Ecosystem Invasion!

Lifecycles, Traits, and Survival

3rd Grade Life Science Storyline to support the Structures of Life kit

ATTRIBUTION

This unit storyline was written by Pranjali Upadhyay, Integrated Curriculum Specialist, with support from Stacy Meyer, Regional Science Coordinator, and Vickei Hrdina, Director of STEM Initiatives, Educational Service District 112. The unit, logos and graphics were designed by ESD 112's Design Services, led by Creative Director Heidi Barnes. Instructional materials are developed to support the following science kit:

- FOSS: Structures of Life

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A digital copy of this document is available on the STEM Materials Center website at: https://www.stemmaterials.org/ecosysteminvasion

STEM
Science
Technology
Engineering
Math

A program of Educational Service District 112 supporting Next Generation Science Standards

A Note of Thanks

We would like to express our sincere gratitude to the Emily Hopple (K-2nd grade teacher, Skamania School District) and Ralph Pruitt (Superintendent, Skamania School District) for providing support in development of this unit and for providing high quality STEM experiences to their students. We are grateful to our partners at [Pacific Education Institute](), Chad Mullen, Lower Columbia FieldSTEM Coordinator and Kathryn Kurtz, Executive Director, for their support in integrating Field STEM experiences to make learning more relevant and engaging. Thank you to Erin Harwood, STEM Coordinator and faculty at Clark College, for providing access to meaningful local phenomena to create an anchoring experience for students. Thank you to Rick Reynolds from [Engaging Every Student]() for providing high quality instructional materials that will help students to further investigate the invasive crayfish phenomenon locally.

Background on the Core Scientific Ideas in this Unit

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

This integrated 3rd grade unit addresses the NGSS Life Science bundles for Interdependent Relationships in Ecosystems (3-LS2-1, 3-LS4-3, and 3-LS4-4) and Inheritance and Variation of Traits: Life Cycles and Traits (3-LS1-1, 3-LS3-1, 3-LS3-2, and 3-LS4-2). Students embark on a mission to protect their native plants and animals by devising a plan to regulate and prevent the spread of invasive species in the area. Through a series of FOSS investigations and other OER (open educational resource) lessons and activities, students learn about how an organism's traits aid in survival, how parents pass on traits to their offspring, and how the environment influences plant and animal traits and behaviors.

Supporting Materials

For your easy access, all supporting materials for this unit are located in this google drive folder. Please make a copy of materials onto your own drive and make adjustments to fit the needs of your students. Additional support materials for teaching strategies and practices in this unit (N2K and KLEWS chart and Claims Evidence Reasoning) are available in this google drive folder.

UNIT OVERVIEW

Lesson No.	Duration	Standards	Focus	Assessment Options
1 page 6	2-3 sessions	3-LS4-3 3-LS4-4	**Students will:** • Engage with the phenomenon of invasive species in the Pacific Northwest • Study different examples of how invasive species cause disturbances in an ecosystem • Create a Need to Know (N2K) chart about what they need to learn to answer the driving question	N2K chart Informal group presentations
2 page 10	7+ sessions	3-LS1-1 3-LS3-1 3-LS4-4	**Students will:** • Create a model showing the plant life cycle • Connect and compare traits that seeds and seedlings have with parent plants • Engage in a field STEM seed hunt to find different seeds in their local habitat • Engage with the phenomenon of the invasive blackberry bush and make comparisons between this invader and native plants	Initial model of plant life cycle Classroom discussion
3 page 13	7+ sessions	3-LS1-1 3-LS3-2 3-LS4-2 3-LS4-3 3-LS4-4	**Students will:** • Continue to develop their model of the plant life cycle • Plan and conduct an investigation to learn about how traits are affected by the environment • Engineer a "Master Invader" • Design a solution to control the blackberry bush.	Model of plant life cycle CER argument about the Himalayan Blackberry Drawing/presentation of master invader Prototype drawing for design challenge

UNIT OVERVIEW (cont.)

Lesson No.	Duration	Standards	Focus	Assessment Options
4 page 18	5+ sessions	3-LS1-1 3-LS4-2 3-LS4-3 3-LS4-4	**Students will:** • Engage with the phenomenon of the invasive crayfish • Research and study to understand the crayfish problem • Identify and describe the structures a land snail uses to survive • Write a CER argument about which animal is better adapted to the local habitat • Engineer a trap to catch the invasive crayfish	Model of crayfish and snails CER argument about crayfish vs snails Design challenge solution
5 page 23	5 sessions	3-LS4-3 3-LS4-4	**Students will:** • Create a campaign to educate the public about invasive species • Use feedback from peers to optimize presentation • Share the procedure and reasoning for their design solution with the public	Final product for public

LESSON 1: Invasion!

Strategy: Engage

Materials Needed

- Computers with internet access.
- Chart paper
- Colored pencils and markers

Introduction for teacher: This unit addresses the 3rd grade NGSS bundles on Inheritance and Variation of Traits (life cycles and traits) and Interdependent Relationships in Ecosystems. Students will start by learning about invasive species and will explore some invasive species that have impacted their region. Through the course of the unit, students will build their understanding of the life cycle of plants and animals and the traits that help them survive, as well as how ecosystem changes can create both barriers and advantages to survival. The driving question that will engage students in the storyline of this unit: How can we protect our local native plants and animals from invasive species?

Entry Event (Introduction lesson):

Start by introducing students to invasive species using one or more of the following videos:

- Invasive species living on debris from Japan Tsunami pose threat to Native Species
- Video about several invasive species around the country
- Cane toads invading Australia

After the video, discuss the concepts of native species, biodiversity, and invasive species using this slides presentation.

Next, provide students with some introductory reading on the topic. Have a group of 2-3 students read each article together and discuss the main points. Provide students with highlighter and ask them to highlight words that seem unfamiliar or words that they are not quite clear about the meaning for. Students can put important words (words that seem especially important for understanding invasive species) on the "Need to Know" chart that will be created later in this lesson. Then, have students summarize their article and share their findings with the class. Please note that these texts may be difficult for students to process based on their reading level. Allow students to focus only on the animals and details about the problem it caused. Guide students using the following questions: What was the animal in the article? How did this animal cause problems for other plants or animals? This activity can be used as an opportunity to make connections to the CCC (cross-cutting concept) of Cause and Effect. Use this cause and effect template to help students organize their thinking.

