A Unit of Study for Grades 4–6

Dow AgroSciences

ScienceWorks

SCIENTIFIC EXPLORERS!






CHILDREN'S MUSEUM INDIANAPOLIS



Acknowledgements

The Children's Museum of Indianapolis is a nonprofit institution dedicated to creating extraordinary learning experiences across the arts, sciences, and humanities that have the power to transform the lives of children and families. It is the largest children's museum in the world and serves more than 1 million people across Indiana as well as visitors from other states and nations.

The museum provides special programs and experiences for students as well as teaching materials and professional development opportunities for teachers. To plan a visit or learn more about educational programs and resources, visit the Teacher section of the museum's website at **childrensmuseum.org**.

Dow AgroSciences

ScienceWorks

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ScienceWorks—The Exhibit

Challenges to use natural resources sustainably and to feed our growing human population have never been greater. As a result, there is a growing demand for scientists to solve critical problems using Science, Technology, Engineering, and Math (STEM).

The Children's Museum of Indianapolis reinvented *ScienceWorks,* one of the museum's most popular exhibits, in 2016 to feed the curiosity of the next generation of young scientific explorers. The exhibit provides an excellent opportunity for students to explore the variety of roles that scientists and science plays in our daily lives. Students examine how to clean and manage water from the Great Lakes all the way to the Mississippi Delta, how water is cleaned and moved in Indianapolis, and how it is used in agriculture. They can also examine a John Deere cab as it harvests corn and find out what animals live in the hillside as they climb along. They can learn to use field journals to draw conclusions about species that exist in caves, hills, fields, and even under houses.

Visitors can explore the work of real scientists, including hydrologists, naturalists, and geologists. Learn how engineers, farmers, and others use scientific process skills to ask questions and seek answers that help us in our daily lives. Additional science experiences are available in the redesigned *DowAgroSciences STEMLab*. The exhibit and *STEMLab* are made possible by the generous support of Dow AgroSciences through the Dow Chemical Company Foundation.

Enduring Ideas

Scientific observation provokes us to form questions and seek answers that help us understand the forces and connections within the natural world. Scientific tools help us study, analyze, and protect what we see in nature. Studying natural systems helps us understand how they work and how to use them sustainably over time.

The Unit of Study

This unit of study is designed to complement the *ScienceWorks* exhibit by inspiring students to use scientific inquiry to examine some of today's most challenging environmental problems. Students will learn about the diverse set of skills needed by people pursuing STEM careers and some of the challenging problems scientists are trying to solve today. In this inquiry-based unit, students use problem-solving skills to examine environmental problems and food supply issues. They develop the skills and practice using the tools needed to investigate nature. As students work to solve problems or use tools, they learn about the multiple ways scientists approach solving some of society's greatest challenges. Student explorers discover the excitement of being a scientist on the cutting edge of discovery!

What's ahead?

In Lesson 1 of this unit of study, students begin investigations of plant life, soil, nutrients, and minerals in the nearby and larger environment, using scientific methods and tools. In Lesson 2, students focus on the impact of water and waterways in shaping the natural environment and sustaining human, plant, and animal life. Students investigate their own use of water. In Lesson 3, students make daily observations of weather and examine weather patterns. They begin to understand the distinction between "climate" and "weather." They use maps to identify major climate regions and waterways of Indiana and the United States and describe the way these systems impact the local environment and are connected to the global climate system.

What will students learn?

This unit of study enables students to develop skills in science, technology, engineering, and math (STEM) aligned with specific national and state academic standards in those subjects as well as in geography and English.

What will students be able to do?

Unit goals

Students will:

- discuss the different kinds of skills, training, and knowledge needed by people with scientific careers, such as hydrologists, naturalists, geologists, farmers, and engineers.
- observe the diversity of plant life, soil, nutrients, and minerals in their own environments.
- explore the myriad ways water and waterways impact and shape the natural environment and sustain human, plant, and animal life.
- compare and contrast water use and water conservation.
- work in groups to make daily observations of weather and examine weather patterns.

- discuss the distinctions between "climate" and "weather."
- evaluate maps of major climate regions and waterways of Indiana and the United States and describe the way these systems affect the local environment, how they are connected to the global climate system, and how they are changing over time.
- explore how our actions and choices affect the world around us.
- examine how understanding the natural world helps us direct its forces for our benefit and use them sustainably for future generations.

Before You Begin

Let other teachers and school support personnel know that you are planning a unit in which students practice STEM skills and examine concepts in environmental science, especially concepts related to sustainability. The visual arts teacher may want to do joint planning to weave art concepts into Lesson 1, in which students create representations of their observations of wildlife.

The social studies teacher may want to integrate social issues prevalent in Lesson 3. Your school media specialist may want to dedicate a display to books about environmental science. See the Resources section of this unit (pages 40-43) for suggestions. Make sure students have access to a computer for web-based research. In preparation for Lesson 1, look for locations near your school that may offer interesting biodiversity to study, such as nature preserves, state parks, or even certified backyard wildlife habitats. Families can enjoy outings to such locations as an excellent opportunity to explore the outdoors together, with a purpose.

Lesson 1: Investigating Nature

Students in **Grades 4–6** focus on plant growth and development as they observe and describe how natural materials meet the needs of plants. Students examine the relationships and interactions of organisms with each other and the physical environment.

Focus Questions

- What animals and plants live at my school or in my neighborhood?
- What characteristics of plants or animals help them survive?
- How do plants respond to stimuli?
- How are rocks and minerals important to people, animals, and plants?
- What would happen if a species were removed from an ecosystem?
- How can we live more sustainably with nature?

Academic Standards

Indiana Science Standards (2016)

4.ESS.4, 4.LS.2, 4.LS.3; 5.ESS.4, 5.LS.1, 5.LS.2; 6.LS.3, 6.LS.4, 6.LS.5

Social Studies – Geography

4.2.7, 4.3.6; 6.3.13, 6.3.14

National Standards

Next Generation Science Standards

4-LS1-1; 5-LS2-1, 5-ESS3-1, 5-PS3-1; MS-LS2-3

Geography for Life

4.4.1; 7.4.1; 8.4.1, 8.4.2; 14.4.3; 15.4.2; 16.4.3

Objectives

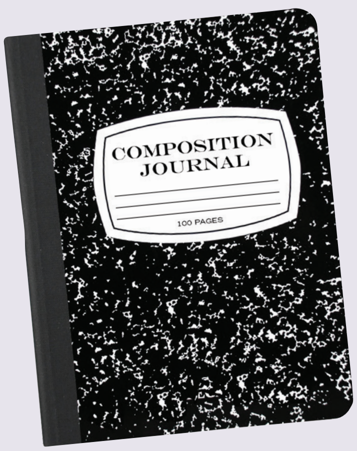
Students will

- Record observations of animals and plants found at their school or in their neighborhood
- Compare and contrast plants and discuss how plant parts help plants survive
- Design an experiment to test how plants respond to at least one stimulus

- Examine characteristics of rocks and minerals and their everyday uses for people, animals, and plants
- Develop and use definitions for sustainability, ecosystems, and native and invasive species.

You will need . . .

- A science journal for recording observations and activities from experiences (1 per group). You can purchase composition notebooks or reuse sheets of paper from your school's recycle bin to create a science notebook that student can decorate.



- Pencils
- Binoculars for observations (optional)
- Plants for comparing parts of a plant (1 per student)
- Seeds and/or seedlings (4 to 8 seeds per group)
- Soil
- Small cups or planters for seed experiments
- Cups or watering cans to water the plants
- Labels for plant containers
- Rocks and minerals kits
- Magnifying lenses
- Handouts on native and invasive species
- Computers with web access

Time

- **Experience 1: 2 class periods**
- **Experience 2: 3 class periods and 6-8 weeks for data collection**
- **Experience 3: 1 class period**

Vocabulary

abiotic
atmosphere
biodiversity
biosphere
biotic
consumer
data
decomposer
detritus
detrivore
ecosystem
experiment
host
hydrosphere
hypothesis
invasive
kingdom
landforms
naturalist
observation
parasite
predator
prey
producer
species
strategies
structures
trophic cascade
variables

Introductory Experience: Science Walk

In this introductory experience, students prepare and personalize journals and use them in direct observations as they take a walk on school grounds, in a nearby neighborhood, or in a local or state park.

Preparation

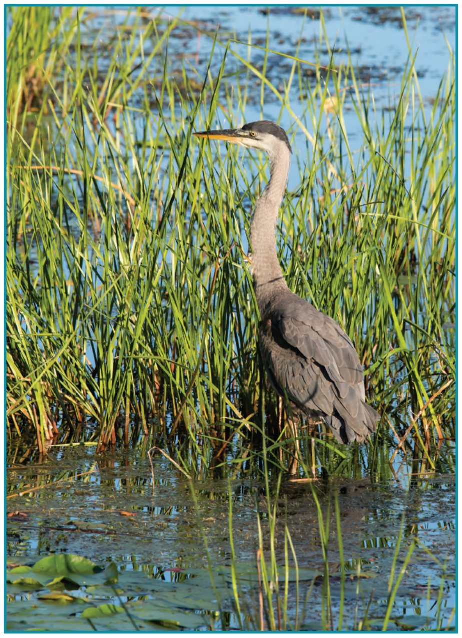
Before teaching Experience 1, preview the outdoor area you will use for student observations of nature to determine what animals, plants, and evidence of living organisms (spider webs, chewed trees, scat, etc.) are available. You can take some pictures to share with students when you preview the area. Some school grounds have low biodiversity with few plants and animals for observation. If your school is not an appropriate place for student observations, contact a local nature club or a local or state park for suggestions on where you can take your students on a walk. Finding a natural area that is not manicured, such as a forest with fallen logs, is likely to provide a greater diversity of animals and plants to observe. An area that includes both native plants and invasive species can be an especially good example of the stark contrast between ecosystems.

Procedures

Day 1

- Introduce students to the idea that they are going to be scientific explorers! Ask students to share information they know about scientific explorers and **naturalists**. Guide the discussion by describing famous scientists or naturalists from the past who helped us understand and protect nature, such as John Muir, Rachel Carson, Gene Stratton Porter, and Richard Lieber (see page 10).
- Ask students if they have ever done any scientific exploration outdoors. They may mention hiking or snorkeling, or may even describe nature they have seen outside at school or in their community. Point out that while much of the physical world has been explored, there are still many unexplored areas to be observed, especially in the ocean.

  Furthermore, the world is always changing. It is important for scientists to monitor the natural world to understand how it is working. Explain that scientific **observation** can help people understand what to do to help keep our planet healthy and protect natural resources for human use.
- Ask students: *How do we find out what naturalists and explorers have learned?* They may mention reading books or watching documentaries. Let students know that the most important work of any great explorer is to make observations and write down a summary of what is found.
- Assign students to groups of 3 or 4. Give each group a composition journal or the materials to make a science journal. Each group should record members' names and take time to personalize their journal with nature-themed stickers, artwork, or other decorations.
- Provide students with a scaffold for the first entry in their journals. Have them record the date and time and instruct them to make detailed observations in their journals about objects inside the classroom. Visit each group to observe their writing and give tips on making detailed observations. When all students have had an opportunity to participate, ask a student in each group to be the spokesperson and share their group's observations of the same objects.
- When all groups have reported their observations, ask students: *Were everyone's observations exactly the same?* Students should observe that while some observations were similar, some were quite different from others. Use those differences to emphasize to students the importance of close observation and details.



- Ask students: *What are the differences between animals, plants, and minerals?* Guide students to discuss the major features of each animal or plant **kingdom**, or group of organisms that are related to each other.

- Introduce students to the concept of **biodiversity**: the variability, or range of differences, among living organisms of all kinds. Biodiversity can occur within animal and plant **species**. A species is a group of organisms in one kingdom that can interbreed or exchange genetic material. There can also be great diversity in minerals and other non-organic materials in the environment.

- Present a brief overview (with photos, if you took any) of the outdoor area the students will be exploring the next day. Ask students to write in their science journals some predictions of the biodiversity they may find there. After all students have had a chance to contribute to their group's ideas, ask a spokesperson from each group to share some of the biodiversity their group expects to find.

- When all groups have reported their expectations, ask students: *Does everyone expect to see the same things tomorrow?* Students should observe that while some expectations are similar, some are quite different from others. Use those differences to encourage students to be open to observing things they do not expect to see. Remind them to record specific details of their observations in their science journals.

- Ask students how they can look for biodiversity on their Science Walk. Give grade-level-appropriate instructions on specific plants, animals, or minerals to look for based on the area they will be exploring. (See planned debriefing suggestions on pages 11-12).

