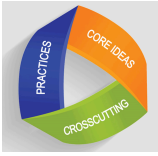
2:2

Unit: 2
Lesson: 2

Time Length: 45–50 min

The Science of Evolution: Key Principles

Evolution and God's Special Creation



NGSS Instructional Outcomes

Next Generation Science Standards

Life Sciences

HS-LS3: Heredity: Inheritance, variation of traits, and understanding the role of DNA and genetics in evolution.

HS-LS4 Biological Evolution: Unity and Diversity: Understanding natural selection, common ancestry, and biodiversity, all of which are key aspects of the lesson.

Science and Engineering Practices

Analyzing and Interpreting Data: Students will analyze data and information about the principles of evolution and how they are understood in different contexts.

Engaging in Argument from Evidence: Discussing and evaluating different perspectives on evolution involves constructing arguments based on evidence.

Crosscutting Concepts

Patterns: Observing patterns in the natural world that can be explained by the theory of evolution.

Cause and Effect: Understanding the mechanisms of evolution, like natural selection and genetic mutation.

CCSS Instructional Outcomes

Common Core State Standards

English Language Arts Standards for Literacy

CCSS.ELA-Literacy.RST.11–12.1: Cite specific textual evidence to support analysis of science and technical texts, making connections between the theory of evolution and various Islamic perspectives.

CCSS.ELA-Literacy.RST.11–12.2: Determine the central ideas or conclusions of a text; provide an accurate summary that distinguishes among fact, reasoned judgment based on research, and speculation.

English Language Arts Standards for Speaking and Listening

CCSS.ELA-Literacy.SL.11–12.1: Initiate and participate effectively in a range of collaborative discussions on the topic of evolution and its various interpretations, integrating and evaluating multiple sources of information.

Content Learning Outcomes:

- Describe and explain the scientific account of Neo-Darwinian evolution.
- Describe, categorize, and evaluate various Muslim responses to Neo-Darwanism.

Materials:

- Instruction/Teacher Facilitation: Slides 2.19–2.38
- Triple-Entry Vocabulary Journal (Student responsibility)
- Lesson 2.2 Assessment (combined with 2.3 Assessment)

Instruction/Teacher Facilitation: Slides for Lesson 2.2

- **Slide 2.19.** The Science of Evolution
- **Slide 2.20.** What is Evolution?
- **Slide 2.21.** Key Principles of Evolution: Deep Time
- **Slide 2.22.** Key Principles of Evolution: Deep Time
- **Slide 2.23.** Key Principles of Evolution: Deep Time
- **Slide 2.24.** What is Evolution?
- **Slide 2.25.** Key Principles of Evolution: Common Ancestry
- **Slide 2.26.** Key Principles of Evolution: Common Ancestry
- **Slide 2.27.** Key Principles of Evolution: Common Ancestry
- **Slide 2.28.** Key Principles of Evolution: Common Ancestry
- **Slide 2.29.** Key Principles of Evolution: Common Ancestry
- **Slide 2.30.** Key Principles of Evolution: Common Ancestry
- **Slide 2.31.** What is Evolution?
- **Slide 2.32.** Key Principles of Evolution: Common Ancestry
- **Slide 2.33.** Key Principles of Evolution: Mechanisms
- **Slide 2.34.** Key Principles of Evolution: Mechanisms
- **Slide 2.35.** Random Mutations
- **Slide 2.36.** Natural Selection
- **Slide 2.37.** What is Neo-Darwinism?

Instruction/ Teacher Facilitation

In Lesson 2.1, we discussed the two big factors in the concept of evolution; the age of the Earth (time factor) and the origin of man from an Islamic perspective (theology-focused). We are going to build on that by looking at it from the perspective of bioscience.

- NOTE: Review Exit Tickets from Lesson 2.1 and see what questions students still have and address them in this lesson.

- Most of this lesson will be a review and a helpful summary of the chapters regarding evolution which should have already been covered in a Biology class. Therefore, throughout this lesson, students can be asked to recall the information being presented and then fill in the gaps with the information within this lesson. If the lessons of evolution have not been covered in a previous Biology class, the teacher might need to go slowly and provide more details.

Slide 2.19: The Science of Evolution

Let us now look at the common narrative of evolution and its key principles.

