Displaced Animal Rescue

A Community-Connected Elementary Science & Engineering Unit

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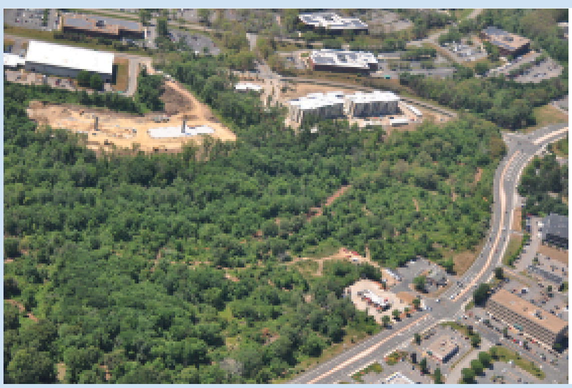
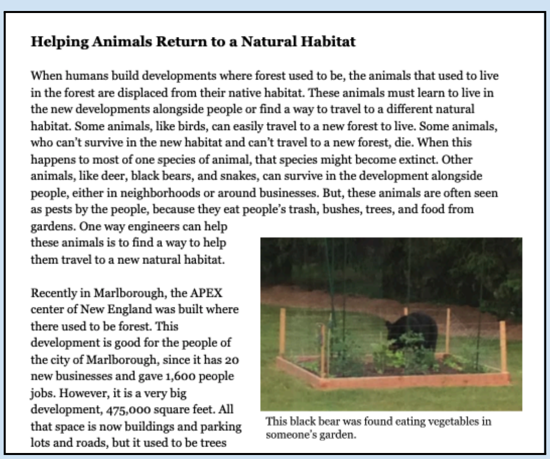


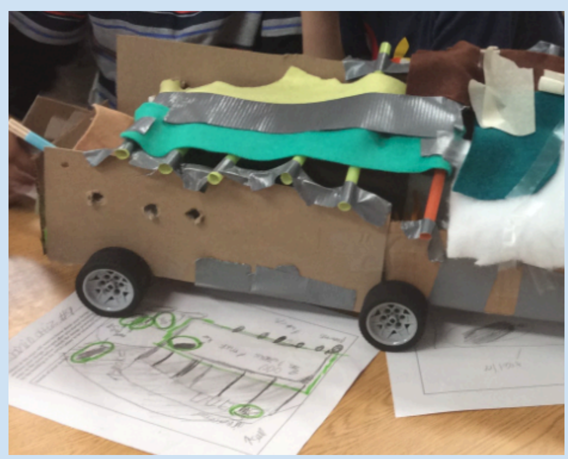


Helping Animals Return to a Natural Habitat

When humans build developments where forest used to be, the animals that used to live in the forest are displaced from their native habitat. These animals must learn to live in the new developments alongside people or find a way to travel to a different natural habitat. Some animals, like birds, can easily travel to a new forest to live. Some animals, who can't survive in the new habitat and can't travel to a new forest, die. When this happens to most of one species of animal, that species might become extinct. Other animals, like deer, black bears, and snakes, can survive in the development alongside people, either in neighborhoods or around businesses. But, these animals are often seen as pests by the people, because they eat people's trash, bushes, trees, and food from gardens. One way engineers can help these animals is to find a way to help them travel to a new natural habitat.

Recently in Marlborough, the APEX center of New England was built where there used to be forest. This development is good for the people of the city of Marlborough, since it has 20 new businesses and gave 1,600 people jobs. However, it is a very big development, 475,000 square feet. All that space is now buildings and parking lots and roads, but it used to be trees

This black bear was found eating vegetables in someone's garden.



Unit Overview

In the “Displaced Animal Rescue” unit, 3rd grade students explore core ideas about animals and their environments, particularly how changes to habitat affect the ability of animals to survive. They have an opportunity to extend and refine these ideas as they design a system to rescue animals displaced from their natural habitat by a commercial development.

The unit addresses standards in the engineering and technology strand (3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 3-5-ETS1-4[MA], 3-5-ETS1-5[MA]) and in life science (3-LS4-3: organisms & their environment; 3-LS4-4: habitat changes, survival, and reproduction).

The unit navigation guide and lesson plans begin on page 6 of this document.

Materials

All materials can all be purchased at general merchandise stores or through internet retailers. For a full list of material quantities and links to purchase, see the table below.

Lesson	Materials
1	● Video, articles, or images to introduce the animal displacement problem (see “Set Context” step in Lesson 1)
2	● animal needs cards ● multi-colored objects (anything could be used like math cubes, colored beads, fruit loops, etc-- **must have 6 colors**: red, orange, yellow, green, blue, white) ● bags or cups for the students to collect the objects
3	● a large open space, indoor or outdoor ● whiteboard or chart paper to make a graph
4	● Chromebooks or other laptops ● https://askabiologist.asu.edu/peppered-moths-game/index.html
5	● Foam tiles or sit spots ● Music, construction sounds, or forest sounds
6-10	● An assortment of found materials, recyclables, and office and craft supplies, such as: paper, felt squares, foam sheets, foil sheets, tape, foam batting, brads, paper clips, thin cardboard, chip board, manila file folders, pipe cleaners, popsicle sticks, rubber bands, straws, paper cups, binder clips, wooden skewers, toothpicks, coffee filters, index cards

Design teams

Students should work in design teams throughout the unit. We recommend assigning students to teams of three or four before beginning the unit and having them work in the same design teams throughout the unit.

Discussing science and engineering ideas with peers can help students build knowledge in more sophisticated ways, as they articulate their own thinking, understand peers' ideas, and decide whether and how to resolve discrepancies. Students may need explicit practice with strategies for listening to each other, re-voicing what they hear, agreeing and disagreeing, asking for clarification, and justifying their own thinking. Remember that friction can be productive, literally and figuratively! Instructors should allow students to disagree about a science explanation or design solution, but help them justify their thinking and identify the source of their disagreement. Helpful resources for supporting student collaboration in science and engineering include the Talk Science Primer[1] and WGBH Design Squad[2] videos.

Design days

On Design Challenge days in the second half of the unit, teams will plan, create, test, and iterate their designs to solve the displaced animal rescue problem, subject to the criteria and constraints. Ideally, they will draw on and extend knowledge from previous lessons to make progress on the task.

Notebooking

Students build knowledge in more sophisticated ways when they have support for documenting their ideas, investigations, and design solutions. Not only does the act of documenting help students slow down and reflect on the quality of their ideas, but it also creates a record they can refer back to while designing and use for end-of-unit reports or presentations. Pages 1 to 4 of the student handouts at the end of this document provide template pages for design challenge documentation. Alternatively, consider using multimedia project notebooks so that students can store text, photos, and videos of their design work. Multimedia notebooks can be kept through Google Slides (our recommended template is here) or any online resource with which your students are familiar.

We recommend students document their progress as a design team in a shared project notebook throughout the unit. With one shared notebook, students must articulate their ideas to each other to record; this allows ideas to be debated and negotiated and requires the team to come to a consensus.

Resources

Some of these lessons require digital resources. These can be found in Google Drive "Resources" folder. The PDF version of this document contains direct links to the appropriate resources in the folder.

1 https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf
2 http://pbskids.org/designsquad/

Some teacher background information and resources about habitat fragmentation, urban sprawl, and habitat destruction can be found here.

