* EVOLUTION :- Changes in flora (plants) & fauna (animals) over million of yr. on Earth

* Evolutionary Biology :- Study of history of life forms on Earth

* Stellar distance :- measured in light years

* Origin of UNIVERSE (= Huge Cluster of Galaxies)

→ 20 BYA

→ BIG-BANG Theory

A single, huge explosion, unimaginable in physical terms

↓

Universe expanded

↓

Temp. cooled down

↓

H_2, He gases formed

↓

↓

Gases condensed under gravity

↓

GALAXIES formed

(clusters of Stars, and Clouds of gases, dust)

↓

MILKY WAY (Our galaxy) (Solar System) (4.5 BYA)

Akash Ganga

↓

Earth formed (4.5 BYA)

* Conditions on Earth (Reducing)

→ No atmosphere on Early Earth

→ Water vapours + Methane (CH_4) + Ammonia (NH_3) + CO_2 released from molten mass

→ $H_2O \xrightarrow[\text{UV rays from Sun}]{\text{No Ozone}} H_2 + \frac{1}{2}O_2$

H_2 ↓ lighter gas, escape into atm.

$O_2 + CH_4 / NH_3 \longrightarrow CO_2, H_2O$, Nitrogen oxides etc.

Free molecular O_2 absent

* As Earth cooled down

↓

H_2O vapour fell as Rain (for millions of yrs.)

↓

filled depressions on Earth

↓

Oceans formed

(Hot water with various chemicals)

* Life appeared 500 million yr. later, after Earth's formation → 4.5 BYA
→ i.e 4 BYA

- 1ST (Proteins, RNA, Polysacc.) Non-Cellular life :- 3 BYA
- 1ST Cellular life form :- 2 BYA (2000 mya)
  (Prokaryotic, Single-celled)
- 1ST Eukaryotic Cell :- 1.5 BYA

→ All in Water

Out of NCERT
PYQ

* 1ST Cellular life form :- (Prokaryote)

a) Heterotrophic bacteria (PYQ)

Reducing atm. (No free O_2)

↓ Chemoautotrophic "

↓ Anoxygenic Photoautotrophic "
(PSB, GSB)

Oxidising

* Oxygenic " " (BGA)
(Release free O_2 into Atm.)

↓ O_3 (Ozone) layer formed.

* Origin of Life on Earth :-

1. Th. of Special Creation (discarded)
   - life appeared as such on Earth
   - Diversity always same & will be same in future
   - Earth 4000 yr. old

2) Th. of Panspermia
3) " Sp. gener.
4) " Biogenesis
5) " Chem. evolⁿ

* Th. of Biolog. Evolution :-

Evolutionary Biology is the study of history of life forms on earth. What exactly is evolution? To understand the changes in flora and fauna that have occurred over millions of years on earth, we must have an understanding of the context of origin of life, i.e., evolution of earth, of stars and indeed of the universe itself. What follows is the longest of all the construed and conjectured stories. This is the story of origin of life and evolution of life forms or biodiversity on planet earth in the context of evolution of earth and against the background of evolution of universe itself.

6.1 Origin of Life

When we look at stars on a clear night sky we are, in a way, looking back in time. Stellar distances are measured in light years. What we see today is an object whose emitted light started its journey millions of year back and from trillions of kilometres away and reaching our eyes now. However, when we see objects in our immediate surroundings we see them instantly and hence in the present time. Therefore, when we see stars we apparently are peeping into the past.

The origin of life is considered a unique event in the history of universe. The universe is vast. Relatively speaking the earth itself is almost only a speck. The universe is very

AR

old – almost 20 billion years old. Huge clusters of galaxies comprise the universe. Galaxies contain stars and clouds of gas and dust. Considering the size of universe, earth is indeed a speck. The **Big Bang** theory attempts to explain to us the origin of universe. It talks of a singular huge explosion unimaginable in physical terms. The universe expanded and hence, the temperature came down. Hydrogen and Helium formed sometime later. The gases condensed under gravitation and formed the galaxies of the present day universe. In the solar system of the milky way galaxy, earth was supposed to have been formed about 4.5 billion years back. There was no atmosphere on early earth. Water vapour, methane, carbondioxide and ammonia released from molten mass covered the surface. The UV rays from the sun brokeup water into Hydrogen and Oxygen and the lighter H_2 escaped. Oxygen combined with ammonia and methane to form water, CO_2 and others. The ozone layer was formed. As it cooled, the water vapor fell as rain, to fill all the depressions and form oceans. Life appeared 500

million years after the formation of earth, i.e., almost four billion years back.

Did life come from outerspace? Some scientists believe that it came from outside. Early Greek thinkers thought units of life called **spores** were transferred to different planets including earth. 'Panspermia' is still a favourite idea for some astronomers. For a long time it was also believed that life came out of decaying and rotting matter like straw, mud, etc. This was the theory of spontaneous generation. Louis Pasteur by careful experimentation demonstrated that life comes only from pre-existing life. He showed that in pre-sterilised flasks, life did not come from killed yeast while in another flask open to air, new living organisms arose from 'killed yeast'. Spontaneous generation theory was dismissed once and for all. However, this did not answer how the first life form came on earth.

Oparin of Russia and Haldane of England proposed that the first form of life could have come from pre-existing non-living organic molecules

(e.g. RNA, protein, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents. The conditions on earth were – high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3, etc. In 1953, S.L. Miller, an American scientist created similar conditions in a laboratory scale (Figure 6.1). He created electric discharge in a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C. He observed formation of amino acids. In similar experiments others observed, formation of sugars, nitrogen bases, pigment and fats. Analysis of meteorite content also revealed similar compounds indicating that similar processes are occurring elsewhere in space. With this limited evidence, the first part of the conjectured story, i.e., chemical evolution was more or less accepted.

We have no idea about how the first self replicating metabolic capsule of life arose. The first non-cellular forms of life could have originated 3 billion years back. They would have been giant molecules (RNA, Protein,

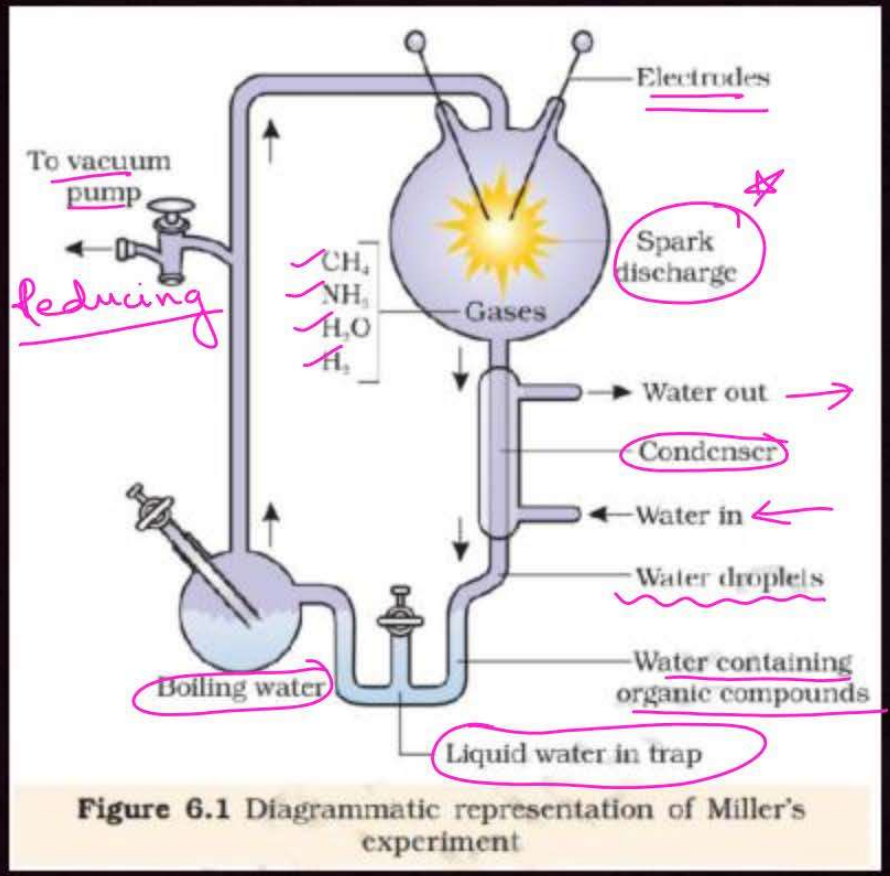


Figure 6.1 Diagrammatic representation of Miller's experiment

Polysaccharides, etc.). These capsules reproduced their molecules perhaps. The first cellular form of life did not possibly originate till about 2000 million years ago. These were probably single-cells. All life forms were in water environment only. This version of a biogenesis, i.e., the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority. However, once formed, how the first cellular forms of life could have evolved into the complex biodiversity of today is the fascinating story that will be discussed below.

6.2 Evolution of Life Forms – A Theory

Conventional religious literature tells us about the theory of special creation. This theory has three connotations. One, that all living organisms (species or types) that we see today were created as such. Two, that the diversity was always the same since creation and will be the same in future also. Three, that earth is about 4000 years old. All these ideas were strongly challenged during the nineteenth century. Based on observations made during a sea voyage in a sail ship called H.M.S. Beagle round the world, Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago. Many such life forms do not exist any more. There had been extinctions of different life forms in the years gone by just as new forms of life arose at different periods of history of earth. There has been gradual evolution of life forms. Any population

has built in variation in characteristics. Those characteristics which enable some to survive better in natural conditions (climate, food, physical factors, etc.) would outbreed others that are less-endowed to survive under such natural conditions. Another word used is fitness of the individual or population. The fitness, according to Darwin, refers ultimately and only to reproductive fitness. Hence, those who are better fit in an environment, leave more progeny than others. These, therefore, will survive more and hence are selected by nature. He called it natural selection and implied it as a mechanism of evolution. Let us also remember that Alfred Wallace, a naturalist who worked in Malay Archipelago had also come to similar conclusions around the same time. In due course of time, apparently new types of organisms are recognisable. All the existing life forms share similarities and share common ancestors. However, these ancestors were present at different periods in the history of earth (epochs, periods and eras). The geological history of earth closely correlates with the biological

history of earth. A common permissible conclusion is that earth is very old, not thousand of years as was thought earlier but billions of years old.

6.3 What are the Evidences for Evolution?

Evidence that evolution of life forms has indeed taken place on earth has come from many quarters. Fossils are remains of hard parts of life-forms found in rocks. Rocks form sediments and a cross-section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth. Different-aged rock sediments contain fossils of different life-forms who probably died during the formation of the particular sediment. Some of them appear similar to modern organisms (Figure 6.2). They represent extinct organisms (e.g., Dinosaurs). A study of fossils in different sedimentary layers indicates the geological

Age of fossils –

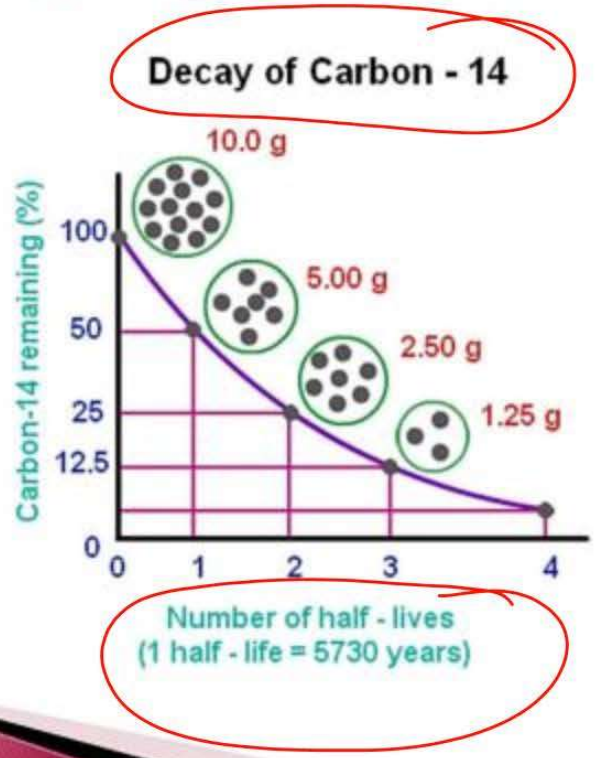
a) Carbon dating methods (C^{14} half life =5730 years) and C^{12} ratio used (for 1 lac /60,000 year old fossil) - by Libby (most common)

b) Potasium – argon method –half life=1.3 * 10^9 (1.3 billion) year , older rocks

c) Uranium 238 – lead 207 method

d) ESR (Electron Spin Resonance) method - most modern and sophisticated

Carbon dating method....



period in which they existed. The study showed that life-forms varied over time and certain life forms are restricted to certain geological time-spans. Hence, new forms of life have arisen at different times in the history of earth. All this is called paleontological evidence. *Do you remember how the ages of the fossils are calculated? Do you recollect the method of radioactive-dating and the principles behind the procedure?*

Embryological support for evolution was also proposed by Ernst Heckel based upon the observation of certain features during embryonic stage common to all vertebrates that are absent in adult. For example, 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 on careful study performed by Karl Ernst von Baer. He noted that embryos never pass through the adult stages of other animals.

Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago.

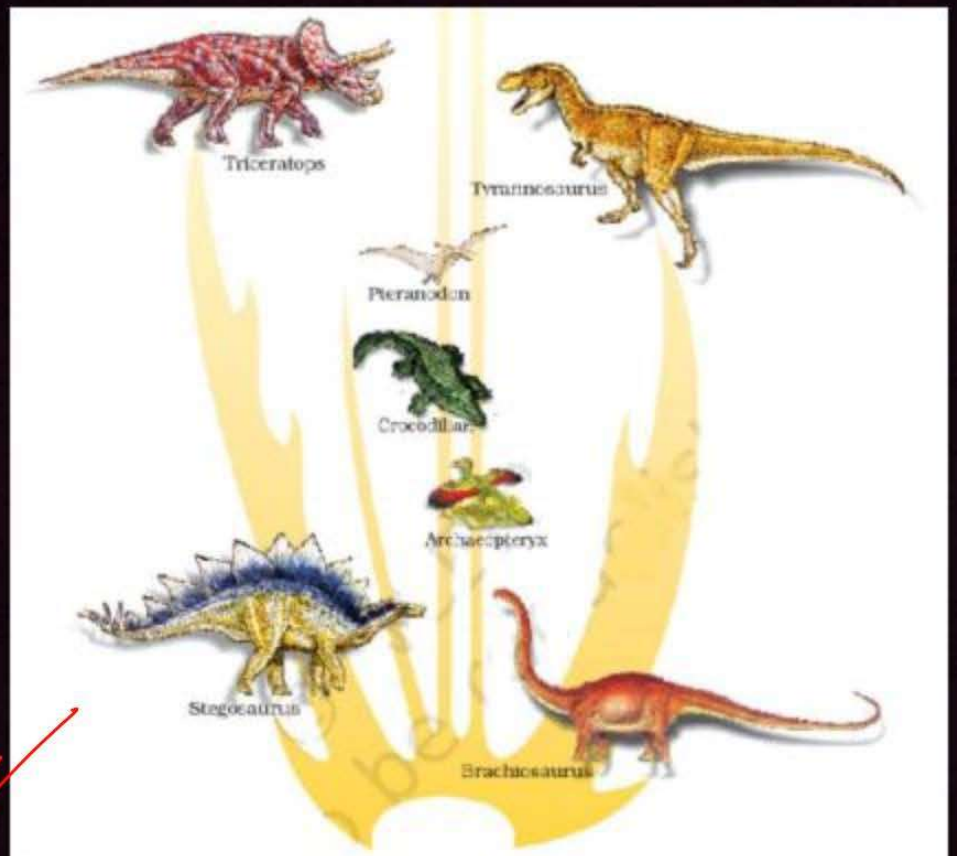
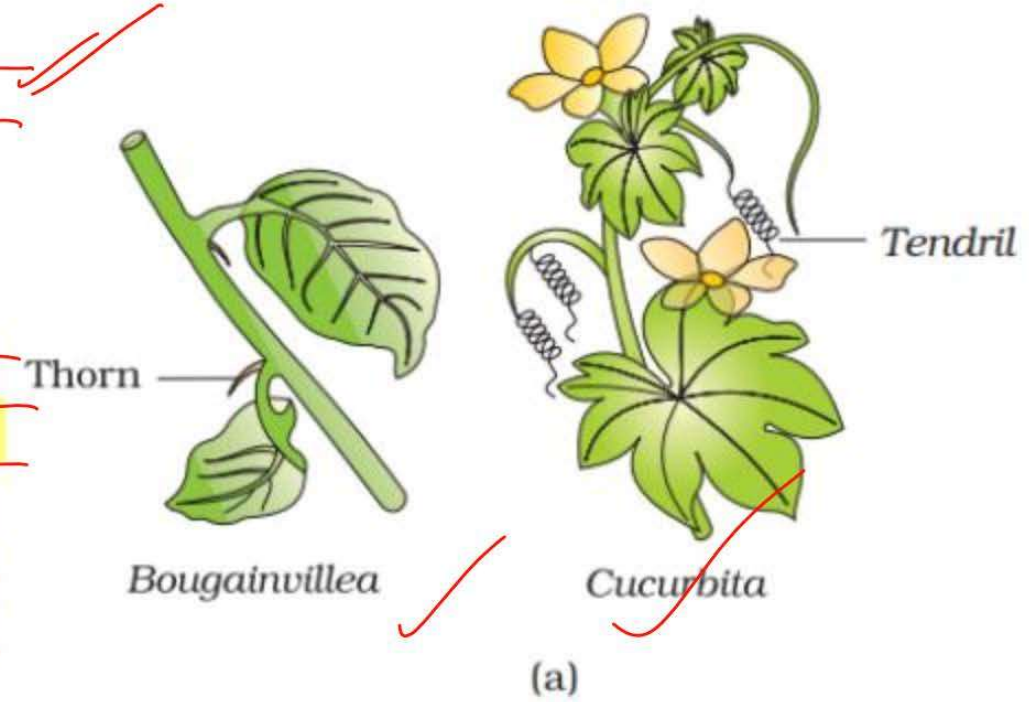


Figure 6.2 A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

Such similarities can be interpreted to understand whether common ancestors were shared or not. For example whales, bats, Cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs (Figure 6.3b). Though these forelimbs perform different functions in these animals, they have similar anatomical structure – all of them have humerus, radius, ulna, carpals, metacarpals and phalanges in their forelimbs. Hence, in these animals, the same structure developed along different directions due to adaptations to different needs. This is **divergent evolution** and these structures are **homologous**. Homology indicates common ancestry. Other examples are vertebrate hearts or brains. In

plants also, the thorn and tendrils of *Bougainvillea* and *Cucurbita* represent homology (Figure 6.3a). Homology is based on divergent evolution whereas analogy refers to a situation exactly opposite. Wings of butterfly and of birds look alike. They are not anatomically similar structures though they perform similar functions. Hence, analogous structures are a result of **convergent evolution** - different structures evolving for the same function and hence having



similarity. Other examples of analogy are the eye of the octopus and of mammals or the flippers of Penguins and Dolphins. One can say that it is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but toward the same function: Sweet potato (root modification) and potato (stem modification) is another example for analogy.

In the same line of argument, similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry. These biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms.

Man has bred selected plants and animals for agriculture, horticulture, sport or security. Man has domesticated many wild animals and crops. This intensive breeding programme has created breeds that differ from other breeds (e.g., dogs) but still are of the same group. It is argued that

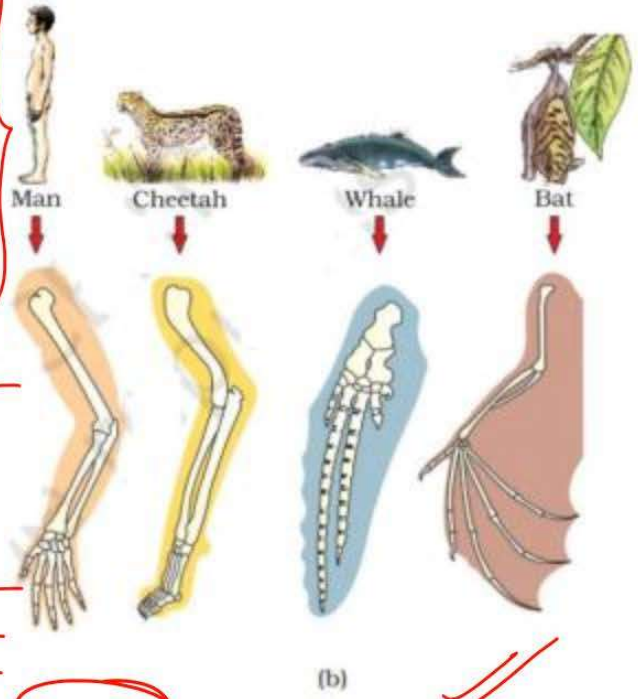


Figure 6.3 Example of homologous organs in (a) Plants and (b) Animals

if within hundreds of years, man could create new breeds, could not nature have done the same over millions of years?

Another interesting observation supporting evolution by natural selection comes from England. In a collection of moths made in 1850s, i.e., before industrialisation set in, it was observed that there were more white-winged moths on trees than dark-winged or melanised moths. However, in the collection carried out from the same area, but after industrialisation, i.e., in 1920, there were more dark-winged moths in the same area, i.e., the proportion was reversed.

(a) (b)

Figure 6.4 Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk (a) In unpolluted area (b) In polluted area

The explanation put forth for this observation was that 'predators will spot a moth against a contrasting background'. During post-industrialisation period, the tree trunks became dark due to industrial smoke and soots. Under this condition the white-winged moth did not survive due to predators, dark-winged or melanised moth survived. Before industrialisation set in, thick growth of almost white-coloured lichen covered the trees - in that background the white winged moth survived but the dark-coloured moth were picked out by predators. *Do you know that lichens can be used as industrial pollution indicators?* They will not grow in areas that are polluted. Hence, moths that were able to camouflage themselves, i.e., hide in the background, survived (Figure 6.4). This understanding is supported by the fact that in areas where industrialisation did not occur e.g., in rural areas, the count of melanic moths was low. This showed that in a mixed population, those

that can better-adapt, survive and increase in population size. Remember that no variant is completely wiped out.

Similarly, excess use of herbicides, pesticides, etc., has only resulted in selection of resistant varieties in a much lesser time scale. This is also true for microbes against which we employ antibiotics or drugs against eukaryotic organisms/cell. Hence, resistant organisms/cells are appearing in a time scale of months or years and not centuries. These are examples of evolution by anthropogenic action. This also tells us that evolution is not a directed process in the sense of determinism. It is a stochastic process based on chance events in nature and chance mutation in the organisms.

6.4 What is Adaptive Radiation?

During his journey Darwin went to Galapagos Islands. There he observed an amazing diversity of creatures. Of particular interest, small black birds later called Darwin's Finches amazed him. He realised that there were many

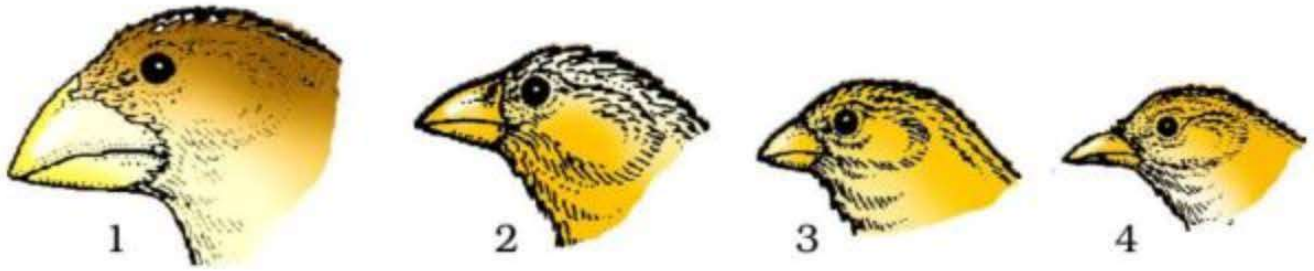


Figure 6.5 Variety of beaks of finches that Darwin found in Galapagos Island

varieties of finches in the same island. All the varieties, he conjectured, evolved on the island itself. From the original seed-eating features, many other forms with altered beaks arose, enabling them to become insectivorous and vegetarian finches (Figure 6.5). This process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats) is called **adaptive radiation**. Darwin's finches represent one of the best examples of this phenomenon. Another example is Australian marsupials. A number of marsupials, each different from the other (Figure 6.6) evolved from an ancestral stock, but all within the Australian island continent. When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing

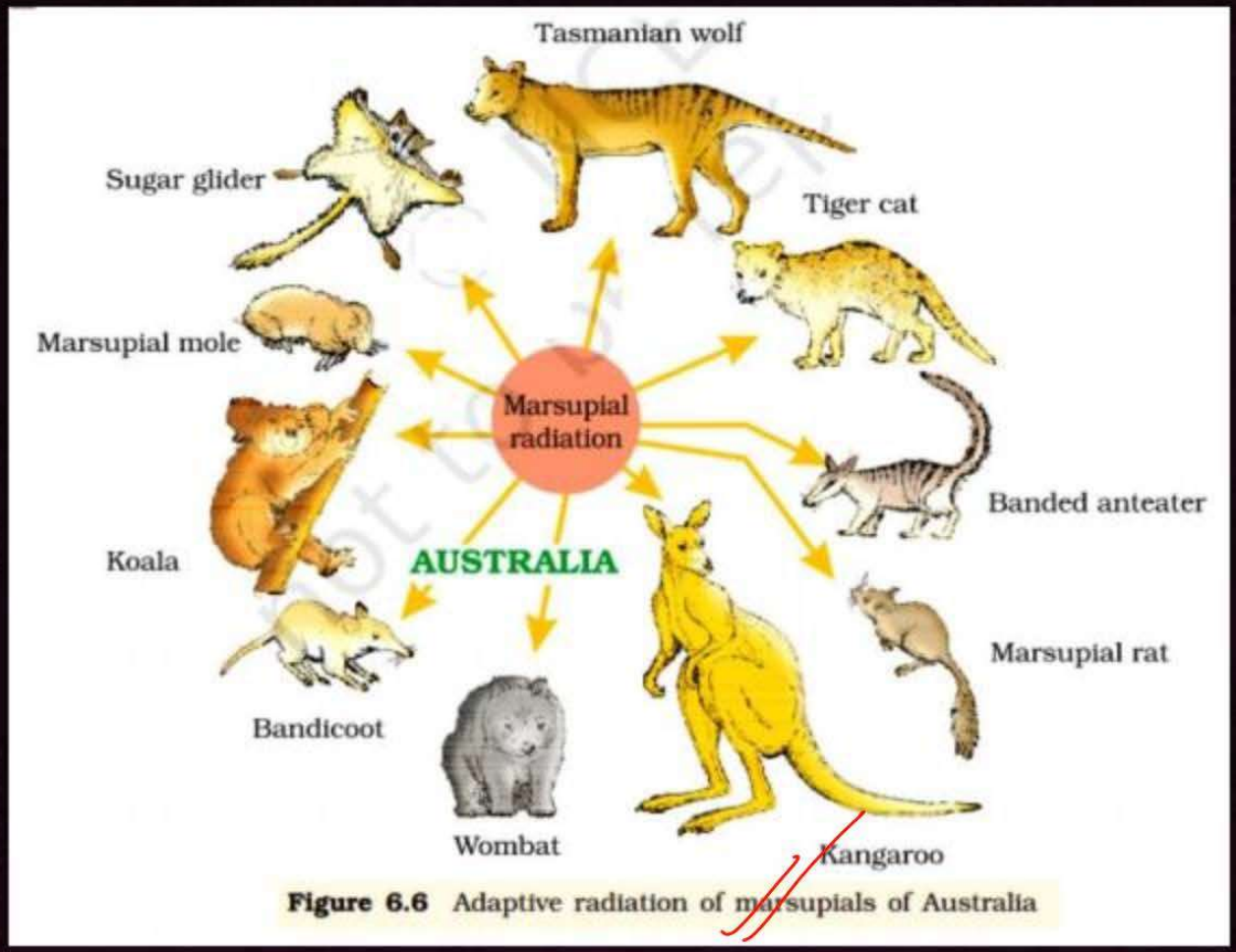
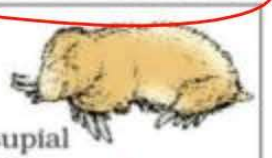
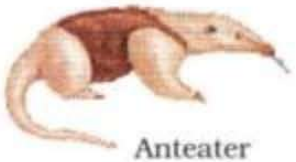
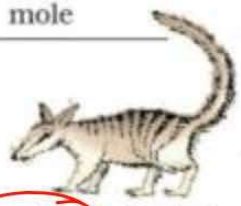
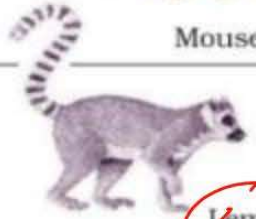
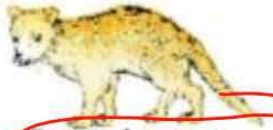


Figure 6.6 Adaptive radiation of marsupials of Australia

Placental mammals	Australian marsupials
 Mole	 Marsupial mole
 Anteater	 Numbat (anteater)
 Mouse	 Marsupial mouse
 Lemur	 Spotted cuscus

different habitats), one can call this convergent evolution. Placental mammals in Australia also exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be 'similar' to a corresponding marsupial (e.g., Placental wolf and Tasmanian wolf-marsupial). (Figure 6.7).