- Demonstrate for students how to use binoculars and magnifying lenses to observe things far away or close up. Allow time for students to practice using these tools to examine objects in the classroom.

- Take time now to explain behavioral expectations for the Science Walk, and review any potential safety issues that may be encountered.

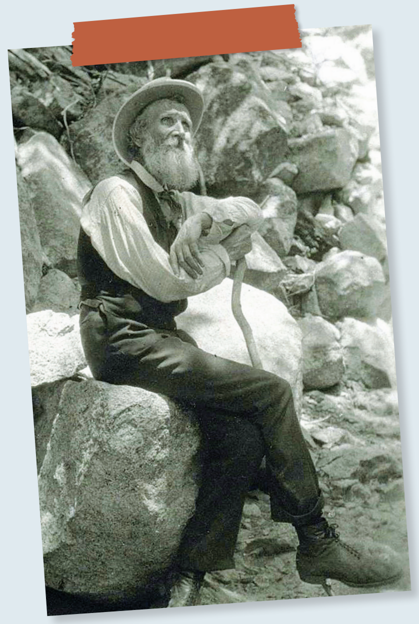
DON'T TOUCH!

Be especially careful to stay away from poison ivy and other plants that can cause painful or even deadly reactions.

Day 2

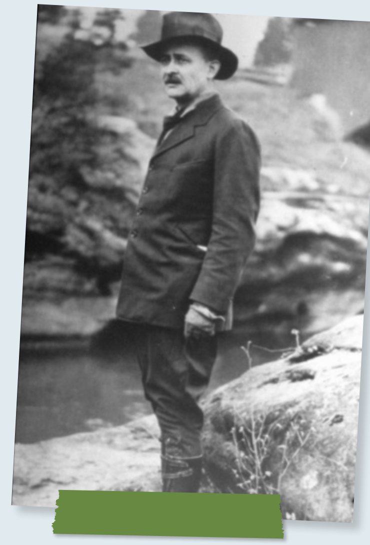
- Accompany students to the nature area they will explore. Give instructions on what to look for and any dangerous areas to avoid. Reinforce the idea that all good explorers document their findings with lots of detail. If time permits, briefly review the students' predictions of what they think they will find.
- Encourage students to record observations in their journals in whatever way they like. For example, they can create tables of data, use tally marks, make drawings, and write detailed descriptions.
- Monitor the students as they explore, and comment on their observations. Point out something they may be missing, such as moss on a log, an anthill on the sidewalk, or a hawk circling overhead, as a living organism to include in their observation notes.
- Warn students when they have five minutes remaining to finish their observations. Explain that, just like scientists, they will meet in their groups to discuss their findings.
- After groups have had time to meet and discuss their observations, ask a spokesperson for each group to summarize the group's findings and highlight any unusual or noteworthy discoveries. Have each group write two questions in their science journal that they are curious about from their observations and would like to explore further. Use their summaries to focus on grade-specific standards in **Experience 1**.

Famous Scientists and Naturalists



JOHN MUIR (1838–1914) was an author, naturalist, and environmental philosopher who studied geology and glaciology. He helped preserve the Yosemite Valley, Sequoia National Park, and other wilderness areas in the western United States.

GENE STRATTON-PORTER (1863–1924) was a nature photographer, naturalist, and American author with tremendous influence on conservation efforts in Indiana. She fought for the conservation of Limberlost Swamp and other wetlands throughout the state. Her novel, *A Girl of the Limberlost*, was made into a movie. Her home and the surrounding 150 acres near Geneva, Indiana, have been designated as the Gene Stratton-Porter State Historic Site and is an excellent fieldtrip destination.



RICHARD LIEBER (1869–1944) was a German-American businessman known as the father of the Indiana state parks system. In 1916 Lieber was appointed the chairman of the State Parks Committee. The first two parks he opened were *McCormick's Creek* and *Turkey Run*. The Indiana state parks system was rated one of the three best systems in the country by the National Park Service in 1934, and was used as a model for other states as they implemented their systems.

RACHEL CARSON (1907–1964) was an aquatic biologist who worked for the U.S. Bureau of Fisheries and became a full-time nature writer in the 1950s. Her book *Silent Spring* (1962) brought environmental concerns to the American people's attention, leading to a nationwide ban on the pesticide DDT, which helped reverse the decline of the Bald Eagle and other bird species.

Experience 1: Plants and Animals

After students have taken their Science Walk, lead them through a discussion of their observations. Ask questions to guide students toward conclusions and help them connect their observations to a general understanding of animals, plants, and ecosystems.

Procedures

- Guide the discussion to the physical characteristics of plants and animals students observed. Give them time to compare specific **structures** (parts) they examined. Ask:
  - How do those internal or external structures function to support survival, growth, behavior, or reproduction?
  - What changes did you observe in the environment?
  - How could the organisms you found adapt to change?
  - Can an oak tree move to avoid something that interferes with its survival? What about a fox?
  - What growth and reproduction **strategies** (behaviors) did you observe? How could you help the organisms you observed survive, grow, or reproduce? (For example, if students observe leaves on a tree, they can explain that the leaves have shapes that capture sunlight and convert it into energy to help the tree grow.
  - What kinds of observations help you document plant and animal structures? (For example, if students find a tree with unusual leaves, they can make a leaf rubbing to include in their journal, which can be shared with the class the next day for help with identification.)
- Ask small groups of students to discuss the components of the Earth's physical systems they saw on their walk. Ask:
  - Did you see any **landforms** (hills, plains, etc.)?
  - Why is our location flat/hilly/mountainous?
  - What did you see in the **atmosphere** (such as clouds, rain)?
  - What components of the **hydrosphere** did you see (such as rivers, streams, lakes, water vapor, a natural spring)?
  - What parts of the **biosphere** did you observe (plants, animals, soil, lakes, etc.)? Where did you see living things?
  - What are the three major components of an **ecosystem**? Provide at least one example of each from your Science Walk (**biomass**, climate, soil).

Grade 5

- Discuss the kinds of organisms they found and how matter and energy were moving in the environment. Give student groups time to draw a model in their science journals of how energy and/or matter moved in the **ecosystem** and how that energy was once from the sun.

INDIANA STATE PARK RULES

Students on a school fieldtrip are permitted to carefully take a few leaf and stem samples for classroom use unless park-specific rules state otherwise. Look for signs about protected species. State park rules require that visitors do not injure or damage any structure, rock, tree, flower, bird, or wild animal. In addition, visitors must not gather limbs, brush, or trees (either dead or alive) for firewood because such detritus rebuilds the natural humus that feeds the ecosystem.

PREDATOR

PREY

- Review vocabulary words that describe the roles organisms play in the environment, including **producer**, **consumer**, **decomposer**, **detritus**, **detrivore**, **predator**, and **prey.**
- Ask:
  - How does matter move through the ecosystem you observed?
  - What role did each organism you observed play in its environment?
  - How does energy move in the ecosystem you observed?
  - Where is the most energy available in the ecosystem?
  - Where did the predators get their energy? Where did the plants get their energy?

TEACHER TIP

One thing that is often left out of discussions of food chains and ecosystems is the role that detrivores play. Consider having students watch the video on **detritus** (see page 41) before or after your exploration outdoors to get students thinking how big a role it plays in our ecosystems.

PARASITE

(Ctenocephalides felis – flea)

Grade 6

- Ask students to describe what relationships they observed (predator/prey, consumer/producer, **parasite**/**host.**) Give them time to record in their journals why they think those interactions exist. Ask:
  - What is the difference between **biotic** (living) and **abiotic** (nonliving) components of a habitat? Give examples of them from your observations.
  - What **invasive** species did you find? What specific impacts did those species have on the ecosystem?
  - How can people help an ecosystem recover from negative impacts? How could people benefit when an ecosystem recovers?
  - To extend the experience after you return to the classroom, allow time for students to watch the *Rewilding* video (see Resources, page 41). Discussion questions about the video could include:

  - What is a **trophic cascade**? What effects does it have on predators and prey in a food web?
  - What was Indiana's original landscape like? (While Indiana originally had many diverse ecosystems, the area was dominated by hardwood forest at the time explorers from Europe arrived.)
  - What might happen in Indiana if we let the forest regrow?

Experience 2: It's Not Easy Being Green

Student groups share their findings and discuss questions they developed during their Science Walk in Experience 1 with the whole class. Students begin a long-term investigation of the common structures of plants and their functions.

Procedures

Day 1

- Have students gather in their assigned groups. Provide each group with real samples or photos of animals, plants, and seeds that can be used to discuss the common structures and functions of plant and animal parts. (See Resources, pages 40–44).
- Ask the groups to compare the samples or photos with the drawings or rubbings they made on their Science Walk. Allow time for students to search online resources to identify any unusual plants or plant structures.
- After students have shared in their small groups, ask a spokesperson from each group to present one or two of their most interesting finding to the whole class.
- Help students begin setting up long-term **experiments** to look at different factors that affect plant growth. Students should refer to the questions they generated about their observations on the Science Walk. They may choose to investigate natural features they saw (such as ponds, marshland, forest, rock formations, etc.) and how those might have influenced what plants were growing nearby or what animals they saw in the area.
- Ask each student group to write an explanation for how the plants and animals might have adapted to their environment and what biotic or abiotic factors could have influenced the plants.
- Explain to the class that they will be testing different **variables** that affect plant growth by conducting an experiment in the classroom or the school garden.
- Have each student group research different plants they may be interested in growing for their experiment (or provide younger students with a few options they can choose from). To help them decide, remind them that their experiment will be focused on plant needs for growth and survival, and that they will be testing different variables to see what may work best. Variables that can be tested include but are not limited to amount or type of light, amount or type of water, type and temperature of soil, and air temperature.
- Each group should write their initial research questions and/or a **hypothesis** (a proposed explanation of what their Science Walk findings indicate) in their science journals.

Day 2

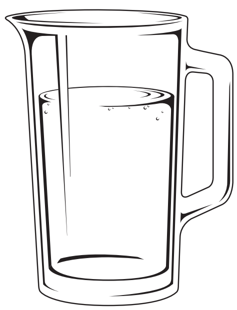
- Provide materials to each student group to start 2 to 4 plants per group in separate containers in order to conduct a long-term experiment on plant growth. One or two of the plants should be control plants where normal conditions are used, and the others are experimental plants, with which the groups manipulate a variable (such as doubling the amount of water given to the plant each day).
- Have the students make brief periodic observations in their science journals starting the day they plant their seeds and again daily or weekly thereafter. Ask them to include measurements of the height of the plant, how many leaves are present, and if flowers develop, until their plants attain a predetermined height.
- Tell students you will be spot-checking each group's **data** records to ensure they are conducting rigorous observations and recording the details properly.

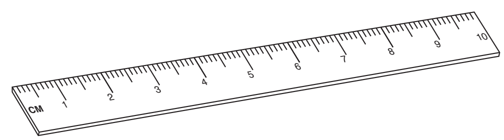
TEACHER TIP

Use clear plastic or glass containers so students can watch the seeds sprout and the roots grow and spread.

After Day 2

- After students have had 6-8 weeks to collect daily or weekly data on their experiment, plan a class period where data analysis and results are discussed. Have the students look for trends in the data they collected, especially differences between the experimental and control plants.
- Help students analyze their data and discuss any trends. Allow time for students to use computers, or their journals to create visual organizers (such as tables, graphs, or drawings) based on their observations. You could make multiple copies of the chart below for students to cut out and paste into their journals.
- Challenge students to discuss how their experiment may be related to a real-world problem that plants would face in nature, such as getting enough light, moisture, and warmth to thrive and reproduce. Ask: *How might a plant change as a result of human or nonhuman intervention in its natural environment?*





Sample Table for Recording Experimental Data

My Experiment

<table>
<tr><td colspan="2">Student Name:</td><td colspan="2">Experiment Name:</td></tr>
<tr><td colspan="2">Experimental variable (or manipulated variable) – The variable I'm changing and how I'm changing it:</td><td colspan="2">My hypothesis – What I expect to happen and my responding variable:</td></tr>
<tr><td>Date</td><td>Subject A</td><td>Subject B</td><td>Notes</td></tr>
<tr><td>Date</td><td>Subject A</td><td>Subject B</td><td>Notes</td></tr>
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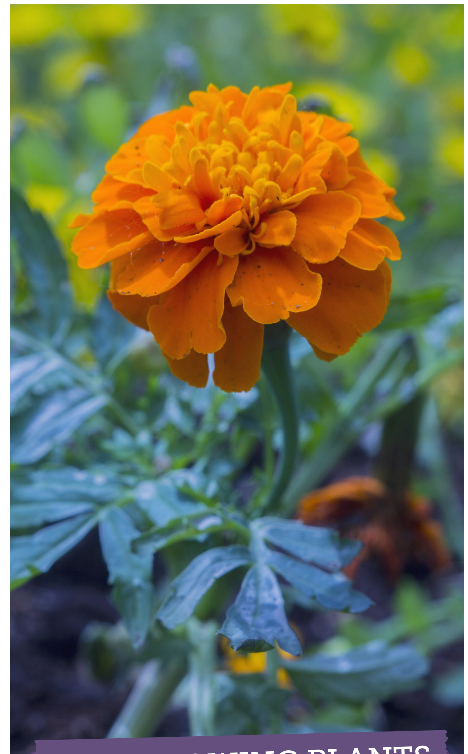


TEACHER TIP

Younger students can focus on manipulating one variable in a single experiment, while older students can grow more plants and set up more than one experimental condition (such as a second set of plants getting double the water of the control group, and a third set of plants getting half the water of the control group). Older students can conduct different experiments on the same organism across all groups so they have different data and results to present to each other (such as one group experimenting with light, another with water, and so on).

