

# EDUCATOR GUIDE



# BACKYARD WILDERNESS

An  
**SK Films**  
Release

**hhmi** Tangled  
Bank Studios

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ACADEMY OF  
SCIENCES**



Dear Educators,

Welcome to the ***Backyard Wilderness Educator Guide***. The guide was created by HHMI Tangled Bank Studios and the California Academy of Sciences to promote outdoor exploration and learning in support of the film ***Backyard Wilderness***. We hope it will be a useful tool for getting your students excited about scientific observation and the natural world.

The guide is tied to NGSS standards, and the activities within have all been carefully designed to stimulate curiosity and engage students in data-driven, scientific investigation of the world around them.

The guide is part of an extensive Educational Outreach effort that also includes a Family Activity Guide offering fun outdoor exploration for children and their caregivers; a Bioblitz Toolkit that will help schools, libraries and science centers put on local citizen science events; and a set of eye-catching library/museum/school displays designed to stimulate interest in outdoor exploration. We have also worked with the California Academy of Sciences' iNaturalist team to launch a new kid-friendly exploration app called *Seek*, which will complement the wildly popular iNaturalist app and give kids and families a fun and easy introduction to the world of observation and citizen science.

We hope you find these materials and programs helpful and welcome your comments about how you are using them and how best to engage your students in learning about nature.

Sincerely,

A handwritten signature in black ink that reads "Sean B. Carroll". The signature is written in a cursive, flowing style.

Sean B. Carroll  
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## EDUCATOR GUIDE (GRADES 3-8)

Film Length: 45 minutes

<http://backyardwildernessfilm.com/>

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## FILM SYNOPSIS

[\*Backyard Wilderness\*](#) will surprise and entertain viewers with the unexpected wonders of nature that are right under our noses—in our own backyards.

Spanning a seasonal year around a suburban home, the film displays a stunning array of unique wildlife images and behavior—all captured by cameras mounted inside dens and nests, and moving along the forest floor and pond bottom, to reveal its inhabitants in rare and breathtaking intimacy.

We follow Katie, a young girl, and her modern family living next to the woods who are blind to the real-life spectacle around them, absorbed by an array of electronic devices in their busy lives. Katie gradually discovers the intricate secrets that nature has hidden so close to her front door and we experience the joy she finds in her interactions with this new world.

The film reminds us that Wi-Fi is not the only connection that matters and that sometimes in ordinary places, you can uncover extraordinary things that could transform you forever – you just need to step outside.

## MAIN THEMES OF THE FILM

*“What makes our planet so special are the millions of living things on it. All life is connected to its environment: to the water, soil, sunlight, and other plants and animals. Each species has its own role to play, and they all depend on each other for survival, fitting together like pieces of a giant puzzle.”*

—Opening lines from Katie’s report

### Main Messages

- Humans are part of ecosystems.
- There is a natural drama happening outside—and inside—your own home, if you step outside and take the time to explore.
- We are changing the environment. Some organisms have been pushed out because of us, while others have successfully adapted to, and thrived with, human presence.
- You can make a difference, however small, to protect nature in your own backyard. We can all explore, understand, and protect the environment.

### Secondary Messages

- A habitat as small as a temporary vernal pool can support a large amount of biodiversity.
- Water is vital for all life to survive.
- Some animals can serve as “indicator species,” letting us know if an ecosystem is healthy.
- We are only just beginning to understand our impact on the environment.

## CHARACTER PROFILE: KATIE

KATIE, the lead of *Backyard Wilderness*, is an intellectually curious 11 year old growing up in the age of electronics. Between school, friends and online distractions, she has a hard time seeing beyond the screen in front of her into the magical wonders of her own backyard. However, a school science project about local animals spurs Katie's fascination and she begins to discover that life outside her suburban house may be much more interesting than she ever imagined. Choosing salamanders as the focus of her assignment, she ventures into the outdoors and encourages her friends and family to find the same excitement with nature as she is developing. By the end of the film, she's grown into a more environmentally aware girl and through the voice of older Katie, the narrator, we find out that she studies to be a biologist at university.



## BACKGROUND FOR EDUCATORS

Reference the [Student-Level Vocabulary](#) for definitions to the terms listed in bold below.

There are many different kinds of **ecosystems**, but in every ecosystem, individual **organisms** live together and interact with each other and their **environment** in ways that are often critical for their survival. One way that organisms interact is in a **food web**, or a system of what-eats-what. Primary **producers** like plants, algae, and some bacteria make their own food from sunlight, water, and carbon dioxide through a process called photosynthesis. Primary **consumers** like deer and many insects eat primary producers and are consumed by secondary consumers, such as coyotes or salamanders, which can be eaten by higher-order consumers.



Scavengers, detritivores, and **decomposers** break down dead material and waste products, returning important nutrients to the ecosystem. There are also symbiotic relationships and interactions between organisms that are vital for ecosystems. Many insects and animals pollinate plants, and without this important service, much of life on Earth could not exist. Birds like blue jays contribute to the growth of new oak trees as they gather and store away acorns in the ground for food. Ecosystems are replete with interactions of all kinds that contribute to the proliferation and diversity of life.

Ecosystems change with the seasons as the intensity of sunlight that fuels primary productivity ebbs and flows. As days grow shorter in the winter, photosynthesis slows and many plants die off. Some animals migrate to warmer places where there is more food while some hunker down and hibernate until spring. When springtime rolls around and the sun's intensity increases, plants and vegetation comes back to life, and with them, animals return or come out of their deep slumber. Organisms like frogs and salamanders make their way to **vernal pools** to mate and lay eggs. Spring and early summer are times of rebirth, as warmer, longer days and an increase in resources allow animals to reproduce and support their young. Summer is the time for organisms to thrive and grow, but as the days grow shorter and autumn approaches, photosynthesis once again slows and the annual cycle begins again.

The cycling of water through Earth's systems is an important part of all ecosystems, as all living organisms need water to survive. Plants absorb water and nutrients from the ground through their roots and transpire water through their leaves. Animals need water to drink, and many animals also rely on water to live or breed. The appearance of vernal pools in the springtime as snow and ice melt and surface runoff increases is crucial to the survival and proliferation of many frogs, toads, salamanders, insects, and shrimp.

Humans play a significant role in many of Earth's ecosystems by changing the landscape and the availability of resources. Cutting down trees can alter the **water cycle** in an ecosystem by decreasing the return of water to the atmosphere through **transpiration**. Clearing forests also destroys the **habitats** of plants and animals. Some animals adapt to the presence of humans, while others are pushed out. But humans can also make choices and act in ways that minimize negative impacts. By spending more time in nature and observing the environment we live in, we can better understand our role in the complex web of life and make choices that sustain healthy ecosystems.

### Living Things Featured in the Film

In order of appearance...

- reeds
- humans
- blue jay
- coyote
- deer
- mouse
- domestic dog
- snowdrop blossoms
- moss
- ferns
- spotted salamander
- spring peeper frog
- salamander eggs
- insect larvae
- crayfish
- raccoon
- wood duck
- wood frog
- tadpoles
- daffodils
- oak trees
- cottontail rabbit
- house wren
- caterpillar
- domestic cat
- moths
- turtle
- ladybug
- dragonfly
- daisies
- ant
- woodpecker
- bumble bee
- clover
- hummingbird
- tiger swallowtail butterfly
- red oak
- chickadees
- centipede

## QUICK AND FUN ACTIVITIES

### Quick Activities Before the Film Viewing



- Draw a map of your home and immediate surroundings, whether urban, suburban, or rural. Try to include at least two plants and two animals that you believe reside in your neighborhood “ecosystem.” If you have a measuring device, create your map to scale or include labels that indicate distance.
- Describe the changes that you have observed take place in your neighborhood across the four seasons. What are winter, spring, summer and autumn like? What differences between winter, spring, summer, and autumn, do you notice?

### Quick Activities Following the Film Viewing



- Return to your map. Reflecting on the range of plants, animals, and natural features Katie noticed, what have you left out of your map? Look again at your home “ecosystem,” and write a reflective journal entry describing what you now notice.
- Be a detective just like Katie! Find an animal and observe it in its habitat, even if this only takes one full minute.
- Walk around your home or neighborhood block. Come up with three questions about nature in your neighborhood that you're curious about.. For example, “Why is the tree outside my house flowering, while my neighbor’s tree is not?” If possible, write down any “clues” you witnessed that can help you solve the mystery—or decide what to focus on next.

## Recall Questions Related to the Film

- In the film, where did animals make their nests/dens and raise their young? What did you notice about their nests/dens?
- How was the water cycle a key part of the ecosystem featured?
- Turn to a partner. Name several instances of interactions between a predator and prey.



## Application Questions

- The narrator thinks of summer as “when forest life grows up.” Consider the Northern Hemisphere ecosystem featured in the film. Why do you think this season in particular is a time when so many young plants and animals grow and develop? Explain your reasoning.
- Two species featured in the film—the snowdrop blossoms and the spotted salamander—are known as “[indicator species](#).” From what you saw or heard in the film, what do these two species tell us about the health or state of their ecosystem? How might you define the term “indicator species” from what you’ve experienced so far?

## Debate Questions

Take a stand! Express your opinion, being sure to use at least some evidence from the film to support your claim. You do not have to agree with the narrator of the film.

Some sample claims to debate:

- All humans are part of a larger ecosystem. Nature’s relationships keep us alive.
- We have impacted the environment in positive ways.
- All plants and animals depend on each other.

## CLASSROOM & OUTDOOR ACTIVITIES FOR GRADES 3-8

[Observing Like a Scientist in Your Own Backyard Wilderness](#) (45 minutes to 1 month)

**Perfect for:** All Grades 3-8

**NGSS Connections:** These activities may be a great time to focus on the Science and Engineering Practices, including asking questions; analyzing and interpreting data; engaging in argument from evidence; and obtaining, evaluating, and communicating information.