6.5 Biological Evolution

Evolution by natural selection, in a true sense would have started when cellular forms of life with differences in metabolic capability originated on earth.

The essence of Darwinian theory about evolution is natural selection. The rate of appearance of new forms is linked to the life cycle or the life span. Microbes that divide fast have

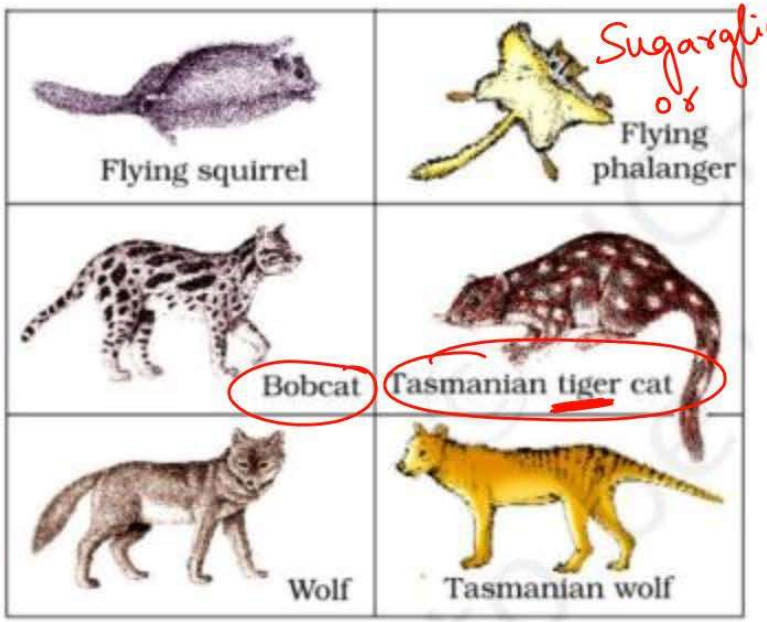


Figure 6.7 Picture showing convergent evolution of Australian Marsupials and placental mammals

the ability to multiply and become millions of individuals within hours. A colony of bacteria (say A) growing on a given medium has built-in variation in terms of ability to utilise a feed component. A change in the medium composition would bring out only that part of the population (say B) that can survive under the new conditions. In due course of time this variant population outgrows the others and appears as new species. This would happen within days. For the same thing to happen in a fish or fowl would take million of years as life spans of these animals are in years. Here we say that fitness of B is better than that of A under the new conditions. Nature selects for fitness. One must remember that the so-called fitness is based on characteristics which are inherited.

Hence, there must be a genetic basis for getting selected and to evolve. Another way of saying the same thing is that some organisms are better adapted to survive in an otherwise hostile environment. Adaptive ability is inherited. It has a genetic basis. Fitness is the end result of the ability to adapt and get selected by nature.

Branching descent and **natural selection** are the two key concepts of Darwinian Theory of Evolution (Figures 6.7 and 6.8).

Even before Darwin, a French naturalist Lamarck had said that evolution of life forms had occurred but driven by use and disuse of

organs. He gave the examples of Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks. As they passed on this acquired character of elongated neck to succeeding generations, Giraffes, slowly, over the years, came to acquire long necks. Nobody believes this conjecture any more.

Is evolution a process or the result of a process? The world we see, inanimate and animate, is only the success stories of evolution. When we describe the story of this world we describe evolution as a process. On the other hand when we describe the story of life on earth, we treat evolution as a consequence of a process called natural selection. We are still not very clear whether to regard evolution and natural selection as processes or end result of unknown processes.

It is possible that the work of Thomas Malthus on populations influenced Darwin. Natural selection is based on certain observations which are factual. For example, natural resources are limited, populations are stable in size except for seasonal fluctuation, members of a population

vary in characteristics (infact no two individuals are alike) even though they look superficially similar, most of variations are inherited etc. The fact that theoretically population size will grow exponentially if everybody reproduced maximally (this fact can be seen in a growing bacterial population) and the fact that population sizes in reality are limited, means that there had been competition for resources. Only some survived and grew at the cost of others that could not flourish. The novelty and brilliant insight of Darwin was this: he asserted that variations, which are heritable and which make resource utilisation better for few (adapted to habitat better) will enable only those to reproduce and leave more progeny. Hence for a period of time, over many generations, survivors will leave more progeny and there would be a change in population characteristic and hence new forms appear to arise.

6.6 Mechanism of Evolution

What is the origin of this variation and how does speciation occur? Even though Mendel had talked of inheritable 'factors' influencing phenotype, Darwin either ignored these observations or kept silence. In the first decade of twentieth century, Hugo deVries based on his work on evening primrose brought forth the idea of mutations – large difference arising suddenly in a population. He believed that it is mutation which causes evolution and not the minor variations (heritable) that Darwin talked about. Mutations are random and directionless while Darwinian variations are small and directional. Evolution for Darwin was gradual while deVries believed mutation caused speciation and hence called it **saltation** (single step large mutation). Studies in population genetics, later, brought out some clarity.

❖ **Trick for Mutation :**

H.W

- Ranveer's – Random , Rare
- Dipika is - Directionless
- Sanjay - Sudden
- Leela's - Large
- Mastani - Mutation

FOR NOTES & DPP CHECK DESCRIPTION

6.7 Hardy-Weinberg Principle

In a given population one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations.

This principle says that allele frequencies in a population are stable and is constant from generation to generation. The gene pool (total genes and their alleles in a population) remains a constant. This is called genetic equilibrium. Sum total of all the allelic frequencies is 1. Individual

frequencies, for example, can be named p, q, etc. In a diploid, p and q represent the frequency of allele *A* and allele *a*. The frequency of *AA* individuals in a population is simply p^2. This is simply stated in another ways, i.e., the probability that an allele A with a frequency of p appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e., p^2. Similarly of aa is q^2, of Aa 2pq. Hence, $p^2+2pq+q^2=1$. This is a binomial expansion of $(p+q)^2$. When frequency measured, differs from expected values, the difference (direction) indicates the extent of evolutionary change. Disturbance in genetic equilibrium, or Hardy- Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as resulting in evolution.

Five factors are known to affect Hardy-Weinberg equilibrium. These are gene migration or gene flow, genetic drift, mutation, genetic recombination and natural selection. When migration of a section of population to another place and population occurs, gene frequencies

- p= frequency of dominant allele T
- q= frequency of recessive allele t

- p^2 = frequency of individuals TT (dominant homozygous)

- q^2 = frequency of individuals tt (recessive homozygous)

- 2pq = frequency of Tt individuals (heterozygous individuals)

change in the original as well as in the new population. New genes/alleles are added to the new population and these are lost from the old population. There would be a gene flow if this gene migration, happens multiple times. If the same change occurs by chance, it is called genetic drift. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and the effect is called **founder effect**.

Microbial experiments show that pre-existing advantageous mutations when selected will result in observation of new phenotypes. Over few generations, this would result in Speciation. Natural selection is a process in which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny. A critical analysis makes us believe that variation due to mutation or variation due to recombination during gametogenesis, or due to gene flow or genetic drift

results in changed frequency of genes and alleles in future generation. Coupled to enhance reproductive success, natural selection makes it look like different population. Natural selection can lead to stabilisation (in which more individuals acquire mean character value), directional change (more individuals acquire value other than the mean character value) or disruption (more individuals acquire peripheral character value at both ends of the distribution curve) (Figure 6.8).

6.8 A Brief Account of Evolution

About 2000 million years ago (mya) the first cellular forms of life appeared on earth. The mechanism of how non-cellular aggregates of giant macromolecules could evolve into cells with membranous envelop is not known. Some of these cells had the ability to release O_2. The reaction

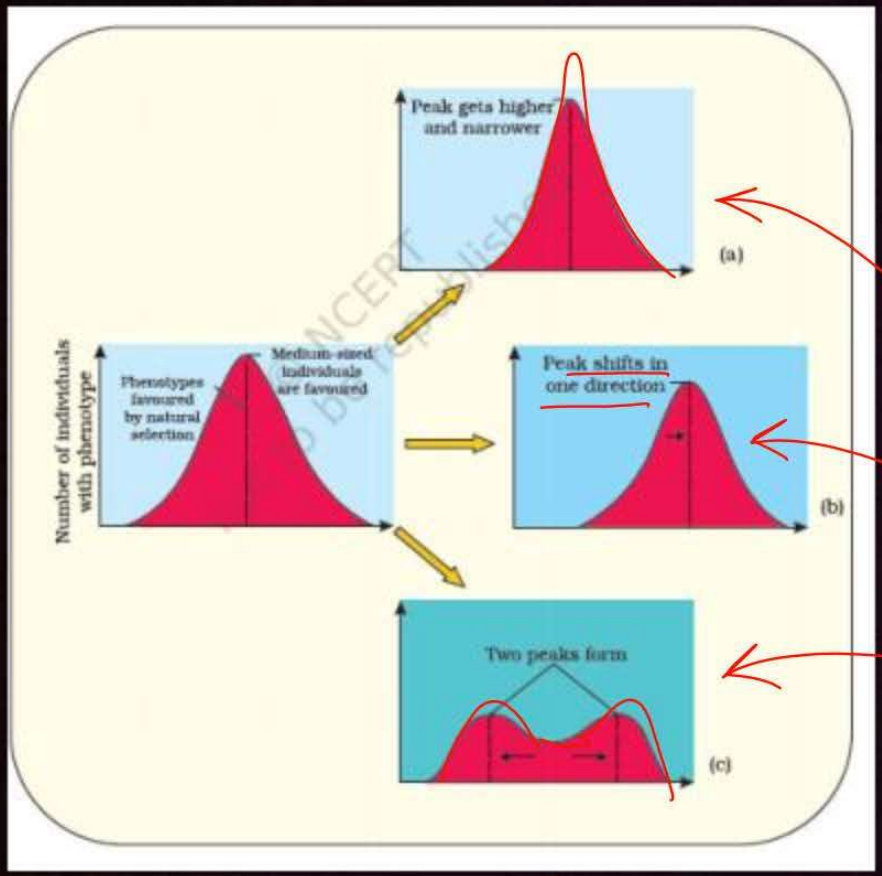


Figure 6.8 Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

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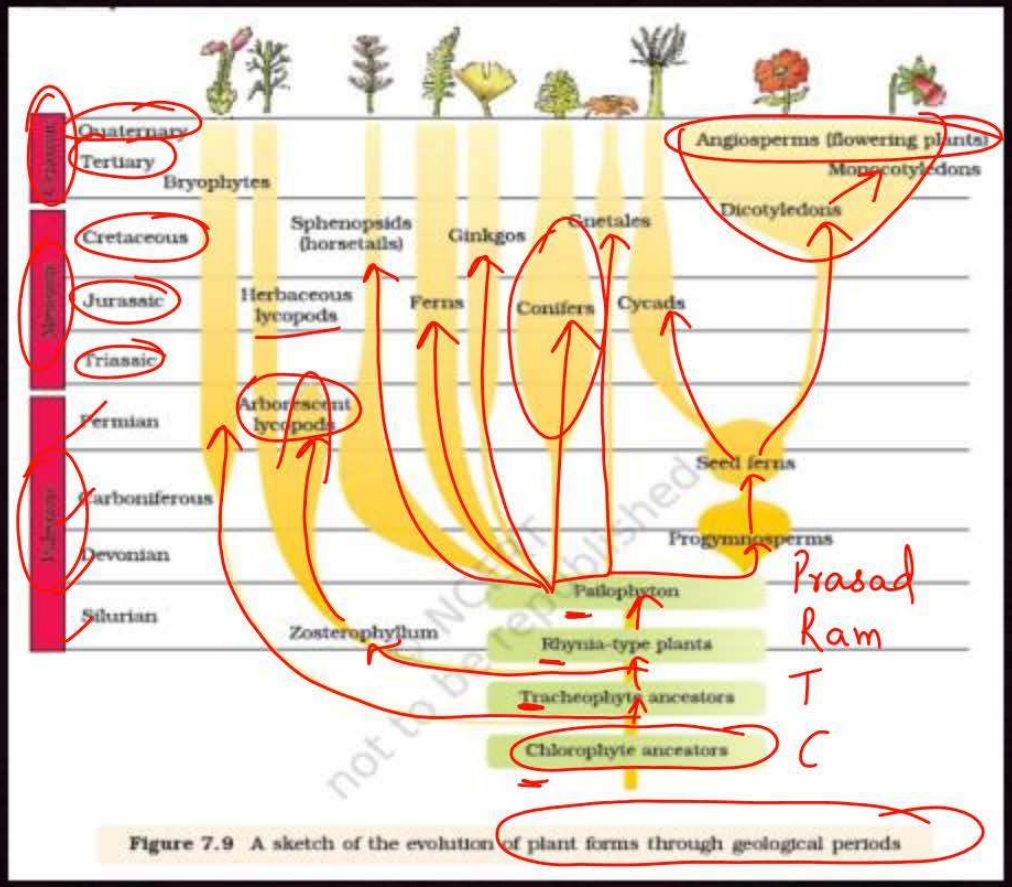


Figure 7.9 A sketch of the evolution of plant forms through geological periods

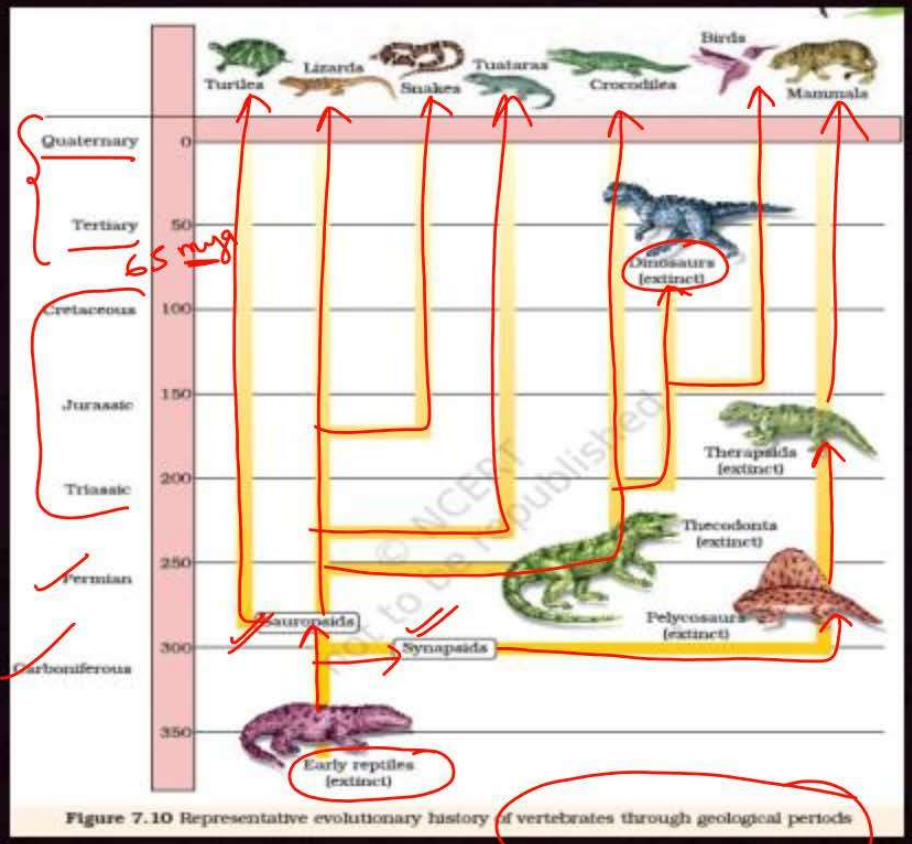


Figure 7.10 Representative evolutionary history of vertebrates through geological periods

could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelised by appropriate light harvesting pigments. Slowly single-celled organisms became multi-cellular life forms. By the time of 500 mya, invertebrates were formed and active. Jawless fish probably evolved around 350 mya. Sea weeds and few plants existed probably around 320 mya. We are told that the first organisms that invaded land were plants. They were widespread on land when animals invaded land. Fish with stout and strong fins could move on land and go back to water. This was about 350 mya. In 1938, a fish caught in South Africa happened to be a Coelacanth which was thought to be extinct. These animals called lobefins evolved into the

first amphibians that lived on both land and water. There are no specimens of these left with us. However, these were ancestors of modern day frogs and salamanders. The amphibians evolved into reptiles. They lay thick-shelled eggs which do not dry up in sun unlike those of amphibians. Again we only see their modern day descendents, the turtles, tortoises and crocodiles. In the next 200 millions years or so, reptiles of different

shapes and sizes dominated on earth. Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly. Some of these land reptiles went back into water to evolve into fish like reptiles probably 200 mya (e.g. *Ichthyosaurs*). The land reptiles were, of course, the dinosaurs. The biggest of them, i.e., *Tyrannosaurus rex* was about 20 feet in height and had huge fearsome dagger like teeth. About 65 mya, the dinosaurs suddenly disappeared from the earth. We do not know the true reason. Some say climatic changes killed them. Some say most of them evolved into birds. The truth may live in between. Small sized reptiles of that era still exist today.

The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the

mother's body. Mammals were more intelligent in sensing and avoiding danger at least. When reptiles came down mammals took over this earth. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc. Due to continental drift, when South America joined North America, these animals were overridden by North American fauna. Due to the same continental drift pouched mammals of Australia survived because of lack of competition from any other mammal.

Lest we forget, some mammals live wholly in water. Whales, dolphins, seals and sea cows are some examples. Evolution of horse, elephant, dog, etc., are special stories of evolution. You will learn about these in higher classes. The most successful story is the evolution of man with language skills and self-consciousness.

A rough sketch of the evolution of life forms, their times on a geological scale are indicated in (Figures 6.9 and 6.10).

6.9 Origin and Evolution of Man

About 15 mya, primates called *Dryopithecus* and *Ramapithecus* were existing. They were hairy and walked like gorillas and chimpanzees. *Ramapithecus* was more man-like while *Dryopithecus* was more ape-like. Few fossils of man-like bones have been discovered in Ethiopia and Tanzania (Figure 6.11). These revealed hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa. They were probably not taller than 4 feet but walked up right. Two mya, *Australopithecines* probably lived in East African grasslands. Evidence shows they hunted with stone weapons but essentially ate fruit. Some of the bones among the bones discovered were different. This creature was called the first human-like being the hominid and was called *Homo habilis*. The brain capacities were between 650-800cc. They probably did not eat meat. Fossils discovered in Java in 1891 revealed the next stage, i.e., *Homo erectus* about 1.5 mya. *Homo erectus* had a large brain around 900cc.

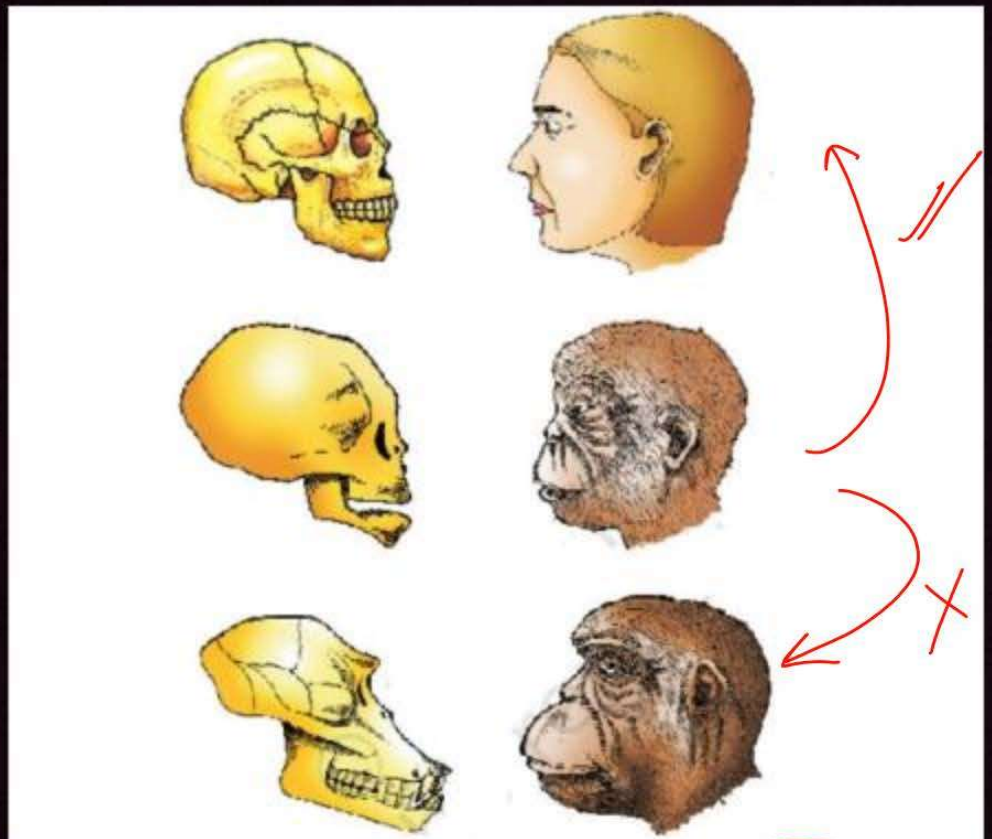


Figure 6.11 A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

FOR NOTES & DPP CHECK DESCRIPTION

Homo erectus probably ate meat. The Neanderthal man with a brain size of 1400cc lived in near east and central Asia between 1,00,000-40,000 years back. They used hides to protect their body and buried their dead. *Homo sapiens* arose in Africa and moved across continents and developed into distinct races. During ice age between 75,000-10,000 years ago modern *Homo sapiens* arose. Pre-historic cave art developed about 18,000 years ago. One such cave paintings by Pre-historic humans can be seen at Bhimbetka rock shelter in Raisen district of Madhya Pradesh. Agriculture came around 10,000 years back and human settlements started. The rest of what happened is part of human history of growth and decline of civilisations.

QUESTION – 01 (2020)

From his experiments, S.L. Miller produced amino acids by mixing the following in a closed flask:

(A) CH_3, H_2, NH_4, and water vapor at 800°C

(B) CH_4, H_2, NH_3, and water vapor at 600°C

(C) CH_3, H_2, NH_3 and water vapor at 600°C

(D) CH_4, H_2, NH_3 and water vapor at 800°C

QUESTION – 02 (2020-Covid)

After about how many years of formation of earth, life appeared on this planet?

A. 50 million years

B. 500 million years

C. 50 billion years

D. 500 billion years

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 04 (2016-I)

Out of NCERT

Following are the two statements regarding the origin of life:

A. The earliest organisms that appeared on the earth were non-green and presumably anaerobes.

B. The first autotrophic organisms were the chemoautotroph's that never released oxygen.

Of the above statements which one of the following options is correct?

(A) ~~II, III, I, IV~~ A, B both correct

(B) ~~II, III, IV, I~~ A, B ~~II~~ Wrong

(C) ~~I, II, III, IV~~ A correct, B wrong

(D) ~~I, III, II, IV~~ A ~~wrong~~, B correct

QUESTION – 05 (2022)

Which of the following statements is not true?

(A) Flippers of penguins and dolphins are a pair of homologous organs

(B) Analogous structures are a result of convergent evolution

(C) Sweet potato and potato is an example of analogy

(D) Homology indicates common ancestry

QUESTION – 06 (2020)

Flippers of Penguins and Dolphins are examples of:

A. Convergent evolution

B. Industrial melanism

C. Natural selection

D. Adaptive radiation

Repeat

Anal. organs.