The concept of evolution was theorized by Charles Darwin, often referred to as the father of evolution. During his voyage to South America, he traveled to the Galápagos Islands, where he closely studied finches and other species. He observed that the finches varied from island to island, particularly in their beak shapes, which appeared to be adapted to different environments. From these observations, Darwin developed several ideas to explain these differences, ultimately leading him to publish his well-known work, The Origin of Species by Means of Natural Selection (1859). Let us now examine the key principles he outlined.

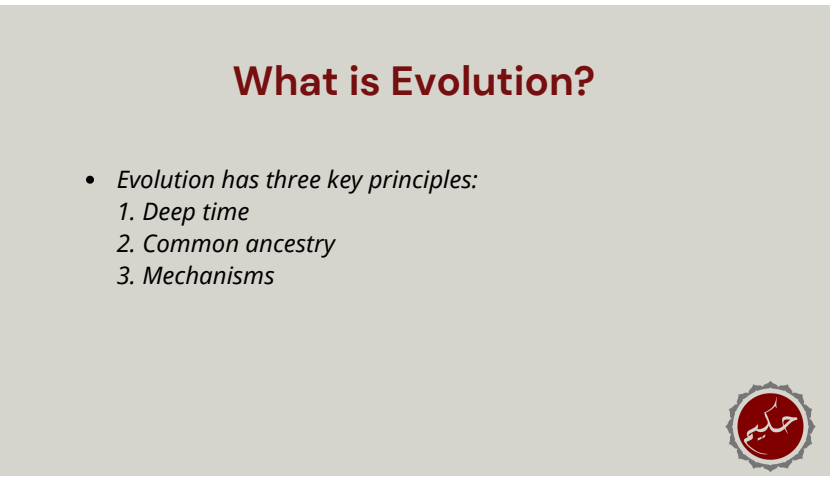
Historically speaking, Darwin was not the first to come up with the concept of evolution as contemporaries and other scholars before that had similar theories.

> What was unique about Darwin's presentation of this idea was that he came up with a process by which evolution takes place, a mechanism to try to explain the diversity of life seen on earth.

> Using the process of induction, he was able to generalize and extrapolate a process for explaining evolution

This lesson will focus on what we understand about evolution today, based on and including, all the scientific advancements that we have had since then. Therefore, there will be differences between Darwin's concept of evolution (at his time) and the modern conception of evolution.

Slide 2.20: What is Evolution?

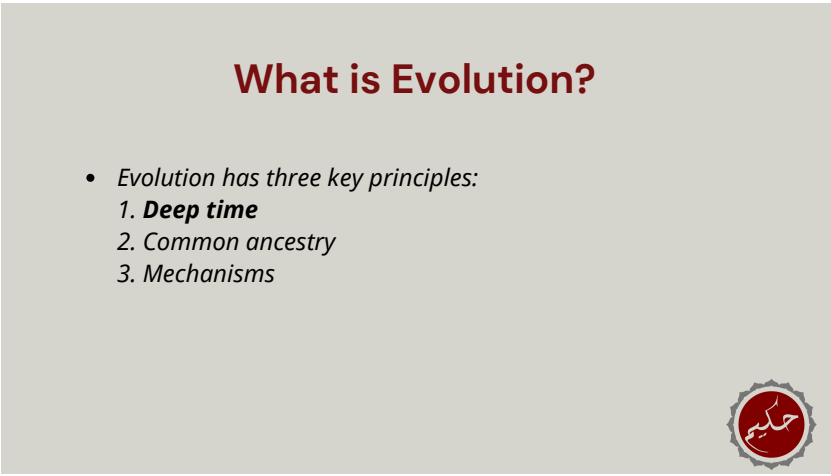


Evolution has three key principles:

1. Deep time (needed for gradualism)
2. Common ancestry (or descent)
3. Mechanisms (natural selection)

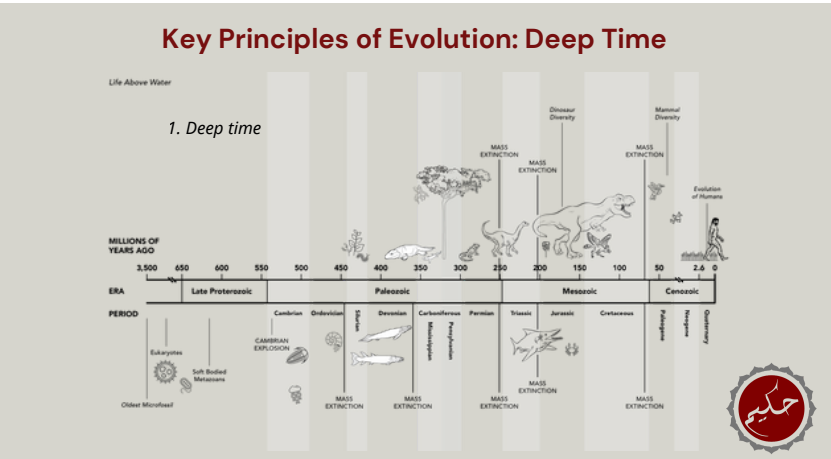
We will look at each one and elaborate on how it is defined in evolution.

Slide 2.21: Key Principles of Evolution: Deep Time



Let us examine the first of the prinicples which is **Deep Time**.

Slide 2.22: Key Principles of Evolution: Deep Time



Deep Time: The First of the Principles of Evolution

At the time of Darwin, the idea of the age of the Earth was just that the earth was really old. No one had a precise measurement, but people assumed that the Earth was old. Tthe Earth was estimated to be around 6,000 to 10,000 years old according to Biblical calculations, considering the number of prophets mentioned and their assumed timeline.

The reason that the age of the Earth is important is because an extremely long period of time is required for the gradual changes seen in nature, according to the concept of evolution. Given the small changes over a long time, an extremely long period is needed to see major changes.

Slide 2.23: Key Principles of Evolution: Deep Time

The estimate of the Earth's age now is around 4.6 billion years. [For a visual and more detailed explanation of how this is divided, see the **Supplemental Material: Prehistoric Timeline** on p. 105.]

Calculations are based on rock samples and isotope measurements within them. The decay of long-lived radioactive isotopes of elements that occur naturally in rocks and minerals is examined. Scientists then compare the present concentration of a radioactive isotope to its decay product in a rock sample, like measuring the amount of cake left in the oven to determine how long it has been baking.

Scientists use radioactive isotopes to determine the age of the Earth through a process called **radiometric dating**. One commonly used method is uranium-lead dating, which relies on the radioactive decay of uranium isotopes into lead. Radiometric dating is a technique that has provided valuable insights into Earth's history, helping us understand its age, geological processes, and the timing of major events on our planet. This is a tool in the field of geology and has greatly contributed to our knowledge of Earth's evolution.

It has been determined that, being such a robust and well-established technique, it has only a 1 percent error range.

Slide 2.24: What is Evolution?

What is Evolution?

- Is this qaṭ'ī or ẓannī?
  - Measurements are based on:
    1. Rock samples
    2. Isotope measurements
  - 1% error range

This leads to the question, is this information about the age of the Earth *qaṭ'ī or ẓannī?*

Give students an opportunity to answer the question and give their reasons as to why they think it is either *qaṭ'ī or ẓannī.*

It would be *ẓannī* still, due to that 1 percent error. Remember, *qaṭ'ī* is only when there is 100 percent certainty, no doubt whatsoever.

[For more information, read The Age of the Earth (1991) by G. Brent Dalrymple.]

Slide 2.25: Key Principles of Evolution: Common Ancestry

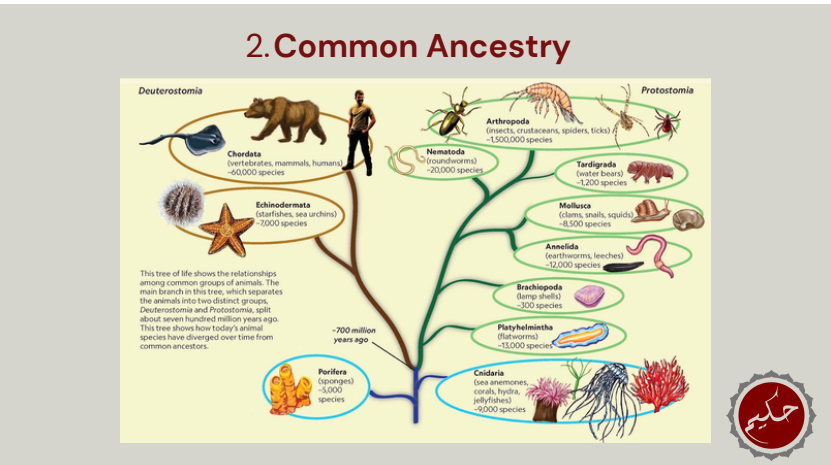
Key Principles of Evolution: Common Ancestry

- Evolution has three key principles:
  1. Deep time - the earth is really old (4.6 billion years)
  2. Common ancestry
  3. Mechanisms

Common Ancestry: Second of the Principles of Evolution

We are all familiar with the concept of a family tree. A family tree allows us to see how different members of that family are related or connected, who the ancestors are, who the descendants are, that is, how generations are linked together.

