Ch 6 · Evolution

अध्याय 6 · विकास

Class 12 Biology · NCERT based · English + हिंदी · ✍️ revision notes

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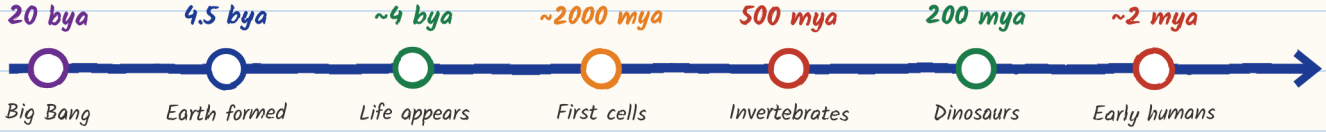
Timeline of life · जीवन की समय-रेखा (approx.)



bya = billion years ago (अरब वर्ष पूर्व) · mya = million years ago (करोड़/दस लाख वर्ष पूर्व)

Infographic: Major events in history of life

1. Origin of Life / जीवन की उत्पत्ति

- **Big Bang theory** – universe originated by a huge explosion ~ 20 billion years ago. Universe expanded, temperature fell → hydrogen & helium formed → condensed into galaxies.
- **Earth** formed about 4.5 billion years back. No atmosphere initially; water vapour, **methane, CO_2, ammonia** released from molten mass covered the surface.
- **UV rays** from sun broke water into **H_2 & O_2**; lighter H_2 escaped. O_2 combined with NH_3 & CH_4 → water, CO_2 etc. **Ozone layer** formed. Earth cooled → water vapour fell as rain → **oceans**.
- Life appeared **500 million years** after formation of earth, i.e., almost 4 billion years back.

Theories of origin of life जीवन की उत्पत्ति के सिद्धांत

Theory	Idea
Panspermia (पैनस्पर्मिया)	Units of life called **spores** came from outer space (early Greek thinkers). Some astronomers still believe it.
Spontaneous generation (स्वतः जनन)	Life came from **decaying & rotting matter** like straw, mud. Disproved by Louis Pasteur.
Chemical evolution (रासायनिक विकास) Oparin (Russia) & Haldane (England)	First form of life came from **pre-existing non-living organic molecules** (RNA, protein, etc.), followed by chemical evolution under conditions of high temperature, volcanic storms & **reducing atmosphere** (CH_4, NH_3).

📌 **Louis Pasteur's experiment:** In **pre-sterilised flasks**, life did not come from killed yeast; in another flask **open to air**, new living organisms arose from killed yeast → "Life comes only from pre-existing life" → spontaneous generation dismissed.

Miller's experiment (1953) मिलर का प्रयोग

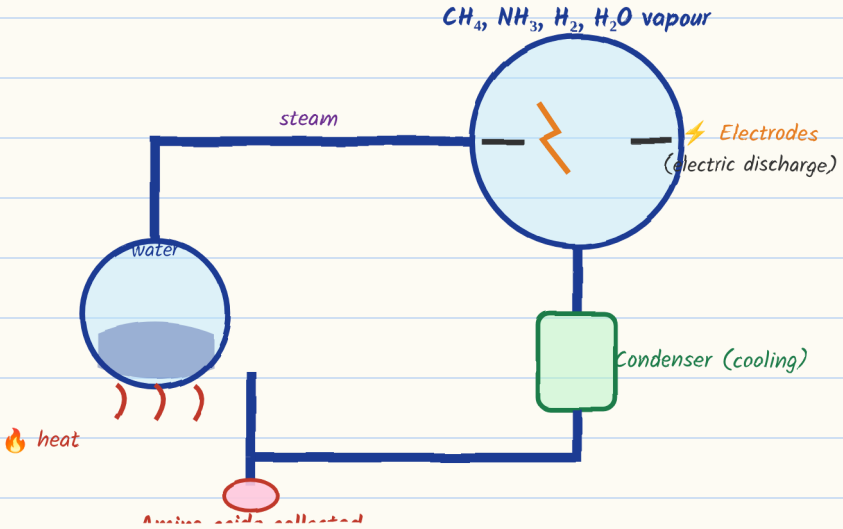


Fig: Miller's experiment (schematic) · मिलर का प्रयोग

- **S.L. Miller** (American scientist, 1953) created similar conditions on a laboratory scale.
- Electric discharge in a **closed flask** containing CH_4, H_2, NH_3 and water vapour at 800 °C.
- Observed formation of amino acids. Others observed formation of **sugars, nitrogen bases, pigments & fats**.
- Analysis of **meteorite** content also revealed similar processes occurring elsewhere in space.
- → Supports **chemical evolution** (Oparin–Haldane).

First **non-cellular forms** of life could have originated **~3 billion years** back – giant molecules (RNA, protein, polysaccharides) that reproduced. First **cellular forms** did not originate till about **2000 million years** ago – probably single cells, in water.

