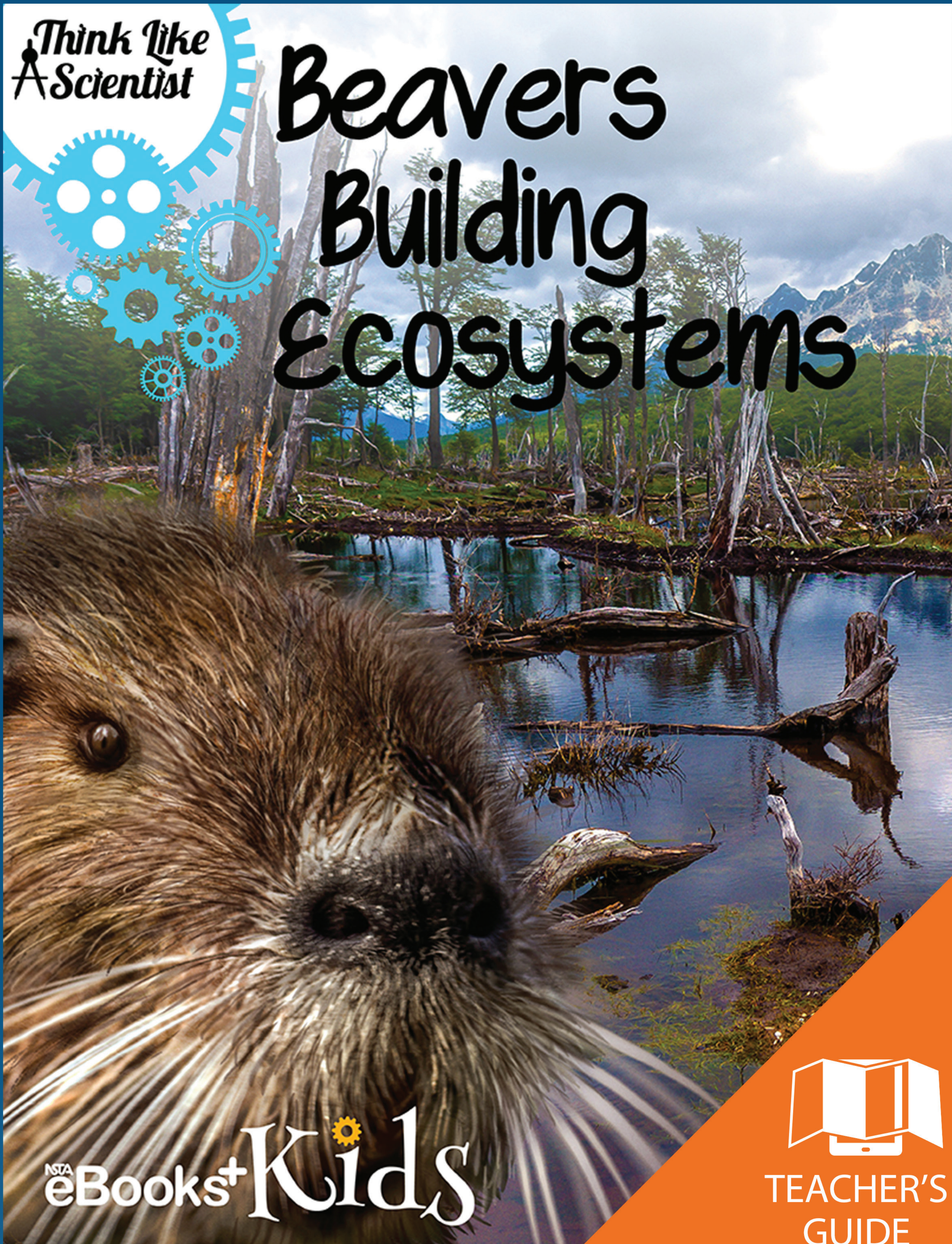
Think Like A Scientist
Beavers Building Ecosystems
NSTA eBooks+ Kids
TEACHER'S GUIDE

Overview

This teacher's guide is designed to provide ideas for how to use pages of the *Beavers Building Ecosystems* e-book with students. It explains the concepts and suggests what to look for in students' learning, while also supplying information about how they are practicing science and using crosscutting concepts.