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 07 (2020)

Which of the following refer to correct example(s) of organisms which have evolved due to changes in environment brought about by anthropogenic action?

A. Darwin's Finches of Galapagos islands.
B. Herbicide resistant weeds.
C. Drug resistant eukaryotes.
D. Man-created breeds of domesticated animals like dogs.

(A) (A) and (C)

(B) (B), (C) and (D)

(C) Only (D)

(D) Only (B)

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 08 (2020)

Embryological support for evolution was disapproved by:

A. *Alfred Wallance*

B. *Charles Darwin*

C. *Oparin*

D. *Karl Ernst von Baer*

QUESTION – 09 (2020-Covid)

Embryological support for evolution was proposed by:

Repeat

(A) *Karl Ernst von Baer*

(B) *Charles Darwin*

(C) *Alfred Wallace*

(D) *Ernst Heckel*

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 10 (2018)

The similarity of bone structure in the forelimbs of many vertebrates is an example of:

A. Homology

B. Analogy

C. Convergent evolution

D. Adaptive radiation

QUESTION – 11 (2018)

Among the following sets of examples for divergent evolution, select the incorrect option:

(A) Forelimbs of man, bat and cheetah

(B) Heart of bat, man and cheetah

(C) Brain of bat, man and cheetah

(D) Eye of octopus, bat and man

Repeat

False

Analog

QUESTION – 12 (2016-I)

Analogous structures are a result of:

A. Divergent evolution

B. Convergent evolution

C. Shared ancestry

D. Stabilising selection

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 13 (2016-I)

Which of the following structures are homologues to the wing of a bird?

Add in notes

Same origin

Forelimbs
Flying

(A) Dorsal fin of a Shark — Post/Hind

(B) Wing of a Moth — Invert
Origin diff
Same fn.
Analog

(C) Hind limb of Rabbit — Orig. diff.

(D) Flipper of Whale — Mamal
Forelimbs
Swimming
fn. diff
Origin diff
diff reptile
Same (reptile)

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 14 (2015-Re)

The wings of a bird and the wings of an insect are:

(A) Analogous structures and represent convergent evolution

(B) Phylogenetic structures and represent divergent evolution

(C) Homologous structures and represent convergent evolution

(D) Homologous structures and represent divergent evolution

QUESTION – 15 (2015 Re)

Industrial melanism is an example of:

A. Natural selection

B. Mutation

C. Neo Lamarckism

D. Neo Darwinism

QUESTION – 16 (2014)

Forelimbs of cat, lizard used in walking; forelimbs of whale used in swimming and forelimbs of bats used in flying are an example of:

(A) Convergent evolution

(B) Analogous organs

(C) Adaptive radiation

(D) Homologous organs

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 17 (2014)

Which one of the following are analogous structures?

Add in notes

(A) Flippers of dolphin and legs of horse — Forelimbs, Swim. / Hindlimbs, Swim. — Org. diff, fn. diff — X

(B) Wings of bat and wings of pigeon — mammal / bird — fn. same — X — diff origin (same origin (reptile))

(C) Gills of prawn and lungs of man — Invert / Vert — fn. same — origin diff — Anal.

(D) Thorns of Bougainvillea and tendrils of Cucurbita — Homol. — X

QUESTION – 18 (2013)

Out of NCERT

diff. origin

The process by which organisms with different evolutionary history evolve similar phenotypic adaptations in response to a common environmental challenge, is called:

(A) Adaptive radiation

(B) Natural selection

(C) Convergent evolution

(D) Non-random evolution

QUESTION – 19 (2013)

The eye of octopus and eye of cat show different patterns of structure, yet they perform similar function. This is an example of:

(A) Analogous organs that have evolved due to divergent evolution

(B) Homologous organs that have evolved due to convergent evolution

(C) Homologous organs that have evolved due to divergent evolution

(D) Analogous organs that have evolved due to convergent evolution

QUESTION – 20 (2021)

Match the following:
Choose the correct answer from the options given below.

	List-I		List-II
(A)	Adaptive radiation	(I)	Selection of resistant varieties due to excessive use of herbicides and pesticides
(B)	Convergent evolution	(II)	Bones of forelimbs in Man and Whale
(C)	Divergent evolution	(III)	Wings of Butterfly and Bird
(D)	Evolution by anthropogenic action	(IV)	Darwin Finches

(A) A-(III), B-(II), C-(I), D-(IV)

(B) A-(II), B-(I), C-(IV), D-(III)

(C) A-(I), B-(IV), C-(III), D-(II)

(D) A-(IV), B-(III), C-(II), D-(I)

QUESTION – 21 (2020-Covid)

The phenomenon of evolution of different species in a given geographical area starting from a point and spreading to other habitats is called-

(A) Co-evolution

(B) Natural selection

(C) Adaptive radiation

(D) Saltation

QUESTION – 22 (2023-NEET)

Natural selection where more individuals acquired specific character value other than the mean character value, leads to:

A. Random change

B. Stabilising change

C. Directional change

D. Disruptive change

QUESTION – 23 (2019)

Variations caused by mutation, as proposed by Hugo de Vries are

(A) Random and directional

(B) Random and directionless

(C) Small and directional

(D) Small and directionless

QUESTION – 24 (2019)

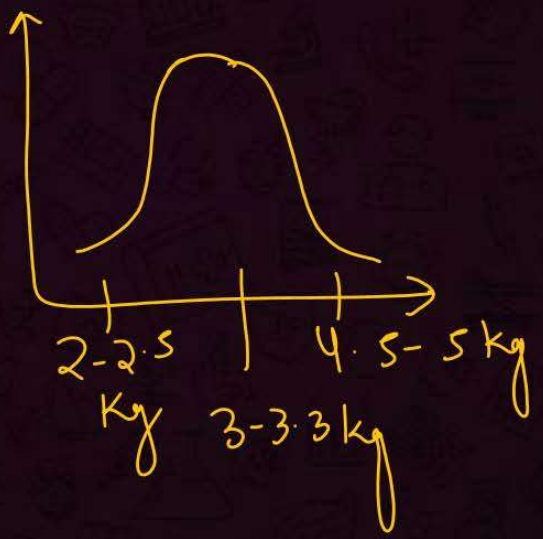
In a species, the weight of newborn ranges from 2 to 5 kg. 97% of the newborn with an average weight between 3 to 3.3 kg survive whereas 99% of the infants born with weight from 2 to 2.5 kg or 4.5 to 5 kg die. Which type of selection process is taking place?

(A) Directional Selection

(B) Stabilising Selection

(C) Disruptive Selection

(D) Cyclical Selection



QUESTION – 25 (2018)

According to Hugo de Vries, the mechanism of evolution is:

(A) Multiple step mutations

(B) Saltation

(C) Phenotypic variations

(D) Mirror mutations

QUESTION – 26 (2017-Delhi)

Artificial Selection to obtain Cows yielding higher milk output represents :

A. Stabilising selection as it stabilises this character in the population.

B. Directional as it pushes the mean of the character in one direction.

C. Disruptive as it splits the population into two one yielding higher output and the other lower output.

D. Stabilising followed by disruptive as it stabilises the population to produce higher yielding cows.

QUESTION – 27 (2013)

According to Darwin, the organic evolution is due to:

A. Reduced feeding efficiency in one species due to the presence of interfering species

B. Intraspecific competition

C. Interspecific competition

D. Competition within closely related species

QUESTION – 28 (2021)

The factor that leads to Founder effect in a population is:

A. Genetic recombination

B. Mutation

C. Genetic drift

D. Natural selection

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 29 (2019)

A gene locus has two alleles A and a. If the frequency of dominant allele A is 0.4, then what will be the frequency of homozygous dominant, heterozygous and homozygous recessive individuals in the population?

(A) 0.36(AA); 0.48(Aa); 0.16(aa)

(B) 0.16(AA); 0.24(Aa); 0.36(aa)

(C) 0.16(AA); 0.48(Aa); 0.36(aa)

(D) 0.16(AA); 0.36(Aa); 0.48(aa)

$p = 0.4$

p^2 $\quad 2pq$ $\quad q^2$

$2pq \rightarrow 2 \times 0.4 \times 0.6 = .48$

$p = 0.4$

$\therefore q = 1 - p$

$= 1 - 0.4$

$= 0.6$

QUESTION – 30 (2016-II)

In Hardy-Weinberg equation, the frequency of heterozygous individual is represented by:

A pq

B q^2

C p^2

D 2pq

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 31 (2016-II)

Genetic drift operates in:

A. Non-reproductive population

B. Slow reproductive population

C. Small isolated population

D. Large isolated population

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 32 (2015)

Which is the most common mechanism of genetic variation in the population of a sexually reproducing organism?

A Genetic drift

B Recombination

C Transduction

D Chromosomal aberrations

QUESTION – 33 (2015)

A population will not exist in Hardy-Weinberg equilibrium if:

(A) There is no migration

(B) The population is large

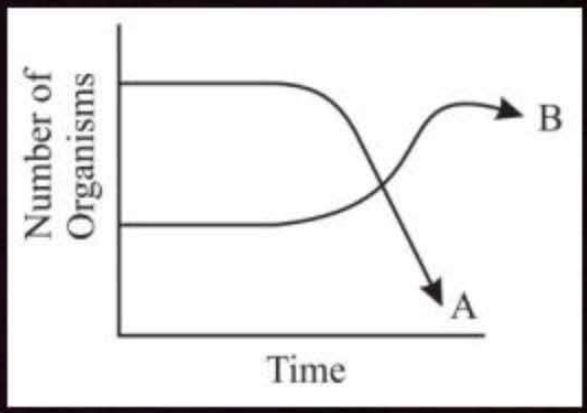
(C) Individuals mate selectively

(D) There are no mutations

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 34 (2015)

The following graph depicts changes in two populations (A and B) of herbivores in a grassy field. A possible reason for these changes is that:



(A) Population A produced more offspring than population B

(B) Population A consumed the members of population B

(C) Both plant populations in this habitat decreased

(D) Population B competed more successfully for food than population A

QUESTION – 35 (2014)

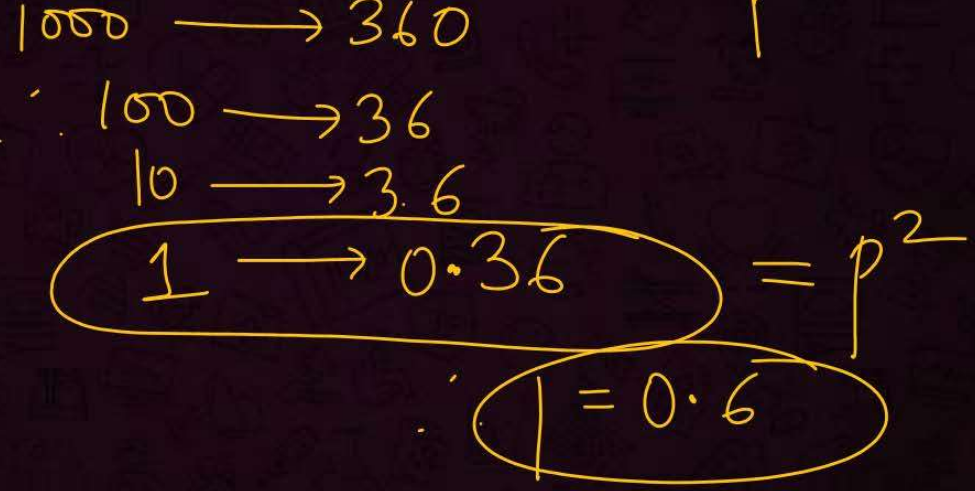
In a population of 1000 individuals 360 belong to genotype AA, 480 to Aa and the remaining 160 to aa. Based on this data, the frequency of allele A in the population is:

(A) 0.7

(B) 0.4

(C) 0.5

(D) 0.6



QUESTION – 36 (2013)

Variation in gene frequencies within populations can occur by chance rather than by natural selection. This is referred to as:

A. Genetic load

B. Genetic flow

C. Genetic drift

D. Random mating

QUESTION – 37 (2013)

The tendency of population to remain in genetic equilibrium may be disturbed by:

A. Lack of random mating

B. Random mating

C. Lack of migration

D. Lack of mutations

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 38 (2020-Covid)

A Hominid fossil discovered in Java in 1891, now extinct, having cranial capacity of about 900 cc was:

(A) Neanderthal man

(B) *Homo sapiens*

(C) *Australopithecus*

(D) *Homo erectus*

QUESTION – 39 (2019)

Match the hominids with their correct brain size :

A.	Homo habilis	i.	900 cc
B.	Homo neanderthalensis	ii.	1350 cc
C.	Homo erectus	iii.	650-800 cc
D.	Homo sapiens	iv.	1400 cc

NCERT

Select the correct option.

(A) A-(iii), B-(i), C-(iv), D-(ii)

(B) A-(iii), B-(ii), C-(i), D-(iv)

(C) A-(iii), B-(iv), C-(i), D-(ii)

(D) A-(iv), B-(iii), C-(i), D-(ii)

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 40 (2016-II)

The chronological order of human evolution from early to the recent is:

A. *Ramapithecus-Homo habilis-Australopithecus –Homo erectus*

B. *Australopithecus-Homo habilis-Ramapithecus -Homo erectus*

C. *Australopithecus-Ramapithecus-Homo habilis -Homo erectus*

D. *Ramapithecus-Australopithecus-Homo habilis -Homo erectus*

QUESTION – 41 (2015 Mains)

Which of the following had the smallest brain capacity?

A. *Homo neanderthalensis* 1400

B. *Homo habilis* 650-800

C. *Homo erectus* 900

D. *Homo sapiens* 1350

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 42 (2023)

Select the correct group/set of Australian Marsupials exhibiting adaptive radiation.

(A) Lemur, Anteater, Wolf

(B) Tasmanian wolf, Bobcat, Marsupial mole

(C) Num bat, Spotted cuscus, Flying phalanger

(D) Mole, Flying squirrel, Tasmanian tiger cat

QUESTION – 43 (NEET-2024)

Repeat PYQ

Given below are some stages of human evolution.
Arrange them in correct sequence. (Past to Recent)

A. Homo habilis
B. Homo sapiens
C. Homo neanderthalensis
D. Homo erectus

Choose the correct sequence of human evolution from the options given below:

(A) D-A-C-B

(B) B-A-D-C

(C) C-B-D-A

(D) A-D-C-B

FOR NOTES & DPP CHECK DESCRIPTION

QUESTION – 44 (NEET-2024)

The flippers of the Penguins and Dolphins are the example of the

Swim bird Mammal. NCERT

(A) Adaptive radiation

(B) Natural selection

(C) Convergent evolution Anal. Org.

(D) Divergent evolution

QUESTION – 45 (NEET-2024)

Match List I with List II:
Choose the correct answer from the options given below :

Out of NCERT

	List I		List II
A.	Mesozoic Era	I.	Lower invertebrates
B.	Proterozoic Era	II.	Fish & Amphibia
C.	Cenozoic Era	III.	Birds & Reptiles
D.	Paleozoic Era	IV.	Mammals

(A) A-II, B-I, C-III, D-IV

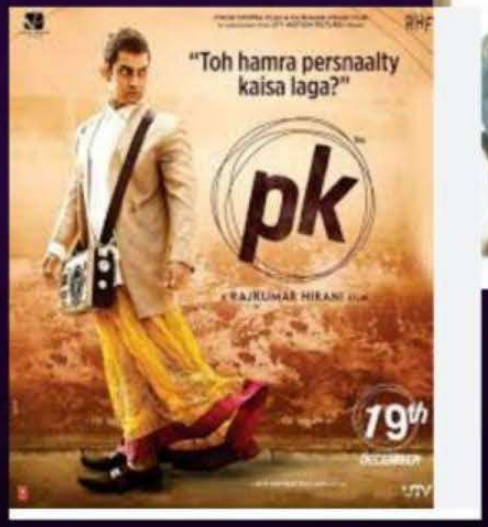
(B) A-III, B-I, C-II, D-IV

(C) A-I, B-II, C-IV, D-III

(D) A-III, B-I, C-IV, D-II

2) Panspermia / Cosmozoic / Extra-terrestial Th.

- Life came from Outside Earth, through Units of life / Spores.
- Early Greek thinkers

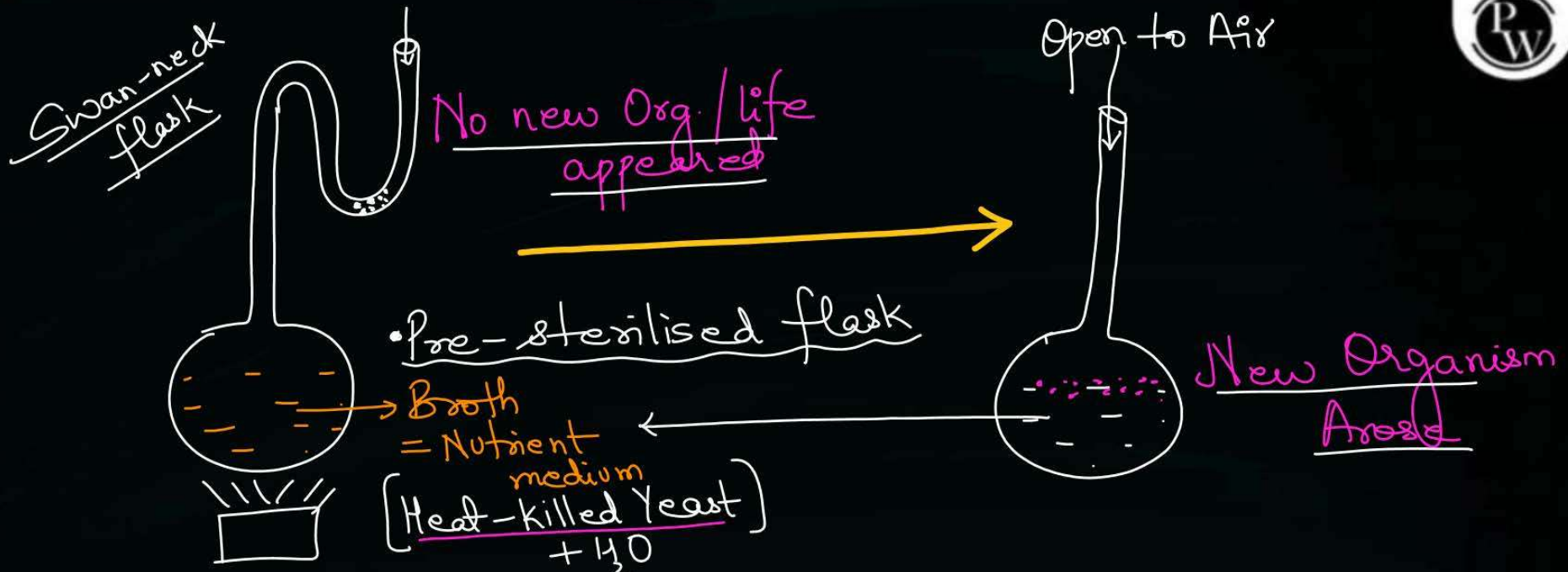


3) Th. of Spontaneous generation :- Abiogenesis (discarded)

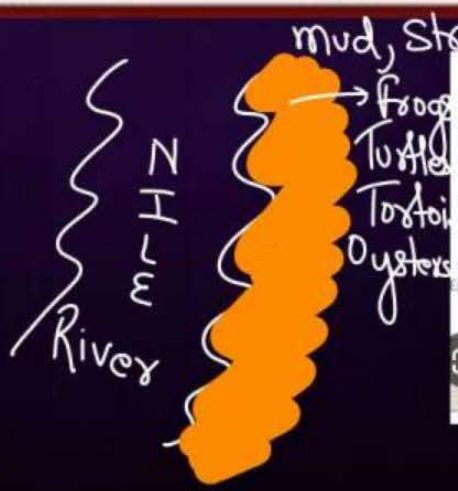
- life came from decaying, rotting matter (mud, straw etc.)

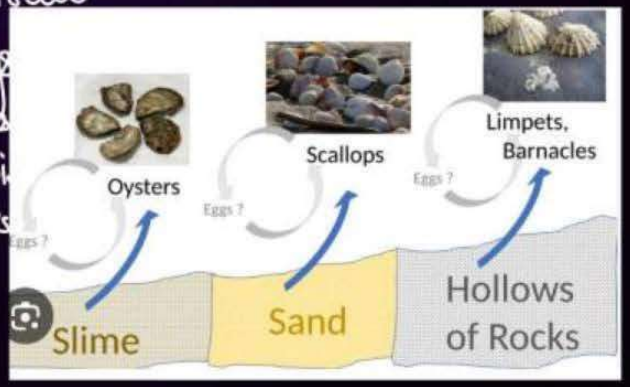
4) Th. of Biogenesis :- Louis Pasteur

- He discarded Th. of Sp. gen, once and for all by Swan-neck exp.
- life possible only from 'Pre-existing life'


Swan-neck flask
No new Org. / life appeared
Open to Air
• Pre-sterilised flask
Broth
= Nutrient medium
[Heat-killed Yeast + H_2O]
New Organism Arose


Recipe for Mice by Dr. Jan Baptista von Helmont
+
+
21 Days
=
Dirty Shirt
Wheat
Time
Mice


mud, straw
Nile
River


Oysters
Scallops
Limpets, Barnacles
Eggs ?
Eggs ?
Eggs ?
Slime
Sand
Hollows of Rocks

Methodology	Control Results	Experimental Results
		
Broth in flask is boiled to kill pre-existing micro-organisms (create a sterile environment)	As broth cools, condensing water collects, sealing mouth of flask (no growth will occur)	If neck is broken, outside air can carry micro-organisms into broth (contamination)

Conclusion

Cells can ***only*** arise from pre-existing cells

❖ **Question Still unanswered ?????**

- **How the first life form came on Earth ?**

5. Th. of Chem. Evolution

By Oparin (Russia) & Haldane (England)

- Free atoms (C, O, H, N etc.) → Molecules (N_2, H_2 etc.) → Inorganic compounds (CO_2, NH_3 etc.) → Simple Organic (Alcohol, aldehy, Keto etc)

- 1ST life appeared from

  Pre-existing Non-living Organic molecules (Proteins, RNA etc.)

  Complex Organic (sugars, Fats, Proteins, N.A) → 1ST life

- Conditions on Earth
  - Reducing atm. [Water Vapour, CH_4, NH_3, CO_2]
  - High Temp. (800 - 900°C)
  - Volcanic eruptions

* Th. of Biological Evolution :-

Discarded

a) Th. of Use & disuse of Organs / Lamarckism

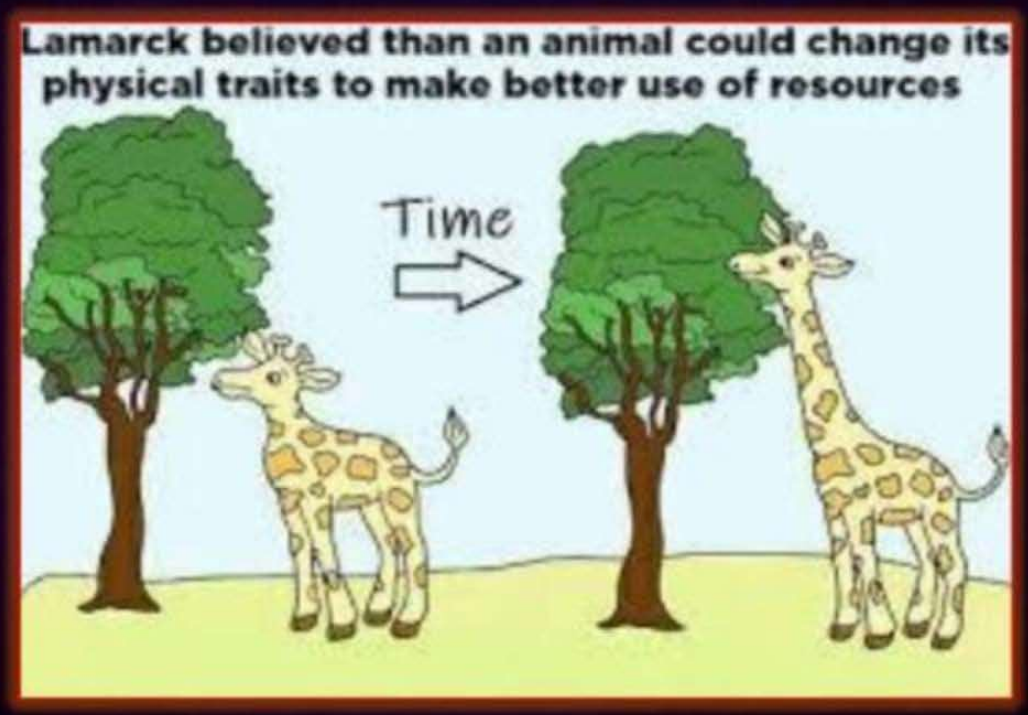
Aquired Inheritance

- by Lamarck (French Naturalist)
- Giraffe elongate neck → to forage leaves on tall trees

↓

Passed this aquired character to next generation

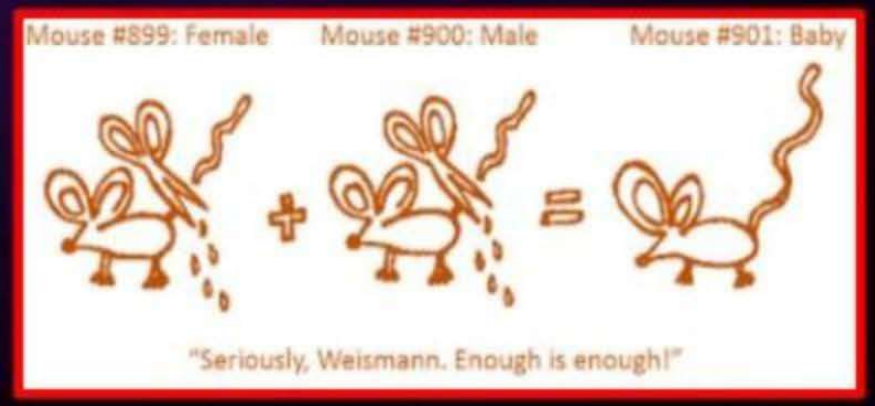
Lamarckism

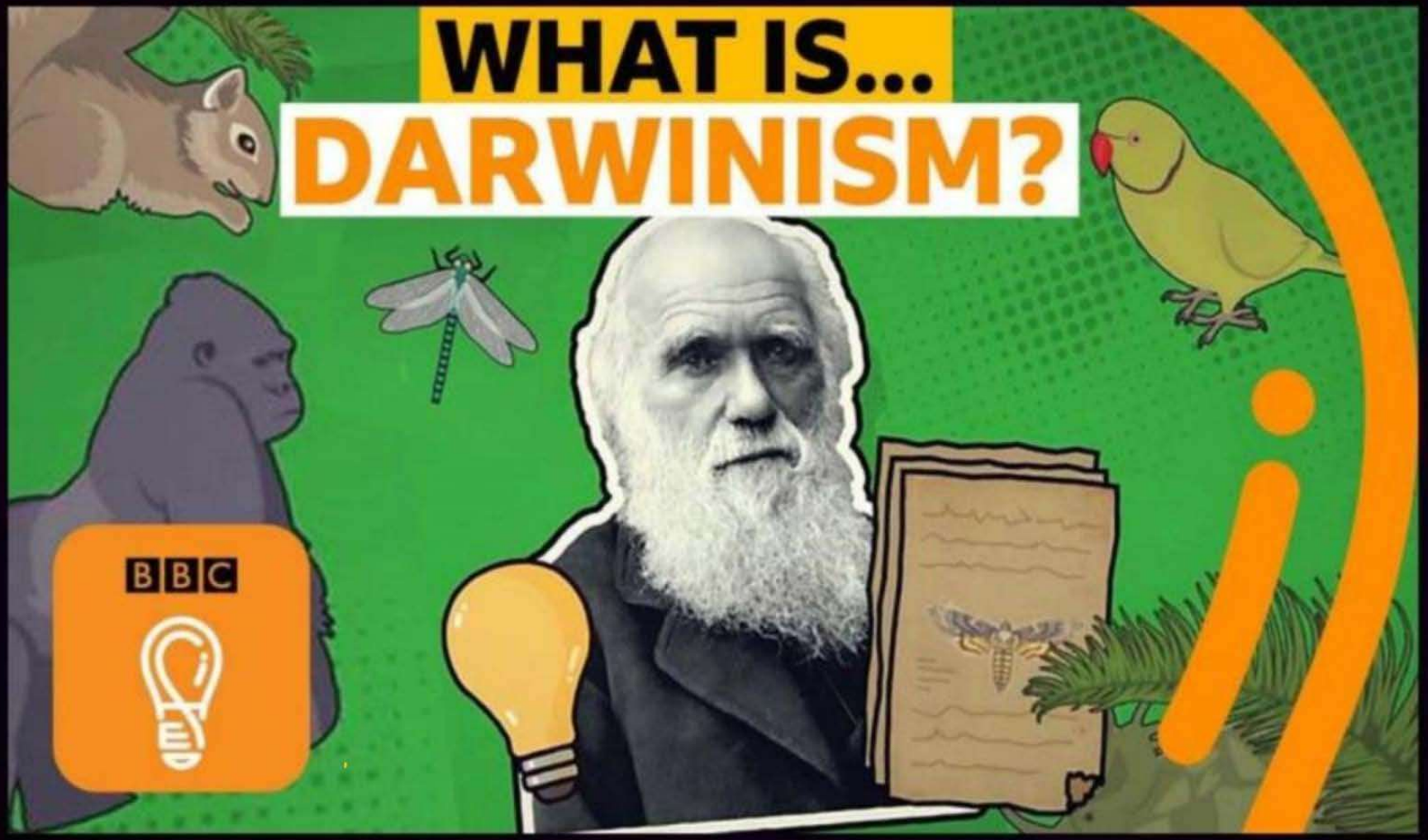

Lamarck believed than an animal could change its physical traits to make better use of resources
Time

b] Th. of Continuity of Germplasm :- by Weismann

2 types of Cells → Somatoplasm
→ Germplasm (Any change is passed to next gen.)

