Lesson 1: Engage

Big Idea: In the same geographical area, populations of a species have slight anatomical differences due to natural selection that led them to be specially adapted to their specific environment.

Lesson Objective: Students will compare and contrast populations of a species, and predict why they are anatomically different.

Lesson Essential Question: Why do populations of the same species look slightly different?

Materials Needed: Fact Cards
Chart paper/butcher paper
Sentence Strips
Markers

Vocabulary: population, species, individual, breed, organism,

Lesson Flow:

1. **Think, Write, Pair, Share (Engage)**
    a. Teacher poses the question: *There are 178 different breeds of dogs (Labradors, German shepherds, Chihuahuas). How do you think the world got this many different types of dogs?*
        i. American Kennel Club (2014).
    b. Students write down an initial response on their worksheet.
        i. Student response will vary: common wolf ancestor, humans choosing for different traits, reproduction, etc.
    c. Students discuss what they initially wrote with their table partners.
    d. Students can revise what they wrote based on what they discussed as a table.
    e. Teacher leads class-wide discussion while charting responses on the board. Students will come back to this question at the end of class.

2. **Find the similarities and differences (Explore)**
    a. Teacher introduces the lesson essential question: *Why do populations of the same species look slightly different?*
    b. Teacher divides class up into 4 groups and passes out the fact cards (one species per group)
    c. Students will observe fact cards of different individuals of the same species. On their worksheet, students will record their observations - what are the similarities and what are the differences.
        i. The observations can come from both the pictures and information on the cards. Students will need to make observations about the anatomical structure and also the environment in which the individuals live.

d. Students will then find others who had the same species as they did to compare observations. Students will revise their observations as necessary.
    i. While doing this, students need to support their observations with evidence. Students need to be using academic language sentence starters.
        1. "One observation I/my group made was ___(Describe the observation)__.
        2. "I agree with the observation that __(Summarize the observation)____ because _____."
        3. "I disagree with the observation that ___(Summarize the observation)__ because _____."

3. Predict why there are similarities and differences (Explain)

a. In groups students will make predictions about why there are differences in species.
    i. "I predict there are differences in the species of _(organism)__ because _____
b. Students will brainstorm individually first, then share with their group using the listen/summarize format.
    i. Student A starts by sharing their prediction.
    ii. Next student summarizes A's prediction then states their own. This continues until the last student has shared.
        1. "(Student Name)'s prediction was _(summarize prediction)__. My prediction is _____".
    iii. The last student shares their prediction, and Student A must summarize.
c. Students will discuss the predictions to revise and create one group prediction that they write on a sentence strip.

4. Class Conclusion (Extend)

a. Student representatives from each group will explain to the class their thinking and evidence for their prediction.
b. Student representatives will paste the sentence strip to the chart paper titled "*Why do populations of the same species look slightly different?"*
    i. Students will refer back to this chart paper during lesson 4 and 5. Post the chart paper somewhere visible in the room for students to ponder during the lesson series.

5. Revision of TWPS (Evaluate)

a. Students will revise what they wrote for the engage question "*There are 178 different breeds of dogs (Labradors, German shepherds, Chihuahuas). How do you think the world got this many different types of dogs?*" based on what they have observed or drawn conclusions from in this lesson.

Are They The Same?

Part 1: What Do You Observe?

Observe the info card at your table. What similarities between the organisms do you see? What differences do you see? What do you notice about the environments the organisms live in? Record your observations in complete sentences below. Be sure to include as much detail as possible.

Assigned Species: _____

Similarities	Differences

Part 2: Why Does This Happen?

I predict there are differences in the species of _____ because
(organism name)

_____

_____.

My group predicts there are differences in the species of _____ because
(organism name)

Lesson 2: Explore

Big Idea: Organisms that are best suited for their environment survive and reproduce. Organisms that are least suited for their environment rarely survive long enough to pass on their favorable traits through reproduction.

Lesson Objective: Students will design and evaluate an "organism" that will maximize the mass of food gathered.

Lesson Essential Question: How well suited is your organism for its environment?