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The goals of this teacher's guide are as follows:

- engage students in grade-level appropriate, three-dimensional learning;
- use the e-book as a tool in class-wide, small group, or independent explorations of its content;
- provide additional ideas and activities that utilize the e-book content but are not included in the e-book;
- explore how STEM content can be effectively integrated into literacy (English language arts);
- facilitate investigations that utilize the e-book content and connect it with students' own classroom and community; and
- assess students on the second-grade content standards to which this e-book is aligned and additional *Common Core State Standards*, in English language arts and mathematics suggested throughout the e-book.

Book Description

Humans are the ultimate ecosystem engineers. We have the ability to use our tools and equipment to alter entire landscapes. At times we remove what was there originally and install the exact landforms, plants, and animals we want in order to create a new environment. Beavers are also described as ecosystem engineers due to the significant changes they affect on their environment. Using their powerful teeth and engineering instincts, they significantly alter the ecology of a place. Beavers' first impact on the environment begins with dam building. Subsequent flooding and slowing of water flow trigger a host of changes in the plants and animals that live in the area. Aquatic plants colonize the new pond and turtles, fish, and other water-loving creatures take up residence. Drowned trees become homes for insects and birds. Larger animals follow these colonizers in, looking for food and shelter. Over the course of many years a wetland forms that supports a diverse array of plants and animals. Studies have shown that wetlands created by beaver dams are more biodiverse than man-made wetlands. In fact, 50% of bird species and 31% of endangered animals depend on this type of wetland for their survival. (From https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045079.pdf)

In addition to creating habitats for a variety of plants and animals, beaver wetlands provide other vital ecosystem services. Dams impound a huge amount of water that seeps into the surrounding soil, raising the water table around the pond or wetland so that the entire area holds a total volume of water much larger than the pond itself. In times of heavy rain or spring melt, the wetlands retain excess water, thus reducing downstream flooding. This excess water is slowly released over the course of weeks and months, allowing for water to continually flow through the watershed at times when rain is scarce. Beaver wetlands also help clean water that runs through them, capturing sediment and excess nutrients in the water that can impact downstream ecosystems.

Despite the fact that beavers have been the subjects of intense research for many years, it wasn't until the mid-1900s that engineers began to consider beaver as allies in ecosystem restoration. Faced with eroding streambeds, flooding, loss of riparian habitat, lowered water tables, and summertime low water flow, government agencies were spending millions of dollars building dams to slow the flow of water. Finally, restorers realized that beavers could provide the same services for a fraction of the cost and with the addition of an extensive list of positive environmental changes. Thus, the beaver became a new wildlife tool to repair ecosystem damage. Reintroduction of beavers to habitat they had not inhabited for over 100 years has become commonplace in many areas of the United States and Canada. New Mexico, Colorado, New York, and Utah are a few states where beaver have become an integral part of broad plans to restore riparian habitat, support rare and endangered species, increase ecosystem resilience, and mitigate erosion and flood damage. It has taken both time and much public education to accept beaver as the valuable resource they are. At times, the beaver's ability to dam streams can be a nuisance for humans. Flooded agricultural land, felled specimen trees, plugged culverts, and swamped roadways, homes, and rail lines can be expensive problems to fix. Finding the balance between respecting human needs and providing beneficial ecosystem changes is one of the things wildlife engineers have to pay attention to when planning for beaver reintroduction.

The intent of this e-book is to introduce students to the ways in which ecosystems can change due to the influences of living and nonliving things. In beaver habitats, the beaver builds a dam that in turn changes the water level of the stream system, which alters the entire habitat. Students will use observation and data to observe how beaver dams change water levels and how that in turn changes the flora and fauna around the site. They will also explore the changes in water flow at the site of the beaver pond and downstream. The book will discuss both positive and negative effects beavers have on their landscape and prompt students to think about how to effectively use beavers to create positive ecosystem changes. As a final assessment of what they have learned, students will be asked to play the role of wildlife managers assessing sites to find an appropriate place to relocate beavers. Students will apply their new understanding to decide where the beavers' presence will be most useful as environmental restorers.

The Driving Question

A driving question is one that drives the teaching and learning for a given unit, or even an entire school year. It provides context for the purpose of student exploration and understanding of a phenomenon. This e-book is written around the driving question:

How do environmental changes affect the plants and animals that live in that ecosystem?

Three-Dimensional Learning and the *Beavers Building Ecosystems* E-book

You will notice throughout the document that certain words and phrases are highlighted in different colors: blue, green, and orange. These colors correspond to the science and engineering practices (blue), crosscutting concepts (green), and disciplinary core ideas (orange). The book also incorporates engineering design (purple). This will help you quickly notice how each of the three dimensions and engineering design are used on a page. Refer back to this section for the full descriptions.

