

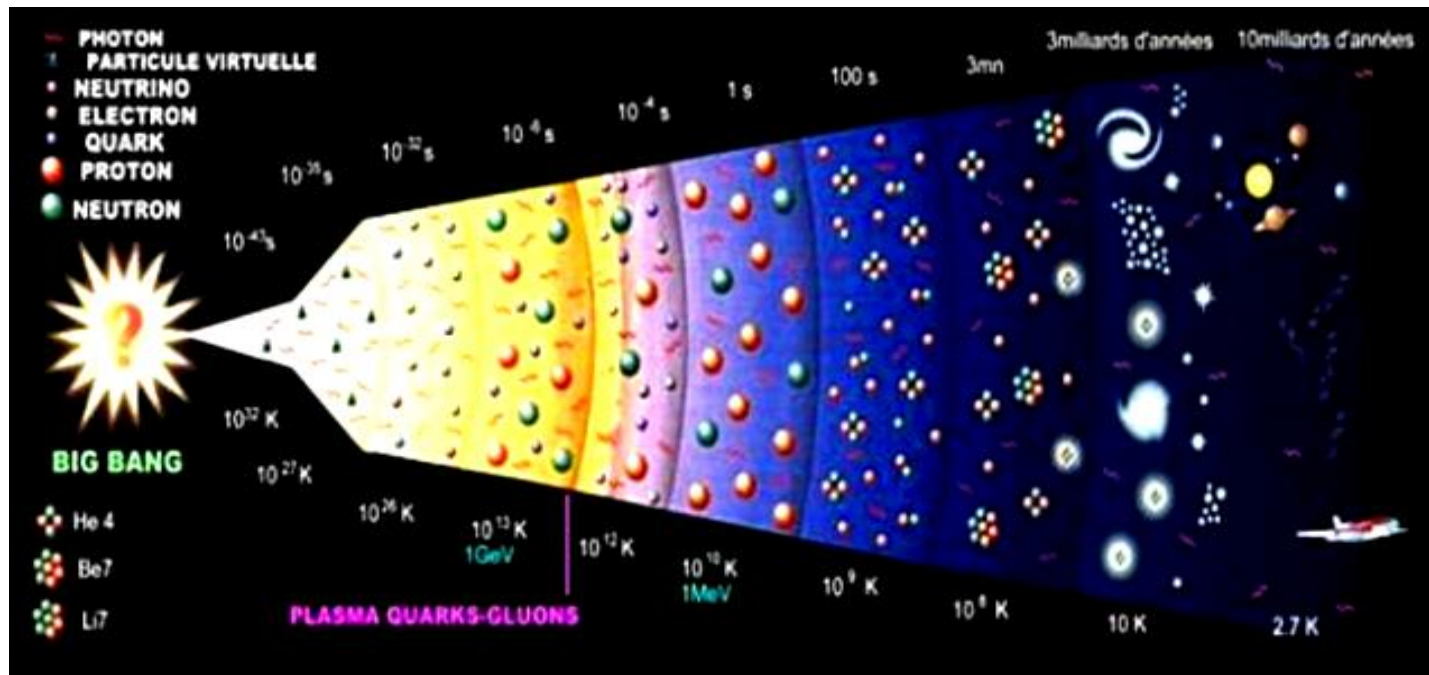
## 7. EVOLUTION

**Evolution** is an orderly change from one condition to functionally efficient condition.

**Evolutionary biology** is the study of history life forms on earth.

### Origin of universe

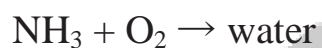
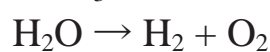
- Universe is around 20 billion years old and comprises of huge clusters of galaxies.
- The origin of universe is explained by **Big Bang theory**:-20 bya explosion of 'Nebula', hot substance → universe expanded → temperature came down → **H** and **He** formed → gases condensed under gravitation → formation of galaxies



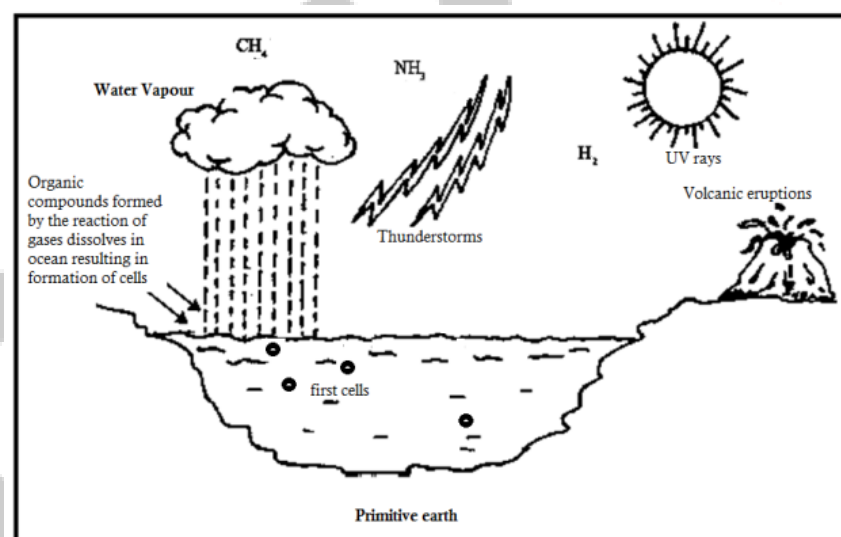
### Origin of Earth

In the solar system of milky-way galaxy, the earth was formed about 4.5 bya.