[Your Very Own Invertebrate Ecosystem!](#) (4 weeks)

**Perfect for:** 3rd, 4th, and 5th Grade

**NGSS Connections:** SEPs: Analyzing and interpreting data; Engaging in argument from evidence; CCCs: Cause and effect; Systems and system models; Structure and function; DCIs: LS2.A, LS4.A, LS4.C, LS4.D; PEs: 3-LS4-3; 3-LS4-4

[Documenting Schoolyard Biodiversity](#) (2-3 hours)

**Perfect for:** All Grades 3-8

**NGSS Connections:** SEPs: Planning and carrying out investigations; analyzing and interpreting data; DCIs: LS4.C LS4.D

[Food Web Modeling](#) (100 min)

**Perfect for:** 5th Grade and Middle School

**NGSS Connections:** SEPs: Developing and using models; CCCs: Systems, Stability and change, Cause and effect; DCIs: LS2.A, LS2.B, LS2.C; PEs: 5-LS2-1, MS-LS2-3, or MS-LS2-4

[Water Cycle Role Play](#) (45 min)

**Perfect for:** 5th and 6th Grade

**NGSS Connections:** SEP: Using models; CCC: Cause and effect; DCI: MS-ESS2.C; PE: MS-ESS2-4

[Decomposition Investigation](#) (7 weeks)

**Perfect for:** All Grades 3-8; here's a example from a [4th grade classroom](#)

**NGSS Connections:** SEPs: Asking questions, Planning and carrying out investigations, Analyzing and interpreting data; CCCs: Stability and change; Patterns; DCIs: LS2.A, LS2.B; PE: 5-LS2-1

## HOW SHOULD I READ THE NGSS CONNECTIONS LISTED ABOVE?

Consider these connections to help integrate these activities into your existing curriculum. You'll notice that most activities relate to **Disciplinary Core Ideas (DCIs)** in the Life Sciences, so it may be best to add them into your teaching calendar when you are completing a related unit. Remember that **Performance Expectations (PEs)** are statements of what students should be able to do at the end of a year of instruction, rather than during a single lesson. The activities above are just some of the many that could help prepare your students to perform the hypothetical tasks listed as Performance Expectations.

The **Science and Engineering Practices (SEPs)** are the tools and techniques that scientists and engineers use. The SEPs are a good entry point into understanding the NGSS, and a good place for teachers to begin bringing the NGSS into their classrooms, since they can be used with students to explore any content. While you should engage in all eight practices over each grade band, you don't have to focus on multiple practices in each activity! Moreover, pay attention to how the practices grow in complexity across grades. The charts in [Appendix F](#) help you see what each practice looks like at your grade level.

We can help students think like experts by providing them with a conceptual framework around which they can build their understanding and form new ideas. The **Crosscutting Concepts (CCCs)** serve as a conceptual framework to help students learn science and think like experts by a) helping students make sense of new content and tackle novel problems, b) allowing students to be more flexible and creative with their science and engineering ideas, and c) helping students to develop their ideas over time. Because applying different Crosscutting Concepts to the same content can bring out different learning outcomes, as educators, we need to make choices as to which CCC, if any, we focus on in a lesson or teaching unit. You'll see some recommended CCCs listed above with each lesson in this guide, as we feel they may serve as appropriate lenses through which to view an activity. However, you can adapt as you see fit. Just remember that you should be thoughtful about how they can be used to draw different ideas out of a single piece of content! You can also scan [Appendix G](#) to see how the CCCs build in complexity as you progress through the grades.

## SHOULD WE USE SCIENCE NOTEBOOKS?

Use whatever materials work for your classroom or afterschool environment! Many upper elementary and middle school teachers find that using a [science notebook](#) regularly can help your students think and act like scientists. With a few simple routines in place, your students can use a notebook for planning investigations, taking notes, reflecting on experiences, and making meaning in science class. Some prefer blank pages, while other prefer lines. [Setting up your science notebooks](#) is easier than you think, and can set your classroom up for success all year long.

If you don't have resources to purchase notebooks, a binder full of blank pages works just as well. Or, create field journals using cardboard boxes or recycled cereal boxes for the binding. Worksheets may be

helpful to structure student learning, but consider weaning students off of teacher-designed (or textbook-designed) worksheets as they become more skilled with planning scientific investigations. Reference [galleries of student notebooks](#) here to get a feel to what might be possible in your own school.

## **WHAT IF MY SCHOOL LACKS DIGITAL TECHNOLOGY?**

Within this guide, we'll point you to digital tools such as [iNaturalist](#) that help you document the natural world. If you have a no-phone policy at your school, or hesitate to dive too deeply into new technologies, don't fret. Student notebooks or a [simple worksheet](#) can serve a similar purpose as you begin your outdoor explorations.



### Why Scientific Sketching?

Most of us associate sketching with making a pretty picture. This association can limit us, especially if we feel we are not good at drawing. A scientist sketches to record and communicate information, not to make art. Along with a drawing, a scientific sketch often includes labels and diagrams, questions and explanations. You don't have to be an artist to create a successful scientific sketch. You simply have to take time, observe closely, and record what you see.

## OBSERVING LIKE A SCIENTIST IN YOUR OWN BACKYARD WILDERNESS

### Perfect for All Grades 3-8

This sequence of lessons introduces students to the concepts of scientific observations and sketching and has them practicing skills and techniques before going outside to observe their own backyard.

**1. Observe like a scientist**

*In this activity, students will be introduced to the practice of scientific observation.*

**2. Introduction to scientific sketching**

*In this activity, students will improve their observation skills and practice scientific sketching.*

**3. Sketching for observation I**

*In this activity, students will use detailed sketching to try and collect data to answer a question.*

**4. Sketching for observation II**

*In this activity, students will sketch an object or system over time to create a useful record of change that can be analyzed.*

**5. Sketching in your backyard**

*In this activity, students will use the scientific sketching and observation skills they've learned to observe nature in their own backyard or school yard.*

### NGSS Connections

These activities may be a great time to focus on the **Science and Engineering Practices**, including asking questions; analyzing and interpreting data; engaging in argument from evidence; and obtaining, evaluating, and communicating information. While we have suggested discussion questions that relate to **Disciplinary Core Ideas** within the Life Sciences, please adapt as necessary to best suit your curriculum.

## **OBSERVE LIKE A SCIENTIST (30 min)**

### **Perfect for All Grades 3-8**

Have you ever walked by a field of flowers that look all the same? What if you could stop and really look at those flowers, closely and carefully? Do you think they'd still look all the same? Close and careful observing is something that scientists often do, and can lead to questions to investigate or answers to questions you've asked. This activity gives you the chance to take a group of objects that seem all the same from far away and observe them scientifically to notice their differences.

### **Objective**

In this activity, students will be introduced to the practice of scientific observation.

### **Materials**

- Enough acorns, shells, pine cones, leaves, pebbles (or another set of objects that all look the same) for the entire class
- Paper and pencil

### **Procedure**

1. Give each student an object. Ask students to write down observations and questions they have about their object—size, shape, color, smell, feel, distinguishing marks, etc—using the sentence frames 'I notice' and 'I wonder.' Ask them to think about what unique characteristics their object has that might distinguish it from others.
2. Collect all of the objects again and mix them up in a bowl or bag, then spread them out on a table. Ask students to use the observations they made to try to find their own object.
3. After this exercise, have a class discussion or assign a writing task in which students explain what it means to observe something, and how 'observing' is different than 'seeing.' *What kinds of skills or techniques do you use when observing? Why do you think scientists make observations about the natural world? What kinds of questions might they be asking or trying to answer?*

## INTRODUCTION TO SCIENTIFIC SKETCHING (45-60 min)

### Perfect for All Grades 3-8

Writing down observations is a useful way to record information about the natural world, but sometimes sketching can help scientists capture details that words alone cannot. Along with a drawing, a scientific sketch often includes labels, diagrams, questions, and explanations. Recording what you see is different from drawing the picture you have in your head. Many of us have cartoon-like images in our head of trees, flowers, houses, apples, rabbits, etc. When you set out to sketch a real thing, it's important to focus on the individual specimen in front of you, rather than the generalized image in your imagination. You can help students understand this by focusing on particularities of an example object – like a leaf with holes in it, or an irregular rock.

### Objective

In this activity, students will improve their observation skills and practice scientific sketching.

