Extended Outdoor Science Lesson Sequence

Adaptations, Structure & Function
Theme Field Experience

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1. Introduction

1.1 Introduction

1.1a. What's in this guide? This write-up documents how an instructor can lead a series of field experiences built around the theme of adaptations, structure and function. The length of the sequence will vary, depending on your situation and goals.

This is a sequence of BEETLES activities tied together with additional material (discussions, questions, and teaching instructions) that help create a cohesive learning experience. Suggested activities and transitions between activities that are not published elsewhere are written up here. For the activities included that are published, see the individual BEETLES activity write-ups at beetlesproject.org. This guide works as an overall script you can print out for the field experience that you then supplement with Field Cards from individual activities as they appear in the script.

1.1b. Strengths of outdoor science. Teaching outdoors can be a powerful tool of science education if it includes authentic exploration and deep thinking. When this happens, outdoor science can meet certain goals in ways that are harder to achieve in a classroom. In the outdoors, students can be surrounded by birds, rocks, streams, tracks, trees, and tons of interesting phenomena, "doing their thing" in the context of the ecosystem. In an outdoor learning environment, students can observe, poke, prod, and interact with things that can only be simulated, viewed through media, or sampled in a classroom. In this rich outdoor setting students can follow their curiosity into deeper inquiry, as they move between observation, questioning, and thinking in ways that mirror how scientists actually work. Outdoor science takes place in an authentic real-world context, and it lends itself to hands-on and physically active experiences, both of which increase student engagement.

Of course, there are also many things that can be done better in a classroom than outdoors. The length of the school year allows for long-term investigations, and for teaching comprehensive science curriculum. The classroom is where students can wrestle with abstract concepts or global perspectives, using resources like maps and models of earthquakes, global temperatures, and ocean currents. A classroom setting is also great for projects that include research using books and online materials. Outdoor science is not a replacement for classroom science; rather, it is a magnificent complement.

Strengths of outdoor science include:

- **Exploring and investigating interesting stuff.** The number and variety of critters, plants and other organisms in even a small area outdoors offers an abundance of intriguing objects and processes to investigate.

• **Opportunities to engage students in science practices.** With authentic curiosity, and wonder, as well as rich and interesting parts of nature, students can ask questions, design investigations, construct explanations, and engage in argument based on evidence, all using their own firsthand observations.
• **Students' autonomy to follow their own interests and curiosity.** When given a balance of guidance and freedom through organized activities in nature, students can be highly motivated to learn. Teaching outdoors can be a powerful tool for accomplishing a lot of other important things too, like social-emotional learning.
• **A mindset of discovering mysteries in the natural world can forever change students' relationship with nature.** Unraveling mysteries encountered outdoors leads to even more opportunities to engage in science practices—specifically, constructing explanations and arguing from evidence—and helps students to be more curious about the world around them.
• **Understanding organisms and environmental processes in context.** Students can observe and investigate the relationships between all the interacting parts of an ecosystem. This supports nuanced understanding of whatever part of nature students are studying, and helps make related concepts clear.
• **Interacting directly with the natural world and developing a close relationship with nature.** It's clear that being outdoors and directly interacting with nature builds a connection to and appreciation for the natural world. That's big!
• **Students gain skills they can apply in their classrooms and outside in their own neighborhood.** If you model and teach a scientific mindset of curiosity, students can become empowered to use the skills and attitudes developed through outdoor science in classroom work, and in their homes and communities. Students who may have never had an interest in science before may see the subject and their relationship to it in a whole new light after sustained outdoor science experiences.

1.1c. Why lead a theme field experience on Adaptations, Structure, and Function?

It's awesome when an outdoor science activity leaves students excited about a topic, interesting ideas, and some aspect of nature. It can be even more rewarding to lead a *series* of activities, starting out by getting a sense of where students are at to begin with, then taking them on a journey of learning, and tying everything together throughout a theme field experience. A thoughtfully sequenced series of activities can help students build understanding of key science concepts, and having a theme that weaves through the activities can make the field experiences coherent, meaningful and memorable. But it can also be more challenging to lead a theme field experience than it is to lead less connected activities.