Sharing and discussion

Throughout the unit, students should have time to discuss ideas with other teams. The goals of this time are for students to reflect on their own ideas and work, to interact with their classmates' ideas and work, and to get feedback on their work. This is an intentional time to step back from the hands-on activities and dig into reasoning. For some classes, this works best at the beginning of a session, when physical materials are not yet out on tables or desks. For other classes, it's a great way to close out a lesson, when students are no longer making much progress on hands-on teamwork. Some structures we recommend:

- **Share-out**: Each team takes a few minutes to describe where they are in the design process and solicit classmates' feedback. Other students ask questions and give advice.
    - *Pros*: Teacher-facilitation keeps discussion on track; you can hear from all teams
    - *Cons*: If there are many teams, students may tune out; it can be hard to concentrate when they want to be designing
    - *Ideal times*: Near beginning, to get feedback on plans and initial ideas before spending too much time designing; at end, to share final designs

- **Gallery walk**: Each team leaves their designs (and documentation) at their workspace and walks around to check out other designs (can do 5 minutes at each team, then all switch together). Often, teams leave feedback (e.g., on sticky notes) for other teams.
    - *Pros*: Get to see all designs in a shorter time period; less likely to tune out
    - *Cons*: With less teacher oversight, some teams can get off track; takes time and practice to write useful, actionable feedback for other teams
    - *Ideal times*: After all teams have tested and have results to report; when students are feeling stuck or frustrated and need new ideas

- **Whole class discussion**: Teacher facilitates a discussion that can be focused on a few selected designs, a problem multiple teams are encountering, a scientific explanation that needs more time or evidence, etc. For example, one approach is to pull out 2 to 3 very different designs that are all performing well to discuss what about the designs is working. This approach has a side benefit of highlighting solution diversity. On the other hand, if students are frustrated with designs not working well, it can be productive to discuss as a whole class specific problems students are facing and brainstorm strategies to address those issues.
    - *Pros*: Teacher can keep discussion on track; can support deeper reasoning and connections between test results and design features; teacher can push students' thinking; can change focus of discussion if interesting ideas pop up
    - *Cons*: Teams might tune out if the discussion doesn't seem directly applicable to their design
    - *Ideal times*: Whenever students aren't very engaged in building and wouldn't be upset at an interruption; can be any time—beginning or end of class, after some natural stopping

point, when a team has a really interesting test result that the whole class would benefit from thinking about

Other recommendations

- **Access to materials**: We recommend allowing students to access samples of the building materials as they are sketching design plans for their playground structure prototypes. Most elementary students need physical models in front of them to create useful sketches of 3D systems. They benefit from planning in ‘3D’, by holding up and gesturing with materials. Handling and manipulating materials also acts as brainstorming for many students. Encourage students to take pictures of manipulated materials to record ideas.
- **Access to testing:** Encourage students to test their design prototypes early and often. Consider setting up one or more testing stations where students can bring their prototype and test it against the design criteria.

Navigation Guide

Learning Goal
• Students will refine their ideas about animals and their environments and engage in an engineering design process to create and test systems to rescue animals displaced from their natural habitats.

NGSS and Massachusetts Standards Addressed
• **3.3-5-ETS1-1.** Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet. • **3.3-5-ETS1-2.** Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem. • **3.3-5-ETS1-4(MA).** Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution. • **4.3-5-ETS1-5(MA).** Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem. • **4.3-5-ETS1-3.** Plan and carry out tests of one or more design features of a given model or prototype in which… failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype. • **3-LS4-3.** Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. • **3-LS4-4.** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.

Anchoring Phenomenon, Driving Question, and/or Design Challenge
Displaced Animal Rescue Problem: When new shopping and entertainment centers are built, animals are often displaced from their natural habitats into environments that are not as ideal for their survival. You are going to design, build, test, and improve on a solution to help animals safely relocate to a conservation area. • How can we use ideas about animals and their environments along with the engineering design process to design a system to help rescue displaced animals?

Lesson	NGSS Alignment	Activities
1 Unit Launch	**3.3-5-ETS1-1.** Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet. **3-5-ETS1-5.** Evaluate relevant design features that must be considered in building a model or prototype of a solution to a design problem	• Set context for the design challenge • Introduce engineering notebook • Students brainstorm initial ideas
2 Inquiry: Simulating Survival	**3-LS4-3** Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. **3-LS4-4** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How are needs different between different types of animals in the same habitat?* Students conduct a simulation of animals gathering food and water, graph the results, and determine if animal needs were met.

3 Inquiry: Habitat Changes	**3-LS4-4** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How does the amount of resources affect the number of individuals in a population?* Students play the "Oh Deer!" game to simulate how a deer population changes over time in response to available resources. As a whole class, they graph and explain the results.
4 Inquiry: Peppered Moth Simulation	**3-LS4-3** Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. **3-LS4-4** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How does a change in the environment affect different members of the same species?* Students use the online Peppered Moth Simulation to investigate how the color of a moth influenced its chance of survival during the industrialization of England in the 1800s.
5 Inquiry: Musical Habitats	**3-LS4-3** Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. **3-LS4-4** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How does the development of land areas affect animals living in the area?* Students simulate a wildlife habitat before and during commercial development through a game similar to musical chairs.
6 Design: Problem Scope and Ideate	**3-5-ETS1-1.** Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet. **3-5-ETS1-4(MA).** Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution.	• Whole-class determines criteria and constraints • Introduce "testing" and test plans as important parts of verifying engineering designs • Student groups write testing procedures • Students begin to generate ideas (and build/test, if time)
7 Design: Build, Test, Iterate (Share)	**3-5-ETS1-2.** Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.	• Students build and test designs, following their test plans • Whole-class discussion around some aspect of building or testing that is salient in the room
8 Design: Peer Feedback	**3-5-ETS1-5(MA).** Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.	• Discuss what giving feedback looks like/why we do it • Student groups come up with a question or issue they want feedback on from another group • Groups pair into "mega-groups" to ask their questions and give feedback • Students continue to build, test, and iterate
9 Design: Iterate and Document	**3-5-ETS1-3.** Plan and carry out tests of one or more design features of a given model or prototype in which … failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.	• Continue building, testing, and iterating on designs, documenting with cards • Prep for expo: finish documentation, get final design ready for public testing during expo
10 Design: Expo	**3-5-ETS1-5(MA).** Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.	Host visitors (other students, administrators, outside guests) who will serve as audience as students share about their designs.

Lesson 1: Design Challenge Launch

NGSS Alignment	Anchor Phenomenon and Focus Question
3.3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet. **3.3-5-ETS1-4(MA).** Gather information using various informational resources on possible solutions to a design problem. SEP 1. Asking questions and defining problems SEP 8. Obtaining, evaluating, and communicating information	*What happens to animals when a new shopping and entertainment center is constructed?*  Before After
Materials ● Video, articles, or images to introduce the animal displacement problem (see "set context" step)	**Assessment/Evidence of Learning** Student notebook entries

1. Set context for the design challenge

- Support students in reading and discussing this article learn about the animal displacement problem in Marlborough.
- Show these images of a commercial development project before and after construction. Have students discuss what they notice (namely, massive deforestation) to get them thinking about the problem. Connect this to the article about the bear; if habitats are destroyed, the animals seek resources they need (like food and water) elsewhere, like in people's gardens.
- If time, show students this video in which Sudbury Valley Trustees (SVT) tell students about professionals who work with conservation land.