- National Geographic article on "Green Invaders
- Newsela article: Stink bugs can be a big pest for U.S. orchards
- Newsela article: The armyworm is eating its way through Africa's key food sources

- [Newsela article: Just a few marsh-eating nutria left in Maryland]
- [Newsela article: Attack of the lionfish]

Whole class reflection: Ask students to talk about the following prompts in small groups (or pairs) and then facilitate a whole group conversation:

- What is an invasive species?
- What are some problems that invasive species create?
- Are these serious problems? Why or why not?

Present students with the driving question: *How can we protect our local native plants and animals from invasive species?*

Follow-up and facilitate discussion using these prompts:

- What are some ideas about possible ways that we can solve these problems?
- What are things that we need to learn in order to solve these problems?
- What questions or wonderings do we have (it may help to have each student take a post it and write one question or wondering)?

As students are discussing, create a Need to Know (N2K) chart by writing down students' ideas on a collective anchor chart that will remain posted in the classroom throughout the unit. This template can be used by the teacher to create a larger chart for the class. Make sure that all student voices are heard. If you anticipate that your students will struggle with formulating questions for the need to know chart and need more structured thinking, the KLEWS chart is another alternative to the traditional KWL chart and can be used to track student thinking. Please see link above for detailed directions about using the KLEWS chart.

Some anticipated questions: What is an invasive species? What is a native species? How will we know what is native and what is invasive? What information do you need to know in order to help protect the plants and animals that have always been living in the area? Why is it important to protect the plants and animals in the area? What might happen if we let invasive species take over? How did invasive species get here in the first place?

How Lesson 1 Supports
Next Generation Science Standards

3-LS4 Biological Evolution: Unity & Diversity

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.
http://www.nextgenscience.org/dci-arrangement/3-ls4-biological-evolution-unity-and-diversity

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. 3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	• Engage in learning about invasive species and how they can change a local habitat in many ways. • Learn about how invasive species have started to outcompete and prey on local native species. • Identify what information and content they still need to know in order to help protect our native species from the invaders.
SCIENCE & ENGINEERING PRACTICES	
Asking Questions and defining problems Obtaining, evaluating and communicating information	• Study the problem of invasive species and ask questions about what they need to still learn about the problem in order to design a solution. • Watch videos and read articles, and then synthesize relevant information to present to the class about how invasive species pose a threat to native wildlife.
DISCIPLINARY CORE IDEAS	
LS4.C: Adaptation LS2.C: Ecosystem Dynamics, Functioning, and Resilience	• Study how invasive species that are better adapted to the habitat are outcompeting native species. • Describe how changes caused by invasive species affect the ability of other organisms to survive.
CROSSCUTTING CONCEPTS	
Patterns Cause and Effect Systems and System Models Structure and Function	• Study how changes caused by an invasive species affect organisms in the ecosystem. • Identify patterns of change that can be used to make predictions when an invasive species is introduced to an area. • Study how populations and species within an ecosystem will change based on invasive species being introduced.

LESSON 2: Responding to the Environment

Strategy: Explore

Introduction for teacher: In this lesson, students will engage with the FOSS Structures of Life Investigation 1: Origin of Seeds and look at the investigative phenomenon of a plant growing through a few different lenses. Students will 1) take detailed observations about the plant life cycle that they observe with their seedlings 2) look at how plants and their offspring have similar traits. Students will also study the origin of seeds, sprout seeds, and compare the plants they are growing to the invasive Himalayan blackberry bush that has taken over many forests and green spaces in Washington.

Day 1: Connections between seeds, seedlings, and plants

FOSS Structures of Life Investigation 1, part 1: Students explore seeds and different sources of seeds. Ask students to make observations and inferences: What are the properties of the different seeds? What are the similarities and differences between how the seeds look and where the seeds are located (in an apple, in a lemon, in a pod, etc.)? What types of plants do you think these seeds come from? Students can draw pictures of each type of seed in their science notebooks. Have students sketch drawing of adult plants in their notebooks. Students may need to go online and research about the plants where the seeds originated. What are the characteristics of these plants? How are they similar and how are they different?

Day 2: Lesson Extension about purpose of seeds

This NSTA recommended lesson SEED DISPERSAL (created by Mpala Live), guides students through an exploration of seeds and their purpose. We recommend modifying/expanding the contents of this lesson into an Engineering Design Challenge where students are able to design their own seed for optimum dispersal using miscellaneous materials from the classroom (ex. construction paper, tissues, popsicle sticks, pompoms, etc). Be sure to ask students to draw their prototype of the seed before building, as drawing a prototype of their design is an important skill to develop during the engineering design process.

Day 3: Why do plants have seeds?

Facilitate a discussion: What are seeds and how does a plant use them? Ask students to draw or write their predictions in their science notebooks. What exactly is a seed and what is its purpose? [plants grow out of the seeds] Where are seeds located in different plants? What are different ways they are dispersed (moved from one place to another)? Why would a plant want to have its seeds inside a delicious fruit? Provide students with some sentence stems to organize their thinking and give them the opportunity to discuss their ideas with a partner before writing or explaining in a whole group:

Materials Needed

Materials for FOSS Structures of Life Investigation 1, part 1:

- Plastic knife
- Bean or pea pods
- 4-6 different types of fruits*
- Paper or plastic plates
- Paper towels*
- Newspaper
- Chart paper and markers

*Not provided in kit

- If a plant has tastier fruit, then____________.
- If a plant has more/less fruit, then it will reproduce more/less, because _________.

Day 4: Seed Hunt

Field STEM opportunity: Take students outside and have them go on a seed hunt. Have students create detailed drawings of the seeds that they find on the seed hunt and consider the following questions: How many different types of seeds can they find? Can you identify the parent plant(s)? If so, what kinds of plants do the seeds come from? Have any of the seeds traveled a far distance from the parent plant?

Day 5

FOSS Structures of Life Investigation 1, part 2: In the lesson, students grow seedlings and compares seedlings to potential parent plant. Ask students to write and draw detailed observations of the seeds. What are the characteristics of the different seeds? How are they similar and how are they different? Then, students can predict, how will the new plants sprouted from the seed look? Will they all look the same, or will they look different? Why?