FAST-GROWING PLANTS

A wide variety of plants are appropriate for growing in the classroom. Some of the most common used in the classroom are lima beans (from the grocery store dried-bean aisle) and commercially available radish, green bean, and pea seeds. All of these seeds sprout within a week under the right conditions. You can also consider fast-growing flowers such as marigolds or zinnias that students can share with family members after the experiment is concluded.

Additional suggestions for plants and seeds are found in the Resources on pages 40–43. Another way to extend learning is to use native plant seeds such as red maple or redbud. After the plants have grown to a size suitable for transplanting outdoors, students can start a native plant garden outside the school and add new species of plants every year. Native plants require less water to get established and need only occasional maintenance after the first year.

Experience 3: Humans and the Environment

One of the emphases of the ScienceWorks exhibit is how scientists use tools to make observations of and to understand the natural world and our impact on it. Our food choices, water usage, and efforts to improve the quality of the natural spaces within our sphere of influence may seem small, but collectively students can have a significant impact. In Experience 3, students investigate whether their observations in experiences 1 and 2 are related to natural forces or to human interaction with ecosystems.

Procedures

Grade 4

- Remind students that life on Earth is not easy. Over 99% of the species that have ever existed on Earth are now extinct. The environment and its biotic (living) and abiotic (nonliving) properties are always changing.
- Have students work together in their groups to brainstorm ways that humans cause changes in the natural environment and how the natural environment causes humans to change their behaviors. Each group should generate a list of both.

- After students have had time to make their lists, have one student from each group write their list on the whiteboard or poster paper to share with the whole classroom.
- After all groups have shared their lists, lead a whole-class discussion on some of the potential solutions to environmental problems that humans face.
- Reconvene the student groups to brainstorm the identified environmental problems and how they relate to their own lives. Guide them in realizing that the choices we make as humans have an impact on the whole planet.
- Ask students to think about which of the choices they could make to implement as a class in order to reduce their environmental impact and/or educate others about environmental impact.
- Ask: *Which choices can you make at home that will make a difference in other people's lives?* Students may identify choices about the food they eat, the trash they create, their water use habits, how they get to and from school, and similar decisions their families make.
- Ask: *Which choices can you make at school that will make a difference in our school community?* Students may suggest that too many trees are cut down to make all the paper that is used. Ask: *Is there any way you could work to reduce the amount of paper used at school?* Their ideas may include using both sides of the paper for documents printed at school, or asking teachers to make assignments that can be prepared and turn in electronically.

Grade 5

- Have students work together in their groups to brainstorm ways that their communities are working to protect Earth's resources and environment. Students can define their community as their classroom, their school, their home, or the entire city where their school is located. Ask a spokesperson from each group to share their group's thoughts about their community's use of resources and protection of the environment.

- Give students time to research the ways their community uses natural resources. As a class, explore some of the questions that students develop based on their research.

- Ask students to work in their groups to come up with ideas for reducing their community's use of resources or to suggest ways the community can reduce its impact on the environment.

Grade 6

- Have students work together in their groups to brainstorm ways that humans are changing biotic and abiotic components in a habitat. For example, in Indiana cities, roads, sidewalks, and lawns that have low biodiversity and no shelter for larger animals have replaced the diverse hardwood forest ecosystem.
- Ask students to refer to their prior observations and experiments from experiences 1 and 2. Have the students highlight any invasive species they observed or expected to find but did not see. Give the students time to research additional case studies or examples of changing biotic/abiotic components and/or invasive species.

- Ask: *What can you do to prevent or reduce invasive species in the habitat you observed?* Help students understand that it does not matter how large an area they can help improve. What is important is that they are aware of and always observing the details of their environment and using science to help improve their community.

TEACHER TIP

Enhance this experience by inviting a local naturalist, conservation expert, or a state environmental office employee to your classroom to talk with students about how their organizations work to protect the environment. In addition to the information they share, these guest speakers can expose students to possible careers related to sustainability that they might not think of on their own. Consider inviting biologists, ecologists, city planners, renewable energy specialists, engineers, naturalists, and nonprofit organization employees who work on environmental issues.

THE POWER OF CHILDREN

Here are a few examples of how students studying together can make a big difference in their own communities:

Indianapolis students petition for public policy change

Orchard School third- and fourth-graders present a case against purple wintercreeper

orchard.org/page/news-detail?pk=852239&fromId=219903

Minnesota students help sustain a community resource

Learning in nature: Winona Middle School students fight invasive species at Lake Winona winonadailynews.com/news/local/learning-in-nature-winona-middle-school-students-fight-invasive-species/article_935a72aa-bbdc-526d-9f27-4cee514de4c7.html

Maine students merge STEM with environmental monitoring

Portland middle school students build submersibles to help fight invasive species

pressherald.com/2015/10/04/portland-middle-school-students-build-submersibles-to-help-maine-fight-invasive-species/

Oregon students bring an ecosystem back to life

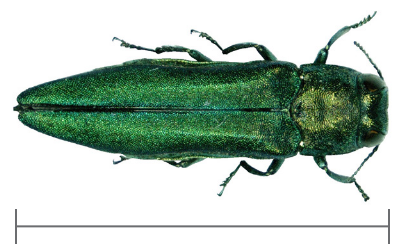
Beaverton middle school students remove invasives and replant with natives

koin.com/2015/02/27/middle-schoolers-help-solve-beaverton-ecosystem/

Indiana Invasive Species

Recognizing invasive species and their impact on ecosystems can be difficult for the untrained eye. There are many online guides for identification of common plants and animals in Indiana as well as some of the more common invasive species (see Resources, pages 40-43). Impacts can be difficult to identify until you learn what to look for. For example, if invasive bush honeysuckle has become well established in a forest understory, you will likely also see a dramatic decrease in ferns and other native plants growing in the same area. The honeysuckle shades out a lot of desirable plants, and some honeysuckle species release chemicals from the roots to prevent germination of native plants from seeds. Wintercreeper, another common but invasive plant, will quickly grow over everything, choking off smaller plants from sunlight.

EMERALD ASH BORER



Actual size: 1/2 inch

Two of the most damaging invasive species currently of concern in Indiana are Asian Bush Honeysuckle and the Emerald Ash Borer. More information and pictures of each can be found in the Resources, pages 40-43. The Emerald Ash Borer has been observed in almost all areas of Indiana and requires professional expertise to eradicate, but students can make a positive impact with a service-learning project to remove honeysuckle in their community. The Children's Museum of Indianapolis has created a guide to service-learning projects: childrensmuseum.org/service-learning.

Lesson 2: The Ways of Water

In this lesson, students focus on the impact of water and waterways in shaping the natural environment and how humans and nature interact with water. Students work to discover the power of water in shaping their own waterway, where the water they drink comes from, and where water goes after they use it.

Focus Questions

- How does water shape our environment?
- How is our tap water brought to us?
- How do we use water?
- Where does our water go? How can we clean it up?

Academic Standards

<u>Indiana Science Standards (2016)</u>

4.ESS.3, 4.ESS.4, 5.ESS.4, 6.LS.4

Social Studies – Geography

4.3.5, 4.3.7, 5.3.6, 6.3.13, 6.3.14

<u>National Standards</u>

Next Generation Science Standards

4-ESS3-2, 5-ESS3-1

Geography for Life

7.4.1, 14.4.3, 15.4.2, 16.4.3

Objectives

Students will

- Discuss what a watershed is
- Record observations of how water is shaping their local environment
- Investigate how tap water is brought to their school and/or home
- Examine common uses of water and how personal choices affect water usage
- Test various ways of cleaning up water pollution
- Explain how preventing water pollution is often cheaper than cleaning up pollution, and that sometimes pollution is irreversible with current technology

You will need . . .

For each group:

- Science journal for recording observations and activities
- 8.5 x 11 paper (1 per student)
- Pencils and water-soluble markers
- Large food-safe plastic bin (1 per group)
- Apples, oranges, grapes, strawberries, cherries, blueberries
- Clean drinking water
- Powdered lemonade mix
- Food-safe utensils
- Colander or strainer (1 per group)
- Paper towels

Time

- **Experience 1: 1-2 class periods**
- **Experience 2: 2-3 class periods**
- **Experience 3: 1 class period**

Vocabulary

conservation

landforms

pollutants

prevention

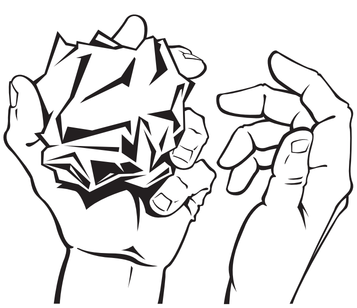
watershed

Experience 1: May the Force Be With You

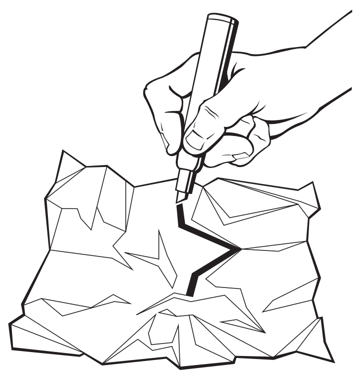
Students examine the force that water exerts on other objects in nature and develop understand of how powerful water is in shaping our planet. Students conduct simple experiments to see how easy it is for water to move heavy objects. Students take measurements, record and organize data, and conduct analysis to determine which objects were the most difficult to move.

Procedures

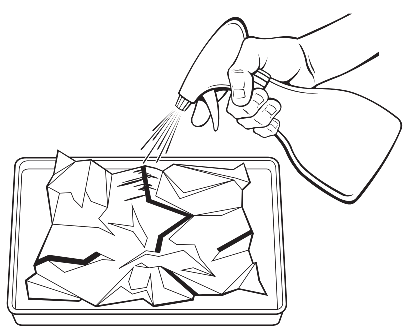
- Show students a map of the **watershed** (See Resources, page 42) where their school is located. Allow time for them for discussion about what they see on the map.
- Explain to students that they are going to create their own maps of a watershed, an area or ridge of land that separates waters flowing to different rivers, lakes, or ponds.
- Give each student an 8.5 x 11-inch piece of paper. Ask them to crumple the paper into a tight ball.



- Then, have the students open their crumpled paper ball and use water-soluble markers to color the ridges on the paper so it looks like the illustration shown here.



- Then have the students slowly spray water over the ridges on the paper to see where the water flows.



- Ask:
  - › Where does the water go?
  - › What happens to the ink that was on the ridges?
  - › What is happening to the water after it flows off the ridge?
  - › What do you think will happen eventually to the soil or plants on the top of the ridges over a long period of time?
  - › Where would you want to build a house on your map?
  - › Where would you want your school to be?
  - › How is your map similar or different to a watershed map?
- If possible, take students outside to find signs of how water moves in the area around their school, or ask them to think about how water moves near their homes. Encourage them to observe or think about how water flows during or just after a heavy rain.
- Using real photos from online or print resources, guide students in a discussion about **landforms** that show obvious signs of having been moved or shaped by water, such as streams and their associated watersheds, and areas of erosion and compaction.
- Allow time for students to identify examples of landforms near the school. Have students record observations in their journals. Then ask:
  - › Where are the ridges near our school?
  - › Where are the streams, ponds, puddles, or low areas that collect water?
  - › What happens to rain that falls on the school's roof?
  - › What happens to rain that falls on the school's yard?
  - › Do you see any evidence of water moving things? (Encourage them to look for leaves, rocks, soil, or mulch that is moving or was recently moved by water.)
  - › Do you see any trash in the ditches or streams near our school?
  - › Is the water moving away from our school being cleaned before it goes into a stream or a sewer drain?
  - › How could we change the flow of water around our school? How could we make it cleaner?