### Materials

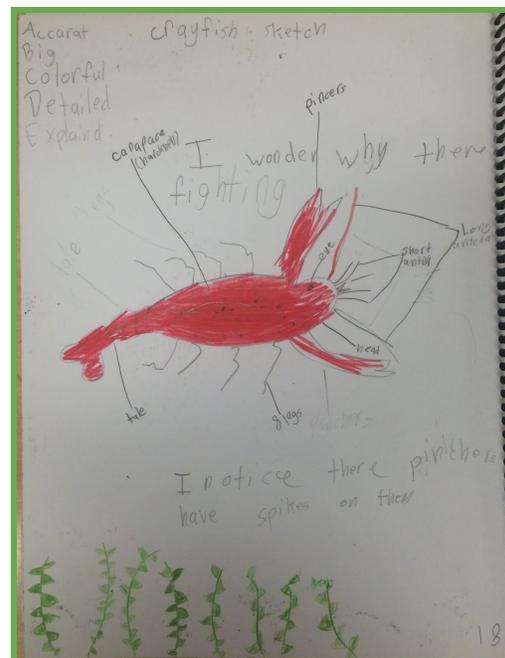
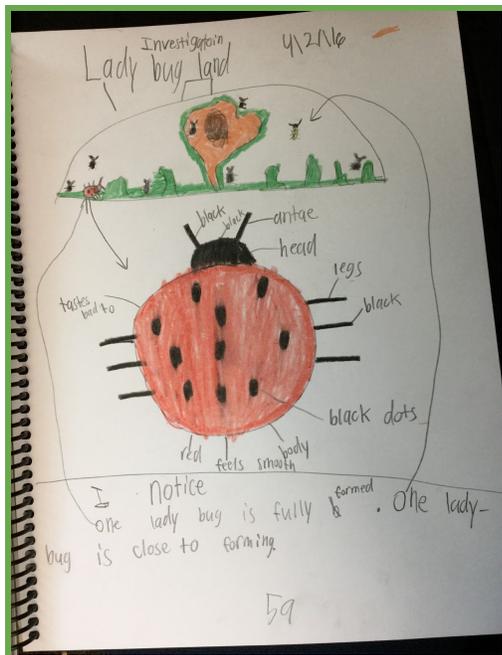
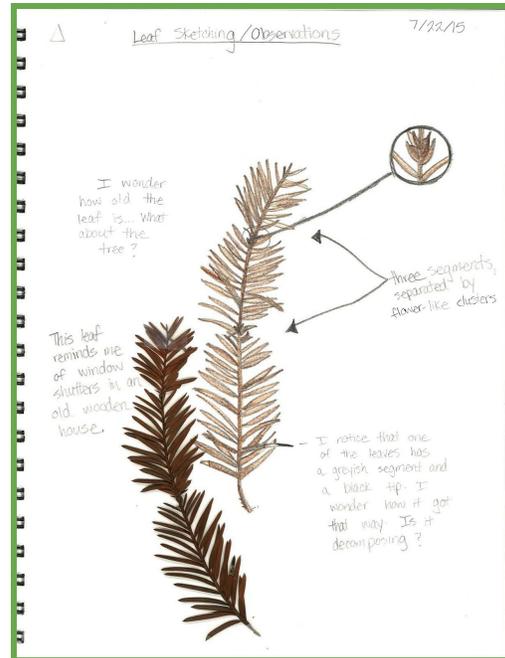
- Notebooks or paper
- Pencils
- Colored pencils
- Collection of items to sketch, like leaves, acorns, pine cones, or flowers (1 per student, who can select from the mix)

### Procedure

1. Explain to students that their task is to make a sketch that is specific enough that another student will be able to pick their object from a pile, based on the sketch alone.
2. Before handing out the objects, provide students with some criteria for a successful scientific sketch (ABCDE):
  - An **accurate** sketch describes the true nature of an object: size, shape, texture, etc.
  - The sketch should be **big** so that we can see details.
  - When possible, communicate more information by making your sketch **colorful**.
  - Use words and drawing to make your sketch as **detailed** as possible.
  - Add labels, questions, and conjectures about what you see. These words make your sketch **explained**.
3. (*Optional*) If you like, show students an example of a [real scientist's sketch](#) before they begin their own. Remind students that there is often a big difference between drawing what you see and drawing what's in your head.
4. Hand out items, and give students about 15 minutes to sketch them.

5. Ask students to lay their drawings out in a circle on the floor with their objects in the middle. Then as a class, try to match each object with its drawing. *What information recorded in the sketch helped you match it to its object?*

Examples of student sketches: the top row shows sketches from secondary students; the bottom row shows sketches from upper elementary students





## SKETCHING FOR OBSERVATION I: CAPTURING DETAIL (45-60 min)

### Perfect for All Grades 3-8

Scientific sketching is data collection, just in picture form. Detailed sketching can help us focus on characteristics we might otherwise miss.

### Objective

In this activity, students will use detailed sketching to try and collect data to answer a question.



### Materials

- Objects such as feathers, leaves, shells, flowers, etc.
- Pencils and colored pencils
- Notebooks or paper
- Magnifying glasses (optional)

### Procedure

1. Tell students that they are going to use scientific sketching to try to better understand how the structure of a [leaf, feather, shell, etc.] relates to its function.  
*Optionally, you may want to begin by showing students a picture of very obvious animal adaptation/structure, such as a [frog's webbed toes](#) or a [spider's web](#) and have a class discussion about how its structure might relate to its function.*
2. Hand out objects to students and ask them to pay close attention to the object's colors, textures, shape, etc. and to think about the following question while sketching the object: **How do the structures you are observing in your object relate to their function?**
3. Give students about 15-20 minutes to sketch their object. Remind them that scientific sketches include labels, written notes, and questions. Use the "ABCDE" framework from the "Introduction to Scientific Sketching" activity.
4. Have students share their sketches and talk about their object's structure and function. Ask students to share any questions that came up for them while they were sketching, and have them think about how they might go about answering these questions.





## SKETCHING FOR OBSERVATION II: CAPTURING CHANGES OVER TIME (weeks or months)

### Perfect for All Grades 3-8

Scientific sketching is data collection, just in picture form. Since a drawing is a snapshot of information at a particular point in time, sketching the same thing over the course of several days or weeks can capture how things change and create a useful record for analysis and to try and figure things out.



### Objective

In this activity, students will sketch an object or system over time to create a useful record of change that can be analyzed.

### Materials

- Objects or systems that will change over the course of hours or days, such as cut flowers; blossoming or fruiting plants; decomposing or browning fruit; water levels in a pond; growing silkworms or hatching butterflies; etc.
- Pencils and colored pencils
- Notebooks or paper

### Procedure

1. Show students a short time-lapse video or gif of a natural phenomenon that exhibits change over time (some examples [here](#)). Ask them to talk about what they notice or wonder about the video/gif.

*If you were to pause the video/gif and sketch it, what exactly would you be sketching? What information would you be capturing? What information would you be missing or leaving out? What information do time-lapse videos or photography give us that sketches do not?*

We can simulate time-lapse video/photography by sketching an object or system over time.

2. Set up the object or system that will change, and have students sketch the object or system at regular intervals over time for a specified time period.
3. At the end of the time period, have students write up a summary of how the object or system changed over time, referring to their sketches to support their conclusions. Include both quantitative explanations (e.g., changes in measured size) and qualitative observations.

## SKETCHING IN YOUR BACKYARD (45 min)

### Perfect for All Grades 3-8

There is probably a lot more going on in the environment around you than you realize! Spending intentional time in nature can open our eyes to the characteristics and behaviors of plants and animals and the changes that happen over time that we might otherwise miss.

### Objective

In this activity, students will use the scientific sketching and observation skills they've learned to observe nature in their own backyard, schoolyard, or nearby open space.

### Materials

- Pencils and colored pencils
- Notebooks or paper

### Procedure

*This activity can either be done as a class during school time, or students can do it individually at home.*

1. Ask students to go outside into their school yard, backyard at home, park, or other natural area and spend 10-15 minutes observing the habitat around them. Give students a choice about what they'd like to focus their observations on. Whatever they choose, students should include both scientific sketching and written notes as part of their observations. Some example include:
  - *Make at least three observations of animals interacting with other animals.*
  - *Make at least three interactions of animals interacting with plants.*
  - *Sketch your surroundings to determine which part of the habitat you think is most important for the biodiversity of the space.*
  - *Focus on one thing, like a particular plant, and sketch how it changes over time.*
2. Have students share out their observations with their classmates. This can be a gallery walk, sharing with a partner or small group, or a presentation to the class. In small groups or as a class, have students discuss the following questions:
  - a. *What did you notice or learn about the habitat you observed?*
  - b. *Were there new things you noticed about the environment/habitat that you've never noticed before?*
  - c. *Do you think the habitat you observed is 'healthy'? How do you know?*
  - d. *How do you fit in to the habitat you observed? What is your role?*



## YOUR VERY OWN INVERTEBRATE ECOSYSTEM! (4 wks)

### Perfect for 3rd, 4th, and 5th Grade

In the film, you witnessed many small creatures, including caterpillars, dragonflies, ants, ladybugs, bumble bees, butterflies, moths, and centipedes. Let's construct a home for these macroinvertebrates! Build and observe your structure, discovering which organisms can survive in different areas and how they change when their environment changes.



### NGSS Connections

SEPs: Analyzing and interpreting data; Engaging in argument from evidence; CCCs: Cause and effect; System models; Structure and function; DCIs: LS2.A, LS4.A, LS4.C, LS4.D; PEs: 3-LS4-3; 3-LS4-4

### Objectives

Through close-hand observation, students will observe organisms that survive well in certain habitats, while others will survive less well. Which home that we build has the highest biodiversity?

### Materials

- An outdoor space no smaller than 3 ft x 3 ft that your students can access for one month or longer; it can be loose soil, a paved area, or even a flower pot!  
*Tip for urban schools: If your site is mostly paved, simply designate an area of pavement for the project and label it as an ongoing investigation. We recommend setting up 4 flower pots around 12 inches in diameter to be your "ecosystem" that will attract insects and other invertebrates.*
- Soil and grass seeds (e.g., cat grass, oats, wheat, etc.)
- Several pieces of untreated (no pesticides or preservatives) wood about 6-12 inches long (e.g., sticks, off-cuts of building wood, firewood, etc.)
- Optional: Pieces of broken pavement, bricks, rocks or ceramic tiles; clear jars or containers to use as bug boxes; paintbrushes; and magnifying glasses.

### Educator Prep

Find an area near the school to place your structure that will become a home for small invertebrates. It does not need to be large, as even a square yard will do nicely. An ideal place:

- Is quiet, away from human traffic areas
- Is damp, close to growing plants or areas of cover
- Has flowers nearby
- Has light soil, not heavy clay
- Will be undisturbed for a month

## Part One - Introduction

1. What do you think lives in our school yard? Make a list of student ideas.
2. Introduce the term “macroinvertebrate,” an animal without a backbone that you can see without using a microscope. Decide which organisms on your list might apply.

**Teacher Tip:** Students often have the misconception that [salamanders](#), [snakes](#), and [lizards](#) are invertebrates. Showing images of these animals’ skeletons can show that they are vertebrates.

3. What might make a good macroinvertebrate home? Students may suggest a variety of habitats, different food sources, places to shelter, temperatures, and moisture levels.

