



SCAN FOR PRACTICE

7.0

INTRODUCTION

- Different theories proposed to explain origin and diversity of life are as follows:
 - **Special Creation**
 - **Spontaneous Generation**
 - **Cosmozoan Theory**
 - **Biochemical Evolution**

Creationism / Fixity of Species

- According to **creationism**, each species was created by God.
- The origin and diversity of life result from *super natural event*.
- Each species **never changed thereafter**.
- This idea remained **unchallenged for about 2000 years**.
- Important names associated with this view are:
 - **Carolus Linnaeus | Suarez**

FTB

- Earth is about **4.5 billion years old**.
- The **oldest fossils** are about **3.7 billion years old**

BTB

- Religious belief states that:
 - Allah created everything in the universe in **6 days**.
 - Human was created on the **6th day**.

7.1

CONCEPT OF EVOLUTION

Definition of Evolution

- Evolution is **change over a period of time**.
- It is **descent with modification**.
- It is the **change in genetic composition of a population from generation to generation**.
- It also provides **scientific explanation for the diversity of life**.*

Aristotle and Early View of Life

- **Aristotle (384–322 BC)** was a **naturalist**.
- He categorized all known living things.
- He proposed **Scala Naturae** or **Ladder of Nature**.
- According to Scala Naturae:
 - Living things were arranged in a ladder-like order.
 - Species were considered **permanent**.
 - Species were considered **never changing**.

New Discoveries and Changing Ideas

- Discovery of lands in **Africa, Asia & America** showed that biodiversity was **much greater than expected**.
- Some species resembled one another, yet displayed variations.
- This led to the idea that:
 - Species may **change**.
 - Some of the similar species may have developed from a **common ancestor**.

STB

- Evolution is the **transformation of form and mode of existence**.
- This definition was described by **Zimmermann**.

PTB

- The idea of evolution existed since the days of **Aristotle**.

KTB

Discovery of Fossils

- Fossils showed a **progression in form**.
- **Lowest and oldest rock layers** contained fossils different from modern species.
- **Younger rock layers** contained fossils more similar to modern species.

*BTB says evolution provides the ONLY scientific for diversity of life.

01

THEORIES PROPOSED TO EXPLAIN EARTH'S HISTORY AND FOSSILS

KTB

Catastrophism

- **Catastrophism** was proposed by **George Cuvier**.
- It explained Earth's history through catastrophic events.
- According to this theory:
 - A vast number of species were created in the beginning.
 - Catastrophes destroyed many species.
 - These catastrophes formed the **fossil layers**.
 - Present-day species are those that **survived**.

Uniformitarianism

- **James Hutton** and **Charles Lyell** explained formation of Earth's layers by:
 - **Wind | Water | Earthquakes | Volcanism**
 - **These are the agents for creating layered pattern.**
- They stated that:
 - These layers of rocks are evidence of **ordinary natural processes**, occurring repeatedly over a long period of time.
 - The **same natural processes operate today**.
- This view is called **Uniformitarianism**..

KTB

- Louis Agassiz** proposed that:
- A **new creation** occurred after each catastrophe.
 - Present-day species are the **most recent creation**.

KTB

- Hutton & Lyell **concluded** that:
- **Earth is eternal**.
 - There is **no vestige of a beginning and no prospect of an end**.

KTB

- Hutton and Lyell provided **time for evolution**, but they did not provide a convincing mechanism for evolution

PTB

Scientist	Years	Contribution
Linnaeus	1707-1778	<ul style="list-style-type: none"> • Sought and found order in the diversity of life. • He introduced binomial nomenclature for naming species.
Lamarck	1744-1829	<ul style="list-style-type: none"> • Published his theory of evolution.
Malthus	1766-1834	<ul style="list-style-type: none"> • Published Essay on the Principle of Population.
Cuvier	1769-1832	<ul style="list-style-type: none"> • Contributed much to taxonomic scheme of animals • Explained Earth's history by Catastrophism.
Lyell	1797-1875	<ul style="list-style-type: none"> • Published Principles of Geology.
Darwin	1809-1882	<ul style="list-style-type: none"> • Voyage of Beagle. • Began his notebooks on origin of species • Wrote his essay on origin of species.
Mendel	1822-1884	<ul style="list-style-type: none"> • Published papers on inheritance.
Wallace	1823-1913	<ul style="list-style-type: none"> • Sent his theory to Darwin.

