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Ministry of education

National Center for distinguished

Seminar title:

Evolution

Made by: Mikdad Muhammad

Supervised by: Mr. Nidal Hassan

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Content:

Intro & problematic:

Evolution is change in the heritable characteristics of biological populations over successive generations. Evolutionary processes give rise to biodiversity at every level of biological organization, including the levels of species, individual organisms and molecules.

Therefore, we are going to talk about the theories of evolution: Lamarckism, Darwinism, Mutation theory and Neo-Darwinism, and show its weaknesses then we will compare these theories to choose the best theory that describe the evolution. [1]

The first Chapter: Lamarckism

Inheritance of acquired characters (Lamarckism):

Jean Baptiste de Lamarck, a great French naturalist proposed it in 1809 A.D in his famous book "Zoological Philosophy". This theory is based on the inheritance of acquired characters which are defined as the changes (variations) developed in the body of an organism from normal characters, in response to the changes in environment, or in the functioning (use and disuse) of organs, in their own life time, to fulfill their new needs. Thus, Lamarck stressed on adaptation as means of evolutionary modification.

Postulates of Lamarckism:

Lamarckism is based on the following four postulates:

I. New needs:

Every living organism is found in some kind of environment. The changes in the environmental factors

like light, temperature, medium, food, air etc. or migration of animal lead to the origin of new needs in the living organisms, especially animals. To fulfill these new needs, the living organisms have to exert special efforts like the changes in habits or behavior.

II. Use and disuse of organs:

The new habits involve the greater use of certain organs to meet new needs, and the disuse of certain other organs, which are of no use in new conditions. This use and disuse of organs greatly affect the form and structure of the organs.

Continuous and extra use of organs make them more efficient while the continued disuse of some other organs lead to their degeneration and ultimate disappearance. Therefore, Lamarckism is also called "Theory of use and disuse of organs."

Therefore, the organism acquires certain new characters due to direct or indirect environmental effects during its own life span and are called Acquired or adaptive characters.

III. Inheritance of acquired characters:

Lamarck believed that acquired characters are inheritable and are transmitted to the offspring so that these are born fit to face the changed environmental conditions and the chances of their survival are increased.

IV. Speciation:

Lamarck believed that in every generation, new characters are acquired and transmitted to next generation, so that

new characters accumulate generation after generation. After a number of generations, a new species is formed. So according to Lamarck, an existing individual is the total of the characters acquired by a number of previous generations and the speciation is a gradual process.

Evidences in favors of Lamarckism:

Phylogenetic studies of horse, elephant and other animals show that all these increase in their evolution from simple to complex forms.

❖ Giraffe (Fig 7.35):

Development of present day long-necked and long fore-necked giraffe from deer-like ancestor by the gradual elongation of neck and forelimbs in response to deficiency of food on the barren ground in dry deserts of Africa. These body parts were elongated to eat the leaves on the tree branches. This is an example of effect of extra use and elongation of certain organs.

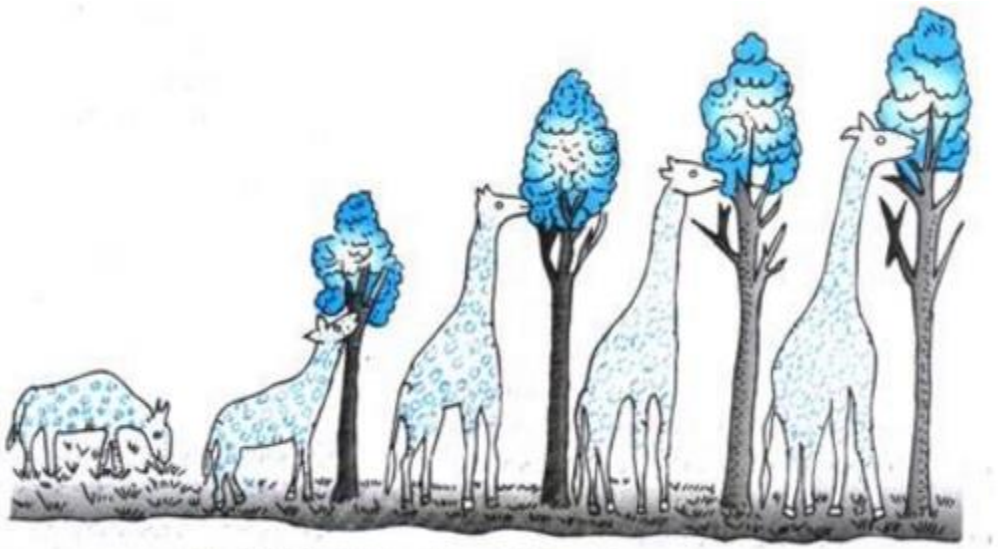

Fig. 7.35. Stages in the evolution of present-day giraffe.

