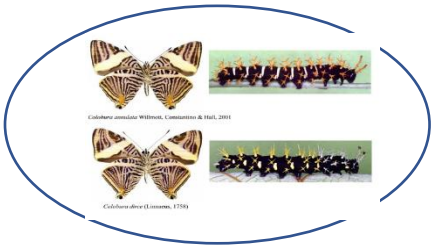

Lesson 3:

Evolution: Changes Throughout Time

7TH & 10TH GRADE

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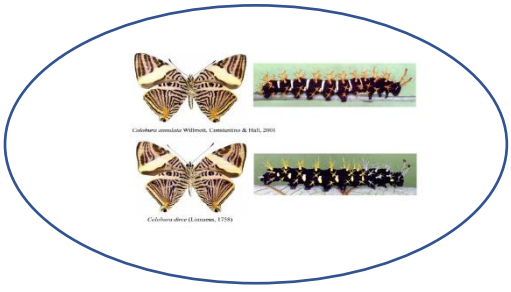
INTRODUCTION

The *Genomic Logic for Underlying Morphological Divergence (EPSCoR)* project aims to bring science-related learning experiences to schools. This lesson is the last of three designed to facilitate learning about the concepts of natural selection (lesson 1), adaptation (lesson 2), and evolution (lesson 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 last lesson, the instructors or teachers of the Biological Sciences (7th grade) and Biology (10th grade) courses, and their participants, will actively participate in some activities where they will understand the principles of evolution. 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.



SUBJECT: Science (Biological Sciences/Biology)

LEVEL: Intermediate - Advanced/ 7th – 10th grade

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PRIMARY CONCEPTS: Evolution, speciation

SECONDARY CONCEPTS: Geographic isolation, reproductive isolation, behavioral isolation

PRIOR KNOWLEDGE: Genetic variation, types of adaptations

LEARNING OBJECTIVES

Throughout the lesson, participants will:

1. Explain what speciation is.
2. Distinguish between geographic isolation, reproductive isolation, and behavioral isolation.
3. Describe and represent examples of speciation mechanisms: geographic isolation, reproductive isolation, and behavioral isolation.
4. Through dramatization, explain an example of how the process of evolution occurs.

Continuous assessment

Throughout the activity, the instructor or teachers will be making observations while moving 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: Biological evolution: unity and diversity

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.

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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.

STANDARDS, EXPECTATIONS AND SPECIFICITIES 10th GRADE – SCIENCE

Standard(s): Interactions and Energy

Area of Expertise: Natural Selection and evolution

Expectation B.CB4: Biological evolution: Unity and diversity

Evidence of common ancestry and diversity: Genetic information provides evidence of evolution.

Adaptation: Evolution is the result of the interaction between four factors: (1) the potential of a species to increase in number, (2) genetic variation among individuals within a species through mutation or sexual reproduction, (3) competition for the limited resources each individual needs to survive and reproduce in the environment, and (4) ensuring the proliferation of those organisms that are best able to survive and reproduce in the environment.

Indicators

ES.B.CB4.IE.1 Construct an evidence-based explanation that the process of evolution results primarily from four factors: (1) the potential of a species to increase in number, (2) genetic variation among individuals within a species due to mutation or sexual reproduction, (3) competition for the limited resources each individual needs to

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survive and reproduce in the environment, and (4) ensuring the proliferation of those organisms that are best able to survive and reproduce in the environment.

BACKGROUND

Evolution is the process of biological changes through which offspring differentiate from their ancestors. There is abundant evidence that supports evolution. These come from fields like molecular biology, developmental biology and paleontology, among others. Some of these evidence that we can mention are genetic and molecular evidence, anatomical and developmental evidence, and fossil and geological evidence (*Las evidencias de la evolución*, 2018).

To analyze evolution and observe how species change through time we can use their genetic variation, selection in populations, and the effects of gene flow (*La evolución de las poblaciones*, 2018).