Once students begin to understand how structure relates to function, and the idea of adaptations, the natural world will make more sense, and a student's experience in it will never be the same. The big idea of structure and function is applicable to just about anything, and if students focus on this as a lens for learning, they can use it to learn when they look at almost any part of the world. How does the particular structure of a birds' beak, or of the leaves of a

tree function to help the organism survive? How do the structure of the gears of a bicycle help with the function of pedaling? How does the structure of a wall function to make it stable?

For adaptations, (inheritable behaviors and structures that help a group of organisms survive in their habitat), it's not about just learning a definition, but about having enough opportunities applying it in nature to actually understand what it really means. The word "adaptation" represents a complex and important concept, one students will understand better if they are able to see examples of it in nature, and develop their comprehension through different learning experiences in the field. Understanding how organisms' structures and behaviors connect to their survival, and the idea of inheritance, is also a foundational piece of the concept of evolution. While you can't see evolution happen because it is a looooong process, students can observe organisms' structures and behaviors, and make explanations of how those characteristics help the organisms survive.

1.1d. Preparing for the theme field experience sequence.

This document includes a list of BEETLES activities that could be used for a theme field experience on Adaptations, Structure and Function. These activities have been thoughtfully sequenced to best support students' developing skills and conceptual understanding incrementally.

This document also includes some discussion questions to introduce the sequence, some "*Thought Swap*" transitional discussion questions, to help students apply concepts they are learning during transitions between activities, and some reflection questions at the end.

This outline does not include activities to promote tone setting, team building, and creating an inclusive learning culture- but those are critical factors for successful student learning. BEETLES activities include opportunities for discourse and discussion. Include many opportunities for students to "Turn and Talk" to each other, to make sure all students are able to talk about their ideas. Setting up an inclusive, equitable learning community is often undertaken differently by different programs, schools, and individual instructors. Use whatever existing protocols you have. Give attention to building a culture of discourse and discussion in your group. For more on how to specifically create an equitable learning culture for discussion, see the BEETLES website- http://beetlesproject.org/resources/integrating-discussion-instruction/.

1.1e. Overall Sequence Outline.

Described here is a flexible set of science field activities tied together in a sequence through the "lens" of adaptations, structure and function. Each activity or "chunk" of activities can be successfully taught in ~45-60 minutes. The first box includes the set of activities that are part of the core sequence. Activities that can be added to extend and deepen the sequence are labeled, [OPTIONAL]. The second box includes optional Focused Exploration activities that can be used to deepen and extend the sequence. The third box includes optional activities that can

deepen the content and extend the experience for older students. Note: Individual BEETLES activities that come with their own write-ups are included in ***bold italic*** font:

Core sequence. Depending on your situation, you can decide how to fit these into your time parameters. The sequence begins with a core set of activities that introduce the theme, followed by a wrap-up reflection at the end. These guide students in acquiring a solid foundation in the basics of adaptations.

- Introduction to Adaptations, Structure and Function Theme (~45-52 minutes)
    - ***Thought Swap*** (~10 minutes)
    - Introduction to Organisms & Adaptations (~5 minutes)
    - ***Whacky Adapty*** Name Game (10 minutes)
    - [Optional] ***Mind Pie*** (~7 minutes)
    - ***Adaptation Intro—Live!*** (~20 minutes)
- ***I Notice, I Wonder, It Reminds Me Of*** field activity (~45-65 minutes)
- ***Structures & Behaviors*** field activity (~45 minutes)
- ***Discovery Swap*** field activity (~60 minutes)
- ***Blending In & Standing Out*** field activity (45-60 minutes)
- ***Most Successful Organism Discussion*** (7-20 minutes.) Grades **[OPTIONAL]**
- ***Thought Swap*** & Reflection (~10-30 minutes)