❖ Horse:

The ancestors of modem horse (Equus caballus) used to live in the areas with soft ground and were short legged with more number of functional digits (e.g. 4 functional fingers and 3

functional toes in Dawn horse-Eohippus). These gradually took to live in areas with dry ground. This change in habit was accompanied by increase in length of legs and decrease in functional digits for fast running over hard ground.

- ### Snake:

  Development of present day limbless snakes with long slender body from the limbed ancestors due to continued disuse of limbs and stretching of their body to suit their creeping mode of locomotion and tonsorial mode of living out of fear of larger and more powerful mammals. It is an example of disuse and degeneration of certain organs. [2][3]

However, Lamarckism was rejected!

A hard blow to Lamarckism came from a German biologist, August Weismann who proposed the "Theory of continuity of germplasm" in 1892 A.D. This theory states that environmental factors do affect only somatic cells and not the germ cells.

As the link between the generations is only through the germ cells and the somatic cells are not transmitted to the next generation so the acquired characters must be lost with the death of an organism so these should have no role in evolution. He suggested that germplasm is with special particles called "ids" which control the development of parental characters in offsprings.

Weismann mutilated the tails of mice for about 22 generations and allowed them to breed, but tailless mice were never born. Pavlov, a Russian physiologist, trained mice to come for food on hearing a bell. He reported that this training is not inherited and was necessary in every generation. Mendel's laws of inheritance also object the postulate of inheritance of acquired characters of Lamarckism.

Similarly, boring of pinna of external ear and nose in Indian women; tight waist, of European women circumcising (removal of prepuce) in certain people; small sized feet of Chinese women etc. They are not transmitted from one generation to another generator.

Eyes, which are being used continuously and constantly, develop defects instead of being improved. Similarly, heart size does not increase generation after generation though it is used continuously.

Presence of weak muscles in the son of a wrestler was also not explained by Lamarck. Finally, there are a number of examples in which there is reduction in the size of organs e.g. among Angiosperms, shrubs and herbs have evolved from the trees.

Neo-Lamarckism:

Long forgotten Lamarckism has been revived as Neo-Lamarckism, in the light of recent findings in the field of genetics, which confirm that environment does affect the form, structure; color, size etc. and these characters are inheritable.

Neo-Lamarckism states:

A. Germ cells may be formed from the somatic cells indicating similar nature of chromosomes and gene make up in two cell lines for example:
    a) Regeneration in earthworms.
    b) Vegetative propagation in plants like Bryophyllum (with foliar buds).
    c) A part of zygote (equipotential egg) of human female can develop into a complete baby (Driesch).
B. Effect of environment on germ cells through the somatic cells e.g. Heslop Harrison found that a pale variety of moth,

Selenia bilunaria, when fed on manganese coated food; a true breeding melanic variety of moth is produced.

C. Effect of environment directly on germ cells. Tower exposed the young ones of some potato beetles to temperature fluctuation and found that though beetles remained unaffected with no somatic change but next generation had marked changes in body coloration.

Muller confirmed the mutagenic role of X-rays on Drosophila while C. Auer Bach ET. Al. confirmed the chemical mutagens (mustard gas vapors) causing mutation in Drosophila melanogaster, so Neo-Lamarckism proved:

i. Germ cells are not immune from the effect of environment.
ii. Germ cells can carry somatic changes to next progeny (Harrison's experiment).
iii. Germ cells may be directly affected by the environmental factors (Tower's experiment).

Table 7.6. Differences between Lamarckism and Neo-Lamarckism

Characters	Lamarckism	Neo-Lamarckism
1. Nature of theory	Original as proposed by Lamarck.	Modified Lamarckism in the light of modern knowledge.
2. Factors inducing variations	Certain internal forces, changes in environmental factors and use and disuse of organs.	Changes in environmental factors but not due to use and disuse of organs and internal forces.
3. Cells involved	Only somatic cells are affected so acquired characters are developed during individuals own life span.	Somatic cells or Germ cells or both are affected.
4. Nature of inherited characters	Acquired characters are inheritable.	Only germinal variations are inheritable or where germ cells are formed from somatic cells.