Speciation is the emergence of two or more species that come from an existing one. For speciation to occur, changes happen through time (over many generations). We can say that some mechanisms of speciation are geographical isolation, reproductive isolation, and behavioral isolation. The causes by which a population can be separated from the rest of its species are very diverse. Possibly the easiest to understand is the one due to geographical isolation of the population. This can generate either an increase in biodiversity (if a new species occurs) or a decrease (if the population extinguishes).

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GLOSSARY

Adaptation – trait in an animal that helps it survive in a specific environment.

Behavioral isolation —the sexual attraction between males and females of a given species can be weak or absent. If the sequence of events in the courtship finding process turns inharmonious in either of the two genders, then all the process will be interrupted.

Biodiversity —the variety of organisms on our planet.

Endogamy —social behavior or attitude in which members of other groups are prevented from joining reproduction with members of a certain group.

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

Genetic drift —random changes that occur from generation to generation.

Genetic variation —physical or genetic differences between members of a population.

Geographical isolation —separation of a population from the rest of its species. Due to any cause, it may produce two effects in it: one, the extinction of the population because of an excess of endogamy and the lack of genetic variability to face changes in their environment; or two, speciation, on determined occasions, when a population remains secluded due to a genetic drift, acquiring their own differential traits that turn that population into a new species. It is not necessary to have a physical barrier, like a river, to separate two or more groups of organisms; it could simply be an unfavorable habitat between both populations that prevents mating between them.

Reproductive isolation —a set of traits, behaviors, and physiological processes that prevent members of two different species from interbreeding or mating between them, produce offspring or that offspring could be viable or fertile.

Speciation —the emergence of two or more species from an existing one; it is an event of formation of lineages that produces two or more different species.

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

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LEARNING 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 starts by referring to the question of the final activity on Module #2 (Memory Game): How do adaptations help animals and plants survive in their environment?
2. The instructor asks the participants if adaptations in organisms occur in a short time period. It is expected that participants will share their answers.
3. Using a PowerPoint presentation, the instructor refers to the geological timeline (image #1) to clear participants' doubts.