📌 **Note:** Origin of life from non-living molecules = **abiogenesis** by chemical evolution; this is accepted by majority. But once formed, how first cellular forms evolved into complex biodiversity is the story of **biological evolution**.

2. Evolution of Life Forms – A Theory / जीव रूपों का विकास

(a) Theory of Special Creation विशेष सृष्टिवाद

Three connotations:

1. All living organisms (species) that we see today were **created as such**.
2. Diversity was **always the same** since creation and will be the same in future.
3. Earth is about **4000 years old**.

All these ideas were strongly challenged during the 19th century.

(b) Darwin's observations डार्विन के अवलोकन

- **Charles Darwin** – sea voyage round the world in the ship H.M.S. Beagle.
- Concluded: existing living forms share similarities among themselves and also with life forms that existed millions of years ago. Many life forms became extinct; new forms arose over the years.
- Gradual evolution of life forms. Any population has built-in **variation** in characteristics. Those characters that enable some to survive better in natural conditions would outbreed others = "survival of the fittest".
- **Fitness** (Darwin) = reproductive fitness – those better fit in an environment leave more progeny. They are **selected by nature** = **natural selection**.
- **Alfred Wallace** (naturalist who worked in **Malay Archipelago**) also came to similar conclusions around the same time.

3. Evidences for Evolution / विकास के प्रमाण

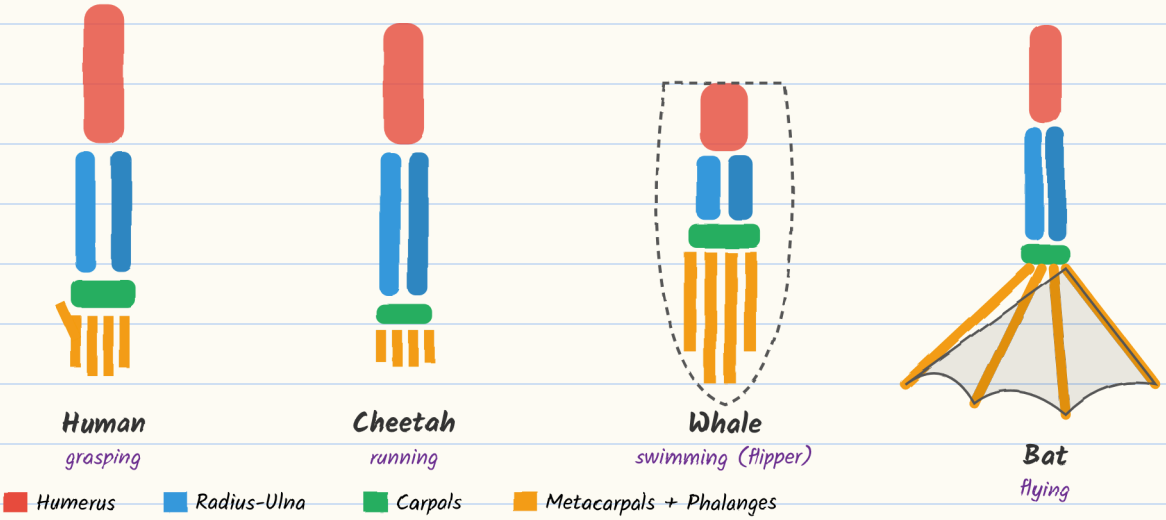
(a) Paleontological evidence – Fossils जीवाश्म

- **Fossils** = remains of hard parts of life forms found in rocks.
- Rocks form sediments; a cross-section of earth's crust shows **arrangement of sediments one over the other** during long history of earth.
- Different-aged rock sediments contain different life forms – probably died during formation of that sediment. Some represent extinct organisms (e.g. **dinosaurs**).

- Study of fossils in different sedimentary layers indicates the geological period in which they existed → life forms **varied over time**; certain forms are restricted to certain geological time-spans.
- Age determined by **radioactive dating**.