Helping Animals Return to a Natural Habitat

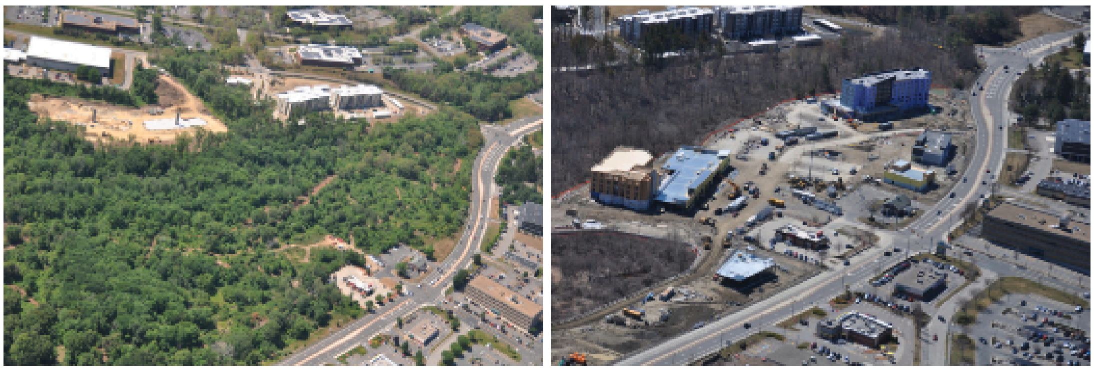
When humans build developments where forest used to be, the animals that used to live in the forest are displaced from their native habitat. These animals must learn to live in the new developments alongside people or find a way to travel to a different natural habitat. Some animals, like birds, can easily travel to a new forest to live. Some animals, who can't survive in the new habitat and can't travel to a new forest, die. When this happens to most of one species of animal, that species might become extinct. Other animals, like deer, black bears, and snakes, can survive in the development alongside people, either in neighborhoods or around businesses. But, these animals are often seen as pests by the people, because they eat people's trash, bushes, trees, and food from gardens. One way engineers can help these animals is to find a way to help them travel to a new natural habitat.

This black bear was found eating vegetables in someone's garden.

Recently in Marlborough, the APEX center of New England was built where there used to be forest. This development is good for the people of the city of Marlborough, since it has 20 new businesses and gave 1,600 people jobs. However, it is a very big development, 475,000 square feet. All that space is now buildings and parking lots and roads, but it used to be trees and forest area full of animals. Many animals that used to live in this forest have now moved into the nearby neighborhoods to look for food and shelter. People have even seen black bears in their yards! The black bears eat food out of bird feeders and scraps out of trash cans. While the black bears do not want to harm people, the neighbors are scared of the bears and do not want them living in their neighborhood. Other animals that have become pests are deer and snakes. The people who live in the neighborhood near the APEX center would like to figure out a safe way to move the animals to a new natural habitat without hurting them. You get to help them think about this problem! After learning more about animal habitats and survival, you will work in teams to plan, design, and build a way to help animals, particularly bears, deer, and snakes, move to a more natural habitat in Marlborough.

Displaced Animal Rescue Design Challenge

Design scenario: A development has just gone up in Marlborough. Many animals have been displaced from their habitat. People are noticing that the animals are in their local communities. This increased chance for interaction between wild animals and humans is not safe for either animals or humans. But a highway, other buildings, and neighborhoods separate the developed area and the conservation lands.



Before After

Goal: Design and build something to help relocate animals displaced by the APEX Entertainment Center.

2. Describe the displaced animal rescue design challenge

Preview the arc of the unit for the students: "After we learn some science about animal survival in their habitat, we're going to design solutions for this engineering problem. You are going to design, build, test, and improve on a solution to help animals safely relocate to a conservation area. Each group gets to figure out what they want to build, how it will work, and what it will be made from. We'll test the different designs to see how well they work. During the science investigations, you will record results and thoughts in your own paper notebook. You will also keep track of your engineering work as a team in an engineering notebook."

3. Introduce engineering design notebooks

- Each student team will use an engineering notebook to organize pictures, video, and text to document their engineering design process. Take 10 minutes to introduce the notebooking system you will be using (paper notebooks, iPad app Design Keeper, Google slide template, etc.). Talk with the students about the importance of notebooking and the kinds of things that are helpful to document, like test results or theories from inquiry lessons.

    - The following links provide example design notebooks. Note that these samples showcase design work for a different design problem. We avoid providing an example for the stopover site problem because it could be taken up by students as the one correct way to approach the task.
    - Sample Notebook 1
    - Sample Notebook 2
- As you introduce design notebooking, consider emphasizing the following aspects:
    - Design notebooks have different types of entries, depending on what the engineers are doing at the moment. Some types of entries occur more often. For example there are multiple ideas pages or test pages.
    - There is no set order to the pages. Designing is not a step-by-step activity, and often different groups will be conducting different activities at the same time.
    - Not all the entries include complete sentences. Sometimes it's important to jot down your thoughts quickly before you forget them. The writing can be perfected in a final product, like a report or a poster..
    - There are lots of photos, which help us remember exactly what something looked like.
    - Design failures are included in the notebook. That's how engineering is supposed to work. Engineers try something, see how it fails, and then figure out how to fix that problem. That's how we learn in engineering. Testing a design is not like a test in school; it's more like the opposite--failing means it's a good problem to be working on.

4. Have students brainstorm initial ideas about the design challenge in their notebooks

- Students can sketch on scratch paper and take pictures of their drawings.

Lesson 2: Simulating Survival

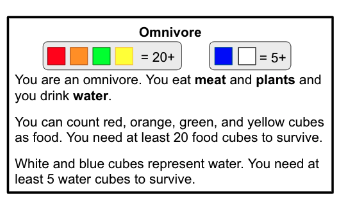
Standard(s) from the MA Curriculum Framework	**Anchor Phenomenon and Focus Question**
3-LS4-3 Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. **3-LS4-4** Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How are needs different between different types of animals in the same habitat?* This lesson is based on the "Vore-acious Eaters" activity from *Concerning Critters*, AIMS Education Foundation, 2012.
Materials ● animal needs cards ● multi-colored objects (anything could be used like math cubes, colored beads, fruit loops, etc-- **must have 6 colors**: red, orange, yellow, green, blue, white) ● baggies or cups for the students to collect the objects	**Assessment/Evidence of Learning** Student notebook entries

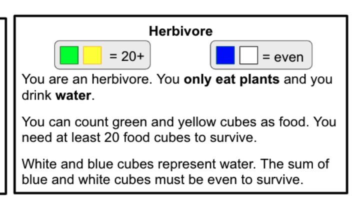
Overview

In this lesson, students play a game using scattered, multi-colored objects to simulate food and water in an environment. Students investigate how, in the same environment, some types of animals (carnivore, herbivore, or omnivore) survive well, some survive less well, and some cannot survive.

1. Preparation

- Set up an area full of colored objects.
- Print and cut out the animal needs cards.





2. Set the stage for the game

- Ask: *What do organisms need to survive?*
    - *Food, water, shelter, space, air*
- How could you group animals based on what they eat? (Intro vocabulary if needed)
    - omnivore: eats both plants and meat
    - herbivore: only eats plants
    - carnivore: only eats meat
- “This lesson focuses on food and water. Today you will be playing a game that will help you understand that different types of animals must have certain types of food to survive in a certain environment.”
- Point out the area where the colored objects have been distributed.

3. Play the “Vore-acious Eaters” game

- Give students 3 minutes to collect objects in their bags/cups.
- Have students return to their desks and create a bar graph in their individual notebook showing how many of each color object they collected.
- Once students have completed their graphs, give them each one animal needs card. Instruct students to determine if their needs were met (they survive) or not.

4. Debrief the activity

- Hold a whole class discussion. Have students share out what type of animal they were and whether or not they survived. Then, use the following questions as a guide:
    - Which animal was best suited for the environment?
        - *the omnivore because it can eat all food*
    - In a habitat with more meat, which animal is most likely to survive?
        - *carnivore*
    - In a habitat with more plants, which animal is most likely to survive?
        - *herbivore*
- The salient point here should be that **even in the same habitat, certain species are more likely to survive than others**. A change to the habitat will change which species are more likely to survive.
- Continue the whole class discussion, using the following questions to push it further:
    - What would you do differently if you could play again?
    - Why is it important that not all animals survive in an environment?
        - *overpopulation, then there would not be enough resources to support them*
    - What would happen if there was too much food in an environment?