Image #1 Geological Timeline

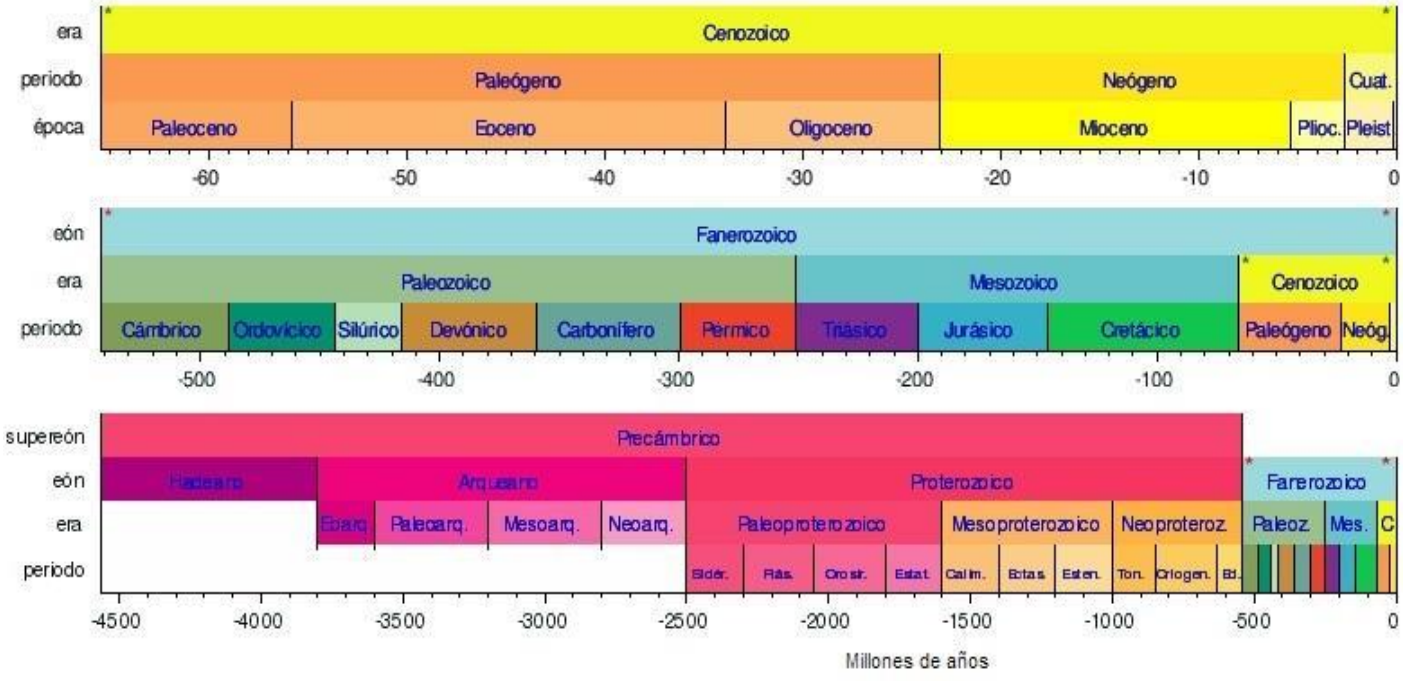

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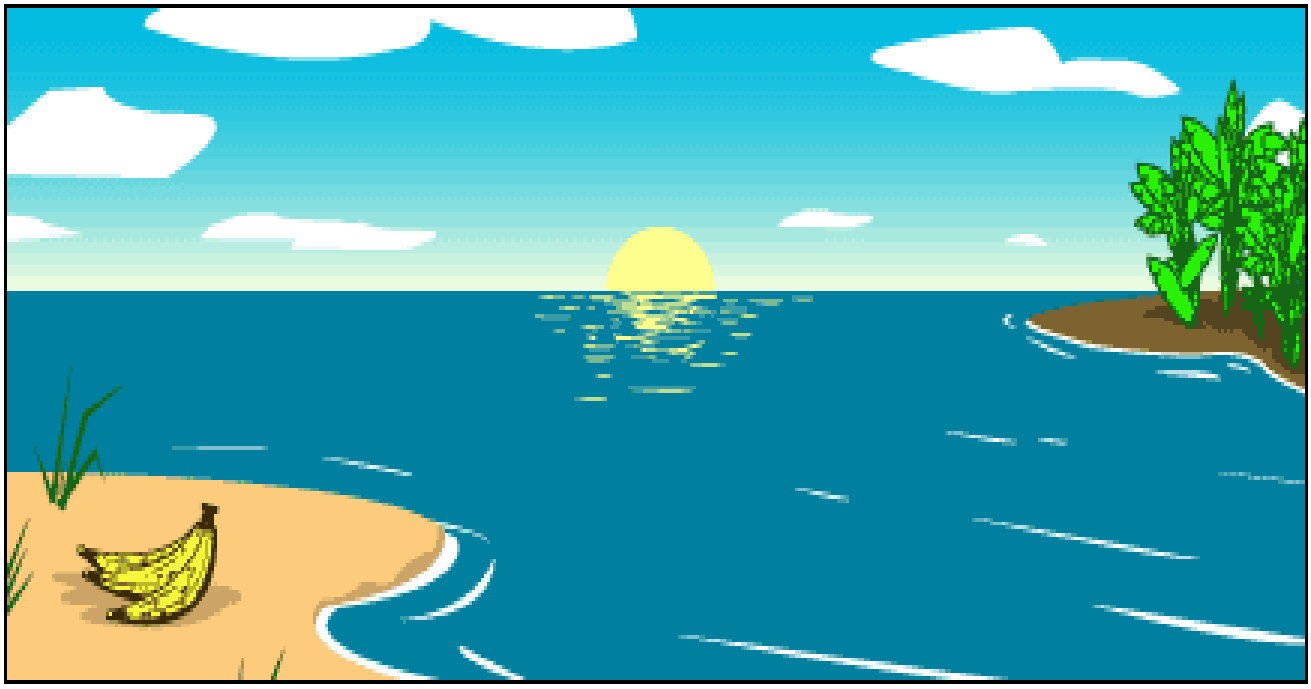
Image #1 taken from: _____

