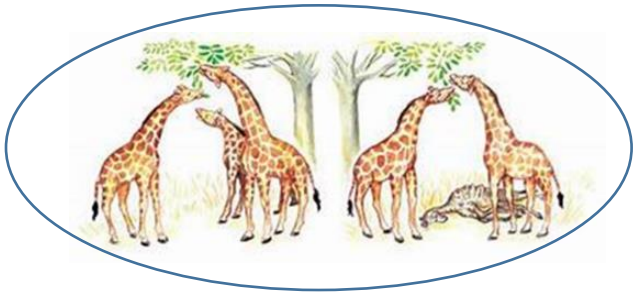

LESSON 1:

Theory of Natural Selection

7th & 10th GRADE

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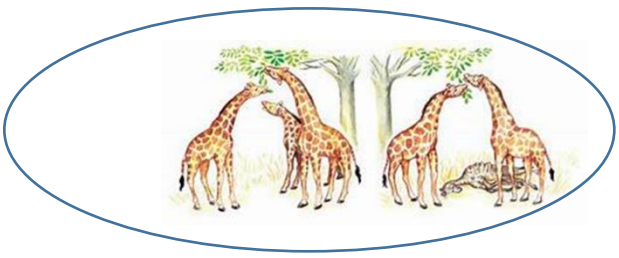
INTRODUCTION

The *Genomic Logic for Underlying Morphological Divergence (EPSCoR)* project aims to bring science-related learning experiences to schools. This lesson is the first of three designed to facilitate learning about the concepts of natural selection (module 1), adaptation (module 2), and evolution (module 3). These lessons will serve as a tool for the trainer or professional in charge of teaching (teacher, professor, among others). For participants, they can be teachers (as part of their professional development) or students.[1]

In this first lesson, the instructors or teachers of the Biological Sciences (7th grade) and Biology (10th grade) courses, and their students, will actively participate in some activities where they will understand the principles of natural selection. Emphasis will also be placed on how changes in the immediate environment affect the evolution of adaptations in species.

This lesson includes:

- ✓ Scientific background of the concepts
- ✓ Glossary
- ✓ Alignment of the content to the standards, expectations, and specificities of the Department of Education of Puerto Rico (DEPR)
- ✓ Educational Process
- ✓ Detailed activities to carry out in the classroom.



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SUBJECT	Science (Biological Sciences/Biology)
LEVEL:	Intermediate - Advanced/ 7th – 10th grade
PRIMARY CONCEPTS :	Natural selection theory, species, adaptation
SECONDARY CONCEPTS:	Biological interactions (predator-prey relationship)
PRIOR KNOWLEDGE:	Similarity, difference, biodiversity, food chains

LEARNING OBJECTIVES

Throughout the lesson, participants will:

1. Given a situation, predict the availability of a species to its predator.
2. Explain the concepts: theory of natural selection, biodiversity, species, adaptation, biological interaction (predator-prey relationship).
3. Establish how human intervention can contribute to or affect the availability of a species.
4. Establishes Darwin's path that led to the development of his theory of natural selection.

Continuous assessment

Throughout the activity, the instructors or teachers will be making observations as they move between the working groups, when participants discuss and when they present their answers to the questions. This allows them to assess the participants' learning.

STANDARDS, EXPECTATIONS AND SPECIFICITIES 7th GRADE – SCIENCE

Standard(s): Interactions and Energy, Conservation and Change

Area of expertise: Natural selection and adaptations

Expectation B.CB4: Biologial evolution: unity and diversity

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Natural and artificial selection: Natural selection leads to the predominance of certain characteristics in a population, as well as the elimination of others. Through artificial selection, humans have the ability to influence certain characteristics of organisms through selective breeding. Desired characteristics of parents determined by genes can be chosen, which are then passed on to offspring.

Adaptation: Adaptation through natural selection acts over generations and is an important process by which species change over time in response to changes in environmental conditions. Characteristics that contribute to survival and successful reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of characteristics in the population changes.

Indicators

EI.B.CB4.CC.4 Explain how genetic variations in the characteristics of a population increase the probability of survival and reproduction of some individuals in a specific environment.

EI.B.CB4.CC.5 Use mathematical representations to support explanations of how natural selection can lead to increases and decreases in specific characteristics in certain populations over time.