Materials Needed: Upcycled materials
Binding materials (tape, glue)
Electronic Balance
Chart paper/butcher paper (or Google drive)
Cups

Vocabulary: engineering design process, trait, favorable, advantage, mass, average

Lesson Flow:

1. **Brainstorm: (Engage)**
    a. Teacher poses the question *"What are the different ways birds gather food?"*
    b. Students answer using prior knowledge.
        i. Possible student answers include: scooping, grabbing, scavenging, etc.
    c. Teacher shows videos of different ways birds gather food.
        i. Pelicans scooping fish out of the ocean
        ii. Crows dropping snails to crack them open
        iii. Woodpeckers pulling grubs out of a tree
        iv. Finch cracking a nut open with it's beak
        v. Toucan pulling fruit out with it's tongue
    d. Short class discussion on different food gathering techniques.

2. **Organism Creation Using the Engineering Design Process (Explore)**
    a. Teacher introduces the task:
        i. Students (in groups) must design and build an "organism" that will gather at least 5g of food from its environment.
    b. Student groups receive their environments and brainstorm best techniques for collecting the food sources. Students record their brainstorm on their worksheet.
    c. Teacher introduces the materials that can be used to create their organism and the criteria for the organism.
        i. Must use at least 2 different base materials.
        ii. Must have a moveable part
        iii. Cannot use more than 5 different base materials.

d. Student groups brainstorm possible designs. Students must draw an initial design and have it approved by the teacher before receiving materials.
e. Students will build and test their designs. Students can redesign as many times as needed during the allotted "design time". Students should be encouraged to conserve materials, and redesign using existing materials or trade materials.
    i. Students must record revisions made to their "organism" and provide reasoning for those revisions on their worksheets.

3. Class-wide Test (Explain)

a. At the end of the allotted design time, teacher has all creation stop. Student then test their designs in final test.
    i. Students get 2 minutes in their environment to collect as much food mass as they can and record their data in a data table.
    ii. Students perform three trials, and take the average.
b. Students will identify the favorable and least favorable traits for their environment.
c. Teacher explains that if the students' organism's average food mass is above 5g then the organism survives and reproduces. If the organism's average food mass is below 5g the organism dies before it can reproduce and pass on traits.
d. Students will record the data and traits on a class spreadsheet for further analysis.
e. Students will explain how the favorable traits allowed their organism to survive. Or why the least favorable traits caused their organism to die.

4. Class-wide Data Analysis (Extend)

a. Students look at the class-wide data to determine the best 2 traits for each environment, and use the mass data to justify why those traits are the most favorable.
b. Students will predict if their organism would have survived in the other environments and justify their prediction using evidence.

5. Thinking Toward The Future (Evaluate)

a. Teacher poses the question *"If you were to receive an environment with all 4 food sources in it, how would you redesign your organism so that it will survive?"*

Lesson 3: Explore

Big Idea: Populations with greater genetic diversity have a higher probability of survival than populations with low genetic diversity.

Lesson Objective: Students will redesign their organism from an assigned list of favorable traits. Students will justify why having a larger list of favorable traits increases the organism's probability of survival.

Lesson Essential Question: Is it better for a population to have more favorable traits than less favorable traits?

Materials Needed: Upcycled materials
Binding materials (tape, glue)
Electronic Balance
Chart paper/butcher paper (or Google drive)
Cups

Vocabulary:

Lesson Flow:

1. **Connections to Lesson 1: (Engage)**
    a. Teacher poses the question "*Think back to Monday's activity in which you looked at fact cards of organisms. From the first organism to today's organism, predict how much time it took for the species to change.*"
    b. Teacher elicits a small discussion on evolution and the time it takes. Emphasize that this process takes thousands of years, and this week's activities are speeding up time. Each time a minor change is made to the student's organisms, those are like "generations" of a species. 10 minor changes = 10 generations.