This e-book does not use all of the grade-level elements for the practices and crosscutting concepts, but that does not mean that you should not be aware of the other practices and concepts your students need to know. For a full list of all grade-level elements for the science and engineering practices and crosscutting concepts, refer to Appendix A.

For engaging in literacy ideas, refer to Appendix B.

This e-book examines an anchor phenomenon related to the following disciplinary core idea:

Disciplinary Core Ideas (DCIs)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die..

Crosscutting Concepts

The crosscutting concepts are the lenses through which scientists think about the natural world. They are the big ideas that connect the sciences and help to understand nature and how science and engineering work. Students who understand the crosscutting concepts will have a deep framework for integrating and understanding science ideas across disciplines.

Through classroom experiences supported by this e-book, students should be able to use the crosscutting concepts in the following ways appropriate for students in kindergarten:

The specific crosscutting concepts elements addressed include:

Patterns

- Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products.

Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change.

Scale, Proportion, and Quantity

- Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.

Systems and System Models

- A system can be described in terms of its components and their interactions.
- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.

Stability and Change

- Change is measured in terms of differences over time and may occur at different rates.
- Some systems appear stable, but over long periods of time will eventually change.

Science and Engineering Practices

> Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study.

(NRC Framework for K-12 Science Education, 2012)

Through classroom experiences supported by this e-book, students should be capable of performing the following practices:

The specific science and engineering practices addressed include:

Asking Questions and Defining Problems

Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships.

- **Ask questions about what would happen if a variable is changed.**
- **Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.**

Developing and Using Models

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- **Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.**
- **Develop and/or use models to describe and/or predict phenomena.**
- **Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.**

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- **Evaluate appropriate methods and/or tools for collecting data.**
- **Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.**
- **Make predictions about what would happen if a variable changes.**

Analyzing and Interpreting Data

Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.
- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- Use data to evaluate and refine design solutions.

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 3–5 level builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.

- Organize simple data sets to reveal patterns that suggest relationships.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.

Engaging in Argument from Evidence

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Construct and/or support an argument with evidence, data, and/or a model.
- Use data to evaluate claims about cause and effect.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena.
- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.

Student Discourse and the *Next Generation Science Standards*

Facilitating student conversations focused on the disciplinary core ideas can be challenging. However, being familiar with a few avenues for directing student conversation known as “talk moves” can make such conversations both more manageable and more productive. “Talk Science Primer,” published by TERC, outlines the following talk moves:

- providing time to think (through actions such as think-pair-share, writing time, and think time);
- prompting students to say more with phrases like,“Tell me more about that;”
- asking students to rephrase or repeat in their own words a statement just shared by a classmate;
- prompting students to share evidence when explaining their thinking with questions like, “What’s your evidence?” and “What made you think that?”;
- challenging student thinking by asking if something always works that way or asking students to compare one student’s thinking with another’s that may be different in substance or conclusion;
- asking students to consider whether they agree or disagree with another student’s thinking; and
- asking students to add on to another student’s thinking.

"Talk Science Primer," free to download from the TERC website, is an invaluable resource for teachers looking to make the leap toward three-dimensional, student-driven learning. Through the use of talk moves and other strategies outlined in this resource, teachers can, over time, develop their skill and comfort level in pushing students to share just as scientists do when constructing scientific explanations and arguing claims with evidence uncovered through research and investigation.

A Note About Safety

Throughout this e-book teacher's guide are hands-on activities and demonstrations that help to foster the learning and understanding of science. The reader will find safety notes and safety statements that help to make it a safer learning experience for students and teachers. In most cases, personal protection equipment (PPE) like safety glasses/goggles, non-latex gloves and aprons are required. Sanitized safety glasses and/or indirectly vented safety goggles noted must meet the ANSI/ISEA Z87.1 D3 safety standard. When dealing with hazardous chemicals, consult with the Safety Data Sheets prior to doing the activity. Make sure there are appropriate engineering controls; e.g., eyewash, shower, etc. Always do a “dry run” of the demonstration prior to doing it in front of students. The safety procedures and use of PPE must be followed based on legal safety standards and better professional safety practices. Teachers should also review and follow local polices and protocols used within their school district and/or school; e.g. chemical hygiene plan, Board of Education safety policies, etc.

For additional safety information, check out the NSTA Safety Portal at http://www.nsta.org/

safety/. A safety acknowledgement form ("Safety in the Science Classroom, Laboratory, and Field Sites"), which is designed to review safety-operating procedures for students, needs to be used to address safety and teacher liability. A sample form is available at http://static.nsta.org/pdfs/SafetyAcknowledgmentForm-ElementarySchool.pdf.

