ENTRI

UNIT 2

EVOLUTION ,ECOLOGY,BIODIVERSITY AND ETHOLOGY

Module 1

EVOLUTION

Evolution of life on earth has not been a simple process. Some explain it as a process while some interpret it as a result of various natural occurrences. The evolutionary theory tries to convey the message of the origin of the earth and how lives on earth evolved. Evolution as a process, explains how the world came into existence. It has resulted in biodiversity.

Evolution

The process by which modern organisms have descended from their ancestors, with changes in their allele frequencies, is called evolution.

The Big Bang Theory

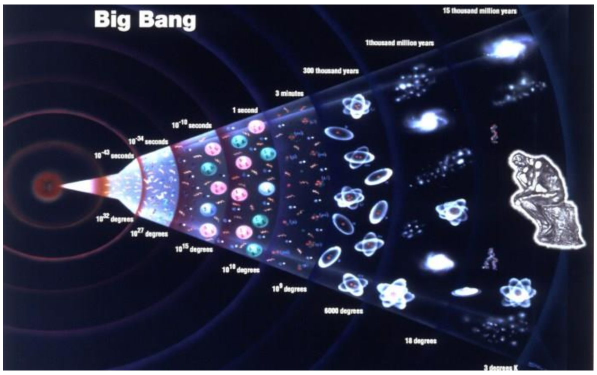
The Big Bang Theory is the most accepted theory regarding the origin of life on earth and different forms of life in it. According to the theory, the universe is a result of a huge explosion, which occurred 20 billion years ago. It took another 10 billion years for the origin of the earth. Once earth originated, it grew, and the living conditions like the temperature and atmosphere stabilised. It is believed that the first life form came into existence on earth around 2000 million years ago (mya).

Even though there is no clear picture of the evolution of the first living cell, it is assumed that the first cell originated from non-cellular molecules. This cell is divided to form more of them. The evolving cells had few characteristic features which helped them to survive. These features include the ability to trap light energy and derived energy from it and the oxygen releasing capacity of the cells. Finally, single unicellular organisms evolved to form much more complex multicellular organisms.

Once the multicellular organisms were evolved, evolution happened at a much faster pace. The further series of development and evolution of new organisms like invertebrates, plants, animals such as reptiles, fish, amphibians, mammals, etc., took place within a time range of 500-300 million years ago (mya). Later these organisms started to evolve in their own way. This commenced the branching of lineages. Environmental conditions like climatic changes, limited resources, predators, etc. played an enormous role in that. During each phase of evolution, one life form dominated over the other. Nature selected one over the other, which was called the fittest of all.

The flow of evolution of animals began with jawless fish (350 mya) before plants (320 mya) invaded the lands. Later, fish which could live on both land and water replaced plants, they fed on them. Amphibians, which were derived from these lobefin animals, later evolved into reptiles. Reptiles of different shapes, size, and life patterns flourished during that many mya. Certain ones lived in water, e.g., Ichthyosaurs (200 mya), others lived on land. Dinosaurs were a known land reptile which existed at that time. Due to some unknown reasons, they became extinct. Followed by reptiles, there was an era of mammals which dominated all other species.

Various processes such as natural selection, genetic drift, gene flow, etc. had contributed a lot to develop the living conditions and organisms as we know them today.



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Evolutionary time scale

Hadean eon

3800 Ma and earlier.

Date	Event
4567.17 Ma	The planet Earth forms from the accretion disc revolving around the young Sun.
4533 Ma	The planet Earth and the planet Theia collide, sending countless moonlets into orbit around the young Earth. These moonlets eventually coalesce to form the Moon. The gravitational pull of the new Moon stabilises the Earth's fluctuating axis of rotation and sets up the conditions for the formation of life.
4100 Ma	The Surface of the Earth cools enough for the crust to solidify. The atmosphere and the oceans form.
Between 4500 and 2500 Ma	The earliest life appears, possibly derived from self-reproducing RNA molecules. The replication of these organisms requires resources like energy, space, and smaller building blocks, which soon become limited, resulting in competition. Natural selection

	favours those molecules which are more efficient at replication. DNA molecules then take over as the main replicators. They soon develop inside enclosing membranes which provide a stable physical and chemical environment conducive to their replication: proto-cells.
3900 Ma	Late Heavy Bombardment: peak rate of impact events upon the inner planets by meteors. This constant disturbance probably obliterated any life that had already evolved, as the oceans boiled away completely; conversely, life may have been transported to Earth by a meteor.
Somewhere between 3900 - 2500 Ma	Cells resembling prokaryotes appear. These first organisms are chemoautotrophs: they use carbon dioxide as a carbon source and oxidise inorganic materials to extract energy. Later, prokaryotes evolve glycolysis, a set of chemical reactions that free the energy of organic molecules such as glucose. Glycolysis generates ATP molecules as short-term energy currency, and ATP continues to be

	used in almost all organisms, unchanged, to this day.

Archean eon

3800 Ma - 2500 Ma

Date	Event
3500 Ma	Lifetime of the last universal ancestor; the split between the bacteria and the archaea occurs. Bacteria develop primitive forms of photosynthesis which at first do not produce oxygen. These organisms generate ATP by exploiting a proton gradient, a mechanism still used in virtually all organisms.
3000 Ma	Photosynthesizing cyanobacteria evolve; they use water as a reducing agent, thereby producing oxygen as waste product. The oxygen initially oxidises dissolved iron in the oceans, creating iron ore. The oxygen concentration in the atmosphere subsequently rises, acting as a poison for many bacteria. The moon is still very close to the earth and causes tides 1000 feet high. The earth is continually wracked by hurricane force winds. These extreme mixing

	influences are thought to stimulate evolutionary processes. (See Oxygen Catastrophe)

Proterozoic eon

2500 Ma - 542 Ma

Date	Event
By 2100 Ma	Eukaryotic cells appear. Eukaryotes contain membrane-bound organelles with diverse functions, probably derived prokaryotes engulfing each other via phagocytosis.
By 1200 Ma	Sexual reproduction evolves, increasing the rate of evolution.
1200 Ma	Simple multicellular organisms evolve, mostly consisting of cell colonies of limited complexity.
850–630 Ma	A global glaciation may have reduced the diversity of life. Opinion is divided on whether it increased or decreased the rate of evolution
580-542 Ma	The Ediacaran biota represent the first large, complex multicellular organisms - although their affinities remain a subject of debate.

580–500 Ma	Most modern groups begin to appear in the fossil record during the Cambrian explosion.
Around 540 Ma	The accumulation of atmospheric oxygen allows the formation of an ozone layer. This blocks ultraviolet radiation, permitting the colonisation of the land.

Phanerozoic eon

542 Ma - present

The Phanerozoic eon, literally the "period of well-displayed life", marks the appearance in the fossil record of abundant, shell-forming and/or trace-making organisms.

It is subdivided into three eras, the Paleozoic, Mesozoic and Cenozoic, which are divided by major mass extinctions.

