FREE EDITION · NOTES + 3 SAMPLE MCQS

CUET · BIOLOGY · CLASS XII · CODE 304

Evolution

CUET unit: Genetics and Evolution → Evolution

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📌 Snapshot

- Evolutionary biology traces the history of life forms on earth, from the Big Bang origin of the universe (~13.8 billion years ago) through chemical evolution, biogenesis, and the natural-selection-driven branching descent of species.
- Establishes core evidence for evolution (paleontology, comparative anatomy/embryology, biochemistry, biogeography, artificial selection, industrial melanism) and core mechanisms (mutation, natural selection, gene flow, genetic drift, recombination).
- Introduces the Hardy-Weinberg principle ($p^2 + 2pq + q^2 = 1$) — the algebraic baseline against which evolutionary change is detected.
- Covers adaptive radiation (Darwin's finches, Australian marsupials), convergent vs divergent evolution, and the stepwise origin and evolution of man (Dryopithecus → Australopithecines → Homo habilis → erectus → Neanderthal → sapiens).
- High CUET yield — typical questions test the Hardy-Weinberg equation, definitions of homology/analogy, fossil chronology, brain capacities of hominids, and the Miller-Urey experiment.

📖 Detailed Notes

2.1 Core concepts

- **The universe is ~13.8 billion years old**; the Big Bang theory explains its origin via a singular explosion, after which expansion cooled it and hydrogen and helium condensed under gravity into galaxies (NCERT §6.1, p. 111).
- **Earth formed ~4.5 billion years back**; the early atmosphere had water vapour, methane (CH_4), CO_2 and ammonia (NH_3) — no free oxygen. UV radiation split water; lighter H_2 escaped; oxygen combined with NH_3 and CH_4 to form water and CO_2; the ozone layer formed and rains filled oceans (NCERT §6.1, p. 111).
- **Life appeared ~4 billion years ago**, i.e., about 500 million years after earth's formation (NCERT §6.1, p. 111).
- **Panspermia** (early Greek idea, still favoured by some astronomers) holds that spores of life travelled from outer space to earth; **spontaneous generation** (life

from decaying matter) was disproved by **Louis Pasteur**, who showed life arises only from pre-existing life (NCERT §6.1, p. 111).

- **Oparin (Russia) and Haldane (England)** proposed chemical evolution — first life came from pre-existing non-living organic molecules (RNA, protein); preceded by abiotic formation of organic from inorganic matter under reducing atmosphere (CH_4, NH_3, high temperature, volcanic storms) (NCERT §6.1, pp. 111-112).
- **S.L. Miller (1953)** simulated early-earth conditions in a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C with electric discharge; observed formation of amino acids (and in similar experiments, sugars, nitrogen bases, pigments, fats). Meteorite analysis confirmed similar compounds form in space (NCERT §6.1, p. 111, Figure 6.1).
- **First non-cellular life** ~3 billion years back (giant RNA, protein, polysaccharide molecules); **first cellular life** ~2000 million years ago — single cells in water (NCERT §6.1, pp. 112; §6.8, p. 121).
- **Theory of special creation** (challenged in the 19th century) claimed species were created as-is, diversity is unchanging, and earth is ~4000 years old — all three points were rejected (NCERT §6.2, p. 112).
- **Charles Darwin** (HMS Beagle voyage) concluded existing life forms share similarities with past forms; gradual evolution operates via **natural selection** — heritable variations that improve reproductive fitness are preserved. **Alfred Wallace** (Malay Archipelago) reached similar conclusions independently (NCERT §6.2, pp. 112-113).
- **Paleontological evidence:** fossils in different sedimentary layers show life forms varied over time, with certain forms restricted to certain geological time-spans; ages are determined by radioactive dating (NCERT §6.3, p. 113).
- **Embryological evidence** proposed by **Ernst Heckel** (vertebrate embryos show vestigial gill slits, etc.) was **disapproved by Karl Ernst von Baer**, who showed embryos never pass through the adult stages of other animals (NCERT §6.3, p. 113).
- **Homologous organs** (whale flipper, bat wing, cheetah forelimb, human arm — all with humerus, radius, ulna, carpals, metacarpals, phalanges) — same structure, different function — result of **divergent evolution**, indicate **common ancestry**. Plant example: thorn of Bougainvillea and tendril of Cucurbita (NCERT §6.3, pp. 114-115, Figure 6.3).
- **Analogous organs** — different structure, same function — result of **convergent evolution**. Examples: wings of butterfly vs birds; eye of octopus vs mammals; flippers of penguins vs dolphins; sweet potato (root) vs potato (stem tuber) (NCERT §6.3, p. 115).
- **Biochemical evidence** — similarities in proteins and genes across diverse organisms indicate shared ancestry (NCERT §6.3, p. 115).
- **Artificial selection** — man's breeding of dogs, crops etc. in hundreds of years argues that nature could do the same over millions (NCERT §6.3, p. 115).