## Part Two - First Visit

1. Take students into the prepared area with their science notebooks or paper on a clipboard. Have them sit down and silently watch the area for 3-5 minutes, drawing or noting any macroinvertebrates they see in or flying past their area. Also take note of any other animals or plants nearby.
2. After passively observing, students can investigate the area close up and use their pencils to lift up any rocks, leaf litter, or sticks to see what is hiding underneath. The focus isn’t on knowing exactly what a creature is, but they should be able to describe it.
3. Back in the classroom, in small groups, construct a list of the macroinvertebrates you observed, describing the environment where they were found.

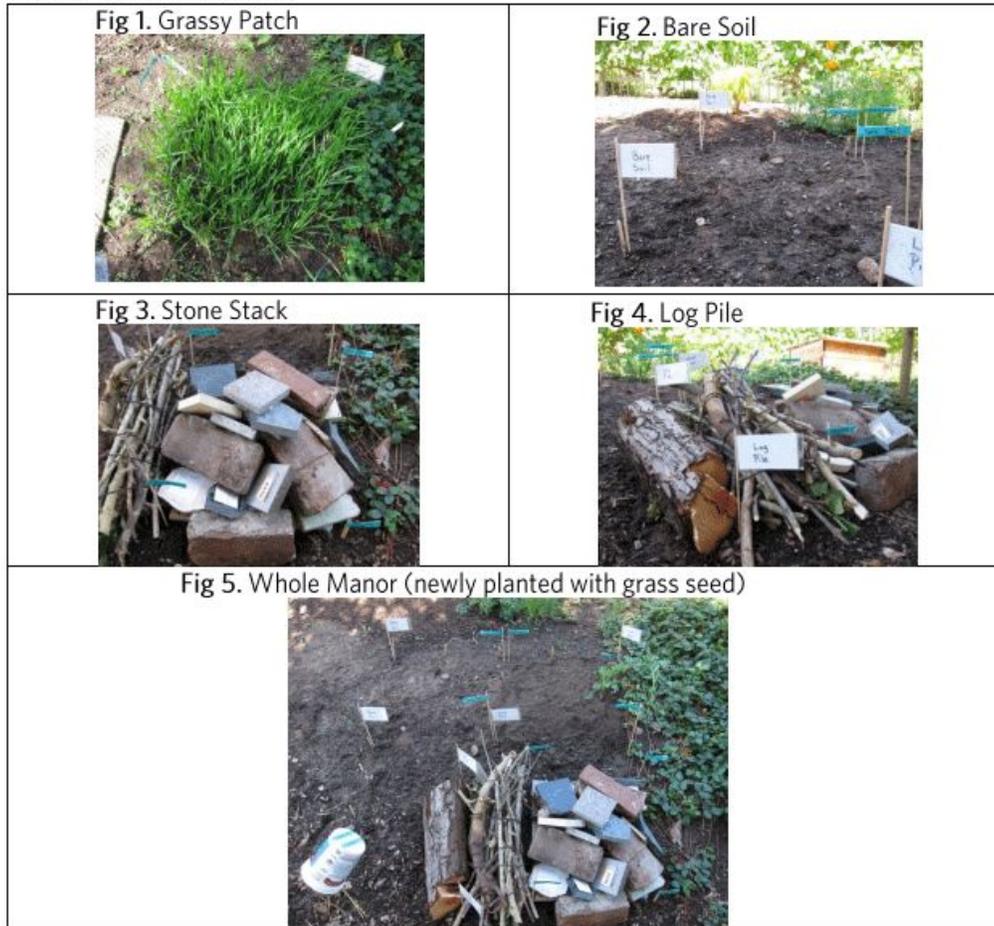
## Part Three - Making and Maintaining the Home for Invertebrates

1. Create 4 separate environments either by sectioning the ground space (16 in x 16 in works well) or having one flower pot for each environment.
2. Divide students into groups, so that each is assigned an environment listed below. While one group works to create their assigned environment, the other groups can create signs for their environment, draw the area as it looked before the home was made, and draw the initial state of the home.
  - a. **Grassy Patch:** Plant grass seeds in soil or keep the grass of your chosen area. If planting grass seeds, remember to help them to grow by watering as needed. Occasionally cut the grass so it’s about 4 inches high. You can scatter the cuttings in the grassy patch!
  - b. **Bare Soil:** Turn the soil in the pot or ground area with a shovel to prevent the soil from being compacted, as if preparing to plant seeds. Keep this environment clear except for small amounts of vegetation that is different from grass (i.e., flowers, moss, seedlings, etc.).



- c. **Log Pile:** Stack several pieces of untreated wood in a pile. Choose pieces of wood that fit within the space or flower pot. Bundle several pieces together with twine or string, leaving gaps between the pieces to allow macroinvertebrates to crawl into the spaces. Place the log pile directly on the bare soil.
- d. **Stone Stack:** Create a solid base of stones directly on the bare soil. Loosely stack stones, broken bricks or bits of broken paving slab on the base of rocks. Leave plenty of small spaces between the pieces to allow entry.

The four areas could look like this:



#### Part Four - Visiting the Invertebrate Home

After the environments have had about 2 weeks to establish, you and your students may find some new macroinvertebrates! Examples include pillbugs, spiders, ants, slugs, flies, beetles, and many more. Observe each area to see the biodiversity of macroinvertebrates in each environment. Keep a record of all the macroinvertebrates, including what type and in which environment they were found in a journal or chart. These records will help you decide if you have a new inhabitant.

### Follow these tips to make the most of your visits:

- Students must care for their macroinvertebrates and try to not harm or kill them while studying them.
- Remember to remove logs and stones carefully to protect the creatures underneath.
- Try not to disturb the creatures too frequently; studying the home once a week is ideal.
- Keep the soil moist and area clear of trash.
- To keep students safe, provide clear plastic boxes or small jars with lids to put organisms in for observation, but remember to release them back into the habitat afterwards.
- Use a utensil such as a shovel or stick when raising the rocks and wood for observation to protect students from stinging insects.
- Paint brushes make great barriers for students who do not want to touch the macroinvertebrates. The bristles are gentle enough to push macroinvertebrates around and into bug boxes without hurting the creatures.

### Part Five - Analyze and Interpret Your Findings

There are various ways to look through student data! Here are some ideas:

- Review which macroinvertebrates have become residents. Note which residents are in the home during different weather patterns.
- Discuss which types of macroinvertebrates prefer which environment and why they might have these preferences.
- Compare the biodiversity of the four environments.
- Study the areas during different seasons to determine if the variety of macroinvertebrates changes with the seasons.
- Have students write or discuss which macroinvertebrates were able to persist in the habitat, which ones moved away and which ones moved in. If they persisted, did the numbers increase or decrease? Have students use evidence from their notes to support their choices.
- Have student groups create a model of the movement of matter within the manor environment. Have groups compare their models and discuss the merits of their choices.

### Extensions

Try the next activity to identify what particular species live in your schoolyard!

## DOCUMENTING SCHOOLYARD BIODIVERSITY (2-3 hours)

### Perfect for All Grades 3-8

The free iNaturalist app allows you to conduct a biological survey, get help with species identification, and connect with a global network of naturalists. Using simple tools and technology, your students can develop and carry out an original scientific investigation about biodiversity on your school campus. Then, analyze your data, draw conclusions, and share your findings to inspire environmental stewardship in your community!

### NGSS Connections

SEPs: Planning and carrying out investigations; analyzing and interpreting data; DCIs: LS4.C LS4.D

### Materials

Mobile device with iNaturalist app downloaded (1 per group of 2-5 students)

Science notebook (1 per student)

### Preparation

- Review the iNaturalist mobile app and website:  
<https://www.inaturalist.org/pages/teacher's+guide>
- Setup login: [www.inaturalist.org/pages/getting+started](http://www.inaturalist.org/pages/getting+started)
- Select your schoolyard study site as your “place”

### Directions

1. Lead a short discussion accessing prior knowledge about schoolyard biodiversity. Ask the students: which species (large or small) have you seen on your school grounds?
2. Show students the iNaturalist website and app and, if applicable, show any data that already exist near your schoolyard. Ask students: which of these species are unfamiliar to you? Who collected these data?
3. Explain that today students will be collecting data using iNaturalist to document the species they can find in their schoolyard.
4. Ask students to log onto iNaturalist on the mobile devices. Model how to take a photo of an individual organism and sync to iNaturalist. Give students time to practice.



5. Have students create a preliminary inventory by using a mobile device to take photos of individual organisms.
6. Divide responsibilities so that everyone has a chance to take photos, sync to iNaturalist, identify species, and complete online entries. (Use the online tutorials to practice this process before teaching the students).
7. Facilitate a discussion about what the students observed. Ask: What kinds of organisms did you observe? What did you see that you didn't expect?
8. After students have a sense of local biodiversity, have them work in small groups to examine the data and compare their schoolyard to a nature preserve (check out the "Projects" listed on the iNaturalist website).
9. Then ask students to answer questions such as: What kinds of organisms are abundant near your school? What is rare? Why do you think that is? How did the organisms near your school get to be there? What do they need to survive?
10. Does anything seem strange, confusing, or interesting to you about what lives in your environment? Have students record all their questions in science notebooks or in a binder they will return to.

### **Recommended Extension**

Continue students' background research on local environmental issues by investigating local news and interviewing community members. Have students develop their own research questions, gather more data on the schoolyard, analyze results, and share them with their community.

## FOOD WEB MODELING (100 min)

### Perfect for 5th Grade and Middle School

Katie explored the vernal pool near her home, noticing how it changed across the seasons and how it served as a breeding grounds for the local spotted salamander. She called it an “engine for biodiversity.” Did you notice the raccoon catching prey in the pond? The tiny organisms that floated in the water? The way plants sprouted directly from the depths? In this activity, your students will get to know the vernal pool ecosystem as they design and use a simple model to test cause and effect relationships involving a food web. To extend their learning, students can design their own hypothetical ecosystems and then rank them according to their stability when faced with a natural or human-made disturbance.