Additional focused explorations. For instructors who have more time available, and who are interested in providing opportunities for students to engage in deeper experiences exploring nature while applying the adaptations theme, there is a series of suggested focused exploration activities to choose from. Depending on what is present at your site, and other aspects of your situation, you might choose between 1-5 of these activities after leading the introductory core sequence. You could then finish the sequence off with the *Thought Swap* & Reflection:

- **More Focused Exploration field activities [Optional]**

Additional BEETLES Activities to Explore Different Organisms (40-60 minutes each)

- **Lichen Exploration** (~45 minutes) Grades 5-8.
- ***Fungi Exploration*** (~60 minutes) Grades 4-8
- ***Spider Exploration*** (~60 minutes) Grades 3-8.
- ***Bird Language Exploration*** (~60 minutes) Grades 3-8.
- ***Interview an Organism*** (~40 minutes) Grades 5-8.

Deepening content. An additional set of activities is available for instructors who teach students 5th grade and up who want to take students into deeper content related to exploring genetic relationships between organisms, reproductive strategies in plants, and further opportunities to reflect on adaptations, structure and function. These would be led after the introductory core sequence, and after any focused explorations you have chosen. In *Card Hike*, students follow a trail of cards “solo.” Each card prompts the reader to do and/or think about

something related to adaptations. This activity serves as a strong review, application, and deepening of adaptation concepts, as well as a meaningful outdoor experience for students. Again, this experience would be wrapped up with the *Thought Swap* & Reflection:

- **Deeper Content Field Activities for Older Students [Optional]** (Grade 5 and up)
  - ***Related & Different*** (~40 minutes) Grades 5–8.
  - ***Mating & Cloning*** (~45 minutes) Grades 5–8.
  - **Card Hike** (50+ minutes) Grades 5–8.

In any of these options, students engage with nature and in discussion to figure things out, and use big ideas in science to guide their thinking. The ability to make observations and explanations, and to use the idea of structure and function to better understand the world, are transferable skills students can take with them after the experience. Practicing these skills will prepare them to continue to engage with the world as scientists and thinkers, and the knowledge of adaptations is a perspective students can apply to any living thing in nature.

1.1f. Next Generation Science Standards (NGSS).

This kind of learning aligns with the vision of the NGSS, which require that students use science practices and use big ideas in science in order to learn concepts. Taking part in a series of field experiences focused on a few concepts, like this one, is one of the deepest science experiences available to many students and can be a rare opportunity.

Next Generation Science Standards

This model field experience incorporates the "three-dimensional" learning that is called for in the Next Generation Science Standards (NGSS). Three-dimensional learning weaves together science practices (what scientists do), crosscutting concepts (thinking tools that scientists use), and disciplinary core ideas (what scientists know).

The Adaptations, Structure & Function Theme Field Experience Sequence engages students in the science practice of Constructing Explanations to build a foundation for understanding disciplinary core ideas related to Structure and Function, Interdependent Relationships in Ecosystems, Natural Selection, and Adaptation, and connect those ideas to the crosscutting concept of Structure and Function. (Note: "Structure and Function" is a crosscutting concept; it is also the title of a category of Disciplinary Core Ideas within the Life Sciences).

Science practices: Engaging students in Constructing Explanations. According to the National Research Council's *A Framework for K–12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about it—students should develop their understanding of science concepts through making their own explanations about natural phenomena. In the Adaptations, Structure & Function Theme Field Experience Sequence, when students observe an organism, then describe how its structures and behaviors might help the organism survive in its habitat, they're constructing their own explanations. For

example, a student who writes, “I think it probably uses its antennae to feel where it’s going,” has constructed a possible explanation for how structures sticking out of an isopod’s head help the organism survive. In order for students to be fully engaged in this practice, they need to go beyond just making explanations as described above. They also need to consciously use tentative language (“I think that...”), base their explanations on evidence, and consider alternate explanations based on that evidence. Discussions in which students share their ideas about possible adaptations are a critical step in these activities, because they offer opportunities to encourage students to include their evidence and reasoning when they give an explanation, and to entertain alternate explanations.