The second Chapter: Darwinism

Theory of Natural Selection (Darwinism):

Charles Darwin (1809 – 1882 A.D) is an English naturalist; he was the most dominant figure among the biologists of the 19th century. He made an extensive study of nature for over 20 years, especially in 1831-1836 when he went on a voyage on the famous ship "H.M.S.

Beagle" and explored South America, the Galapagos Islands and other islands.

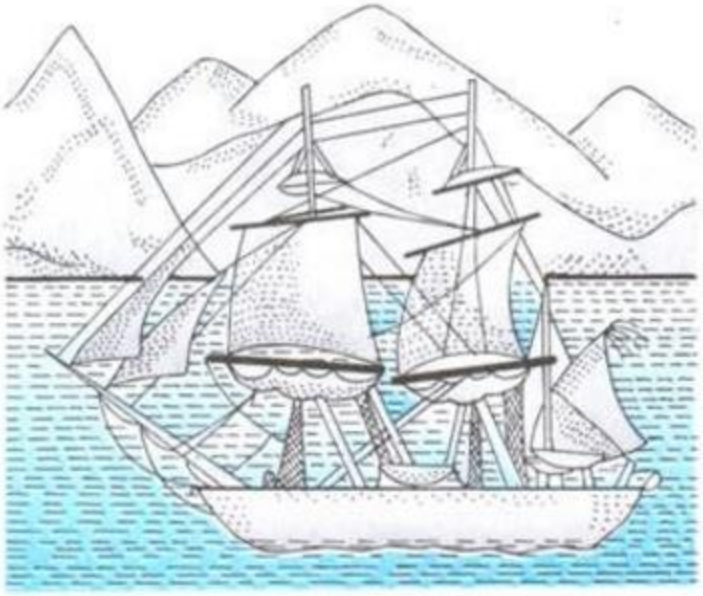

Fig. 7.37. H.M.S. Beagle ship.

He collected the observations on animal distribution and the relationship between living and extinct animals. He found that existing living forms share similarities to varying degrees not only among themselves but also with the life forms that existed millions of years ago, some of which have become extinct.

He stated that every population has built in variations in their characters. From the analysis of his data of collection and from Malthus's Essay on Population, he got the idea of struggle for existence within all the populations due to continued reproductive pressure and limited resources and that all organisms, including humans, are modified descendants of previously existing forms of life.

In 1858 A.D., Darwin was highly influenced by a short essay entitled "On the Tendency of Varieties to Depart Indefinitely from the Original Type" written by another naturalist, Alfred Russell Wallace (1812-1913) who studied biodiversity on Malayan archipelago and came to similar conclusions.

Darwin and Wallace's views about evolution were presented in the meeting of Linnaean Society of London by Lyell and Hooker on July 1, 1858. Darwin's and Wallace's work was jointly published in "Proceedings of Linnaean Society of London" in 1859.So it is also called Darwin-Wallace theory.

Darwin explained his theory of evolution in a book entitled "On the Origin of Species by means of Natural Selection". It was published on 24th Nov. 1859. In this theory, Charles Darwin proposed the concept of natural selection as the mechanism of evolution.

Postulates of Darwinism:

1. Population Multiply.
2. Limited food and space.
3. Struggle for existence.
4. Variations.
5. Natural selection or Survival of the fittest.
6. Inheritance of useful variations.
7. Speciation.

1. Geometric increase:

According to Darwinism, the populations tend to multiply geometrically and the reproductive powers of living organisms (biotic potential) are much more than required to maintain their number e.g.,

Paramecium divides three times by binary fission in 24 hours during favorable conditions. At this rate, a Paramecium can produce a clone of about 280 million Paramecia in just one month and in five years, can produce Paramecia having mass equal to 10,000 times than the size of the earth.

Similarly, the plants also reproduce very rapidly e.g., a single evening primrose plant produces about 1, 18,000 seeds and single fern plant produces a few million spores.

Even slow breeding organisms reproduce at a rate which is much higher than required e.g., an elephant becomes sexually mature at 30 years of age and during its life span of 90 years, produces only six offsprings. At this rate, if all elephants survive then a single pair of elephants can produce about 19 million elephants in 750 years.

These examples confirm that every species can increase manifold within a few generations and occupy all the available space on the earth, provided all survive and repeat the process. Therefore, the number of a species will be much more than can be supported on the earth.