### NGSS Connections

SEP: Developing and using models; CCCs: Systems, Stability and change, Cause and effect; DCIs: LS2.A, LS2.B, LS2.C; PEs: 5-LS2-1, MS-LS2-3, or MS-LS2-4

### Objectives

After this activity, students will be able to recognize a food web as a system and describe it in terms of its components and its interactions. They will understand how a healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.

### Materials

- [Ecosystems and Ecological Networks](#) video clip
- [Vernal Pool Organism Cards](#) (1 per student for Day 1, extra copies of each for Day 2; designed to be printed double-sided, folded down the center, and held in one’s hands OR made to hang on one’s neck by hole-punching where indicated and connecting with yarn)
- Yarn (~3 foot pieces, perhaps 2 per student for Day 1, then entire skein for Day 2)
- Butcher paper
- Scissors, markers, tape
- Science notebooks

### Day 1

#### Educator Prep

1. Print out one organism card per student. You’ll notice that 14 organisms are included, and we’ve doubled or tripled some of them to remind you that a food web needs more producers than consumers (while the ratio isn’t representative of exact abundance of each species, it will help all students play a role!) If you have a small class size, remove some of the consumers such as the deer or raccoon.
2. Select something to serve as the sun, from which all food chains made of yarn will start (e.g., drawing on the board, your desk).

## Engage (15 min.)

1. Pass out organism cards randomly. Students can fill in the blanks on the right side. Make sure they understand what their organism eats.
2. Have the students play games to explore the animals in the ecosystem to notice similarities and differences, and connect to prior knowledge.
  - a. Find a partner who...(makes food from the sun, is smaller than a cell phone, swims with fins or flippers). Talk and share.
  - b. Line up in size order from the smallest creature to the biggest one. Use your best guess!
  - c. Organize into four groups according to your role: producer vs herbivore vs carnivore vs decomposer.

## Explore (30 min.)

1. Task for the class: Self-organize into many food chains by standing in a line from the start of energy production at the sun (e.g., teacher's desk) to the end of the energy flow, placing your hand on the shoulders of the student who is giving you energy. Each food chain should include at least three organisms (teacher tip: a producer + consumer + decomposer OR a producer + herbivore consumer + carnivore consumer). See examples below, starting at the sun:
  - grass – rabbit – mushroom
  - clover – wood duck – raccoon
  - clover – snail – turtle
  - cabbage – snail – salamander
  - oak tree – deer – coyote
2. Freeze and verbally review. In turn, have producers, consumers, etc. raise their hand, and have students notice the pattern. Discuss the size of the creatures, and the size of the population of said creatures. Review the transfer of matter and energy, and highlight how it starts at the sun.
3. Pass out two pieces of yarn per student. They can remain the same organism for the next task. Explain that the yarn represents the interaction between the organisms, in the same way that our arms connected us before.
4. Task for the class: Self-organize to make a full web, connecting yourself to two other organisms.
5. Through discussion, walk through the following:
  - a. What are the component parts? (Living organisms which play different roles in the food web.)
  - b. How are they related? (They interact by eating each other, which translates into sharing matter and energy.)

- c. What does the yarn symbolize as an interaction? What is flowing through the system? (Sharing matter and energy is the basis of a food web.)
- d. The yarn doesn't show the direction of energy flow. How can we model this? (Students receiving the energy could wiggle or raise their fingers.)
- e. Can we find an organism that could be removed from the web, without leaving another species high-and-dry with nothing at all to eat? (This depends on which organisms you end up selecting. While the woodland ecosystem with a temporary vernal pond highlighted in this lesson does not have a keystone species, you may be interested in [watching part of this video](#) to learn more!)

### Explain (10 min.)

1. Show students selected sections from the [Ecosystems and Ecological Networks](#) tutorial, as appropriate for their level.
  - a. What are the main points from the video?
  - b. What makes an ecosystem extra resilient to change/keeps it stable?
  - c. Considering the woodland with its vernal pool as an example of an ecosystem network, which of the organisms might play a more crucial role than others?

### Day 2

#### Educator Prep

1. Post up butcher paper on three walls or the ground.

#### Elaborate (25 min.)

1. Split class into three large groups.
2. Group task: Design the most healthy, most stable vernal pool/woodland ecosystem on your piece of butcher paper. Yesterday we stood up to make the model with our bodies; now you will make a flat model on this piece of butcher paper. This is a model that shows how energy and matter is travelling through the food web, and how each organism interacts with others. After 25 minutes, we will test these 3 ecosystems against each other by altering the circumstances according to a real-life scenario. So, try to make your food web as realistic and stable as possible. (Teacher tip: this involves including as many different kinds of species as possible, but don't spill the beans. The more organisms and connections there are, the less likely the web will crash if one species is affected severely by a natural or human-made cause). Refer to your notes from yesterday. You have only 25 minutes and can use all these pictures, yarn, colored dots, markers, etc. Be sure to include:
  - a. The sun
  - b. Something that shows the number and variety of organisms (the components of the system)
  - c. Something that shows how energy and matter is being transferred through the food web (the interactions of the system)

3. Check for understanding: As students are working, remind them to indicate how many of each creature exists. While the numbers don't matter, the relative numbers do – producers should outnumber consumers. Also, check their understanding of the energy flow up the chain.
4. As students finish, write the “Which Ecosystem is Most Stable?” table on the board, along with a rough numeric rubric.

### Evaluate (25 min.)

1. Explain that when you read through the scenarios below, the class will discuss what domino effects will occur in each sample ecosystem, and rate each one on their stability.
  - a. Scenario 1: There is an outbreak of a beetle eating up the oak trees! Most of them die.
  - b. Scenario 2: As global temperatures rise, there are seasons in which drought persists for months on end.
  - c. Scenario 3: There was an incident in which a coyote killed a housecat, so people who live nearby often shoot coyotes on sight.
  - d. Scenario 4: An invasive grass comes into the areas, and is better than local species at growing tall and strong quickly.
  - e. Scenario 5: A new highway is built that separates parts of the forest.
2. Using the students' ideas, walk through the cause and effects. Don't adjust the physical webs; simply discuss and use this as a springboard to tackle key content. The teacher can assign a 1-5 rating for each ecosystem for stability, and add it to the chart on the board.
3. Total up the columns. Which of the three ecosystems was highest functioning when changes came along? Why?
4. Ecosystems need to be balanced, but involve regular change. What are some examples of changes that might be beneficial for the ecosystem as a whole?

### Assessment

Have students explain how they would revise the most stable ecosystem model based on what they learned through the scenarios.

You can also have them answer one of the following review questions:

- What are the components of the food web system, and how do they interact with each other?
- Why does a healthy ecosystem need multiple species of different types to remain stable?
- List one example of a natural ecosystem disturbance, and another that is caused by humans.



## FOR THE TEACHER: FOOD WEB MODELING

This portion of the activity is not designed in order to encourage competition among groups, nor is it designed to understand the “right answer” for what occurs in this woodland forest ecosystem when each of the sample scenarios takes place. Instead, use the activity to allow students to **practice making arguments from evidence** and **construct explanations**. Why do they think a given organism is affected by the change, and what might they expect to happen to the full food web? Promote discourse amongst the students rather than serving as the “keeper of answers.” Lastly, don’t take the rubric too seriously; it is merely a tool to analyze changes. The analysis and discussion are the important parts, not the results!

### Which Ecosystem is Most Stable?

Highest scores wins!

	Ecosystem 1	Ecosystem 2	Ecosystem 3
Scenario 1			
Scenario 2			
Scenario 3			
Scenario 4			
Scenario 5			
Total Score:			

### Rough rubric to rate each outcome from 1-5:

1 – **Collapse!** (the ecosystem network completely collapsed!)

2 – **Drastic Change** (likely causes: low biodiversity, low number of organisms within a population, or not enough alternative paths for the energy to flow)

3 – **Not Very Stable** (likely causes: low biodiversity, low number of organisms within a population, or not enough alternative paths for the energy to flow)

4 – **Stable** (some changes occurred, but the network still provides a way for enough energy to flow to all the organisms)

5 – **Very Resilient** (there was a high variety of organisms, a balanced number of them (e.g., enough producers), and there were enough interactions in the network to keep the remaining organisms connected)



## WATER CYCLE ROLE PLAY (45 min)

### Perfect for 5th and 6th Grade

The water cycle in a woodland area is an important key to keeping the forest healthy and strong. In this role-playing skit, your students will be able to describe the various processes of the water cycle as they occur near a vernal pool.

### NGSS Connections

SEP: Using models; CCC: Cause and effect; DCI: MS-ESS2.C; PE: MS-ESS2-4



### Objectives

Students will be able to describe the various processes of the water cycle and will understand that this cycle runs continuously with different processes happening at the same time.

### Materials

- [cards for each role](#) (one per student)
- 2 bags labeled “cloud”
- 2 bags labeled “ocean”
- 1 large bag of cotton balls (representing rain drops)
- if desired, grab branches from outside that can serve as props for the “leaves”

### Teacher Prep

1. Print a role card for each student (see table on next page to see how many of each card to print).
2. Gather materials. If desired, grab branches to act as props for the “Leaves” actors.
3. Select an open area to use as the “stage” for the role play.

### Introduction

1. Introduce or review the [water cycle](#). The water cycle helps us understand how water moves around in the environment – in the air as vapor, on land as bodies of water, and in living things.
2. Remind students that water can exist in the form of a solid, liquid, or a gas. In a woodland ecosystem, you’ll find water as ice during the winter, and you’ll find plenty of water in the form of liquid (in bodies of water, plants, and animals!) or gas (held by air as water vapor). Have students identify points in the water cycle where water changes from one form to another.

### Role-play Activity



1. Break the class into teams of actors who will play each role. Distribute role cards and props and give students time to read about their roles, recite their lines, and practice any gestures (these are all described on the role cards and also explained below).