Experience 2: Where Water Comes From

Students examine where water comes from to their home or school. Students examine city and watershed maps and regional or state patterns related to water use. Students research common uses of water and observe how they use water on a daily basis. They discover the "hidden" water used to produce the products we use. Students create graphs or charts of their water use at school and at home and develop ideas that could help reduce their water usage.

TEACHER TIP

Consider inviting a speaker from your local water utility to speak to your students (or to multiple classes at a larger assembly) about where their drinking water comes from and how it is cleaned.

Procedures

Day 1

- Ask students: *How does drinking water make it to the tap at your kitchen sink, or to the water fountains here at school? Is drinking water readily available in our state, or is it sometimes contaminated or in short supply?*
- Allow class time for students to use the computer or classroom resource center to research the answers to these questions.
- After students have had time to discover some information, come back together as a group to review their findings. Ask: *Where does our drinking water come from? How and where is it cleaned? When could it be necessary to conserve water in our community?*

- Let students work in small groups to brainstorm ways they use water every day. One member of each group can record the ways in the group's science journal.
- When all students have had an opportunity to participate, ask the groups to decide together how all the ways they have listed should be ranked. Have them rank every item in their list, beginning with 1 for the way they use the most water every day.
- Ask students to make a chart in their journals or use the chart below for one week to keep track of all the water they use.

Day 2

- Reconvene the groups and ask students to share their tracking charts. When all groups are ready, ask a spokesperson for each group to share the top three ways their members use water. Ask: *What do all our groups have in common? What are the differences? Now that you have heard these ideas, what do you think is the number-one way we use the most water every day?* (The U.S. Geological Survey says that the largest use of household water is to flush the toilet, followed by taking showers or baths, and doing laundry.)
- Introduce students to the concept of hidden water use, such as in manufacturing and agriculture. Explain that hidden water is often a more significant use than brushing teeth or taking showers. For example, the average person uses 80 to 100 gallons of water each day. In comparison, if you eat a single serving of beef at lunch, you are using about 1,200 gallons of water. Eating a single serving of chicken uses 330 gallons, a savings of 870 gallons from one meal. Other examples: It takes twice as much water to produce a plastic water bottle than the amount of water in the bottle. It takes 80,000 gallons of water to manufacture the steel used to build a car. Counting hidden water, the average person in the United States uses 2,200 gallons of water per day.

Water Usage Tracking

Date/Activity	Water Usage (Actual/Hidden)	Alternative Activity	Water Usage (Actual/Hidden)	Water Savings
				TOTAL SAVINGS

Experience 3: Cleaning Our Water

How do people clean water so it can be used? In this experience students "pollute" some water and experiment with different ways to clean it. Students learn how to plan for water use and conserve water, how water can be filtered by nature, and that pollution prevention is often easier and less costly than pollution cleanup. To extend the experience students in grades 5 and 6 might explore different technologies that people use to clean up water.

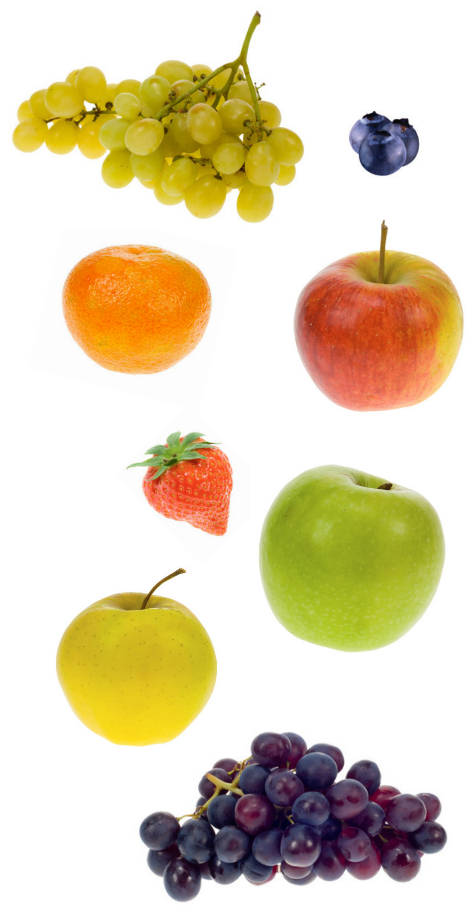
Teacher Tip—Keep it Clean!

The web is full of classroom activities where students add various pollutants to clean water in order to conduct experiments. However, once those activities are finished, the students have contributed to pollution by discarding contaminated water down a drain or toilet or out the back door of the school. Instead, try this activity that creates a snack for students while still teaching them about strategies for cleaning water and the difficulty of removing all pollutants from water.

Time: 1 class period

Procedures

- Before class, wash and dry:
  - a food-safe bin for each group that holds about 2 liters of liquid.
  - a variety of whole (not cut) fruits. Use any combination of apples, oranges, grapes, strawberries, cherries, and blueberries. Make sure to use a variety of fruits in different sizes, including some that will sink and some that will float in water.
  - a selection of food-safe implements each group will use to stir their water and to remove the "pollutants" in it. For example, you could include slotted spoons, chopsticks, forks, spoons, ice cream scoops, etc. Have plenty of paper towels on hand to soak up spills.
  - 1 small, perforated colander (or mesh strainer) and 1 bowl or other container per group. The bowl or container should hold at least 1 liter of liquid.
- Assign students to small groups of 3 or 4 and have all students take turns washing their hands thoroughly.



- Give each group with a selection of the fruits that you prepared. These will serve as some of the **pollutants** in this experience. Give each group some of each type of fruit on paper towels.

The city of Chicago gets its water from Lake Michigan. What pollutants might be present in the water?

- Ask the whole class to choose a pollutant to be represented by each type of fruit. For example, apples could represent discarded plastic bags, blueberries could represent soil eroded by a storm, and grapes could represent dog waste left on lawns. They should make a list of the representations in their science journals.
- Give each group of students a food-safe bin with enough clean drinking water to make a liter of lemonade.
- Have each group measure and add powdered lemonade mix to the water in their bin. As they stir the mix to dissolve it, explain that the powder represents a pollutant like road deicing salt that dissolves in water and cannot be easily removed.
- Ask students to add in each of the fruits, one at a time, and announce to their group what pollutant each one represents.

- When all the pollutants are in the water, ask each group to spend just a few minutes brainstorming how they can clean the water. Their goal is to get back to the original clean drinking water. They should record their ideas in their science journals.
- Provide each group with the food-safe tools you cleaned earlier. Challenge the students to remove all the pollutants without putting letting their hands touch the water. Circulate among the groups and ask questions about their progress.
- Have students place the fruits they remove onto the paper towels. Ask: *Which pollutants are easiest to remove? Which are the most difficult to remove?* Students will probably say that larger items are easiest to remove because they are easy to see, and that items floating are easier to remove than those that sank to the bottom.
- Give each group a colander or strainer lined with paper towel, and ask them to remove the final pollutant from the water—the lemonade mix. (Younger students may need some assistance with this step.) Removing the dissolved powder is almost impossible, which mirrors the difficulty and expense of removing dissolved pollutants from drinking water. Students should conclude that pollution **prevention** is easier than cleaning water.
- After the lesson is over, wring out and recycle the used paper towels. Students can enjoy lemonade and fresh fruit and watch a video about how to clean drinking water (see Resources, page 42).

Lesson 3: Weathering the Climate

In this lesson, students make daily observations of weather and examine weather patterns. They begin to understand the distinction between the terms "climate" and "weather." They use maps to identify major climate regions and waterways of Indiana and the United States and describe the way these systems affect the local environment and are connected to the global climate system. In the **Culminating Experience**, they also prepare a summary of their knowledge gained during the unit to present to their peers, family, or members of their community.

Above: Whitewater flows over icicles at a frozen Upper Cataract Falls with a red covered bridge upstream. Photographed on Mill Creek near Cloverdale, Indiana.

Academic Standards

Indiana Science Standards (2016)

4.ESS.2, 4.ESS.4, 5.ESS.4

Social Studies – Geography

4.3.7, 5.2.10, 6.3.13, 6.3.14

National Standards

Geography for Life

4.4.3, 15.4.2, 16.4.3, 17.4.2

Next Generation Science Standards

4-ESS3-1, 4-ESS3-2, 5-ESS2-1, 5-ESS3-1, MS-ESS3-5

Vocabulary

average
climate
climate zone
region
data
gauge
graph
precipitation
region
sustainable
weather

You will need . . .

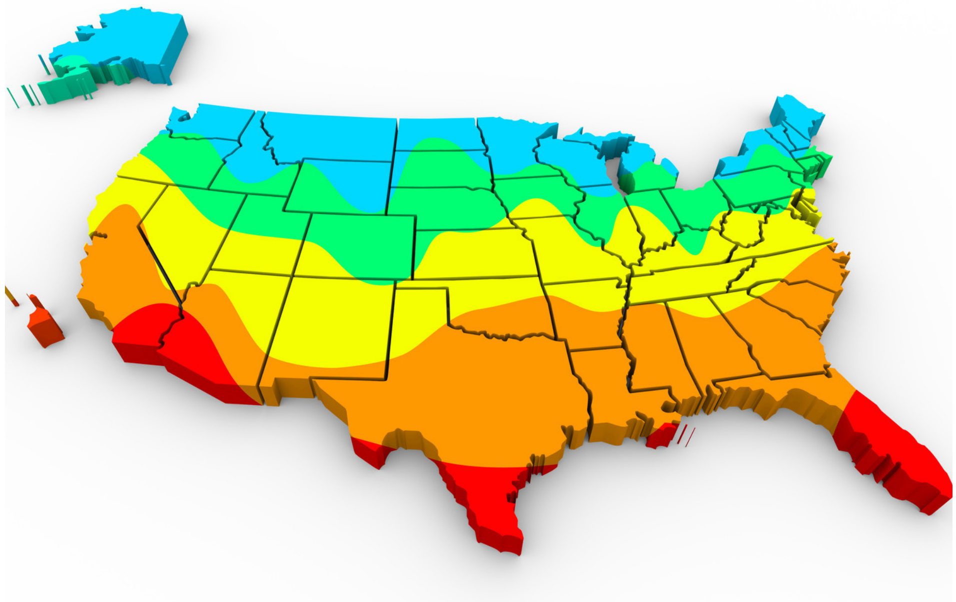
For each group:

- Science journal (1 per group)
- Weather data collection charts (See sample on page xx)
- Maps of state, national, and world climate regions and climate zones
- Calculators or paper and pencils
- Computer access
- Whiteboards, PowerPoint presentations, poster board

Time

- **Experience 1:** 1 class period to set up for data collection, 4–6 weeks to collect data, 1 class period to analyze data
- **Experience 2**: 3–5 class periods
- **Experience 3:** 3–5 class periods

Meteorological station and tools on the blue background of the sky.



A map of the U.S. with regions color coded to illustrate average temperatures with hottest areas in red and coldest in blue.

Focus Questions

- How are weather and climate different?
- How do scientists collect weather data?
- How do scientists analyze data to understand what has happened on Earth over long periods of time in the past?
- What are climate zones and how do they change over time?
- How are natural events and human activities affecting weather and climate?
- How do my choices and those of my community affect the environment?
- How do scientists communicate information to the public?

Objectives

Students will

- Record weather data and discuss how the data can be analyzed
- Investigate what the weather and climate are like at their school and how it changes over short periods (seasons) and longer periods (climate zones)
- Analyze maps of different climate regions and zones and compare and contrast adaptations by plants and animals that help them survive in their climate
- Predict what might happen to plants and animals adapted to one climate if they are placed in a different climate
- Examine how their own homes, families, and schools get and use energy
- Discuss how their use of energy sources affects climate and ecosystems
- Examine common energy sources, including renewable and nonrenewable sources, and the benefits and constraints of each source of energy
- Research how energy and resources are used at their school and in their daily lives, and propose solutions that would reduce their collective impact on the environment
- Select an environmental issue of their choice and prepare a presentation that proposes potential actions humans can take to live more sustainably. The presentations will be based on their data analysis and how their data fits into a larger local, regional, national, or international context.

Experience 1: Tracking Our Weather

In tracking local weather conditions, students in Grades 4–6 will begin to understand the differences between weather and climate. Students will take simple measurements of weather data and then record, organize, and graph their data. They will use this data to carry out an analysis of how weather changes over time.