- **Industrial melanism** (England, peppered moths) — before industrialisation (1850s) white-winged moths dominated on lichen-covered trees; post-industrialisation (1920) dark/melanised moths dominated on soot-blackened trunks. In unpolluted rural areas melanic count remained low. Demonstrates natural selection; no variant is completely wiped out (NCERT §6.3, pp. 115-116, Figure 6.4).
- **Anthropogenic evolution** — pesticide/herbicide/antibiotic resistance arises in months-to-years, showing evolution is a stochastic (chance-based) not directed process (NCERT §6.3, p. 116).
- **Adaptive radiation** — evolution of different species in a geographical area from a point and radiating to other habitats. **Darwin's finches** of Galapagos (varied beaks: seed-eating → insectivorous → vegetarian) and **Australian marsupials** (multiple forms from common ancestral stock) are the classic examples (NCERT §6.4, pp. 116-117, Figures 6.5, 6.6).
- **Convergent evolution at the radiation level:** placental mammals (e.g., placental wolf) and Australian marsupials (Tasmanian wolf-marsupial) — two adaptive radiations in isolated areas producing similar forms (NCERT §6.4, pp. 117-118, Figure 6.7).
- **Branching descent and natural selection** are the two key concepts of Darwinian theory (NCERT §6.5, p. 118).
- **Lamarck's theory** (use and disuse of organs, inheritance of acquired characters — e.g., giraffe neck elongation) — no longer believed (NCERT §6.5, pp. 118-119).
- Darwin was influenced by **Thomas Malthus** on populations: natural resources are limited, populations would grow exponentially if unchecked, hence competition; heritable variations favouring resource use leave more progeny → new forms arise (NCERT §6.5, p. 119).
- **Hugo de Vries** (working on evening primrose) proposed **mutation theory** — large, sudden, random, directionless changes cause **saltation** (single-step large mutation), in contrast to Darwin's small directional gradual variations (NCERT §6.6, p. 119).
- **Hardy-Weinberg principle:** allele frequencies in a population are stable and constant across generations — "genetic equilibrium." For two alleles A (p) and a (q): p^2 (AA) + 2pq (Aa) + q^2 (aa) = 1; this is a binomial expansion of $(p+q)^2$. Deviation from expected indicates evolutionary change (NCERT §6.7, pp. 120-121).
- **Five factors that disturb Hardy-Weinberg equilibrium:** (i) gene migration / gene flow, (ii) genetic drift, (iii) mutation, (iv) genetic recombination, (v) natural selection. **Founder effect** — when drift-altered allele frequencies make the founders of a new population a new species (NCERT §6.7, p. 121).
- **Three types of natural selection** (Figure 6.8): **stabilising** (mean character favoured — peak narrows), **directional** (peak shifts toward one extreme), **disruptive** (two peaks at extremes) (NCERT §6.7, p. 121).
- **Geological/evolutionary timeline:** first cellular life ~2000 mya; invertebrates by 500 mya; jawless fish ~350 mya; sea-weeds and plants ~320 mya; plants invaded

land first; lobefins (Coelacanth-type fish with stout fins) gave rise to first amphibians ~350 mya; amphibians → reptiles (thick-shelled eggs); dinosaurs dominated land; Tyrannosaurus rex was ~20 feet tall; some reptiles re-entered water (Ichthyosaurs, ~200 mya); dinosaurs disappeared ~65 mya (NCERT §6.8, pp. 121-124, Figures 6.9, 6.10).