5. Notebooking

- Have the students sit in their design challenge groups and work on their individual notebook spread. They should have finished the graph during the activity; now they can answer the focus question.
- Once students have finished their individual notebook pages, they should work as a team to brainstorm ideas for the design challenge and enter them into the shared notebook.

Lesson 3: Habitat Changes

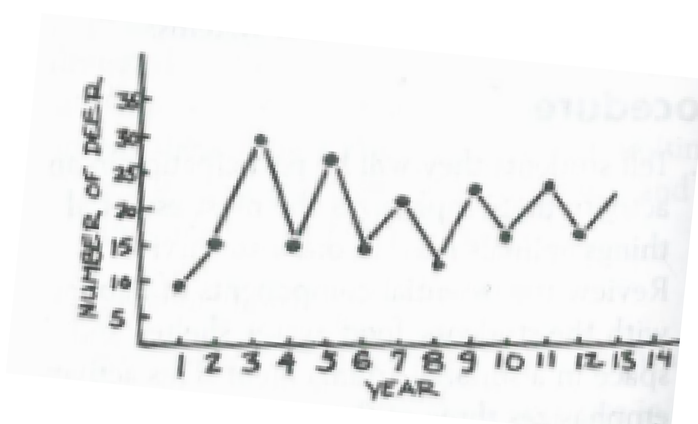
Standard(s) from the MA Curriculum Framework	**Anchor Phenomenon and Focus Question**
3-LS4-4 Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How does the amount of resources affect the number of individuals in a population?* This lesson is based on the “Oh Deer!” activity from the Project WILD K-12 Guide, Association of Fish & Wildlife Agencies, 2008.
Materials • a large open space, indoor or outdoor • whiteboard or chart paper to make a graph	**Assessment/Evidence of Learning** Student notebook entries

Overview

In this lesson, students play a game called “Oh Deer” to simulate and observe how the amount of food, water, and shelter in a habitat affect the number of individuals in a deer population.

1. Preparation

- Set up a graph to track deer population ahead of time on the board or a piece of chart paper. The x-axis should be labeled “Years” and the y-axis should be labeled “Number of Deer,” as shown below.



- Familiarize yourself with the rules and hand signals for the “Oh deer!” game (see step 3). It may be useful to play a practice round with students at another time before this lesson.

- Find a space to space to play the game. It can be played in the classroom on the rug or with tables moved away. It can also be played outside or in the gym or cafeteria, if available.
- If desired, prepare to share the following vocabulary.
  - **Habitat**: the place or type of place where a plant or animal naturally or normally lives or grows
  - **Population**: a group of one or more species of organisms living in a particular area or habitat
  - **Resource**: something (as in food, water, shelter, etc) that is found in nature and is valuable to a species

2. Probe for initial ideas and introduce the activity

- Begin by holding a discussion to set up the activity and probe for ideas about the relationship between resources and survival. Ask:
  - *What resources are essential for survival?* (Food, water, shelter, air, etc.*)*
    - You can relate this to the "Voracious eaters" activity and discussion; students only survived if they had enough food and water.
  - *What do you think would happen if there were not enough resources to go around for all the individuals of a population?*
  - *What if there were more than enough resources for everyone?*
- Explain to the students that they are going to play a game called "Oh Deer!" This game will help them understand how the number of individuals in a population changes based on the amount of available resources. To relate more directly to the standard, discuss how habitat (i.e. resources) affects a species' ability to survive and reproduce (# of individuals in population).

3. Play the "Oh deer!" game

How to play "Oh deer!"

- ➢ One fourth of the class are "deer." Three-fourths of the class are "resources." The "deer" and "resources" line up on opposite sides of the play area **with their backs to each other.**
- ➢ Each resource can decide if it wants to be food, water, or shelter. They show what resource they would like to be by making the following hand signals:
  - **Food** two hands on the stomach
  - **Water** two hands on the mouth
  - **Shelter** two hands above the head in a tent shape
- ➢ Each deer can decide if it wants to look for food, water, or shelter. They show what resource they would like to look for by the same hand signals. **Once the students decide, they cannot change for the remainder of the round!**
- ➢ On the count of three, have both lines turn and face each other. Each deer can go and select a matching resource from the opposite side to bring back to the deer side. Congratulations deer! You were able to find a resource and you

reproduced! If a deer cannot find a matching resource, s/he dies and becomes a resource for the next round. The student who was a resource is now a deer.

➢ Repeat these steps to play another round. Resources and deer can change their hand signals at this point.

- Explain the rules of the "Oh deer!" game to the students, focusing on what the hand signals are, not changing them during the game, and lining up back to back (no peeking!).
- Tell students that they (as a class) will be keeping track of how many deer there are in each round. Show students the line graph with "Years" on the x-axis and "Number of Deer" on the y-axis and graph the starting number of deer at Year 1. For example, for a class of 20 students, you will have 5 deer at Year 1.
    - Students will be recreating this graph in their notebooks later.
- Play one round of "Oh deer!" slowly, ensuring students understand the rules. Graph the new deer population at Year 2 with the students.
- Play for 12-15 rounds, asking students to make predictions along the way:
    - *How do you think the deer population will change this round? Why do you think so? How is the habitat changing each round?*
    - Students can usually predict when there will be a crash in the deer population because there are not enough resources to go around.
    - **Again, the main idea is that habitat (ie resources) affects a species' ability to survive and reproduce (# of individuals in population).**

4. Debrief the activity

- Hold a whole-class discussion around the line graph. Ask students to share any patterns they notice. **Students should see that the graph is a series of population climbs and crashes.**
- Ask students to determine the maximum number of deer this habitat could hold. Encourage students to think about why that is.

5. Notebooking

- Have the students sit in their design challenge groups and work on their individual notebook spread. They should copy the graph made during the activity, then answer the focus question.
- Once students have finished their individual notebook pages, they should work as a team to brainstorm ideas for the design challenge and enter them into their shared notebook.

6. Optional extension

- Gather students for a whole class discussion. Tell students that in some areas, there are designated days where hunters are allowed to hunt deer to reduce the deer population. This is called "culling." Ask:
    - *Do you think that culling is helpful or harmful to the deer and their environment?*

- *Would your answer change depending on the year (from the line graph) that the culling happened?*

Lesson 4: Peppered Moth Simulation

Standard(s) from the MA Curriculum Framework	**Anchor Phenomenon and Focus Question**
3-LS4-4 Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce. **3-LS4-3** Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive.	*How does a change in the environment affect different members of the same species?* Peppered Moth Simulation https://askabiologist.asu.edu/peppered-moths-game/index.html
Materials ● Chromebooks or other laptops ● https://askabiologist.asu.edu/peppered-moths-game/index.html ● Sticky notes (2 colors, preferably one light and one dark)	**Assessment/Evidence of Learning** Student notebook entries