(b) Comparative anatomy & morphology तुलनात्मक शारीरिकी व आकारिकी

Homologous forelimbs – same bones, different functions · समजात अग्रपाद



Infographic: Homologous organs – divergent evolution · अपसारी विकास

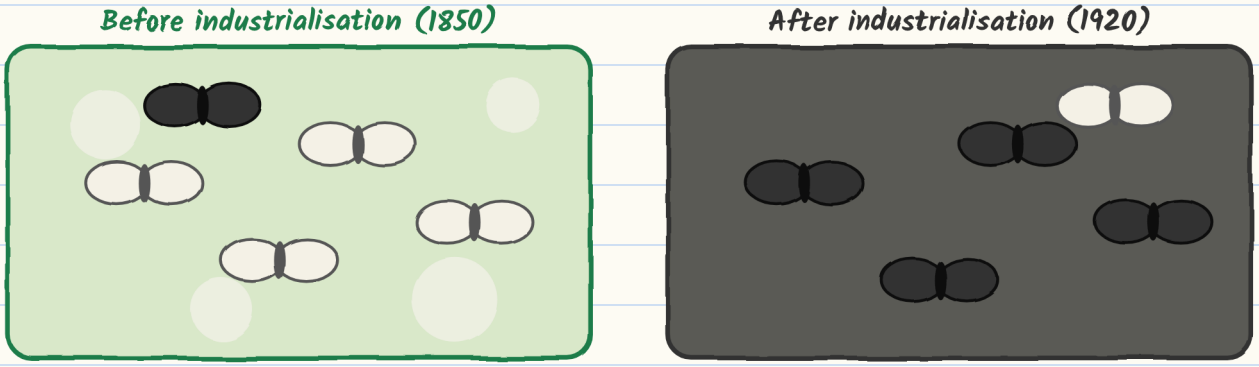
Homologous organs (समजात अंग)	Analogous organs (समरूप अंग)
Same structure/origin, different functions	**Different structure/origin**, same function
Indicate common ancestry	**Not** common ancestry; result of similar habitat
Divergent evolution (अपसारी विकास)	Convergent evolution (अभिसारी विकास)
· Forelimbs of **whales, bats, cheetah, human** (humerus, radius, ulna, carpals, metacarpals, phalanges) · **Heart** of vertebrates · **Brain** of vertebrates · **Thorn of Bougainvillea** & **tendril of Cucurbita** (plants)	· **Wings of butterfly & birds** · **Eye of octopus & mammals** · **Flippers of penguins & dolphins** · **Sweet potato** (root modification) & **potato** (stem modification)

📌 **Exam Tip:** Sweet potato (root) & potato (stem) = **analogous** – both store food, but different origin. Thorn of Bougainvillea & tendril of Cucurbita = **homologous** – both are modified axillary structures (stem origin), different functions. Very frequently asked!

(c) Biochemical similarities जैव रासायनिक समानताएँ

Similarities in **proteins & genes** performing a given function among diverse organisms give clues to **common ancestry**.

(d) Natural selection in action – Industrial melanism औद्योगिक अतिकृष्णता



Infographic: Industrial melanism in England (peppered moth) · औद्योगिक अतिकृष्णता

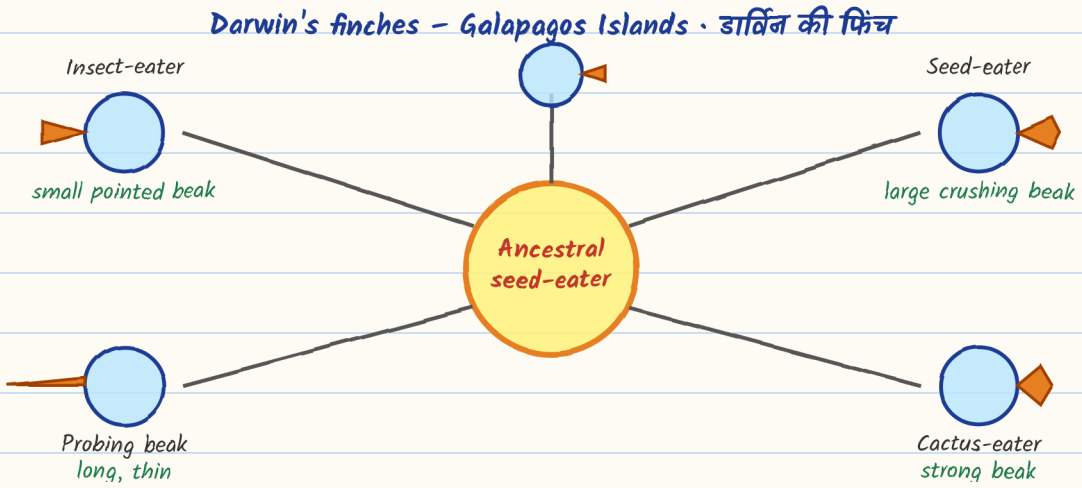
- In England, collection of moths made in **1850s** (before industrialisation) showed **more white-winged** moths on trees than dark-winged. In collection made in **1920** (after industrialisation), there were **more dark-winged** moths in the same area.
- **Explanation**: after industrialisation, tree trunks became dark due to industrial smoke & soot → white moths could not camouflage → picked by **predators**; dark moths survived.
- Before industrialisation, thick growth of almost white-coloured **lichens** covered trees → white moths survived; dark moths picked by predators.
- Lichens can be used as industrial pollution indicators – they don't grow in polluted areas.
- In rural areas (no industrialisation) count of melanic moths was low → **in a mixed population, those better adapted survive & increase**. No variant is completely wiped out.