Be aware that conditions of actual use of activities and demonstrations may vary and the safety procedures and practices described in this e-book teacher's guide are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors/reviewers do not warrant or represent that the procedures and practices in this e-book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors/reviewers disclaim any liability for personal injury or damage to property arising out of or relating to the use of this e-book, including any of the recommendations, instructions, or materials contained therein. Selection of alternative materials or procedures for these activities may jeopardize the level of safety and therefore is at the user's own risk.

How to Work: Nine Steps Toward a Safer and More Productive Classroom

Teaching children how to work together safely in groups is crucial for creating a positive educational environment. Present students with the following guidelines:

1. Always ask permission.
2. Wear appropriate protective gear when directed, e.g., safety goggles, boots, and other outdoor gear. Teachers must have all participants wear safety glasses or goggles during all phases of this inquiry activity (set-up, hands-on investigation, and take down) when required.
3. Share all materials.
4. Walk indoors; never run.
5. Give each member of your group a chance to speak.
6. Listen when each person speaks.
7. Respect each team member's suggestions.
8. Take turns.
9. Ask for help if disagreements arise that can't be resolved by the team.

Consider using this e-book in the classroom as a digital Big Book. Project this onto a screen then decide when you want the class to break into groups to discuss an item in the e-book or to collaborate on an idea. This can help students with independent reading and language development, as well as model how children can participate in science.

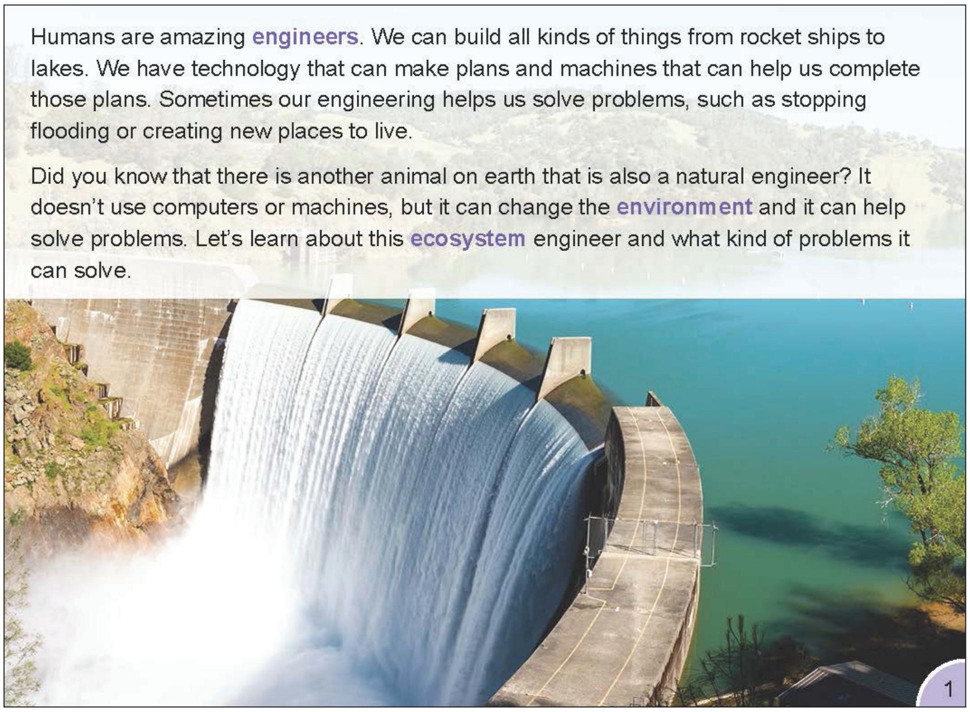
Topic 1

Beavers As Ecosystem Engineers

By the end of the topic, students will be able to:

- identify beavers and state how parts of their bodies are used for building and survival;
- observe how beavers build dams that change the environment around them;
- use models to describe how the environment changes once a beaver has built a dam; and
- interpret graphs, charts, and observational data that show how plants and animals in the environment change over time to create a new ecosystem.

Page 1



This page introduces the concept of an engineer. An engineer designs and builds things. Humans are engineers because we design and build things every day.

Have students gather evidence to support the statement that humans are engineers and that engineering can be large in scale or small. Brainstorm ways in which students are engineers every day. Do they design and build things in school, at home, or on the playground? (Forts, LEGO worlds, Minecraft, etc.)