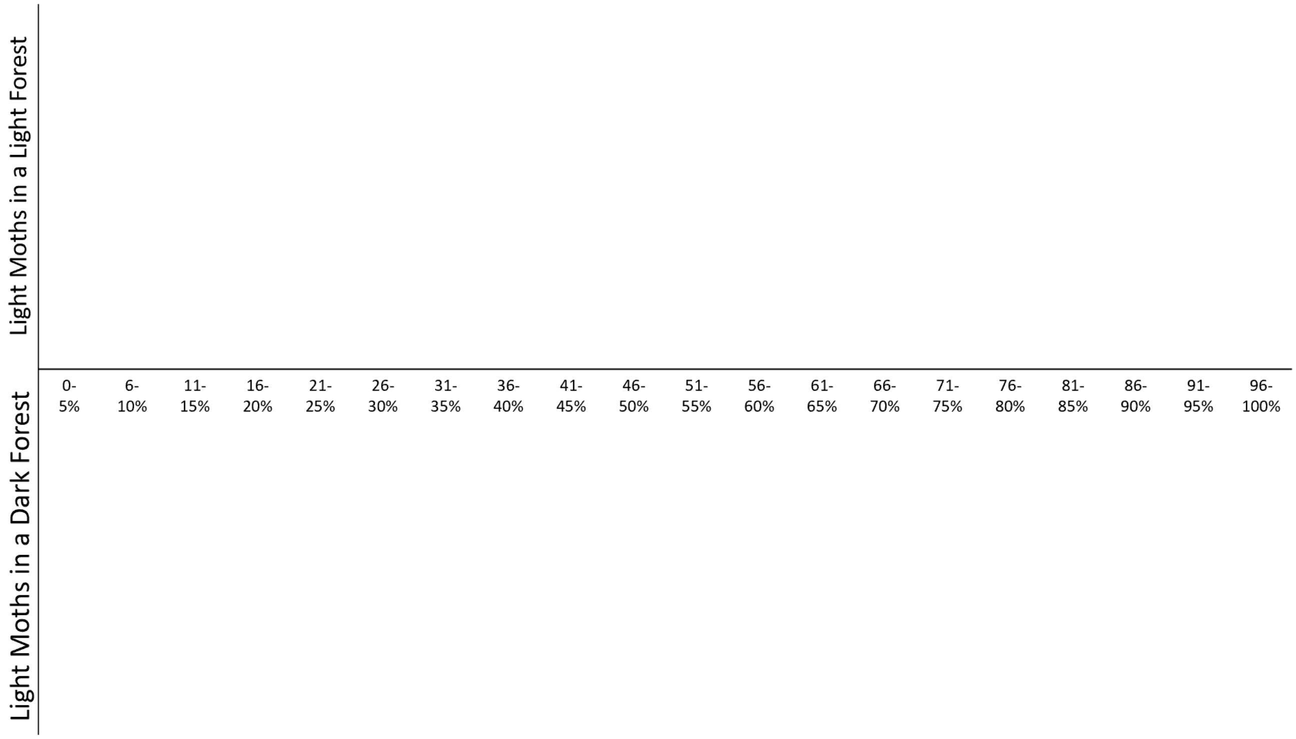
Overview

In this lesson, students use an online simulation of peppered moth population to observe the effect of an altered environment on members of the same species.

1. Preparation

- Ensure students will have access to a computer for this lesson, whether that means going to a computer lab or using Chromebooks from the classroom or anything in between.
- *Optional*: Pre-load the peppered moth simulation website onto student computers.
- Prepare two charts to record the results of the simulation. For more information on how this will be used, see step 4.
    - One chart should have “Light moths in a **light** forest” on the y-axis. The other chart should have “Light moths in a **dark** forest” on the y-axis.
    - The x-axis of both chart should have “bins” for every 5% or 10% (ex. 5-10%, 70-80%) the width of a sticky note.

- ○ One example of this is shown below, where the x-axis is shared and split into “bins” for every 5%. These charts could also overlap, with the sticky note color differentiating between the light and dark forest, or could exist on two separate charts, side-by-side.

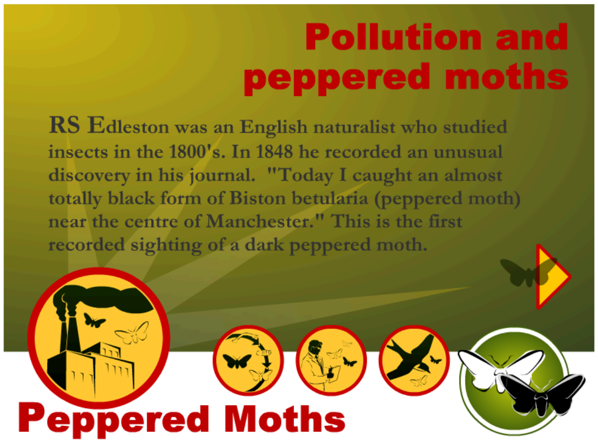


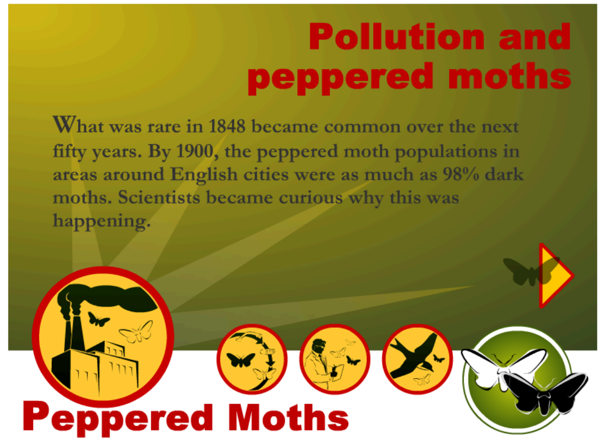
2. Introduce the activity

- Remind students how they learned that the amount of particular resources in a habitat can affect the number of individuals in a population.
- Tell students that today they will run a simulation of a real-world change that happened in England to a species called “peppered moths.” They will explore how human-made changes in the environment can affect individuals of a species, and how an environment affects the ability to survive of different members of the same species. Ask:
  - ○ In what ways do humans change the environment?
  - ○ What do you think happens to animals if that happened?

3. Provide background information about the peppered moth

- Open the Peppered Moth Simulation on the projector and click on the 2nd circle from the left titled “Pollution and Peppered Moths.”
- Set the stage for the activity by reading **only the first two pages** with your students. Explain that in England in the early 1800s, most peppered moths were light and dark peppered moths were very rare. By the early 1900s, most peppered moths were dark. Use these pages to pose this puzzle to the students.

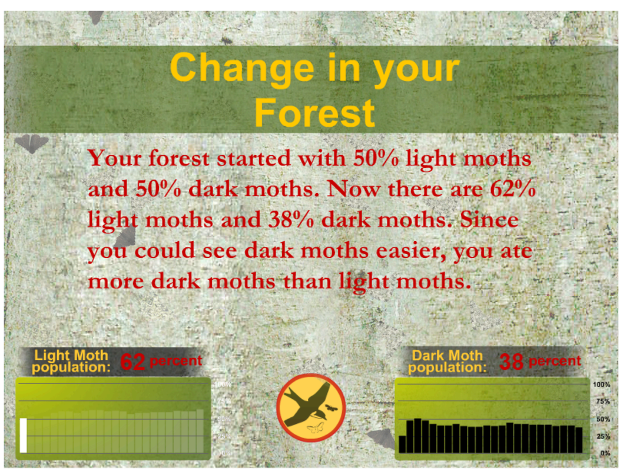


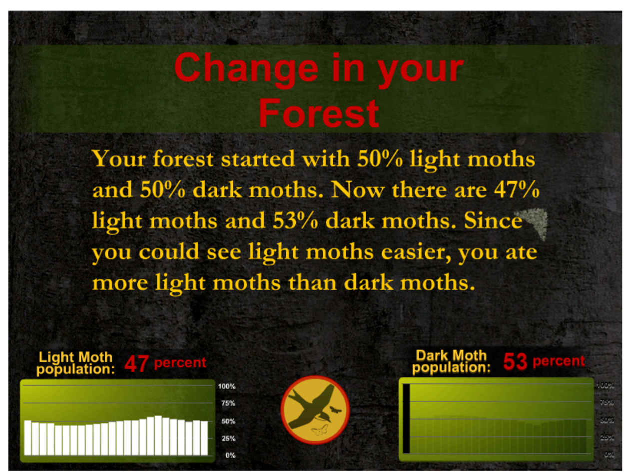


- The rest of the pages go through some possible reasons that the peppered moth population may have changed, settling on natural selection. **These slides give away the game!** Return to the explanation of how natural selection played a role after students have done the activity.