Weismann




WHAT IS...
DARWINISM?
BBC

9] Theory of Natural Selection / Darwinism :- by

Charles Darwin (England) went on Sea voyage in H.M.S Beagle Ship to Galapagos Island (Pacific ocean)

and

Alfred Wallace, at the same time, went on Sea voyage to Malay Archepelago (Indian Ocean)

* Both Influenced by "Essay on Population" by Thomas Malthus

Both Came up with Similar Conclusions for Evolution of Species

Darwin published book "ORIGIN of SPECIES", based on Th. of Natural Selection

- Population ↑ geometrically (1 → 2 → 4 → 8 . . .)
- Resources limited

↓

- Still Size of Population Stable, except Seasonal fluctuations

↓

- Competition for limited resources (Struggle for Existence)

[Intra-specific ; between members of same species ; Inter-specific ↓ between diff. species ; Environment struggle ↓ Rain, Heat, Cold etc.]

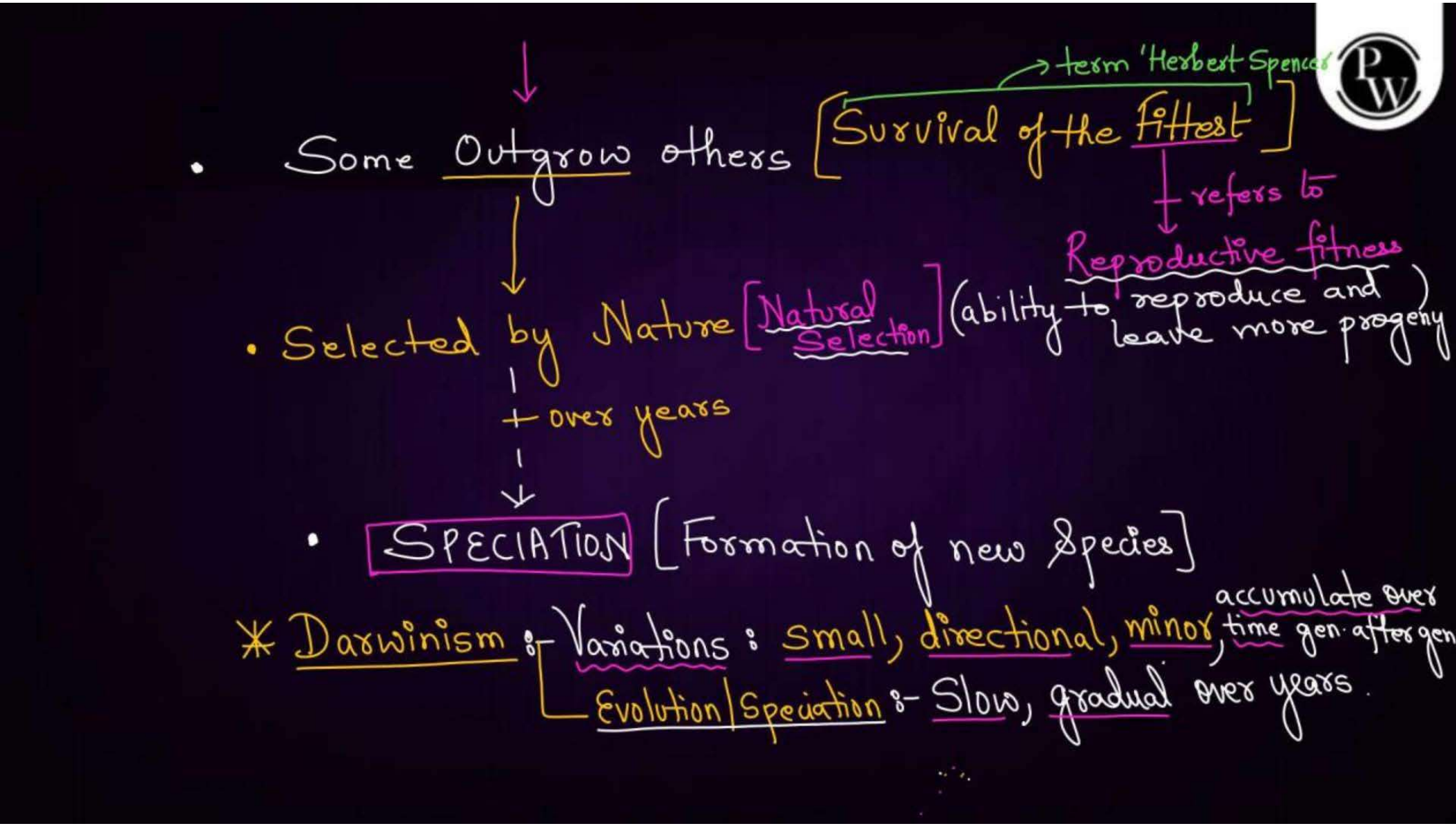
↓

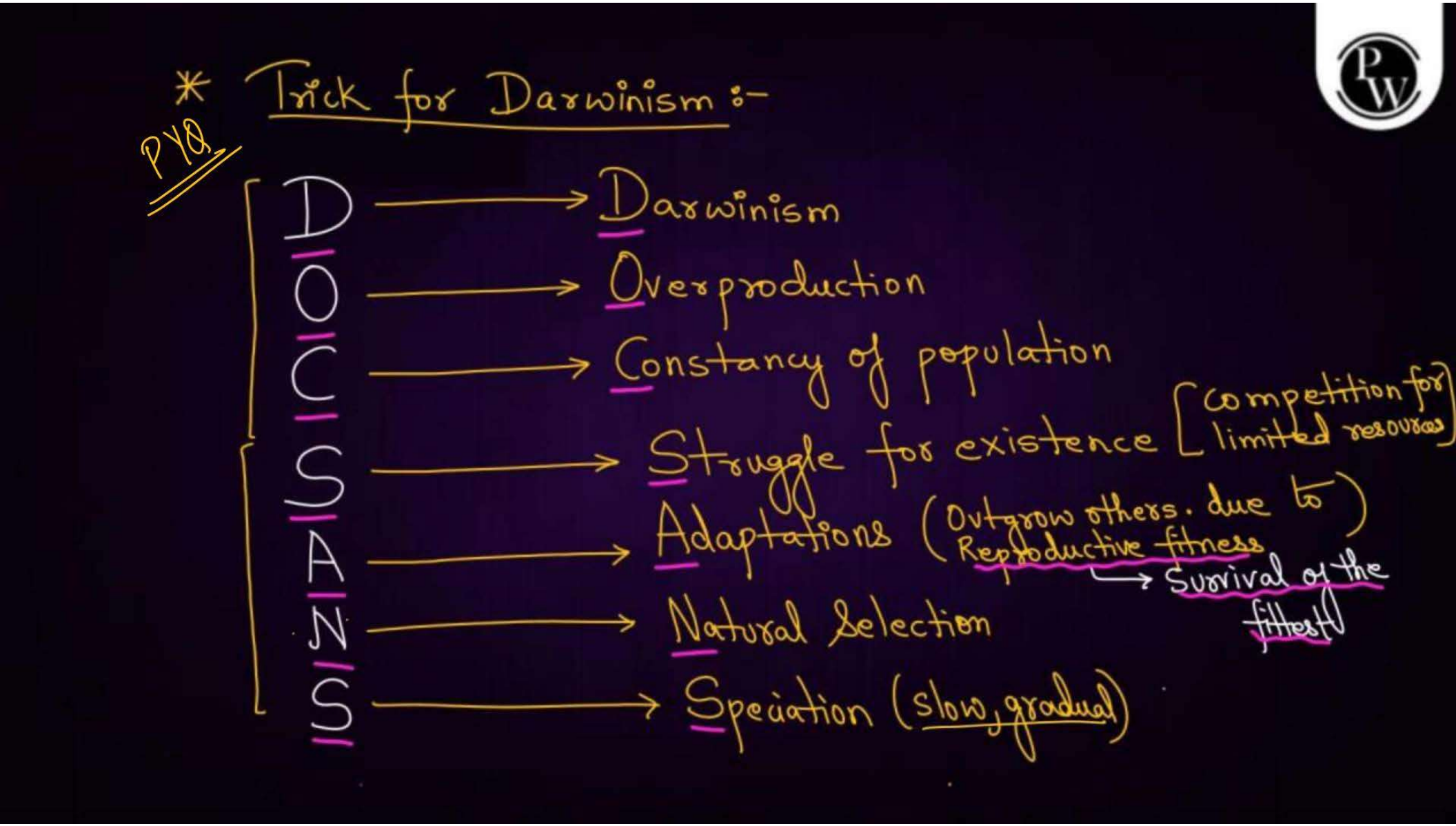
- Members of a population Vary in character
  [No 2 individuals are Alike]

- Most of the variations are Inheritable

- ADAPTATIONS :- Useful inheritable variations; help to survive in a given environment

- Survive, Reproduce and leave more progeny


Some Outgrow others
Survival of the fittest
term 'Herbert Spencer'
refers to
Reproductive fitness
(ability to reproduce and leave more progeny)
Selected by Nature [Natural Selection]
over years
SPECIATION [Formation of new Species]
* Darwinism :- Variations : small, directional, minor, accumulate over time gen. after gen
Evolution/Speciation :- Slow, gradual over years.


* Trick for Darwinism :-
PYQ
DOCUSAINS
Darwinism
Overproduction
Constancy of population
Struggle for existence [competition for limited resources]
Adaptations (Outgrow others. due to Reproductive fitness → Survival of the fittest)
Natural Selection
Speciation (slow, gradual)

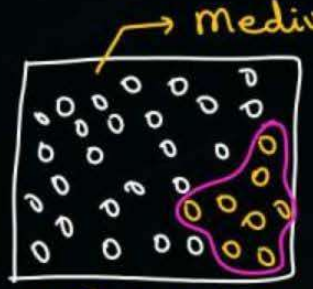
Out of NCERT
PYQ

Limitation of Darwinism :-

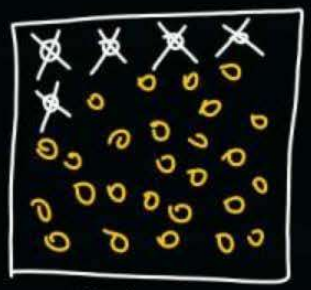
They could not tell the "Source of Variations"

- Genetic recombination / Crossing over (Pachytene of Prophase-I) during gamete formation
- Variations :- Minor, Small, directional

* Rate of appearance of new life forms is linked to life cycle or life span (according to Darwinism)



Change in Medium



* Colony 'A' of Bacteria (well-adapted to environment/medium)

* Colony 'B' of Bacteria

↓

Adapted to new medium and outbreed others

↓

Speciation within days [Shorter life span]

(Formation of new species)

- Microbes divide fast & ability to multiply & become millions within hours

* For Fishes or Fowl (Birds);

↓

Speciation takes millions of years

↓

As life Span is in years

* Fitness of 'B' is better than 'A' in new conditions

d) MUTATION / Saltation Theory :-

— Hugo-de-Vries, on Evening primrose (Oenothera Lamarckiana)

- A single step, large mutation = Saltation
  → resp. for Speciation
- Mutation :- [large, Single-step, Random, Direction-less
  Sudden differences, arising in a population
  ↓
  Result in Speciation

e) Modern Synthetic Theory :- For Evolution / Speciation

1) Natural Selection
2) Genetic Recombination
3) Mutation / Saltation
4) Gene flow / migration (Immig / Emmigration)
5) Genetic drift

* Examples of Natural Selection :-

1] Darwin Finches (Later)

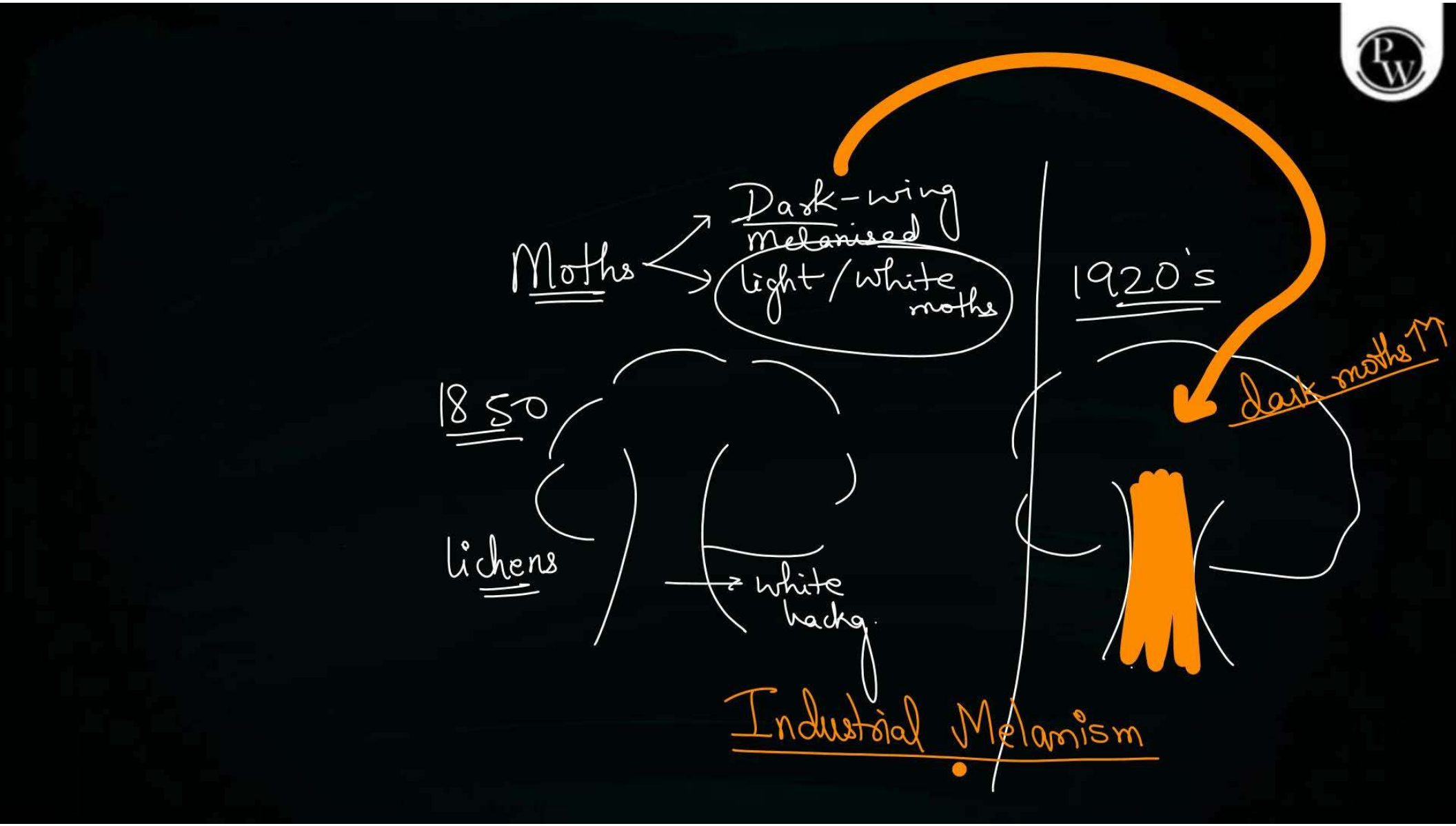
2] Industrial Melanism

3] Antibiotic - resistant bacteria / microbe

4] DDT / Pesticide - resistant mosquitoes

} due to human activity (Anthropogenic action)

- $Hb^A Hb^A$ (N) → die of Malaria
- SCA $Hb^S Hb^S$ disease → " " SCA disease
- Malaria-prevelant areas: $Hb^A Hb^S$ Carrier (Co-dominant) → Selected by Nature


Moths
Dark-wing melanised
light/white moths
1920's
dark moths ↑↑
1850
lichens
→ white backg.
Industrial Melanism

V. imp *

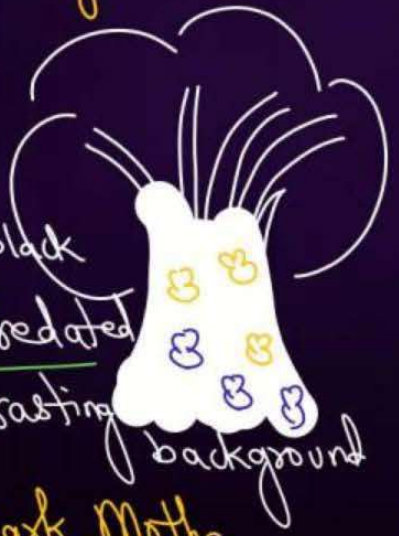
Industrial Melanism :- England forest

(A) 1850's (Before Industrialisation)

Dark moth ↓ Biston Carbonia

- Unpolluted areas
- Lichens ⊕
- Tree trunk light Colored

(Biston betularia) White-winged moths Camouflage in light background but dark/Black winged moths were predated by birds due to Contrasting background



White moths >> Dark Moths
(selected by Nature)

(B) 1920's (After Industrialisation)

- Pollution ↑
- Lichens disappeared
- Tree trunk dark Colored due to Carbon, soot etc.

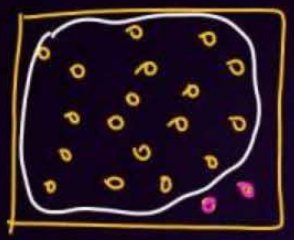
Dark moths Camouflage while White moths were predated.

Dark moths >> White moths
(Selected by Nature)

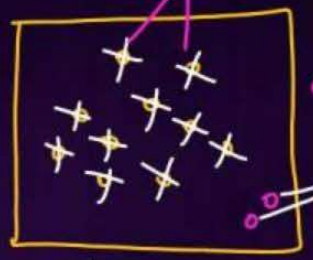
ANTHROPOGENIC

Evolution (Man-made)

* Pesticide / DDT – resistant Mosquitoes :-



Introduction of DDT / Insecticide / Pesticide / Herbicide

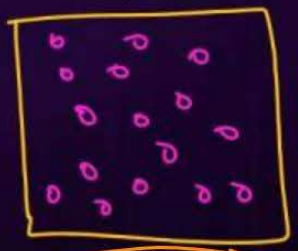


DDT- Sensitive mosquitoes

• DDT- Resistant Mosquitoes

They have some pre existing Variation

Selection of Resistant varities



DDT- resist. mosq. ↑↑↑

Advantageous and Enabled them to Survive & reproduce against DDT

Selected by Nature

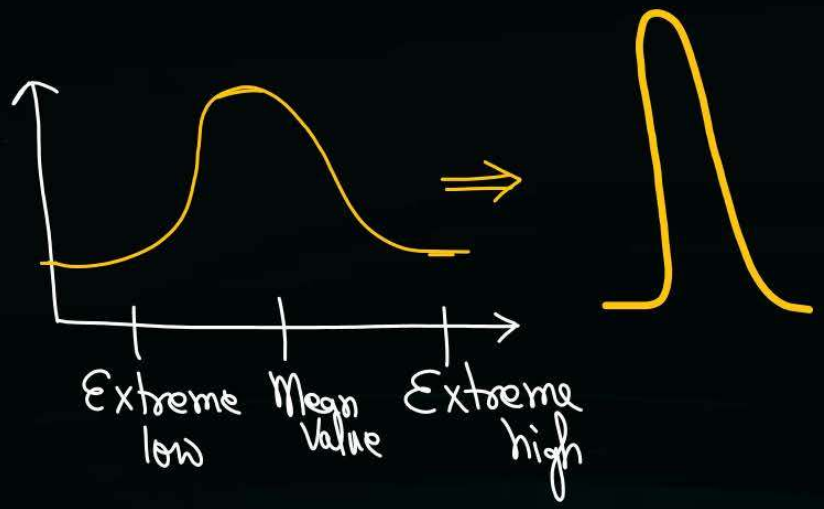
* Same with Drug / Antibiotic-resistant Bacteria

⇒ Pre-existing Advantageous Mutation, when Selected → chance mutations → Result in New phenotypes → Over the years, results in SPECIATION

V.V. imp

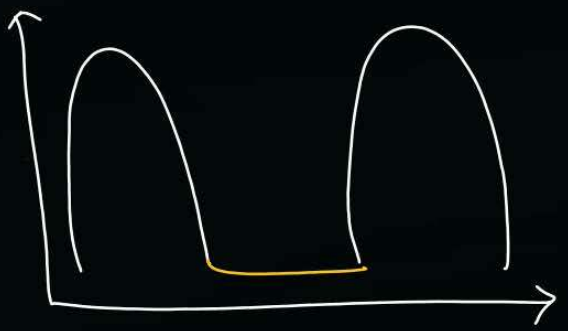
* Types of Natural Selection :- 3 types

1) Stabilising (Most common)
   - Extremes rejected
   - Mean value selected
   - eg: Birth wt, Height
   - Single peak gets narrower → taller & higher



2) Disruptive type (Rare)

- Mean rejected
- Both extreme selected
- Aquire peripheral character than mean value
- 2 peaks at a time



eg: Shell in Snails

Out of NCERT

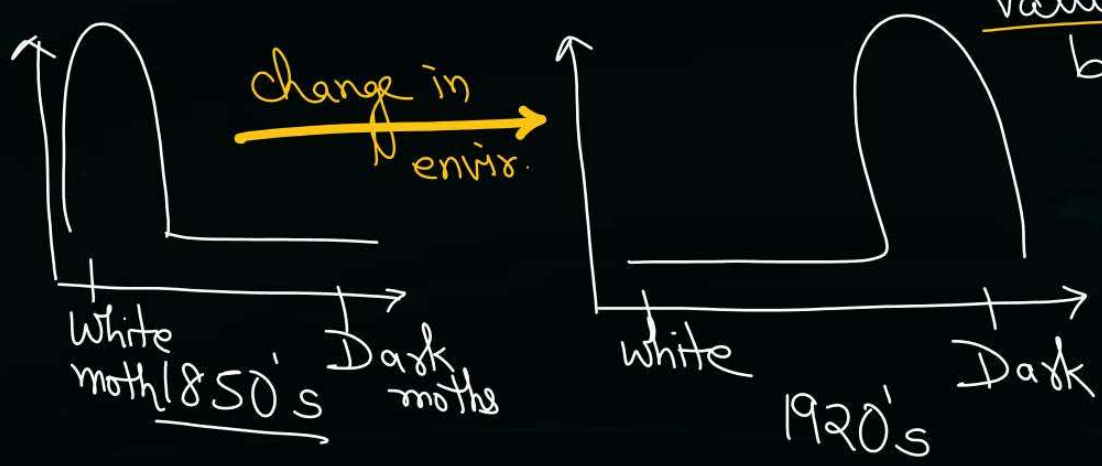
1) Black ✓
2) White ✓
3) Grey ✗

3) Directional/Progressive type → Peak shifts in one direction.