Teacher Tip

Weather stations are a great way to conduct this experience but if your school does not have access to one, you can use simpler devices or go online to gather weather data. A simple rain gauge can be installed outside the classroom window to make observations easy and quick. Students can use the web to get data on the daily low and high temperatures and the temperature at a specific time of day. Phone weather apps can also be used.

Procedures

- Guide students in using their journals to set up data tables for recording the date, time, weather, temperature, amount of precipitation, etc. A sample chart is included on the next page to get students started.
- Establish a weather data collection responsibility for the whole class and rotate students through data collection tasks to prevent boredom.
- When 4 weeks of data (or more) have been collected, conduct an activity where the data is analyzed. Explain to the students that scientists collect data over time and then analyze that data to determine what their observations are telling them about the natural world.
- Break the students into small groups and ask them to do the following:
- Graph the data for each measurement they took over time.
- Calculate averages for each data set and note the minimum and maximum values recorded.
- Note any days where the data departed significantly from the average or where unusual readings were taken.
- Ask students to relate the data to the season they are currently experiencing. Collecting data during the transitions between seasons can be an interesting activity, especially heading into spring and fall in Indiana. Try these questions to guide student analysis of data:
  - What trends do we see in the data?
  - What was the temperature like on cloudy days versus sunny days?
  - Did recording the data at different times of day make a difference?
  - Were there any unusual or unexpected readings? Why?
  - Based on your data, what do you think the weather will be like over the next week? Over the next month?
  - How does your data compare to the historical averages for this time of year? (Students can find historical weather data online. See Resources, pages 41-42.)

Weather Data Collection Chart

Student Name:			Weather Data Month:	
Date and Time	**Conditions**	**Temperature**	**Precipitation**	**Notes**

WEATHER OR CLIMATE?

Students, like the general public, may have difficulty understanding the relationship of weather to climate. As defined by NASA, the difference between weather and climate is a measure of time. **Weather** refers to atmospheric conditions over a short period of time. **Climate** refers to how the atmosphere "behaves" over relatively long periods of time. Weather can change from minute to minute, hour by hour, and day by day. Climate change is measured by long-term averages over years, decades, and even hundreds of thousands of years. For more information visit: https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

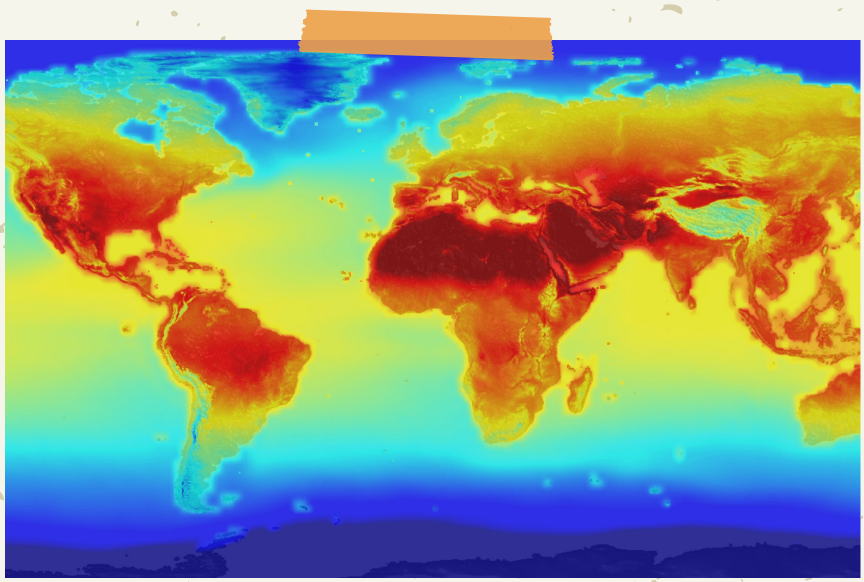
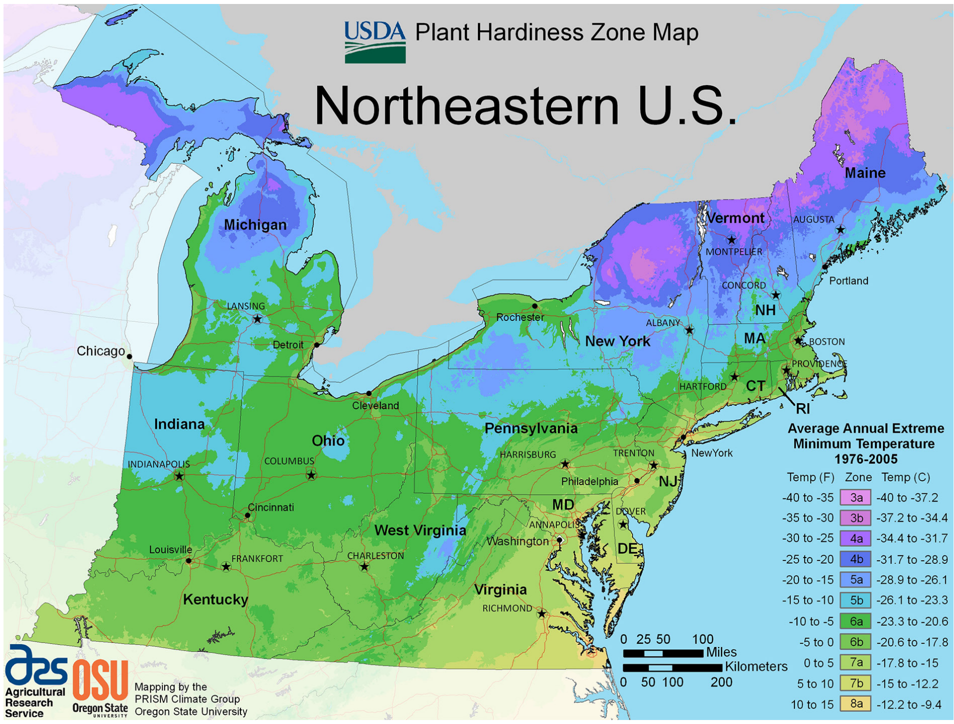


IMAGE CREDIT: NASA

The new NASA global data set combines historical measurements with data from climate simulations using the best available computer models to provide forecasts of how global temperature (shown here) and precipitation might change up to 2100 under different greenhouse gas emissions scenarios.



Experience 2: Clarifying Climate

In this experience, students in **Grade 4** use data from climate maps of Indiana and identify the ecosystems the climate supports. They collect data about Indiana's average yearly temperature and use the information they have collected to consider how changes in climate might affect plant and animal life. Students in **Grade 5** analyze national climate maps, while students in **Grade 6** examine world climate maps and record data regarding average temperatures in different parts of the United States and the world. They consider the kinds of ecosystems and industries that would be affected by rapid changes in climate in these regions.

Teacher Tip

Climate zones are identified on USDA Plant Hardiness Zone Maps and Climate Zone Maps (see Resources, page xx).

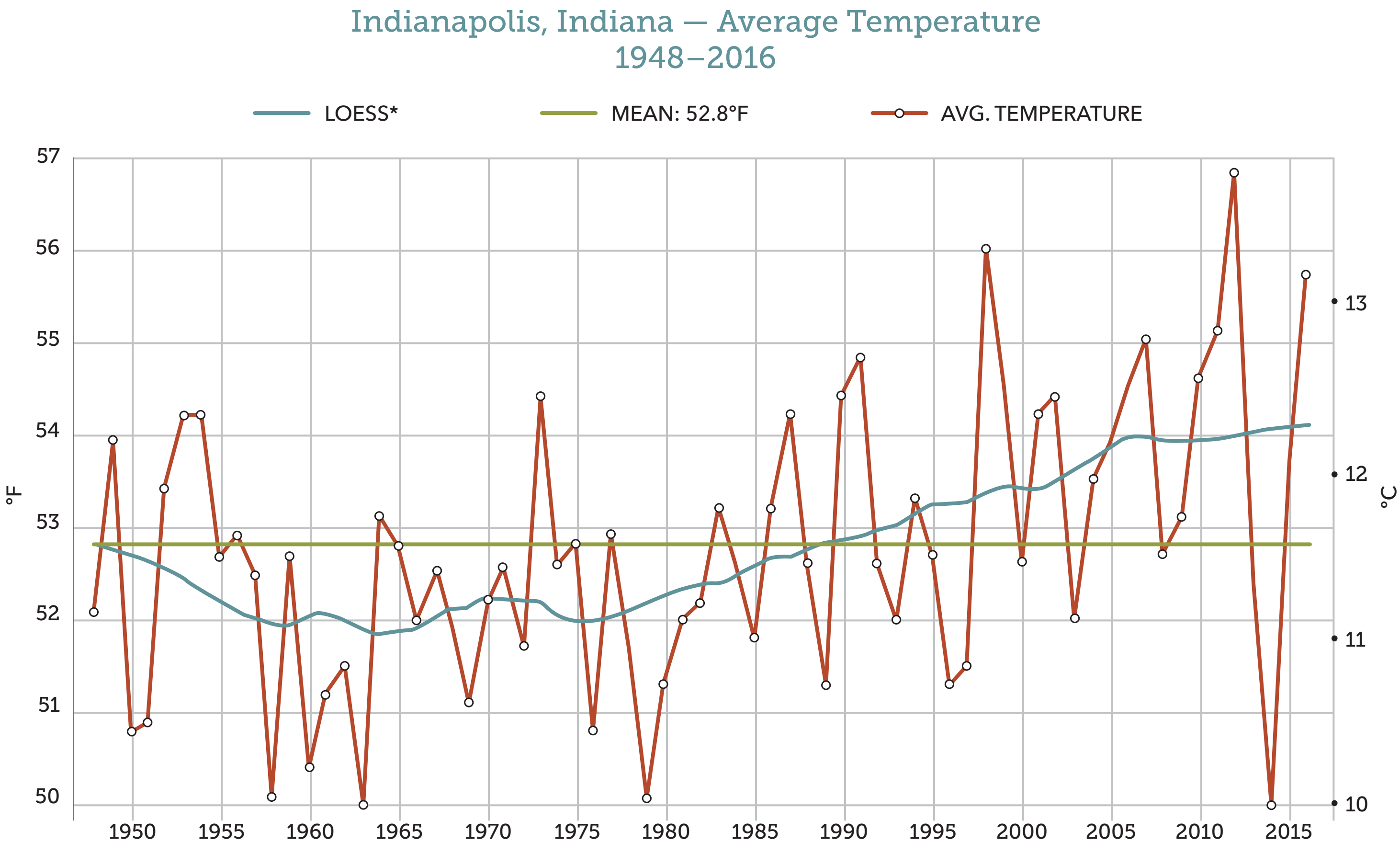
Procedures

Grade 4

- Provide climate maps of Indiana and help students identify the characteristics of each zone. Help students analyze the **climate zones** and determine the kinds of plants and animals that can live in a **region**.
- Show students photos of different species of plants and animals that live in Indiana.
- Ask: What plants and animals do you see in the following pictures? How have they adapted to live here?
- Explain that plants and animals have adapted to living in the environment and climate that surrounds them over thousands of years.
- Examine some of the adaptations that allow specific plants and animals to survive in Indiana's climate. Ask: Would their adaptations continue to help them if they were forced to move to a different climate or if the climate changed rapidly?
- Explain that Indiana's climate has changed gradually over time and discuss some of the animals that lived here thousands of years ago, such as mammoths and saber-tooth cats.

Has Indiana's climate changed over time?

Climate is defined as the weather conditions that prevail in an area over a long period of time. Climate, rather than weather, determines which plants and animals can survive in a specific location. The ecosystems we see outdoors have adapted to the climate zones in Indiana. However, climate changes over time. Around 10,000 years ago, large parts of northern Indiana were covered in glaciers, some up to a mile thick as far south as Indianapolis. The average air temperature was likely 6°C to 12°C cooler than today. Mastodons, mammoths, musk oxen, giant ground sloths, and saber-tooth cats roamed the pine and spruce forests.



**LOESS (Locally Weighted Smoothing: an analysis procedure that helps scientists see trends and relationships in data.)*

SOURCE: NOAA NATIONAL CLIMATIC DATA CENTER

- Have students research and collect information about average yearly temperatures in Indiana. (See Resources, page 42.) Help students use their journals to record the data.
- Assist students in using the data they have recorded to construct a graph that represents Indiana's average yearly temperature over several decades.
- Ask students to examine the graph to see if they can discover any trends. Are average temperatures becoming warmer, colder, or remaining the same?
- Ask: What does this data indicate about the kinds of plants and animals that will be able to live in Indiana in the future? If they don't have time to adapt, will some species be unable to survive? Will different species move in?