Note: Part 3 of Investigation 1 is optional.

Observing the seeds as they sprout: Students will observe the seeds over the next week as they begin to sprout. Ask them: What do your little seedlings need in order to grow? Have students draw a quick model showing the seedling and the things in the habitat that are necessary for survival. Ask students to use arrows and words to describe their thinking.

Day 6: The Himalayan Blackberry

Connect with the storyline: Introduce students to the Himalayan Blackberry which is an invasive bush that has caused problems in many ecosystems here in Southwest Washington. These video also presents students with a great introduction to the invasive blackberry:

- How to tame Himalayan blackberry
- More info about the characteristics of the Himalayan blackberry

Ask students if they have seen this plant around their neighborhood. What does a blackberry seed look like? What are the structures that a blackberry seed has that make it easy to spread and reproduce? If possible, bring in blackberries for your students to dissect and eat so each student can have a chance to see, feel, taste and smell the fruit surrounding a blackberry seed. What is a potential benefit of having the blackberry in the local community (students will likely talk about

Materials Needed

Materials for FOSS Structures of Life Investigation 1, part 2:

- Container (1/4 L)
- Container lid
- Round coffee filter
- Seeds (bush bean, sunflower, pea, popcorn)
- Sprouter
- Brush
- Container (1/2 L)
- Plastic cups
- Pitcher
- Metric spoons
- White glue*
- Water
- Bleach*
- Transparent tape*

Materials for FOSS Structures of Life Investigation 1, part 3 (optional):

- Minisprouter with seeds
- Lima bean seeds
- Hand lenses
- FOSS balance
- Plastic cups
- 1 gram pieces
- Student sheets

*Not provided in kit

blackberries as a food source throughout the summer). What might some of the disadvantages be?

Make a Venn diagram comparing and contrasting the seeds of a blackberry with the seeds of one of the plants you were sprouting. What do you notice about the number of seeds in each fruit? What else do you notice about the blackberry seeds versus the other seeds we planted? Which one do you think would spread more easily and why? What would make a fruit more appealing to animals?

Day 7: Start formulating a solution

In the next lesson, students will be designing a solution to help control the blackberry population in their area. Give students a head start by asking them to think about this and write their ideas on post-its. How can we prevent the Himalayan blackberry from spreading as it does? What are some of your ideas to prevent those seeds from dispersing? Create a space for students to post their ideas. Ask students to go home and talk to their families about the invasive blackberry. Ask students to collect family experiences and bring them in to share the next day.

Teacher resources:

- Information on the Himalayan blackberry
- The Strange, Twisted Story Behind Seattle's Blackberries

How Lesson 2 Supports Next Generation Science Standards

3-LS4 Biological Evolution: Unity & Diversity

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.
http://www.nextgenscience.org/dci-arrangement/3-ls4-biological-evolution-unity-and-diversity

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death. 3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. 3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.	• Analyze the similarities between seedlings and parent plants. • Compare how plants that come from different parents have different characteristics. • Discuss the beginning of the life cycle and how it is similar for plants with seeds. • Discuss the use of seeds a natural part of the plant's life cycle aimed towards reproduction. • Discuss how the quality (size, taste, quantity, etc.) of fruit can help a plant reproduce more effectively. • Compare the blackberry plant and its seeds to other seeds that were sprouted and infer why the blackberry seeds are better at spreading. • Begin to collect data about why the blackberry plant is better adapted to the environment than the native plants, which allows it to take over.
SCIENCE & ENGINEERING PRACTICES	
Asking Questions and Defining Problems Constructing explanations and designing solutions Obtaining, Evaluating, and Communicating Information	• Discuss how fruits/seeds enable a plant to produce and why the Himalayan blackberry has such an advantage. • Start to formulate a solution that prevents the blackberry from spreading and taking over the native ecosystem. • Collect information and communicate their ideas about the blackberry and why it is better adapted to its environment.

How Lesson 2 Supports Next Generation Science Standards (cont.)

Peformance Expectation	Connections to Classroom Activity, *Students:*
DISCIPLINARY CORE IDEAS	
LS1.B: Growth and Development of Organisms LS3.A: Inheritance of Traits LS3.B: Variation of Traits LS4.C: Adaptation	• Study that birth and reproduction is a common part of the life cycle of a plant. • Analyze and draw how seedlings are similar to their parent plants • Compare the different traits of plants that come from the same and different species. • Compare the invasive blackberry to other native plants and begin to construct an argument about why one is better adapted to the environment than the other.
CROSSCUTTING CONCEPTS	
Patterns Cause and Effect Structure and Function	• Patterns in inheritance can be used to predict the traits of a seedling. • Patterns in life cycles of a plant can be used to make predictions. • Some traits cause an organism to survive better than others. • Identify and compare structures that allow an organism to become better adapted to an ecosystem.

LESSON 3: Traits

Strategy: Explain

Introduction for teacher: In this lesson, students will wrap up their plant life cycle observations and create a model to show the life of a plant. They will also more deeply investigate the Himalayan Blackberry Bush and identify the traits that help invasive species take over an ecosystem. Using the understanding of traits and survival, they will craft a CER (Claims, Evidence, and Reasoning) argument and then engaging in a mini-engineering task where they design a "master invader." This lesson culminates with students engaging in an engineering design challenge to battle the invasive blackberry bushes that are taking over the PNW.

Day 1 (and then observe daily for about a week)

FOSS Investigation 2: Growing Further parts 1-3: In this part of the FOSS investigation, students will compare four different types of seeds as they become little plants. Students will observe how plants change over time. As students continue to make observations of the growing plants, students should record their observations in their science notebooks. Daily observations will be helpful when students draw a model of the plant life cycle. After students have observed the seed sprout, become a seedling, and then become a young plant, have students use this information to create a diagram to show the life cycle of a plant. Students can use this template to create their model. What stage of the life cycle are the plants currently in? Can you predict what changes will occur a week, a month, and/or a year from now?