(e) Anthropogenic action & artificial selection मानवजनित क्रिया

- Excess use of **herbicides, pesticides** → selection of resistant varieties in much shorter time scale.
- Microbes against which we use **antibiotics or drugs** → resistant organisms/cells appear in a time scale of **months or years**, not centuries.
- These are examples of **evolution by anthropogenic action**. Evolution is a stochastic process based on chance events in nature & chance mutation.
- **Artificial selection**: breeding of animals/plants for desired traits, e.g. many varieties of **dogs** – shows evolution can happen in short time.

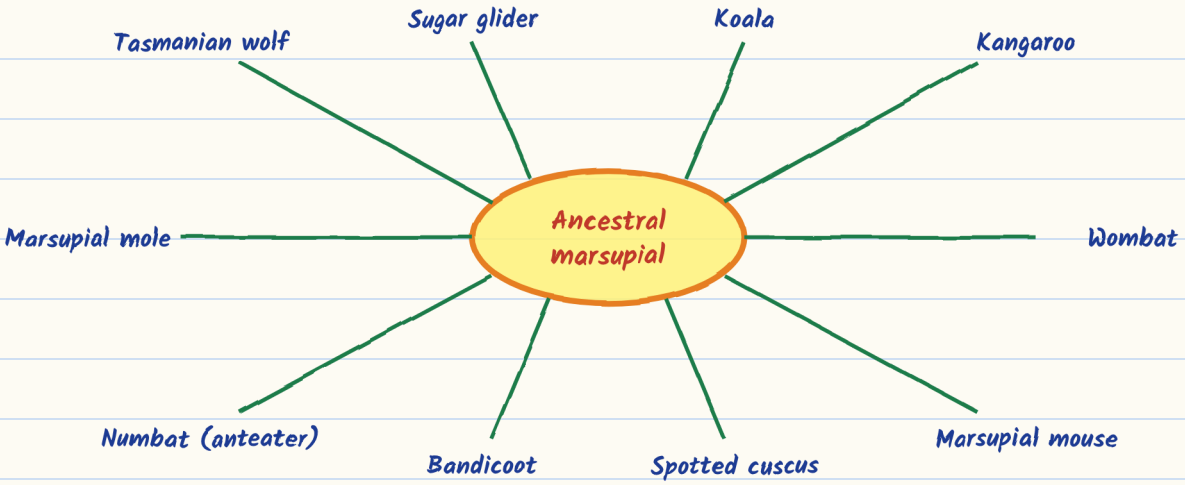
4. Adaptive Radiation / अनुकूली विकिरण

Process of evolution of ***different species in a given geographical area*** *starting from a point and literally radiating to other areas of geography (habitats).*



Infographic: Adaptive radiation in Darwin's finches (beak varieties)

- ***Darwin's finches*** *– Galapagos Islands. From original* ***seed-eating*** *features, many other forms arose with altered beaks →* ***insectivorous*** *and* ***vegetarian*** *finches.*
- ***Australian marsupials*** *– a number of marsupials, each different from the other, evolved from an* ***ancestral stock****, all within the Australian island continent.*
- *When more than one adaptive radiation appears in an isolated geographical area (different habitats) →* convergent evolution*. e.g.* ***placental mammals*** *in Australia also show adaptive radiation into varieties, each appearing similar to a corresponding marsupial.*



Infographic: Adaptive radiation of marsupials in Australia · ऑस्ट्रेलियाई शिशुधानी प्राणी

Placental mammal	Similar Australian marsupial
Mole	Marsupial mole
Anteater	Numbat (banded anteater)
Mouse	Marsupial mouse
Lemur	Spotted cuscus
Flying squirrel	Flying phalanger
Bobcat	Tasmanian tiger cat
Wolf	Tasmanian wolf

Placental vs marsupial pairs = convergent evolution · अभिसारी विकास

5. Biological Evolution & its Mechanism / जैव विकास व क्रियाविधि

- Evolution by natural selection really started when cellular forms of life with differences in metabolic capability originated on earth.
- Essence of Darwinian theory = natural selection. Rate of appearance of new forms is linked to life cycle or life span.
- Microbes divide fast → millions of individuals within hours. A colony of bacteria (A) on a medium; if medium composition changes, only a part of population (B) that can survive will grow → in due course B outnumbers A. Nature selects for fitness.
- **Fitness** is based on characteristics which are **inherited** → must have genetic basis for getting selected & evolve.
- Two key concepts of Darwinian theory: branching descent & natural selection.

📌 **Lamarck (लैमार्क)**: Evolution of life forms occurred by **use and disuse of organs** (inheritance of acquired characters). Example: **giraffes** – stretching necks to forage leaves on tall trees → elongated necks passed on to progeny → gradually long necks. Nobody believes this conjecture any more.