2. **Organism Creation Using the Engineering Design Process (Explore)**
    a. Teacher introduces the task:
        i. Students (in groups) must re-design and their "organism", using a list of favorable traits created by the class the previous day, that will gather at least 5g of food from its environment.
            1. This time though, all student groups have the same set of mixed food sources.
        ii. The list of traits will be different for each group of students. Some groups may have more favorable traits (more genetic diversity) than others.
            1. This will be different class by class, group by group - it all depends on the student analysis in Lesson 2.
    b. Teacher reminds students of the materials that can be used to create their organism and the criteria for the organism.
        i. Must use at least 2 different base materials.
        ii. Must have a moveable part

iii. Cannot use more than 5 different base materials.

c. Student groups brainstorm possible designs. Students must draw an initial design and have it approved by the teacher before receiving materials.
d. Students will build and test their designs. Students can redesign as many times as needed during the allotted “design time”. Students should be encouraged to conserve materials, and redesign using existing materials or trade materials.
    i. Students must record revisions made to their “organism” and provide reasoning for those revisions on their worksheets.

3. Class-wide Test (Explain)

a. At the end of the allotted design time, teacher has all creation stop. Student then test their designs in final test.
    i. Students get 2 minutes in their environment to collect as much food mass as they can and record their data in a data table.
    ii. Students perform three trials, and take the average.
b. Students will identify the favorable and least favorable traits for their environment.
c. Teacher explains that if the students’ organism’s average food mass is above 5g then the organism survives and reproduces. If the organism’s average food mass is below 5g the organism dies before it can reproduce and pass on traits.
d. Students will record the data and traits on a class spreadsheet for further analysis.
e. Students will explain how the groups with more favorable traits to choose from were able to survive while groups with less favorable traits to choose from were not able to survive as well/not at all.

Organism Design

Task: With your group, you must design and build an organism that will gather at least 5g of food from its environment.

Requirements: Must use at least **2** different base materials
Must have a **moveable** "mouth"
Cannot use **more than 5** different base materials

Part 1: Brainstorm

1. Describe the food source. What does it feel like? What does it look like?

2. Brainstorm with your group ways you could pickup and carry the food. Record your ideas below (does not need to be complete sentences).

3. Draw what you believe your organism will look like. Label important parts and materials you wish to use.

Part 2: Design Process

As you design and build your organism, it wont be perfect the first time. Record the modifications (changes) you make to your original design below, and provide justification why you changed what you did.

Modification	Justification

Part 3: Final Design

Drawing of Your Final Organism (label all parts)	Material List

Part 4: Group Testing and Data Analysis

Record your data from the three trials below.

Trial #	Mass of Food + Cup	Mass of Cup	Mass of Food
1			
2			
3			

Average mass of food = _____ + _____ + _____ =

3

1. Which traits (parts) of your organism helped it pickup and carry the food?

2. Which traits (parts) of your organism did not help it pickup and carry the food?

3. Was your organism able to collect enough food to survive? Why or why not?

4. Class-wide data:

Food Source	Favorable Traits	Prediction
		I predict my organism *(would/would not)* survive with this food source because
		I predict my organism *(would/would not)* survive with this food source because

		I predict my organism *(would/would not)* survive with this food source because
		I predict my organism *(would/would not)* survive with this food source because

Part 5: Organism Re-Design

Additional Traits to use:

As you re-design and build your organism, record the modifications (changes) you make to your original design below, and provide justification why you changed what you did.

Modification	Justification

Drawing of Your Final Organism (label all parts)	Material List

Part 6: Final Testing and Data Analysis

Record your data from the three trials below.

Trial #	Mass of Food + Cup	Mass of Cup	Mass of Food
1			
2			
3			

Average mass of food = _____ + _____ + _____ =
3

1. Was your organism able to collect enough food to survive? Why or why not?

2. How many *favorable traits* did your organism have?

Class Data:

Group #	Number of Favorable Traits	Survive/Not Survive
1		
2		
3		
4		
5		

3. What do you notice about the organisms that survived?

4. Did the survivors have more or less favorable traits than the non-survivors?

5. Populations with *(more / less)* favorable traits are (*more / less*) likely to survive. I believe this because

Lesson 4: Explain

Big Idea: Adaptations to environments allows certain individuals to survive in environments. Over time, the most favorable traits are passed on through natural selection.

Lesson Objective: Students will compare

Lesson Essential Question: What causes organisms to change over time?