Day 2 (after seeds have sprouted into small plants)

Investigation Extension to address DCI 3.B (3-LS 3-2): Extend FOSS investigations by presenting students with a new investigation focus: How does the environment affect the life cycle of the plants we are growing? For example, what would happen if we stopped watering some of the plants or put them in a closet where it is very dark? Ask students to make predictions. Then present students with the idea that we will be investigating what happens to the traits of a plant when conditions in the environment change. NOTE: This investigation will be more effective if soil is used instead of the hydroponic set-up. Simply have students plant sprouted seeds in small cups and place in desired locations. Have different groups in the class select a different variable (ex. one group will make frequent observations of a plant that is placed in the closet and away from light, while another group will make observations of a plant that will not be watered for several days). Have all groups label a plant that is part of the "control group" and place it in a location with normal light and provide normal amount of water. Have students make observations of their plants daily for one week to note any changes. If changes are not notable after a week, continue the investigation for several more days. At the end of the designated time,

Materials Needed

Materials for FOSS Structures of Life Investigation 2

Part 1:
- Minisprouter with seeds
- Paper towels*
- Sprouting Seed Place mat
- Hand lenses
- Class sprouter

Part 2:
- Germinated bean seeds
- Basics (6 L)
- Hydroponic plant holders
- Hydroponic nutrient powder
- Set of metric spoons
- Straw
- Paper towels*
- Water

Part 3:
- Scissors
- White glue
- Sheets of unlined paper
- Hydroponic setups with plants (OR substitute with regular soil)
- Hydroponic nutrient powder (or substitute with regular soil)
- Metric spoons
- Hand lenses
- Pitcher
- Water
- Straws
- Paper towels*
- Transparent tape*
- Sticky notes
- Meter tape*
- String*
- Masking tape*

Materials for Engineering Design Activity:
- Chart paper
- Markers/colored pencils
- Lots of post-its

*Not provided in kit

ask students to look at the data they collected through their daily observations. Did the traits of the plants change at all? If so, what changes do you observe? Why do you think those changes occurred? How did the traits of the plant in the experimental group differ from the control group?

Day 3

Connect with the storyline and craft a CER (Claims Evidence Reasoning) argument: Compare the structures of a blackberry bush and some of the plants that live in the native northwest. Here are some slides with the pictures of different native plants. Plant profiles with details about the plants can be found on this website by the Washington Invasive Species Education Society. This poster of native plants might also be of interest to students who want to identify native species. What are some of the important traits that plants in the PNW have that help them survive? What traits does the blackberry bush have that help it to thrive and potentially out-compete the native plants? Work with students to craft a CER (Claims Evidence Reasoning) argument that answers the question: Is the Himalayan blackberry better adapted to the PNW than the bean sprouts we grew in class? You can use this template as a guide to create a large chart with catalogued pieces of evidence and students reasoning. Facilitate a discussion where students share pieces of evidence to show why the blackberry bush is better adapted. This sample CER can be used by the teacher to understand how a completed template may look.

Days 4-5: **Engineering Design Challenge: Designing a Master Invader**

Have students design a plant that has traits that will help it survive and reproduce the best in an environment. This slides presentation can be used to introduce students to the task and help facilitate some discussion where they are reviewing some of the material they have learned and preparing for the mini-engineering task. Working in pairs may be a helpful strategy to allow students to support each other and engage in some creative collaboration. For the final stage of the activity, facilitate a gallery walk protocol where teams can get a chance to share their plant drawings and give each other feedback. Once students' models/ drawings are complete, post them in a place in the classroom.

Days 6-7: Engineering Design Challenge: Beating the Blackberry Bush!

Present students with the following scenario about the Himalayan Blackberry bush using this slides presentation and allow them to engage in the Engineering Design Process, which focuses on preserving our native species and controlling the blackberry bush. You can start the activity by sharing this scenario and then highlighting the STEM career of Forest Ranger using this pamphlet.

Scenario: Controlling the Himalayan Blackberry. You are a park ranger who works at a local forest. It is your job to protect the plants and animals that live in the forest. You have noticed that an area of the forest is being taken over by blackberry bushes. This will make it hard for the small plants to survive, or for animals to access parts of the forest for food. **Your task:** Design a solution to help protect the forest from the invasive blackberry bush. Your solution should include a description of your plan, drawings/diagrams of any materials you will need, and reasons for why you think your solution is a good one.

Plan: Have students discuss the problem that they are trying to solve. What problem is the blackberry bush creating for native species? What are some more things that we need to know in order to solve the problem? What do you need to research in order to solve the problem? What are some of the criteria or constraints in solving the problem? This is a video by Bozeman Science that overviews the engineering design process.

LESSON 3 (cont.)

Design: Guide students through the process of coming up with design solutions to the problem. They may want to use the internet to research and evaluate solutions that already exist, which is fine. Also, at this point in the process, encourage students to use their creativity to come up with as many design solutions as possible (no matter how silly). After the brainstorming process, students will evaluate their ideas and pick the best one. Ask students to include reasoning to justify why the one solution they picked is actually the best one. Why is this one the best? How will their solution affect plants and animals within the environment? What is expected to happen after the solution is implemented?

Career connections: Call students' attention to the STEM career of a forest ranger. In the previous activity, they were practicing some of the same skills and tasks that a forest ranger would! Use this one-pager to have students read about what a forest ranger does. Ask students to highlight some of the things they were doing that are similar with what a forest ranger does.

Check: During this part of the engineering design process, provide students with the opportunity to receive peer feedback. Guide them through the Charrette Protocol, a method used by actual engineers to get feedback on their work-in-progress.

Share: Facilitate a gallery walk or other preferred protocol to have students share their work. Students will also have the option of sharing their work with a public audience at the end of the unit where they pick a design solution to talk about in their awareness campaign.

How Lesson 3 Supports Next Generation Science Standards

3-LS4 Biological Evolution: Unity & Diversity

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.
http://www.nextgenscience.org/dci-arrangement/3-ls4-biological-evolution-unity-and-diversity

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death. 3-LS3-2: Use evidence to support the explanation that traits can be influenced by the environment. 3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates and reproducing. 3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. 3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	• Continue to develop and refine model of plant life cycle. • Plan and conduct an investigation to observe how environmental conditions (amount of light and water) affect the traits of a plant. • Identify the traits that allow a plant to survive and reproduce. • Construct a CER about why the Himalayan Blackberry is an invasive species. • Engineer a "master invader" that has some traits that will aid in survival and reproduction. • Engineer a solution to the problem of the invasive blackberries in the PNW.
SCIENCE & ENGINEERING PRACTICES	
Developing and using models Engaging in Argument from Evidence Defining Problems and Designing solutions	• Use their model of a plant life cycle to study the current development of growing plants. • Engage in an argument based on evidence for why the Himalayan blackberry is an invasive species in the PNW. • Engineer a solution to the blackberry problem in the PNW. • Engineer a "master invader" using their understanding of traits and survival.