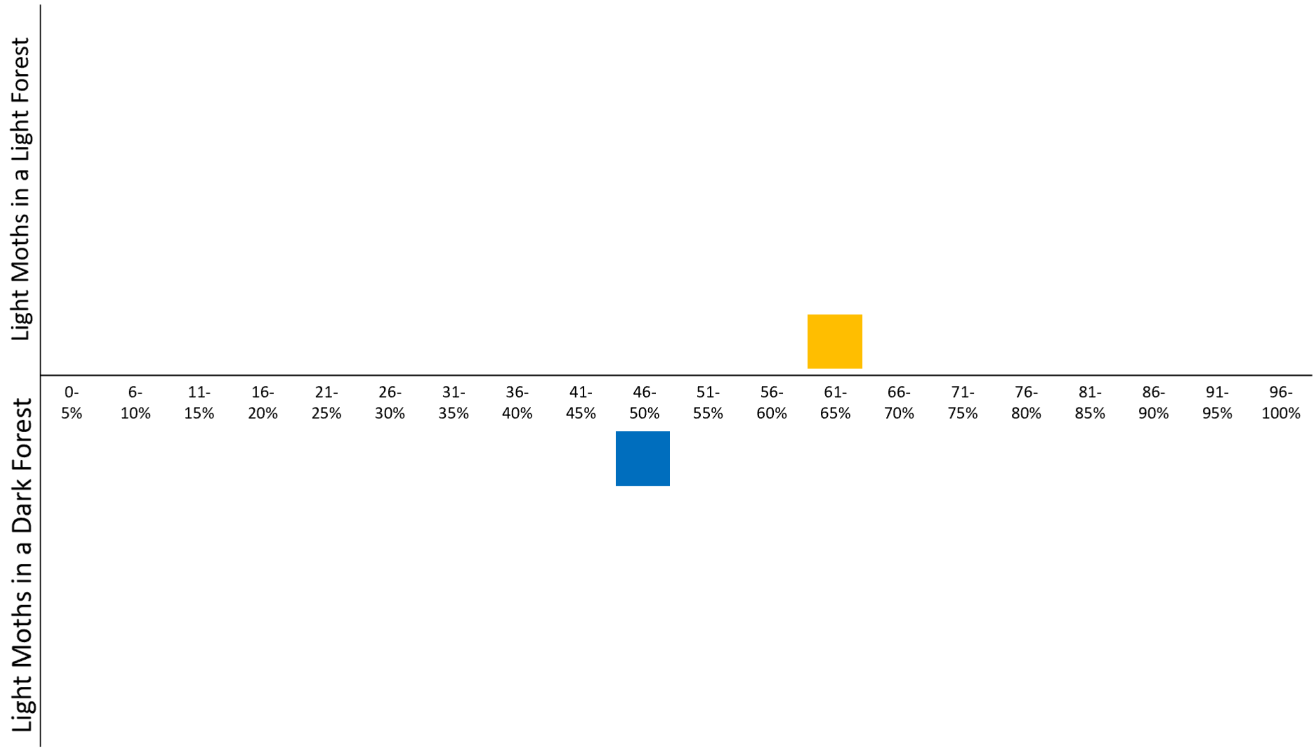
4. Run the simulation and record results

- Tell students that now they will have a chance to see how the color of a moth helps it survive in its environment.
- On the projector, navigate to the right-most circle titled “A Bird’s Eye View of Natural Selection.” Read the directions with the students, emphasizing that they are trying to eat **as many moths as possible in one minute**. Show students how they can choose from a “light forest” or a “dark forest.” As an example, play one round on the projector, eating as many moths as possible. When you get to the results screen, point out that it gives you a percentage of light moths and dark moths.

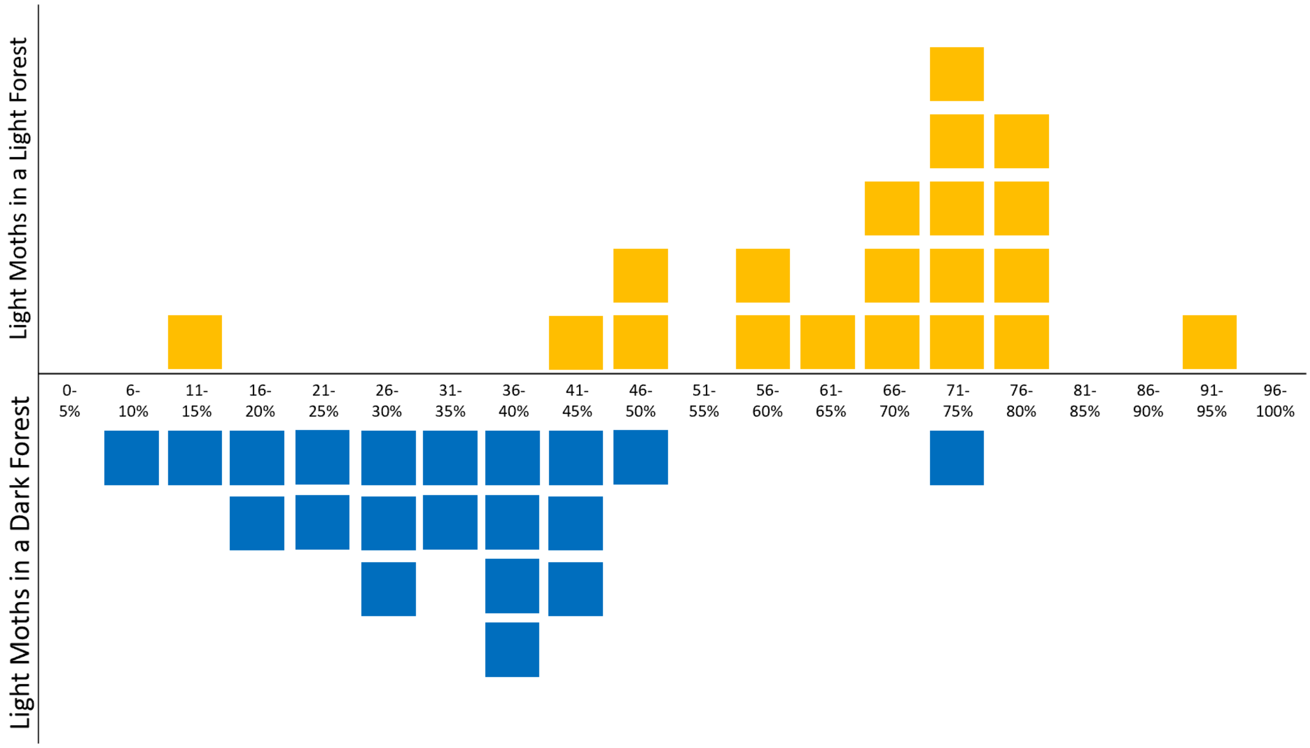




- Plot the result from this practice round on the chart that corresponds to the environment you chose by putting a sticky note into the appropriate column. Always record the percentage of **light moths** left in the population. The example below shows what this might look like for one trial in each environment:



- Explain that you will be running the rest of this experiment as a class. Each student will complete one trial, and their trial will be represented by one sticky note.
- Distribute Chromebooks to each student and have them navigate to the simulation website and click on the right-most circle, “A Bird’s Eye View of Natural Selection.”
- Have half the class click “light forest” and half the class click “dark forest” and play the simulation. Alternatively, you could play two rounds where every student does light forest, and then every student does dark forest.
- When students complete a round, have them call out their **light moth** percentage, or put their own sticky note into the appropriate bin.
- The final chart should look something like this:

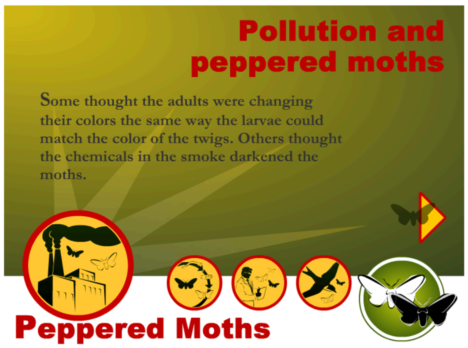


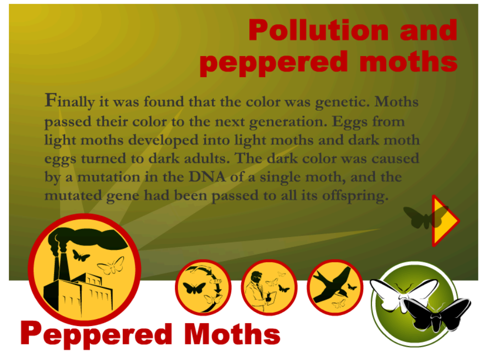
- Once you complete the chart, spend a few moments making sense of it graphically before moving on to connect the concepts to the life science principles. Possible discussion topics include:
    - **Outliers**: There will likely be outliers if students purposely try to eat the hard-to-see moth. This is an opportunity to talk about why doing multiple trials is important.
    - **Mean/median/mode**: Though these topics are advanced, in this histogram form students can begin to see where the average lies and which percentage occurred most. Have students identify which bin the most sticky notes are in for each environment. In our example, the mode would be in 71-75% for light forest and 36-40% for the dark forest.

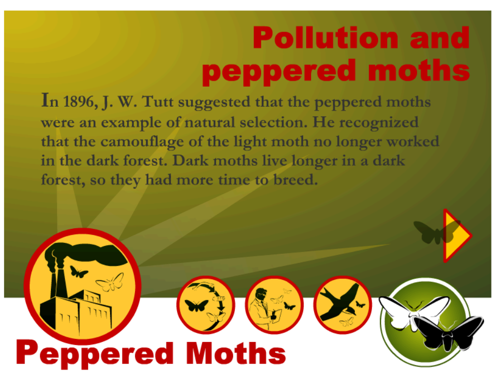
5. Debrief the activity

- Hold a whole-class discussion around the following topics:
    - *Which environment did the light moths survive better in? (light forest)*
    - *What effect did pollution (dark forest) have on the moths?*
        - *Heavily polluted forests will support more dark moths and clean forests will support more light moths.*
        - *Dark moths on dark trees are less likely to be eaten by birds. Light moths on light trees are less likely to be eaten by birds. But a light moth will stand out against a dark, polluted tree and will easily be eaten!*
    - *All moths in this activity were peppered moths. Why didn't they all survive?*
    - The idea here is that **even in the same species, certain individuals were able to survive better than others**.

- *In this activity, we saw that pollution caused by humans changed the environment and affected the peppered moth. What other changes do humans make that can affect wildlife?*
- If necessary, return to the simulation and read the explanation of natural selection in the "Pollution and Peppered Moths" section.







6. Notebooking

- Have the students sit in their design challenge groups and work on their individual notebook spread to recreate the simulation results and answer the focus question.
- Once students have finished their individual notebook pages, they should work as a team to brainstorm ideas for the design challenge and enter them into their shared notebook.

Lesson 5: Musical Habitats

Standard(s) from the MA Curriculum Framework	**Anchor Phenomenon and Focus Question**
3-LS4-4 Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	*How does the development of land areas affect animals living in the area?*
Materials ● Foam tiles or sit spots ● Music, construction sounds, or forest sounds	**Assessment/Evidence of Learning** Student notebook entries

Overview

In this lesson, students play a game similar to musical chairs to simulate the effect of development on habitats and the animals who live in those habitats.

1. Preparation

- Make sure your classroom has enough chairs for every student, plus a few extra, and there is room to move around freely.

2. Set the stage for the game

- Reiterate the needs of all animals: food, water, shelter, space, air. Ask:
    - What are some of the problems facing wildlife today?
    - If the discussion doesn't end up on human impacts, remind the students what they figured out during the peppered moth simulation and connect it back to the design challenge: humans change things in the environment and it affects wildlife. In the case of the design challenge, development is forcing wildlife out of their natural habitats.
- Revisit the images in this slideshow (thumbnail versions below). They show the evolution of the land from natural habitat to what is now the APEX Entertainment Center. These images were gathered from this site.

- Explain to students that today they will play a game to simulate a wildlife habitat before and after development, like the APEX entertainment center.

3. Play the game

How to play "musical habitats"

This game is similar to the familiar musical chairs. Students, playing as wildlife, will meander through their environment, searching for habitable land in every round. Rather than removing a chair each round, the teacher, acting as the "developer," covers chairs with increasingly large settlements. When a student can't find a chair, it is as if an animal doesn't have enough resources and can't survive.

- ➢ Pull chairs out from desks so they are easy to get in and out of. Ideally, begin with a few more chairs than students.
- ➢ Play one or two rounds without any developments. This represents the animal's natural habitat, before any human developments. Turn on the music (or forest sounds!) and have students walk around the classroom; feel free to have them weave between chairs and desks, not adhering to a circle like standard musical chairs. When the music stops, students must find a new chair to sit in. If a student can't find a chair, they are out and can sit on the rug and watch the remainder of the game.
- ➢ Now, tell the students that developers are going to start building in the area. Start small, covering one or two chairs with the tiles. Feel free to have fun with it! Small developments could be coffee shops, fast food restaurants, etc. Make sure students know that "developed land" (chairs with tiles on them) cannot support any wildlife (the students). Play a few rounds like this, adding small developments. This would be a good time to switch to construction noises instead of forest noises.
    - ○ You can also incorporate roads and highways, covering chairs in lines and fragmenting the habitat. Add the restriction that students can't cross a road or highway.
- ➢ Continue to introduce larger and larger developments, driving wildlife out of the area. Play until most students are out, or play until there is no "wildlife" remaining.

4. Debrief the activity

- Begin a whole class discussion about the effects of the development on the habitat.
    - How many animals died? From what causes?
    - Was it easy to find a new area at the beginning at the game? At the end of the game?
    - Did the location of the developments change how easy it was to find a new area? Or who could find a new area more easily?
    - Could the developer have done anything differently to change the consequences?
    - Would it have reduced negative consequences for wildlife if the development was in a different area of the habitat?

5. Notebooking

- Have the students sit in their design challenge groups and work on their individual notebook spread, documenting what it was like to play the game.
- Once students have finished their individual notebook pages, they should work as a team to brainstorm ideas for the design challenge and enter them into their shared notebook.

Lesson 6: Problem Scope and Ideate

Today students will focus on defining how they will approach the problem and plan a testing procedure. The focus question is *How will you test your design to find out whether it solves the problem?*

1. Whole-class discussion: criteria, constraints, what is a test (20 min)

Talk with the class about what criteria and constraints mean. In general:

- **Criteria** are the things a design must be able to do
- **Constraints** are the limitations on the design (typically time, materials, size, cost)

As a class, come up with criteria and constraints for the design challenge. Think about the ideas students are already having. For instance, if students are thinking about a bridge, their criteria might be that it needs to support the weight of an animal, be able to fit a car under it, and be safe for the animals. Constraints may be the materials given and how much time they have to build. If the class has lots of different approaches to the design problem, choose a few to identify criteria and constraints for.