1.Paleozoic era

542 Ma - 251.0 Ma

Date	Event
530 Ma	The first known footprints on land date to 530 Ma, indicating that early animal explorations may have predated the development of terrestrial plants.
475 Ma	The first primitive plants moved onto land,having evolved from green algae living along the edges of lakes. They are accompanied

	by fungi, which may have aided the colonisation of land through symbiosis.
363 Ma	By the start of the Carboniferous period, the Earth begins to be recognisable. Insects roamed the land and would soon take to the skies; sharks predated the oceans,and vegetation covered the land, with seed-bearing plants and forests soon to flourish. Four-limbed tetrapods gradually gain adaptations which will help them occupy a terrestrial life-habit.
251.4Ma	The Permian-Triassic extinction event eliminates over 95% of species. This "clearing of the slate" may have led to an ensuing diversification.

2.Mesozoic era

Date	Event
From 251.4 Ma	The Mesozoic Marine Revolution begins: increasingly well-adapted

	and diverse predators pressurise sessile marine groups; the "balance of power" in the oceans shifts dramatically as some groups of prey adapt more rapidly and effectively than others.
220 Ma	Gymnosperm forests dominate the land; herbivores grow to huge sizes in order to accommodate the large guts necessary to digest the nutrient-poor plants.
200 Ma	The first accepted evidence for viruses - the group Geminiviridae at least exists. Viruses are still poorly understood and may have arisen before "life" itself, or may be a more recent phenomenon.
130 Ma	The rise of the Angiosperms: These flowering plants boast structures that attract insects and other animals to spread pollen. This innovation causes a major burst of animal evolution through co-evolution.

3.Cenozoic era

65.5 Ma - present

Date	Event
65.5 Ma	The Cretaceous–Tertiary extinction event eradicates about half of all animal species, including all non-avian dinosaurs.
35 Ma	Grasses evolve from among the angiosperms; grassland dominates many terrestrial ecosystems.
14,000 years ago	The term Anthropocene has been used to describe the period of time during which Man has had a major impact on the planet and its inhabitants. Its beginning is marked by the megafaunal extinction in the Americas which signifies the onset of the Holocene extinction event. Fierce debate rages about the influence of man in the initiation of this extinction, but no one can deny that humanity is contributing to its propagation.
Present day	With a human population approaching 6.67 billion, the impact of humanity is felt in all corners of the globe. Overfishing, anthropogenic climate change, industrialisation, intensive agriculture, clearance of rain

	forests and other activities contribute to a dramatically rising extinction rate. At current rates, humanity will have eradicated one-half of Earth's biodiversity over the next hundred years.

Theories and modern concepts of organic evolution: classical and synthetic theories of evolution

Darwin's Theory of Evolution

Darwin had the following ideas regarding the theory of natural selection:

- Species keep on evolving or changing with time. As the environment changes, the requirements of an organism also change and they adapt to the new environment. This phenomenon of changing over a period of time as per the natural requirements is called adaptation.
- As per Darwin's theory, only the superior changes are naturally selected and the inferior ones are eliminated. Thus, not all adaptations contribute to progressive evolution. For example, people living in tropical countries have more melanin in their body to protect them from the sunlight.
- Almost all organisms share common ancestry with some organism. According to Darwin, all organisms had one common ancestor at some point in time and kept on diverging ever since. His

evolutionary theories support the convergent theory and divergent theory of evolution with examples.

- He also studied that the birds of Galapagos Island (Darwin's finches) developed different beaks as per the availability of the food. This proved adaptive radiation. Similarly, he also observed the Australian Marsupials which showed a number of marsupials emerging from an ancestor.
- According to Charles Darwin, evolution is a very slow and gradual process.He concluded that evolution took place over a very long period of time. As we talk about the time period in evolution we usually refer to billions of years. The generation of a species from another takes a long period of time. It is a very steady process as the changes and adaptation take a long time to stabilise and give rise to a new species.

Evolutionary Theory After Darwin

- Since Darwin's time, scientists have gathered even more evidence to support the theory of evolution. Some of the evidence comes from fossils, and some comes from studies that show how similar living things are to one another. By the 1930s, scientists had also learned about genes. As a result, they could finally explain how characteristics of organisms could pass from one generation to the next and change over time.
- Using modern technology, scientists can now directly compare the genes of living species. The more genes different species share in common, the more closely related the species are presumed to be. Consider humans and chimpanzees. They share about 98% of their genes. This means that they shared a common ancestor in the not-too-distant past. This is just one of many pieces of evidence that show we are part of the evolution of life on Earth.

Modern Synthetic Theory of Evolution

The Modern Synthetic Theory of Evolution (also called Modern Synthesis) merges the concept of Darwinian evolution with Mendelian genetics, resulting in a unified theory of evolution. This theory is also referred to as the Neo-Darwinian theory and was introduced by a number of evolutionary biologists such as T. Dobzhansky, J.B.S. Haldane, R.A. Fisher, Sewall Wright, G.L. Stebbins, Ernst Mayr.

It describes the evolution of life in terms of genetic changes occurring in the population that leads to the formation of new species. It also describes the genetic population or Mendelian population, gene pool and gene frequency. The major concepts coming under this theory include genetic variations, reproductive and geographical isolation and natural selection. The Modern Synthetic Theory of Evolution showed a number of changes as to how the evolution and the process of evolution are conceived. The theory gave a new definition of evolution as "the changes occurring in the allele frequencies within the populations, " which emphasises the genetic basis of evolution.

Mechanism of Evolution

The mechanism of evolution occurs due to the changes in the gene pool- the collection of genes. There are four key mechanisms that cause a population.
These include:

- Mutation.
- Gene Flow.
- Genetic Drift.
- Natural Selection.

1.Mutations

Mutations are defined as the changes in the DNA sequence of a living organism. The mutations occurring in the germ cells, i.e The egg or sperm cells only are passed onto future generations. These mutations are inherited from the parents and are present in every cell throughout a person's life. These are the mutations that lead to evolution. The acquired mutations occur during a person's life and are present only in some cells. These are caused due to environmental factors such as ultraviolet radiations and do not pass on to future generations. They are not a part of evolution.

2.Gene Flow

The transfer of genes from one population to another is called gene flow. For eg., pollen moving from one place to another by the action of wind or people moving to different cities or countries. When a person from one country moves to the other and mates with a person there, a transfer of genes occurs between the individuals. This is how the gene flows between different populations. Gene transfer can be horizontal, i.e., transfer of genetic material from one population to another by asexual means. This phenomenon is prevalent in prokaryotes.

3.Genetic Drift

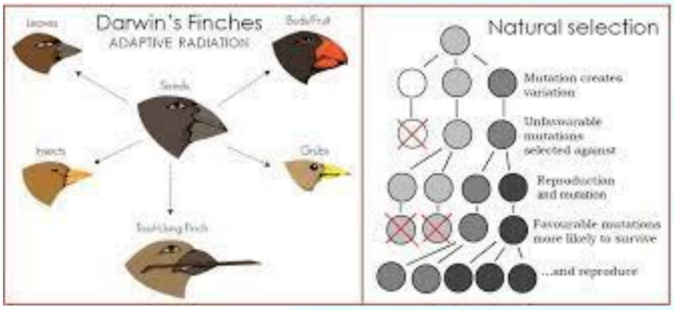
It refers to the change in the allele frequency of a population as a matter of chance. It is a random event whose effect is larger in smaller populations and smaller in larger populations. The two examples of genetic drift are the bottleneck effect and founder effect.