How Lesson 3 Supports Next Generation Science Standards (cont.)

Peformance Expectation	Connections to Classroom Activity, *Students:*
DISCIPLINARY CORE IDEAS	
LS1.B Growth and Development of Organisms LS3.B Variation of traits LS4.B Natural Selection LS4.C: Adaptation	• Include reproduction in their model explaining the life cycle of plants. • Create an investigation and collect data to show how traits can change depending on the conditions of the environment. • Discuss how certain plants and animals of the same species are better adapted because of their traits. • Create a CER showing how invasive organisms are better adapted to the environment than the native species, which is why they take over.
CROSSCUTTING CONCEPTS	
Systems and System Models Interdependence of Engineering Technology, and Science on Society and the Natural World Patterns Cause and effect	• Study how a change in a system can cause resulting changes (ex. invasive species affecting the entire ecosystem). • Design a solution using creativity to help reduce negative impact of invasive species. • Identify patterns in the life cycle of the plant and use it to make predictions. • Write a CER explaining how an invasive species (the Himalayan Blackberry) affects its ecosystem.

LESSON 4: Survival

Strategy: Explain

Introduction for teacher: This lesson takes a step away from looking at plants and focuses on having students look at the traits that animals have to aid in survival. Students start by learning about the invasive crayfish. Then, students meet the land snail and analyze the structures it uses for survival. The lesson culminates with students comparing the structures of a crayfish with the structures of a native snail and write an argument to describe why the crayfish is creating problems for the local ecosystem. Students can also be shown this OPB PBS video about an invasive species cook-off to recapture engagement before the lesson.

Days 1: **Investigative phenomenon: Invasive Crayfish**

Start by presenting the investigative phenomenon of the invasive crayfish.

- This video about the invasive crayfish and how it was introduced to the Pacific Northwest can be a helpful introduction to the problem. During/After the video ask students to recall the following information:
    - How were they introduced to the area?
    - Which animals have they caused problems for?
    - Why do you think they are causing problems?
- Present students with this article to read about the crayfish in Washington. Ask students to identify important information that will help them answer the guiding question that was presented at the beginning of the unit: How can we protect our local native plants and animals from invasive species?
- Students can read pages 34-41 in the FOSS reader (Structures of Life) to learn more about the structures that the crayfish have that help them survive in their environment. There is also a section titled "Being Environmentally Responsible" (pages 40-41) that talks about the problems that can be created when crayfish are released into the wild.
- Ask students to create a model of an invasive crayfish and the structures it has that help it survive in our native environment and outcompete our native animals. The model should show the crayfish and have arrows and words to describe the different parts of the crayfish and how these parts help the crayfish survive. This slides presentation from the River Mile crayfish unit has some helpful visuals of crayfish adaptive structures and life cycle. Also, ask students to think about the crayfish life cycle and have students share their thoughts about why they think the invasive crayfish have been so good at spreading and taking over many ecosystems in the PNW.

Crayfish Extension Resources: These resources created by Rick Reynolds for the River Mile project can be used to extend learning about crayfish and their impact on the Pacific Northwest. Within this set of resources, this introductory lesson about crayfish can be used before students create a model of the crayfish. This lesson can be used to expand on the differences between the native and invasive crayfish.

Materials

FOSS Investigation 4: Structures of Life

- Land snails
- Plastic cup
- Cup lid
- 2 sheets of unlined paper*
- Basins
- Basin covers
- Water mister
- Carrots or spinach*
- Rubber bands*
- Chalk or cuttlebone*
- Paper towels*

Materials for Engineering Challenge (not a part of SMC kit):

- Recyclable materials such as large plastic bottles, cardboard, cartons, etc.
- Rubber bands
- Tape and glue
- Scissors

*Not provided in kit

LESSON 4 (cont.)

Day 2-3

FOSS Investigation 4: Meet the Land Snail: For better alignment with NGSS, skip parts 3 and 4 from this investigation to better focus on the DCI LS4.C (For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all). Please see the lesson outline below as an alternate to the FOSS guide lesson. Start by presenting students with the land snail and tell students that they will studying the structures of the snail and comparing it to the invasive crayfish.

- **Part 1: Land Snails at home.** Have students look closely at the structures of the snail. What are some of the traits that they can observe? How do these traits help the land snails survive? Students can read pages 64-65 in their FOSS reader to obtain more information. Students can also use these links to research the structures of land snails online. It may be best to ask students to explore only one website so they are not overwhelmed:
    - DK about snails
    - Snail World: Snail Information
    - Fun Snail Facts
- Once students have started to develop an understanding of the structures of a snail, have students create a model to show the structures that a snail has that help it survive in its environment. The model can look similar to the model of the crayfish; emphasis should be on using drawings, pictures and arrows to explain how the snail interacts with and survives in its environment.
- **Part 2: Comparing Crayfish and Snails.** Use FOSS guide for steps in how to engage students in further observation of snails. Work with students to create a Venn diagram comparing and contrasting the structures that snails and crayfish have.

Connect with the storyline: Writing a CER argument: Present students with the question: Which animal is better adapted to survive in our local habitat, a crayfish or a snail? Use this CER template to help organize students' thoughts. Since students probably have not encountered a CER before, this can be a process that is modeled by the teacher. This sample CER can be used by the teacher to help guide students with the process.

Days 4-5: Engineering Design Challenge: Trapping the Crayfish!

Present students with the following scenario about the Invasive Crayfish using this slides presentation and allow them to engage in the Engineering Design Process, which focuses on preserving our native species and controlling the invasive crayfish.

Career connections: You can start the activity by sharing the scenario below and then highlighting the STEM career of Conservation Biologist using this pamphlet. Ask students to look at the skills of a conservation biologist. Then present students with the scenario below and ask them to highlight he skills that they will be practicing that are similar to a conservation biologists. Have students return to the pamphlet to highlight skills that they used throughout the task.