Displaced Animal Rescue Design Challenge

Design scenario: A development has just gone up in Marlborough. Many animals have been displaced from their habitat. People are noticing that the animals are in their local communities. This increased chance for interaction between wild animals and humans is not safe for either animals or humans. But a highway, other buildings, and neighborhoods separate the developed area and the conservation lands.

Before After

Goal: Design and build something to help relocate animals displaced by the APEX Entertainment Center.

Criteria:

- What does your design need to have?
  ____
  ____
- What does your design need to be able to do?
  ____
  ____

Constraints:

- What materials can you use to build your solution?
  ____
  ____
- How much time do you have to design, build, and test your solution?
  ____
  ____

Now shift to talking about tests. **Tests show us whether or not we've met the constraints**. This slideshow can be used to discuss testing in the real world with a problem very different from the one students are working on. In this example, engineers are designing a method to clean up oil spills. They test their solution with a small oil spill in a pool. Introduce the problem, then show students the images. Ask, *Why would these engineers want to test their solution in a pool?* Students will probably have a lot of ideas! List them on the board. Answers may include:

- Smaller, cheaper, safer
- Don't want to actually pollute a real river
- Do it small to try lots of things with less money
- You can control things more

Now pivot the discussion back to the problem the students are solving. Discuss:

- "If you were trying to convince your local government to build your design, HOW would we show that it works? (WITHOUT building a full size one)? How can we test your design?"
    - Write down student responses somewhere.
    - Students might only reference the provided criteria, constraints, and testing strategies. If students have other ideas about what to consider in their design or other ways to test their prototypes, explore those.
- "Another way to think about the test is, How can we show that it works or know what to change?"
    - Compile more answers if they have them

2. Design teams: Write down testing procedure (15 min)

Have students sit in their design teams to come up with and record their testing procedures. These should look like step-by-step instructions, and students should have an idea of what "success" looks like. Generally, it's a good idea to have one or more tests for each criterion. For instance, if your criteria is "design must support the weight of an animal," your test plan might look like this:

Test #1: Supporting weight
Step 1: Put the animal on the bridge Step 2: Wait for 1 minute Step 3: Observe the bridge. Success looks like: the bridge is strong and straight. It does not fall down. Needs more work if: the bridge is bending in the middle. The bridge falls down.

This sheet can be used for students to record their criteria, constraints, and test procedure, or they can write on a blank or lined sheet of paper.

Test:

- How will you know that you met the criteria and constraints? What will you measure? What tests will you do?

For each test you want to do, write the instructions below.

Test #__: ____

____

____

____

____

____

3. Whole class: Share out testing procedures (10 min)

Bring everyone together to talk about their testing procedures. Have some groups share their step-by-step instructions. You could even have one group read their instructions and try to follow them.

Your discussion might look like this:

"From what everyone is saying, I think one useful way to break it down is there are 2 parts of testing: that it physically works & that it's safe and desirable for animals"

- For 1: to ensure it physically works, we have to think about forces
    - How can you support the weight of the animals?
    - How can we test that?
    - How can you make [a bridge] that can stand on its own? [A truck] that can hold a bear? A structure that is stable when the floor shakes?
- For 2: safety and desirability, we have to think about the animals
    - Are animal needs met?
    - Can we role play how an animal would use the equipment?
    - How will we know that an animal is safe? How will we know that animals would want to use [the bridge]? How will we know that animals can get in and out of [the truck]?

4. Generate multiple design solution ideas (5 min)

- Encourage sketching and drawing
- Can take pictures of materials or partially constructed designs
- Encourage multiple ideas

5. Build and test (if time)

Groups build first iteration of design and possibly begin testing first iterations, recording photos and notes

Lesson 7: Build, test, iterate (share)

1. Continue building and testing (In groups, all class)

Tell students that the next class they will be asking another team for feedback and helping another team with their questions, so they need to have something built by the end of this day. It does NOT have to be perfect/finished, just something to ask for feedback on.

- Make sure groups are building and testing soon during this day. Adults may need to push some "planning" groups to get to work making something physical.
- Encourage Test cards and Feature cards
- Push students to think about animal needs and other ideas from the inquiry lessons.

2. Examples from groups

- If you notice some good design work happening in a group, or a few groups, or good notebooking, consider pulling the class together to share their notebook or their design. This can be a great way to highlight work done by students who are often overlooked.
- It's especially great to show groups that documented how their design evolved, particularly if something failed and they recorded that and how it improved. Then you can push other groups to think about their own designs and how they will test them and improve them.

3. Press for reasoning

- When talking to students, try to push for mechanistic reasoning, getting to "why," beyond just showing that something works. Ask them about the forces acting on their design that affect its performance.

Lesson 8: Build, peer feedback, build

1. Engage student thinking about feedback processes (10 min)

- Tell students that today they will be asking for and giving feedback on a problem they're having. This is something engineers do because working so hard on one design can make it difficult to see weaknesses that other people can see. First they will come up with at least one question for the group they are paired with -- something they want advice on.
    - One benefit of asking for feedback on a specific issue proposed by the students is that the team receiving feedback will be able to steer the conversation. Instead of inviting a team to critique something they are proud of, the receiving team can direct the team group to something on which they truly want help.
- Ask students why we request feedback. What do we hope to get out of asking for feedback?
    - A new perspective on…
    - A new idea for…
    - Help with…
    - ***Note****: there is often a big emotional gain in face-to-face peer feedback. It's useful to hear that other people have struggled with similar problems (and how they overcame them, if relevant).*
- Ask students why we give feedback. What do we hope to get out of giving feedback to others?
    - Share what we've learned…
    - Help my classmates succeed…
    - See other approaches to the same problem...
    - ***Note****: similarly, there is an emotional gain in giving feedback. Students who may be struggling with their own design have the opportunity to help another team with something they're struggling with in a useful or clever way.*
- Ask students to give examples of non-useful and useful feedback (such as, "I don't like the color of your design" vs. "The design seems like it might let light through because...")

2. Prepare to request feedback (5 min)

- In their design teams, students can think about all the design related problems they are facing. They should, as a team, think of all the problems and make a list to share with their peers, so that they can seek peer advice.

3. Peer-to-peer feedback (20 min total, switch who's asking their question halfway)

- Pair each team with one other team. Have teams bring their project notebooks and their prototypes to a meeting with the other team.
    - Pictures or videos of their prototypes may come in handy here!
- One team should go first, asking the question(s) they came up with using the anchor chart above and listening to the ideas of the other group. After 10 minutes, repeat with the other team asking their question(s).

4. Build, test, iterate (in groups, rest of class)

- Groups break back into design teams to continue building and testing their designs. Students may choose to incorporate the feedback they received, or continue on with any of their own ideas.

Lesson 9: Iterate and Document

If you ran out of time on Day 8, have students finish building their physical design (with or without the feedback they got from the other group). By the end of the day, both the physical designs and notebooks should be ready for the Expo. Students who are ready early can continue to flesh out their notebook to really capture their process and begin thinking about the questions in Lesson 10.

Lesson 10: Design Expo

Students should get their design and notebook ready to show visitors. Encourage visitors to test out the designs, look through the notebooks, and ask students about their process in addition to their final design.

It may be a useful scaffold to have students think about how they would answer questions like…

- How did you decide on this design?
- Why did the group think this was the best design to create?
- How did the group make sure the design was safe?
- How did the group make sure the animals were comfortable and safe?
- What changes did you make from the original design?
- What was the hardest part of making the design?
- What do you think is the most important part of your design?
- What part of your design are you most proud of?
- What would you continue to improve if you had more time?