There was no atmosphere on early earth. Water vapour,  $\text{CH}_4$ ,  $\text{CO}_2$  &  $\text{NH}_3$  released from molten mass covered the surface.



Then the ozone layer was formed. As it cooled (from 5000-6000°C), the water vapour fell as rain to form oceans.



### Origin of life

Non-cellular form of life originated on earth about 3 bya, and cellular form-2 bya

#### Theories:-

- Theory of **Panspermia**-Life has originated from **spores** transferred in meteorites or in spaceship to diff. planets including earth.
- Theory of **Spontaneous generation/Abiogenesis**- Life came out of lifeless matters like straw, mud, etc. in a spontaneous manner.
- Theory of **Biogenesis**-Life formed from pre-existing life (rejected since it did not answer how the first life forms).

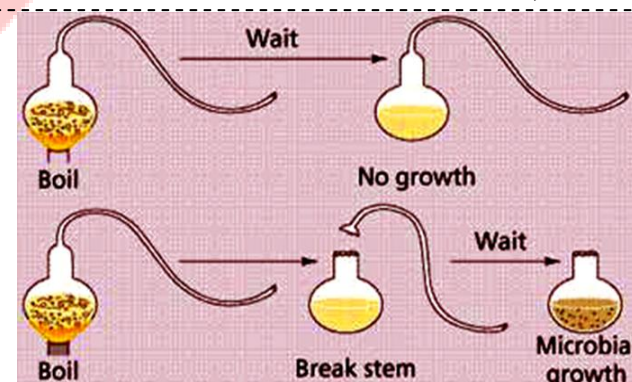
#### → Proved by Louis Pasteur

Experimental procedure-

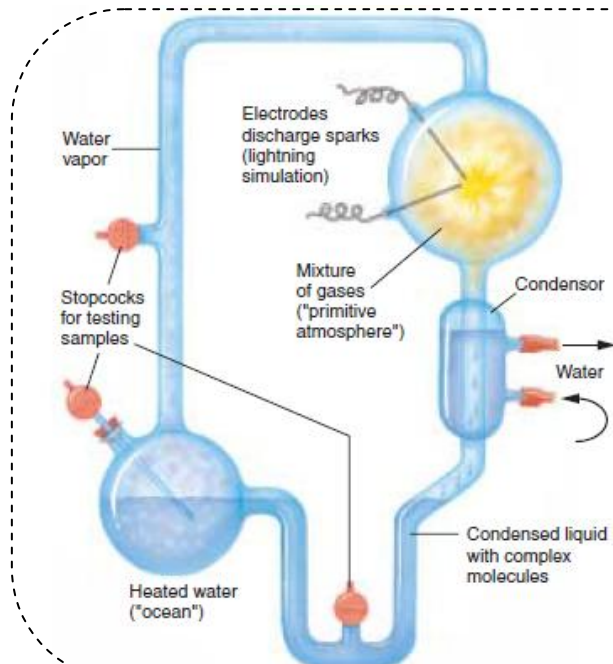
**Case 1.** In pre-sterilised swan-necked flasks, yeast gets boiled (killed). No microbial growth (life) seen in it after.

*NB: This step disprove abiogenesis.*

**Case 2.** In another pre-sterilised flasks, yeast gets boiled. Then broken the stem of flask (i.e., microbes may entered from air into it). After a few days, microbial growth seen in it.



(d) Theory of **Chemical evolution** (By Oparin & Haldane) -Inorganic chemicals accidentally reacted in water to form life.



**Urey-Miller's exp.-** To prove Chemical evolution, simulated the primitive earth's atmosphere in a specially created sealed chamber.

#### Oparin- Haldane hypothesis

1. **Life formed** from 1000m of years evolution
2. **Atmosphere containing**  $\text{CH}_4$ ,  $\text{NH}_2$  etc. get accidentally collided.
3. **Water vapour** formed by volcanic storm
4. **Source of energy** is lightning
5. **Reducing atmosphere** because no  $\text{O}_2$
6. **Water vapour condensed** (fell as rain) as atm. cooled due to ozone layer formation
7. **Formation** of RNA, protein etc. in ocean

#### Urey- Miller experiment

- 18 day experiment
- Took  $\text{CH}_4$ ,  $\text{H}_2$ ,  $\text{NH}_2$  in a 5ℓ flask
- Formed by boiling water @ 800°C
- By electric discharge (75,000v)
- Air has removed using vacuum pump
- Used condenser for liquefying the gases in the flask
- Formed amino acids in the trap



(e) Theory of **Special creation**- Life was created by some super natural power either once or at successive intervals.