Scenario: As you know, invasive crayfish are taking over streams, lakes and riverbeds in Southwest Washington! Imagine you are a Conservation Biologist trying to help save the local native species from the invasive crayfish. Design a trap to help catch invasive crayfish and plan a way to present this to the public as a solution to help control the invasive crayfish population.

LESSON 4 (cont.)

Plan: Have students discuss the problem that they are trying to solve. What problem is the invasive crayfish creating for native species? What are some things that we need to know in order to solve the problem? What must an effective crayfish trap be able to do? (For example, our design should be able to catch crayfish without harming them so that we do not accidentally harm the native species as well.)

Design: Guide students through the process of coming up with design solutions to the problem. Also, at this point in the process, encourage students to use their creativity to come up with as many design solutions as possible (no matter how silly). After the brainstorming process, students will evaluate their ideas and pick the best one. They may also want to use the internet to research and evaluate solutions that already exist, which is fine. Ask students to include reasoning to justify why the one solution they picked is actually the best one. Why is this one the best? Depending on the resources available to your students, you may have them actually build the crayfish trap, or simply to create a detailed prototype drawing of the device. If students are creating a drawing, ask them to draw and caption to help explain how their device works. Also, call attention to the fact that while we are trying to catch invasive crayfish, we do not want to harm native crayfish. How will we be able to help people using the trap identify which crayfish are native and which are not? Encourage students to go back to their research about the crayfish and create a guide to help users of their trap identify which crayfish are native and should be returned to their habitat. Students can use media from the internet (ex. print photos of native and non-native crayfish to create a pamphlet) or create their own drawings that help a user distinguish between native and invasive crayfish.

Check: During this part of the engineering design process, provide students with the opportunity to receive peer feedback. Guide them through the Charrette Protocol, a method used by actual engineers to get feedback on their work-in-progress. Allow students time to work on improving their design.

Share: Facilitate a gallery walk or other preferred protocol to have students share their work. Students will also have the option of sharing their work with a public audience at the end of the unit where they pick a design solution to talk about in their awareness campaign.

How Lesson 4 Supports Next Generation Science Standards

3-LS4 Biological Evolution: Unity & Diversity

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.
http://www.nextgenscience.org/dci-arrangement/3-ls4-biological-evolution-unity-and-diversity

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death. 3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates and reproducing. 3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. 3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	• Process and synthesize information about the crayfish and snail life cycle, as well as the structures they have for survival. • Identify and explain how certain traits can allow organisms to survive better in their environment (invasive species). • Write a CER using evidence to explain why Crayfish are so well adapted to survive in the PNW. • Evaluate preexisting solutions and use research and content knowledge to design a solution to help capture the invasive crayfish.
SCIENCE & ENGINEERING PRACTICES	
Constructing Explanations and designing solutions Asking Questions and Defining Problems Engaging in argument from Evidence Obtaining, evaluating and Communicating information	• Obtain information about the invasive crayfish and make comparisons with this invasive animal and the native animals being affected. • Create a model of the structures and life cycle of the crayfish and how these factors aid in its survival. • Write a CER argument for why the crayfish is better adapted for survival than the snail. • Design a trap to capture the crayfish and a plan of implementation to ensure that native crayfish are not being harmed by the trap.

How Lesson 4 Supports Next Generation Science Standards (cont.)

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
DISCIPLINARY CORE IDEAS	
LS1.B Growth and Development of Organisms LS3.B Variation of traits LS4.B Natural Selection LS4.C: Adaptation Ecosystem Dynamics, Functioning, and Resilience LS4.D Biodiversity and Humans	• Create a model to show the life cycle of the crayfish and the snail. • Collect observational data about the structures and behaviors that a crayfish/snail has to survive in its environment. • Discuss how certain plants and animals of the different species are better adapted because of their traits. • Create a CER showing how invasive organisms are better adapted to the environment than the native species, which is why they take over. • Ask questions to understand the problem being caused in PNW ecosystems by the invasive crayfish.
CROSSCUTTING CONCEPTS	
Systems and System Models Interdependence of Engineering Technology, and Science on Society and the Natural World. Patterns Cause and effect	• Study how a change in a system can cause resulting changes (ex. invasive species affecting the entire ecosystem). • Design a solution using creativity to help reduce negative impact of the invasive crayfish. • Create a presentation to share a message with the public about

LESSON 5: Spotlight Species to Save

Strategy: Explain

Introduction for teacher: In this unit, students have been learning about different invasive species and the impact that they have on their ecosystem. Two of the invasive species that students studied in depth are the Himalayan Blackberry Bush and the Invasive Crayfish. Students have even worked hard to engineer solutions to help save our native species from these invaders. This lesson will allow students to finish demonstrating their understanding of the content through the development of a public campaign that they will share with the community. You can plan a public engagement event based on what works best for your community. This article describes options for involving an authentic audience for student presentations.

Creating the campaign: Ask students to reflect on which invasive species they would like to educate the public about, and which design solution they are most excited to share with their community. Their goal for the campaign should be to mobilize the public to make a change in the community that helps protect native species.

Before students begin creating their campaign, have them think about the following points:

- The audience: Who will be in the audience? Why is the message important for the audience to hear/see? What is the best way to reach this audience?
- The public product: What will the public product look like? What will we create and how will we make sure that people see or hear our message?
- The argument: How will we convince people that our argument is a serious one? What evidence will we need to include? (Have students go back and revisit/revise their CER arguments from previous lessons)

Provide students with the opportunity to work with a team that is focusing on a topic and through a medium that they want to use (ex. a team may want to create a YouTube video to educate the public, while another team may want to create a podcast).

For the teacher: Coach students during the process of constructing their public product. Remind them to adjust their product so that it will have maximum impact on their audience. For students wanting to present using a slides presentation, provide guidance on effective delivery of a presentation (ex. not reading off the slides presentation the whole time).

Getting Feedback: Used your preferred protocol (such as a gallery walk or charrette protocol) to allow students to give each other feedback before the products "go live" with a public audience. Here are some resources for supporting students in giving each other peer feedback. Give students time to go back and make revisions on their work.

The big day: Whether you are having your students present their public products to a live audience or helping them launch their product digitally (ex. YouTube video or website), this is time to celebrate all of the hard work and dedication that the students (and you) displayed throughout the unit.