The abilities involved in using science practices (combined with crosscutting concepts)—looking at nature and figuring things out, using certain lenses to guide thinking, and understanding adaptations more deeply—are mindsets and tools students can take with them and apply anywhere to deepen their understanding of nature. And, they’re interesting and fun to do! There are a lot of science practices featured in the Adaptations, Structure & Function Theme Field Experience, particularly Constructing Explanations.

Crosscutting concepts: These are big ideas in science that can be used in all science disciplines. The crosscutting concept *Structure and Function* (and, to a lesser extent, *Patterns* and *Stability and Change*) are the “lenses” featured here to deepen student understanding of the processes at work in the natural world during these field experiences.

Learning science through the lens of Structure and Function. The idea that structure and function complement each other is a useful tool for explaining things in science. In the designed world and in any natural system, the shape and material of a structure is related to what it does, and vice versa. In *Structures & Behaviors*, for example, students observe an organism’s structures, and make possible explanations for how each one helps the organism survive in a specific environment. In other words, students look at structures and think about how they might function. Yet, students aren’t introduced to the specific language and scientific application of “structure and function” until they are asked to reflect on their own thinking processes toward the end of the activity. If students don’t get the chance to consider how the idea of structure and function connects to the explanations they’re making, they miss the opportunity to recognize the idea of structure and function as an important way of looking at the natural world. They also might not realize that the idea of structure and function also applies in other scenarios, such as looking at a certain model of car and thinking about what it was designed to do. Make sure to emphasize this with students, and to provide additional opportunities in their field experiences to apply the idea of structure and function in different contexts.

Disciplinary core ideas: The sequences of BEETLES activities included in this model field experience are intended to help students build their own understanding of the disciplinary core ideas related to Structure and Function, Growth and Development of Organisms, Interdependent Relationships in Ecosystems, Biological Evolution: Unity and Diversity, and Adaptation.

To further develop your own understanding of NGSS science practices, crosscutting concepts, and content related to Structure and Function and Adaptations, see the Instructor Support section of this guide, as well as the Instructor Support sections of each individual BEETLES activity you choose to use.

1.1g. Choosing optional activities and adjusting the length of your field experience.

The same exact sequence of field experiences won't work with every group. Learning experiences should be somewhat flexible, based on learners and conditions. The structure of this document includes the core activities of the theme field experience, as well as optional activities you may choose to do after those that deepen your students' experience and help them focus on specific concepts. Choose the option(s) that work within your time constraints, meet your goals, will be successful at your site, and best suit(s) your group of students in terms of their age, background knowledge, and group dynamics. Specifically, think about the following when deciding on what to include in your field experience:

- **Time constraints.** How long will you have with students? How much time will you need to spend moving between locations for activities? How much time will that leave to do activities? Use the Overall Sequence Description on page 11 to see what each activity offers, as well as how long each activity and phase of the field experience will take as you do your planning.
- **Your group of students.** What are things they'd be excited to do? What prior knowledge about the topic do you think they might have? Which optional activities would help them grow their understanding of these concepts? See the descriptions in the Overall sequence activity description to help you make decisions about which optional activities to include or leave out. And, be responsive to students' needs.
- **The natural phenomena at your site.** If you're going to include any listed optional activities, make sure the part of nature it focuses on is present at your site (it's kinda hard to do *Fungus Explorations* if you don't have fungi present!). See the Overall Sequence Description on page 11, as well as the individual descriptions in each activity, to help you make these decisions.
- **Outdoor conditions at your site.** If it's cold and raining or snowing, or if it's blazing hot, or if there are lots of mosquitoes, then it can be more challenging to sit down and discuss something for a while. Pay attention to students' physical comfort needs, and adjust the field experience accordingly.
- **Your goals for students.** Think about your experiential and conceptual goals for your group of students, and use these to inform the decisions you make. If you have the goal of helping students become excited about being in nature, think about what would be engaging for them and what would make them want to explore more. Think through other questions, like: What is their conceptual understanding of adaptations, structure

and function? Which optional activities would be best to engage them, confront any misconceptions they may have, and help take their understanding further?