STANDARDS, EXPECTATIONS AND SPECIFICITIES 10th GRADE – SCIENCE

Standard(s): Interactions and Energy

Area of expertise: Natural selection and adaptations

Expectation B.CB4: Evolución biológica: unidad y diversidad

Natural Selection: Natural selection occurs only if both characteristics are present: (1) variation in genetic information among organisms in a population and (2) variation in the expression of genetic information—that is, variation in characteristics—leading to

differences in performance among individuals. Characteristics that positively influence survival will be more likely to prevail and therefore be more common in the population.

Indicators

ES.B.CB4.IE.2 Determine the effects of different types of natural selection on an organism's gene pool.

ES.B.CB4.IE.4 Construct an evidence-based explanation of how natural selection leads to the adaptation of populations.

ES.B.CB4.IE.5 Evaluate the role of natural selection in the development of the theory of evolution.

BACKGROUND

Natural selection is a mechanism through which individuals that have inherited advantageous adaptations demonstrate successful differential reproduction. In other words, natural selection implies that nature "*selects*" how organisms reproduce, according to their properties, and therefore favors adaptation, fostering the evolution of species. The term "natural selection" is part of the theories proposed by British naturalist **Charles Darwin to** explain the **evolution of species**. Natural selection theory explains how evolution can occur. According to **Darwin**, diverse biological species share a **common descendant** that has been diversifying through **evolution.** Darwin proposed his theory of evolution using as reference his five-year trip aboard the *HMS Beagle*, in which he could collect specimens and study natural history. Out of all of his observations, his most remarkable ones come from those related to Galapagos Islands' finches (or Darwin's finches).

Darwin understood that natural selection respected certain premises. The scientist, in his works, explained that the selected trait is **hereditary** and that a **variability** of this trait exists among specimens. This variability provokes differences in **biological adaptation** (survival) and makes it so that only certain characteristics from new apparitions extend throughout all of the **population**. The accumulation of these variations that survive the course of different generations constitutes the **evolutionary process** (Porto, J**.** & Merino, M., 2016).

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GLOSSARY

Adaptation —traits of an animal that helps it survive in a specific environment.

Biodiversity – variety of organisms on our planet.

Biological interactions —relations among organisms of a biological community within an ecosystem.

Difference —quality that lets something distinguish itself from another thing.

Evolution —change in inheritable traits of a population through time.

Food chains, or trophic chains – details food relations among producers, consumers, and decomposers. In other words, this chain reflects who eats whom (a living creature feeds from what precedes it in the chain, and at the same time, it is eaten by what follows it).

Morphological diversity —there are differences or variety amongst one species, but they share common traits that let those organisms reproduce and have viable and fertile offspring.

Natural selection – the process through which organisms adapt to their environment.

Natural selection theory —a theory proposed by British naturalist **Charles Darwin** to explain the **evolution of species**.

Predator/prey relationship —In ecology, predation is a kind of biological interaction in which an individual from an animal species (the predator) hunts another individual (the prey) to subsist. That same individual can be a predator for some species and prey for other species, and in all cases the predator is either carnivorous or omnivorous. This interaction serves an important role in natural selection.

Similarity—a relation among people, animals, or things that have common traits.

Species—a group of organisms that can interbreed to produce fertile descendants.

Variation—physical or genetic differences between members of a population.

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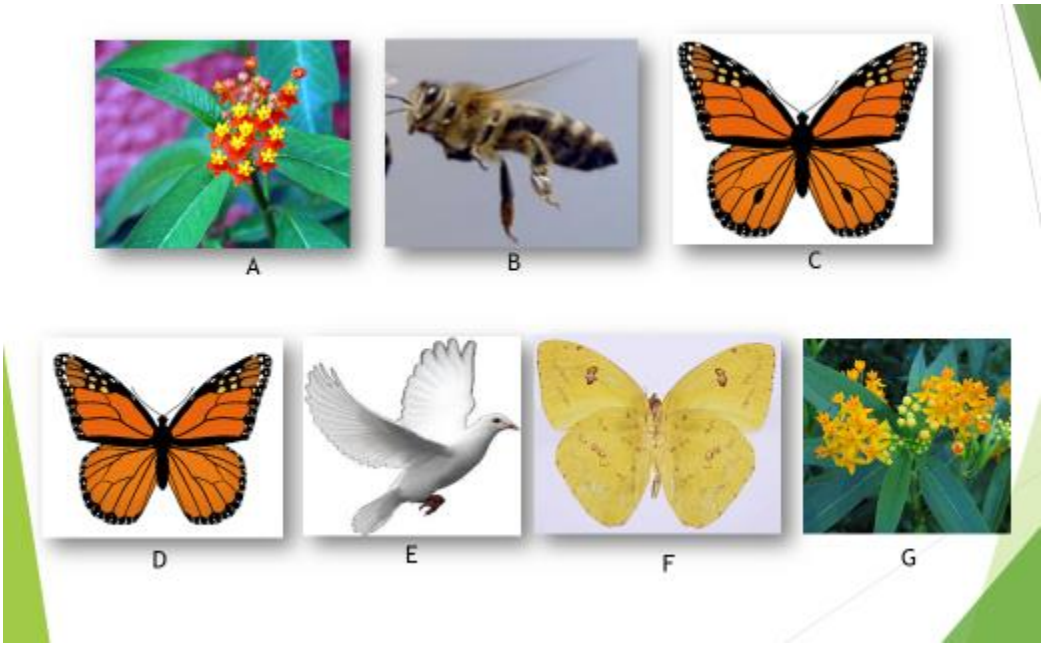
LESSON PROCESS (BEGINNING, DEVELOPMENT, AND CLOSURE)