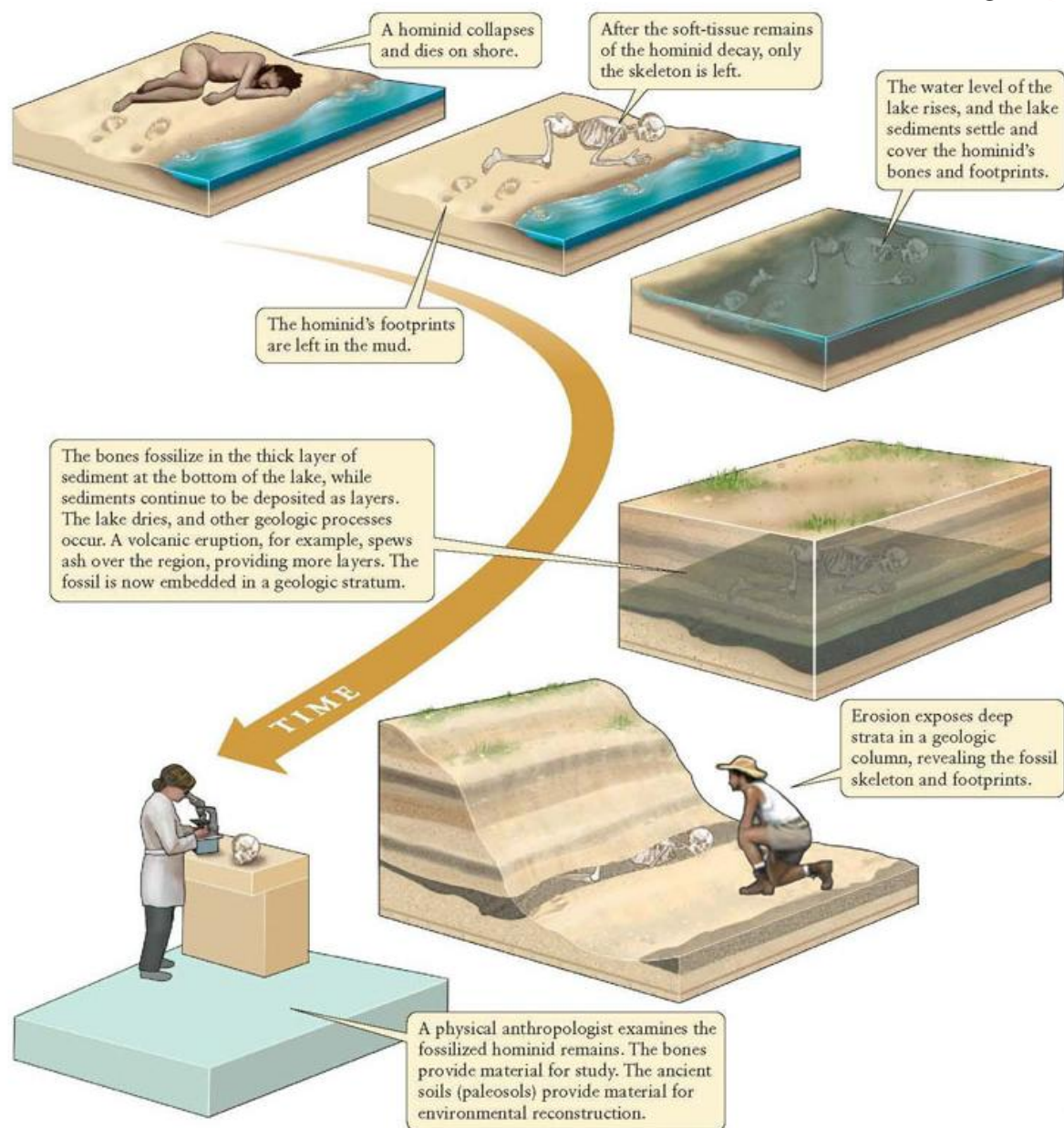
- 3 connotations  
(Additions to the theory)
- Earth is about 4000 years old.
  - All living organisms were created as such.
  - Diversity was always the same (since creation and in future)

This is illogical & irrational. Not supported by empirical evidences.

## EVIDENCES FOR BIOLOGICAL EVOLUTION

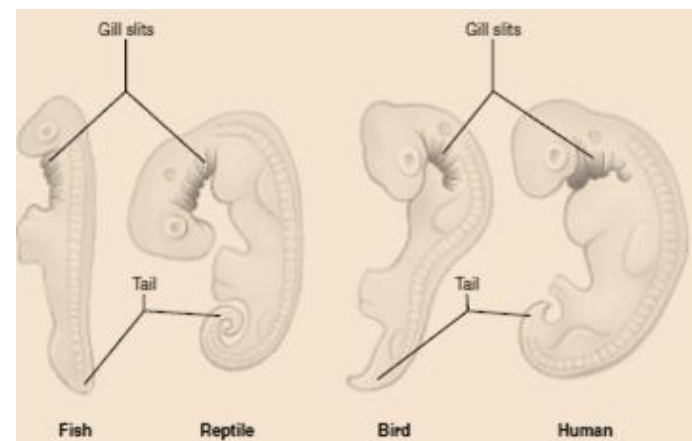
### 1. Paleontological Evidences

- **Paleontology:** The study of fossils. **Fossils** are remnants of life-forms found in rocks.
- **Significance of fossils:**
  - ✓ To study **phylogeny** (evolutionary history or race history).
  - ✓ To study about **extinct animals**. E.g. Dinosaurs
  - ✓ To study about **geological period** by analyzing fossils in different **sedimentary rock layers**. The study showed that life forms varied over time and certain life forms are restricted to certain geological time spans.