- **Bottleneck Effect**: It occurs when there is a sudden decrease in the population due to some environmental factors, such as an earthquake, tsunami, epidemics, etc. In this event, some genes are depleted from the population. This causes a drastic reduction in the genetic diversity of the original gene pool. That means that the genetic makeup of the surviving population becomes different from that of the original one.

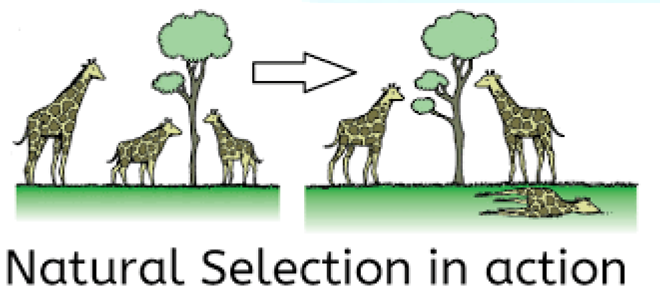
- **Founder Effect**: When a small number of individuals separated from a larger population make up a new population, there is a loss of genetic diversity. They do not carry the genetic diversity of the previous population. Due to this, some genetic traits become more prevalent than the others, which results in genetic diseases in future generations.

4.Natural Selection

Some individuals with certain traits have higher survival and reproductive rate than others. They pass on these genetic features to their offspring which brings an evolutionary change in the future generations. This selection of the genetic qualities that prove beneficial for survival in future generations is known as natural selection.



Darwin's Finches



Microevolution

Most evolutionary changes are small and do not lead to the creation of a new species. When populations change in small ways over time, the process is called microevolution. Microevolution results in changes within a species.

An example of microevolution is the evolution of mosquitoes that cannot be killed by pesticides, called pesticide-resistant mosquitoes. Imagine that you have a pesticide that kills most of the mosquitoes in your state. Through a random mutation, some of the mosquitoes have resistance to the pesticide. As a result of the widespread use of this pesticide, most of the remaining mosquitoes are the pesticide-resistant mosquitoes. When these mosquitoes reproduce the next year, they produce more mosquitoes with the pesticide-resistant trait. Soon, most of the mosquitoes in your state are resistant to the pesticide.

This is an example of microevolution because the number of mosquitoes with this trait changed. However, this evolutionary change did not create a new species of mosquito because the pesticide-resistant mosquitoes can still reproduce with other non-pesticide-resistant mosquitoes.

Macroevolution

Macroevolution refers to much bigger evolutionary changes that result in new species.

Macroevolution may happen

1. When microevolution occurs repeatedly over a long period of time and leads to the creation of a new species.
2. As a result of a major environmental change, such as a volcanic eruption, earthquake, or an asteroid hitting Earth, which changes the environment so much that natural selection leads to large changes in the traits of a species.

After thousands of years of isolation from each other, Darwin's finch populations have experienced both microevolution and macroevolution. These finch populations cannot breed with other finch populations when they are brought together. Since they do not breed together, they are classified as separate species.

Coevolution

Coevolution refers to the evolution of at least two species, which occurs in a mutually dependent manner. Coevolution was first described in the context of insects and flowering plants, and has since been applied to major evolutionary events, including sexual reproduction, infectious disease, and ecological communities. Coevolution functions by reciprocal selective pressures on two or more species, analogous to an arms race in an attempt to outcompete each other.

Classic examples include predator-prey, host-parasite, and other competitive relationships between species. While the process of coevolution generally only involves two species, multiple species can be involved. Moreover, coevolution also results in adaptations for mutual benefit.

An example is the coevolution of flowering plants and associated pollinators (e.g., bees, birds, and other insect species).

Anagenesis

Anagenesis is an evolutionary process in which species continue to exist and survive as an interbreeding population. It is also referred to as phyletic transformation and involves evolution within a single lineage. It does not always indicate the formation of new species. It takes thousands and millions of years for a new species to evolve.

Punctuated Equilibrium

This states that a species undergoes very little to no change for thousands of years. This is known as stasis. Speciation occurs when a population splits into two due to some geographical events. These two populations diverge from one another forming two different populations known as clades. That is why punctuated equilibrium is also known as cladogenesis.

Anagenesis vs Cladogenesis

Anagenesis	Cladogenesis
Anagenesis is the evolution with the lineage.	Cladogenesis is the evolution due to the splitting of the lineage.
It is a slow transition of one species to another.	The species are rapidly separated into two or more groups.
No geographical barrier is responsible for the process.	A geographical barrier is responsible for creating the new species.
The parent species is gradually transformed into a new species and does not exist.	The parent species and the new species might exist together unaware of the fact they evolved from the same species.
For eg., the evolution of giraffe	For eg., Darwin's Finches

Neutral theory

The neutral theory of molecular evolution contends that most evolutionary change at the molecular level is driven by genetic drift rather than natural selection.

The neutral theory does not suggest that random drift explains all evolutionary change: natural selection is still needed to explain adaptation. However, the neutral theory states that evolution at the level of the DNA and proteins, but not of adaptation, is dominated by random processes; most evolution at the molecular level would then be non-adaptive.

The neutral theory can be contrasted with the idea that almost all molecular evolution has been driven by natural selection.

The difference between the two ideas can be understood in terms of the frequency distribution for the selection coefficients of mutations, or genetic variants. Given a mutation of a certain selection coefficient, the theories of neutral drift and selection apply in a mathematically automatic way: if the selection coefficient is positive, the mutation increases in frequency; if it is negative, it is eliminated; if it is zero, the gene frequencies drift: there is nothing to dispute about here. The dispute is about how likely it is that mutations will arise with one selection coefficient or another to begin with.

The neutral theory, or neutralism, was first put forward by Kimura, and King and Jukes in the late 1960s and has become one of the most contentious issues in evolutionary theory. It should not be confused with pan-neutralism.

The neutral theory of molecular evolution suggests that molecular evolution is mainly due to neutral drift. Alternatively, molecular evolution may be mainly driven by natural selection.

Summary of Neutral Theory

- The neutral theory of molecular evolution suggests that molecular evolution is mainly due to neutral drift. Alternatively, molecular evolution may be mainly driven by natural selection.
- Four main observations were originally interpreted in favour of the neutral theory: molecular evolution has a rapid rate, its rate has a clock-like constancy, it is more rapid in functionally less constrained parts of molecules, and natural populations are highly polymorphic.
- Kimura argued that the high rate of evolution, and the high degree of variability of proteins, would, if caused by natural selection, impose a high genetic load. Neutral drift, however, can drive high rates of evolution, and maintain high levels of variability, without imposing a genetic load.
- The constant rate of molecular evolution gives rise to a 'molecular clock'.