BEGINNING

During this part, participants' prior knowledge about the concepts to be developed is explored; in this case, the theory of natural selection, species, and adaptation. This will let the instructor recognize misconceptions that participants may have and ensure that they can be corrected during the educational process.

1. The instructor will start the activity by reviewing the concepts of *similarity, difference, biodiversity,* and *species* with the participants using images or a PowerPoint presentation. These pictures could include plants, insects (butterflies), birds, mammals, etc.
   Are there any similarities between some of these organisms? How are they similar, and how are they different? Do they belong to the same species?



2. The participant will be asked to group organisms according to their similarities (some trait that they may have in common).

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Expected answers:

The butterflies, the bee, and the bird can fly because they have wings. Plants cannot move from one place to another like the rest of the organisms, and they have leaves and flowers. Organisms C, D, and F are butterflies. Organisms B, C, D, and F are insects because they have wings and antennae but no feathers, unlike the dove. Organisms C, D, and F are butterflies and organism B is a wasp.

3. The instructor will ask the participants if they know the term that describes all organisms that share specific characteristics that distinguish them from other organisms and that let them interbreed to produce fertile descendants (offspring that could also produce offspring). It is expected that the participants will answer with the term **species**.
4. Do organisms D and F belong to the same species?

   Answer: No. Although both are butterflies, they don't have the same shape and coloration in their wings.
5. Do butterflies C and D belong to the same species? Do you observe any difference between them?

   Answer: Yes, they belong to the same species. If participants do not mention the black dot that the Monarch butterfly has (organism C), the instructor can mention that this is an easy way to identify the male Monarch butterfly.
6. Can we say that butterfly F belongs to a different species than butterflies C and D?

   Answer: Yes.
7. Do plants A and G belong to the same species? Do you observe any similarities between them?

   Answer: Yes. Both plants belong to the same species (named *Asclepias curassavica*), their leaves and flowers have the same shape.
8. How are the two plants different?

   Answer: They differ in that one produces red flowers, and the other one produces yellow flowers.
9. Reflect with participants about differences between organisms of the same species.
10. What term is used when we say that among the same species, we can find differences? For example, the coloration and shape of some parts of the organisms.

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Answer: When this occurs, we say that there is morphological diversity. This means that there are differences or variety among the same species, but that they share enough common traits that let those organisms reproduce and have viable, fertile offspring.

11. Oral discussion activity—

What do these organisms have in common? In what way do they differ? Do they belong to the same species?

These organisms are similar in that they:

- are butterflies
- have wings
- have antennae
- can fly
- are insects

These organisms differ in:

- the color of their wings
- the shapes of their wings and bodies

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These butterflies belong to different species.

- What do these organisms have in common? In what way do they differ? Do they belong to the same species?

Both belong to the same species, but the flowers have different coloration.

Both plants are a variety of the same species; therefore, they present morphological diversity. This means that they vary in some traits from the species. In this case, it's the flower's color.

12. The instructor reflects with the participants. It has been reviewed that there are many kinds of organisms, whether they are plants or animals. Each species has organisms that share traits that distinguish them from other species. This lets us have abundant biodiversity.

    What do you understand about biodiversity?

    Expected answer: The word "biodiversity" means that we have a large variety of organisms on our planet. Each of these organisms has traits that distinguish them and let them survive in a place or environment.