Mechanism of evolution विकास की क्रियाविधि

- Mendel spoke of inheritable "factors" influencing phenotype; Darwin was silent on origin of variation.
- **Hugo de Vries**, based on work on evening primrose (*Oenothera lamarckiana*), brought forth the idea of **mutations** – large differences arising suddenly in a population.
- He believed **mutation causes evolution**, not the minor variations (heritable) that Darwin talked about.

- Single-step large mutation = **saltation** (सॉल्टेशन / उत्परिवर्तन छलांग).

Darwinian variations	de Vries mutations
Small	Large
Directional	**Random & directionless**
Gradual (slow) evolution	Speciation by **saltation** (single step)

Studies in population genetics later brought some clarity.

6. Hardy–Weinberg Principle / हार्डी-वेनबर्ग सिद्धांत

- In a given population, frequency of occurrence of alleles of a gene (or a locus) can be found. This frequency is supposed to remain **fixed** and even the same through generations.
- **Statement:** Allele frequencies in a population are stable and constant from generation to generation.
- Gene pool (total genes & their alleles in a population) remains constant = genetic equilibrium. Sum total of all allelic frequencies = 1.

Alleles A (frequency **p**) and a (frequency **q**): $p + q = 1$

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

p^2 = frequency of **AA** · $2pq$ = frequency of **Aa** · q^2 = frequency of **aa**

यह द्विपद व्यंजक (binomial expansion) है।

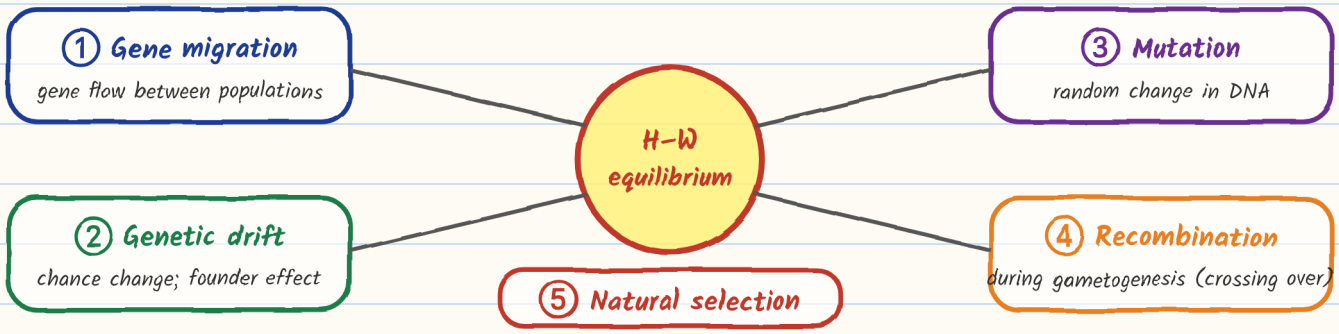
📌 **Numerical:** If frequency of recessive phenotype (aa) = 16% → $q^2 = 0.16$ → $q = 0.4$ → $p = 0.6$.

AA = $p^2 = 0.36$ (36%); Aa = $2pq = 0.48$ (48%); aa = 0.16 (16%). ✔ Total = 1.

When measured frequency differs from expected → **extent of evolutionary change**.

Disturbance in genetic equilibrium = **evolution**.

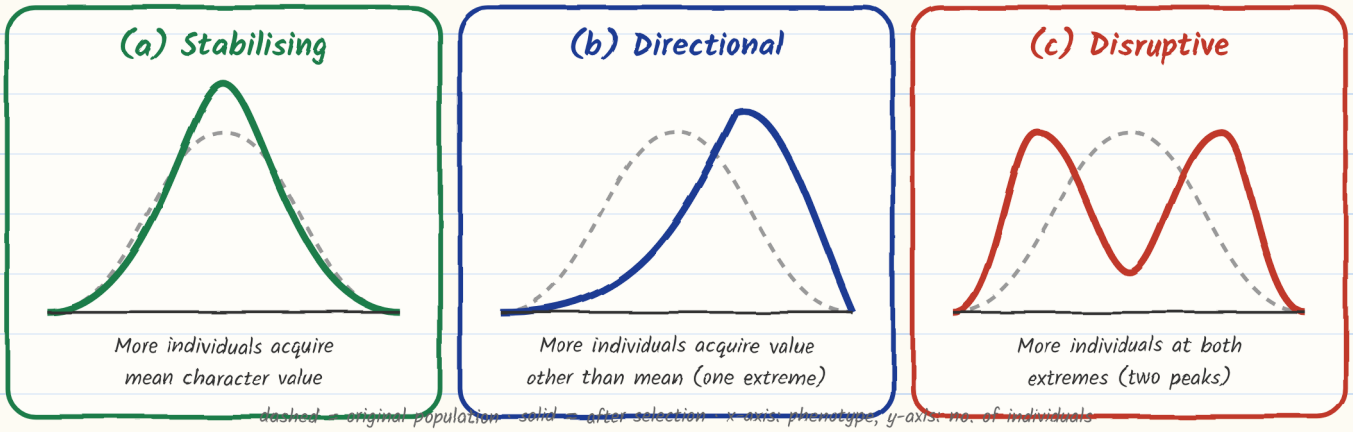
Factors affecting Hardy-Weinberg equilibrium संतुलन को प्रभावित करने वाले कारक