- **First mammals were shrew-like**, viviparous, intelligent; took over after reptiles declined. **Continental drift** explains why North American fauna overran South American mammals, and why Australian pouched mammals (marsupials) survived in isolation (NCERT §6.8, p. 124).
- **Human evolution (§6.9):** Dryopithecus and Ramapithecus ~15 mya — Ramapithecus more man-like, Dryopithecus more ape-like. Hominid fossils from Ethiopia/Tanzania show ~3–4 mya upright primates (<4 feet). Australopithecines ~2 mya in East African grasslands; hunted with stone weapons but ate fruit. **Homo habilis** — first hominid, brain 650–800 cc, did not eat meat. **Homo erectus** — fossils Java, 1891, ~1.5 mya, brain ~900 cc, ate meat. **Neanderthal man** — brain 1400 cc, 1,00,000–40,000 years back, used hides, buried dead. **Homo sapiens** arose in Africa; modern Homo sapiens during ice age (75,000–10,000 years ago). Pre-historic cave art ~18,000 years ago (e.g., Bhimbetka, Raisen, MP). Agriculture ~10,000 years back (NCERT §6.9, pp. 124-125, Figure 6.11).

2.2 Definitions to memorise

Term	Definition	Page
Panspermia	Theory that spores (units) of life were transferred to different planets including earth from outer space	111
Spontaneous generation	Discredited theory that life arose from decaying/rotting matter (straw, mud); disproved by Louis Pasteur	111
Chemical evolution	Formation of diverse organic molecules from inorganic constituents — preceded life (Oparin-Haldane)	111
Big Bang theory	Singular huge explosion that originated the expanding universe ~13.8 bya	111
Homologous organs	Anatomically similar structures with different functions, indicating divergent evolution and common ancestry (e.g., forelimbs of whale, bat, cheetah, human)	114-115
Analogous organs	Anatomically different structures performing similar functions, indicating convergent evolution (e.g., wings of birds and butterflies; eye of octopus and mammals)	115
Divergent evolution	Same structure developing in different directions due to adaptations to different needs	114
Convergent evolution	Different structures evolving for the same function in similar habitats	115

Term	Definition	Page
Adaptive radiation	Evolution of different species in a given geographical area, starting from a point and radiating to other habitats (e.g., Darwin's finches, Australian marsupials)	117
Natural selection	Process by which heritable variations enabling better survival/reproduction leave greater number of progeny	113, 121
Fitness (Darwinian)	Reproductive fitness — those better fit in an environment leave more progeny	113
Branching descent	Concept that existing species share common ancestors who lived at different periods in earth's history	118
Saltation	Single-step large mutation (de Vries) believed to cause speciation	119
Hardy-Weinberg principle	Allele frequencies in a population remain stable and constant across generations; $p^2 + 2pq + q^2 = 1$	120-121
Genetic equilibrium	Constancy of gene pool (allele frequencies) in a population over generations	120
Gene flow	Migration of a section of population leading to addition/loss of alleles	121
Genetic drift	Random change in allele frequency by chance	121
Founder effect	When drift in a founder population is so different that it becomes a new species	121
Stabilising selection	More individuals acquire the mean character value (peak gets higher and narrower)	121
Directional selection	More individuals acquire a value other than the mean (peak shifts in one direction)	121
Disruptive selection	More individuals acquire peripheral values at both ends of the distribution (two peaks form)	121
Industrial melanism	Increase in frequency of dark-winged moths in industrially polluted areas due to better camouflage	115-116
Lobefins	Fish with stout, strong fins (e.g., Coelacanth) — ancestors of first amphibians	122-124
Australopithecines	~2 mya East African grassland hominids; used stone weapons but ate fruit	124

2.3 Diagrams / processes to remember

- **Figure 6.1 — Miller's experiment apparatus** (p. 112): closed flask with electrodes, gases CH_4, NH_3, H_2O, H_2, spark discharge, condenser with water in/out, boiling water flask, U-shaped trap for liquid water containing organic compounds. Conditions: 800°C, electric discharge.