Grades 5 and 6

- Tell students they will play the role of scientists collecting climate data. Place students in teams of three or four students and assign each team a climate zone or region to research.
- Have teams use climate maps of the United States and the world to find data and use the information to create a map highlighting their region.
- Ask each team to use online and print sources to identify ecosystems and human activities such as agriculture, industry, tourism, and recreation that are important in the area and add this information to their map.
- Have teams use long-term average temperature data for their region to develop a chart or graph showing temperature trends.
- After each team has gathered and organized their data, ask them to come together with other teams in a "conference" to discuss their findings.
- After each team presents their data, ask: What trends have you found? Do the trends seem to be national? Do they seem to be worldwide? What impact do you think these trends will have for your part of the world? How will ecosystems and human activities be affected?

Experience 3: Energy and Climate

In this experience students consider data that indicates relationships between energy use and rising temperatures and discuss the impact this could have. They examine how energy is used at home, at school, and in their community and research the advantages and disadvantages of different types of energy sources. They identify sustainability efforts and needs that might serve as the focus for future projects.

Teacher Tip—Energy Sources

This experience will focus on common energy sources used today, including oil, natural gas, coal, nuclear power, solar, hydroelectric, biofuel, wind, and geothermal. Student research can be implemented in two ways. You can assign research projects to small groups and have each group examine one or two energy sources and prepare a presentation to the entire class on their source(s) of energy. Older students can work in groups or individually to research all of the common energy resources, consider which ones might be most sustainable, and present their findings. Have students focus on both the positive and negative aspects of each source. (Find recommended Resources on pages 41-43).

Procedures

Grade 4

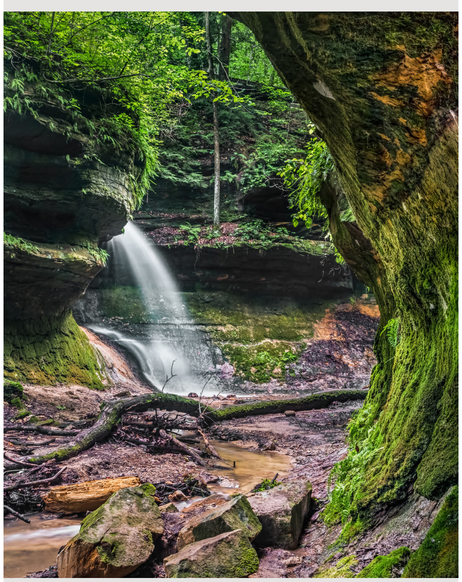
Students begin to consider the connections between climate and other factors, including energy use, and explore the energy sources they use every day.

- Remind students of the trends they discovered as they examined Indiana's long-term temperature averages in Experience 2. What were the possible impact for plants and animals?
- Ask students if they think there also will be consequences for people. How might their own everyday lives be affected? Is there anything people can do to improve the situation?
- Ask students to speculate about possible reasons for significant increases in average temperature. Explain that many scientists believe the evidence from climate data shows that human activity, especially the way we use energy and other resources, is contributing to rapid increases in average temperatures around the world.
- Place students in small groups to brainstorm about energy sources they know and use in their lives. Some suggestions for discussion questions might include:
  - What energy did you use today from the moment you woke up?
  - How did you get to school?
  - Did you use any hot water at home?
  - What is the energy source that supplies electricity to your home?
  - What energy source do you use to heat and cool your home?
- Help students trace the energy they use to its original source. For example, they may know that electricity lights their home, but what is the source of the electricity? How is it generated? Electricity might come from coal-fired, wind-, or solar-powered generators. Some communities incinerate household waste to produce steam heat.
- Discuss advantages and disadvantages of different energy sources. Which ones would be more **sustainable**—reliable, accessible, and renewable over a long period of time?

Sand desert in Monument Valley National Tribal Park, Navajo, Utah USA

Why does the climate change?

The climate on Earth has always changed naturally and plants and animals have had to adapt or move as conditions change. Plants and animals that were unable to adapt have become extinct. Today, humanity is beginning to have an impact on global climate, primarily by the release of greenhouse gases through the burning of fossil fuels, deforestation, and carbon intensive farming. As the concentration of greenhouse gases in the atmosphere goes up, the global temperature goes up. This, combined with other environmental impacts, makes it important for people to make appropriate choices when deciding on new energy sources.



Devil's Punchbowl in Indiana's scenic Shades State Park.

- After students identify 4 or 5 different energy sources, student groups can be assigned specific kinds of energy sources to research, such as wood, coal, oil, natural gas, wind, water, and sun. After students have finished their research, each group can present their findings and the whole class can summarize what everyone learned.

Grade 5

In this experience students research their school as a community. Guide your students in starting investigations in how energy, water, and other resources are used and conserved in their school. You may want to invite the principal or other administrative staff to the classroom to be interviewed by students.

- Ask:
  - How does our school get its energy?
  - What energy efficiency efforts already exist in our school?
  - Where in our school are there classrooms or support rooms (such as libraries, media centers, or computer labs) that have the lights on all day even when no one is in them?
  - What does our school recycle?
  - Where do buses and cars wait to pick up students? What energy do they use?
  - How does our school minimize water usage?
  - When does our school have an energy audit?
- **Extending Experience:** Students may be able to identify some sustainability improvements at school. You can assign student groups to list any sustainability efforts currently taking place, identify additional needs, and brainstorm potential solutions. Their ideas may be appropriate to present to the school board or other governing body, an activity that can be planned in the **Culminating Experience** for this Unit of Study.

How Will Climate Change Impact Indiana?

Several online resources are available that detail changes in Indiana due to predicted climate change (see Resources, page 43). Predictions are that some crop yields may be higher due to higher temperatures, but increased incidents of damaging rainfall events and drought will lower agricultural productivity in Indiana and increase the risk of crop failures. Ranges for wildlife populations will shift, with some species becoming more common and others becoming scarce. White-tailed deer are likely to suffer heavier midge infestations. People will have cheaper heating bills in the winter but higher cooling bills in the summer as the number of days over 90°F will increase from a historical average of around 15 to 30 or more days.

Grade 6

In this experience students focus on the sustainability efforts and needs in their own community. One of the best ways to combat climate change and other environmental pollution is to examine how a community is using energy resources and then find ways it can use less or use them differently, which usually means it can also save money as well.

- Ask students to predict how life in their community might change if the world climate were to get warmer.
  - Use some of these questions to help guide them: What plants and animals might thrive in warmer temperatures?
  - What species might suffer?

  - What effects would hotter summer temperatures have on people?
  - How do people on limited budgets stay cool during a hot summer?

  - What impacts could a warmer climate have on farm production or other industries?
  - What impacts could a warmer climate have on you and your family?
  - Would a warmer climate affect the way people make a living?
  - How would stronger or more frequent storms in summer or winter affect people?

- **Extending Experience**

Have students check to see if their own community government has a website that might help them identify local sustainability efforts. Students could follow up by interviewing local government officials to learn more about sustainability initiatives and needs. This preliminary information gathering might lead to the identification of a specific need they wish to research and propose potential solutions. Their ideas may be appropriate to present to the school board or other governing body, an activity that can be planned in the **Culminating Experience** for this unit of study.

Culminating Experience
Communicating Scientific Information

Part of what scientists do is communicate the results of their data analyses to the general public and offer recommendations to policymakers about what steps people can take to reduce negative impacts and improve sustainability efforts.

In this experience, students prepare the summary report of their data collection and research efforts from **Lesson 3** for delivery to an appropriate organization that can take action or help inspire others to take action. See the **Teacher Guide** on understanding scientific claims (pages 37–39) to help guide your students on the question they have chosen to research.

Depending on the interests of students and the research they collected, the product of this experience can vary widely, but the basic steps that all students take are similar. Guide your students through the same process that scientists typically go through when releasing their results or presenting to policy boards (see Student Project Example and Preparing for a Science-Based Presentation, page 36).

- Help students summarize the data they collected in simple and easy to understand graphs, charts, or maps. Ask: *What does your data tell you about nature?*
- Have students work in their groups to prepare a presentation for the class or another audience that describes the context of their research and explains what their data show. Ask: *Why is your data important to people?*
- Help students relate their findings to the broader scientific understanding of the question they researched. Ask: *How does your data compare to larger data sets or larger questions?*
- Students should include in their presentation an explanation of any actions they are recommending based on their research and the broader scientific understanding. Ask: *What actions would you like the community to take? Do you have any suggestions for how the actions should be implemented?*
- Encourage students to ask their audience for a community commitment to addressing the issues or taking the actions they are suggesting. Ask: *How can you get your audience to support your ideas by taking action?*

Students will sometimes focus on emotional appeals for addressing environmental issues, and those can be supplemental, but students should be guided to use solid science (either research they did, or that other scientists have done) as the primary support for their presentations. As you are reviewing your students' presentations, be sure to ask: *How are you using science to support your argument?* Help students determine whether mainstream scientific understanding supports their argument.

Encourage your students to develop creative ways of presenting their proposals that are appropriate for the audience. If the students are presenting to other students at school, skits or raps or some other performance may engage the audience. If they are presenting to families at a school event, a more formal presentation may be in order. If they are presenting their findings to a local legislator or a school board, a PowerPoint presentation accompanied by a written handout may be more appropriate. Regardless of the style, it is important to let students use their creative strengths to prepare a presentation they are passionate about delivering.

Student Project Example
No-Idling Zone

As students proceed with their own projects, it can be useful to show them a concrete example of environmental action taken as a result of scientific data. One common action that many schools have implemented is a no-idling zone for vehicles whose drivers are waiting to pick up students at the end of the day. Following suggested steps for this experience, the student project could be presented in a similar way to this example:

- **Step 1:** Students spend four weeks collecting data on how many cars are idling outside of their school each afternoon. The students create a bar graph showing how many cars were idling each day and calculate that an average of 75 cars were idling for 15 minutes each day and 15 school buses were idling for 30 minutes each day. This is their data that supports their research about air pollution.

- **Step 2:** Students write a position paper to stress that pollutants from idling vehicles have three major impacts on the environment: They contribute to climate change through carbon dioxide emissions; the pollutants found in vehicle exhaust have been correlated to increased rates of cancer, asthma, bronchitis, and other human ailments; and idling vehicles waste gasoline, which wastes money and natural resources. Students cite the sources where they found the information to back up these claims.

- **Step 3:** Students present data they found from reliable online sources on how much fuel idling vehicles waste and how widespread the problem is. They also present success stories of how air quality improved when no-idling zones were implemented at other schools or in other locations.

- **Step 4:** Students suggest that the school district implements no-idling zones at all schools in the district, for all vehicles that use fuel. Then they present a graph showing data they have gathered on how much money people will save by not idling their cars and how much money the school district will save from buses not wasting diesel fuel.

- **Step 5:** Students research that their request to implement no idling zones in the district will need to go in front of the school district's board of commissioners. Their teacher helps them request to be added to the schedule, and they then prepare a short PowerPoint presentation supplemented by charts and graphs. The school district sees the economic benefits of saving money and the health benefits to the community, and passes the resolution to implement no-idling zones district-wide, with enforcement responsibility shared between the school staff and the student clubs at each school.