Slide 2.26: Key Principles of Evolution: Common Ancestry



Similarly, biology takes this same concept and applies it to an entire species. The theory of evolution seeks to explain that all biological life is connected over a long period of time, which defines this concept of **common ancestry**.

This is represented and examined through a Phylogenetic Tree of Life, which shows that all life came from the very same cell and continued to develop/adapt and branch off into different forms of life.

Common ancestry is explained by the branching and diversification of lineages as populations adapted primarily through natural selection.

This is not only a way to explain the diversity of life (of all living things), but it also is a way of understanding the unity of life (core requirements that all living things have in common). While living things come in many different forms, they all share common features. For example, all living things have cells with similar structures and functions, use DNA built in the same way, and are made from the same basic organic molecules.

Slide 2.27: Key Principles of Evolution: Common Ancestry

2. Common ancestry

- An important distinction between:
  - Origins of **life** – abiogenesis
  - Origins of **species** – evolution

An important distinction that needs to be made is between the origin of life versus the origin of species.

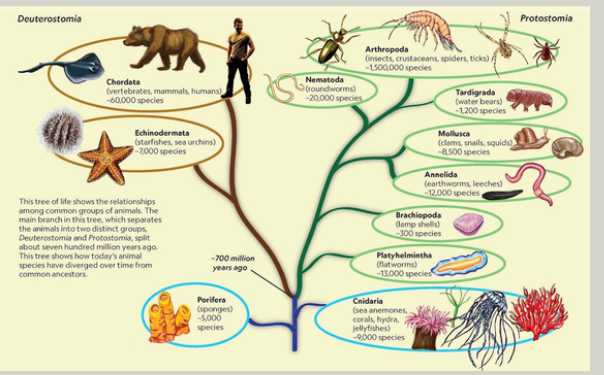
Origins of life (abiogenesis) refers to the very first life form (from which all life then originates).

Origins of species (evolution) refers to how species evolve into other species.

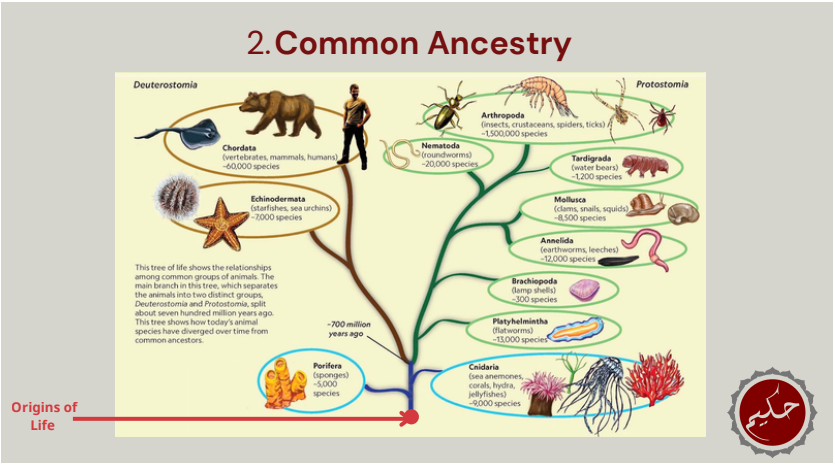
- It is interesting and important to note that Darwin never mentioned humans in his book when talking about the origin of species. He primarily focused on animals and insects. His book was called the Origin of Species not the "Origin of Life."