### 2. Embryological evidences

- **Ernst Heckel** proposed **biogenetic law**, which states that ontogeny (development of the embryo) is recapitulation of phylogeny (development of race). This means an organism repeats its ancestral history during the development.  
**E.g.** The embryos of all vertebrates including human develop a row of vestigial gill slit just behind the head but it is a functional organ only in fish and not found in any other adult vertebrates.
- However, this proposal was disapproved by **Karl Ernst von Baer**. He noted that embryos never pass through the adult stages of other animals.



### 3. Anatomical & morphological evidences

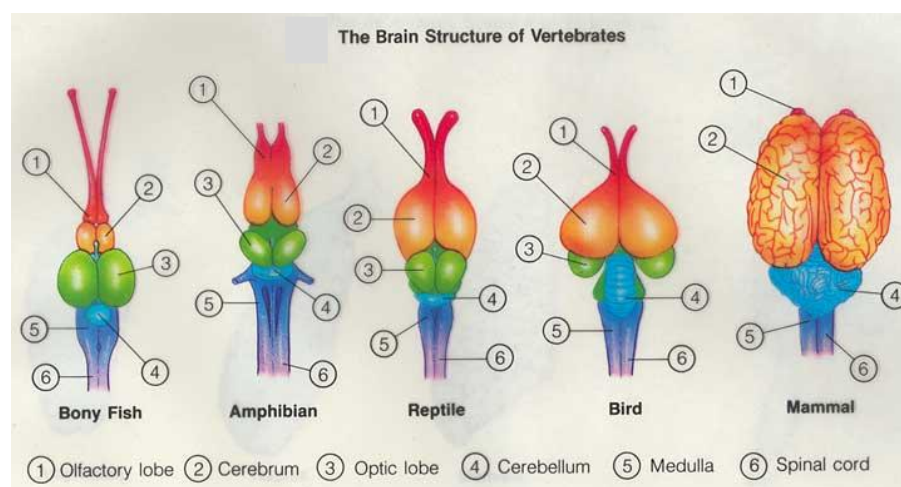
- Comparative anatomy and morphology shows that different forms of animals or plants have some common structural features. This include:-

#### a. Homologous organs

Homologous organs are the organs with similar in structure of different animals based on common ancestry, but perform diff. functions.

- E.g.:** i. Human hand, Whale's flippers, Bat's wing, and Cheetah's foot. All these perform different functions, but are constructed on the same plan.
- ii. Vertebrate hearts or brains.
- ii. Thorns of *Bougainvillea* and tendrils of *Cucurbita*.

- The origin of homologous organs is due to **Divergent evolution** (It is the process by which **related species** become **less similar** in order to survive and adapt in **different environmental needs**).