Student Handout
Preparing for a Science-Based Presentation

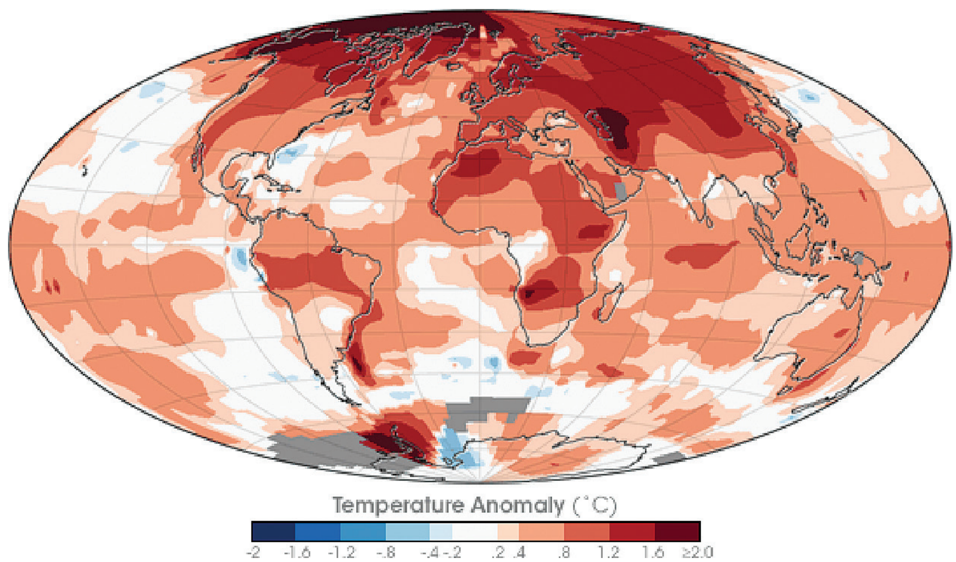
As part of this experience it is important to remember to prepare a presentation that is based on commonly accepted scientific data and theory. While it is important to build a persuasive argument for your intended audience, you should remember your main argument should be based on science and data, not other factors. Use the following five sets of questions to organize your thoughts for your presentation:

1. **What do your data tell you about what you researched?** What do the data say about nature? What were the most important findings? Did the data show any trends or unexpected results?	
2. **How does your data set compare to or contribute to larger data sets, or a bigger picture?** How can you present your data to an audience in an easy to understand format? How does your data relate to long-term data collected from the same location or other locations? What data can you use from other sources to support your presentation?	
3. **Why would your topic or data be important to other people?** Why is understanding nature important for people? Why is it important to understand the difference between scientific and public debate?	
4. **What actions are you suggesting that people should take?** How should those actions be implemented? How will those actions reduce the environmental problem that you investigated? How will these actions benefit plants or wildlife? How will these actions benefit people?	
5. **What audience has authority or power to take action on your issue?** How can you get your audience to support your ideas by taking action? Why would they want to say yes or no to your suggested actions? How can you persuade them that your ideas are important? What is the potential cost of taking action or not taking action?	

Use your answers to these sets of questions to draft your presentation's main points and your strategy for persuading your audience based on science and data.

Teacher Guide
Understanding Debates in Science

One of the responsibilities of scientists who study the natural world is to separate opinions and guesses from scientific understanding based on data or models. Good scientific research results from careful data collection or modeling followed by an interpretation or conclusion about what that data indicates. This is often a long process.



This map shows the difference in average surface temperature in 2006 compared to the average from 1951 to 1980. Most of the globe is anomalously warm, with the greatest temperature increases in the Arctic Ocean, Antarctic Peninsula, and central Asia. NASA's effort to track temperature changes will help societies evaluate the consequences of global climate change. *(Map based on data from NASA GISS Surface Temperature Analysis.)*

Scientists do their research, publish the data, and debate their findings within the scientific community. Most scientific issues are therefore debated in two separate places: 1) within the scientific community and 2) among the general public. It may be difficult for students to understand that what they and other members of the public learn about scientific research has been interpreted for them by print, television, radio, and web media outlets.

We can use climate change as a good example of the need to understand the difference between scientific and public debate. Scientists in the 1970s debated different influences on climate, including sulfates, particulates, solar irradiance (the amount of electromagnetic energy reaching the Earth), and greenhouse gases (gases that absorb and emit radiation in the atmosphere). Sulfate emissions, which have a cooling influence on the climate, were increasing at that time, and some scientists were concerned this could cool the Earth and reduce agricultural productivity. Following scientific investigation of sulfate emissions, some scientists published peer-reviewed papers on how sulfates had the potential to cause cooling of the world's climate. In reaction, some newspapers and magazines published articles warning that Earth might be heading into the next ice age. A prominent example of this was a 1974 Times magazine article titled "Another Ice Age?" Media articles like that one received a lot of public attention and are still remembered today. Now, some people argue that because scientists reported on the possibility of global cooling back in the 1970s and it didn't happen, scientists today must not know what they are talking about when they publish scientific papers about climate change.

However, Dr. Thomas Peterson and co-authors published a peer-reviewed article in 2008, "The myth of the 1970s global cooling scientific consensus." Dr. Peterson and his colleagues reviewed all scientific papers related to climate change from 1965 to 1979 and found seven that predicted cooling and 42 that predicted warming. The fact is that in the 1970s there was some scientific concern about global cooling, but scientists were six times more likely to predict warming. The hype about a new ice age came from the media and not from the scientific community. Scientists did debate various influences on climate in the 1970s and there were many unsettled scientific questions, but the media were not accurately portraying what scientists were most concerned about. Another 40 years of data since then have shown that the scientists who predicted global warming were more accurate with their predictions than those who predicted cooling. As a result, contemporary scientists have refined their understanding of how our climate works and what influences it. Today 97% of scientists agree that our planet will continue to warm and the climate will change due to that warming.

This is exactly how the peer-review process in scientific publishing is supposed to work. Scientists present data they have worked on, and over time they and other scientists discuss which ideas or theories most accurately represent the reality of the world around us. In the 1970s, some scientists were concerned about sulfates cooling the Earth and published those ideas. Many more scientists published data and ideas on how greenhouse gases could warm Earth, and they turned out to be right.

Scientists began a concerted effort in the 1960s to examine the question: Is our climate changing now? Since that time, scientists have been able to study all direct temperature measurements from the 1880s to the present day and they show our climate is warming, as seen in Figure 2:

It is at this point that scientific debate and public debate on the issue of climate change started to diverge. Scientists were in agreement that Earth was warming and that warming was being caused by human activities through the emission of greenhouse gases, primarily carbon dioxide and methane. Yet public discussions continue to question whether Earth is really warming, and if it is, whether that warming is really caused by people. Scientists have answered both of these questions using data collected during decades of research, yet public debate persists. Why do you think that is?

All major scientific bodies in the world have supported the following claim: Earth's climate has changed in the past and continues to change; Earth's climate is warming and that warming is primarily from human activities. Warming will cause a mixture of negative and positive impacts for humanity, although mostly negative.

The only scientific debate over these statements concerns minor efforts to refine historical data and the question of how quickly the impacts of climate change will be felt. Yet major public debate about the reality of climate change continues to this day. Why would public debate on a settled scientific debate persist?

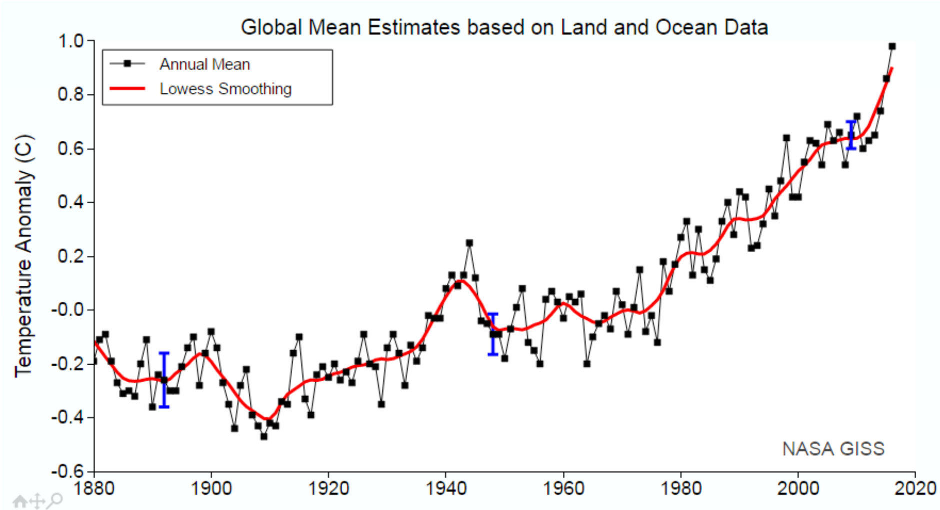


Figure 2: Change in Earth's average temperature from 1880 to 2016, a roughly 1.0°C (1.8°F) increase over the 1951–1980 baseline. Source: NASA GISS https://data.giss.nasa.gov/gistemp/graphs/

Scientists have agreed that a warmer climate will have mostly negative impact for humanity and the rest of the species on Earth. So the scientific debate has now shifted to these questions:

- Now that we are already feeling the negative impacts of climate change, how quickly will they worsen?
- What can we do to prevent the worst impacts from happening?
- How do we solve the climate change problem?
- What can we do to support data collection that can help inform policymakers on these questions?
- How can we help inform the public on this important issue?

Public debate has followed along similar lines but also includes these questions:

- What can societies do to solve climate change?
- How can people help?
- What are the costs of different solutions to climate change?

The answers to these questions lead to a tremendous amount of information available to students studying climate change, although the quality of that information varies widely. Peer-reviewed scientific data is the best source of information for understanding the issue, but it is often the most difficult for young students to access and understand. Some governmental and nonprofit websites provide accurate information, but many other websites provide contradictory statements. So how can students become good consumers of information when they have limited access to easy-to-understand, peer-reviewed data? How can students understand a scientific issue when there are conflicting claims about the problem or potential solutions? Most claims can be evaluated on four points: who is making the claim, the claim itself, the evidence supporting the claim, and additional reasoning.

Considering Claims:

Guide your students in understanding claims by using questions around these four points:

1. WHO: Who is the person making the claim? What is that person's background? Is the person a scientist? Is the person a scientist in that area of study? If not, why are they making a claim? Is the person making the claim a reporter or another person interpreting a scientist's research?
2. THE CLAIM: What exactly does the claim say? Does the claim state an absolute truth with no exceptions? Or does it state only what the data show?
3. THE EVIDENCE: What is the context of the claim? Was the scientist cautious in making the claim? Was the entire statement by the scientist repeated, or only a small portion of it? How strong was the scientific study that was used to support the claim? How solid is that research? Was statistical significance found? How large was the data set?
4. REASONING: Is the claim a new or special claim? The scientific understanding of any particular scientific issue can take years or decades to develop. If the claim is new, is it based on previous research? Who funded the research? Is there any possibility that bias was introduced into the research? How is scientific reasoning connecting the claim and the evidence?

Neil deGrasse Tyson testifies before the Senate Commerce, Science and Transportation Committee, March 7, 2012.

Example: One claim that has been popular online and even repeated by some mainstream media is: "Volcanoes are worse for climate change than people because volcanoes emit more carbon dioxide than people do." Using the four steps above, what is the validity of this claim?

1. WHO: An Australian geologist first made this claim based on his own opinion, without any supporting evidence. Now it circulates online as an argument against the reality of climate change.
2. THE CLAIM: Science does not support this claim. Even if we use high estimates for CO_2 from volcanoes and low estimates of CO_2 from human activity, volcanoes produce no more than 1% of the total amount of carbon dioxide produced by human activity each year.
3. THE EVIDENCE: This is where a lot of false claims fall apart. There is no scientific data to support the claim. In fact, the data shows that contributions by volcanoes are minimal compared to human activity. Therefore, the claim is refuted by scientific data.
4. REASONING: Because there is no scientific research that supports this claim, any reasoning based on the claim is inaccurate and possibly misleading.