Slide 2.28: Key Principles of Evolution: Common Ancestry

2. **Common Ancestry**

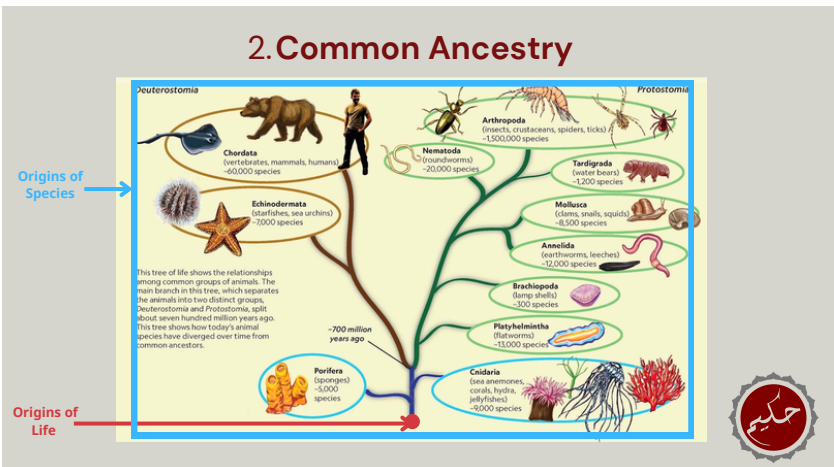


Slide 2.29: Key Principles of Evolution: Common Ancestry



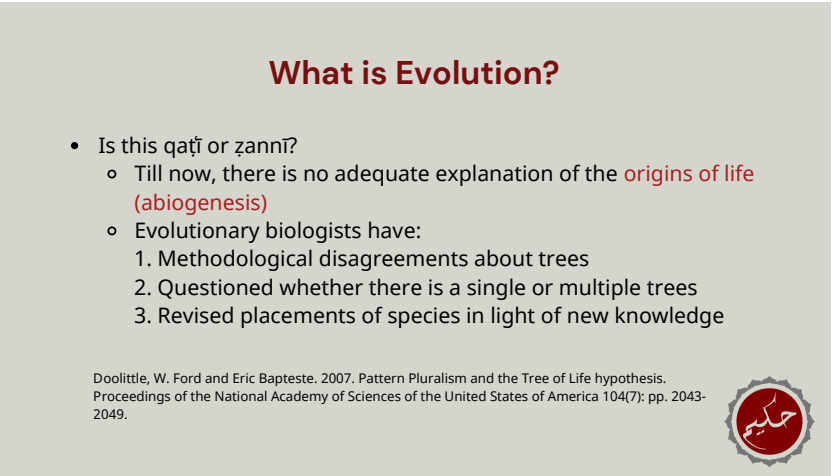
On a phylogenetic tree of life, the organism or cell at the very bottom tip would depict the origin of life.

Slide 2.30: Key Principles of Evolution: Common Ancestry



The rest of the tree depicts the origin of species.

Slide 2.31: What is Evolution?



Evaluating if this principle is *qaṭ̓ī or ẓannī*

- Until now, there is no adequate explanation of the origin of life, abiogenesis, from a scientific perspective.
- Evolutionary biologists have:
  - Methodological disagreements about these phylogenetic trees (where they should branch, which species to be included where or under which previous species, and so on).
  - The branching patterns of phylogenetic trees often disagree even when they have been constructed using different portions of the same data. This phylogenetic discord can be explained by real differences in evolutionary process or history but also may be due simply to random chance or sampling error.
  - It is questioned whether there should be a single tree or multiple trees to accommodate all the disagreements and interpretations of the data.
  - Constantly revised placements of species in the light of new knowledge. Scientists cannot go back in time and investigate or analyze extinct species. Scientists can only use inferences based on current traces and project them backwards, onto the past.
- As a result, what we get from this is that inferences and projections are constantly changing due to new information being deciphered.
- This would mean that the principle of common ancestry is very *ẓannī* in terms of its truth, seen through the constant adjustments and disagreements.

[For more information, read W. Ford Doolittle and Eric Bapteste, "**Patterns of Pluralism and the Tree of Life Hypothesis.**" *Proceedings of the National Academy of Sciences of the United States of America 104 (7) (2007): 2043–2049.]*

Slide 2.32: Key Principles of Evolution: Common Ancestry

Key Principles of Evolution: Common Ancestry

- Evolution has three key principles:
  1. Deep time - the earth is really old (4.6 billion years)
  2. Common ancestry - all biological life is interconnected through a long, historical lineage like a family tree
  3. Mechanisms