DEVELOPMENT

Activity # 1: Our speciation drama…

1. The purpose of this activity is that participants make a drama to represent the mechanisms of speciation.
2. The instructor divides the class into 3 groups.
3. Each group will be handed a different illustration (#2, #3, and #4) with the description of an event to exemplify how speciation may happen.

Illustration #2: *A disaster occurs*



A hurricane drags the plantains to the ocean alongside some flies that they had. The plantain cluster ends up being dragged to an island far off the continent's coast. The

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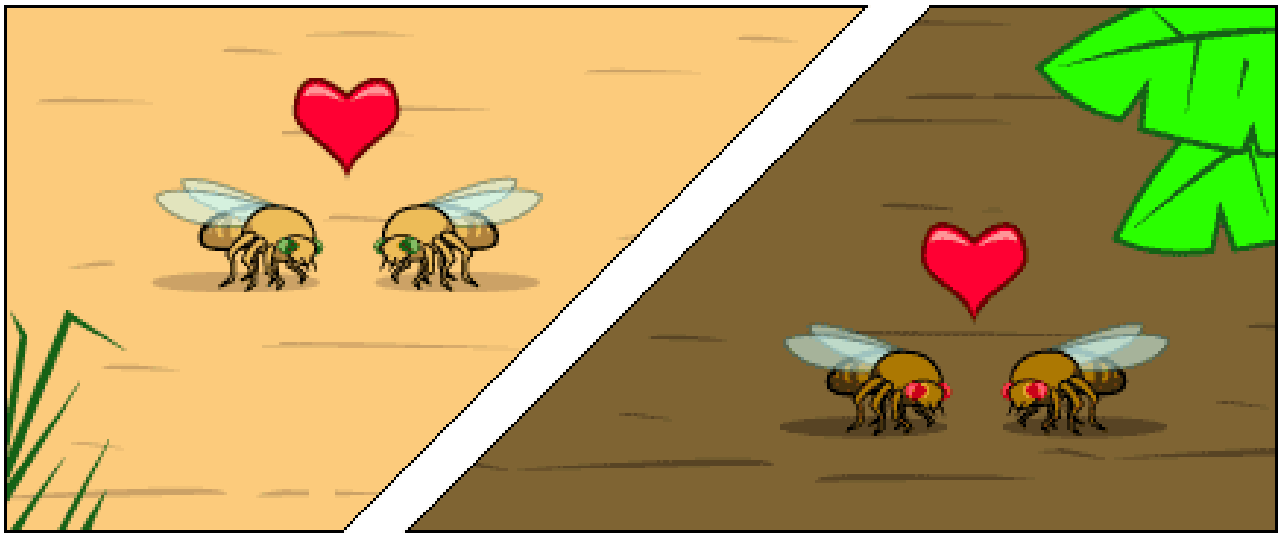
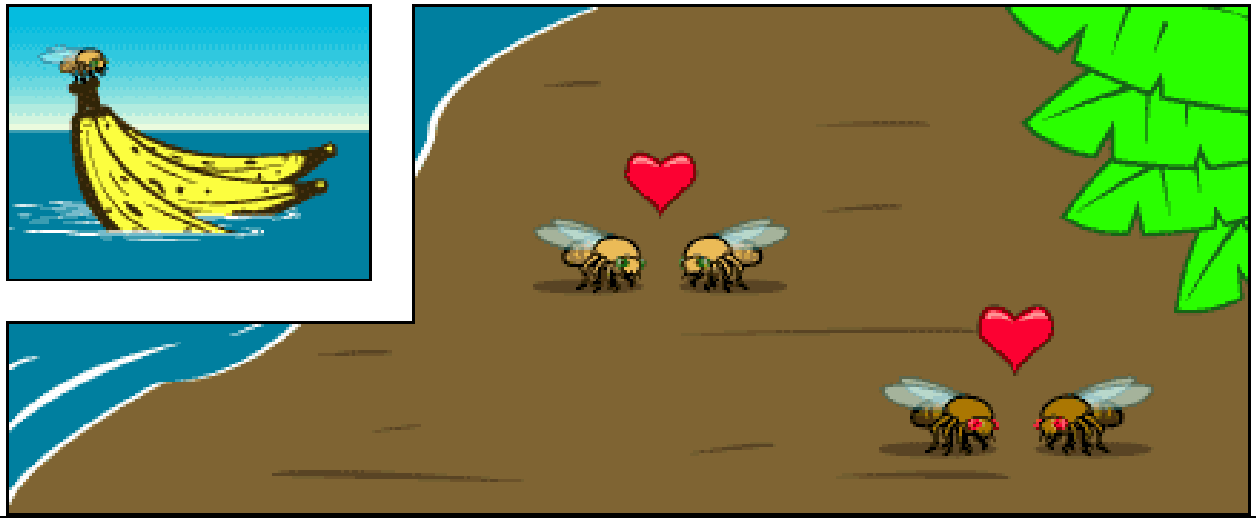
fruit flies emerge from their nest and arrive on the island. Both parts of the population, the continental one and the insular one, are too far to be joined by gene flow.