02

MECHANISM FOR EVOLUTION: EARLY VIEWS

- Lamarck proposed the **inheritance of acquired characteristics**.
- According to Lamarck, all organisms have:
 - An **innate drive for perfection**
 - An urge to climb the **Ladder of Nature**

Darwin and Wallace

- In **1858**, Darwin and Wallace independently proposed that the force behind evolutionary change is **natural selection**.

STB

- **George Buffon** was the first to **implement geological time scale**.
- He developed the idea that living beings **evolve constantly**.

7.2 EVOLUTION OF EUKARYOTES FROM PROKARYOTES

01

ORIGIN OF LIFE

Vent Hypothesis

- According to the **vent hypothesis**, life originated near **hydrothermal vents**.
- Hydrothermal vents are:
 - Located **deep in oceans** | **Underwater hot springs**
- Hydrothermal vents supplied:
 - **Energy** | **Raw material**
- The first organism was a **prokaryotic absorptive heterotroph**.
- Later **chemoautotrophs** were evolved.
- As life expanded, a **new source of nutrients** was needed.

Evolution of Photosynthesis (Biochemical evolution):

- Photosynthesis became a major source of food and energy.
- The **first photosynthetic organisms** appeared about **3.2 billion years ago**.
- These early photosynthetic organisms used **H₂S** as the source of hydrogen.
- Later, organisms similar to **cyanobacteria** used **H₂O** as the source of hydrogen.
- When water began to be used in photosynthesis:
 - **O₂ began to accumulate**
 - **Ozone layer formed**
 - **UV radiations decreased**
 - Atmosphere changed from **reducing** to **oxidizing**
 - Organisms began to use **O₂**
- Due to formation of **O₃** about **420 million years ago**, life became possible on land.

Present condition:

- Life **cannot arise abiotically now**.

PTB

- The first cell was a **prokaryote**.
- It appeared about **3.5 billion years ago**.

PTB

- **Archaeobacteria** can tolerate temperatures up to **120°C**.
- They seem to have undergone *less evolutionary changes*.
- This supports the vent hypothesis that early life could survive in extreme hot environments.

STB

- Early autotrophs included:
 - **Sulphur bacteria**
 - **Iron bacteria**

 Mentri Insight

- Life became possible on land because the **ozone layer** protected life from harmful ultraviolet radiations.
- It increased the biodiversity on earth.

02

FROM PROKARYOTES TO EUKARYOTES

Feature	Description
First cell	<ul style="list-style-type: none"> • Prokaryote • Appeared about 3.5 billion years ago
First eukaryote	<ul style="list-style-type: none"> • Appeared about 1.5 billion years ago

General Evolutionary Trend

- Evolutionary sequence of living organisms is as follows:
 - **First unicellular organism forms**
 - Then **multicellular organism forms**
 - Then it develops more complex **tissues and organs**

Proposed Pathways for Origin of Eukaryotes

- Two proposed pathways are:
 - **Endosymbiosis hypothesis / theory**
 - **Membrane Invagination hypothesis**

Mentri Insight

First Eukaryote appearance:

- 1.5-2 Billion years ago (KTB)
- 1.9-2.1 Billion years ago (FTB, BTB)
- 1.5 Billion years ago (PTB)

PTB

- The formation of the **eukaryotic cell** led to a dramatic increase in the:
 - **Complexity**
 - **Diversity of life forms**

03

ENDOSYMBIOSIS HYPOTHESIS

- **Endosymbiosis** was proposed by **Lynn Margulis**.
- According to this hypothesis:
 - A large **anaerobic amoeboid prokaryote** ingested small **aerobic heterotrophic bacteria**.
- These bacteria became **mitochondria**.

Origin of Other Organelles

- Ingestion of **spirochetes** gave rise to **flagella**.
- Ingestion of **photosynthetic cyanobacteria (blue-green algae)** gave rise to **chloroplasts**.

Evidences for Endosymbiosis

- Mitochondria and chloroplasts:
 - Are **similar in size to bacteria**
 - Have their **own genes**
 - Contain **circular DNA and RNA**
 - Have **ribosomes similar to bacteria**
 - Produce their **own limited enzymes and proteins**
 - Reproduce by **binary fission**
 - Reproduce **independently of the host cell cycle**

KTB

Possible Explanations for Origin of Mitochondria

- The engulfed bacteria may have entered as:
 - A **direct parasite**
 - An **indigestible food source**

FTB

- Endosymbionts transferred some of their genes to the **host nucleus**.
- They gradually lost their independence for the sake of a **symbiotic relationship**.

KTB

Mitochondria and chloroplast appear to be more similar to prokaryotes than eukaryotes.