Glossary

abiotic: Not derived from living organisms; something physical rather than biological, such as sunlight, temperature, precipitation, and wind patterns.

atmosphere: The envelope of gases surrounding Earth or another planet.

average: The result obtained by adding several quantities together and then dividing the total by the number of quantities.

biodiversity: The variety of living organisms in a particular ecosystem.

biosphere: The living world; the part of the Earth's crust, waters, and atmosphere that supports living organisms.

biotic: Living or previously living organisms; something related to or caused by living organisms.

climate: The prevailing weather conditions in an area over a long period of time.

climate zone: A regional division of Earth's general climate according to average temperatures and precipitation.

conservation: Planned management of natural resources, including vegetation and wildlife, to prevent exploitation, destruction, or neglect.

consumer: A person who purchases goods and services for personal use.

data: Facts about something that can be used to calculate, reason, or plan. Qualitative data include notes taken during observations or interviews. Quantitative data describes numerical amounts or ranges, such as average temperatures.

decomposer: An organism, usually a bacterium or a fungus, that breaks down dead plants and animals or their waste, which makes their organic nutrients available to the ecosystem.

detritus: Organic waste resulting from the decomposition of plants and animals.

detrivore: An organism such as a bacterium, a fungus, a worm, or an insect, that feeds on organic waste from dead plant or animal matter.

ecosystem: A biological community of interactive living organisms and their physical environment.

experiment: A scientific procedure performed under controlled conditions in order to test a hypothesis, demonstrate a known fact, or make a discovery.

gauge: An instrument used to measure the size, quantity, or capacity of something.

graph: A diagram representing the connections between two more data measurements.

host: An animal or plant on or in which a parasite lives.

hydrosphere: All of Earth's water, including surface water, groundwater, snow cover, ice, and water vapor.

hypothesis: An idea or theory used as the basis for an experiment.

invasive: A plant, fungus, or animal that is not native to a location and spreads to the point where it is believed to cause damage to the ecosystem.

kingdom: A group of organisms that have certain fundamental characteristics in common, such as animals, plants, or fungi.

landforms: Natural features of Earth's surface.

native: A species that originates, lives, and thrives in a particular region.

naturalist: A person who studies plants and animals in their natural habitats.

observation: The process of closely viewing and noting facts about something for a scientific purpose.

parasite: An organism that lives in or on another organism, called the host, by taking nutrients from its host.

pollutants: Natural or artificial substances that contaminate air, water, or soil, such as carbon dioxide or pesticides, that occur in harmful concentrations in a specific environment.

precipitation: Any form of water, including, rain, mist, ice, snow, or hail, that falls from the sky toward Earth.

predator: An animal that naturally hunts and kills other animals for food.

prevention: The effort made to keep something bad, such as pollution, from happening.

prey: An animal that is hunted and killed by another animal for food.

producer: An organism, such as a plant or an insect, that serves as a source of food for other organisms in a food web.

region: An area in a country or the world that has specific physical characteristics but not necessarily fixed boundaries.

species: A group of physically similar plants or animals capable of breeding to produce new plants or animals.

strategies: A range of adaptations by animals or plants in response to their environment that improve their chances of survival and reproduction.

structures: The physical form and external characteristics of a plant.

sustainable: In environmental science, the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance.

trophic cascade: A series of interrelated changes that occur in a system when a species is removed or added.

variables: Characteristics, conditions, or factors that are likely to change.

watershed: An area of land that drains all its surface water and rainfall to a common outlet, such as a river, a reservoir, a bay, or any point along a stream channel.

weather: The state of the atmosphere in a specific place at a particular time.

BOOKS

Aitken, Stephen. *Ecosystems at Risk.* New York, NY: Cavendish Square, 2014.
A serious look at climate change and its effects on the world's ecosystems, this book focuses on observable results and scientific predictions with short case studies and carefully cited fact boxes. Suitable for Grades 5 and 6.

Bow, James. *Earth's Climate Change: Carbon Dioxide Overload*. New York, NY: Crabtree, 2016.
Carbon dioxide produced by human activities causes the climate to change. This book looks at how people in different parts of the world are using new forms of sustainable energy to try to reverse the trend. Students in Grades 5 and 6 can make use of the historical examples and in-depth analysis to understand the advantages and disadvantages of various energy sources.

Close, Edward. *Endangered Animals.* New York, NY: PowerKids, 2014.
Which animals are at risk from human behavior, and which are already extinct? Students in Grades 4–6 can find these facts illustrated with easy-to-read charts and graphs, along with examples of animal adaptations and human interventions that have saved some species.

Gosman, Gillian. *What Do You Know About Earth's Atmosphere?* New York, NY: PowerKids, 2014.
This general overview describes composition and function and also includes information about how air pollution affects Earth's atmosphere. Suitable for students in Grades 4 and 5, especially reluctant readers.

Gosman, Gillian. *What Do You Know About Weather and Climate?* New York, NY: PowerKids, 2014.
This title asks and answers 20 questions in brief sections designed with illustrations and diagrams about topics including landforms, precipitation, the greenhouse effect, and climate change. Suitable for students in Grades 4 and 5, especially reluctant readers.

Kalillo, Jamie. *12 Things to Know About Climate Change.* Mankato, MN: 12-Story Library, 2015.
In just 32 colorful pages, this title takes a balanced look at the facts and impacts of climate change, covering everything from farming to terrorism and how people can make a difference. Suitable for Grades 4–6.

Mulder, Michelle. *Brilliant! Shining a Light on Sustainable Energy.* Victoria, BC: Orca Book, 2013.
While this book addresses the drawbacks of fossil fuels, it focuses most of its upbeat 48 pages on renewable energy sources, including wind and solar power as well as surprising resources such as algae, fungi, and dog waste. Suitable for Grades 4–6.

Rosenberg, Pam. *Watershed Conservation.* Ann Arbor, MI: Cherry Lake, 2008.
What is a watershed and why is it important? Students in Grades 4–6 can learn more about the human water supply, how people affect it in both negative and positive ways, and what to do to help keep Earth's freshwater sources clean and safe.

Sneiderman, Joshua. *Climate Change: Discover How It Impacts Spaceship Earth.* White River Junction, VT: Nomad, 2015.

Earth is in constant transition and humans have an effect on what happens. Students in Grades 4–6 can read real studies on planetary science, Arctic ice bubbles, and migratory patterns; explore the history of human impact from the Industrial Revolution to modern-day technology; and learn about innovations under way around the world to address global climate change.

Surges, Carol S. *Food Chains.* Minneapolis, MN: ABDO, 2014
Including explanatory text and sidebars, charts and photos, and references to more information online, this book provides learning activities and promotes critical thinking about life science, biodiversity, and even science careers. Suitable for Grades 4–6.

VIDEOS

Due to advertising or viewer comments, some websites may not be suitable for students to view without supervision. Please preview these videos before sharing them to make sure they are appropriate for your students.

Climate Change

How Global Climate Change Works (in Under 4 Minutes)
http://www.howglobalwarmingworks.org/in-under-4-minutes-ab.html

Can Wildlife Adapt to Climate Change?
https://www.youtube.com/watch?v=ZCKRjP_DMII

Ecosystems

Detritus' Role in Ecosystems
https://www.youtube.com/watch?v=KI7u_pcfAQE

Rewilding Our World: From the Top of the Food Chain Down
https://www.youtube.com/watch?v=t3I9gDocYdk

Dead Stuff: The Secret Ingredient in Our Food Chain
https://www.youtube.com/watch?v=KI7u_pcfAQE

Why Is Biodiversity So Important?
https://www.youtube.com/watch?v=GK_vRtHJZu4

Energy

Renewable Energy
https://www.youtube.com/watch?v=T4xKThjcKaE

Different Sources of Energy [Renewable and Nonrenewable]
https://www.youtube.com/watch?v=wMOpMka6PJI

Energy Systems Map [interactive with embedded videos]
https://www.studentenergy.org/map

Water

Explore the Process of Wastewater Treatment with LeVar Burton/ Reading Rainbow uTech
https://www.youtube.com/watch?v=r7JO_mPdq8E

Discovery Channel "How It's Made" Drinking Water Episode
https://www.youtube.com/watch?v=eIoSt0-K7wI

What If All the Ice Melted on Earth? [Bill Nye]
https://www.youtube.com/watch?v=b6CPsGanO_U

What Is a Watershed? [Indiana Department of Environmental Management]
https://www.youtube.com/watch?v=y1SQIh0KGsc

WEBSITES

Climate and Weather

Congress mandated the **U.S. Global Change Research Program** in 1990 to "assist the nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." According to the program, "the impacts of climate change are evident across the country and around the globe." Explore regions and topics at http://www.globalchange.gov/explore

Scientists in northern Indiana were already seeing signs of climate change in 2003. The Union of Concerned Scientists and the Ecological Society of America published those findings as **Confronting Climate Change in the Great Lakes Region**; this is a fact sheet based on them. http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/ucssummaryinfinal.pdf

In 2008, scientists at Purdue University prepared a report for Indiana Senator Richard Lugar on **"Impacts of Climate Change for the State of Indiana"** if greenhouse gas emissions continued to increase. Their predictions included the increased occurrence of hot weather, severe thunderstorms, droughts and flooding, agricultural crop losses, and endangered species. https://www.purdue.edu/discoverypark/climate/resources/docs/ClimateImpactsIndiana.pdf

A recent report from scientists at the University of Massachusetts Climate System Research Center summarizes observed and projected climate changes and their impacts in this **Indiana Climate Report.** https://www.geo.umass.edu/climate/stateClimateReports/IN_ClimateReport_CSRC.pdf

The U.S. Environmental Protection Agency published this 2016 summary of **Climate and Health Resources for Indiana**, including risks and actions for citizens.
https://www.epa.gov/sites/production/files/2016-11/documents/indiana-fact-sheet.pdf

Help students fill in the fields to plot their own time series graph on **Climate at a Glance**, an interactive site from the National Climatic Data Center (now part of the National Centers for Environmental Information). https://www.ncdc.noaa.gov/cag/

The National Centers for Environmental Information also provides resources on **weather and climate's effects on society and the economy** (https://www.ncdc.noaa.gov/societal-impacts/), **climate extremes** (https://www.ncdc.noaa.gov/extremes/cei/), and temperature, precipitation, and drought (https://www.ncdc.noaa.gov/temp-and-precip/).

Younger students may enjoy NASA's interactive Q-and-As on **Global Climate Change**, https://climatekids.nasa.gov/

Learn how global and local climate has changed since the **Ice Age in Indiana,** https://igs.indiana.edu/Surficial/IceAge.cfm

The Indiana State Climate Office provides a **Climate Fact Sheet** showing monthly temperatures and total precipitation from 1971 to 2000. Students can also find notes about extreme weather events and links to other resources at https://iclimate.org

The library of the National Oceanic and Atmospheric Administration provides access to historic **U.S. Daily Weather Maps** at
https://www.lib.noaa.gov/collections/imgdocmaps/daily_weather_maps.html. (Viewing the weather maps requires a free browser plug-in.)

The federal Centers for Disease Control and Prevention offers this infographic on the **Impact of Climate Change on Human Health**, https://www.cdc.gov/climateandhealth/images/climate_change_health_impacts600w.jpg

The National Wildlife Federation presents scientific data on **Threats to Wildlife from Global Warming**,
https://www.nwf.org/Wildlife/Threats-to-Wildlife/Global-Warming.aspx

What Is the Greenhouse Effect? Carbon dioxide traps heat in Earth's atmosphere, which causes the planet to heat up. http://globalwarming-facts.info/greenhouse-effect/

This is what the U.S. Environmental Protection Agency published about the **Causes of Climate Change** on its website prior to Jan. 19, 2017. https://19january2017snapshot.epa.gov/climate-change-science/causes-climate-change_.html

Scientists in 2009 analyzed shells in deep sea sediments and found that **The Last Time CO_2 Was This High, Humans Didn't Exist**. http://www.climatecentral.org/news/the-last-time-co2-was-this-high-humans-didnt-exist-15938

Energy

Plants and animals make up an important part of the **Food Chain and Food Web** from which our energy sources are derived. Learn more about the energy cycle at http://www.ducksters.com/science/ecosystems/food_chain_and_web.php

"About 91% of the energy consumed in the United States comes from non-renewable energy sources." Learn more about the differences between renewable and nonrenewable **Energy Sources** on this site from the U.S. Energy Information Administration, https://www.eia.gov/kids/energy.cfm?page=2

Maps

Science in Your Watershed [interactive map]
https://water.usgs.gov/wsc/map_index.html

USDA Plant Hardiness Zone Map
http://planthardiness.ars.usda.gov/PHZMWeb/

Hardiness Zones–World Map
http://www.plantsdb.gr/en/general-cultivation/hardiness-zones/274-hardiness-zones-map

NOAA Climate Regions Map
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/regions.shtml

Plants and Wildlife

From Johnny Appleseed to Rachel Carson, here are short biographies of **8 Naturalists That Changed Outdoor History.** http://blog.theclymb.com/out-there/8-naturalists-changed-outdoor-history/

Learn about the **Native Plants of Indiana** best suited for the state's soil and weather conditions, and also about exotic plants to avoid, at http://www.indianawildlife.org/wildlife/native-plants/

Discover information about **Native Animals of Indiana** at http://www.in.gov/dnr/fishwild/3357.htm

Which plants and animals are **Invasive Species** in Indiana? Find out at http://www.in.gov/dnr/3123.htm

Water Use

This U.S. Geological Service resource offers maps and graphics to show **Water Use in the United States.** http://water.usgs.gov/edu/wateruse.html

The definitions of a **water footprint** and **hidden water** can be found at

http://www.gracelinks.org/825/water-footprints. To discover **The Hidden Water in Everyday Products**, go to http://www.gracelinks.org/285/the-hidden-water-in-everyday-products

This **Water Footprint Calculator** can help older students calculate their personal water use. http://www.watercalculator.org/

National Geographic provides **Water Conservation Tips** for reducing usage. http://environment.nationalgeographic.com/environment/freshwater/change-the-course/water-footprint-calculator/

The water footprint of commonly used items is displayed in this **Water Footprint Product Gallery** that shows the volume of fresh water required for each item. http://waterfootprint.org/en/resources/interactive-tools/product-gallery/