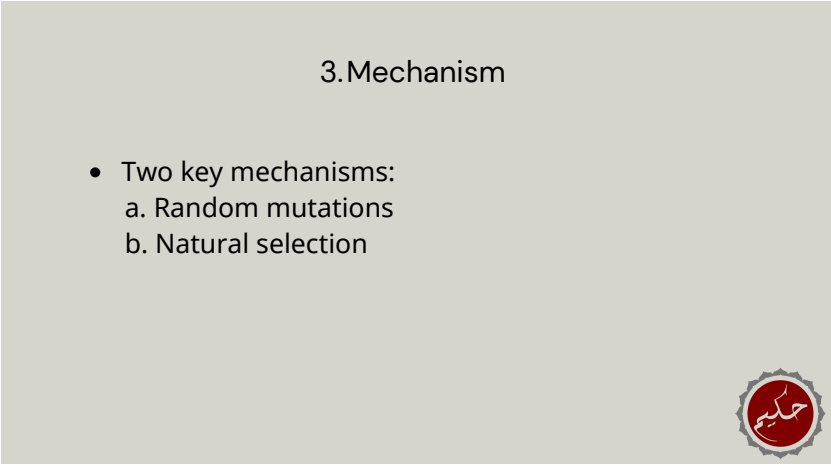
Slide 2.33: Key Principles of Evolution: Mechanisms

Key Principles of Evolution: Mechanisms

- Evolution has three key principles:
  1. Deep time - the earth is really old (4.6 billion years)
  2. Common ancestry - all biological life is interconnected through a long, historical lineage like a family tree
  3. Mechanisms

Mechanisms: Third of the Key Principle of Evolution

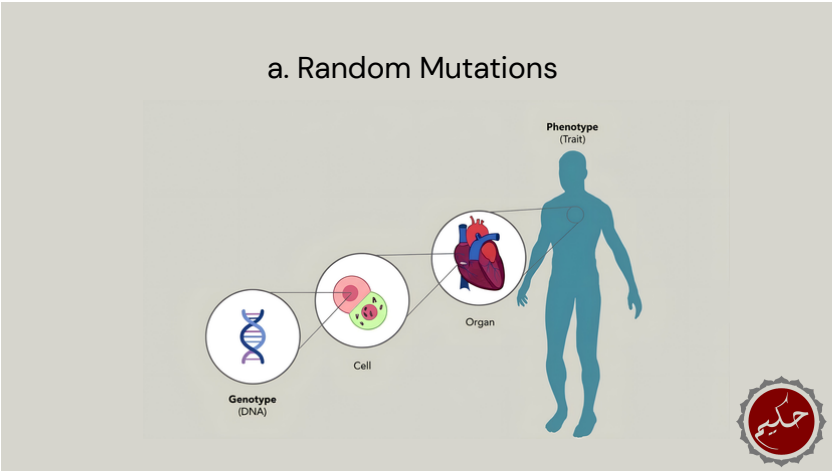
Slide 2.34: 3. Mechanisms



There are two key mechanisms in evolution:

1. Random mutations
2. Natural selection

Slide 2.35: Random Mutations



Random mutations are changes in the nucleotide sequence of DNA that occur without a pattern (i.e., randomly) and introduce new variations into a population.

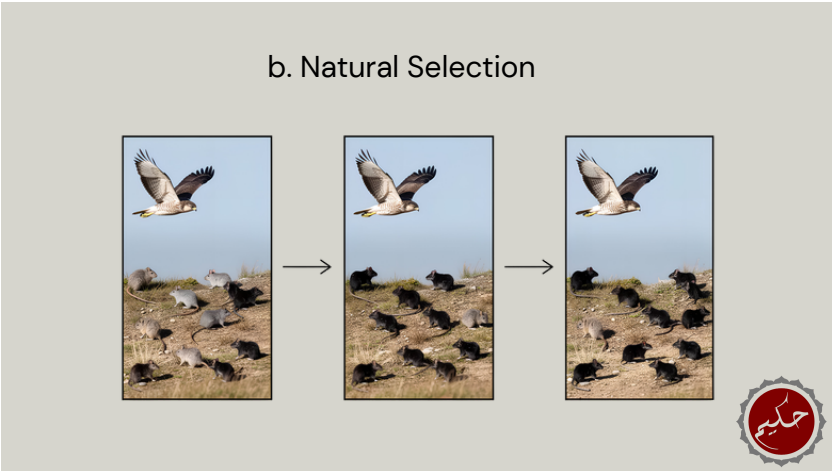
These genes are then combined or mixed on very probabilistic measures.