Making Changes. Try not to substantially change the overall *order* of the activities or to leave out learning cycle phases of an activity. Avoid changing broad questions into narrow questions. The broad questions, and the sequence within each of these activities are important and have been thoughtfully created to best support students in developing skills and conceptual understanding. Make minor adjustments to activities to meet the needs of your students (e.g. shorten a discussion if the group becomes antsy), but try to stick to the overall structure of the individual activities. As far as the overall theme field experience goes, more flexibility may be needed. If it feels like your group is dragging, or if it seems like there's too much discussion for your group to handle, switch things up. It's hard to learn when you are not engaged, and it's usually better to move on to something else or a different modality, rather than to force students to keep doing something they're not into at the moment.

1.2. Important Teaching Notes

1.2a. Prepare yourself as an instructor to facilitate your students' engaging, discussing, and exploring. See other BEETLES Instructor Support Resources to help develop your practice, like: Discussion Strategy Videos (http://beetlesproject.org/resources/for-field-instructors/#1452105513095-6b9e796a-4527), *Engaging and Managing Students in Outdoor Science*, *Encouraging Student Discussion and Productive Talk,* and the Instructor Support sections of each BEETLES student activity.

1.2b. Preparing your students to engage, discuss and explore. Students will be able to engage with this field experience more successfully if they have developed some skills for discussion, exploration and learning beforehand. If possible, do some *Turn & Talk*s, and *Thought Swaps* before the field experience. This outline does not include activities for tone setting and creating an inclusive learning culture, though these are *critical* for successful student learning. See the resource *Engaging and Managing Students in the Outdoors* and *BEETLES Discussion Videos* for more on these.

1.2c. Materials Preparation. To get started with the Introduction to Adaptations, Structure & Function Theme, there is a minimal amount of materials preparation described at the top of the field experience write-up. You'll also need to print out the write-ups/Field Cards of each of the individual activities (*Thought Swap*, *Whacky Adapty*, *Mind Pie*, and *Adaptation Intro-Live!*). Look at those write-ups for preparation notes and materials you'll need for each of those activities. Carry the Field Cards with you to use as you teach. As you move through the sequence, do the same with *I Notice, I Wonder, It Reminds Me Of, Structures & Behaviors*, *Discovery Swap*, and *Blending In & Standing Out*. Continue doing the same for any of the optional More Focused Exploration field activities and Deeper Content field activities for Older Students activities.

1.2d. Vocabulary

It takes about seven exposures to a “hard word” for students to fully adopt it. “Hard words” are concepts - and students can’t learn a concept just by learning the definition of a word. Give students the opportunity to develop understanding of the concept, then introduce the word. Introducing too many hard words at the same time can lead to student confusion. It’s best to choose just a few hard words to focus on, give students experiences that lead to curiosity about the word/concept, explain their meaning, use them multiple times, and encourage students to use them.

Suggested adaptations, structure and function vocabulary:

- Structure, function, organism, adaptation, habitat, inherit; individual, population, generation; evolve, mutation. [In Spanish: estructura, función, organismo, habitat, heredar, individual, población, generación, evolucionar, mutación]

Suggested science inquiry vocabulary:

- Evidence, explanation, observation [In Spanish: evidencia, explicación, observación]

Flexible implementation. Don’t lose sight of the most important things: that students are making connections with nature, with the place, with each other, with themselves, and with ideas! Don’t follow this outline and these activities rigidly. Every group is different, and outdoor settings change, so your plan needs to be adaptable. Read your setting and read your group to apply what is here flexibly. If you are feeling like the next activity you have planned is not what the group needs at the moment, then switch things up. If you’re noticing that your group needs more time moving, or exploring, or sitting, or doing sense-making, then figure out an activity that addresses their needs, while keeping your goals in mind. If a really interesting critter appears that isn’t part of the activity you’re doing, it’s great to diverge from your plan to embrace the teachable moment, incorporate it into the theme if appropriate (eg: what structure and behaviors of that gopher might be adaptations that help it survive in its habitat?), then segue back into your activity when it feels right. This plan is designed to help you plan how to take students on a flowing journey, and to channel that flow through ongoing adjustments, while allowing yourself and your students to be swept up and go with the flow.