Materials Needed: Natural Selection Reading
Natural Selection Analysis Questions (optional)
Brainpop - Natural Selection (optional)
Natural Selection - Crash Course Biology #14 (optional)
https://www.youtube.com/watch?v=aTftyFboC_M

Vocabulary: natural selection, adaptation, fitness, variation, heritance,

Lesson Flow:

1. **Brainpop (Engage)**
    a. Show students the brainpop or crash course video.
    b. Have students discuss what natural selection is and examples they have seen/know.

2. **Natural Selection Explained Reading (Explore)**
    a. Students pair read the natural selection reading.
        i. Student A reads a paragraph out loud to Student B.
        ii. Student B summarizes the paragraph to Student A.
        iii. Both students write a one sentence summary in the margin.
        iv. Roles switch each paragraph until the reading is finished.

3. **Natural Selection Explained Analysis Questions (Explain)**
    a. Have students answer the analysis questions.
    b. Alternatively a class discussion could be had instead.

4. **Peppered Moth Simulation (Extend)**
    a. With access to technology or a smart board students can play the peppered moth game to act as a predator and track the moth populations.

5. **Bring it all together (Evaluate)**
    a. Teacher poses the question "*The organism you and your group designed was specially adapted for a certain food source. Explain how your design process shows natural selection.*"

Natural Selection Explained

Adapted from BBC: GCSE – Evolution
and Chapter 16 *Evolutions of Populations*

Darwin's theory of evolution explains how species of living things have changed over geological time. The theory is supported by evidence from fossils, and by the rapid changes that can be seen to occur in microorganisms such as antibiotic-resistant bacteria. Many species have become extinct in the past and the extinction of species continues to happen.

Charles Darwin (1809-1882)

Charles Darwin was an English naturalist. He studied variation in plants and animals during a five-year voyage around the world in the 19th century. He explained his ideas about evolution in a book called On the Origin of Species, which was published in 1859.

Darwin studied the wildlife on the Galápagos Islands – a group of islands on the equator almost 1,000 kilometers west of Ecuador. He noticed that the finches – songbirds – on the different islands there were fundamentally similar to each other, but showed wide variations in their size, beaks and claws from island to island. For example, their beaks were different depending on the local food source. Darwin concluded that, because the islands are so distant from the mainland, the finches that had arrived there in the past had changed over time.

Natural selection

The theory of evolution states that evolution happens by natural selection. Here are the key points:

- Individuals in a species show a wide range of variation (changes).
- This variation is because of differences in genes.
- Individuals with characteristics most suited to the environment are more likely to survive and reproduce.
- The genes that allowed the individuals to be successful are passed to the offspring in the next generation.

Individuals that are poorly adapted to their environment are less likely to survive and reproduce. This means that their genes are less likely to be passed to the next generation. Given enough time, a species will gradually evolve.

Testing Natural Selection in Nature

Now that you know the basic mechanisms of evolutionary change, you might wonder if these processes can be observed in nature. The answer is yes. In fact, some of the most important studies showing natural selection in action involve descendants of the finches that Darwin observed in the Galapagos Islands.

Those finch species looked so different from one another that when Darwin first saw them, he did not realize they were all finches. He thought they were blackbirds, warblers, and other kinds of birds. The species he examined differed greatly in the sizes and shapes of their beaks and in their feeding habits, as shown in the table below. Some species fed on small seeds, while others ate large seeds with thick shells. One species used cactus spines to pry insects from dead wood. One species even picked at the tails of large sea birds and drank their blood!

Galápagos Islands Finches

Shape of Head and Beak						
Common Name of Finch Species	Vegetarian tree finch	Large insectivorous tree finch	Woodpecker finch	Cactus ground finch	Sharp-beaked ground finch	Large ground finch
Main Food	Fruits	Insects	Insects	Cacti	Seeds	Seeds
Feeding Adaptation	Parrotlike beak	Grasping beak	Uses cactus spines	Large crushing beak	Pointed crushing beak	Large crushing beak
Habitat	Trees	Trees	Trees	Ground	Ground	Ground

Once Darwin discovered that these birds were all finches, he hypothesized that they had descended from a common ancestor. Over time, he proposed, natural selection shaped the beaks of different bird populations as they adapted to eat different foods.