After this combining/mixing of genes happens to produce offspring, we cannot absolutely determine which gene came from which parent. For example, if we are calculating the projectile of a tossed ball, we would be quite accurate based on the speed, its angle, distance, and the like. But this is not the case with genes. We cannot say with certainty which genetic makeup will be passed on to the offspring.

- Example: toss a coin and you can never know with absolute certainty that the coin will land on heads or tails.

- We consider this “random” only because we have not figured out what the particular mechanism is that determines such information.

Slide 2.36: Natural Selection



Natural Selection is an organism’s ability to survive in a specific environment, in other words, nature’s ability to select the ones that are the most capable to survive in that environment. Because of the organism’s survival, they are able to live long enough to reproduce, passing on that successful trait to their offspring.

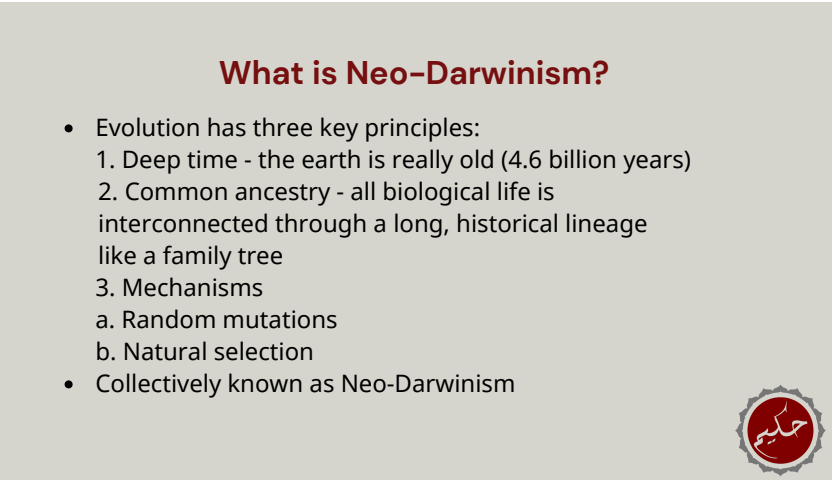
Famous examples:

- A longer neck allows animals to reach the leaves in trees to eat, and those who cannot reach it will have more competition with other organisms who eat food at a lower height. Therefore, giraffes survive, passing on their gene to their offspring which continue to reproduce due to the lack of competition and consistent food sources.

- In a dark field, there are white mice and dark mice (black or brown). Because white mice are easily seen on dark terrain, they become easy targets for predators; predatory birds to be specific. This results in the dark mice surviving longer and reproducing and passing on that dark color gene. The dark mice are selected by nature to survive in this environment.

> Note that if the terrain was light in color, the white mice would be selected for, and would survive, whereas the dark mice would be selected against and eaten much easier by predators. Therefore, a key aspect to remember is that the environment in which the organism lives plays a vital role in which the organism survives.

Slide 2.37: What is Neo-Darwinism?



In summary, what is evolution?

Evolution is characterized by three key principles:

1. Deep time: the earth is really, really old (4.6 billion years old).
2. Common ancestry: all biological life is interconnected through a long, historical lineage like a family tree.
3. Mechanisms
    a. Random mutations
    b. Natural selection

Collectively, this is known as **Neo-Darwinism**.

> Neo-Darwinism is defined as a theory of evolution that represents a synthesis of Charles Darwin's theory in terms of natural selection and adds modern population genetics.

> The key difference to note is that Darwinism was based on phenotypic differences passed down for speciation, but Neo-Darwinism has been updated to include genetics to explain these differences and the understanding that variant genes are inherited and passed down.

Biological Connections

- This lesson can be connected to the chapter on concepts of evolution and biodiversity of life in Biology classes
- These concepts can also be connected to the definition of mammals, due to the concept of *Al-Ḥayawān an-Nāṭiq*.
- This lesson can also be connected to cellular reproduction (mitosis and meiosis) and genetics (DNA and inheritance) in Biology classes, which includes genetic mutations (usually Unit 2, according to most Biology textbooks).

Lesson 2.2 Assessment

[Note: Lesson 2:2 Assessment is combined with **Lesson 2:3 Assessment**. (See p.150)**]**