Materials
Access to computers with internet.
Art supplies for creating posters/ diagrams
Video camera (for taking videos or recording sound)

How Lesson 5 Supports Next Generation Science Standards

3-LS4 Biological Evolution: Unity & Diversity

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.
http://www.nextgenscience.org/dci-arrangement/3-ls4-biological-evolution-unity-and-diversity

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. 3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	• Create a campaign to present one of their design solution targeted towards a specific invasive species with a public audience. • Evaluate the feasibility and effectiveness of their design solution while comparing it to solutions that already exist.
SCIENCE & ENGINEERING PRACTICES	
Asking Questions and Defining Problems Constructing Explanations and designing solutions Obtaining, Evaluating, and Communicating Information	• Define the problem being caused by the invasive species and the reason that it is important issue for the community. • Refine the design solution and create a public product to share with the community. • Use evidence and information collected throughout the unit to create a compelling argument with using a planned medium.
DISCIPLINARY CORE IDEAS	
LS1.B Growth and Development of Organisms LS3.B Variation of traits LS4.B Natural Selection LS4.C: Adaptation Ecosystem Dynamics, Functioning, and Resilience LS4.D Biodiversity and Humans	• Use the information they gathered throughout the investigations of this unit to create a compelling argument about the effects of the invasive species on their local ecosystems.

How Lesson 5 Supports Next Generation Science Standards (cont.)

Peformance Expectation	Connections to Classroom Activity, *Students:*
CROSSCUTTING CONCEPTS	
Systems and System Models Interdependence of Engineering Technology, and Science on Society and the Natural World. Patterns Cause and effect	• Design solutions that discuss how the crayfish has affected the local ecosystem. • Present their engineering design solution to the invasive blackberry or crayfish problem and express their concerns to the public audience while aiming to mobilize them into action. • Identify how invasive species have affected local plants and animals in a negative way.

Causes and Effects of Invasive Creatures

Causes

Effects

KLEWS Chart Template

Follow the KLEWS chart to design your inquiry-based learning approach.

Instructors are encouraged to create a remix of this resource, fill out the chart and share back to the community. You can also export this format and print to use in class.

Procedure:

1. Write the **essential question** at the top of the chart. This question guides the entire lesson and is revisited again and again through observations and discussions.
2. Begin with the **"K"** column. Determine what students already **Know** by asking them the essential question. Have students write their responses on a post-it note and place the notes under the K column.
3. Move to the **"E"** column. Ask students to provide **Evidence**. Record student observations in the E column. Note that NGSS standards require that students make their own observations rather than being given the content.
4. Move to the **"L"** column, which stands for **Learning**. This column shows what they've learned from their observations. This relates to the NGSS Crosscutting Concepts.
5. The **"W"** column gives students an opportunity to **Wonder** about some of their observations. They write their wonderings on post-it notes and put them on the chart. If they discover an answer to their wondering during the lesson or by doing independent reading, the post it is moved to the L column.
6. The **"S"** column is the last column to be completed. It contains **Science Understanding** and helps students develop science vocabulary.

Essential Question:

K What do we think we *know?*	L What are we *learning?* (claims)	E What is our *evidence*?	W What do we still *wonder* about?	S What *scientific* principals/vocabulary help explain the phenomena?

Name______________________

KNOW/NEED TO KNOW LOG

Date______________Period____

What Do We Know?	What Do We Need to Know?	What Should We Do?
		(keywords, search engine, directory, etc.)

My Final Scientific Claim

Question: Is the Himalayan blackberry better adapted to the PNW than the bean sprouts we grew in class?	
My Claim (aka, my answer to the question): The Himalayan blackberry bush is better adapted to survive and grow than the bean plants we grew in class.	
Evidence # 1: It was brought to the U.S. from a different country.	This evidence is important because: an invasive species is
Evidence # 2:	This evidence is important because:
Evidence # 3:	This evidence is important because:

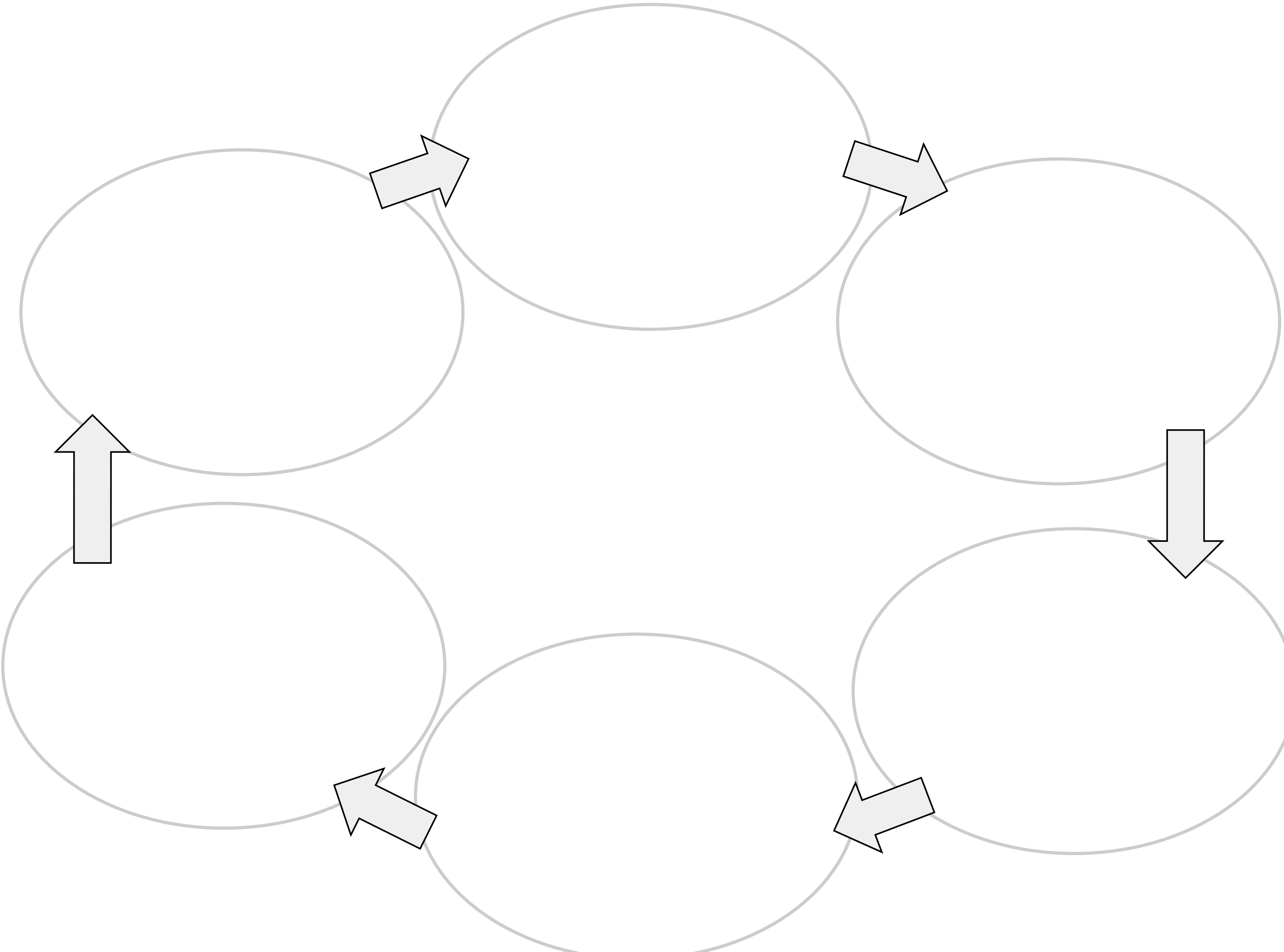
Evidence # 4:	This evidence is important because:
Evidence # 5:	This evidence is important because:
Evidence # 6:	This evidence is important because:

My Final Scientific Claim

Question: Is the Himalayan blackberry better adapted to the PNW than the bean sprouts we grew in class?	
My Claim (aka, my answer to the question):	
Evidence # 1:	This evidence is important because:
Evidence # 2:	This evidence is important because:
Evidence # 3:	This evidence is important because:

Evidence # 4:	This evidence is important because:
Evidence # 5:	This evidence is important because:
Evidence # 6:	This evidence is important because:

Plant Life Cycle



STEM Careers that fight invasive species!

Forest Ranger

Many people imagine **forest rangers** skiing through the trees, providing information and assistance to public visitors. While this is often a part of the job, forest rangers may be involved in a wide range of activities, including:

- Planting seedlings
- Monitoring seedling growth and inspecting tree stands for signs of pests and disease
- Spraying or injecting pesticides to protect trees and shrubs
- Counting numbers of trees examined during forest inventories
- Fighting forest fires
- Improving trails
- Conducting informational and educational programs
- Participating in search and rescue missions
- And much more!

Information from: https://www.environmentalscience.org/career/forest-ranger

Conservation Biologist

A **conservation biologist** makes observations in nature and tries to understand what is happening in the ecosystem around us. Here are some of the things a conservation biologist does:

- Collects information that shows how healthy the ecosystem is.
- Studies how many plants and animals live in an ecosystem.
- Studies problems in the environment and the causes.
- Analyze the needs of plants and animals in an area.
- Propose methods of improving the health of the ecosystem.
- Help keep ecosystems healthy.
- Educate the public about threats to the health of ecosystems.

Image of Dr. Claudia Segovia-Salcedo from: https://thefemalescientist.com/portrait/claudia-segovia-salcedo/702/meet-claudia-segovia-salcedo-conservation-biologist-and-co-founder-of-the-the-ecuadorian-network-of-women-in-science/

Charrette Protocol

The Charrette Protocol is used by engineers and other STEM professionals to get meaningful feedback from their colleagues regarding work that is in progress. The point of the Charrette is to use collaboration to optimize a specific piece of work. Each team decides where they need feedback, which gives them control over the feedback process. Please see directions to charrette included below:

1. Ask students to work with their team to identify one area of need in their design that they need help with. Where were you struggling and what could you still use help with?
2. Pair up student teams. Try to be intentional about the pairings (ex. pair teams that have complementary strengths).
3. Actual Protocol
    a. 1-2 minutes: One team shares their design plan and presents their problem area where they would like feedback. Then, this team must stop talking (can be very hard for kids, or adults).
    b. (5-10 min) The other team discusses the first team's problem and talks through some potential solutions. The first team is not allowed to talk, they have to listen to the other team discussing their problem.
    c. When the first team feels they have gotten enough out of the conversation to answer their question or to address their problem, they thank the second team for the feedback and end the session.
    d. Teams switch roles and go through protocol again.

Tips and tricks:

- ★ Give students 5 minutes to discuss their project with their own team and come up with a problem that they need help with. This may be hard for students to identify, but every project has something that can be improved.
- ★ Emphasize that the team that is presenting the problem should not be talking while the other team discusses.

My Final Scientific Claim

Question: Which animal is better adapted to the local habitat, crayfish or snails?	
My Claim (aka, my answer to the question):	
Evidence # 1:	This evidence is important because:
Evidence # 2:	This evidence is important because:
Evidence # 3:	This evidence is important because:

Evidence # 4:	This evidence is important because:
Evidence # 5:	This evidence is important because:
Evidence # 6:	This evidence is important because:

My Final Scientific Claim

Question: Which animal is better adapted to the local habitat, crayfish or snails?	
My Claim (aka, my answer to the question): The crayfish is better adapted to survive in the local habitat.	
Evidence # 1: The crayfish has eight legs and a tail that allows it to paddle in the water. The slug has a foot and a body that allows it to slither around.	This evidence is important because: Since the crayfish can move around better than the snail in both water and on land, they will be better at catching animals for food or escaping predators. This makes it better adapted to survive in the habitat.
Evidence # 2: The crayfish uses its pincers to grab food or break it into pieces. The snail uses its mouth to eat food. They both have antennae to "smell" food.	This evidence is important because: Since the crayfish has extra structures to help it find food, it will most likely survive better than the snail, which only has its mouth to eat.
Evidence # 3: The crayfish can swim or crawl quickly away from predators or fight them to survive. The snail can hide in its shell when predators attack.	This evidence is important because: The crayfish has structures that are better at helping it to defend itself from predators. Therefore, it will survive better in its environment and is better adapted.