eg: DDT-resist mosquitoes
Antibiotic " bacteria
Industrial Melanism

→ More individuals aquire extreme value (other than mean value)

→ Peripheral/Extreme Value is selected but one at a time

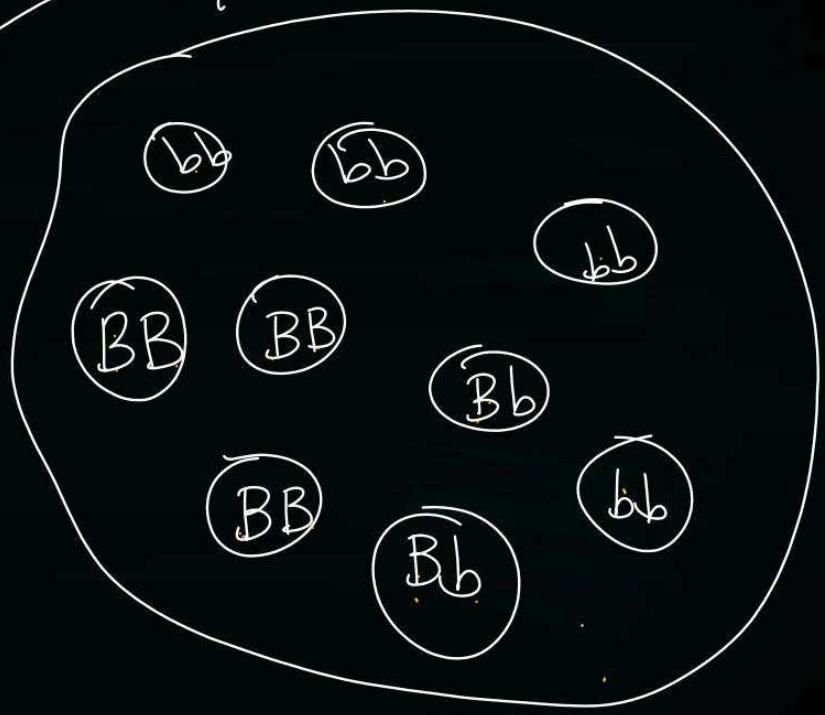


p = freq or % dominant allele

$= \frac{8}{18} \times 100$

q = freq or % recessive allele

$= \frac{10}{18} \times 100$



* Gene pool = Sum total of all genes and alleles in a population

(Alternate forms of a gene)

eg:- Mice population = 200

White hair (120)

Black hair (80 in no.)

frequency of White hair mice

$= \frac{120}{200} = \frac{6}{10} = 0.6$

$= 60\%$

freq. of Black mice

$= \frac{80}{200} = \frac{2}{5} = 0.4$

$= 40\%$

∴

* **Hardy–Weinberg Principle :-**

In a large, randomly-mating population, if there is:-

1) No Natural Selec.
2) No G. Recomb.
3) No Mutation
4) No Gene flow
5) No Gen. drift

$\Rightarrow$ Gene Pool Constant (Ideal situation which does not exist)

↓

No Evolution occuring

↓

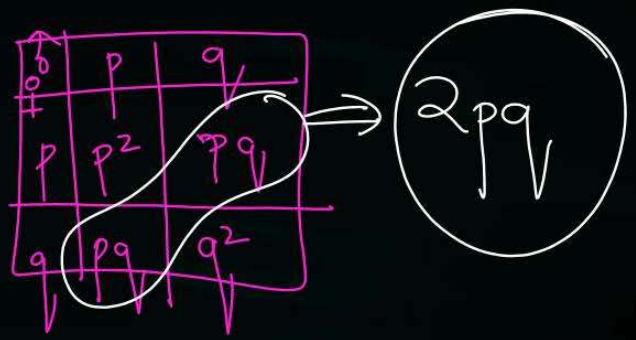
Population is in H. W Equilibrium / Principle

* H. W Equilibrium

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

- p^2 → homozy. dominant indiv. (pp)
- $2pq$ → heterozy. indiv. (Pq)
- q^2 → homozy. recessive individuals (qq)



* 5 factors which affects / disturbs H.W Equilibrium :-

1) Mutation
2) G. Recomb.
3) Natural Selection
4) Gene flow
5) Gen. drift

$\Rightarrow p + q \neq 1$

• Difference in freq → indicates extend of evolution

V. Imp!

GENETIC DRIFT

Sewall-Wright Effect

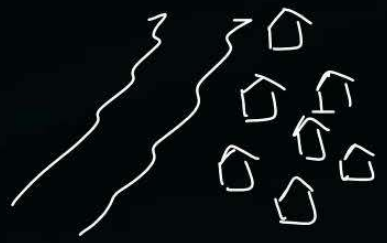
↳ Out of NCERT

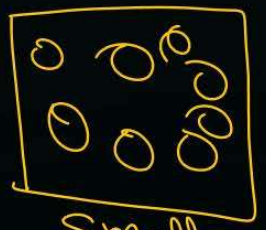
PYQ

→ change in allelic frequency by Chance (Natural Calamity / Hunting)

→ In Small, isolated popul called Bottle neck effect

→ FOUNDER Effect





Small Isol. population

→ original Drifted population becomes founder members of new species

* EVIDENCES FOR EVOLUTION :-

1. Morphological and Anatomical evidence
   - Homology
   - Analogy
   - Vestigeal Organs
   - Connecting links
2. Biochemical evidence
3. Embryological "
4. Palaeontological " ⟶ Best evidence
5. Artificial Selection

V.V. imp * (1) **Homologous Organs**

Same **

- Organs with **Same Origin** & **Same basic plan** but **function** may be **different** or Same

eg: 1) Forelimbs of Man, Cheetah, Whale / Dolphin, Bats — Mammals

Running — Swimming — Aquatic — Flying

- **All have** Humerus, Radius, Ulna, Carpals, Metacarpals, phalanges

2) **Thorn of Bougainvillea** & **Tendril of Cucurbita**

Grasping

Thorn: protect / defence

Tendril: Climbing / support

- Both origin from **Axillary bud**

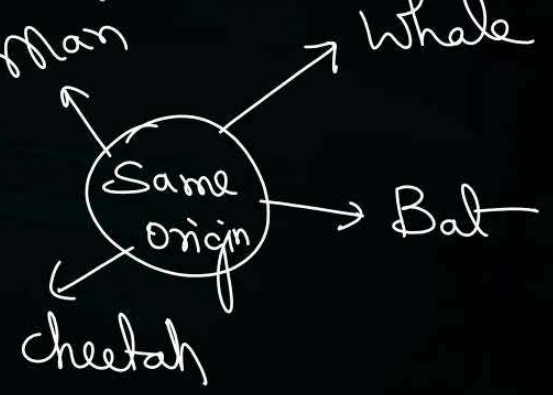
- Same origin
- Same function

3) Heart of Vertebrates (2/3/4-chambered)
4) Brain of "

* Homology indicates 'Common Ancestory'
* Same Ancestor / Origin / Anatomical features

Different habitat
↓
Diff. Needs
↓
Diff. adaptations
↓
Diff. functions

* Result of DIVERGENT EVOLUTION



Trick for Homologous organs –

H.W

- Hero - Homologous
- Virat's Heart & Brain – Vertebrate Heart , Brain
- Beats for Test Cricket Today – Cucurbita Tendril
- Lets Catch Best & Win Match – Limbs Cheetah , Bat , Whale , Man

Bougainvillea Thorn ,

② Analogous Organs

- Origin / Ancestor / Anatomy — Different but Same function

eg: 1) Potato tuber (stem) & Sweet potato (Root)

- Diff. Origin
- Same fn. (Food Storage)

2) Eye of Octopus (Invert.) & Eye of Man (Verteb.)

(Vision - Same fn)

3) Flippers of Penguin (Bird) and Dolphin (Mammal) } Same fn Swimming

4) Wings of Bird / Bats (mammal) & Wing of Butterfly / Insect } Flying

* Diff. Origin but Similar habitat / environment

↓

Similar needs

↓

" adaptations

↓

Similar functions

* Result of Convergent Evolution

Trick for Analogous organs –

H.W

- All - Analogous
- Politicians of Delhi & Faridabad are-

Penguin , Dolphin Flippers

- Sweet & Polite –

Sweet potato & Potato

- Which is Best Breed in –

Wings of Birds & Butterfly

- Man's Open Eyes –

Man & Octopus Eye

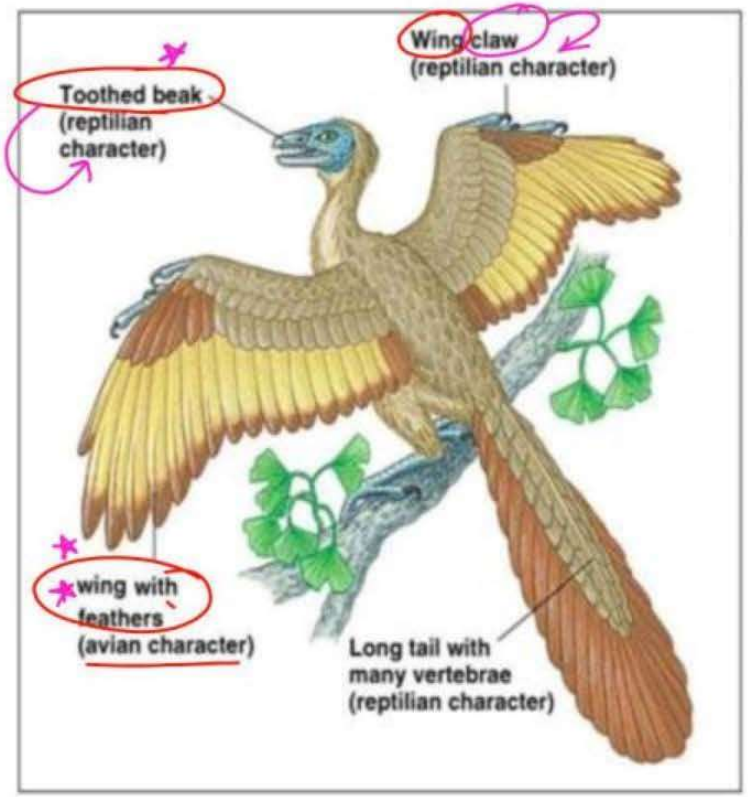
* Out of NCERT / PYQ

VESTIGEAL ORGANS / Rudimentary :- Now Non-functional but gives an evidence that they might have been functional in our ancestors

eg :-
- 3rd Molar / Wisdom tooth
- Ear pinna muscles
- Coccyx / tail bone
- Canines etc.
- Nictitating membrane
- Appendix

* Connecting link (Missing link) → only fossils available
eg: Archeopteryx (Between Reptile & Birds)

Archaeopteryx is a ***connecting link*** between the reptiles and birds.



Avian characters

1. Beak
2. Feathers
3. Wings

Reptilian characters

1. Toothed beak
2. Claws
3. long tail

II Biochemical Evidence :-

- Similarities in *Proteins and *genes, performing a given function among diverse organisms gives clues about common ancestory

eg : 1. Similarities in DNA between Human & Chimpanzee

2. Similar enzyme 'Trypsin' found in whole Animal Kingdom

III Embryological Evidence :-

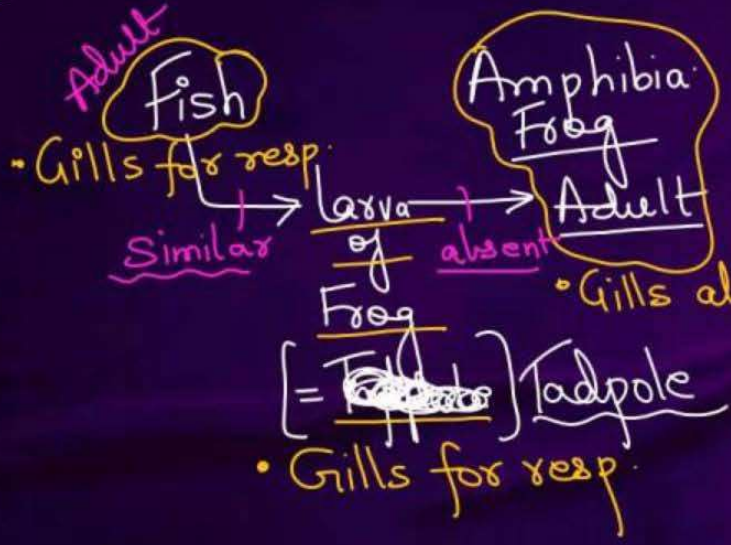
Ernst Haeckel

* Certain features during Embryonic stage are common to all vertebrates that are absent in some adults

eg: embryo of all vertebrates (including human) have vestigeal gill slit, just behind head but it is functional only in fish and not found in any other adult vertebrate.

Out of NCERT / PYQ *

Ernst Haeckel gave "Biogenetic law/Recapitulation Theory"

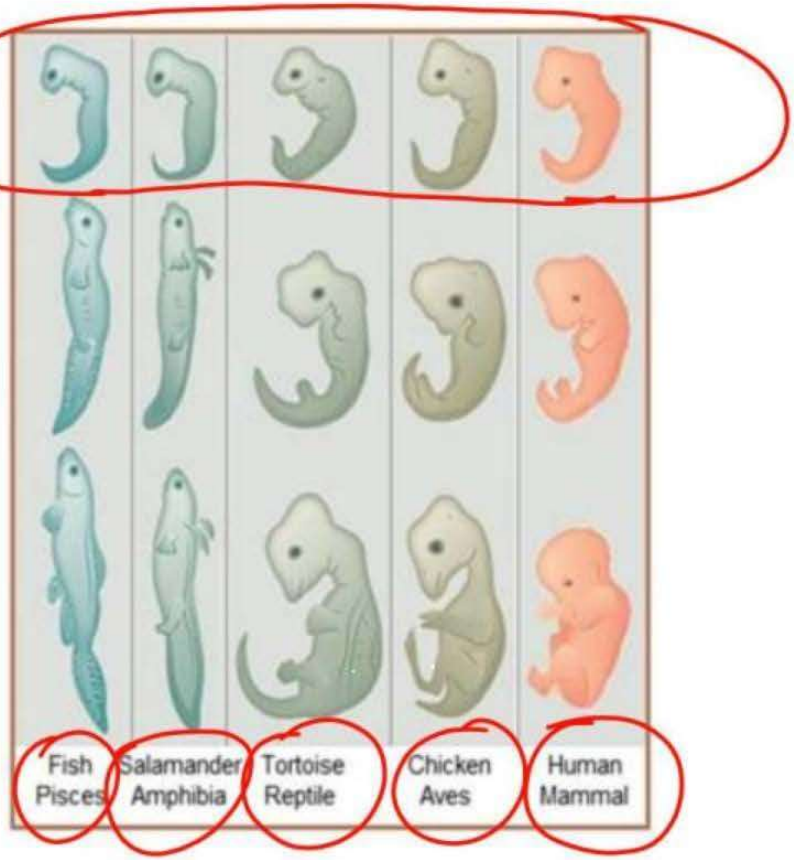


"Ontogeny Recapitulates Phylogeny"

[Embryonic development of an organism] [Repeat] [Similar ancestor / Evolutionary history]

Embryonic development of an organism passes through stages that resemble their ancestral adults.

EMBRYOLOGICAL EVIDENCES....



* Karl Von Baer disapproved Recapitulation theory

PYQ

→ Embryo never passes through adult stages of any other organism

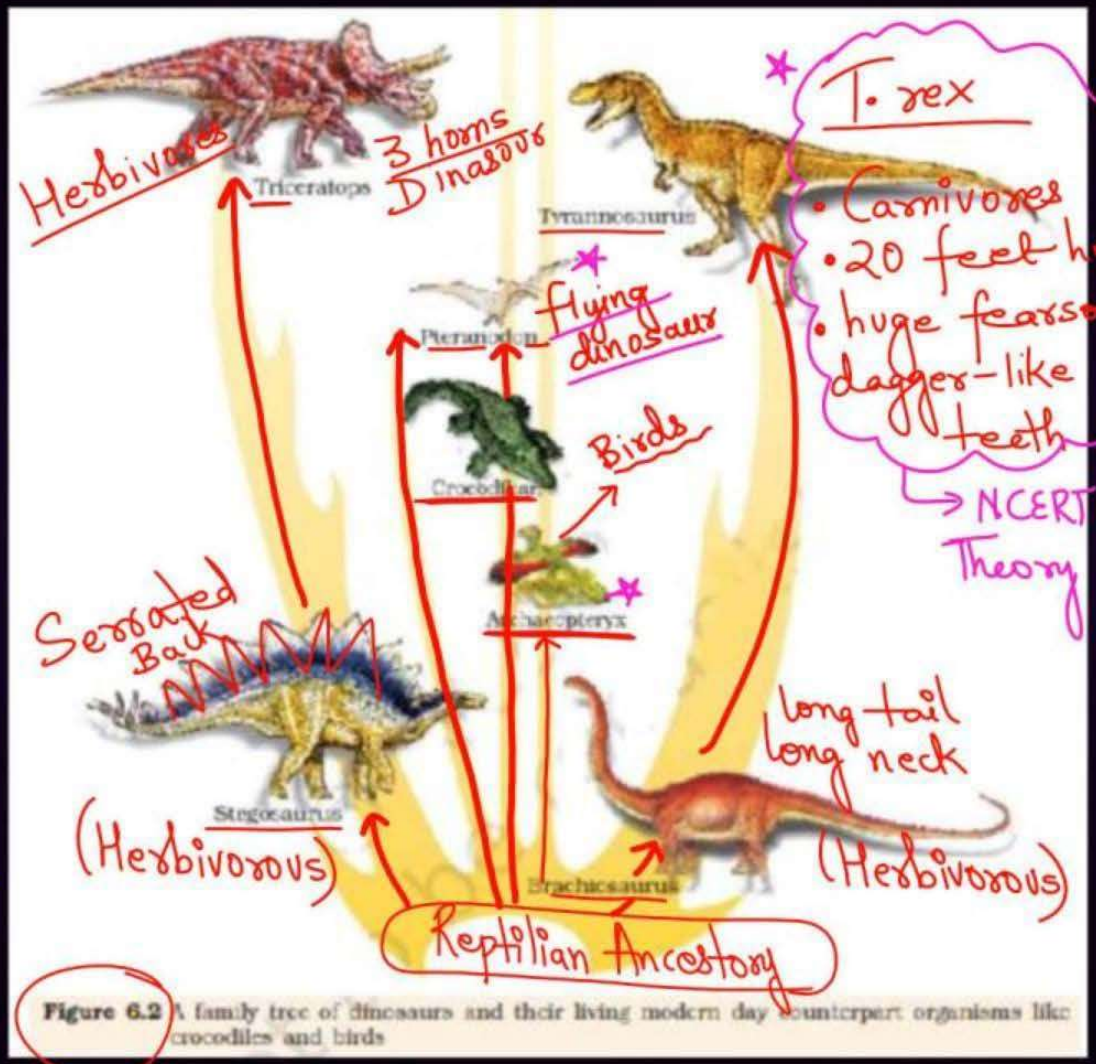


Figure 6.2 A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

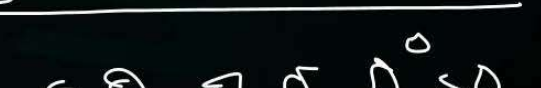
IV Palaeontological Evidence

(FOSSILS)

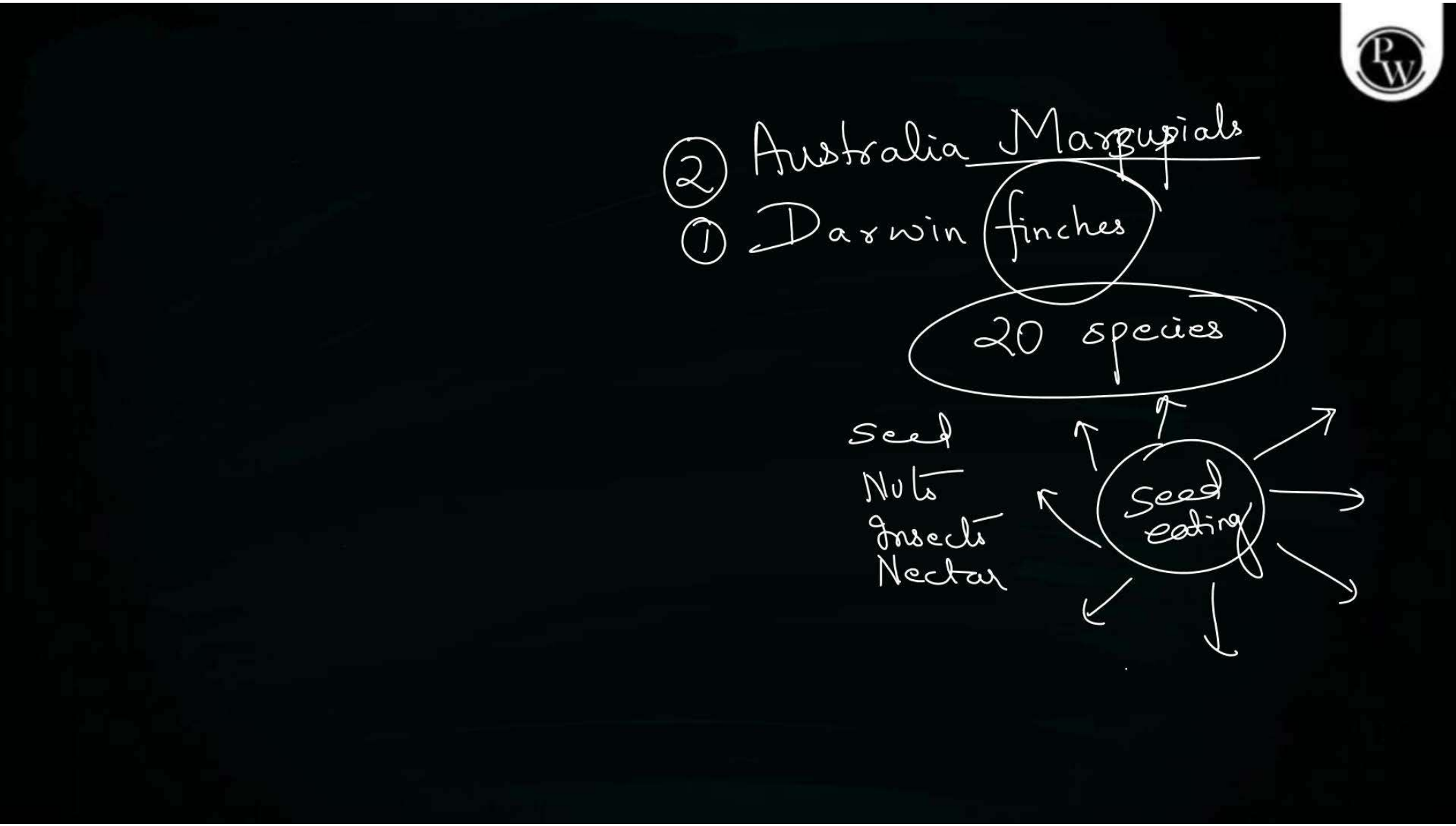
→ Remains of Hard parts of life forms found in Rocks (Sedimentary)

- Represent Extinct Organisms
- Age of fossils
  - → Carbon-dating
    - Ratio $\frac{C^{14}\text{ (Radioactive)}}{C^{12}}$
    - Every 5730 yr = half-life (C^{14})

Newer / Top layers

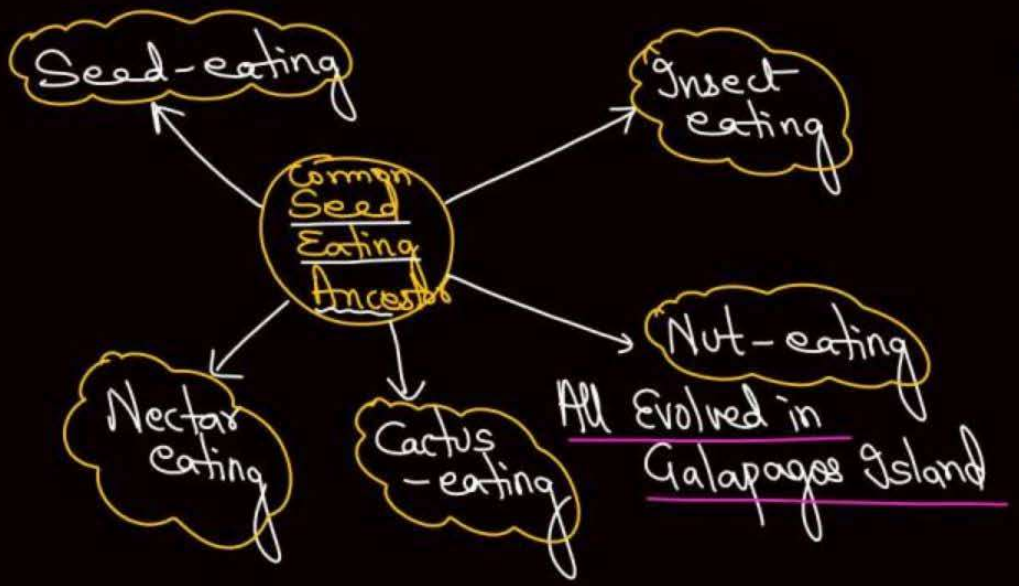


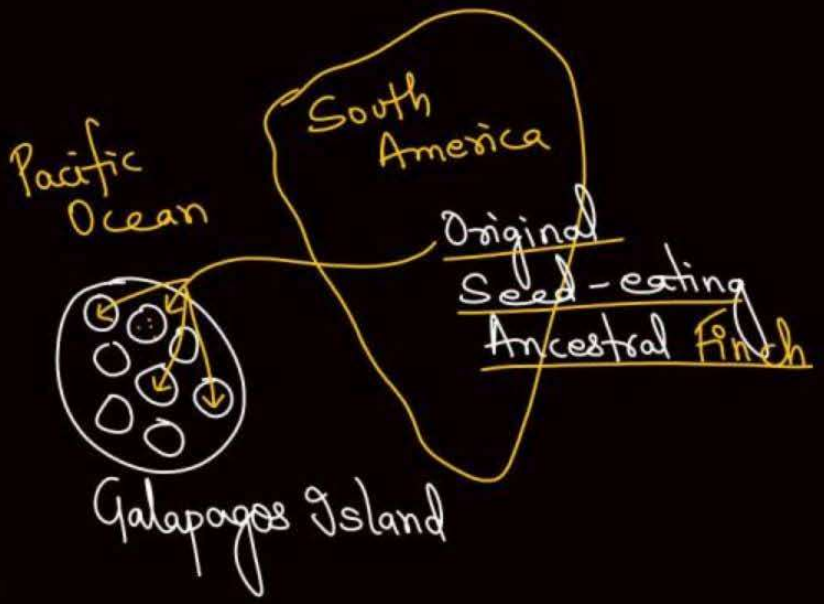
Oldest / deeper


(2) Australia Marsupials
(1) Darwin finches
20 species
Seed
Nuts
Insects
Nectar
Seed eating