04 MEMBRANE INVAGINATION & INFOLDING HYPOTHESIS

- According to the **membrane infolding** hypothesis, the host cell membrane **infolded** during invasion.
- The infolded membrane surrounded invading prokaryote cells.
- This membrane became the **outer layer of the double membrane**.

Evidences

- **Inner membrane** of mitochondria and chloroplasts is similar to **prokaryotes**.
- **Outer membrane** shows **eukaryotic characteristics**.

Genome-Based Explanation

- **Genome duplication** occurred.
- Cell membrane **invaginated** to enclose copies of genome.
- This led to formation of **double membrane-bounded organelles**, such as:
 - **Mitochondria**
 - **Nucleus**
 - **Chloroplast**
- During this process:
 - **Nuclear genome enlarged**
 - Genomes of other organelles **lost many genes**

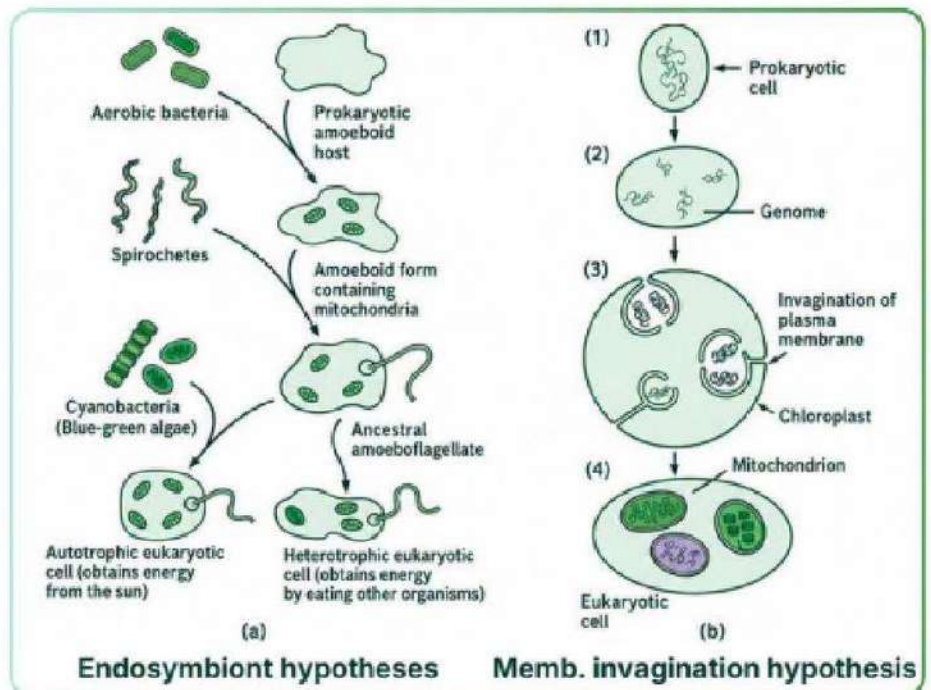
Overall Conclusion

- Through **prokaryotic, symbiotic, and multicellular interactions**, the first eukaryote originated.

KTB

Formation of Endomembrane System

- Continued membrane infolding may also have formed the **endomembrane system**.



7.3

LAMARCKISM

- **Lamarckism** is the **first theory of organic evolution**.
- It was proposed by **Jean Baptiste Lamarck**.
- Lamarck explained evolution through **two main conditions**:
 - **Use and disuse of organs**
 - **Inheritance of acquired characters**

KTB

- Lamarck presented his ideas in his book **Philosophie Zoologique**.

01

USE AND DISUSE OF ORGANS

- According to Lamarck:
 - Organs that are **used more** become **stronger** and **more efficient**.
 - Organs that are **not used** gradually **deteriorate**.

Examples of Use:

Example	Explanation
Blacksmith	<ul style="list-style-type: none"> • Develops bigger biceps • Especially in the arm that works the hammer
Aquatic birds	<ul style="list-style-type: none"> • Developed webbed feet • Due to constant spreading of toe bones and skin between them • Webbed feet help in: <ul style="list-style-type: none"> ◦ Swimming ◦ Finding food ◦ Escaping predators

Examples of Disuse:

Example	Explanation
Snakes	<ul style="list-style-type: none"> • Lost their legs: <ul style="list-style-type: none"> ◦ Due to creeping behavior into small holes and crevices. This habit helped to avoid enemies & obtain food ◦ Due to crawling and concealing habit
Humans	<ul style="list-style-type: none"> • Lost the contractile feature of ear muscles. • Humans now change position of the head to collect sound
Flightless birds	<ul style="list-style-type: none"> • Ancestors of ostrich used to fly but their wings became vestigial with time because of following reasons: <ul style="list-style-type: none"> ◦ Due to environmental changes i.e. <ul style="list-style-type: none"> ■ A lot of food available ■ Protection available ◦ Due to no use of wings

02

ACQUIRED CHARACTERS

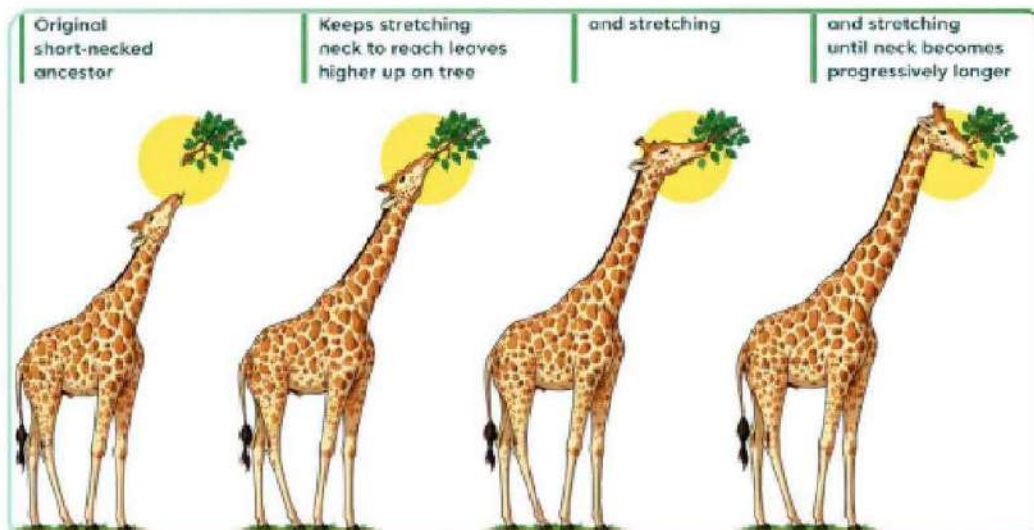
- **Acquired characters** are **structural changes** induced due to **certain changes in environment or function.**

Giraffe Example

- Ancestors of giraffe had **not enough grass to eat.**
- They started **browsing upon foliage of trees.**
- This resulted in:
 - **Elongation of forelimbs**
 - **Elongation of neck**
- Lamarck believed that this increase was **passed on to the next generation.**

FTB

- Lamarck believed that acquired characters are **heritable.**



03

DRAWBACKS OF LAMARCKISM

- Environment can produce **phenotypic changes** - this is correct.
- But these changes are:
 - **Non-genetic**
 - Have **no effect on genotype**
 - **Cannot be inherited**

BTB

- **August Weismann** disproved Lamarck's theory experimentally.
- He removed the **tails of 68 mice** for many generations.
- No mouse was born:
 - **Without tail** or with a **shorter tail**
- This proved that **acquired somatic changes are not inherited.**

FTB

Main Objections:

- There is **no experimental proof** of Lamarckism.
- **Use and disuse of organs** cannot alter genotype.
- **Somatic changes** are not inheritable.
- Organs are not modified according to the **wish** or **requirement** of the organism.

7.4

DARWINISM

01

DARWIN'S OBSERVATIONS

Voyage of Beagle

- Darwin travelled on **HMS Beagle**.
- The voyage lasted **5 years** around the world.
- It started in **1831**.
- Darwin was **22 years old** at that time.
- Purpose of voyage was to prepare **navigation charts** for the **British Navy**
- Darwin started the trip believing in the theory of **special creation**.
- During the voyage, he collected and studied **thousands of plants and animal**

Darwin's Major Observations During Voyage

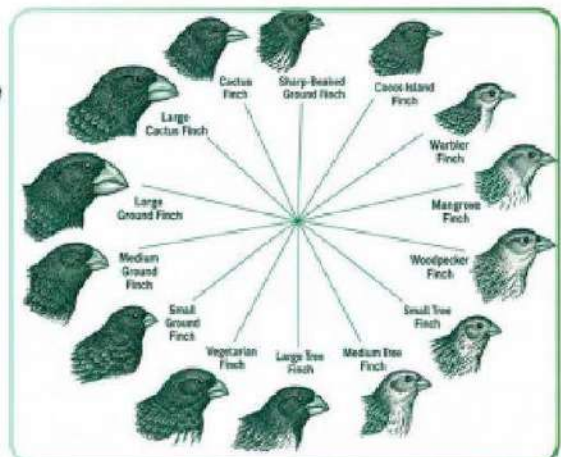
- Darwin was surprised by the diversity of:
 - **Giant tortoises | Finches**