1.3. Overall sequence activity description

Included below are brief descriptions of all the activities (core and optional) included in the Adaptations, Structure & Function Theme Field Experience.

Thought Swap (~10 minutes) Any age. **[CORE]**

(http://beetlesproject.org/resources/for-field-instructors/thought-swap/)

A discussion routine to help learners access their prior knowledge and tap into their interests on the theme. *Thought Swap* can be done in one place (stationary version) or while a group is moving from one location to the next (moving version). In both versions, students discuss

prompts and questions in rotating pairs. This routine is used throughout the Adaptations, Structures and Function field experience sequence, at the beginning and end of activities, and when moving from one location to another.

Introduction to Organisms & Adaptations (~5 minutes) Grades 3-8. **[CORE]**
This is a brief introduction to the theme and the vocabulary: organisms and adaptations.

Whacky Adapty (~10 minutes) Grades 3–8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/whacky-adapty/)
In this adaptation name game, students sitting or standing in a circle play a version of tag, with one person in the center. Later, students pause to brainstorm strategies to improve their performance, then play some more. Students learn that this was a representation of how certain structures and behaviors help organisms survive in their habitat, and that these are adaptations that species inherit over time. If your students already know each other's names well, it's still a fun game to play, as well as a light-hearted introduction to the adaptations theme.

[Optional] ***Mind Pie*** (~7 minutes) Grades 3-8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/mind-pie-2/)
In this Assessment Routine, students use a Mind Pie chart to express how comfortable and confident they feel about certain topics and activities they will encounter during the field experience. The chart provides the instructor with some information about the group, which they can use to inform their instruction. It also gives students an idea of what to expect from the field experience.

Adaptation Intro—Live! (~20 minutes) Grades 3-8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/adaptation-intro/)
A brief introduction to adaptations as the group observes a live animal together (abundant enough that every pair can put one in a cup and observe it closely, such as isopods from a compost bin, earthworms, beetles, or ants OR a single captive animal big enough that everyone can see). Students start out observing an organisms' structures, trying to figure which might help it survive in its habitat and which are inheritable. Then, they do the same with behaviors: attempting to figure out which ones are behavioral adaptations.

I Notice, I Wonder, It Reminds Me Of (~45-65 minutes) Grades 3-8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/notice-wonder-reminds/)
Note: *The write-up comes with a short video to help you prepare to lead the activity.*
Many field instructors cite this Exploration Routine as their most effective teaching tool. It supports students to develop a mindset of curiosity and use language to actively and directly engage with the natural world. Students choose a natural object, then make I notice . . . statements out loud with a partner and with the group. They do the same with I wonder . . . questions and It reminds me of . . . connections. Then, students practice using these tools focused on whatever they find interesting. Using this routine makes any field experience more student- and nature-centered.

Structures & Behaviors (~45 minutes) Grades 3-8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/structures-and-behaviors-2/)

Pairs of students find an organism, then observe and record its structures and behaviors. Students apply the lens of adaptations as they come up with explanations for how their organisms' structures and behaviors might help it survive in its habitat. In a group discussion, students consider the relationship between organisms' structures and possible functions. This activity helps students develop a definition of adaptation that includes both behavioral and structural adaptations and gives students the experience applying that definition to an organism in the local ecosystem.