• Neutral drift should drive evolution at a stochastically constant rate; Kimura pointed to the contrast between uneven rates of morphological evolution and the constant rate of molecular evolution and argued that natural selection would not drive molecular evolution at a constant rate.
• The molecular clock for proteins ticks over according to absolute time rather than generational time. But for silent changes in DNA, lineages with shorter generation times probably evolve faster. Neutral drift should cause the molecular clock to run according to generational, not absolute, time.
• Selection can operate without producing impossible genetic loads, and Kimura's original case for the neutral theory is no longer convincing.
• The neutral theory explains the higher evolutionary rate of functionally less constrained regions of proteins by the greater chance that a mutation there will be neutral.
• Selectionists explain the higher evolutionary rate of functionally less constrained regions of proteins by the greater chance that a mutation there will be a small, rather than a large, change.
• Pseudogenes and silent changes in third codon positions may be relatively functionally unconstrained. These parts of the DNA evolve faster than do the first two positions in codons, and meaningful third base changes. Neutralists attribute this high rate of evolution to enhanced neutral drift.
• For amino acids encoded by more than one codon, there are consistent biases in the frequencies of the codons. Changes between the silent codons are therefore not completely unconstrained.
• The neutral theory predicts a positive relation between the degree of variability of a molecule and its rate of evolution.

Molecular Clock

The molecular clock measures the number of random mutations of an organism's gene (DNA or protein sequences) at a relatively constant rate over a specific timeframe. It is calibrated with fossil records and geological timescales. It measures how long-ago different organisms were on Earth and when the divergence of a new species happened.

When an organism inherits genetic material from the previous generation, the change occurs steadily, and the genes are said to be neutral. They are neither disadvantageous nor advantageous, meaning they do not inhibit natural selection or fitness but are rather due to genetic drift. Different genes containing different nucleotide substitutions are studied to determine the rate at which the sequences of the genes have been evolving. This occurrence happens over a timeframe of millions of years as the genes are passed down and altered from one generation to the next.

How does the Molecular Clock Work?

Molecular clocks are helpful by showing the linear relationship between the genetic distance and time since a species has diverged from another, which usually dates back further than the fossil record. This divergence essentially shows how many mutations are present in a population during a specific time frame, which correlates with the timescale of Earth and fossil records (present or not).

When looking at the difference in base pairs of two DNA sequences (AAA changes to AAG), the mutations over the years can be 1 of 2 things:
They are either fixed into a population where the gene is passed on from generation to generation or lost due to genetic drift. Thus, the change in the nucleotide sequences AAA to AAG is either fixed (passed on) or not. When the gene is passed on time and time again, scientists can then, at a later stage, deduce the percentage of the difference between the DNA sequences being studied. Scientists can then conclude whether a specific gene they are looking at is mutating at a relatively constant low rate or constant fast rate. Each gene acts as a separate clock, and each clock ticks at different rates. Thousands of genes and proteins within each

organism evolve at different rates. However, they all represent the same evolutionary events

If you analyse the DNA of a specific gene in two related species (C and D) and find that 2000 mutations are different between them, you can trace back the date. By knowing the mutation rate, say 1000 new mutations every one million years (0,001 mutations per year), one can then divide the number of mutations by the mutation rate to determine the time frame:

2000 mutations divided by 0.001 mutations per year = 2 million years old

Thus, one will find that species C and D diverged from a common ancestor around 2 million years ago.

When the clock for a particular gene or protein is calibrated against an event on the fossil record or geological time scale, then the actual date when all other events occurred can be determined as well. This process happens by examining the protein or gene substitution rate along the phylogenetic tree.

Species

Species are often defined as a group of individuals with similar characteristics, where they can interbreed to produce fertile offspring.

Important Concept Of Species

1.Typological Species Concept

In this concept, there is a finite number of varieties of living organisms that exist on earth. These types do not exhibit any relationship with each other. Such varieties are termed as species. This inequality is regarded as an unimportant and irrelevant phenomenon.

Aristotle and Plato stated this concept in their philosophies. In the year of 1954 and 1956, Cain regarded the Typological species concept as the morphospecies concept. As the members of the species or a taxon can be identified by their essential characteristics, a group of scientists refer to this as essentialist species concept.
Morphospecies concept states that the species can be differentiated from other species by their physical features and can be identified by their morphological attributes. This is called the morphological species concept.

2.Nominalistic Species Concept

The nominalistic species concept is the concept of Occam and his followers, of the belief that nature only produces individuals. Species are the creation of man. In nature, they lack definite exis-tence. These concepts do not have any scientific basis.

It believes that the species have been inven-ted to refer to big numbers of individuals jointly. During the 18th century in France, this concept was in demand and even now is used by some botanists.

3.Biological Species Concept

In the middle of the 18th century, a fresh concept called the biological species concept appeared. This concept was acknowledged in the later half of the nineteenth-century once Darwin's "Origin of Species" was published (in 1859). This is also known as the Newer Species concept.

K. Jordan was the first to formulate this concept in 1905. Later in 1940, Mayr supported this concept. As per this concept, "a species is a group of interbreeding natu-ral population that is reproductively iso-lated from other such groups". Mayr described that the members of a species exhibit these attributes:

1. **Reproductive community**: For the purpose of reproduction the individuals of a species recognize one another as potential mates.
2. **Ecological Unit**: The species' mem-bers differ from each other due to many attributes, but all the members cooperatively form a unit. They interact with other species as a unit in any environment.
3. **Genetical unit**: Species comprises a large, inter-communicating gene pool, although the individual is simply a non-permanent vessel comprising a small part of the contents of the gene pool for a shorter duration.

4.Evolutionary Species Concept

The flaws of the biological species concept had led the palaeontologists to formulate the evolutionary species concept.

1. Simpson (in 1961) had defined it as "an evolu-tionary species is a lineage (an ancestral- descendant sequence of populations) evol-ving separately from others and with its own unitary evolutionary role and tendencies".
2. Wiley (in 1978) had provided a revised definition of the evolutionary species concept. He stated that "an evolutionary species are a single lineage of ancestral-descendant popu-lation which draws its identity from other such lineages and has its own evolutionary tendencies and historical fate".

Types of Species

Following are the different types of species:

1.Taxonomic Species

It includes a group of morphologically similar organisms.

2.Microspecies

The population is obtained from a single parent.

3.Biological Species

It includes the population that involves sexually reproducing individuals.

4.Evolutionary Species

It is a combination of sexually reproducing organisms, phyletic lineages and uniparental organisms.

5.Successional Species

It includes phyletic lineages.

Speciation

A species is a group of organisms with similar characteristics and can interbreed to give fertile offspring. Speciation is an evolutionary process of the formation of new and distinct species. The species evolved by genetic modification. The new species are reproductively isolated from the previous species, i.e. the new species cannot mate with the old species.

Speciation Types

1.Allopatric Speciation

Allopatric speciation is the type of speciation caused by geographical isolation. In this, the population is separated by a physical barrier.

2.Parapatric Speciation

This is a type of allopatric speciation in which the species are not formed by any physical barrier. Instead, they are beside each other. This occurs by an extreme change in the habitat. Though the individuals in these areas can interbreed, they develop different characteristics and lifestyles.