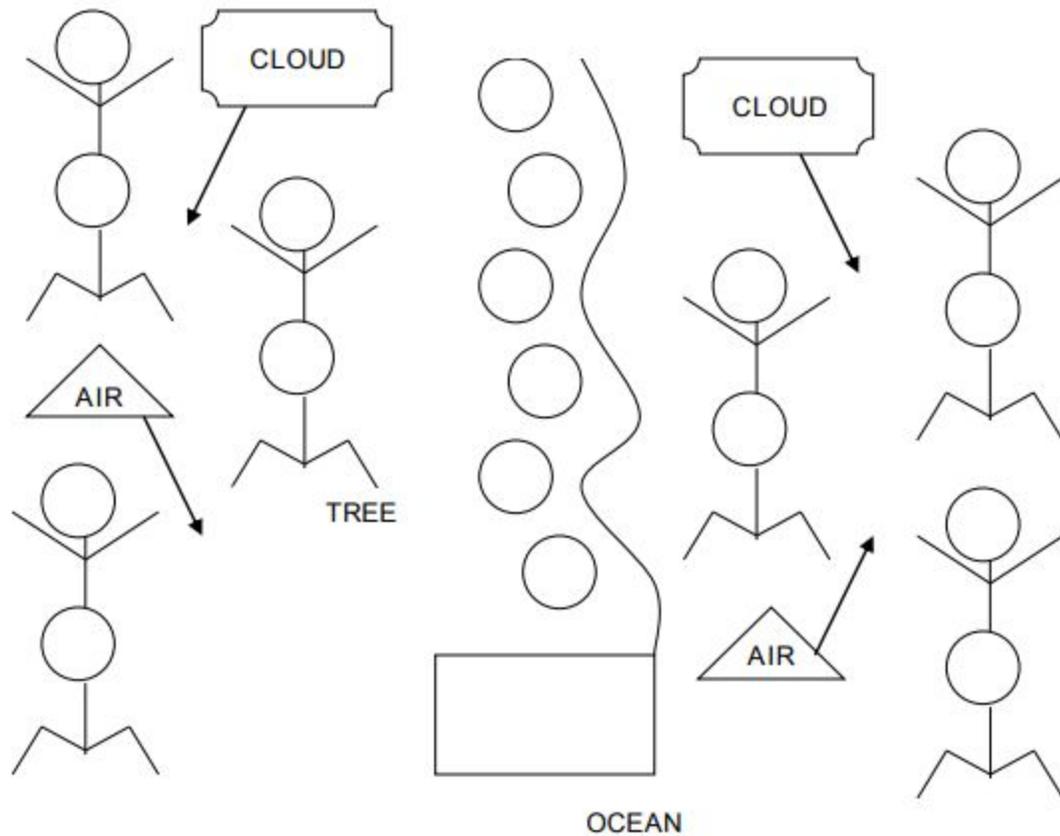
ROLE (cycle process)	# of KIDS	SCRIPT LINES	STAGE POSITION	PROPS or MOVEMENTS
<b>CLOUDS</b>  (precipitation)	~2	It's cold up here!  Pre-ci-pi-tate	Walks in a slow circle around the trees	High-fives <i>Air</i> when condensing; Drops rain throughout habitat
<b>AIR</b>  (condensation, with clouds)	~2	I'll carry up that water.  Condense! (loud, abrupt)	Free to travel anywhere on stage to collect water vapor	Adds drops to "cloud bag" and high-fives to condense
<b>ROOTS of the TREE</b>  (uptake)	~6	My tree is thirsty!  Aaah, water. Up you go!	Seated at <i>Leaves</i> feet, knees up to resemble roots	Pulls water from the soil and stretches the drops up to the leaves
<b>LEAVES of the TREE</b>  (transpiration)	~6	I need water and carbon dioxide to grow tall!  Transpire (long, quiet, refreshing)	Standing behind <i>Roots</i> with arms outstretched high	Fans out arms as branches and transfers drops to <i>Air</i> passing by
<b>RIVER</b>  (runoff)	~6	Flow, flow, downhill	Seated in a row between the trees	Rocks back and forth, waves arms to mimic flow; Stretches to collect fallen drops to pass down line.
<b>OCEAN</b>  (accumulation and evaporation)	~2	Movement won't stop – I'll give a bit off the top! Evaporate! (sudden, joyful)	Sitting cross-legged facing the <i>River</i>	Stores drops in "slotted box"; May occasionally hold a few out for <i>Air</i> to collect

**Teacher Tip:** Be prepared for a degree of noise and chaos (and fun!) as the cotton balls start traveling



and your whole class calls out their lines at the same time. Establish a signal that will tell students when to stop the role-play.

2. Position students on the “stage.” The river actors should be seated on the floor in a line, with the ocean actors at one end of the river. Tree actors can be situated on either side of the river, with the root actors seated on the floor and leaves actors standing above them. Cloud and air actors should roam freely around the stage.



3. Distribute cotton balls randomly around the stage, describing how, at any one time, different water droplets are involved in the various water cycle processes. In our woodland, water is in the river, is flowing up tree trunks, and is hanging out in the air.
4. Dress rehearsal: begin a 1-minute practice round of the role-play after confirming students understand their responsibilities. As a rule, actors must stick to the script, only passing water drops to and from specific actors as designated on the role cards. Allow for a degree of mistake, practice, and adjustment!
5. Performance: begin the skit once more; this time, instruct actors that this act will be considered “Take 1”, so they should be careful to distribute drops correctly, use props appropriately, and follow the script. If problems arise, feel free to “cut” and begin a new “take.”

- a. Freeze the cycle after 1 - 2 minutes of proper role-play. Have students look around to see where the water drops are located at this point in time.
- b. Continue the action and freeze again after a few minutes. Look around again and see what has changed. Review the multiple paths water can take in the cycle, and how air, heat, gravity, and plants contribute to its movement.

### Wrap-Up

Discuss the following questions:

- Where were the raindrops when the role-play was stopped at different time? Was this always the same?
- Did water drops always move through the cycle in the same order? At the same pace? (Textbook diagrams often make the water cycle seem like a steady, organized, step-by-step process. In reality, water can move between states in any order, sometimes quickly and sometimes slowly, all depending on the conditions and circumstances.)

### Extensions

- Introduce a water drop that is a different color than the rest (e.g. a colored cotton ball or craft puff ball), and follow its path through the water cycle. Make note of where this drop is each time you pause the action, and talk about how it got there. If desired, diagram the progress of this water drop, highlighting the points where it changed from liquid to vapor or vice versa.
- Explore cause and effect by introducing changes to the environment, such as “cutting down” all the trees (removing those actors from the stage) or damming the river (preventing the river actors from passing along their drops.) Have students observe what happens to the water in these situations and compare it to what happened in the original scenario.



## DECOMPOSITION INVESTIGATION (set up, then wait 7 weeks)

### Perfect for all Grades 3-8

In this two-part inquiry-based activity, students will practice using the scientific method while learning about decomposition, exploring how some types of garbage will decompose while others will not. Students can then go on to design their own experiment to test different variables affecting the rate of decomposition.



### NGSS Connections

SEPs: Asking questions, Planning and carrying out investigations, Analyzing and interpreting data; CCCs: Stability and change; Patterns; DCIs: LS2.A, LS2.B; PE: 5-LS2-1

### Objectives

In this lesson, students will learn that trash is composed of two types of waste: organic and inorganic. They will learn that decomposers are important in breaking down organic waste. Students will also practice asking scientific questions and gain experience designing an experiment to answer a question.

### Materials

- 6 clear jars
- At least one “set” of trash: an apple core, a piece of plastic, two leaves from outside, a piece of bread, a piece of tin or aluminum foil, a piece of paper
- Soil, enough to fill six jars (from outside, not store-bought)
- Each student will need their science notebook or a worksheet

### Introduction

1. Present the objects (leaves, paper, apple core, bread, plastic, foil) to the students. Allow students to carefully observe, touch, and pick up the objects. *Teacher tip: If possible, have a few sets of the same objects so students will all be able to observe without crowding.* Have students discuss and then answer the following questions in their science notebooks, along with their observations:
  - a. What do you notice about these objects? Record initial observations of each object. Make sure they include size (length, width, and height), color, shape, and a simple sketch.
  - b. Is there anything that two or more objects have in common?
  - c. Is there anything that makes some of these objects different?

2. Introduce the scientific practice of planning and carrying out an investigation. Explain that scientists conduct investigations to understand how the world works, and that the students will be conducting an investigation to see how the objects change. With this experiment, we will all be answering the same question and using the same procedure, but everyone will be creating their own hypotheses.
3. Have students write down the question they are answering in their science notebooks. The question this experiment is answering is “How do you think these objects will change over time?” Make sure they don’t try to answer it right away – that’s what the hypothesis is for!

### Procedure - Part One

1. Set up the experiment. Place each trash item in a clean, empty mason jar. Try to place the item against the glass, so you can monitor it over time.
2. Fill each jar to within 1 inch from the top with soil. Make sure the soil is from outside to ensure that it contains the bacteria and microorganisms necessary for decomposition. The soil should naturally contain decomposing bacteria, fungi, and microorganisms— soil bought from a store will not have these. Don’t worry if you see small insects, the more the better. Soil not including these decomposers will cause the trash to take much longer to break down. *Teacher tip: Have students help fill the jars with soil. Older students can do this on their own, and younger students can add soil while you hold the jar and supervise.*
3. Explain that you will be leaving the objects in the soil for seven weeks, and ask the question again: “How do you think these objects will change over time?” Use this question to guide writing their hypothesis. Their hypothesis is each student’s prediction on how they think the objects will change. Their hypotheses should indicate how they think each object will change, not just one or two. Students will record their hypothesis in their notebooks.
4. Add a few tablespoons of water to the jar, and keep the lid off. Continue adding water to each jar as necessary to keep the soil moist but not soaked over the next seven weeks. *Teacher tip: Include students to make sure the jars stay damp, but supervise to make sure they don’t get soaked. Spray bottles work well for this.*
5. Each week have students record observations for each trash item in their science notebooks. They should note color, shape, and size of all the objects, and even include a sketch if they want. *This will become more difficult as things turn to soil.*
6. At the end of seven weeks, record final observations. They should observe a tremendous difference in some jars between the first and last week.