- **Figure 6.2 — Dinosaur family tree** (p. 114): Triceratops, Tyrannosaurus, Pteranodon, Crocodilian, Archaeopteryx, Stegosaurus, Brachiosaurus — modern crocodiles and birds are living counterparts.
- **Figure 6.3 — Homologous organs** (p. 115): (a) plants — thorn of Bougainvillea vs tendril of Cucurbita; (b) animals — forelimbs of man, cheetah, whale, bat all share humerus + radius + ulna + carpals + metacarpals + phalanges.
- **Figure 6.4 — Industrial melanism** (p. 116): white-winged and dark-winged (melanised) moths on (a) unpolluted lichen-covered trunk (white survives) vs (b) polluted soot-covered trunk (dark survives).
- **Figure 6.5 — Darwin's finches** (p. 117): four beak varieties from Galapagos — adaptive radiation from seed-eating ancestor to insectivorous/vegetarian forms.
- **Figure 6.6 — Australian marsupial radiation** (p. 117): Tasmanian wolf, sugar glider, marsupial mole, koala, bandicoot, wombat, kangaroo, marsupial rat, banded anteater, tiger cat — all from one ancestral stock.
- **Figure 6.7 — Convergent evolution** (p. 118): pairs of placental mammals vs Australian marsupials — mole/marsupial mole, anteater/numbat, mouse/marsupial mouse, lemur/spotted cuscus, flying squirrel/flying phalanger, bobcat/Tasmanian tiger cat, wolf/Tasmanian wolf.
- **Figure 6.8 — Types of natural selection** (p. 120): (a) stabilising (peak higher and narrower), (b) directional (peak shifts in one direction), (c) disruptive (two peaks form).
- **Figure 6.9 — Plant evolution timeline** (p. 122): Paleozoic → Mesozoic → Cenozoic; from chlorophyte ancestors → tracheophyte ancestors → Rhynia-type plants → Psilophyton → seed ferns → progymnosperms → conifers/cycads/ginkgos/gnetales → angiosperms (monocots, dicots).
- **Figure 6.10 — Vertebrate evolutionary tree** (p. 123): early reptiles (~350 mya) → sauropsids and synapsids → therapsids, thecodonts, pelycosaurs, dinosaurs (all extinct) → modern turtles, lizards, snakes, tuataras, crocodiles, birds, mammals.
- **Figure 6.11 — Skull comparison** (p. 125): adult modern human, baby chimpanzee, adult chimpanzee — baby chimp skull is more like adult human skull than adult chimp skull.

2.4 Common confusions / NTA trap points

- **Homology vs analogy:** homology = same structure, different function, common ancestor, divergent evolution; analogy = different structure, similar function, convergent evolution. Distractors often swap "divergent" and "convergent."
- **Hardy-Weinberg algebra:** if dominant allele frequency p = 0.6, then heterozygotes are 2pq (not p^2 or q^2). Remember q = 1 − p; recessive homozygotes are q^2 (often the easiest unknown to extract from a stated frequency).

- **Brain capacities of hominids:** Homo habilis 650–800 cc, Homo erectus ~900 cc, Neanderthal 1400 cc — students confuse the order. Homo erectus ate meat; Homo habilis did NOT.
- **Heckel vs von Baer:** Heckel proposed the embryological evidence; von Baer disapproved it by showing embryos do not pass through adult stages of other animals.
- **Miller's experiment gases:** CH_4, H_2, NH_3 and water vapour at 800°C — distractors often add O_2 (early atmosphere had no free oxygen) or remove ammonia.
- **Lamarck vs Darwin vs de Vries:** Lamarck = use/disuse + inheritance of acquired characters (giraffe neck); Darwin = small, gradual, directional, heritable variations + natural selection; de Vries = saltation by large, sudden, random, directionless mutations.
- **Five Hardy-Weinberg factors:** gene flow/migration, genetic drift, mutation, recombination, natural selection — students often forget recombination.
- **Convergent at two scales:** (i) analogous organs in unrelated species, and (ii) entire radiations producing similar forms in isolated continents (placental wolf vs Tasmanian wolf) — both are convergent.
- **Sweet potato vs potato** is analogous (root vs stem); **thorn of** Bougainvillea and tendril of Cucurbita is homologous (both modified shoots).

🎯 Practice MCQs

Q1. In Miller's 1953 experiment, electric discharge was passed through a flask containing a mixture of gases at 800°C. Which of the following combinations correctly represents the gases used?

A. CH_4, O_2, NH_3 and water vapour

B. CH_4, H_2, NH_3 and water vapour

C. CO_2, H_2, N_2 and water vapour

D. CH_4, H_2, O_2 and water vapour

Q2. Which of the following pairs is an example of analogous organs (convergent evolution)?