3.Peripatric Speciation

This is a type of allopatric speciation in which new species are formed from an isolated peripheral population. In this, the populations are prevented from exchanging genes Therefore, it is difficult to distinguish between them.

4.Sympatric Speciation

It refers to the evolution of new species from the surviving ancestral species in which both the species continue to live in the same geographical region.

Factors Affecting Speciation

There are several factors that lead to speciation. Two of them are:

1.Geographical Isolation

Due to some geographical changes, few members of a species get isolated from other members. Later, this isolated group grows in a different land and eventually evolves as a new species with new adaptations according to its environment. Natural selection and genetic drift have a major role to play in this.

Let's understand this concept with an example.

Suppose earlier there was a species of flies living on land A. Some of them fed on dead animals. Evidently, there was a flood that washed off the dead animals and the flies feeding on them. Consequently, a few groups of flies get isolated from the other members to another land B. The species on land A and land B are too far to unite. Moreover, the environmental conditions in land B are different from those on mainland A. The groups of flies which now live inland B start to adapt themselves according to their environmental conditions. Gradually, the individual's structure and functions alter to give rise to a new species. This is speciation.

The new species are different from the flies in mainland A as well as from the flies who got introduced to land B by the flood. Even if this new species was reintroduced to mainland A, they would not mate with those flies. New species start to mate amongst themselves. Thus a population of new species arrives.

2.Hybridization

Hybridization is an artificial method of developing a new species. In animal husbandry, two parents from different species are mated to form a third species. Hybridization has numerous and various impacts on the process of speciation.

There are many hybrid animals, which have been crossed between the same species and the genus. Below is the list of a few successfully crossed hybrid animals:

- Zebroid- It is a hybrid cross between a male zebra (Equus quagga) and a female donkey (Equus asinus) or with any other female members of the horse family.
- Liger – It is a hybrid cross between a male lion (Panthera leo) and a tigress (Panthera tigris).

Adaptive Radiation

Adaptive Radiation refers to the adaptation of an organism that enables them to spread successfully or radiate into other environments.

What is Adaptive Radiation?

According to Darwin's Theory of Evolution, living organisms change their physical and anatomical structures over a long period of time for better adaptations to the changing environment.

The initiation of the point of evolution was when organisms wanted to exploit a niche and they were not able to do so with their existing body design or structural component. Organisms started to split and adapt various versions for better survival.

Adaptive radiation is the evolutionary process by which many species originate from one species in an area and radiate to different species.

The phenomenon of adaptive radiation was first observed by Darwin when he travelled to a place called Galapagos Island. There he observed that there were finches with different types of beaks. So, he concluded that all of these inches radiated on the same island from a single ancestor Finch. All of these finches developed beaks according to the kind of food available to them. Hence, they evolved from the conventional seed-eating finches to vegetarian and insectivorous finches. They later came to be known as Darwin's finches

Human Evolution

Evolution involves the gradual changes from simple to more complex forms. Humans are believed to have developed from simpler forms. Evolution is hypothesised to have begun in the oceans billions of years ago. Darwin gave the theory of evolution. In his book -The Origin of Species, Darwin has stated that evolution has come through a series of natural selection. The theory emphasised the following points:

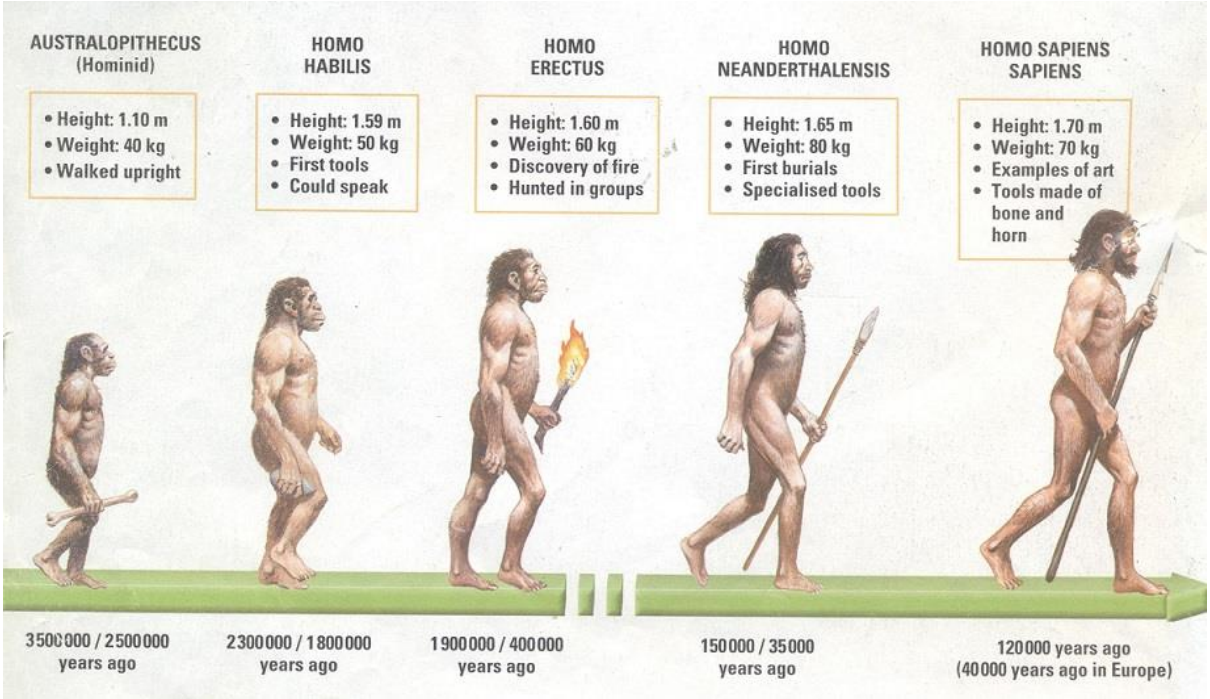
- Natural Selection
- Variation
- Struggle To Exist
- Survival of the Fittest

Evolution is the outcome of the interaction amongst the following five processes:

- Mutation
- Genetic Recombination
- Chromosomal Abnormalities
- Reproductive isolation
- Natural Selection

Stages in Human Evolution

ENTRI



The following are the stages of human evolution:

1. Dryopithecus

These are deemed to be the ancestors of both man and apes. They lived in China, Africa, Europe and India. The genus Dryopithecus refers to the oak wood apes. When Dryopithecus was alive, the tropical lowlands which it inhabited were densely forested, so the members could have predominantly been herbivores.

2. Ramapithecus

Their first remains were discovered from the Shivalik range in Punjab and later in Africa and Saudi Arabia. They lived in open grasslands. Two pieces of evidence confirm their Hominid status:
Thickened tooth enamel, robust jaws and shorter canines.
Usage of hands for food and defence and extrapolations of upright posture.

3. Australopithecus

The fossil of this genus was first discovered in 1924 in South Africa. They lived on the ground, used stones as weapons and walked erect. They were 4 feet tall and weighed 60-80 pounds.