Infographic: 5 factors that disturb genetic equilibrium

- **Gene migration / gene flow** (जीन प्रवाह): when a section of population moves to another place, gene frequencies change in both original & new populations. New genes/alleles added. If migration happens multiple times = gene flow.
- **Genetic drift** (आनुवंशिक विचलन): same change occurring **by chance**. Sometimes change in allele frequency is so different in new sample that they become a different species; original drifted population becomes **founders** = founder effect.
- **Mutation**: pre-existing advantageous mutations selected → new phenotypes; over few generations → **speciation**.
- **Genetic recombination**: during gametogenesis → variations.
- **Natural selection**: heritable variations enabling better survival → more progeny.

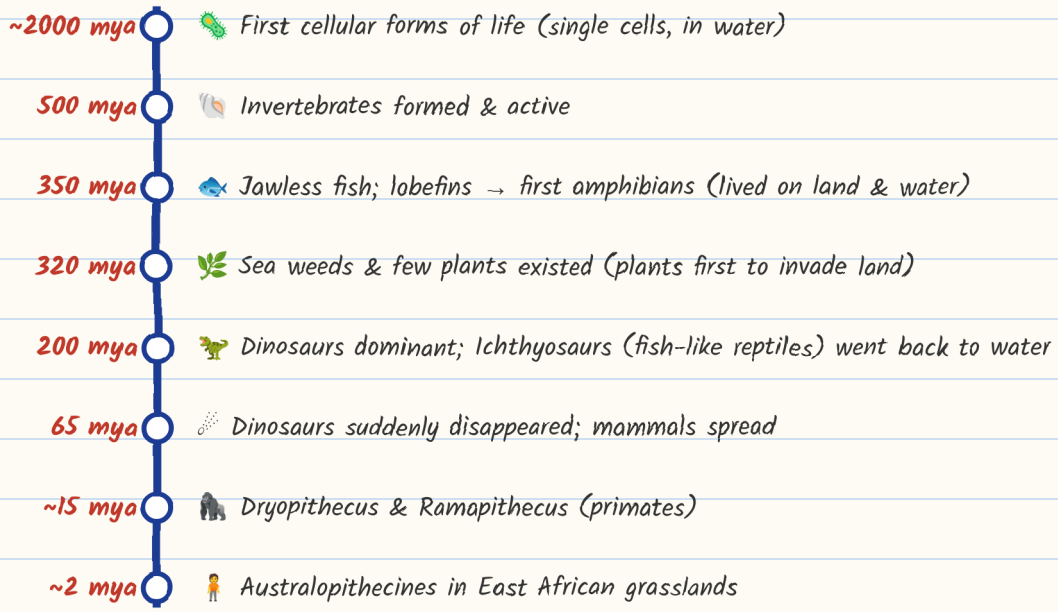
Types of natural selection प्राकृतिक वरण के प्रकार



Infographic: Operation of natural selection on different traits · स्थायीकारी, दिशात्मक, विदारक

- **Stabilising** (स्थायीकारी): more individuals acquire **mean** character value; peak gets higher & narrower.
- **Directional** (दिशात्मक): more individuals acquire value **other than the mean** character value; peak shifts in one direction.
- **Disruptive** (विदारक): more individuals acquire **peripheral** character value at **both ends**; two peaks form.