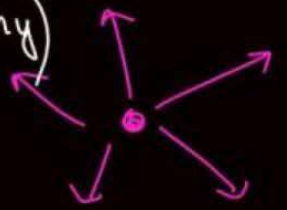
* ADAPTIVE RADIATION :-

eg: Darwin's Finches (Small black birds) :- Their beaks modified (adaptation) according to food they explored



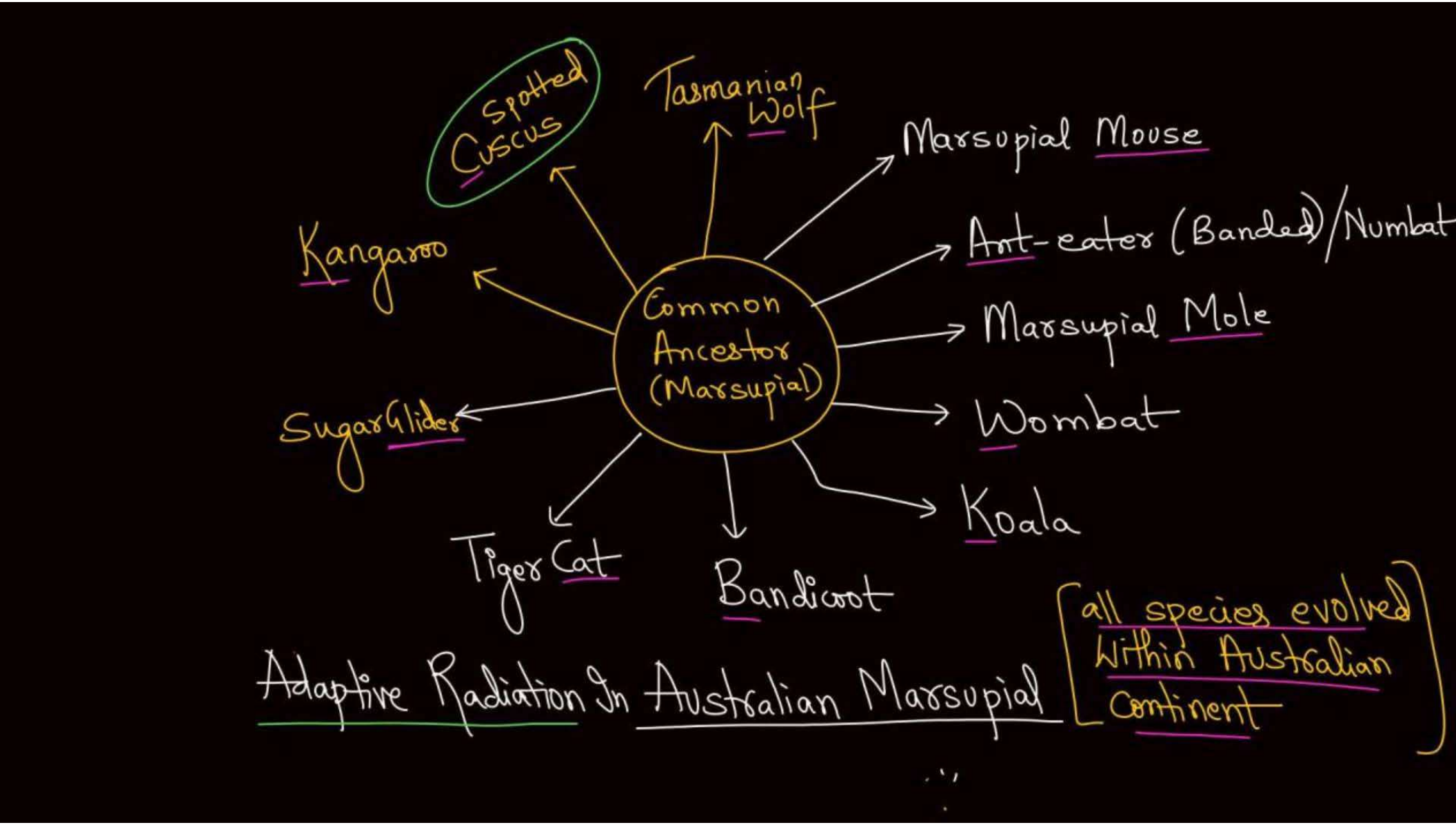


- **Adaptive Radiation :-** It is Evolution of different species in a geographical area starting from a common geographical point area, radiating along different directions (other areas of geography / habitats)

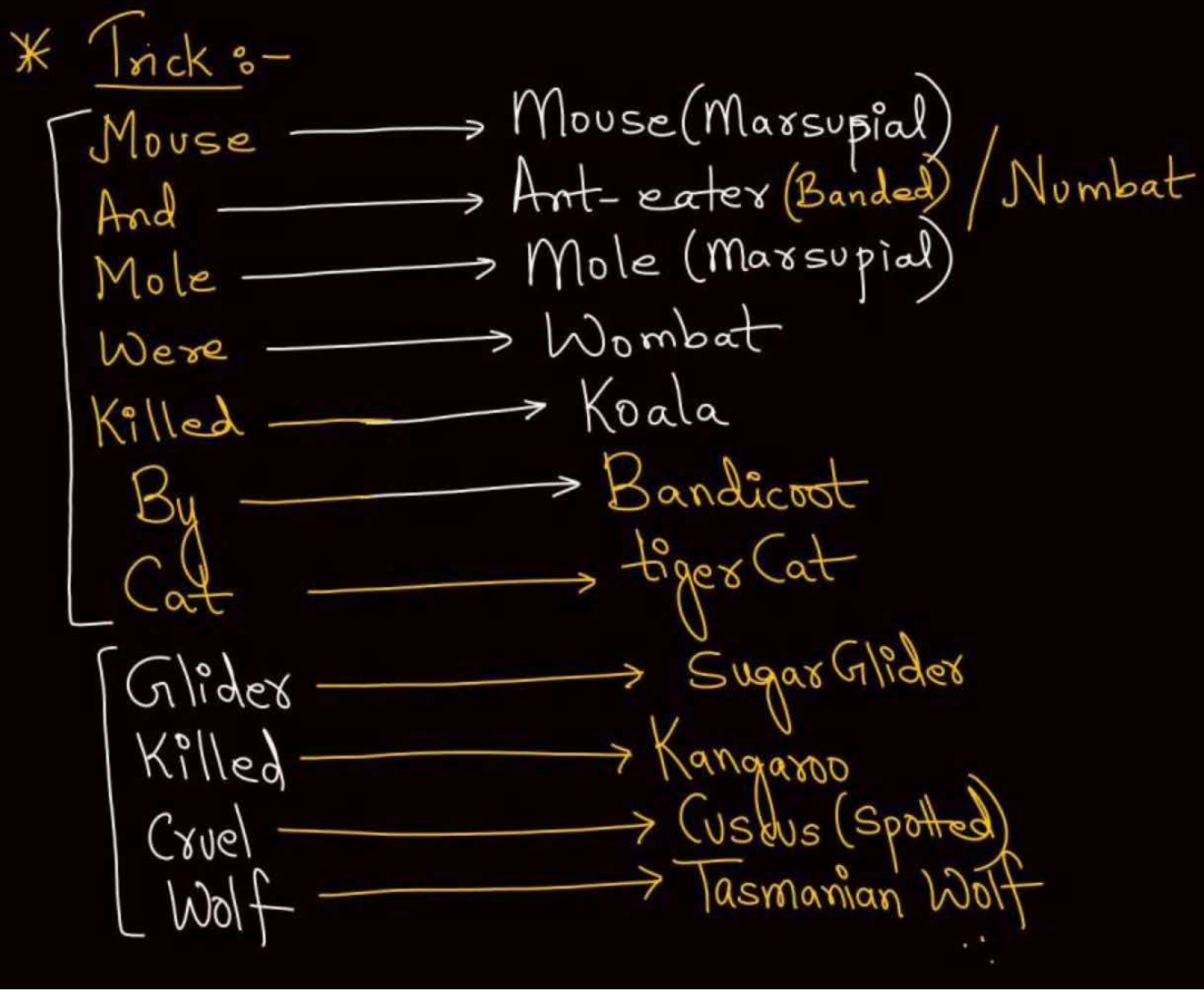


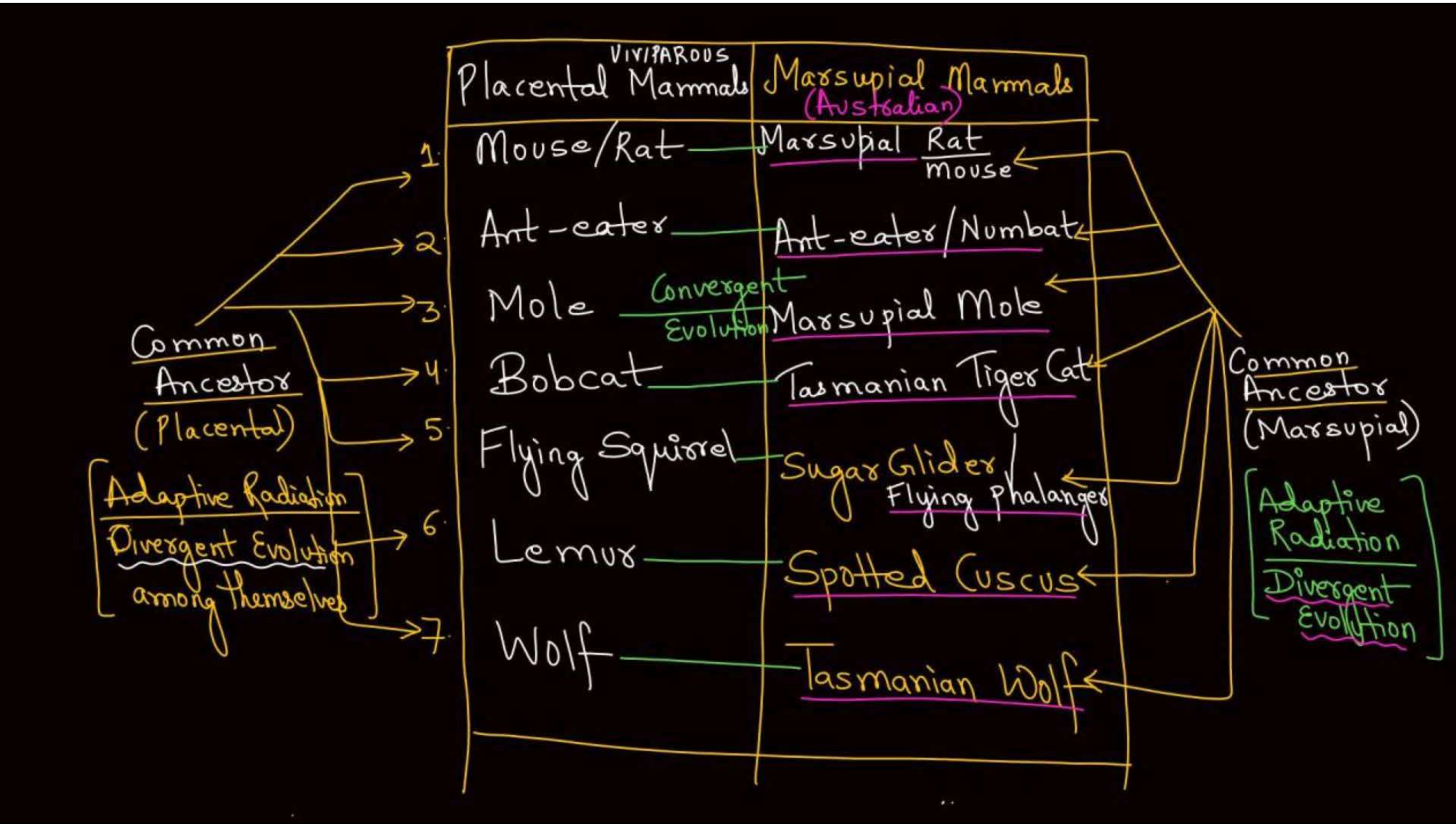
eg :- ① Australian Marsupials (Pouched mammals)

② Darwin finches (small, black birds)



Adaptive Radiation In Australian Marsupial [all species evolved within Australian continent]


* Trick :-
Mouse → Mouse (Marsupial)
And → Ant-eater (Banded) / Numbat
Mole → Mole (Marsupial)
Were → Wombat
Killed → Koala
By → Bandicoot
Cat → tiger Cat
Glider → Sugar Glider
Killed → Kangaroo
Cruel → Cuscus (Spotted)
Wolf → Tasmanian Wolf
..


VIVIPAROUS
Placental Mammals
Marsupial Mammals
(Australian)
Mouse/Rat
Marsupial Rat
mouse
Ant-eater
Ant-eater/Numbat
Mole
Convergent Evolution
Marsupial Mole
Bobcat
Tasmanian Tiger Cat
Flying Squirrel
Sugar Glider
Flying phalanger
Lemur
Spotted Cuscus
Wolf
Tasmanian Wolf
1.
2.
3.
4.
5.
6.
7.
Common Ancestor (Placental)
Adaptive Radiation
Divergent Evolution among themselves
Common Ancestor (Marsupial)
Adaptive Radiation
Divergent Evolution

* Convergent Evolution :- When >1 Adaptive Radiation occurs in a given geographical area (representing different habitats)

eg: Placental mammals in Australia and corresponding Australian Marsupial look Similar alike

appears to be similar

Add in Notes

- The process by which organisms with different evolutionary history evolve similar phenotypic adaptations in response to a common environmental challenge (NEET)

diff. ancestors

Out of NCERT

PYQ

→ External appearance

Ans: Convergent Evolution

✳ GEOLOGICAL TIME SCALE :-

↓ divided into

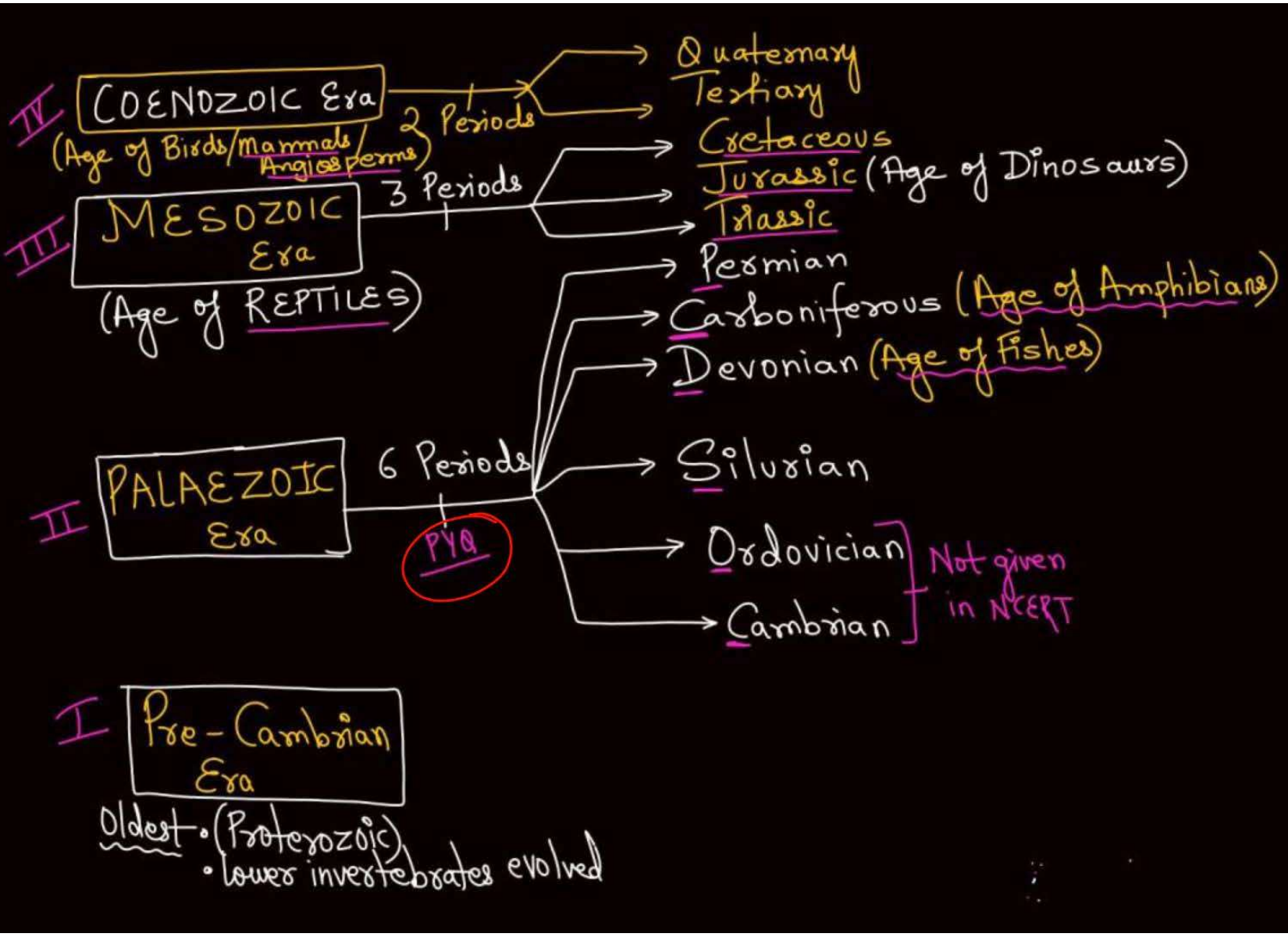
ERA

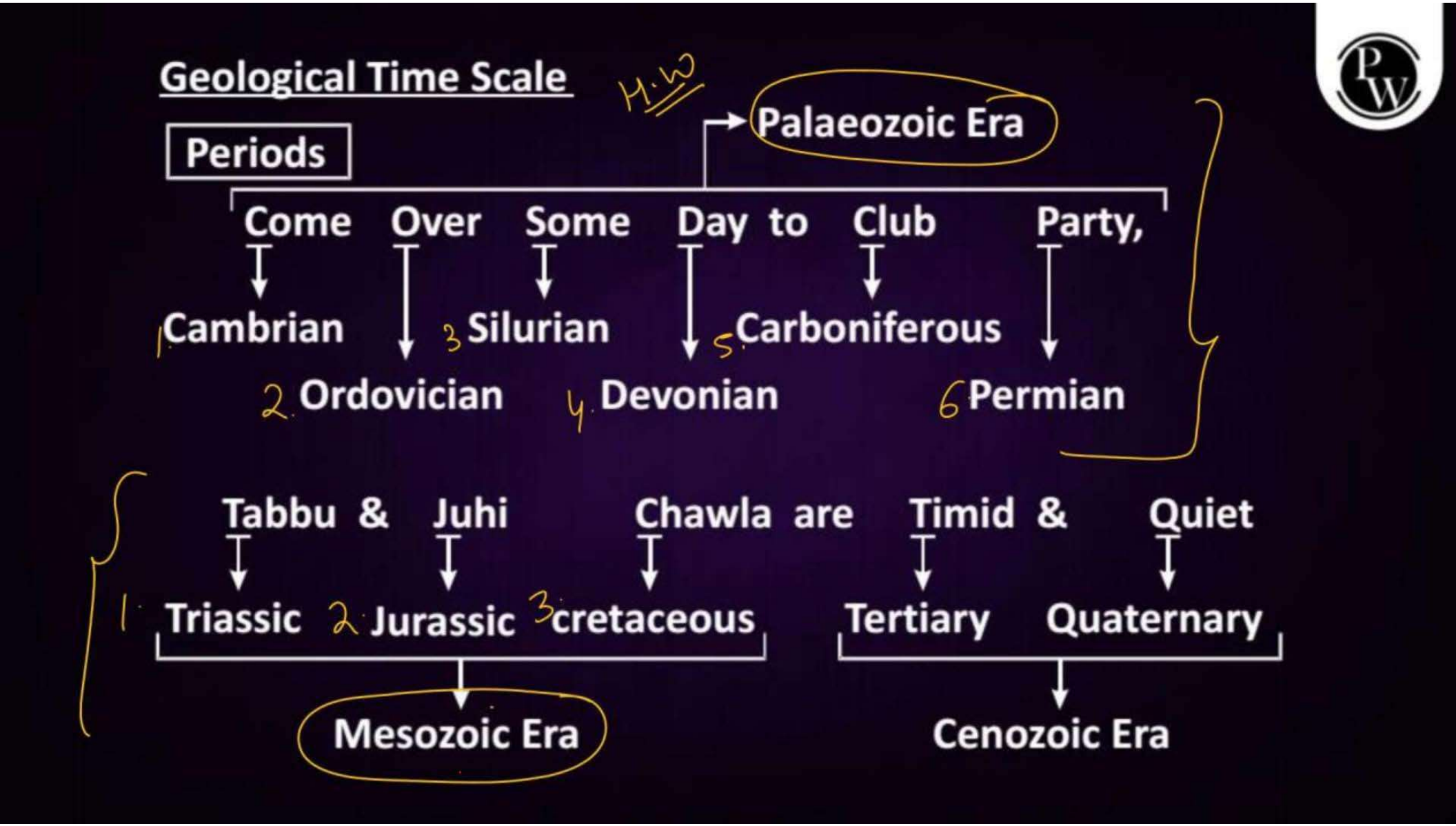
↓ divided into

PERIODS

↓ divided into

EPOCHS (out of NCERT)


IV
CENOZOIC Era
(Age of Birds/Mammals/Angiosperms)
2 Periods
Quaternary
Tertiary
III
MESOZOIC Era
(Age of REPTILES)
3 Periods
Cretaceous
Jurassic (Age of Dinosaurs)
Triassic
II
PALAEZOIC Era
6 Periods
PYQ
Permian
Carboniferous (Age of Amphibians)
Devonian (Age of fishes)
Silurian
Ordovician
Cambrian
Not given in NCERT
I
Pre-Cambrian Era
Oldest
(Proterozoic)
• lower invertebrates evolved


Geological Time Scale
H.W
Periods
Palaeozoic Era
Come Over Some Day to Club Party,
1 Cambrian
2 Ordovician
3 Silurian
4 Devonian
5 Carboniferous
6 Permian
Tabbu & Juhi Chawla are Timid & Quiet
1 Triassic
2 Jurassic
3 cretaceous
Mesozoic Era
Tertiary Quaternary
Cenozoic Era

H.W

BRIEF ACCOUNT OF EVOLUTION

* 1ST Cellular form of life : 2000 million years ago (2 BYA)
  - Some can break H_2O during photosynthesis and release O_2 : Cyanobacteria
* Slowly single-celled became Multicellular life forms
* By 500 mya : Invertebrates formed & active
* 350 mya :
  - Jawless fishes evolved
  - Fish with stout and strong fins could move on land and go back to Water (Coelocanth)
  - In 1938, Coelocanth (lobefins) caught from South Africa (thought to be extinct)
* 320 mya
  - Sea-weeds & few plants existed
  - 1ST organisms that invaded land were Plants [Widespread, when animals invaded land]

* Lobefins Evolved into 1ST Amphibians, lived on both land & water
(no specimens left)

↓

Ancestors of Modern-day Frogs, Salamanders

↓

Amphibians Evolved into Reptiles
[Thick-shelled eggs → do not dry in Sun]

↓

- Modern day Descents, Turtles, Tortoises, Crocodiles etc.

Mesozoic Era

- Next 200 million yrs, reptiles of diff. shapes/sizes dominate Earth
- Giant ferns (Pteridophytes) fell to form Coal deposits slowly
- Some land reptiles went back to Water → Evolved into Fish-like reptiles, Ichthyosaurs : 200 mya
- Land reptiles : Dinosaurs

- Biggest dinosaur : Tyranosaurus Rex [20 feet height, Huge, fearsome dagger like teeth]
- * 65 mya : Dinasaurs suddenly disappeared from Earth
  - → Climatic changes killed them (some say)
  - → Evolved into Birds (some say)
- Small-sized reptiles of that Era still exist today

↓

- 1ST mammals were like Shrews (Fossils small sized)
- Mammals → Viviparous, Protect unborn inside mothers body
  - → More intelligent in sensing & avoiding danger

↓

When Reptiles came down, Mammals took over Earth

↓

- South American mammals : resembling Horse, Hippopotamus, Bear, Rabbit etc.