4. Homo Erectus

The first fossil of Homo Erectus was found in Java in 1891. These were named as Pithecanthropus Erectus. These were considered as the missing link between the man and apes. Another discovery made in China was the Peking man. This specimen had large cranial capacities and is believed to have lived in communities. Homo erectus used tools comprising quartz. Tools made of bones and wood were also discovered. There is evidence of collective huntings. There is also evidence of the use of fire. The Homo Erectus is believed to dwell in caves.

5. Homo Sapiens Neanderthalensis

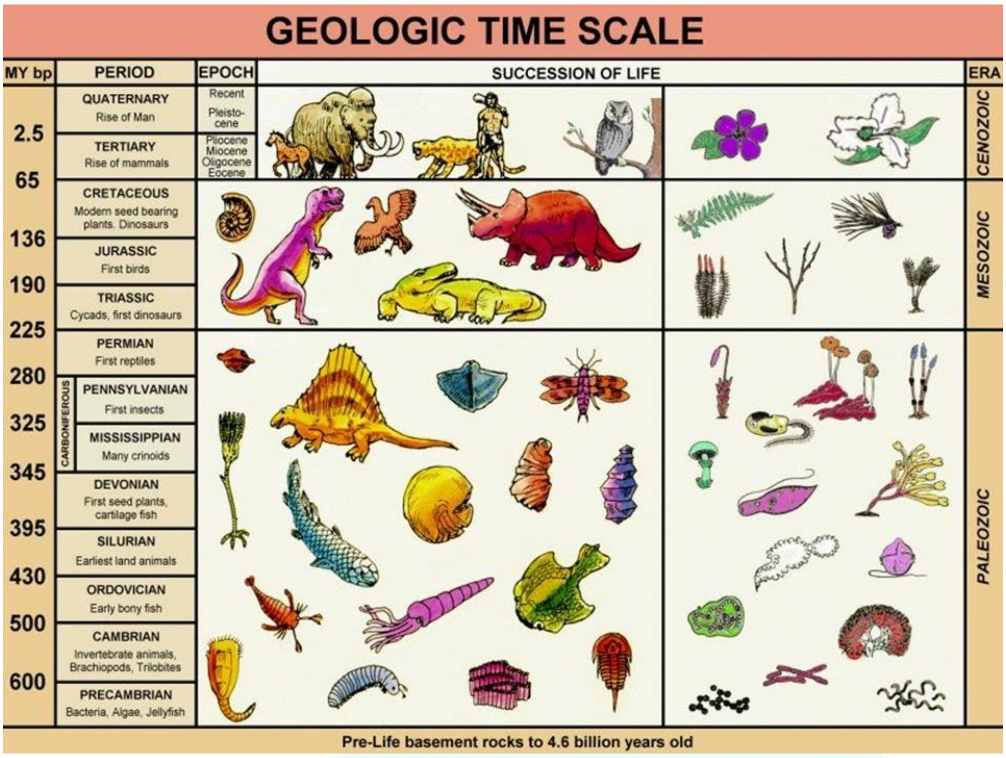
The Homo Erectus evolved into Homo Sapiens. During evolution, two subspecies of Homo Sapiens were identified- Homo sapien Neanderthal and Homo sapiens sapiens. The cranial capacity of Neanderthal grew from 1200 to 1600 cc. Some small hand axes had also been discovered. This species of hominids could hunt big names such as mammoths.

6. Homo Sapiens Sapiens

The remains of Homo Sapiens were first discovered in Europe and were named Cro-Magnon. In these, the jaws are quite reduced, the modern man’s chin appeared, and the skull was rounded. Their cranial capacity was about 1350 cc. They gathered food through hunting. Art first appeared during this time.

Hominid Fossil

The hominid fossil record is one of the best known and most complete of any mammal. This has been the product of intensive search for appropriate fossils, by the highly favourable taphonomic conditions of East and South Africa, and by the fact that early hominids were unusually demographically successful.



CULTURAL EVOLUTION

Cultural Evolution is the idea that human cultural change, that is, changes in socially transmitted beliefs, knowledge, customs, skills, attitudes, languages, and so on can be described as a Darwinian evolutionary process that is similar in key respects (but not identical) to biological/genetic evolution.

Cultural evolution is an evolutionary theory of social change. It follows from the definition of culture as "information capable of affecting individuals' behaviour that they acquire from other members of their species through teaching, imitation and other forms of social transmission".

Cultural evolution is an evolutionary theory of social change. Previously, it was believed that social change resulted from biological adaptations, but anthropologists now commonly accept that social changes arise as a consequence of a combination of social, evolutionary and biological influences.

As such, human behaviour is shaped by both genetic and cultural evolution. The same can be said for many other animal species; like the tool use of chimpanzees or Caledonian crows or the complex social organisation of hives for ants, bees, termites, and wasps.

This passage is from Morgan's masterwork Ancient Society (1877), in which he also described seven stages of cultural evolution: lower, middle, and upper savagery; lower, middle, and upper barbarism; and civilization. Cultural evolutionary theory has led to significant advances in our understanding of the effects of nonrandom mating, revealing that the transmission and dynamics of cultural traits can be sensitive to both phenotypic and environmental assorting.

There have been a number of different approaches to the study of cultural evolution, including dual inheritance theory, sociocultural evolution, memetics, cultural evolutionism and other variants on cultural selection theory. The approaches differ not just in the history of their development and discipline of origin but in how they conceptualise the process of cultural evolution and the assumptions, theories and methods that they apply to its study. In recent years, there has been a convergence of the cluster of related theories towards seeing cultural evolution as a unified discipline in its own right.

Cultural evolution has been criticised over the past two centuries for advancing its development into the form it holds today. Morgan's theory of evolution implies that all cultures follow the same basic pattern. Human culture is not linear, different cultures develop in different directions and at differing paces, and it is not satisfactory or productive to assume cultures develop in the same way.

A further key critique of cultural evolutionism is what is known as "armchair anthropology". The name results from the fact that many of the anthropologists advancing theories had not seen first hand the cultures they were studying. The research and data collected was carried out by explorers and missionaries as opposed to the anthropologists themselves. Edward Tylor was the epitome of that and did very little of his own research. Cultural evolution is also criticised for being ethnocentric, cultures are still seen to be attempting to emulate western civilization. Under ethnocentricity, primitive societies are said to be not yet at the cultural levels of other western societies. Much of the criticism aimed at cultural evolution is focused on the unilineal approach to social change.

Unilineal Evolutionism

Unilineal evolution, also referred to as classical social evolution, is a 19th-century social theory about the evolution of societies and cultures. It was composed of many competing theories by various anthropologists and sociologists, who believed that Western culture is the contemporary pinnacle of social evolution.

Unilineal Theory

In the 19th century cultural evolution was thought to follow a unilineal pattern whereby all cultures progressively develop over time. The underlying assumption was that Cultural Evolution itself led to the growth and development of civilization.

Thomas Hobbes in the 17th Century declared indigenous culture to have "no arts, no letters, no society" and he described facing life as "solitary, poor, nasty, brutish, and short." He, like other scholars of his time, reasoned that everything positive and esteemed resulted from the slow development away from this poor lowly state of being.