7. The next step for students is to analyze their data. Using the information they have gathered over the past seven weeks, they will choose to either accept or reject their hypotheses. Was their prediction correct? What evidence do they have to support this? Students can record their analysis in their science notebooks or on their paper.
8. Finally, for a conclusion, have students summarize what happened over time to each piece of trash, and encourage them to draw conclusions about different types of trash. Ask the students:
  - a. Which pieces of trash changed the most? Why?
  - b. Which didn't decompose at all? Why?
  - c. What made these pieces different?

## Wrap-Up

1. Introduce the word "[decompose](#)." Ask students if anyone has heard this word before, and if anyone knows what it means. After going over the definition, ask students if any of their objects decomposed.
2. Revisit the fact that not all of their objects decomposed. Why do they think this is? [Define the terms organic and inorganic waste](#), and ask students for some other possible examples of each. What are the differences between organic and inorganic waste? *Teacher tip: The word 'organic' has become synonymous with healthy eating, so be careful of any misunderstandings here.*
3. Discuss what causes decomposition to occur. Name some decomposers and explain why they are important. *(Bacteria, fungi, beetles, ants, flies. All of these organisms eat decaying animal and plant matter, returning nutrients back into the earth. It may appear that matter breaks down by itself, but in reality we just cannot see all of these organisms hard at work. Without them dead matter would never convert back into nutrients and Earth's ecosystems would not function properly.)*
4. What takes longer to break down – organic or inorganic waste? Why? *(Organic waste is made of matter that was very recently alive, like plants and animals. Inorganic matter is made of matter that was not alive, or was alive millions of years ago, like minerals and petroleum. Inorganic matter takes longer to break down because it is not decomposed by other organisms. It is left to break down on its own with the help of the sun and water, which takes a very long time, sometimes thousands of years.)*
5. What are the benefits of composting for the environment? *(It returns essential nutrients back to the soil. If organic waste is landfilled, it permanently removes those nutrients from the earth.)*
6. What can we do at home or at school to help organic trash complete its life cycle? *(Compost! See resources from [Life Lab](#) for guidance.)*

7. What can we do at home to keep inorganic trash from piling up in landfills? (*Use less products made of non-recyclable materials, and recycle or compost everything we can.*)

### Procedure - Part Two

Once students have a basic handle on the concept of decomposition and how to set up the jars, they will be able to design an experiment to answer another question.

1. Start by having students generate questions about their results. A simple way to ask students to generate questions is to ask them “what do you wonder?” Have students discuss with groups and record their questions, and then share them with the class and write them on the board.
2. Next, go through the questions to pick out the ones that a second experiment could answer. Some examples are below:
  - a. Does temperature matter? What if it’s warmer or colder?
  - b. Does the substrate matter? What if we tried soil from a different place?
  - c. What if we moistened the soil with something other than water?
  - d. Do different types of organic matter decompose faster? Slower?
3. Have a class vote to choose one of these questions to answer with an experiment. Teacher tip: If appropriate and resources allow, students can be broken into groups and each group can answer a different question.
4. Have students design the experiment. This is a good point to define the terms “variable” and “control.” In the first experiment, the question was ‘how do you think the objects will change over time,’ so it was comparing all of the objects to each other. If the question is about how the parameters of the decomposition jar changes the rate of change, then there must be a control to compare to the variable. For example, if a group is testing how temperature affects the rate of decomposition, they may use three jars: one that is warmed up (variable), one that is kept in the fridge (variable), and one that is left at room temperature (control). As students design their experiments, be sure they are including a control and a variable if appropriate.
5. Carry out and analyze the experiment(s) as you did with the first one. Be sure to include a hypothesis, analysis, and a conclusion. After students have their results, you could have them do research to help back up why they saw their results.

## STUDENT-LEVEL VOCABULARY

Feel free to revise these definitions for your grade level or for your teaching unit. Adding pictures next to the terms in a word bank helps English-Language Learners!

**adaptation (n):** any structure or behavior of an organism that improves its chances for survival

**biodiversity (n):** the numbers of species in an area; the variety of life on Earth

**carnivore (n):** an animal that eats meat (i.e., other animals)

**compost (n):** a mixture of decayed or decaying organic matter used to fertilize soil

**condensation (n):** the change of a gas or vapor to a liquid

**consumer (n):** an organism that eats other animals or plants

**decompose (v):** to separate or resolve into components or elements

**decomposer (n):** an organism that breaks down organic material over time

**detritus (n):** dead and decaying matter, including animal waste

**ecosystem (n):** the community of different species in a particular geographic area and all of their interactions with each other and the physical environment

**energy (n):** the ability to do work or cause change

**environment (n):** everything living or non-living that surrounds and influences an organism

**food chain (n):** a series of events in which one organism eats another and obtains energy

**food web (n):** the pattern of overlapping food chains in an ecosystem

**habitat (n) :** a place where plants and animals live

**herbivore (n):** an animal that eats plants; also called a primary consumer

**indicator species (n) :** an organism that reflects a specific environmental condition

**inorganic waste (n):** waste not from organisms, or from organisms that existed millions of years ago, that cannot be easily broken down

**nourish (v):** to provide with the substances necessary for growth, health, and good condition

**macroinvertebrates (n):** an animal without a backbone that you can see without using a microscope, such as snails, slugs, insects, worms, and spiders

**microorganism (n):** a living thing, such as bacteria, algae, and fungi, that is so small that it can only be seen with a microscope

**organic waste (n):** waste from organisms or their life processes that can easily be broken down

**organism (n):** a living or formerly living thing

**precipitation (n):** a form of water, such as rain, snow, or sleet, that condenses from the atmosphere, becomes too heavy to remain suspended, and falls to the Earth's surface

**predator (n):** an animal that hunts and kills other animals for its food

**prey (n):** an animal that is hunted and eaten by another animal

**producer (n):** an organism, such as a plant, that can make its own energy-rich food molecules from inorganic materials and an energy source such as sunlight

**scavenger (n):** an animal that eats dead organisms or parts of dead organisms

**species (n):** a distinct type of organism

**suburban (n):** related to a residential district located on the outskirts of a city

**transpiration (n):** the process of giving off vapor containing water and waste products, especially through the stomata on leaves

**uptake (n):** the process of the roots of a plant taking up water from the soil

**vernal pool (n):** a temporary pond that forms seasonally after the rains

**water cycle (n):** the continual movement of water among Earth's atmosphere, oceans, and land through evaporation, condensation, and precipitation

**woodland (n):** a natural habitat covered with trees, grasses, and bushes



## NEXT GENERATION SCIENCE STANDARDS CONNECTIONS

### Disciplinary Core Ideas (DCIs)

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS4.C: Adaptation
- LS4.D: Biodiversity and Humans
- MS-ESS2.C: The Roles of Water in Earth’s Surface Processes
- MS-ESS3.C: Human Impacts on Earth Systems



### Science and Engineering Practices (SEPs)

- Asking Questions
- Developing and Using Models
- Planning and Carrying Out Investigations

### Cross-Cutting Concepts (CCCs)

- Systems and System Models
- Stability and Change
- Cause and Effect

### Related Performance Expectations (PEs)

*Activities in this guide are just some of many that could help prepare your students to perform the following hypothetical tasks that demonstrate their understanding:*

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.

5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-ESS2-4: Develop a model to describe the cycling of water through the Earth’s systems driven by energy from the sun and the force of gravity.

View detailed standards, storylines, and appendices at <https://www.nextgenscience.org/>



## INTRODUCTION TO iNATURALIST

[iNaturalist](#) is a free social media platform designed for citizen scientists of all ages to record observations of plants and animals in nature, share what you've found, add sightings to citizen science projects, learn more about nature, and contribute to a global dataset of biodiversity information.



With smartphones or cameras, students and/or families can explore their local ecosystem to actively engage with the surrounding wildlife. In doing so, they are engaging in science and contributing to databases of research such as the Global Biodiversity Information Facility, which real experts use to track species migration! Thanks to iNaturalist, children, teachers and parents can explore their surroundings with new observation and identification skills.

## HOW TO GET STARTED IF YOU ARE AN EDUCATOR OR PARENT

The first step on your citizen science journey is to visit the [iNaturalist website](#) to set up your account. It's free and easy. Then, download iNaturalist to any of the mobile devices that you may be using out in nature. iNaturalist works on both Android and iOS devices. Once you have your account set up, you have many choices for how to participate:

**Keep Track.** Record your encounters with other organisms and maintain life lists, all in the cloud.

**Crowdsourcing Identifications.** Connect with experts who can identify the organisms you observe.

**Learn About Nature.** Build your knowledge by talking with other naturalists and helping others.

**Create Useful Data.** Help scientists and resource managers understand when and where organisms occur.

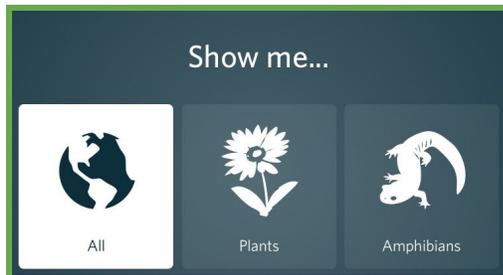
**Become a Citizen Scientist.** Find a project with a mission that interests you, or start your own.