Galapagos Islands

- Flora and fauna of Galapagos were *very distinct from the life form of Europe*.
 - They resembled those of **South America** more than those of any other region.
- At the same time, they also showed **distinct differences**.
- Darwin observed **13 types of finches**.*
- These finches were:
 - Quite similar
 - But different species

BTB

- **Galapagos Islands** were named after the **giant tortoise**.
- Giant tortoises showed differences in shell shape. They had:
 - **Dome-shaped shells**
 - **Or Saddle-shaped shells**
- Their important features were:
 - Size - **4 feet**
 - Weight - **475 pounds**
 - Life span - **100 years**
 - Feed on **plants**



*FTB says 14 types of finches.

- Their beaks differed in:
 - **Size**
 - **Shape**
- These beaks were adapted for feeding on **different kinds of food**
- Similarly, he observed **giant tortoises**.
 - They had difference in shell shape.
- Some had **dome shaped shell** and other had **saddle shaped**.

FTB

- Some finches were **unique to individual islands**
- Some were distributed in **two or more closely situated islands**

02

DARWIN'S INITIAL CONCLUSION

- **Origin of species** and **adaptations** are closely related processes.
- New species arise by:
 - **Gradual accumulation of adaptations** in **different environments** after being separated from the original habitat by **geographical barriers**

03

DEVELOPMENT OF DARWIN'S THEORY

- Darwin began formulating his theory in the **late 1830s**.
- He wanted **more evidence** before announcing it publicly.

Early Written Work

Year / Period	Development
1842	<ul style="list-style-type: none"> • Prepared a brief 35-page sketch • It was for himself only
1844	<ul style="list-style-type: none"> • Wrote a 230-page essay • Showed it to friends • But it was not published
Next 15 years	<ul style="list-style-type: none"> • Continued collecting more facts • Also got inspired by works of others

04

CONTRIBUTORS TO DARWIN'S THINKING

Lyell and Hutton

- Darwin took the book '**Principles of Geology**' by Lyell on the voyage.
- This book supported Jame Hutton's theory of **uniformitarianism**.
- Main ideas of this book were:
 - Mountains, valleys, deserts, rivers, and lakes were formed by **existing forces** and **natural conditions**.
 - A river creates a valley.
 - Mountains are worn down to hills and finally to **plains**.
 - Earth developed through a series of **slow changes**.

STB

- According to Principles of Geology, geological processes at the beginning of time were the **same as today**.

- Therefore, Earth is **very old**.
- Darwin thought that life also changed in the **same gradual way**.

Thomas R. Malthus

- Darwin was influenced by **An Essay on the Principle of Population** by Malthus.
- It stated that:
 - Population increases **exponentially**.
 - Food supply increases **arithmetically**.
- This leads to:
 - **Struggle for food**
 - **Struggle for existence**

Alfred R. Wallace

- In **1858**, Wallace sent an essay to Darwin.
- Darwin forwarded Wallace's essay to **Lyell**.
- Darwin found that Wallace had reached a theory of **origin of species by means of natural selection**.
- Darwin's and Wallace's works were presented together under a single title as:
 - **On the Tendency of Species to Form Varieties; and on the Perpetuation of Selection**
- This work was presented on **July 1, 1858**.

BTB

- Hutton was also the **first person to propose a mechanism of natural selection** to account for evolutionary change over time.
- Darwin was also inspired by Hutton's work.

KTB

- Human population, if unchecked, would **double every 25 years**.

7.5 DARWIN'S THEORY OF EVOLUTION

- Darwin explained evolution in his book **The Origin of Species**.
- His theory has **two main points**:
 - **Descent with modification**
 - **Natural selection and adaptation**