A. Forelimbs of whale and bat

B. Thorn of *Bougainvillea* and tendril of *Cucurbita

C. Vertebrate hearts of different mammals

D. Eye of octopus and eye of mammals

Q3. In a Hardy-Weinberg population, the frequency of the recessive allele (a) is 0.4. What is the frequency of heterozygous (Aa) individuals?

A. 0.16

B. 0.36

C. 0.48

D. 0.24

📊 PYQ Alignment

The Evolution chapter is one of the highest-yielding units in the CUET Biology paper, typically contributing ~10–12 MCQs across CUET 2023–2025 papers. Recurrent question types include: (i) numerical problems on the Hardy-Weinberg equation (extracting p, q, 2pq, q^2 from a stated frequency); (ii) homology vs analogy classification using standard NCERT examples (forelimbs, Bougainvillea/Cucurbita thorn-tendril, sweet potato vs potato, eye of octopus vs mammals); (iii) chronology of human evolution and hominid brain capacities; (iv) Miller's experiment composition (gases, temperature, products); (v) matching scientists to their contributions (Darwin, Lamarck, de Vries, Oparin-Haldane, Pasteur, Wallace, Heckel, von Baer); and (vi) assertion-reason pairs on adaptive radiation (Darwin's finches, Australian marsupials) and the five factors that disturb Hardy-Weinberg equilibrium.

CUET 2025 — Actual PYQs from this chapter

Q.21 (CUET 2025) Arrange geological periods from latest to oldest: (A) Triassic (B) Carboniferous (C) Tertiary (D) Jurassic

- A) [option not extracted — see source]

- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.25 (CUET 2025) Which statements are true regarding homologous organs? (A) Homology indicates common ancestry (B) Whale and cheetah share similar forelimb bone pattern (C) Vertebrate heart is example of homologous organ (D) Thorn of Bougainvillea and tendril of Cucurbita

- A) [option not extracted — see source]
- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.26 (CUET 2025) Arrange plant groups according to appearance on earth: (A) Angiosperms (B) Seed ferns (C) Rhynia-type plants (D) Psilophyton

- A) [option not extracted — see source]
- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.28 (CUET 2025) Thorn of Bougainvillea and tendril of Cucurbita are:

- A) Homologous structures
- B) Analogous structures
- C) Vestigial structures
- D) Developing structures

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.44 (CUET 2025) How many episodes of mass extinction of species have occurred since the origin and diversification of life on Earth?

- A) Two
- B) Three
- C) Five
- D) Seven

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.47 (CUET 2025) Which of the following is not a stage of growing embryo in dicot plants?

- A) Heart-shaped stage
- B) Globular stage
- C) Pre-embryo stage
- D) Rhombus stage

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

CUET 2024 — Actual PYQs from this chapter

Q.15 (CUET 2024) Analogous structures result from:

- A) Convergent evolution
- B) Divergent evolution
- C) Parallel evolution
- D) Retrogressive evolution

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.16 (CUET 2024) Which does not affect Hardy-Weinberg equilibrium?

- A) Natural selection
- B) Genetic drift
- C) Gene pool
- D) Gene migration

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.17 (CUET 2024) Which primate was more like an ape?

- A) Homo erectus
- B) Dryopithecus
- C) Australopithecus
- D) Ramapithecus

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.35 (CUET 2024) Population having equal number of young and mature individuals indicates:

- A) Expanding population
- B) Declining population

- C) Stable population
- D) S-shaped population

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.43 (CUET 2024) Which population growth curve is logistic growth?

- A) J-shaped
- B) S-shaped
- C) Linear
- D) Exponential

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

CUET 2023 — Actual PYQs from this chapter

Q.15 (CUET 2023) Identify the factor which does not affect Hardy-Weinberg equilibrium:

- A) Genetic drift
- B) Natural selection
- C) Genetic recombination
- D) Genetic equilibrium

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.16 (CUET 2023) Single step large mutation leading to speciation is called:

- A) Founder effect
- B) Saltation
- C) Branching descent
- D) Natural selection

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key

Q.17 (CUET 2023) Paleontological evidence for evolution refers to:

- A) Development of embryo
- B) Homologous organs
- C) Fossils
- D) Analogous organs

Tests: aligns with §2 (evolution) Answer: Not in extracted key — verify against official NTA key