    What do the terms "bio" and "diversity" mean?

    Expected answers: bio (life) and diversity (variety).

DEVELOPMENT

After the instructor ensures that all prior knowledge has been clarified, activities 1 and 2, related to the Natural Selection Theory, will be carried out.

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Activity #1: *The most suitable mouse* **Worksheet #1**

Materials:

Paper bags

Construction paper (5 different colors)

Piece of cloth (or a square shape drawn on paper)

Before the activity:

- The instructor must prepare a small bag (bag #1) for each work group. It will contain 20 pieces of construction paper. Five different colors will be used. Therefore, 100 pieces of paper will be needed for each work group. These pieces of paper represent the mice population.
- Prepare another bag (bag #2) with 10 additional pieces of paper per color (these will be used to represent future descendants).
- Prepare an area that represents the habitat. It could be a piece of cloth or a square shape drawn on paper. The piece of cloth should be colorful. The idea is to confuse the cloth and the pieces of construction paper (mice).

Procedure:

1) Divide participants into groups of 3 or 4.
2) Each group should have bags #1 and #2.
3) Place a piece of cloth or square shape, handed by the teacher, on the work desk. This will represent the mice's habitat.
4) In bag #1, count 20 pieces of construction paper per color, for a total of 100 pieces. This will be the initial mice population.
5) A participant will randomly scatter the pieces of paper from bag #1 in the area that represents the habitat (*make sure that the pieces of paper don't overlap; they should be visible*). The rest of the group should not watch this process.
6) The rest of the participants represent owls. These participants should pick 75 pieces (from the mice population), one by one, at random, and as soon as they see them. Count carefully. Twenty-five pieces of paper should remain in the habitat.
7) Remove the 25 surviving mice.

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8) In the data spreadsheet, write the remaining mice in the population after the first predation, sorted by color.
9) Assume that each survivor has three offspring. Place 3 pieces of paper of the same color for each survivor. Use additional pieces of paper from bag #2.
10) Write numbers in the data spreadsheet (number of mice after first reproduction). Note: You should have 100 pieces of paper again (on this occasion, colors may not be in equal quantities).
11) Shuffle the 100 pieces of paper. A participant (*different from the first round*) will scatter the pieces of paper in the habitat.
12) The remaining participants will be owls. Repeat steps 4 to 8 again. This will be the second predation.
13) Repeat until three generations of mice have been completed.
14) Complete the data spreadsheet (Table #1)
15) Answer the analysis questions.

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Table I: ***Effect of predation in a mice population throughout time***

Generation		Color				
Stage	**# of mice**	**1**	**2**	**3**	**4**	**5**
Start	**At the beginning**	**20**	**20**	**20**	**20**	**20**
1	**After first predation**					
	After first reproduction					
2	**After second predation**					
	After second reproduction					
3	**After third predation**					
	After third reproduction					

Analysis questions:

1) Graph your data. What pattern can you identify with the obtained data?
2) What trait seems beneficial to survive in this environment? Explain.
3) Explain why the number of some mice increases throughout time, while the rest decreases.
4) How do you think these results could change if the experiment continues to a total of five predated generations?

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Activity # 2: Following Darwin's Footsteps **WORKSHEET #2**

Once the first activity is over, Charles Darwin's background and his trip aboard the scientific ship Beagle will be read.

Materials:

Table #1 (with coordinates)

World map

Procedure:

1. Using table #1, identify the coordinates in which each event happened on the world map.
2. Once all coordinates have been placed, connect the dots.
3. The line traced on the map represents the route that Darwin took.

Table #1: Charles Darwin and his trip boarding the scientific ship *HMS Beagle*

Latitude	Longitude	Date and place	Events
50°N	**4°O**	December 27, 1831 Plymouth, England	Darwin embarked in the HMS (*Her Majesty's Ship*) Beagle as the captain's assistant.
14°N	**23°O**	January 16, 1832 Cape Verde Islands	Darwin makes his first observations. *"I realized that maybe I could write a book about the geology of the different countries I visited, and the idea excited me"*- Darwin's words.
23°S	**43°O**	February, 1832 San Salvador, Bahía, Brazil	Darwin explores tropical jungles for the first time.
55°S	**73°O**	September, 1832 Punta Alta, Argentina December, 1832 Tierra del Fuego, Argentina	Darwin is intrigued by the giant fossils he sees. For example, the fossil of a giant armadillo, or *glyptodon*.
34°S	**59°W**	August, 1833 Río Negro, Argentina	Darwin explores the fertile lowlands called Pampas with the zone's natives, called "gauchos."