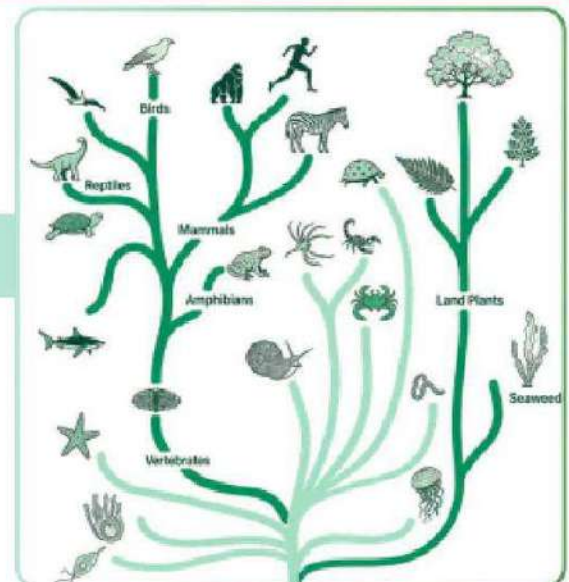
01 DESCENT WITH MODIFICATION

Unity in Life

- Darwin believed in **perceived** unity in life, in which:
 - All organisms **descend from a common ancestor**.
 - Adaptation to various environments results in **diversity**.

History of Life

- Darwin described the history of life as a **tree**. This tree shows:
 - **Multiple branching** from a common trunk.
 - At each fork, there is an **ancestor common to all lines of evolution** branching from there.
 - *Tips of the living twigs* shows current **biodiversity** of organisms.



BTB

- **Descent with modification** is the **backbone of Darwin's theory of evolution**.

02

NATURAL SELECTION AND ADAPTATION

- **Natural selection and adaptation** form the second major part of Darwin's theory.
- Natural selection is based on **differential reproductive capacities**.
- Some organisms reproduce **better than others**.
- Darwin explained natural selection through **four observations**.

Observation 1: Overproduction

- Organisms produce **more offspring** than can survive.
- Resources are **limited**.
- Therefore, only **limited offspring survive**.

Observation 2: Variations

- Individuals show variations in:
 - **Form**
 - **Size**
 - **Colour**
 - **Habit**
 - **Physiology**
- Not even **identical twins** are exactly alike.
- Variations are of two types:
 - **Harmful variations** - place individuals at a great disadvantage
 - **Useful variations** - increase the chances of survival.

Observation 3: Struggle for Existence

- When there are **more individuals** and **fewer resources**, competition occurs.
- Organisms struggle:
 - For **food** and **space**
 - For **mates**
 - Against **adverse environmental conditions**
- This struggle aims at:
 - **Self-preservation**
 - **Self-perpetuation**

Observation 4: Natural Selection / Survival of the Fittest

- Survival is **not random** - depends on part of *hereditary constitution* of the surviving individuals.
- In the struggle for existence, individuals with **advantageous variations** survive.
- This process is called:
 - **Natural selection** — by Darwin
 - **Survival of the fittest** — by Herbert Spencer

BTB

- The theory of evolution states that species change over time. The primary mechanism for this change is natural selection. The fossil record, morphology, biogeography, comparative anatomy, embryology and a molecular biology all provide evidences for evolution.

Type	Description
Intra-specific struggle	<ul style="list-style-type: none"> • Occurs among members of the same specie • Includes competition among rivals
Inter-specific struggle	<ul style="list-style-type: none"> • Occurs among members of different species • Includes prey or predation relationships
Extra-specific struggle	<ul style="list-style-type: none"> • Also called environmental struggle • Occurs against forces of nature

FTB

- The fittest individuals are those that **reproduce most successfully**.

Speciation

- Surviving individuals transmit **useful variations** to succeeding generations.
- Over time, descendants become **different enough** to be called a **different species**.
- This process is called:
 - **Formation of new species**
 - **Descent with modification**
 - **Evolution**

02

ADDITIONAL HIGH-YIELD POINTS

- The *ultimate source* of all changes is **mutation**.
- **Crossing over** produces **genetic variations** among offspring.
 - Genetic variations lead to tremendous **variations** in their **traits**.
 - *Variations* provide **raw material** for evolution by letting them adapt successfully to the changing environment.
- A **population** is the **smallest unit** that can **evolve**.
- Evolution leaves observable signs.
- **Visual record by fossils** is the strongest evidence of evolution.
- Strongest evidence based on *unity and diversity of life* is **molecular biology**.
- Natural selection can amplify or diminish only **heritable characteristics**.
- **Biogeography** gave Darwin the **first idea** that species change/evolve over time.

BTB

- Evolution rarely follows a straight line from one species to another. Instead, it is more like a branching tree. Some branches give rise to new branches, while others become dead ends.

PTB

- Carolus Linnaeus, as a natural theologian, believed that species were permanent. A century later, the taxonomic system of Linnaeus became a focal point in Darwin's arguments for evolution.