Discourse

Have students think about structures in their area that have been built by engineers and discuss the following questions.

- Do they have bridges, tunnels, or buildings?
- Are there any places where a new structure is being built right now?
- How do humans change the environment to create a place for those new structures?
- Have they chopped down trees or used bulldozers to level a hill?

After students have brainstormed engineered structures, have them discuss why these structures were built. How do they help humans or animals? Some important concepts to guide students to think about are how structures help us travel, provide places to live and work, and keep us safe.

Engineering can also be done by animals other than humans. In subsequent pages students will use evidence to discover how beavers are engineers. They will identify ways in which beavers change the environment around them to create a place where they can be safe, build a home, travel, and find food.

Before moving on, make sure students understand what *environment* means in this context. It is the immediate surroundings in which a person, animal, or plant lives. When thinking about beavers changing the environment, we are taking into account a relatively small area in which the beavers live. We are exploring a phenomenon that takes place on a small scale but affects the environment on a large scale.

Thinking Beyond

Have humans always been engineers? Advanced students may want to do some research into structures humans have built in the past. How far back can they go and still find evidence of human engineering? What kinds of historical engineering are in your local area? Do you live near ancient burial mounds, stone structures, or irrigation canals? Students could also think about the Great Wall of China, Stonehenge, or the pyramids. Why are these places evidence of engineering?

Page 2

Many scientists think the beaver is an ecosystem engineer.

The beaver that lives in North America is the species *Castor canadensis*.

Take a look at the pictures on the right and look carefully at the beaver's body parts. Make a list of ways you think beavers use their different body parts to live in their environment. Which body parts could be used to change the environment?

Eyes, ears, and nose above the water for seeing and breathing.

2

Before diving into this page, you may want to have students create a list of things they already know about beaver bodies. Then read this page and spend time carefully observing the photographs. What can students add to their list of beaver body parts? How do beavers use these body parts to survive in their environment? How does the structure of the body parts help a beaver survive in its environment?

Here are some things you can learn from the pictures:

- Eyes, ears, and nose above the water: The eyes, ears, and nose of a beaver are all aligned on the top of its head so that it can spend time in the water while still being able to see, hear, and breathe.
- Large back feet and tail for swimming: Beavers are accomplished swimmers because their back feet are webbed and their tails act like rudders, helping them steer through the water.
- Sitting on tail: Beavers are a little awkward on land. Their large tail can get in the way, although they do use it to sit upright. You may also notice in this picture that the beaver's fur is wet. Beavers have special oils they rub on their fur to help shed the water.
- Beaver paws: Their front paws are not webbed but instead are agile and can grip food and sticks. This allows them to carry building materials such as sticks, stones, and mud.
- Teeth and ability to chew down trees: Beavers have strong teeth that are perfect for chewing on wood. Their teeth are highly composed of iron, which makes them very strong and orange. Their teeth continue to grow throughout their lives. If beavers' teeth didn't continue growing, they would eventually wear them down from chewing on wood all the time!