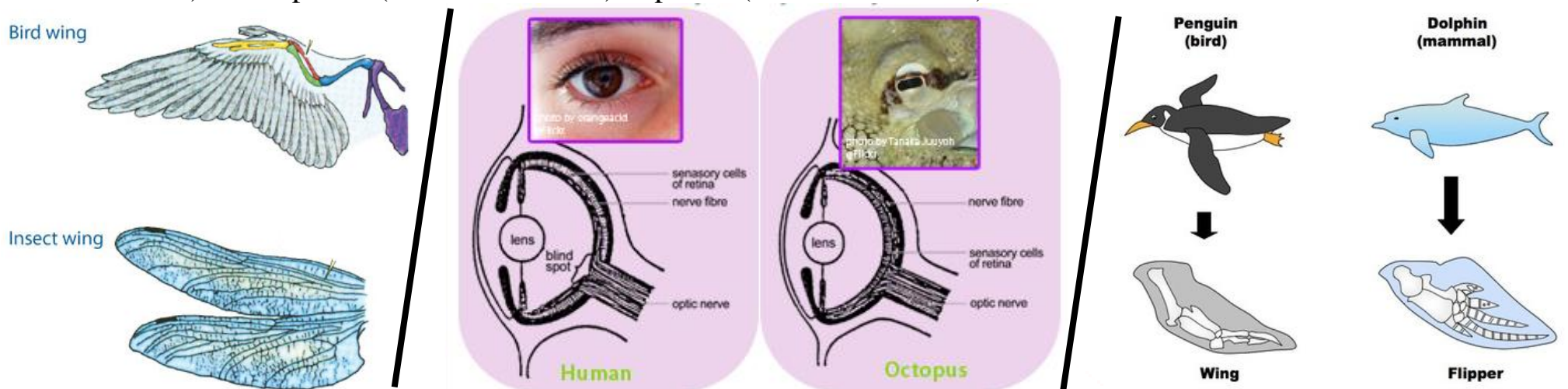




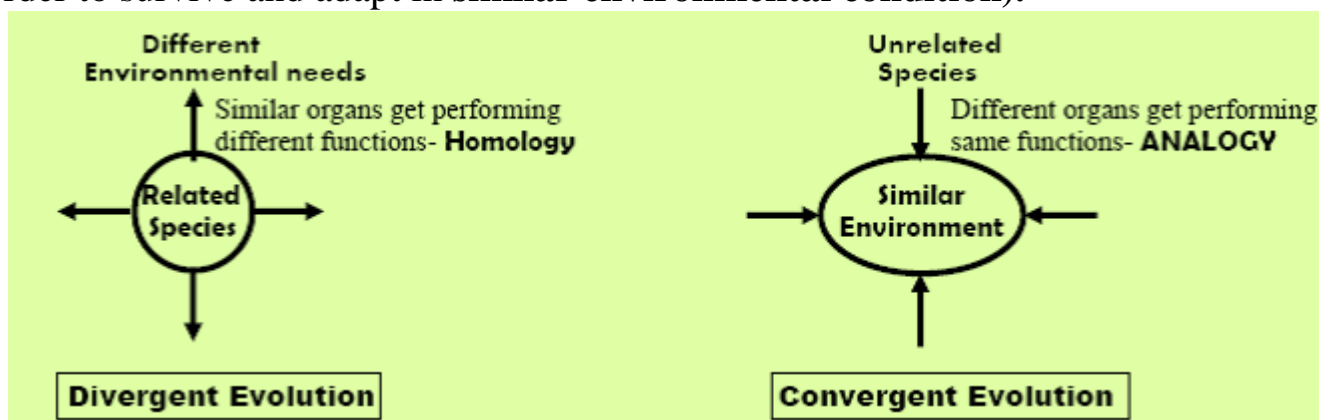
## b. Analogous organs and Analogy

Analogous organs are organs with diff. in structure but perform similar functions.

- Eg:** i) Wings of butterfly (formed of thin flap of chitin) and birds (modified forelimbs)  
 ii) The eye of the octopus (retina from skin) and of mammals (retina from embryonic brain)  
 iii) The flippers of Penguins and Dolphins.  
 iv) Sweet potato (root modification) & potato (stem modification).

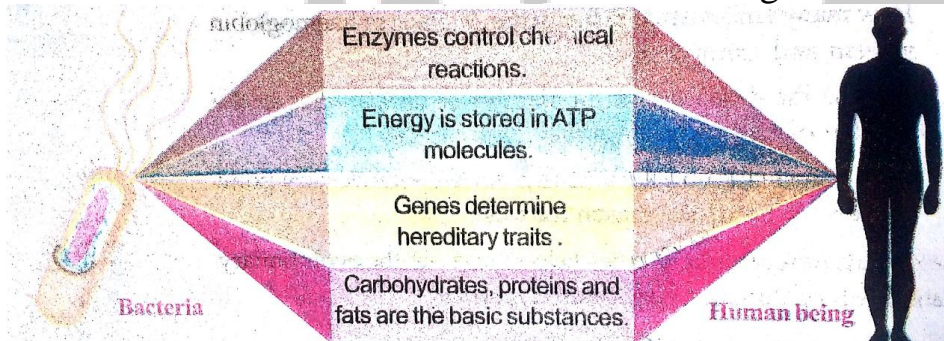


- Origin of analogous organs is due to **Convergent evolution** (It is the process by which **unrelated species** become more **similar** in order to survive and adapt in **similar environmental condition**).



## 4. Biochemical evidences

- Similarities in biomolecules and metabolism among diverse organisms show they are evolved from a common ancestor.



## 5. Evidences from breeding

- Nowadays, by **artificial selection & breeding**, human created different breeds belonging to same group which may later evolve as new type. (This is the same thing nature doing by millions of years).

**Eg:** Dogs



## 6. Evidences from Anthropogenic actions

- i) Industrial Melanism (In England)

**Before industrialisation** (1850s): There were more white winged moths than dark winged or melanised moths.

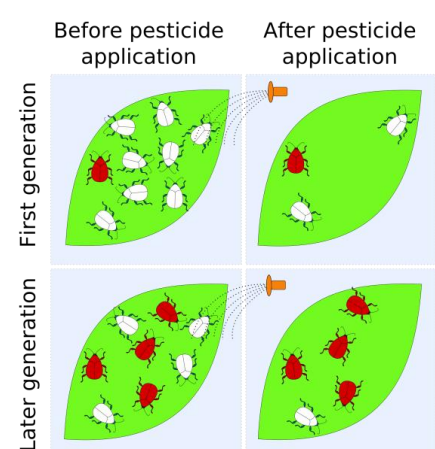
**Reason:** There was white coloured lichen covered the trees. In that background, the white winged moths survived but the dark coloured moths were picked out by predators.

**After industrialization** (1920): More dark winged moths and less white winged moths.

**Reason:** The tree trunks became dark due to industrial smoke and soot. No growth of lichens. Under this condition the white winged moth did not survive because the predators identified them easily. Dark winged moth survived because of suitable dark background.