Under the theory of unilineal Cultural Evolution, all societies and cultures develop on the same path. The first to present a general unilineal theory was Herbert Spencer. Spencer suggested that humans develop into more complex beings as culture progresses, where people originally lived in "undifferentiated hordes' ' culture progresses and develops to the point where civilization develops hierarchies. The concept behind unilineal theory is that the steady accumulation of knowledge and culture leads to the separation of the various modern day sciences and the build- up of cultural norms present in modern-day society.

In Lewis H. Morgan's book Ancient Society (1877), Morgan labels seven different stages of human culture: lower, middle, and upper savagery; lower, middle, and upper barbarism; and civilization. He justifies this staging classification by referencing societies whose cultural traits resembled those of each of his stage classifications of the cultural progression. Morgan gave no example of lower savagery, as even at the time of writing few examples remained of this cultural type. At the time of expounding his theory, Morgan's work was highly respected and became a foundation for much of anthropological study that was to follow.
Lewis H. Morgan, an anthropologist whose ideas have had much impact on sociology, in his 1877 classic Ancient Societies differentiated between three eras:

(i) savagery
(ii) barbarism
(iii) civilization,

which are divided by technological inventions, like fire, bow, pottery in the savage era, domestication of animals, agriculture, metalworking in barbarian era and alphabet and writing in civilization era. Thus Morgan introduced a link between social progress and technological progress. Morgan viewed technological progress as a force behind social progress, and any social change—in social institutions, organisations or ideologies have their beginning in the change of technology. Morgan's theories were popularised by Friedrich Engels, who based his famous work "The Origin of the Family, Private Property and the State" on it. For Engels and other Marxists, this theory was important as it supported their conviction that materialistic factors—economical and technological—are decisive in shaping the fate of humanity.

Neo-evolutionism

Neoevolutionism as a social theory attempts to explain the evolution of societies by drawing on Charles Darwin's theory of evolution while discarding some dogmas of the previous theories of social evolutionism. Neoevolutionism is concerned with long-term, directional, evolutionary social change and with the regular patterns of development that may be seen in unrelated, widely separated cultures.

Sociological neoevolutionism emerged in the 1930s. It developed extensively in the period after the Second World War—and was incorporated into anthropology as well as into sociology in the 1960s.

Neo-evolution Theory

Neo Evolutionary theories are based on empirical evidence from fields such as archaeology, palaeontology, and historiography. Proponents say neoevolutionism is objective and simply descriptive, eliminating any references to a moral or cultural system of values.

While 19th-century cultural evolutionism attempted to explain how culture develops by describing general principles of its evolutionary process, historical particularism dismissed it as unscientific in the early-20th century. Neo Evolutionary thinkers brought back evolutionary ideas and developed them, with the result that they became acceptable to contemporary anthropology.

Neoevolutionism discards many ideas of classical social evolutionism, notably the emphasis on social progress, so dominant in previous sociological evolution-related theories. Neoevolutionism discards the determinism argument and introduces probability, arguing that accidents and free will have much impact on the process of social evolution. It also supports counterfactual history asking "what if?" and considering different possible paths that social evolution may (or might) have taken, and thus allows for the fact that various cultures may develop in different ways, some skipping entire "stages" others have passed through.

Neoevolutionism stresses the importance of empirical evidence. While 19th-century social evolutionism used value judgments and assumptions when interpreting data, neoevolutionism relies on measurable information for analysing the process of cultural evolution.

Leslie A. White (1900–1975), author of The Evolution of Culture: The Development of Civilization to the Fall of Rome (1959). Publication of this book rekindled interest in evolution among sociologists and anthropologists. White attempted to construct a theory explaining the entire history of humanity. The most important factor in his theory is technology: Social systems are determined by technological systems, wrote White in his book, echoing the earlier theory of Lewis Henry Morgan (1818-1881). As a measure of societal advance he proposed measuring the energy consumption of a given society (thus his theory became known as the energy theory of cultural evolution).

White introduced a formula: C=E*T, where E is a measure of energy consumed, and T is the measure of efficiency of technical factors utilising the energy. This theory resembles the later theory of the Kardashev scale proposed in the 1960s by the Russian astrophysicist Nikolai Kardashev (1932–).White differentiates five stages of human development:

- First, people use the energy of their own muscles.
- Secondly, they use the energy of domesticated animals.
- In the third, they use the energy of plants (White refers to the agricultural revolution here).
- In the fourth, they learn to use the energy of natural resources: coal, oil, gas.
- In the fifth, they harness nuclear energy.

Leslie White and Lewis Henry Morgan.

He views technological progress as the most basic factor in the evolution of societies and cultures. Unlike White, who defined technology as the ability to create and utilise energy, Lenski focuses on information, its amount and uses. The more information and knowledge (especially when they allow the shaping of natural environments) a given society has, the more advanced it is. He distinguished four stages of human development, based on the advances in the history of communication.

- In the first stage, information is passed by genes.
- In the second, when humans gain sentience: they can learn and pass information on by experience.
- In the third, humans start using signs and develop logic.
- In the fourth, they can invent symbols, and develop language and writing. Advances in the technology of communication translate into

advances in the economic and political systems, the distribution of goods, social inequality and other spheres of social life. Lenski also differentiates societies based on their level of technology, communication and economy:

- Hunters and gatherers.
- Simple agricultural.
- Advanced agriculture.
- Industrial.
- Special (like fishing societies)

Julian Steward (1902–1972), author of Theory of Culture Change: The Methodology of Multilinear Evolution (1955, reprinted 1979), developed the theory of "multilinear" evolution, which examined the way in which societies adapted to their environment—a more nuanced approach than White's theory of "unilinear evolution". He questioned the possibility of forming a single social theory encompassing the entire evolution of humanity, however he argued that anthropologists are not limited to descriptions of specific, existing cultures. He believed it possible to develop theories analysing typical, common culture, representative of specific areas or regions. As the decisive factors determining the development of a given culture he pointed to technology and economics, and noted secondary factors such as political systems, ideologies and religion. All those factors push the evolution of a given society in several directions at the same time, hence the multilinearity of his theory of evolution.

- In the 20th century there evolved Neo Evolutionism with Leslie White, Julian Steward,Marshall Sahlins and Elman Service as main propounders.
- Leslie White emphasised that the evolutionary stages are abstractions applicable to the growth of human culture. He also believed that culture is to be studied in its own terms. He suggested the term culturology to the science of culture. He is known to be the proponent of General Evolution where he says that it has been studied entirely on a culturological level. According to him culture

grows out of culture with new combinations, syntheses continually formed. He also says that technology is the basic determinant of cultural evolutionism. He also refers to it as Cultural Materialism. According to him, the other factors remaining constant, culture evolves as energy harnessed per capita,per year is increased, the system not only increases in size but becomes more highly evolved , they become more differentiated and more specialised functionally.

- Julian Steward says that Cultural Evolution may be defined as a quest for regularities or laws. There are three ways in which evolutionary data can be analysed.

Leslie Alvin White (January 19, 1900, Salida, Colorado – March 31, 1975, Lone Pine, California) was an American anthropologist known for his advocacy of theories of cultural evolution, sociocultural evolution, and especially neo-evolutionism, and for his role in creating the department of anthropology at the University of Michigan Ann Arbor. He was president of the American Anthropological Association (1964).