That was a reasonable hypothesis. But was there any way to test it? No one thought so, until the work of Peter and Rosemary Grant from Princeton University proved otherwise. For more than twenty years, the Grants have been collaborating to band and measure finches on the Galapagos Islands. They realized that Darwin's hypothesis relied on two testable assumptions. First, in order for beak size and shape to evolve, there must be enough heritable variation in those traits to provide raw material for natural selection. Second, differences in beak size and shape must produce differences in fitness that cause natural selection to occur.

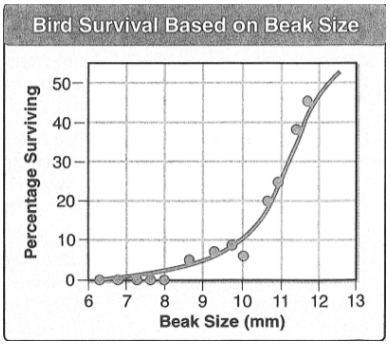
The Grants tested these hypotheses on the medium ground finch on Daphne Major, one of the Galapagos Islands. This island is large enough to support good-sized finch populations, yet small enough to enable the Grants to catch and identify nearly every single bird belonging to the species under study.

Variation

The Grants first identified and measured as many individual birds as possible on the island. They recorded which birds were still living and which had died, which had succeeded in breeding and which had not. For each individual they also recorded characteristics such as wing length, leg length, beak length, beak depth, beak color, feather colors, and total mass. These data indicate that there is great variation of heritable traits among the Galapagos finches.

Natural Selection

Other researchers who had visited the Galapagos Islands did not see the different finches competing or eating different foods. During the rainy season, when these researchers visited, there is plenty of food. Under these conditions, finches often eat the most available type of food. During the dry-season drought, however, some foods become scarce, and others disappear altogether. At that time, differences in beak size can mean the difference between life and death. To survive, birds become feeding specialists. Each species selects the type of food its beak handles best. Birds with big, heavy beaks, for example, select big, thick, seeds that no other species can crack open.



The Grants' most interesting discovery was that individual birds with different sized beaks had different chances of survival during the drought. When food for the finches is scarce (not enough), individuals with the largest beaks were more likely to survive, as shown in the graph to the right. The Grants observed that average beak size in that finch population increased dramatically over time.

By documenting natural selection in the wild, the Grants provided evidence of the process of evolution: the next generation of finches had larger beaks than the generation before selection had occurred. An important result of this work was their finding that natural selection takes place frequently – and sometimes very rapidly. Changes in the food supply on the Galapagos caused measurable changes in the population over a period of decades (a decade is 10 years long). This is markedly different from

the slow, gradual evolution that Darwin imagined.

Natural Selection Explained Analysis Questions

1. In your own words create a definition for natural selection.

2. What happens to organisms who are not adapted to their environment?

3. What was Charles Darwin's theory about why the finches in the Galapagos Islands have different sized beaks?

4. The sharp-beaked ground finch and the large ground finch both eat mostly seeds. Predict why they have very different beak shapes.

5. Why was it so important for the Grants to be able to test Darwin's hypothesis?

6. What are the two assumptions the Grants based their experiments on?

7. Why would it be important for the Grants to examine and id almost every bird on the island Daphne Major?

8. The Grants recorded data on seven finch characteristics. What does this information tell you about the genetic variation of the population?

9. Why was the rainy season not an *ideal* (good) time to study the finches eating habits?

10. From this study the Grants made two conclusions. What are they?

11. Use the graph *Bird Survival Based on Beak Size* to answer the following questions. If a finch has a beak size of 11mm what is its percentage of survival?

12. What does a 50% chance of survival mean?

Lesson 5: Explain

Big Idea: Populations with more genetic diversity (favorable traits) are more likely to survive changes in the environment.

Lesson Objective: Students will craft a well written mini essay explaining how genetic diversity is favorable in natural selection.

Lesson Series Essential Question: How can humans mimic natural selection by designing an organism to be better suited for its environment?

Materials Needed: Paragraph Frames
Student Data / scientific notebooks

Lesson Flow:
Students will construct a mini essay (3-4 paragraphs) to answer the essential question using the paragraph frames. Students will use evidence from their Engage, Explore, and Explain activities. Evidence must be presented in both qualitative and quantitative forms.