- ii) Selection of resistant varieties

- Excess use of **herbicides**, **pesticides** or **antibiotics** etc resulted in selection of resistant varieties.



## 7. Biogeographical evidence

- **Adaptive radiation** is the evolution of closely related species starting from a common point in a given geographical area radiating to other areas of geography (habitats)  
**E.g.:** i) Darwin's finches (Seen in Galapagos Island)  
ii) Australian marsupials  
iii) Placental mammals in Australia
- When more than one adaptive radiation is appeared in an isolated geographical area, this leads to **convergent** evolution.  
**E.g.:** Australian Marsupials and Placental mammals.

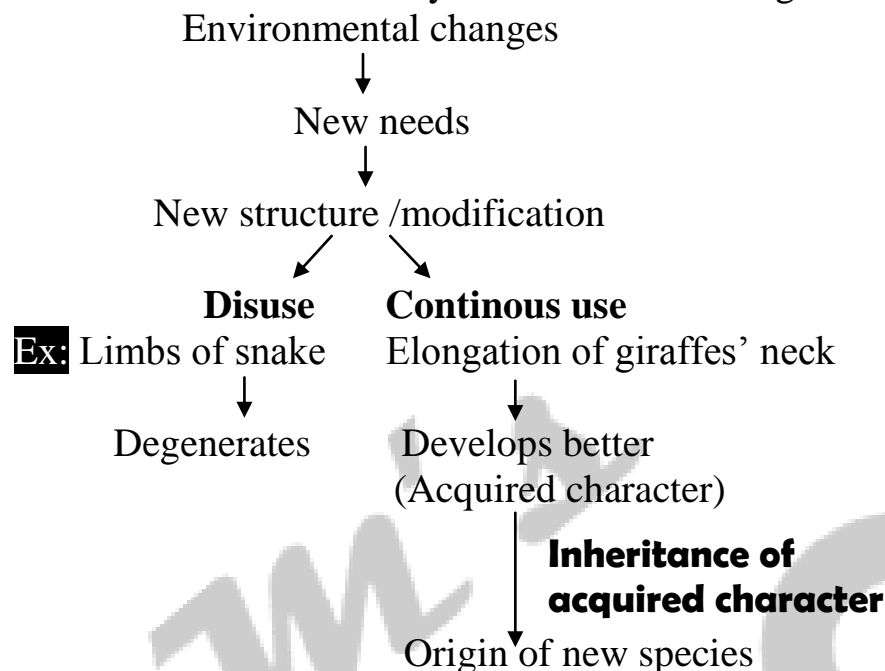
# THEORIES OF BIOLOGICAL EVOLUTION

## 1. Theory of Inheritance of Acquired Character-By Lamarck (French naturalist)-1809

Book- *Philosophic Zoologique*

It states that evolution of life forms occurred by use and disuse of organs.

Concept map→



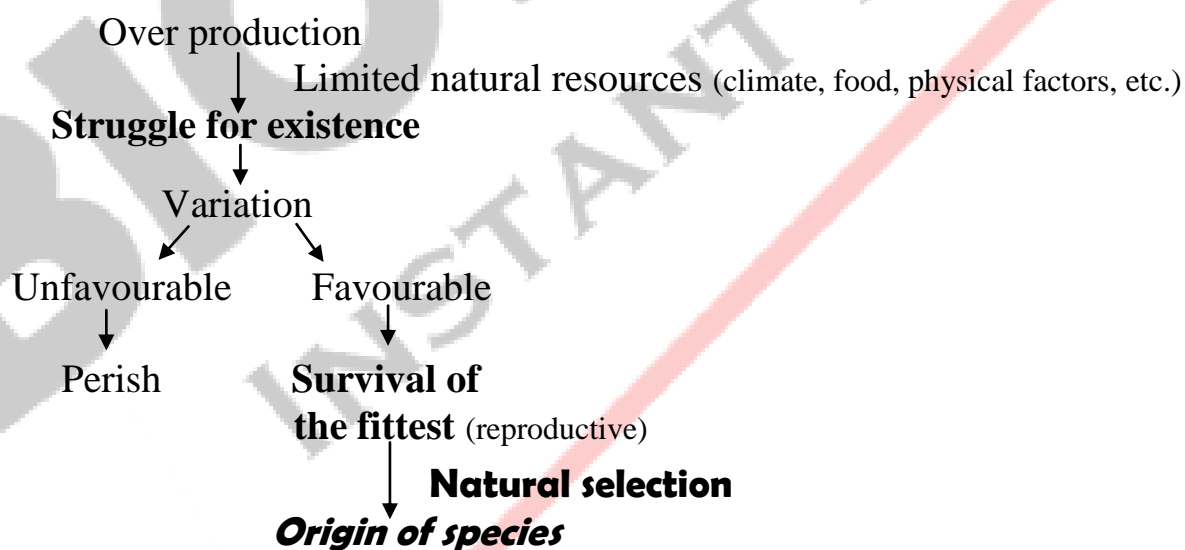
## 2. Theory of natural selection-By Darwin (British Naturalist) and Alfred Wallace (Dutch Naturalist)

- Darwin's Book- *The Origin of Species by Natural Selection*
- Influenced by the work of **Thomas Malthus** (British Economist- *An essay on the Principle of Population*). It suggests that 'though the multiplication rate of a population is very high, the population size will be almost stable due to the limited supply of natural resources'.