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42°S **39°S** **37°S**	**73°W** **73°W** **73°W**	January-February, 1835 Chiloe Islands, Chile	Darwin witnesses Osorno's eruption while he's in Chiloe and experiments an earthquake in the forests near Valdivia.
0°S,	**90°W**	September-October, 1835 Galápagos Islands	Darwin finds many species of plants, birds, and turtles endemic to Galápagos, but they look mysteriously related to species on the continent. Among the many observed iguanas in Galápagos, the marine iguana is especially characteristic: no other iguana swims and feeds in the ocean. Intrigued, Darwin opens the stomachs of some of them and only finds seaweed! Many animals from Galápagos were as unusual as their habitat, and their colors often mimicked lava. Back in London, Darwin is shocked when he finds that the species group from Galápagos that he believed included many different birds actually actually belonged to the same kind: finches.
33°S,	**151°E**	January, 1836 Sydney, Australia	Marveled by marsupials, Darwin asks himself why there is a completely different group of mammals in Australia.
12° S,	**96° E**	April, 1836 Coconut Islands	Darwin studies coral reefs that grow around the islands to probe his theory regarding atoll formation.
20°S,	**57°E**	May, 1836 Mauritius	*"I took a quiet stroll along the north coast of the city; the plain, almost uncultivated, consists of a black lava field covered with coarse grass and shrubs, most of which are mimosa"* words according to Darwin's observations.
50°N	**5°W**	October 2, 1836 Falmouth, England	"*Last night, late, I arrived home. I find myself confused with so much joy.*" – Darwin's words after returning.

Information in the table was modified from:

http://www.juntadeandalucia.es/averroes/centrostic/29009260/helvia/sitio/upload/Exposicion_Darwin.pdf

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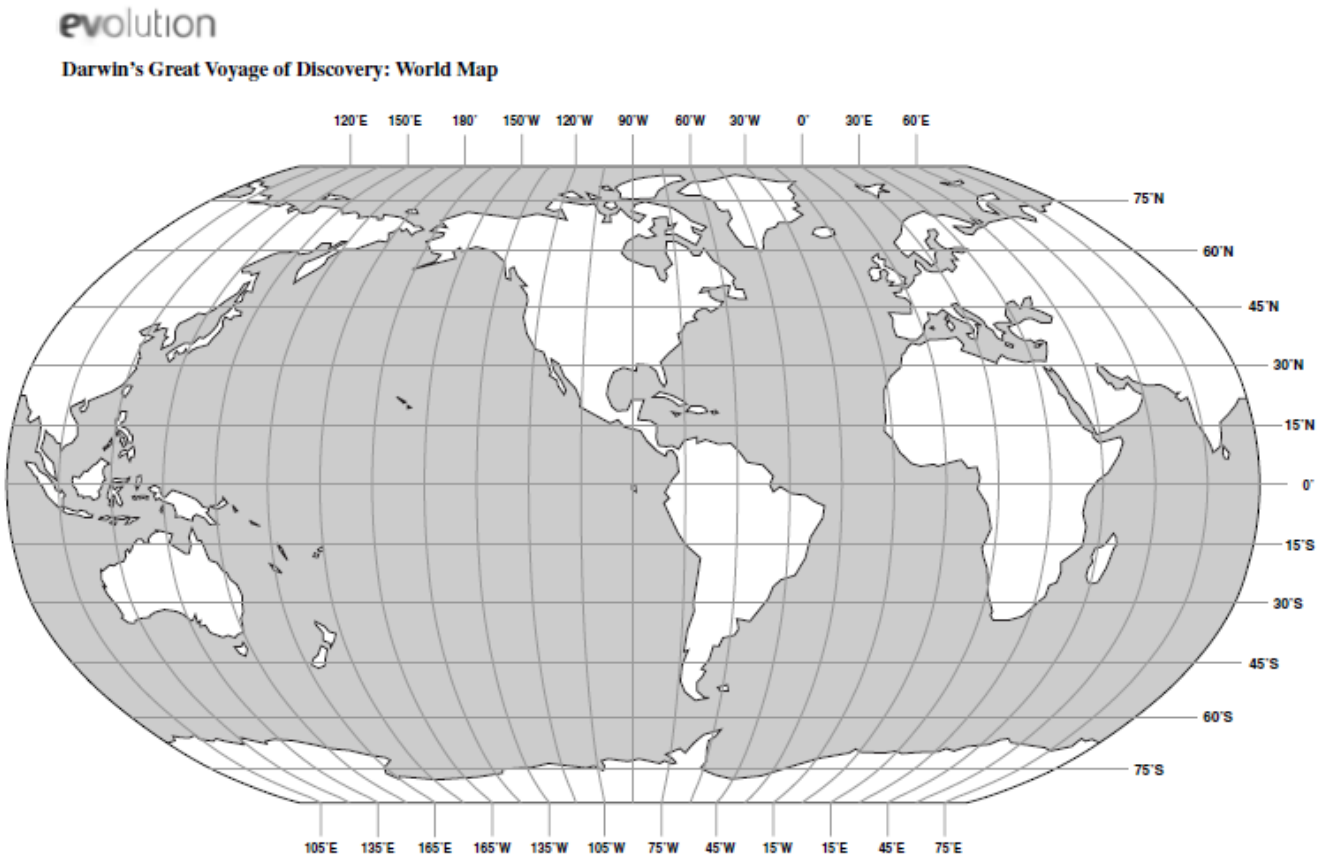
https://www-tc.pbs.org/wgbh/evolution/educators/teachstuds/pdf/darwins_excerpts.pdf