Illustration #3: *Populations diverge*



The ecological conditions are slightly different on the island, so the island's population evolves under different selective pressures and experiences random events that are different from those of the continental population. The shape, dietary preferences and courtship exhibitions change during the course of many generations of natural selection.

Illustration #4: *We meet again*



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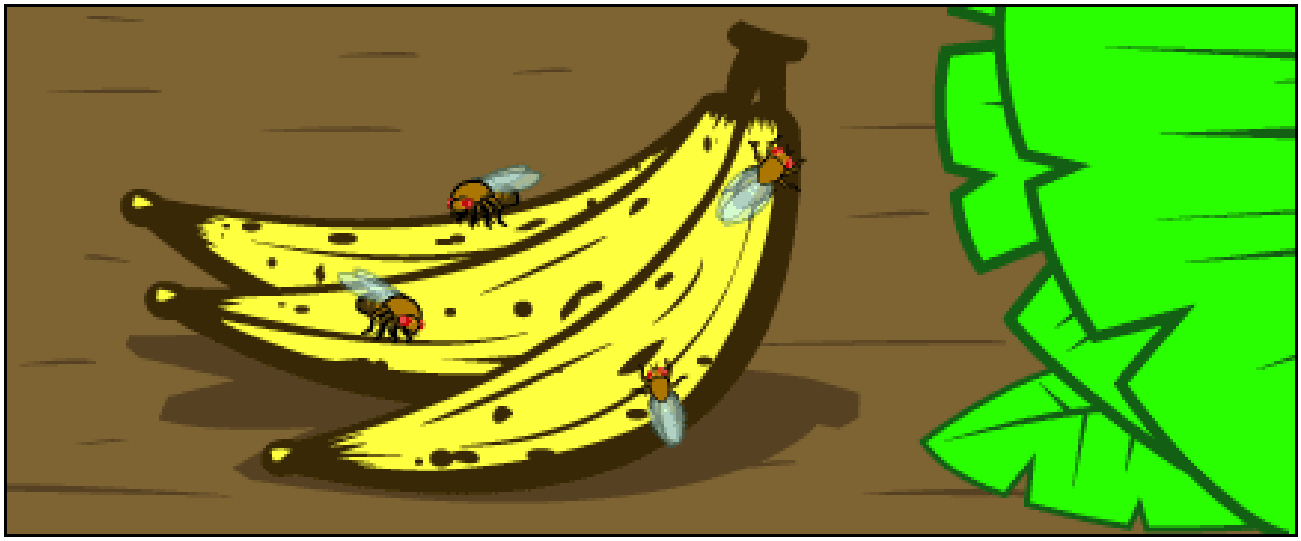
When another storm introduces the island's flies into the continent again, they don't mate easily with the continental flies because they have developed different mating behaviors. The few that do mate with the continental flies will produce unviable eggs due to other genetic differences between both populations. The lineage has separated now that genes can't flow between populations.