2. Limited food and space:

Darwinism states that though a population tends to increase geometrically, the food increases only arithmetically. So two main limiting factors on the tremendous increase of a population are limited food and space, which together form the major part of carrying capacity of environment. These do not allow a population to grow indefinitely which are nearly stable in size except for seasonal fluctuation.

3. Struggle for existence:

Due to rapid multiplication of populations but limited food and space, there starts an everlasting competition between individuals having similar requirements. In this competition, every living organism desires to have an upper hand over others. **This competition between living organisms for the basic needs of life like food, space, mate etc., is called struggle for existence, which is of three types:**

a. Intraspecific:

Between the members of same species, e.g. two dogs struggling for a piece of meat.

b. Interspecific:

Between the members of different species e.g. between predator and prey.

c. Environmental or Extra specific:

Between living organisms and adverse environmental factors like heat, cold, drought, flood, earthquakes, light etc.

4. Variations:

Variation is the law of nature. According to this law of nature, no two individuals except identical (monozygotic) twins are identical. This everlasting competition among the organisms has compelled them to change according to the conditions to utilize the natural resources and can survive successfully.

Darwin stated that the variations are generally of two types- continuous variations or fluctuations and discontinuous variations. Based on their effect on the survival chances of living organisms, the variations may be neutral, harmful and useful.

Darwin proposed that living organisms tend to adapt to changing environment due to useful continuous variations {e.g., increased speed in the prey; increased water conservation in plants; etc.), as these will have a competitive advantage.

5. Natural selection or survival of the fittest:

Darwin stated that as many selects the individuals with desired characters in artificial selection; nature selects only those individuals out of the population, which are with useful continuous variations and are best adapted to the environment while the less fit or unfit individuals are rejected by it.

Darwin stated that if the man can produce such a large number of new species/varieties with limited resources and in short, period by artificial selection, then natural selection could account for this large biodiversity by considerable modifications of species with the help of unlimited resources available over long span of time.

Darwin stated that discontinuous variations appear suddenly and will mostly be harmful, so are not selected by nature. He called them "sports". Therefore, the natural selection is an automatic and self-going process and keeps a check on the animal population.

This sorting out of the individuals with useful variations from a heterogeneous population by the nature was called Natural selection by Darwin and Survival of the fittest by Wallace. Therefore, natural selection acts as a restrictive force and not a creative force.

6. Inheritance of useful variation:

Darwin believed that the selected individuals pass their useful continuous variations to their offsprings so that they are born fit to the changed environment.

7. Speciation:

According to Darwinism, useful variations appear in every generation and are inherited from one generation to another. Therefore, the useful variations go on accumulating and after a number of generations, the variations become so prominent that the individual turns into a new species. So according to Darwinism, evolution is a gradual process and speciation occurs by gradual changes in the existing species.

Evidences in favor of Darwinism:

- There is a close parallelism between natural selection and artificial selection.
- The remarkable cases of resemblance e.g. mimicry and protective coloration can be achieved only by gradual changes occurring simultaneously both in the model and the mimic.
- Correlation between position of nectarines in the flowers and length of the proboscis of the pollinating insect. [4][5][6][7]

Evidences against Darwinism!

- The inheritance of small variations in those organs, which can be of use, only when fully formed e.g. wing of a bird. Such organs will be of no use in incipient or underdeveloped stage.
- Inheritance of vestigial organs.
- Inheritance of over-specialized organs e.g. antlers in deer and tusks in elephants.
- Presence of neuter flowers and sterility of hybrids.
- Did not differentiate between somatic and germinal variations.
- He did not explain the causes of the variations and the mode of transmission of variations.
- It was also refuted by Mendel's laws of inheritance which state that inheritance is particulate.

Therefore, this theory explains only the survival of the fittest but does not explain the arrival of the fittest so Darwin himself confessed, "natural selection has been main but not the exclusive means of modification."

The third Chapter: Mutation Theory

Mutation Theory of Evolution:

The mutation theory of evolution was proposed by a Dutch botanist, Hugo de Vries (1848-1935 A.D.) in 1901 A.D. in his book entitled "Species and Varieties, Their Origin by Mutation". He worked on evening primrose (Oenothera lamarckiana).

Fig. 7.38. Hugo de Vries (1848—1935 A.D.)

Experiment:

Hugo de Vries cultured O. lamarckiana in botanical gardens at Amsterdam. The plants were allowed to self-pollinate and next generation was obtained. The plants of next generation were again subjected to self-pollination to obtain second generation. Process was repeated for a number of generations.