Discovery Swap (~60 minutes) Grades 3-8. **[CORE]**

(http://beetlesproject.org/resources/for-field-instructors/discovery-swap-2/)
Note: the write-up comes with a short video to help you prepare to lead the activity.
This flexible, student-centered Exploration Routine guides students to search for, observe, research, and share discoveries about organisms. *Discovery Swap* can be used to focus on any type of organism you choose, such as macroinvertebrates in streams or ponds, plants, insects, under-log organisms, fungi, insects caught with nets, or seeds. First, students explore an ecosystem in pairs, collecting and examining many organisms. Then, each pair chooses one organism to study through drawing and recording observations and questions in writing. Students also use tools such as field guides or identification keys (if you have them) to identify and further research their organisms. Then, in a Cool Organism Convention, one member of each pair stays with their organism, while the other member circulates to check out the other organisms. Students discuss their discoveries, questions, and ideas with one another and then, after a few minutes, pairs swap roles so everyone has a chance to look at other organisms and to share about their own.

Blending In & Standing Out (45-60 minutes) Grades 2–8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/blendinginstandingout/)
Colors and patterns in nature are a great entry point to understand adaptations. Students tend to be fascinated by colors and patterns of organisms, and by thinking and learning about these and other adaptive strategies. This activity focuses on how organisms' patterns and colors help them stand out or blend in with their environment, and how this helps them survive. Students observe the main colors in the landscape, then search for plastic animals hidden there, noticing which blend in with their surroundings and which stand out. Then, students discuss what made the animals blend in or stand out, construct explanations for how this could help the animals survive, and learn four categories for color and pattern adaptations: camouflage, mimicry, warning, and attraction. Students apply these concepts as they search for real organisms in the area, then discuss how patterns and coloration might help the organisms survive in their habitat. This activity builds towards beginning to think about natural selection, and how populations of organisms change over time to have colors beneficial for survival in their habitats.

Most Successful Organism Discussion (7-20 minutes) Grades 3-8. **[OPTIONAL]**
(http://beetlesproject.org/resources/for-field-instructors/most-successful-organism/)
This is a fun, casual "mini discussion" that can be used to get students generating and sharing ideas in a low-stakes setting, and to help build a culture of discourse and develop discussion skills within a group. As a short activity, it can be inserted anytime you like in the sequence. Some use it to "run in the background" while the group is eating lunch or a snack, or whenever they seem ready to sit and chat.

More Focused Exploration field activities [OPTIONAL]
Additional BEETLES Activities to Explore Different Organisms (40-60 minutes each)**.** If you have the time, and want your students to focus in on one specific organism or group of organisms that are present in your area, lead one or more of the following activities:

- **Lichen Exploration** (~45 minutes) Grades 5-8. Adaptable for younger or older students. (http://beetlesproject. org/resources/for-field-instructors/lichen-exploration-2) Lichen is an interesting example of how a relationship between organisms can be an adaptation to survive. Students study lichen and discuss the unique relationship between the two organisms that make up lichen (fungi and algae).
- ***Fungi Exploration*** (~60 minutes) Grades 4-8 (http://beetlesproject.org/resources/for-field-instructors/fungi-exploration/) Students investigate and discuss adaptations of fungi.
- ***Spider Exploration*** (~60 minutes) Grades 3-8. (http://beetlesproject.org/resources/for-field-instructors/spider-exploration/) An interesting example of how spiders' ability to build a structure that serves as an extension of their body is an adaptation. Many students are squeamish about spiders. But when you spray spider webs with a water mister, they are easy to see and gorgeous, and just about anyone can get caught up in exploring them! Students explore webs, then learn about different web types, then use a key to identify different kinds of webs. They also make explanations about how the structures of the webs they find function to catch different kinds of prey.
- ***Bird Language Exploration*** (~60 minutes) Grades 3-8. (http://beetlesproject.org/resources/for-field-instructors/bird-language-exploration/) Students think about how bird calls are adaptations to fill needs birds have, and discuss the different messages birds might communicate, then they individually watch and listen to birds from a Sit Spot. When the group gathers again, students compare their observations and make a large map of the bird vocalizations and behaviors they observed.
- ***Interview an Organism*** (~40 minutes) Grades 5-8. (http://beetlesproject.org/resources/for-field-instructors/interview-an-organism/) This is an exploration routine in which pairs make deep observations of a single organism and how it interacts with living and nonliving things in its surroundings. They hone their observation skills by focusing on asking questions about the organism that they can answer through further observations.