4. As a means of modeling, the instructor will oversee dramatizing *Illustration #1: The Scene,* included up next. The instructor will explain the instructions to carry out the drama according to the illustration that has been assigned to each group.
   - Important information for the instructor (explanation)
     - This is a simplified model for speciation by geographical isolation, but it gives an idea of some of the processes that may act on speciation.
   - It is important to remember that speciation is an event of lineage formation that produces two or more different species. This event can happen due to various factors: *geographic isolation, reproductive isolation, and behavioral isolation*.

Illustration #1: *The Scene*



A population of fruit flies are in various rotting plantain clusters, laying their eggs in the fruit.

5. With illustration #1, the story begins. This image should be visible in a place in the classroom (it could be printed as a poster, or it could be projected in a PowerPoint presentation). See Table #1 with the possible explanations of each illustration.

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Table #1

Possible explanations of each illustration to exemplify speciation.

Illustration	Explanation
Illustration #1: ***The Scene*** ***instructor***	The story begins with this image. Some fruit flies can be seen in rotting plantain clusters.
Illustration #2: ***A disaster occurs*** **GROUP #1**	A hurricane dragged the plantains to the sea. This makes flies abandon the plantains. Then, some flies remain in a part of the continent, and their offspring, some of whom come out of the eggs, remain on the island (where the plantains arrive). Note to the instructor: On this point no speciation has been produced yet; any fruit fly that would have returned to the continent could have mated with the continent's flies and produced healthy offspring.
Illustration #3: ***Populations diverge*** **GROUP #2**	Through time, the flies from the island develop differently versus the continent's flies. The shape, dietary preferences and courtship exhibitions change during the course of many generations of natural selection.
Illustration #4: ***We meet again*** **GROUP #3**	Another storm occurs and introduces the island's flies into the continent. These will not mate easily with the continental flies. Now that genes can't flow between both populations, the lineage has separated.

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6. The instructor will place cards, containing the type of speciation and its definition (image #2), on the board. Participants will identify the cause of speciation that their group represents (it can be more than one speciation mechanism).
7. The participants will place the illustration below the definition that corresponds to their picture. In the end, all illustrations should be placed on the chalkboard.
8. Once the dramatization has finished, the instructor will clarify the concepts that they were working on.

Image # 2: Cards to place on the board

Geographical Isolation

Occurs when the populations are isolated due to a factor, for example, deforestation, which gives as a result that individuals from the secluded groups can't interbreed. It can lead to the formation of new species.

Reproductive Isolation

Occurs when organisms that once interbred, cannot produce offspring. For example, they develop different mating seasons.

Behavioral Isolation

It is related to reproductive isolation because organisms that once interbred now cannot produce offspring due to a change in their behavior or lifestyle. For example, they start eating different things, change habitat, develop other courtship methods, etc. These changes provoke that species don't feel attracted and look for new mating partners.

CLOSURE

1. The participants will create, individually, an acrostic using the word **EVOLUTION**. It is expected that participants include learned concepts in the acrostic (speciation, kinds of isolation, evolution, etc.).
2. Voluntarily, some of the acrostics will be presented to review what has been learned in this lesson.

Example of an acrostic using the word EVOLUTION:

E vidence of change through time in species

V ariations in species lets them adapt to their environment

O rganisms need to change in order to survive

L ineages in recent species are very different from their primitive

U nique environmental conditions make species change

T he idea of changing species was proposed by Charles Darwin

I mportant: adaptations guarantee species availability

O rigin and maintenance of species

N o species will survive unless they adapt to their environment

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