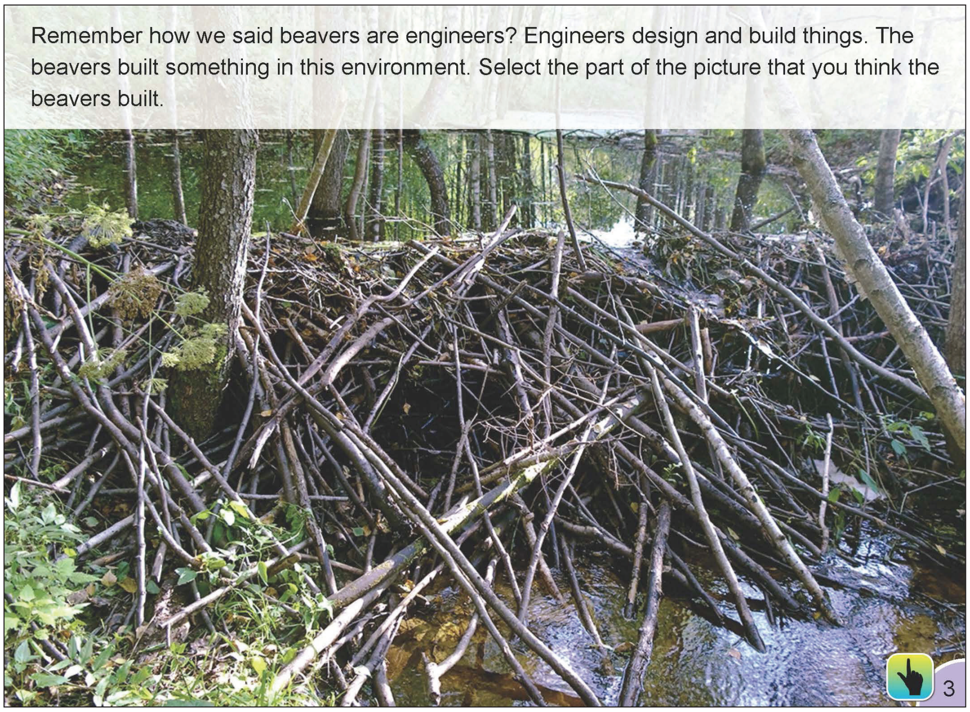
Background Information

The American species of beaver is *Castor canadensis*. European beavers are *Castor fiber*. They look very similar but are genetically quite different and cannot interbreed.

Differentiation

You may want to create a graphic organizer to help your students record their ideas. This can be used again later when you read about otters. A simple chart with two columns and five rows will suffice. For students who may need graphics, include a picture of a beaver that has the body parts labelled. The other side of the chart can be used for words or pictures that remind the students of your discussion. More able students can practice their note-taking skills by recording all the ideas themselves. Advanced students may also want to include some questions they have that they can look into later.

Page 3



Students will identify the dam as a structure that a beaver built. Many students will know that beavers build dams; however, they may not think of dam building as engineering. Analyze what beavers need to do to design and build this dam. Discuss how they would need to find a stream, select a spot to build the dam, locate and move materials, and finally put the dam together so it will hold back the water. You can also see evidence of design in the dam itself. Have students observe the pattern of sticks in the pile. Do they see a pattern in how the sticks are placed? Beavers actually place a large number of sticks on the downstream side of their dams. This provides strength to the dam and helps keep it up despite the water pressure on the far side.

Thinking Beyond

Do all beaver dams look the same? Do a search on the internet for beaver dams and take a look at several pictures. What differences and similarities do you see? People sometimes walk right over a beaver dam without even realizing it. Dams that have been around longer look very different from new dams like the one shown on page 3 of the e-book. The look of a dam changes with time as it blends in more with its environment. Without careful observation, you may not even realize that one side of a wetland you are looking at was engineered by beavers.

Language Arts Connection

The longest beaver dam ever discovered is in Alberta, Canada and was discovered by aerial imagery. A wonderful book written about the beavers at the Alberta dam is *Build, Beaver, Build! Life at the Longest Beaver Dam* by Sandra Markle.

Page 4

Do you remember the picture of the beaver using its large front teeth to take down a tree? Beaver's teeth are one of the most important tools that they use to change the environment.

Beavers are most famous for building **dams**. They listen for the sound of running water. When they hear it, they will use branches and other materials around them to stop the water from flowing. Take a look at these beaver dams. What

Check Your Thinking

Here are several beaver dams.

4

Have students examine this picture carefully and make a list of items they see in the dam. This list may include sticks, branches, rocks, mud, grass, plants, or leaves. Have the students create their list of materials in the dam before clicking the "Check Your Thinking" button and comparing it with their own list. You will see this button throughout the book. It gives students the opportunity to pause and consider their own answer before moving on.

Hands-On Activity

Building a dam that holds back water looks easy—until you try it yourself! Have your students develop and use a model by building their own dam. Using a long container (seedling trays work well for this), have students construct a dam using a variety of materials. Ask students to predict what will happen when water reaches the dam. Carefully pour water into one side of the container. How long does it take for the water to flow through the dam to the other side? Allow students to ask questions about what would happen if a material were changed. They can then change or add to their dam and test it again.

Safety Notes

- *Follow school safety procedures. Also see the section titled "A Note About Safety" at the beginning of this teacher's guide.*
- *Make sure students wear goggles and gloves. See NSTA guidelines for recommendations.*
- *Plan this activity for a warm day so kids won't get too cold when they get wet (because they will definitely get wet!).*

- *Have piles of materials ready for them to use. Kids will gladly go in search of rocks and sticks, but in doing so they may cause damage or injure themselves.*
- *Find a space outside where you can spread out to keep students from stepping on others' materials. Remind them that stones are not for throwing and sticks are not for stabbing.*
- *Be sure to clean up carefully at the end so that your exploration does not become a hazard for anyone else on the school grounds.*
- *Wash hands with soap and water after completing the activity.*