Observations:

Majority of plants of first generation were found to be like the parental type and showed only minor variations but 837 out of 54,343 members were found to be very different in characters like flower size, shape and arrangement of buds, size of seeds etc. These markedly different plants were called primary or elementary species.

A few plants of second generation were found to be still more different. Finally, a new type, much longer than the original type, called O. gigas, was produced. He also found the numerical chromosomal changes in the variants (e.g. with chromosome numbers 16, 20, 22, 24, 28 and 30) up to 30 (Normal diploid number is 14).

Conclusion:

- The evolution is a discontinuous process and occurs by mutations (L. mutate = to change; sudden and inheritable large differences from the normal and are not connected to normal by intermediate forms). Individuals with mutations are called mutants.
- Elementary species are produced in large number to increase chances of selection by nature.
- Mutations are recurring so that the same mutants appear repeatedly. This increases the chances of their selection by nature.
- Mutations occur in all directions so may cause gain or loss of any character.
- Mutability is fundamentally different from fluctuations (small and directional changes).

So according to mutation theory, evolution is a discontinuous and jerky process in which there is a jump from one species to another so that new species arises from pre-existing species in a single generation (macrogenesis or saltation) and not a gradual process as proposed by Lamarck and Darwin.

Evidences in favor of Mutation theory:

- Appearance of a short-legged sheep variety, Ancon sheep, from long-legged parents in a single generation in 1791 A.D. It was first noticed in a ram (male sheep) by an American farmer, Seth Wright.

Fig. 7.39. Appearance of short-legged Ancon sheep mutant.

- Appearance of polled Hereford cattle from horned parents in a single generation in 1889.
- De Vries observations have been experimentally confirmed by McDougal and Shull in America and Gates in England.
- Mutation theory can explain the origin of new varieties or species by a single gene mutation e.g. Cicero gigas, Nuval orange. Red sunflower, hairless cats, double- toed cats, etc.
- It can explain the inheritance of vestigial and over-specialized organs.
- It can explain progressive as well as retrogressive evolution. [8]

Evidences against Mutation theory!

- It is not able to explain the phenomena of mimicry and protective coloration.
- Rate of mutation is very low, i.e. one per million or one per several million genes.
- Oenothera lamarckiana is a hybrid plant and contains anamolous type of chromosome behavior.
- Chromosomal numerical changes as reported by de Vries are unstable.
- Mutations are incapable of introducing new genes and alleles into a gene pool.

The fourth Chapter: Neo-Darwinism

Synthetic Theory of Evolution or Modern Concepts (Neo-Darwinism):

Modern or synthetic theory of evolution was designated by Huxley (1942). It emphasizes the importance of populations as the units of evolution and the central role of natural selection as the most important mechanism of evolution.

The scientists who contributed to the outcome of Neo-Darwinism were J.S. Huxley, R.A. Fischer and J.B.S. Haldane of England; and S. Wright, Ford, H.J. Muller and T. Dobzhansky of America.

Postulates of Neo-Darwinism:

1) Genetic Variability:

Variability is an opposing force to heredity and is essential for evolution as the variations form the raw material for evolution. The studies showed that the units of both heredity and mutations are genes, which are located in a linear manner on the chromosomes.

Various sources of genetic variability in a gene pool are:

i. Mutations

These are sudden, large and inheritable changes in the genetic material. On the basics of amount of genetic material involved, mutations are of three types:

A. Chromosomal aberrations:

These include the morphological changes in the chromosomes without affecting the number of chromosomes. These result changes either in the number of genes (deletion and duplication) or in the position of genes (inversion).

These are of four types:

- Deletion (Deficiency) involves the loss of a gene block from the chromosome and may be terminal or intercalary.
- Duplication involves the presence of some genes more than once, called the repeat. It may be tandem or reverse duplication.
- Translocation involves transfer of a gene block from one chromosome to a non-homologous chromosome and may be simple or reciprocal type.
- Inversion involves the rotation of an intercalary gene block through 180° and may be par acentric or pericentric.

B. Numerical chromosomal mutations:

These include changes in the number of chromosomes. These may be euploidy (gain or loss of one or more genomes) or aneuploidy (gain or loss of one or two chromosomes). Euploidy may be haploidy or polyploidy.

Among polyploidy, tetraploidy is most common. Polyploidy provides greater genetic material for mutations and variability. In haploids, recessive genes express in the same generation.

Aneuploidy may be hypoploidy or hyperploidyl Hypoploidy may be monosomy (loss of one chromosome) or nullisomy (loss of two chromosomes). Hyperploidy may be trisomy (gain of one chromosome) or tetrasomy (gain of two chromosomes).