Lesson 6: Extend

Big Idea: Artificial selection is not a new or natural process. Artificial selection plays a large role in our agriculture production today.

Lesson Objective: Students will justify if their design process was natural selection or artificial selection.

Lesson Essential Question: When designing your organism to be the best suited for its environment was that natural selection or was it artificial selection?

Materials Needed: Artificial Selection Reading

Vocabulary:

Lesson Flow:

1. **Assessing Prior Knowledge (Engage)**
    a. Teacher shows students pictures of wild strawberries vs store bought strawberries.
        i. http://1.bp.blogspot.com/-fDQBm9NDQI0/UbZ_0V-4MoI/AAAAAAAADr0/F2rjZKgt8o4/s1600/strawberry+comparison.jpg
    b. Teacher poses the question *"Why are these strawberries so different?"*
    c. Students answer using prior knowledge and knowledge of natural selection.

2. **Artificial Selection Reading (Explore)**
    a. As students read they will use text tags to talk with the text.
    b. Students must use at least 5 text tags.
    c. Students will explain 3 of their text tags using the sentence starters.

3. **Class Discussion (Explain)**
    a. Discuss with students:
        i. Techniques for artificial selection
            1. Crossbreeding
            2. Genetic modification
        ii. Positives and Negatives to the environment
        iii. Positives and Negatives to the human race

4. **What have we done? (Evaluate)**
    a. Teacher poses the question *"Think back to when we designed organisms to be best suited for their environment. Was this natural selection or artificial selection? Provide evidence to support your claim."*

Artificial Selection at Work

http://www.learner.org/courses/essential/life/session5/closer1.html

What is artificial selection?

Artificial selection is the intentional reproduction of individuals in a population that have desirable traits. In organisms that reproduce sexually, two adults that possess a desired trait — such as two parent plants that are tall — are bred together. In this example, the mechanisms of heredity dictate that the next generation will consist of more tall plants than previous generations. If artificial selection is continued, all of the population will ultimately be tall. Also called selective breeding, artificial selection is perhaps best understood as a contrast to natural selection, where the random forces of nature determine which individuals survive and reproduce. In both cases, the outcome is the same: a population changes over time, so that certain traits become more common.

What are some examples of artificial selection?

Teosinte (left) and its modern descendent, corn.

Artificial selection has generated untold diversity in both plants and animals. In agriculture, superior strains of corn, wheat, and soybeans have resulted from careful breeding. The *Brassicas* are great examples of artificial selection. Cabbage, broccoli, cauliflower, Brussels sprouts, collards, and kale are all members of the same species, *Brassica oleracea*. Gardeners have cultivated flowers such as roses and orchids, carefully manipulating heredity to produce the "perfect" hybrid.

A variety of vegetables of the *Brassica oleracea* species

Some consider domesticated animals to be the ultimate products of artificial selection. Thoroughbred racehorses are one example of artificial selection of animals. The meats we eat are the result of the careful selective breeding of cows, pigs, sheep, and chickens. Our pets are a far cry from their "wild" ancestors. Cats and dogs, which were originally domesticated for pest control, hunting, or shepherding, eventually were bred to become companion animals. A glance at a group of dogs — all of the species *Canis familiaris* — reveals an astounding diversity of body type, size, and coloration.

There can be a down side to artificial selection. Because this process essentially removes variation in a population, selectively bred organisms can be especially susceptible to diseases or changes in the environment that would not be a problem for a natural population. Inbreeding — the mating of closely

related individuals — is also a problem. In dogs, this has resulted in breeds that have health issues ranging from decreased life span to hip dysplasia

Lesson 7: Evaluate

Lesson Objective: Students will research an artificially selected organism and determine its environmental footprint.

Lesson Essential Question: Are all artificially selected organisms a positive influence on our environment?

Materials Needed: Technology or access to a library of books

Lesson Flow:
Students will research an artificially selected organism. They will explain how it is selected (what technologies are used), why it is being artificially changed, and what traits are being artificially selected for. Students will provide an opinion on whether the organism is a benefit to the human society and/or the environment. Students will provide evidence from their research.