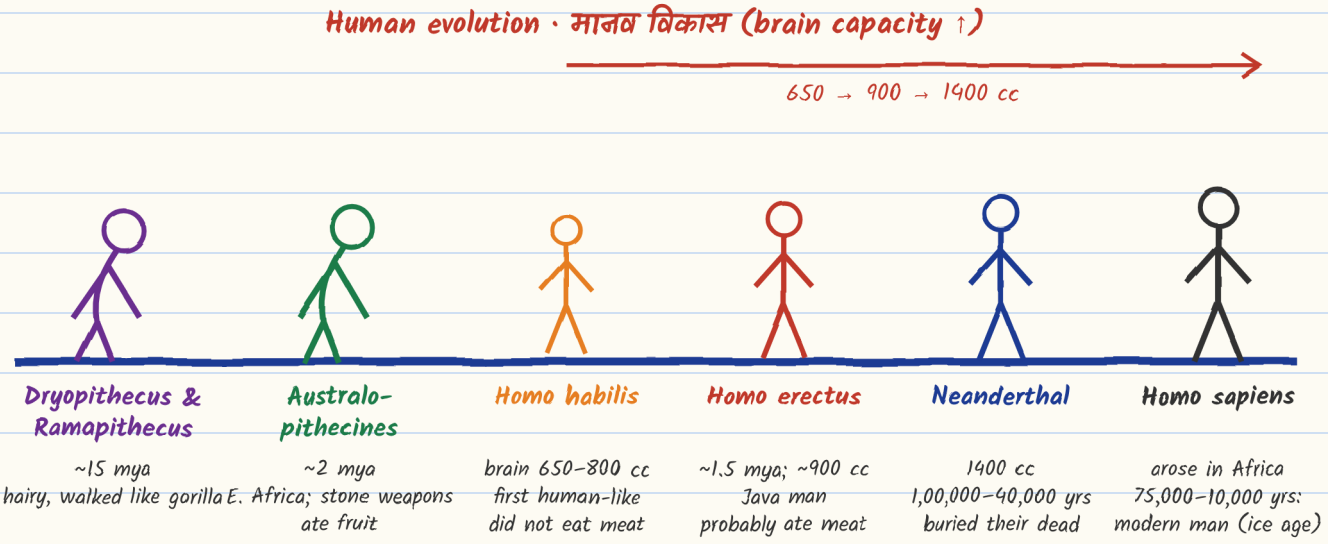
7. A Brief Account of Evolution / विकास का संक्षिप्त विवरण



Infographic: Geological timeline of evolution · भूवैज्ञानिक समय-रेखा

- **Lobefins** evolved into the first **amphibians** that lived on both land & water. **Coelacanth** – a lobefin caught in **South Africa in 1938**; it was thought to be extinct.
- Amphibians → **reptiles**: lay **thick-shelled eggs** which do not dry up in sun, unlike amphibian eggs.
- Giant ferns (pteridophytes) present but fell to form **coal deposits** slowly.
- **~200 mya**: some land reptiles went back into water → fish-like reptiles = **Ichthyosaurs**. Land reptiles = **dinosaurs**. Biggest: *Tyrannosaurus rex* – about **20 feet** high, huge fearsome dagger-like teeth.
- **~65 mya**: dinosaurs suddenly disappeared (climatic changes? evolved into birds? – true answer unknown).
- First mammals were like **shrews**; fossils are small-sized. Mammals were **viviparous**, protected unborn young inside mother's body; more intelligent in sensing & avoiding danger.
- Pangaea split → continents drifted. When South America joined North America, they were overridden by North American fauna.
- Due to **continental drift**, when Australia separated, **pouched mammals (marsupials) survived** because of **lack of competition** from other mammals.
- Mammals that went back to water: **whales, dolphins, seals, sea cows**.
- Plant evolution: **Psilophyton** → ferns, gymnosperms; **Chlorophyte ancestor** → bryophytes, pteridophytes, gymnosperms, angiosperms.
- Evolution of horse, elephant, dog, etc. are special stories of evolution.

8. Origin & Evolution of Man / मानव की उत्पत्ति व विकास



Infographic: Evolution of man · मानव का विकास

Stage	Time	Brain	Key features
Dryopithecus & Ramapithecus	~15 mya	—	Primates; hairy, walked like gorillas & chimpanzees. **Ramapithecus more man-like**; **Dryopithecus more ape-like**.
Australopithecines	~2 mya	—	East African grasslands; probably hunted with **stone weapons**, essentially ate **fruit**. Fossils of man-like bones discovered in Ethiopia & Tanzania.
Homo habilis	~2 mya	**650–800 cc**	First human-like being; probably **did not eat meat**.
Homo erectus	~1.5 mya	**~900 cc**	Fossils discovered in **Java (1891)** – "Java man"; probably **ate meat**.
Neanderthal man	1,00,000–40,000 yrs ago	**1400 cc**	Lived in **near east & central Asian** countries; used **hides** to protect body; **buried their dead**.
Homo sapiens (modern man)	75,000–10,000 yrs ago	~1350 cc	Arose in **Africa**, moved across continents, 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 painting – Bhimbetka rock shelter in **Raisen district, Madhya Pradesh**.
- **Agriculture** came around **10,000 years** back → human settlements started. Rest is part of human history & civilisation.

📌 **Trick for order:** "**D**on't **A**sk **H**ow **E**ach **N**ew **S**tage came" → **D**ryopithecus → **A**ustralopithecus → ***H. habilis*** → ***H. E**rectus* → **N**eanderthal → ***H. S**apiens*.

Brain: **650–800** → **900** → **1400** cc.

