DNA genes and chromosomes.

Differences between artificial and natural selection

Artificial selection	Natural selection
1. Man selects the characteristics it wants to perpetuate	Nature selects the best or the most favorable variation
2. It leads to the formation of new species in a much shorter time, may be in a few years.	It takes hundreds of years for new species to emerge.
3. It involves selective breeding of few populations only.	It operates on a wide scale in natural populations
4. It has led to evolution of a few economically important plants and animals only.	It has led to great diversity in nature.

Criticism of the natural selection theory

1. While natural selection theory explains **survival of the fittest**, it does not explain the arrival of the fittest.
2. **Over specialization** of some organ like tusks of elephant, antler of deer have developed so much that instead of providing usefulness to the possessor they often give hindrance to them.
3. Natural selection cannot account for **degeneracy**: to say an organ is no longer useful and, hence, disappears, are to the state the effect and not the cause.
4. On the classical objection to natural selection is that new variation would be lost by '**dilution**' as the individual possessing them breed with others without them.