World map with coordinates



READING (can be used to resume route):

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Charles Darwin explained that the evolution of species would occur because of a series of slow and gradual changes aided by natural selection on individuals.

It was based on the variability in the offspring, which means that not all the descendants of a couple are the same; some are higher, others lower, of different colors, etc. Different environmental changes would cause the survival of the fittest, due to a natural selection that would leave out the less adapted.

His ideas were forged during his five-year journey around the world as a naturalist on the Beagle scientific ship.

While the crew drew new maps, he collected samples and made observations in the different places they visited.

In some areas, such as the Galápagos Islands, he observed the subtle differences between different species of different islands, such as the famous "Darwin's finches".

He came to the conclusion that they derived from the same common form that surely came from the continent. From it there would be slight variations, and on each island, natural selection would only survive one of the variants, thus creating new species over thousands of years.

The same was observed in the turtles. It was very helpful for him to observe the great variability of domestic species, such as birds or dogs that, belonging to the same species (can breed among them), show very different shapes and sizes.

Upon returning from the trip, Darwin began to write his conclusions. But it took him a long time to publish his book *The Origin of Species*.

Modified/Taken from:
http://www3.gobiernodecanarias.org/aciisi/cienciasmc/web/u4/contenido2.5_u4.html

CLOSURE

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Carry out **Darwin's Great Idea** activity on **Worksheet # 3.**

Activity #3: Darwin's Great Idea ***WORKSHEET* # 3**

Instructions:

1. Place the images from the worksheet in the chronological order that represents Darwin's natural selection theory and explain it.
2. Once the participants complete the worksheet, it will be discussed orally.

The most advantageous trait turns into the most frequent one among the population.

_____ _____

_____

_____

_____

Surviving brown beetles have additional brown beetle offspring.

_____

_____

_____

_____

There is a diversity of traits.

_____

The environment cannot sustain an unlimited growth in population (differential reproduction).

_____

The instructor, alongside the participants, will discuss the activity's results.

Answers:

There is a diversity of traits.

Some beetles are green and others are brown.

The environment cannot sustain an unlimited growth in population (differential reproduction).

Birds tend to eat Green beetles, who have managed to survive and reproduce less frequently tan brown beetles.

Surviving brown beetles have additional brown beetle offspring.

This occurs because the brown color trait has a genetic base.

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The most advantageous trait turns into the most frequent one among the population. The brown color is the most advantageous trait. This lets beetles have more offspring. If this process continues, ultimately, all individuals in the population will be brown.

4

The instructor will ask the participants, "Taking into account the activities that we have worked on, what do you understand by *natural selection?"*

BIBLIOGRAPHY

Julián Pérez Porto & María Merino. Published: 2014. Updated: 2016.
Definition of: selección natural (https://definicion.de/seleccion-natural/)

https://evolution.berkeley.edu/evolibrary/article/side_o_0/biospecies_01_sp

http://www3.gobiernodecanarias.org/aciisi/cienciasmc/web/u4/contenido2.5_u4.html

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