### Key Concepts-

- ✚ **Branching descent** - Present complex plants and animals have evolved from earlier simpler forms of life by gradual change.
- ✚ **Nature selects** for fitness (who are better fit in an environment, leave more progeny than others).
- ✚ The rate of appearance of new forms is linked to the life cycle or the life span.

Concept map→



## 3. Theory of Mutation-By Hugo De Vries (Dutch Botanist)-1901

Book- *Species & varieties, Their Origin by Mutation*

- Mutation causes large difference arising suddenly in a large population leading to speciation-**Saltation**.

### Variation <sup>v</sup>/<sub>s</sub> Saltation

In <b>Natural Selection</b>	In <b>Mutation</b>
By Darwin	By Hugo de vries
*Studied on finches	*On prime rose ( <i>Oenothera lamarckiana</i> )
* <b>Variations</b> - Small	* <b>Mutations</b> -Large
-Gradual process	-Sudden(single step)
-Directional	-Directionless
*Ignored 'factors'	*A/c to 'factors'



# HARDY-WEINBERG PRINCIPLE

- **G.H. Hardy** (British Mathematician) and **W. Weinberg** (German physician) states that '*the **gene pool** (total genes and their alleles in a population) remains constant from generation to generation-**Genetic equilibrium**- in an infinitely large interbreeding population in which mating is random and no selection, migration or mutation occurs*'.

In other words, sum total of all the allelic frequencies is 1.

➤ To explain this mathematically-

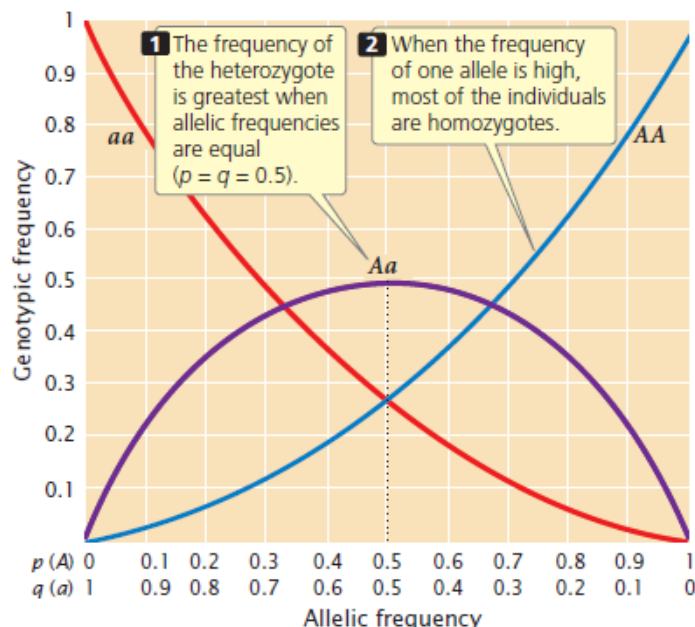
Consider **A** (dominant) and **a** (recessive) are two alleles of a particular trait in a population, with frequency **p** and **q** respectively.

Possible allelic combination: AA-Aa-aA- aa

Their frequencies-  $p^2$   $pq$   $qp$   $q^2$

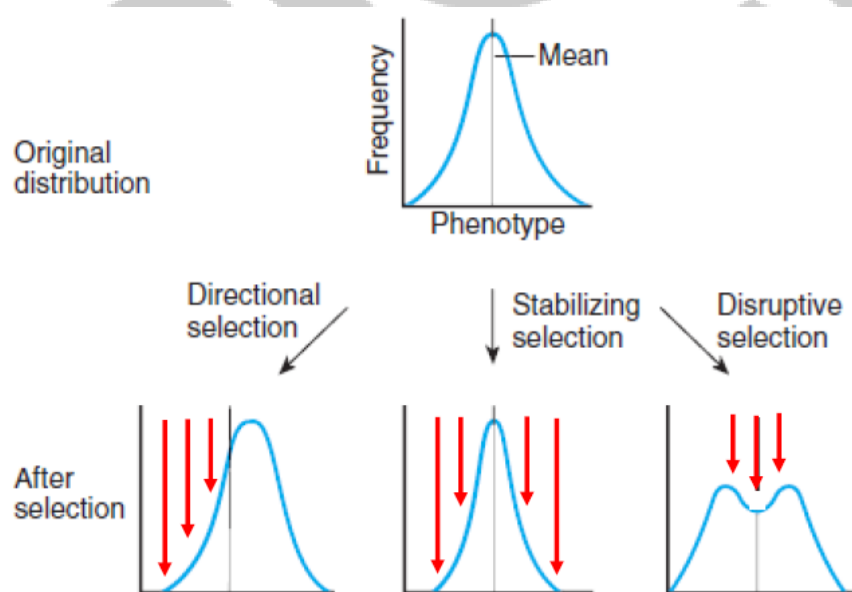
Hence  $p^2 + 2pq + q^2 = 1$  [binomial expansion of  $(p+q)^2$ ]

➔ Disturbance in this equilibrium, i.e., change of frequency of alleles in a population results in **evolution**.