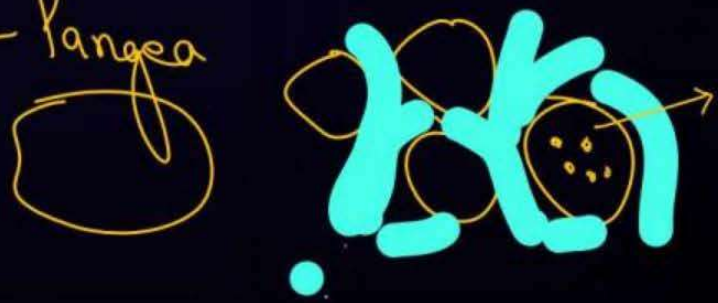
↓

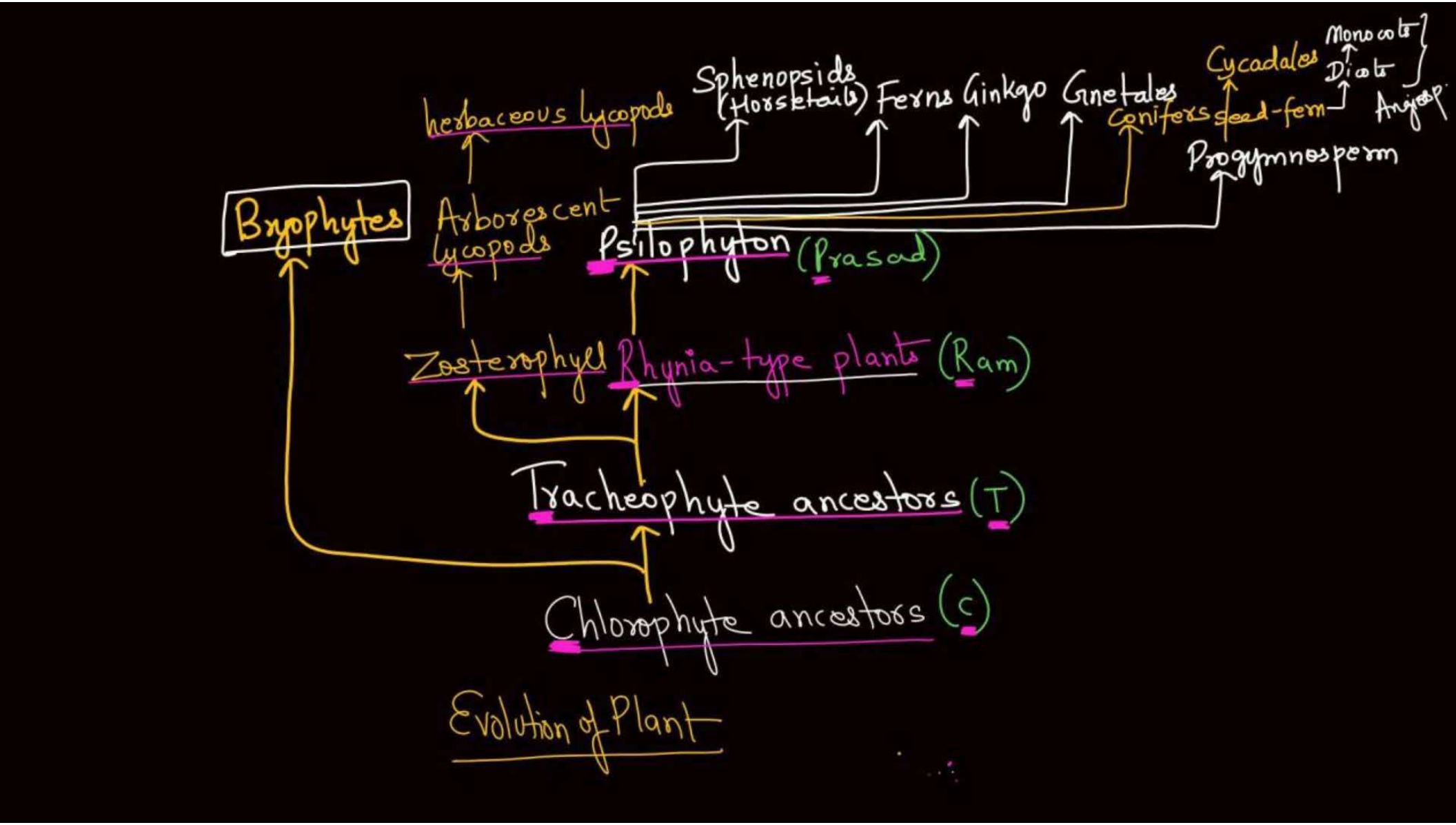
- Due to Continental Drift, when (a) S. America joined North America; these above animals were over-ridden by N. American fauna

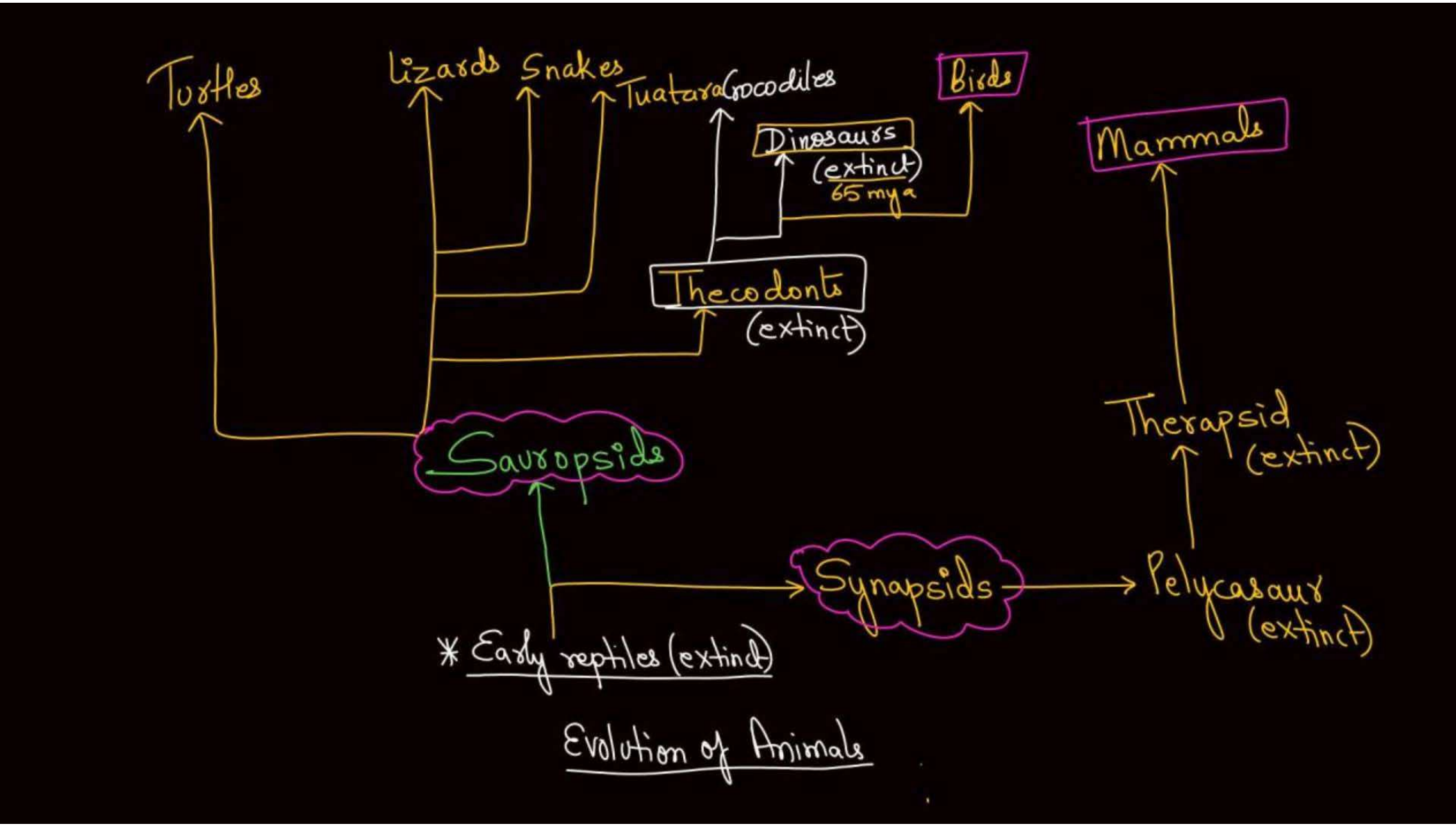
- (b) Pouched mammals of Australia survived as they lack competition from any other mammal (AR)

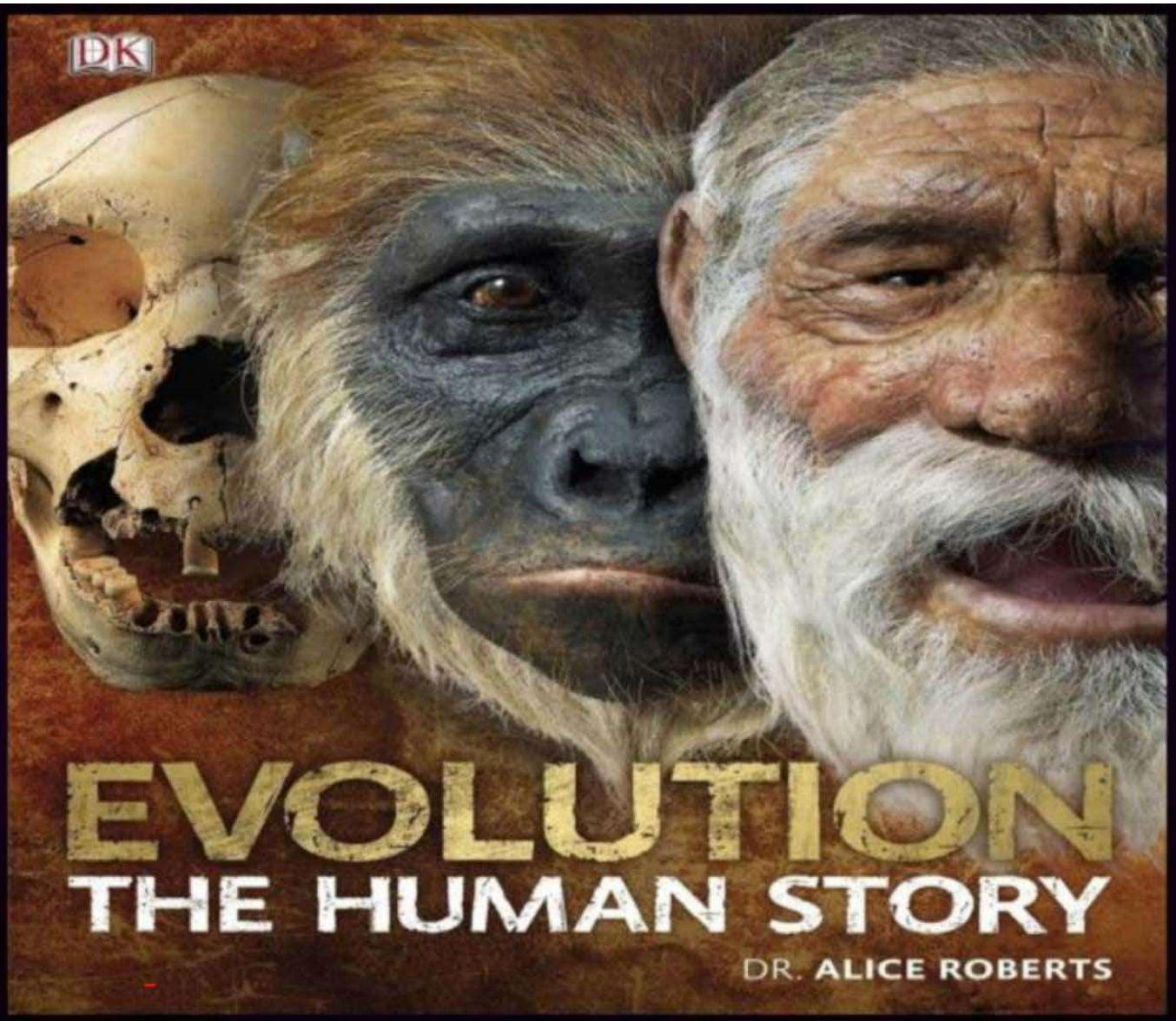
- Some mammals live Wholly in Water : Whale, Dolphins, Seals, Sea-cows

* Earlier, Single land :- Pangea




Bryophytes
herbaceous lycopods
Arborescent lycopods
Sphenopsids (Horsetails)
Ferns
Ginkgo
Gnetales
Conifers
Cycadales
seed-fern
Monocots
Dicots
Angiosp.
Progymnosperm
Psilophyton (Prasad)
Zosterophyll
Rhynia-type plants (Ram)
Tracheophyte ancestors (T)
Chlorophyte ancestors (C)
Evolution of Plant


Turtles
Lizards
Snakes
Tuatara
Crocodiles
Birds
Dinosaurs
(extinct)
65 mya
Mammals
Thecodonts
(extinct)
Therapsid
(extinct)
Sauropsids
Synapsids
Pelycosaur
(extinct)
* Early reptiles (extinct)
Evolution of Animals


DK
EVOLUTION
THE HUMAN STORY
DR. ALICE ROBERTS

* Humans → Mammals → Primata → Man/Human (closest), Apes: Chimpanzee, Gorilla; Monkeys

- Most significant ⟹ ↑ in brain capacity (Cranial)

Dryopethicus (More Ape-like) & Ramapethicus (More Man-like) 15 mya

- Modern Man 1350-1400 cc
- Cromagnon Man 1600-1650 cc

1400 cc (1 lac - 40,000 yr)

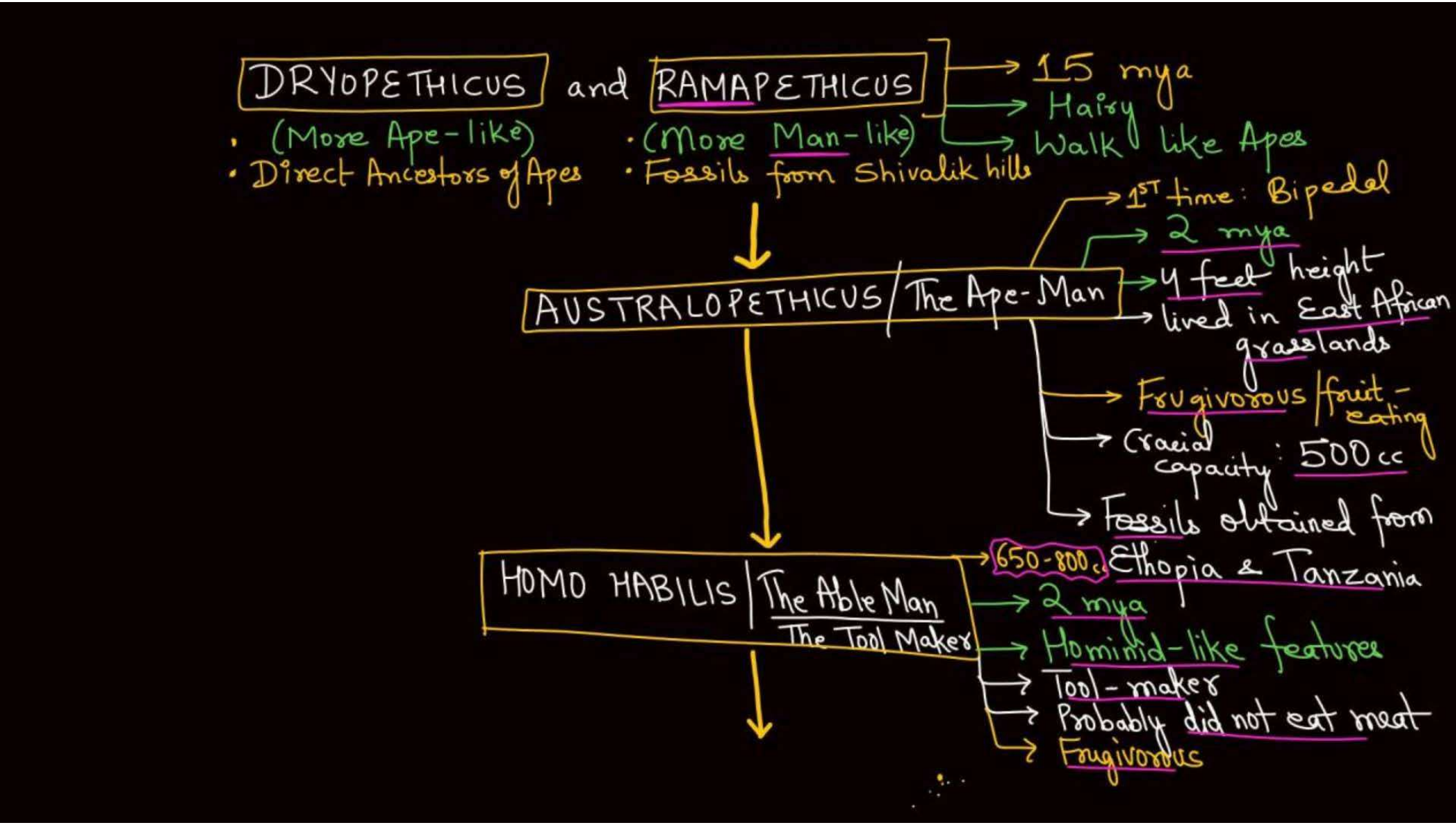
- Neanderthal Man

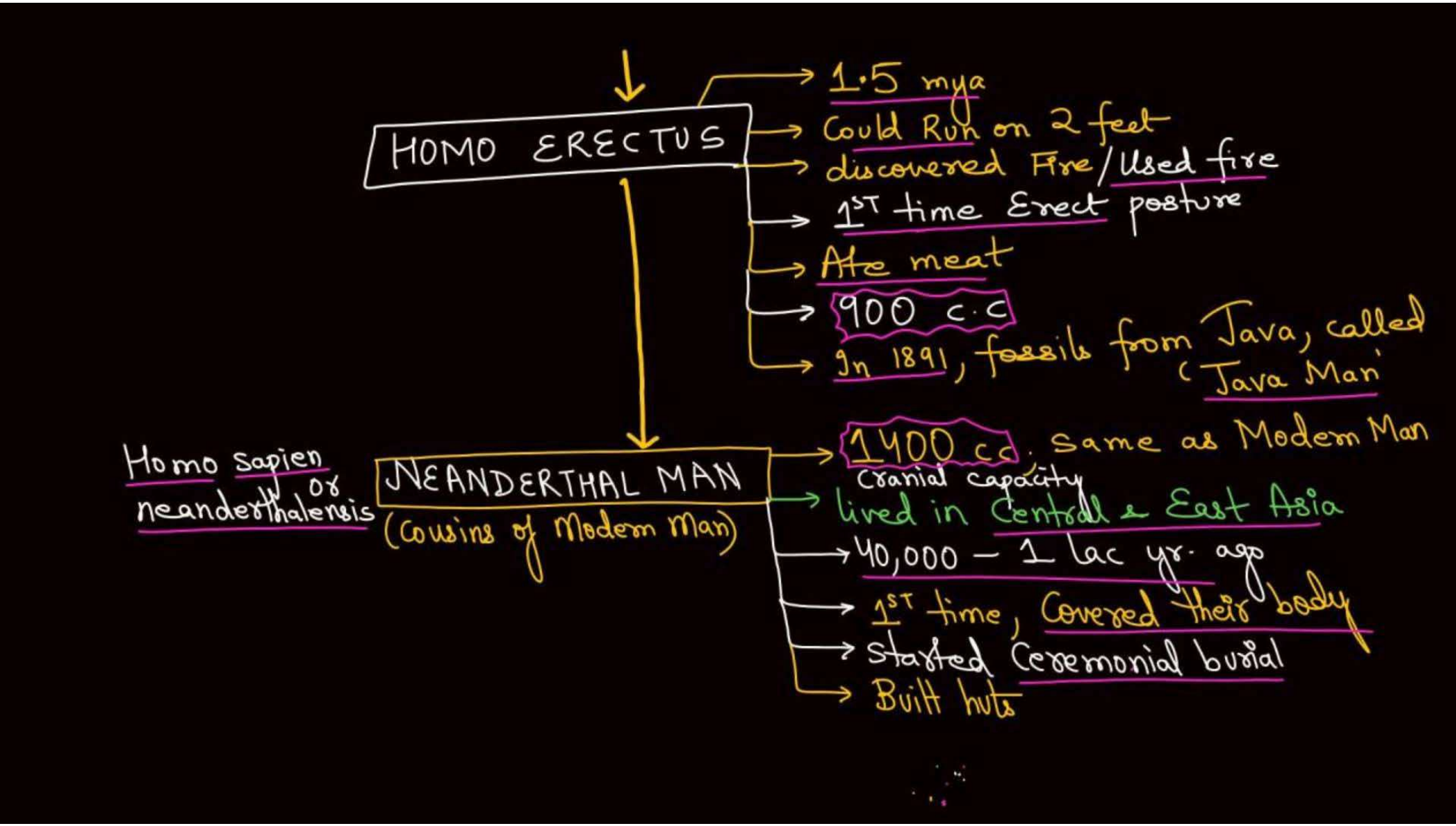
Ramapethicus → Australopethicus 2 mya (C.C = 500 cc)

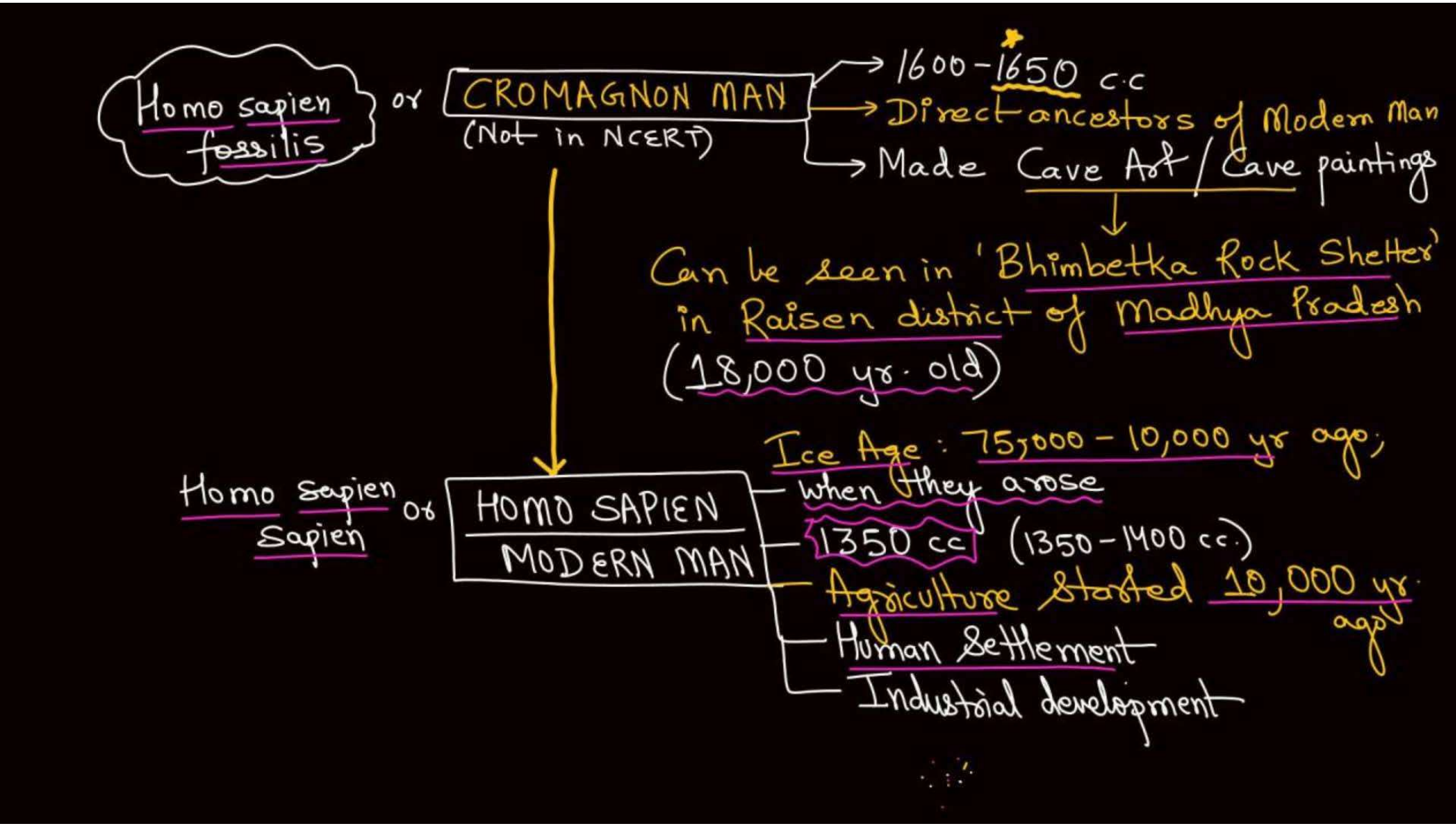
Australopethicus → Homo habilis/Tool maker 650 cc 2 mya

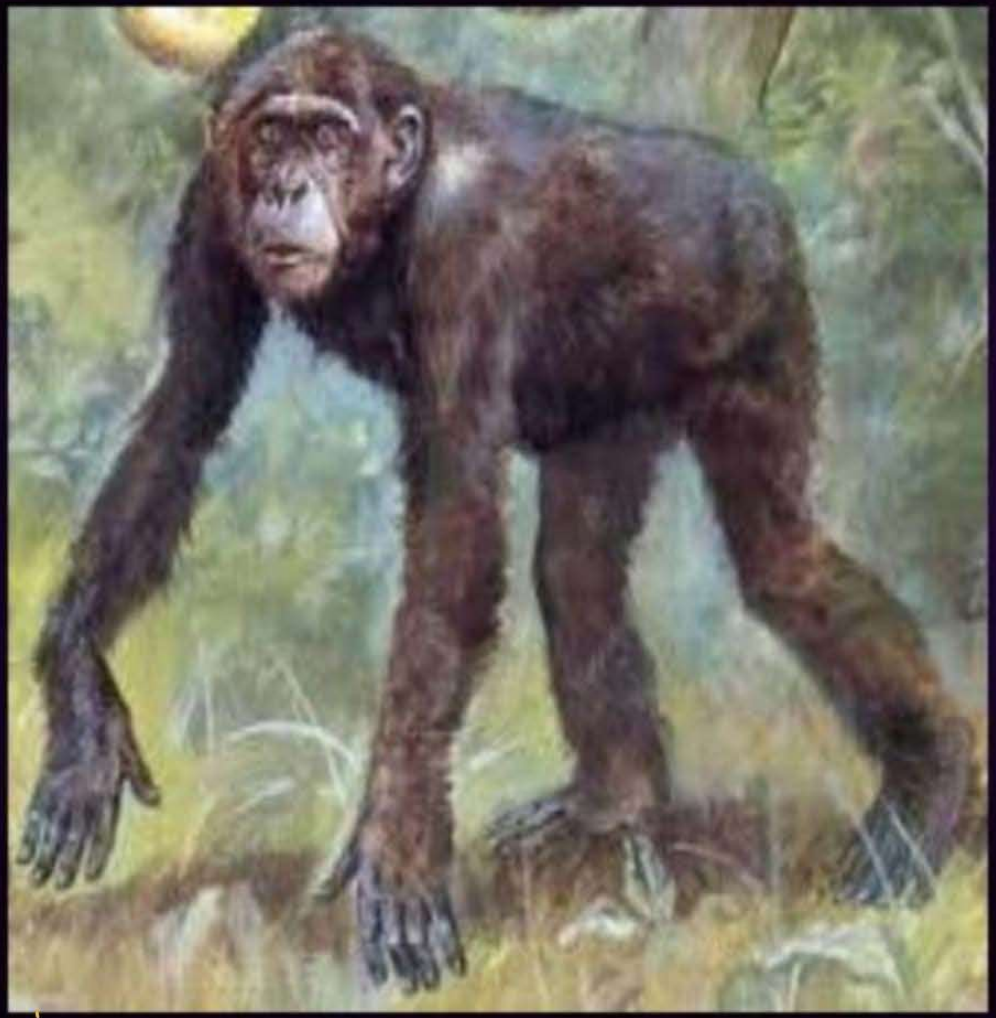
Homo habilis → Homo erectus (Java Man) 900 cc 1.5 mya