Leslie White, (author of The Evolution of Culture: The Development of Civilization to the Fall of Rome (1959), attempted to create a theory explaining the entire history of humanity. The most important factor in his theory is technology. Social systems are determined by technological systems, wrote White in his book, echoing the earlier theory of Lewis Henry Morgan. He proposes a society's energy consumption as a measure of its advancement.

He differentiates between five stages of human development. First, people use the energy of their own muscles. In the second, they use the energy of domesticated animals. In the third, they use the energy of plants (so White refers to agricultural revolution here). In the fourth, they learn to use the energy of natural resources: coal, oil, gas. In the fifth, they harness nuclear energy.

White introduced a formula, P=E·T, where E is a measure of energy consumed, and T is the measure of efficiency of technical factors utilising the energy.

This theory is similar to Russian astronomer Nikolai Kardashev's later theory of the Kardashev scale.

Julian Haynes Steward (January 31, 1902 – February 6, 1972) was an American anthropologist best known for his role in developing "the concept and method" of cultural ecology, as well as a scientific theory of culture change.
Julian Steward, author of Theory of Culture Change: The Methodology of Multilinear Evolution (1955, reprinted 1979), created the theory of "multilinear" evolution which examined the way in which societies adapted to their environment. This approach was more nuanced than White's theory of "unilinear evolution." Steward rejected the 19th-century notion of progress, and instead called attention to the Darwinian notion of "adaptation", arguing that all societies had to adapt to their environment in some way. He argued that different adaptations could be studied through the examination of the specific resources a society exploited, the technology the society relied on to exploit these resources, and the organisation of human labour. He further argued that different environments and technologies would require different kinds of adaptations, and that as the resource base or technology changed, so too would a culture. In other words, cultures do not change according to some inner logic, but rather in terms of a changing relationship with a changing environment. Cultures therefore would not pass through the same stages in the same order as they changed—rather, they would change in varying ways and directions. He called his theory "multilineal evolution". He questioned the possibility of creating a social theory encompassing the entire evolution of humanity; however, he argued that anthropologists are not limited to describing specific existing cultures. He believed that it is possible to create theories analysing typical common culture,

representative of specific eras or regions. As the decisive factors determining the development of a given culture he pointed to technology and economics, but noted that there are secondary factors, like political system, ideologies and religion. All those factors push the evolution of a given society in several directions at the same time; hence the application of the term "multilinear" to his theory of evolution.

Culture

Culture is a word for the 'way of life' of groups of people, meaning the way they do things. Excellence of taste in the fine arts and humanities, also known as high culture. An integrated pattern of human knowledge, belief, and behaviour. The outlook, attitudes, values, morals, goals, and customs shared by a society.

Culture – set of patterns of human activity within a community or social group and the symbolic structures that give significance to such activity. Customs, laws, dress, architectural style, social standards, religious beliefs, and traditions are all examples of cultural elements.

Culture is the beliefs, behaviours, objects, and other characteristics shared by groups of people. ... Some cultures place significant value in things such as ceremonial artefacts, jewellery, or even clothing. For example, Christmas trees can be considered ceremonial or cultural objects.

Culture is the characteristics and knowledge of a particular group of people, encompassing language, religion, cuisine, social habits, music and arts. ... The word "culture" derives from a French term, which in turn derives from the Latin "colere," which means to tend to the earth and grow, or cultivation and nurture.

Language, symbols, values, and norms are among the important elements of culture. Our religious beliefs, customs and traditions, art, as also history, taken together can be considered as the cultural elements.

Cultural trait

A cultural trait is a characteristic of human action that's acquired by people socially and transmitted via various modes of communication. Cultural traits are things that allow for a part of one culture to be transmitted to another. If they combine with other cultural traits, they may change.

Culture has five basic characteristics: It is learned, shared, based on symbols, integrated, and dynamic.

All cultures share these basic features.

- Culture is learned. ...
- Culture is shared. ...
- Culture is based on symbols. ...
- Culture is integrated. ...
- Culture is dynamic.
- Culture traits.

The least unit of culture is called Culture Trait. There are millions of culture traits, a trait can be an object, a technique, a belief or an attitude. For example; a pencil is a culture trait, football, bat, fishhook, keeping cattle, handshake, gestures, and house.

Cultural Complex

A group of culture traits all interrelated and dominated by one essential trait: Nationalism is a culture complex.

A number of traits when organised together make a culture complex. A watch, football match, attitudes and actions, prayer, Hajj, Eids, agriculture system, market system, a political party, a constitution, an industrial unit, an examination system are the examples of culture complex.
For example; a pencil is a culture trait, football, bat, fishhook, keeping cattle, handshake, gestures, and house. Culture Complex. Culture traits are interrelated with each other, their collective function forms a culture complex. Football is a cultural trait, and the football match is a cultural complex.

Culture Area

Culture areas are geographical territories in which characteristic culture patterns are recognizable through repeated associations of specific traits and, usually, through one or more modes of subsistence that are related to the particular environment. As one formulation within the general school of historical particularism that has developed in anthropology in the United States, the concept of culture area reflects the theoretical position that each culture, on whatever level it may be analysed, must be examined with regard to its own history and also with regard to the general principles of independent invention, culture borrowing, and cultural integration. Although many factors at the base of any recognizable culture area are ecological in nature, the culture-area concept is one that conforms to the doctrine of limited possibilities rather than to a simple geographic determinism.

Viewed in this light and assessed according to the size and character of the geographic units and the degree of complexity of cultural similarities within, and differences between, the units, the culture-area concept takes shape as a classificatory device of marked utility in describing the cultural regions of the world. Since “culture” and “area” are both generalised terms, their use in combination gives no real clue as to precise meaning, which must be specified. When contrasting one culture area with another, the level of abstraction must be the same.

In its original formulation the culture-area concept applied primarily to the ethnographic present and occupied an important niche in the natural-history phase of anthropology that was concerned with the orderly description of the cultures of the world. The geographic distribution of culture traits within such areas served as indirect evidence for the reconstruction of cultural histories. The formulations for each of the major continents were used for convenience in the ordering of ethnographic descriptions but were otherwise ignored or discarded as being too limited in time, too static in concept, and too generally conceived to be of much use to the developing trends of concern with inter-personal and social dynamics.

The culture-area concept is a means of organising a vast amount of variegated ethnographic data into comprehensible units within a classificatory system. Like all such systems, it depends upon an increasing number of criteria or determinants in the isolation of units in a descending order of magnitude. Major considerations in recognizing these areas and subareas are ecological zones, patterns of cultural integration, and correlations of independently diffused traits. Although initial recognition may depend in part upon familiarity and intuition, distribution studies serve as effective controls. Important determining processes seem to be cultural adjustments to the environment and the inward focusing of contacts within an area, caused by regional topographic patterns which produce cultural isolates. These factors persist through time and find expression either in the continuities of cultural traditions or in the reappearance of the same areas and boundaries, even when the local culture history is discontinuous.