## Factors affecting Hardy-Weinberg equilibrium

- Gene migration or gene flow**- It occurs when addition/ removal of alleles while individuals join/ leave a population. Here allelic frequencies change in both gene pool.
- Genetic drift** -It is the random change in the frequency of alleles occurring by chance.  
**Sewall Wright effect/ Founder effect**- It is an instance where small group of individuals (**founders**) drifted or isolated from their parental population to find a new settlement. Since founders represent only a fraction of the parental population, they evolve into a **new species** with a **different allelic frequency**.
- Mutation**- Mutations result in formation of new phenotypes. Over few generations, this leads to speciation.
- Recombination**- During gametogenesis, genetic variation due to recombination results in new phenotype.
- Natural selection**: The process of selection of organisms with favourable character. 3 types-
  - Stabilizing selection**: Here, nature prefers more individuals with mean character value and there by variation is reduced.
  - Directional selection**: Here, individuals of one extreme are more favoured.
  - Disruptive selection**: Here, more individuals acquire peripheral character value at both ends of the distribution curve.



**NOTE:** ↓↓ indicates strength of selection against a character

# A BRIEF ACCOUNT OF EVOLUTION

## Geological Time Scale

(To be read from below upwards)

Era	Periods	Epochs	Age (in million years)	Animal Features	Plant Features
<b>Coenozoic</b> (Age of mammals and angiosperms)	Quarternary	Holocene (Recent)	0.01	<b>Modern man</b> , mammals, birds, reptiles, fishes, and insects dominate.	<b>Angiosperms</b> dominates
		Pleistocene	2	Extinction of great mammals.	Adaptive radiation of <b>angiosperms</b>
	Tertiary	Pliocene	5	Emergence of man	
		Miocene	23	First man-like apes formed	
		Oligocene	38	Rise of first monkey	
		Eocene	54	Adaptive radiation of mammals. Rise of small-sized reptiles	
		Paleocene	65	Dinosaurs disappeared- (climatic changes killed /evolved into <i>Pteranodon</i> - ‘flying dinosaur’)	
<b>Mesozoic</b> (Age of reptiles and gymnosperm)	Cretaceous		135	Rise of modern birds and placental mammals ( <i>shrew</i> )	Adaptive radiation of <b>gymnosperms</b> ( <b>Ginkgos</b> and <b>Gnetales</b> ). Rise of dicot <b>angiosperms</b>
	Jurassic		170	Dinosaurs become large ( <i>Tyrannosaurus</i> -20 ft). Extinction of mammal-like reptiles ( <i>Therapsids</i> ) and toothed birds ( <i>Archaeopteryx</i> ); snakes evolved	<b>Gymnosperms</b> dominates (cycads and conifers)
	Triassic		225	Dinosaurs appear.	
<b>Paleozoic</b> (Age of amphibians and bryophytes)	Permian		280	Adaptive radiation of reptiles. Fraction of them evolved to fish like <i>Ichthyosaurs</i> and modern-day <b>descendents</b> like turtle, lizard, tautaras, crocodiles etc.	Origin of conifers, abundant tree ferns ( <b>Pteridophytes</b> ) fell to form coal deposits
	Carboniferous		350	Origin of reptiles (lay shelled egg).	First land plant- <b>Seed ferns</b> (common ancestor of gymnosperms & angiosperms)
	Devonian		400	Origin of amphibians	Rise of sea weeds and specialized lineage of <b>pteriodophyte</b> (horse tails)
	Silurian		450	Diversity of jawless fishes	Origin of <b>Psilophyton</b> - Vascular plant with sporangia at the tip.
	Ordovician		500		Advanced <b>Rhynia</b> and branching of <b>lycopsida</b> ( sporangia at the base of their leaves)
	Cambrian		570	Multi-cellular life forms; Origin of marine invertebrates	<b>Tracheophyte</b> and branching of earliest <b>bryophyte</b>
<b>Proterozoic</b> (Era of early life)	Precambrian		2300		Aquatic <b>chlorophytes</b> (release O <sub>2</sub> )
			3800	Origin of <b>biomolecules</b> (like RNA, polysaccharides, protein etc.)	
<b>Archeozoic</b>			4600	Formation of the Earth’s crust	

## ORIGIN AND EVOLUTION OF MAN

15 mya	-	<i>Dryopithecus</i> and <i>Ramapithecus</i> (hairy and walked like gorillas and chimpanzees)
3-4 mya	-	Man-like primates (height upto 4ft, walked up right)
2 mya	-	<i>Australopithecines</i> (hunted with stone weapons, ate fruit)
	-	<i>Homo habilis</i> (650-800cc)
1.5 mya	-	<i>Homo erectus</i> (900cc, ate meat)
1-0.4 mya	-	<i>Homo neaderthalensis</i> / Neanderthal man (1400cc, protect their body and buried dead)
0.75-0.1 mya	-	<i>Homo sapiens</i> (1700cc)