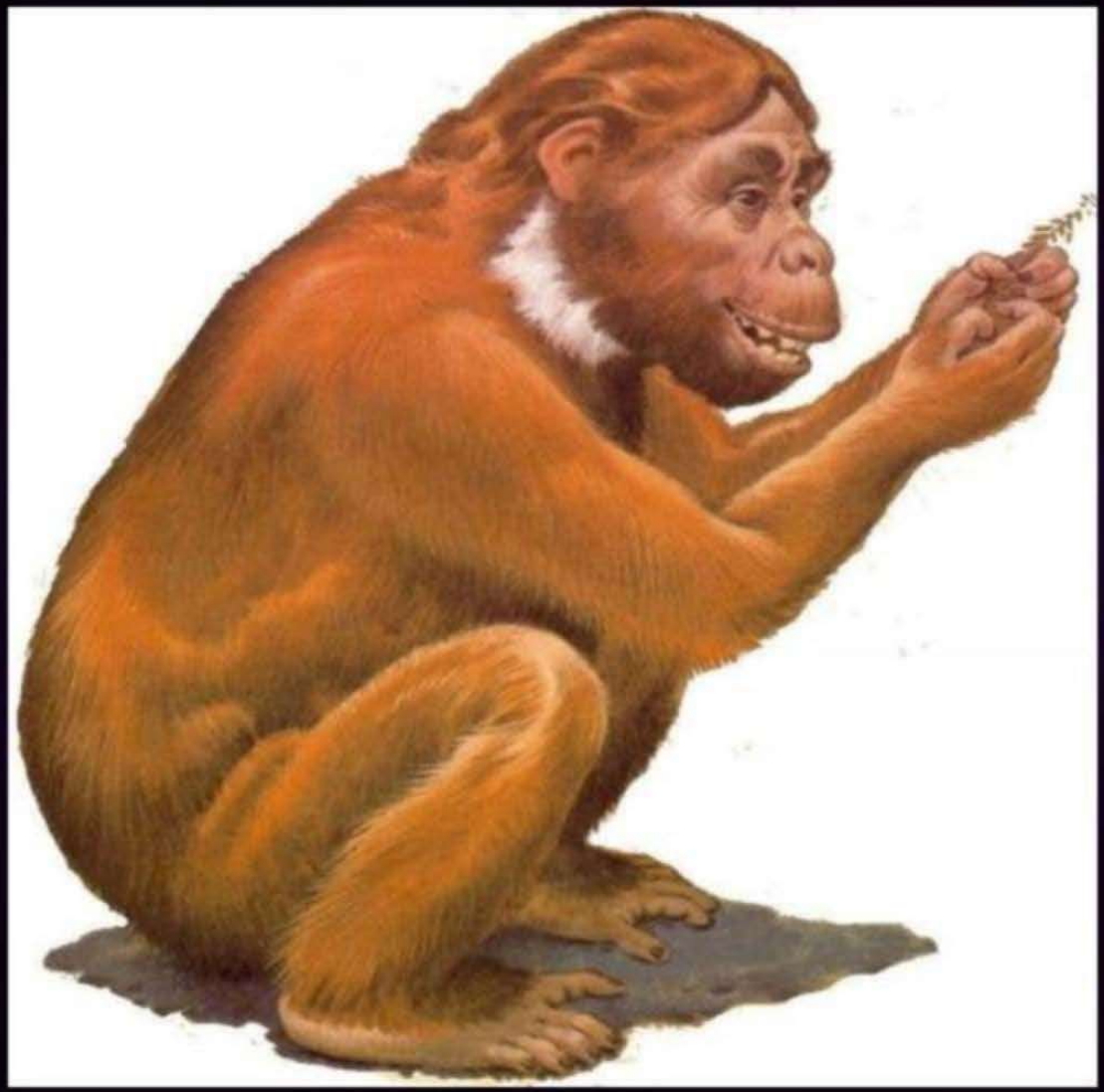
Homo erectus → Neanderthal Man

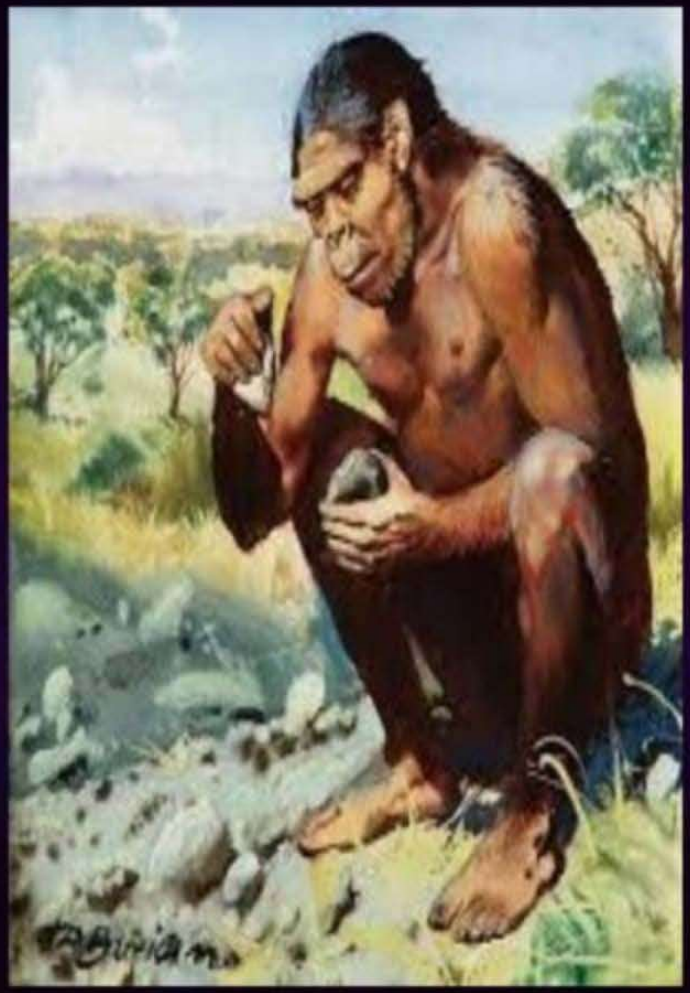

DRYOPETHICUS and RAMAPETHICUS
15 mya
Hairy
Walk like Apes
(More Ape-like)
Direct Ancestors of Apes
(More Man-like)
Fossils from Shivalik hills
AUSTRALOPETHICUS / The Ape-Man
1ST time: Bipedal
2 mya
4 feet height
lived in East African grasslands
Frugivorous / fruit-eating
Cranial capacity: 500 cc
Fossils obtained from Ethopia & Tanzania
HOMO HABILIS / The Able Man / The Tool Maker
650-800 cc
2 mya
Hominid-like features
Tool-maker
Probably did not eat meat
Frugivorous


HOMO ERECTUS
1.5 mya
Could Run on 2 feet
discovered Fire / Used fire
1ST time Erect posture
Ate meat
900 c.c
In 1891, fossils from Java, called 'Java Man'
Homo Sapien neanderthalensis
NEANDERTHAL MAN
(Cousins of Modern Man)
1400 cc. Same as Modern Man
Cranial capacity
lived in Central & East Asia
40,000 – 1 lac yr. ago
1ST time, Covered their body
Started Ceremonial burial
Built huts

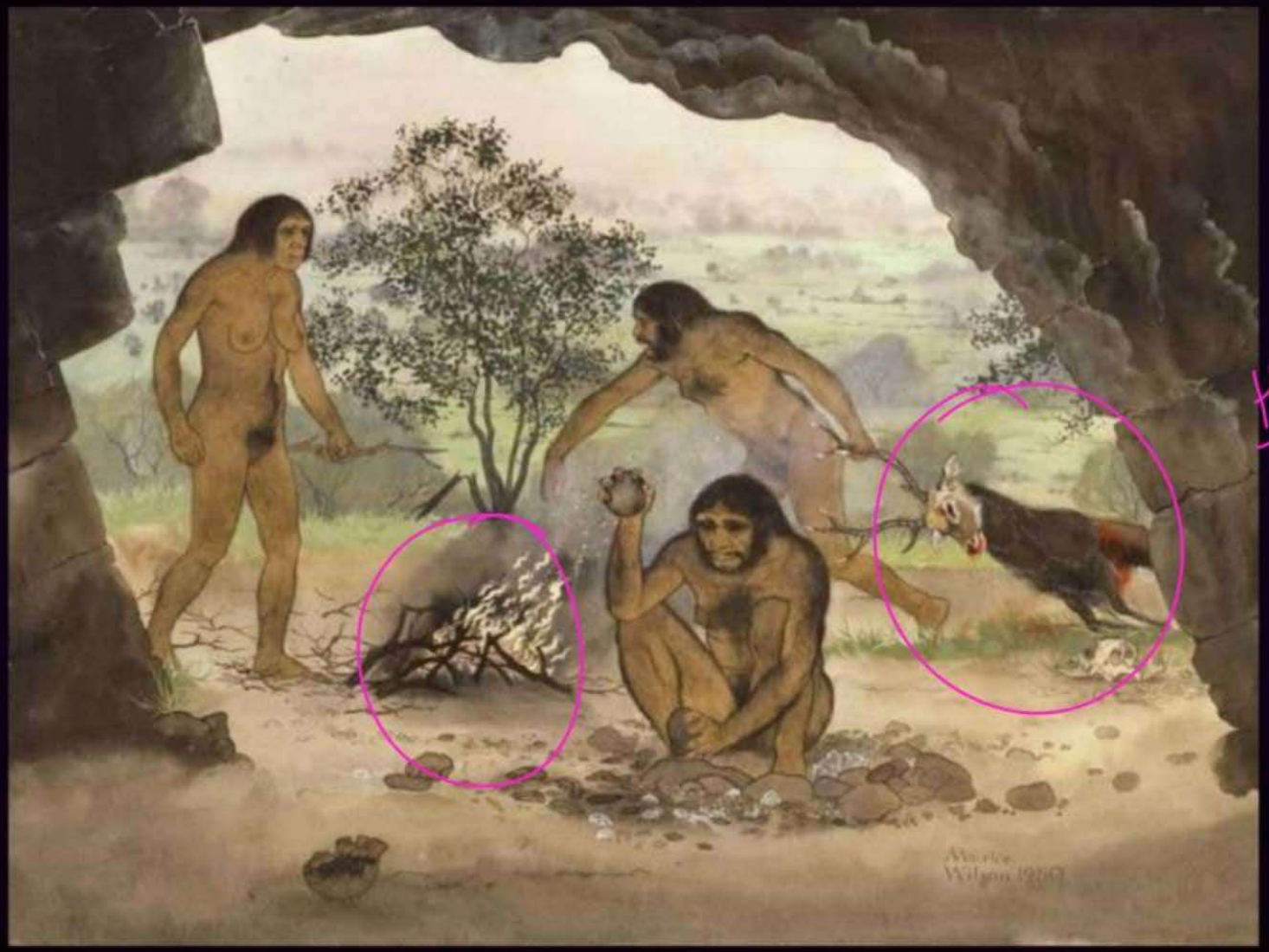

Homo sapien fossilis
or
CROMAGNON MAN
(Not in NCERT)
1600-1650 c.c
Direct ancestors of Modern Man
Made Cave Art / Cave paintings
Can be seen in 'Bhimbetka Rock Shelter' in Raisen district of Madhya Pradesh (18,000 yr. old)
Homo Sapien Sapien
or
HOMO SAPIEN
MODERN MAN
Ice Age : 75,000 - 10,000 yr ago; when they arose
1350 cc (1350-1400 cc)
Agriculture started 10,000 yr ago
Human Settlement
Industrial development



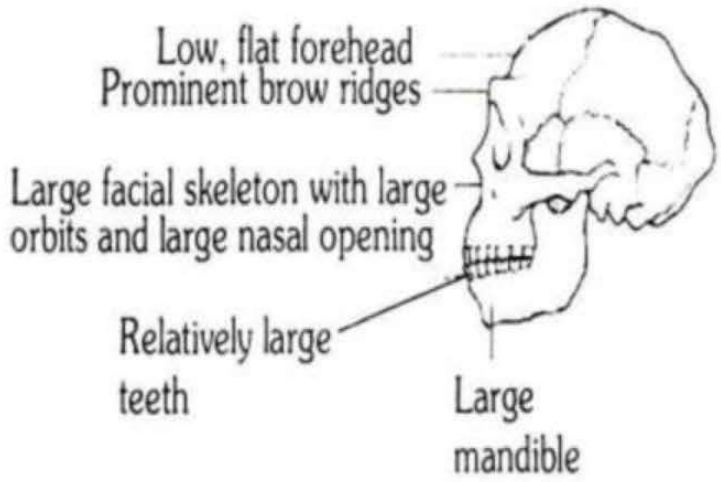


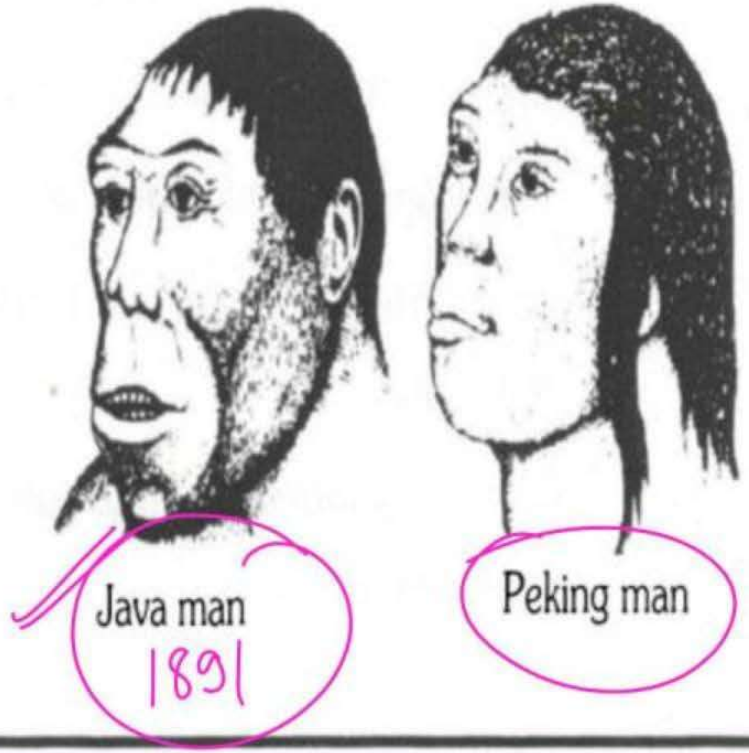


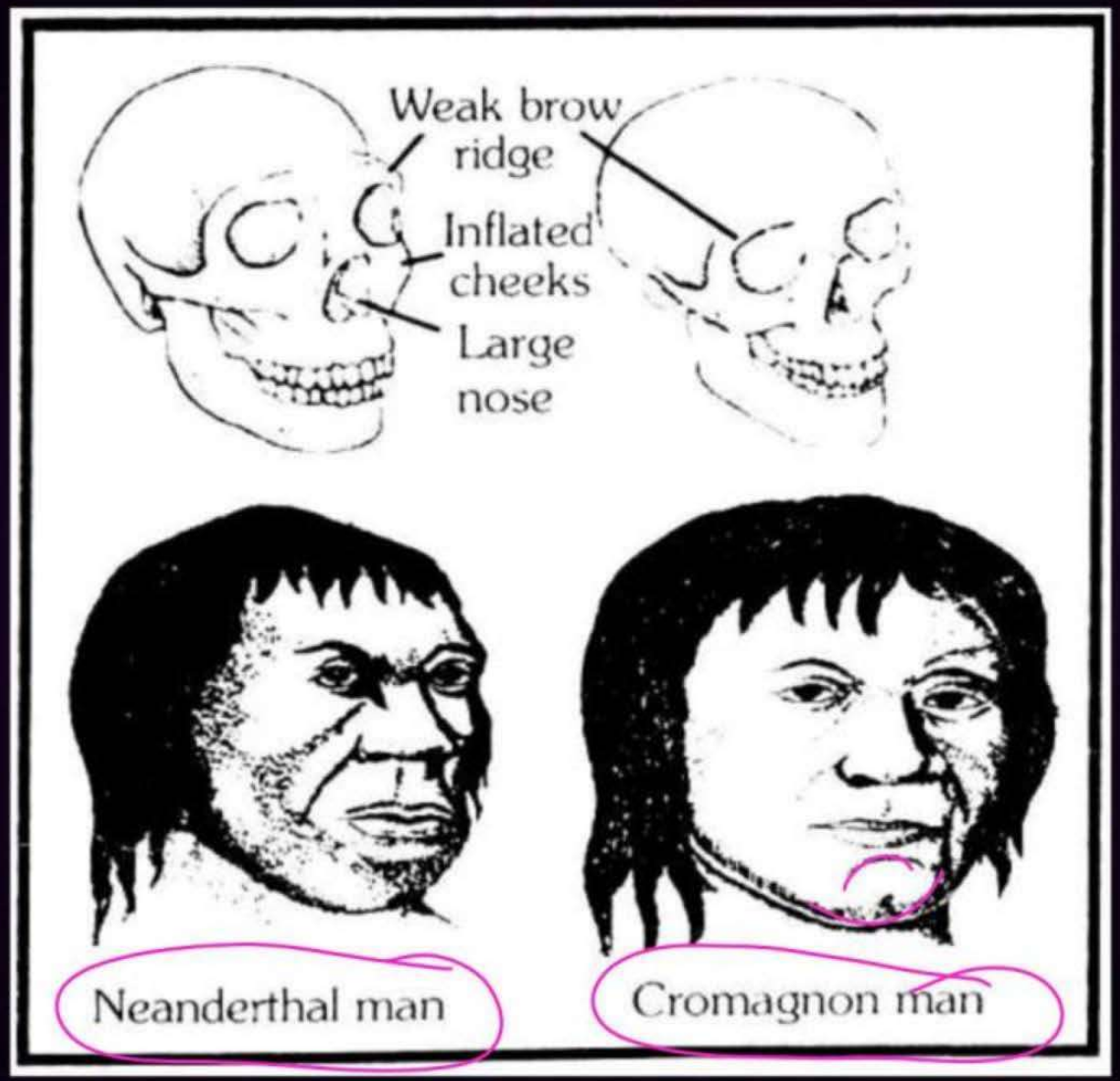
H. habilis

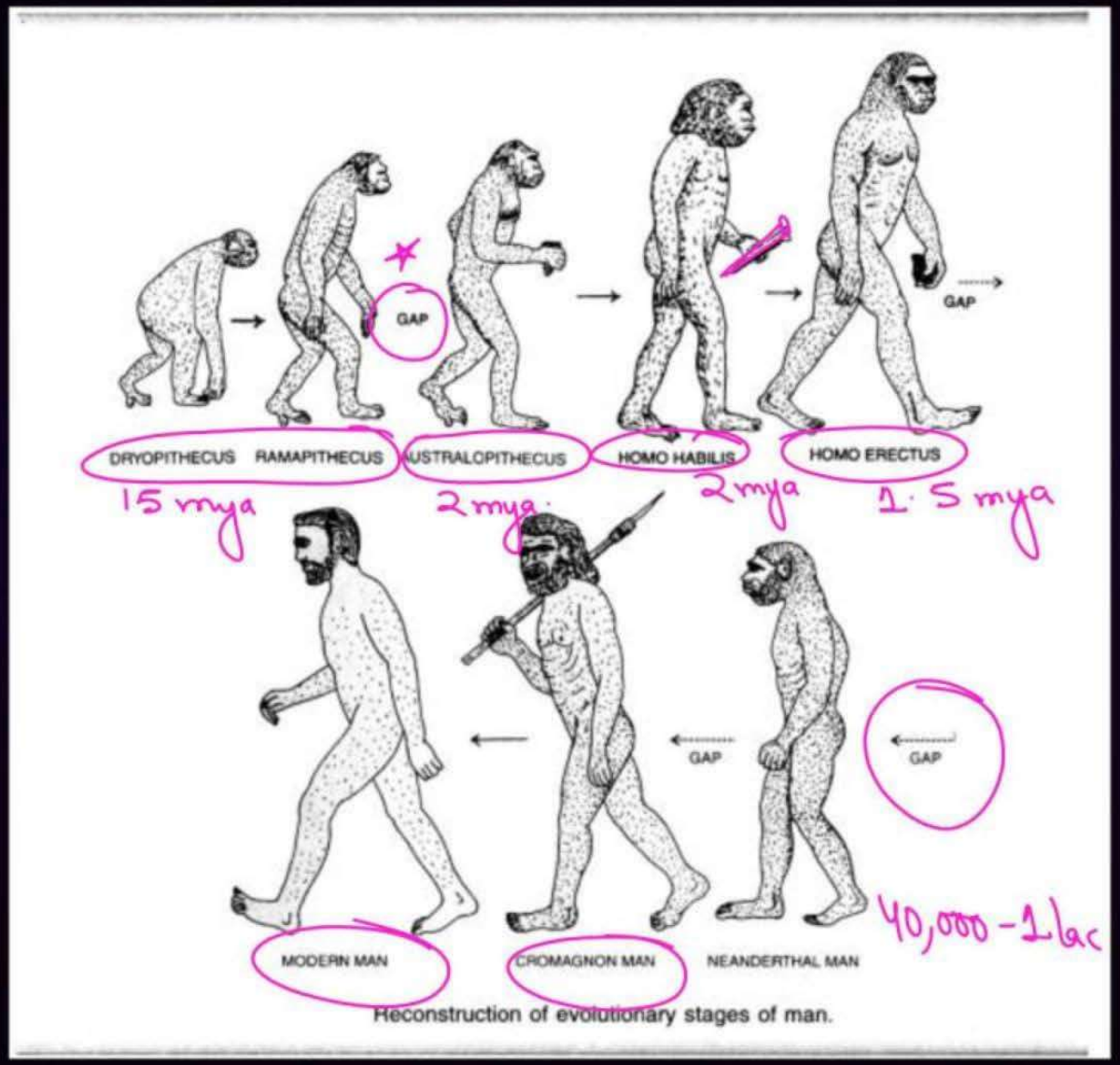


H. erectus


Low, flat forehead
Prominent brow ridges
Large facial skeleton with large orbits and large nasal opening
Relatively large teeth
Large mandible


Java man
1891
Peking man


Weak brow ridge
Inflated cheeks
Large nose
Neanderthal man
Cromagnon man



Reconstruction of evolutionary stages of man.

Trick for Human Evolution :-

Miocene

Dr. Appu — 15 mya — Ramapecithus (man-like)

Ram is

Dryopethicus

- Direct Ancestor of modern Ape
- Common Ancestor of Man and Ape
- Ape-like

Pliocene

Austrialia's — Australopecithus — 2 mya

Best, — Bipedal

His Heart — Homo Habilis

Trans plant — Tools (Stones) — Frugivorous

EFFORTS are

Erectus — Fire — Run — Tools

Omnivorous

Nice, — (Cave/clothing/ Ceremonial burial) — Neanderthal

- C.C same as H.Sapiens

Creative & — Cromagnon — 18000 yr.

- Cave paintings
- Ornaments
- C.C largest (1650 C.C)
- Orthognathus
- Direct-ancestor of modern man

Superb — Sapiens

- Most intelligent
- Agriculture (10,000 yr. ago)

H.W

1] Universe → 20 BYA
2] Earth → 4.5 BYA
3] Life appeared on Earth — after 500 million yr — 4 BYA
4] 1ST Non-cellular life form — 3 BYA
5] 1ST Cellular " " — 2 BYA (2000 MYA)
6] Invertebrates — 500 MYA
7] Jawless fishes — 350 mya
8] Fish with stout & strong fins — 350 mya
9] Sea weeds & few plants — 320 MYA
10] Coelocanth — South Africa — 1938
11] Fish-like Reptiles (eg. Ichthyosaurs) — 200 mya
12] Dinosaurs extinct — 65 MYA
13] Dryo / Ramapithecus — 15 mya — East African grass
14] Australopithecus — 2 mya
15] Homo habilis — 650-800 cc
16] Java Man — 1891 — H. erectus 900 cc
17] Neanderthal man — 1 lac to 40,000 yr → 1400 cc, East & Central Asia
18] Ice age → 75000-10,000 yr ago — Modern H. sapiens arose
19] Cave art → 18,000 yr ago
20] Agriculture → 10,000 yr ago
21] Aquatic mamals → Whale, Dolphins, Seals, Sea cow

22) Louis Pasteur —— dismissed Spontaneous gen. theory

23) Oparin & Haldane —— Chem. Evolution theory
(Russia) (England)

24) S.L. Miller — 1953 —— Spark discharge expert.

25) Darwin —— Galapagos Island — HMS Beagle — Natural Selection

26) Alfred Wallace — Malay Archipelago

27) Thomas Malthus — Essay on Population, Influenced Darwin

28) Ernst Haeckel — Embryological Support

29) Karl Ernst Von Baer — Disapproved " "

30) Industrial Melanism — England → 1850s White > Black
eg. of N. selection → 1920s Black > White

31) Adaptive Radiation → Darwin finches
→ Australian Marsupials

32) Convergent Evolution → Australian Marsupials
→ " Placental mammals

33) Lamarck — French — Th. of Use & disuse of Organs
Acquired Inheritance

34) Hugo-de-Vries — Mutation / Saltation Theory

35) Hardy-Weinberg Principle → $p+q=1$
→ $p^2+2pq+q^2=1$

36) Sewall Wright — Genetic drift

37) Homologous Organs
① Forelimbs of Mammals
② Vertebrate Hearts
③ " Brains
④ Thorn of Bougainvillea & Tendril of Cucurbita

38) Analogous Organs
① Wings of Butterfly & Birds
② Sweet potato & Potato
③ Eye of Octopus & Mammals
④ Flippers of Penguin & Dolphins

39) 5 factors affect Hardy Weinb. equil.
a) Gen-drift
b) Gen. recomb
c) Gene flow
d) Mutation
e) Natural Selection