⚡ Quick Revision / त्वरित पुनरावृत्ति

Scientist	Contribution
Louis Pasteur	Disproved spontaneous generation (killed yeast)
Oparin & Haldane	Chemical evolution theory
S.L. Miller (1953)	Amino acids from CH_4, H_2, NH_3, H_2O at 800 °C
Charles Darwin	Natural selection; HMS Beagle; Darwin's finches
Alfred Wallace	Malay Archipelago; similar conclusions as Darwin
Lamarck	Use & disuse of organs (giraffe)
Hugo de Vries	Mutation theory; evening primrose; saltation
Hardy & Weinberg	$p^2 + 2pq + q^2 = 1$

Key examples	Concept
Forelimbs of whale, bat, cheetah, human	Homologous – divergent evolution
Wings of butterfly & bird; eye of octopus & mammal	Analogous – convergent evolution
Peppered moths in England	Industrial melanism – natural selection
Darwin's finches; Australian marsupials	Adaptive radiation
Placental mammals vs marsupials in Australia	Convergent evolution
Antibiotic / pesticide resistance	Anthropogenic evolution
Coelacanth (1938)	Lobefin – "living fossil"
Bhimbetka (MP)	Pre-historic cave paintings (~18,000 yrs)

⭐ Exam Corner / परीक्षा उपयोगी प्रश्न

1-Mark Questions (1M)

Q1. Name the gases used by Miller in his experiment. / मिलर के प्रयोग में प्रयुक्त गैसें?

→ CH_4, NH_3, H_2 and water vapour.

Q2. What is saltation?

→ Single-step large mutation causing speciation (Hugo de Vries).

Q3. Thorn of Bougainvillea and tendril of Cucurbita are examples of which type of organs?

→ Homologous organs.

Q4. Give an example of convergent evolution.

→ Wings of butterfly & bird / eye of octopus & mammal / flippers of penguin & dolphin.

Q5. What is the brain capacity of Homo erectus?

→ About 900 cc.

Q6. Why are lichens called pollution indicators?

→ They don't grow in polluted (smoke, SO_2) areas.

Q7. Which plant did Hugo de Vries work on?

→ Evening primrose (Oenothera lamarckiana).

2/3-Mark Questions 2-3M

Q8. Differentiate between homologous and analogous organs with examples.

→ See comparison table (origin vs function; divergent vs convergent).

Q9. Explain industrial melanism. How does it support natural selection?

→ White moths (1850) vs dark moths (1920) in England due to soot-darkened trunks; predators pick visible moths → better adapted survive.

Q10. What is adaptive radiation? Give two examples.

→ Evolution of different species in a geographical area from one point radiating to other habitats; Darwin's finches, Australian marsupials.

Q11. State Hardy–Weinberg principle. List the factors affecting it.

→ Allele frequencies constant across generations; gene migration, genetic drift, mutation, recombination, natural selection.

Q12. In a population, 9% individuals show recessive trait. Find frequency of heterozygotes.

→ $q^2 = 0.09 \rightarrow q = 0.3, p = 0.7 \rightarrow 2pq = 0.42$ (42%).

Q13. Differentiate Darwinian variations and de Vries mutations.

→ Small & directional vs large, random & directionless (saltation).

Q14. What is founder effect?

→ Genetic drift where a small drifted population with changed allele frequencies becomes founders of a new species.

Q15. Explain Lamarck's theory with an example. Why is it rejected?

→ Use & disuse of organs; giraffe's neck; acquired characters are not inherited (no genetic basis).

5-Mark Questions SM ★★★

Q16. Describe Miller's experiment with a labelled diagram. What did it prove?

→ Closed flask, $CH_4 + H_2 + NH_3 + H_2O$ at 800 °C, electric discharge → amino acids; supports chemical evolution (Oparin–Haldane).

Q17. Describe the various evidences of evolution.

→ Fossils, comparative anatomy (homologous/analogous), biochemical similarities, industrial melanism, anthropogenic evolution, artificial selection.

Q18. Explain the three types of natural selection with graphs.

→ Stabilising, directional, disruptive (draw bell curves).

Q19. Trace the evolution of man from Dryopithecus to Homo sapiens.

→ Use the human evolution table with time, brain capacity & features.

✏ **Diagrams to practise / अभ्यास हेतु चित्र:**

1. Miller's experiment ⭐
2. Homologous forelimbs
3. Industrial melanism (white vs dark moths)
4. Darwin's finches
5. Adaptive radiation of marsupials ⭐
6. Three types of natural selection (graphs) ⭐
7. Human evolution timeline

🎯 **Last-minute tips:** Always state whether an example is **divergent or convergent** · Write Hardy–Weinberg equation clearly & solve numericals step by step · Remember brain sizes (650–800, 900, 1400 cc) · Darwin's key words: **variation, natural selection, survival of the fittest, reproductive fitness, branching descent**.

~ All the best! / शुभकामनाएँ! ~