**Run a Bioblitz.** Hold an event where people try to find as many species as possible.

## INTRODUCING SEEK!

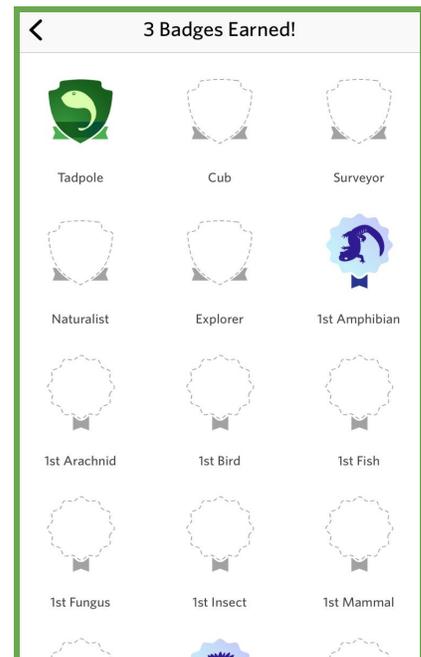
*Seek* by iNaturalist is a new child-friendly portal into the iNaturalist species. The app uses iNaturalist data to create treasure hunts customized to your very own backyard! The app uses artificial intelligence to identify what you saw and award you with badges.

**Check out the species near you.** Interested in plants? Mammals? Birds? With *Seek*, you can select which type of organism you like best. Then, ask *Seek* to tell you what's likely to be growing or living near you.



**Collect your favorite organisms--Virtually!** Once you discover your favorite creature or plant, collect it virtually using *Seek*. *Seek* will also guide you on the best time of year to find your favorite animal or plant.

**Compete for Badges.** Find a scavenger hunt with a mission that interests you, or start your own. Compete with other youth or teams to see who can make the most identifications and complete the most challenging quests.



## MONTGOMERY HIGH SCHOOL ECOLOGY PROJECT

*An example of how one school successfully used iNaturalist for classroom and outdoor learning!*

**Location:** Santa Rosa, CA (San Francisco Bay Area)

**Total Time:** 3-4 weeks

**Subject:** Biology

**Grade Level:** 10th-12th

**Participants:** 150 students

**Educator Reflection:** The [Montgomery High School Ecology Project](#) on iNaturalist was a great way to engage my students in observations of the natural world and to connect them to local scientists. iNaturalist is essentially a collection of digital field notebooks, made by individual users, but shared among a large community. This makes it an ideal platform for technologically-minded and social media-savvy teenagers, and is more likely to engage them than paper datasheets. My students clearly understood they were collecting research-grade data during this service-learning project due to the easy-to-use format of the project website and smartphone applications, and the communication and species identification they received from the corps of naturalists online. Scaffolding and specific guidelines were presented to help every student document biological observations in their local community.



The project was conducted as a “competition” to collect the most research-grade data, with the additional incentive of a “Unit Exam Pass” for overall observations, effort, and teamwork. I allowed my students to use their iNaturalist.org accounts during class time, which led to increased engagement and enthusiasm. They were also given time to present their observations and data reports to the class as a whole. This project aligned well to our existing unit and class goals, and I was able to use iNaturalist to introduce a unit on classification. Additional activities connected to the project included a computer-based webquest, PowerPoint citizen science technology training, lectures, video clips related to invasive species and biodiversity, and a field trip to an adjacent semirural site. I also invited guests from the Audubon Society and local iNaturalist participants who had been assisting with online identifications, to help reinforce the importance of community connections in science research.

To address the issue of access to technology, my students completed a survey noting their access to mobile and digital technology. I then organized them into groups of three, assuring that at least one student per group had iNaturalist app availability so the group could upload their observations.

The learning outcomes for my biology classes at that time were focused on themes of classification, ecology, technology and inquiry. These themes were embedded in a larger project, which included the

use of field lab notebooks and plant presses. Online photos and written exchanges between my students and global naturalists were shared via the iNaturalist online platform. Students were able to obtain research-grade data and contribute these to the global scientific community. One observation in particular piqued the interest of the scientific community: A student posted a picture of a collared lizard in Howarth Park in Santa Rosa, which caught the attention of scientists because the lizard, native to the desert east of the Sierra Nevada, was far from its usual home range. Scientists suspected the lizard was a pet that was released into or escaped to the park. Not only was this observation exciting, but it also helped highlight an important learning goal in our unit. My students realized that as climate changes, collared lizard populations are likely to move further north and as a result, will be found more frequently in our Santa Rosa region in the future.

## CITIZEN SCIENTIST RESOURCES

These related links include guides for getting started with your own citizen science projects, indexes to existing projects that you can join, and a wide range of educational resources. While examples are focused on life science, the resources apply to diverse subject matter.

**[iNaturalist](#)**: A platform to record observations of plants and animals in nature, share what you've found, add sightings to citizen science projects, meet others with similar interests, learn more about nature, and contribute to a global dataset of biodiversity information.

*-iNaturalist and the California Academy of Sciences*

**[Nature Watch](#)**: A portal to citizen science and nature-related activities designed for and taking place in National Forests.

*-USDA Forest Service*

**[SciStarter](#)**: A resource that matches people with projects that suit their interests and suggests ways to find funding for citizen science projects

of all types. Structured with project descriptions and accompanying blog by educators who have used the projects.

*-SciStarter*

**[Your Wildlife](#)**: A portal to citizen science projects that explore the microflora and fauna that live on and in our bodies—our own human microecosystems.

*-North Carolina State University, National Science Foundation*

**[Zooniverse](#)**: A collection of internet-based citizen science projects to further science and the public understanding of the scientific process. Projects range from astronomy to climatology to archaeology. *-Citizen Science Alliance*

## [Choosing and Using Citizen Science: A Guide to When and How to Use Citizen Science to Monitor](#)

### [Biodiversity and the Environment](#)

A handbook for educators, community members, and scientists with step-by-step guidance on designing effective citizen science projects.

*-Scottish Environment Protection Agency Pocock, M.J.O., Chapman, D.S., Sheppard, L.J. and Roy, H.E. Centre for Ecology & Hydrology. ISBN: 978-1-906698- 50-8, 2014, 28pp*

## [Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes](#)

A guide for K-12 teachers to introduce their students to the methodologies used for scientific field research and to guide them through the process of conducting field studies.

*-Association of Fish and Wildlife Agencies' North American Conservation Education Strategy; Pacific Education Institute*

## [Guide to Citizen Science](#)

Written by scientists and educators, covers developing, implementing, and evaluating citizen science for biodiversity studies.

*-Natural History Museum of London; Natural Environment Research Council's Centre for Ecology & Hydrology*

## [Biome Viewer](#)

An interactive to explore biomes, climate, biodiversity, and human impacts across the globe.

*-HHMI BioInteractive*

## [WildCam Lab](#)

A part of WildCam Gorongosa, an online citizen science platform where users identify animals in trail camera photos. Using the WildCam Lab, students can investigate ecological questions and test hypotheses by exploring trail camera data using an interactive map.

*-HHMI BioInteractive*

## LINKS TO FURTHER READING AND RELATED RESOURCES

### [Citizen Science: 15 Lessons that Bring Biology to Life, 6-12](#)

Offers flexible classroom activities for indoors or outdoors, designed to make data collection and analysis easy.

*-Trautmann et al., eds; NSTA Press (2013)*

### [Citizen Scientists: Be Part of Scientific Discovery from Your Own Backyard](#)

Covers four seasons of citizen science, with kid-friendly outdoor activities.

*-L.G. Burns; Henry Holt and Company (2012)*

### [Frontiers in Ecology and the Environment Special Issue](#)

Citizen Science – new pathways to public involvement in research. The August 2012 journal issue is entirely devoted to citizen science, with articles ranging from data quality to engaging students to case studies.

*-Ecological Society of America; various authors; Frontiers in Ecology and the Environment (2012): 10(6)*

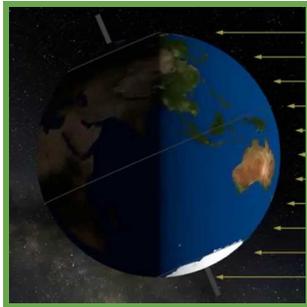


## RELATED CLASSROOM VIDEOS



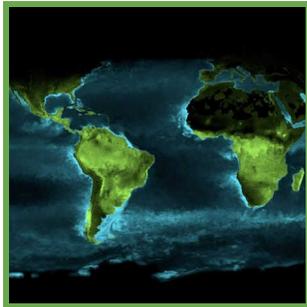
### [Gorongosa's Water Cycle](#)

Gorongosa National Park sits at the southern end of Africa's Great Rift Valley in Mozambique and is centered around Lake Urema. Watch this animation to learn how these features affect Gorongosa's water cycle, which starts with the evaporation of water from the Indian Ocean.



### [Why Do We Have Different Seasons?](#)

Did you know that the Sun's light shines differently on Earth at different times of the year? In this visualization, watch as the Earth orbits the Sun, rotating, like a slightly tilted, spinning top. This rotation changes the angle at which sunlight hits the surface of our planet, creating the different seasons we experience here on Earth.



### [Timelapse: Photosynthesis Seen From Space](#)

Now that your students understand the reason for the seasons, extend the unit to explore the instrumental role the sun plays in fueling food webs, starting with producers. This video illustrates the influence of the sun on the seasonal abundance of plant matter produced on land and in our oceans.



### [Why Do Birds Migrate?](#)

In this visualization, you'll see how seasonal changes drive patterns in animal behavior. Track the movement of two migratory birds of prey—ospreys and turkey vultures—as they travel between North and South America over a single calendar year. Assist your students to make connections as to how populations of organisms are dependent on the living things on which they prey.

For more free teaching resources, visit [www.hhmi.org/biointeractive](http://www.hhmi.org/biointeractive) or [www.calacademy.org/educators](http://www.calacademy.org/educators).

## REFERENCES & ACKNOWLEDGMENTS

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The *Backyard Wilderness* film is a production of