C. Gene mutations (Point mutations):

These are invisible changes in chemical nature (DNA) of a gene and are of three types:

- Deletion involves loss of one or more nucleotide pairs.
- Addition involves gain of one or more nucleotide pairs.

- Substitution involves replacement of one or more nucleotide pairs by other base pairs. These may be transition or Trans version type.

These changes in DNA cause the changes in the sequence of amino acids so changing the nature of proteins and the phenotype.

ii. Recombination of genes:

Thousands of new combinations of genes are produced due to crossing over, chance arrangement of bivalents at the equator during metaphase – I and chance fusion of gametes during fertilization.

iii. Hybridization:

It involves the interbreeding of two genetically different individuals to produce 'hybrids'.

iv. Physical mutagens (e.g. radiations, temperature etc.) and chemical mutagens (e.g. nitrous acid, colchicine, nitrogen mustard etc.).

v. Genetic drift:

It is the elimination of the genes of some original characteristics of a species by extreme reduction in a population due to epidemics or migration or Sewell Wright effect.

The chances of variations are also increased by non-random mating.

2) Natural Selection:

Natural selection of Neo- Darwinism differs from that of Darwinism that it does not operate through "survival of the fittest" but operates through differential reproduction and comparative reproductive success.

Differential reproduction states that those members, which are best adapted to the environment, reproduce at a higher rate and produce more offsprings than those, which are less adapted.

Therefore, these contribute proportionately greater percentage of genes to the gene pool of next generation while less adapted individuals produce fewer offsprings.

If the differential reproduction continues for a number of generations, then the genes of those individuals, which produce more offsprings, will become predominant in the gene pool of the population as shown in Fig. 7.40.

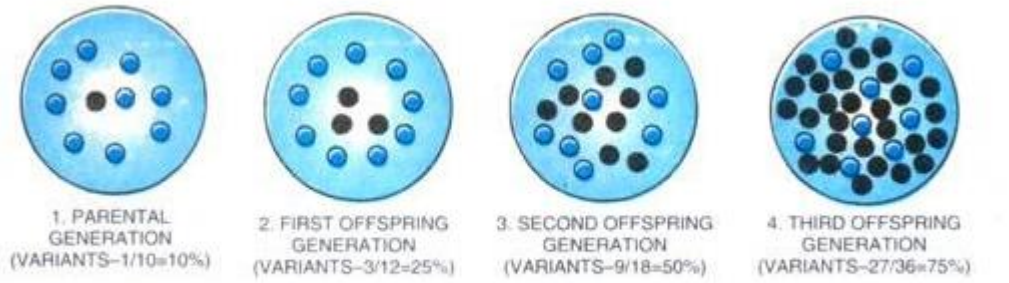

Fig. 7.40. Spread of genetic variability by differential reproduction.

Due to sexual communication, there is free flow of genes so that the genetic variability which appears in certain individuals, gradually spreads from one deme to another deme, from deme to population and then on neighboring sister populations and finally on most of the members of a species. Therefore, natural selection causes progressive changes in gene frequencies, ‘i.e. the frequency of some genes increases while the frequency of some other genes decreases.

Which individuals produce more offsprings?

- Mostly those individuals, which are best, adapted to the environment.
- Whose sum of the positive selection pressure due to useful genetic variability is more than the sum of negative selection pressure due to harmful genetic variability?
- Which have better chances of sexual selection due to development of some bright colored spots on their body e.g. in many male birds and fish.

- Those who are able to overcome the physical and biological environmental factors to successfully reach the sexual maturity.

Therefore, natural selection of Neo-Darwinism acts as a creative force and operates through comparative reproductive success. Accumulation of a number of such variations leads to the origin of a new species.

3) Reproductive isolation:

Any factor, which reduces the chances of interbreeding between the related groups of living organisms, is called an isolating mechanism. Reproductive isolation is must to allow the accumulation of variations leading to speciation by preventing hybridization.

In the absence of reproductive isolation, these variants freely interbreed which lead to intermixing of their genotypes, dilution of their peculiarities and disappearance of differences between them. Therefore, reproductive isolation helps in evolutionary divergence. [9][10]

Conclusion:

We discuss four main theories about evolution and we specified its weaknesses and we talked about reasons that make us refuse the theory, then scientists work out a better theory by putting those theories together.

Therefore, the best theory that describe evolution is Neo-Darwinism until now.

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