Deeper Content Field Activities for Older Students (Grade 5 and up) **[OPTIONAL]**
***Related & Different* and/or *Mating & Cloning*:** The activities in this section take the content to deeper levels. To support the Adaptations, structures & functions Theme, do one or all three of these activities, depending on how much time you have, the energy of your students, and where they're at in their conceptual understanding. In *Related & Different*, In *Mating & Cloning*, students explore reproductive strategies in plants. In *Card Hike*, students follow a trail of cards "solo." Each card prompts the reader to do and/or think about something related to adaptations.

• ***Related & Different*** (~40 minutes) Grades 5–8.
(http://beetlesproject.org/resources/for-field-instructors/related-and-different/)
Students explore genetic relationships between organisms they find, and learn how these are represented on a "Tree of Life Diagram." This activity helps students develop a foundation for understanding key ideas about evolution.

• ***Mating & Cloning*** (~45 minutes) Grades 5–8.
(http://beetlesproject.org/resources/for-field-instructors/mating-cloning/)
Understanding inheritance and adaptation can give students a new lens through which to see the diversity of life around them. This activity brings to life the concept of inheritance through observation and rich discussion, and builds towards beginning understandings of adaptations and natural selection. Students use a "Field Guide to Mating in Flowering Plants, Conifers, Ferns & Mosses" to find and explore flowers, seeds, berries, cones, and spores (evidence of plant reproduction). They realize that there are plants reproducing all around them! A final discussion focuses on advantages and disadvantages of sexual (mating) and asexual (cloning) reproduction.

• ***Card Hike*** (50+ minutes) Grades 5–8. **[CORE]**
(http://beetlesproject.org/resources/for-field-instructors/card-hike/)
Card Hikes are common activities in outdoor science programs designed to give students a safe "solo" experience in nature and are often powerful and memorable experiences for students. Guided quiet or alone time in the outdoors is one way for students to build their own relationships with nature. A thoughtful *Card Hike* offers students a chance to reflect on and extend their learning and to spend time connecting with nature (and themselves).

2. Script for Adaptations, Structure & Function Field Experiences

Grades 3-8 (adaptable for younger or older students)

Print this script and carry it with you as you lead these field experiences.

2.1 Materials & Preparation

2.2 Introduction to Adaptations Theme (~45-52 minutes) [CORE]

- ***Thought Swap*** (~10 minutes)
- **Introduction to Organisms & Adaptations** (~5 minutes)
- ***Whacky Adapty*** **Name Game** (10 minutes)
- **[Optional]** ***Mind Pie*** (~7 minutes)
- ***Adaptation Intro—Live!*** (~20 minutes)

2.3 *I Notice, I Wonder, It Reminds Me Of* field activity (~45-65 minutes) [CORE]

2.4 *Structures & Behaviors* field activity (~45 minutes) [CORE]

2.5 *Discovery Swap* field activity (~60 minutes) [CORE]

2.6 *Blending In & Standing Out* field activity (45-60 minutes) [CORE]

2.7 More Focused Exploration field activities [OPTIONAL]
Additional BEETLES Activities to Explore Different Organisms (40-60 minutes each)

- **Lichen Exploration** (~45 minutes), Grades 5-8
- ***Fungi Exploration*** (~60 minutes)***,*** Grades 4-8
- ***Spider Exploration*** (~60 minutes)***,*** Grades 3-8
- ***Bird Language Exploration*** (~60 minutes)***,*** Grades 3-8
- ***Interview an Organism*** (~40 minutes)***,*** Grades 5-8

2.8 Deeper Content Field Activities for Older Students [OPTIONAL] (Grade 5 and up)

- ***Related & Different*** (~40 minutes), Grades 5–8
- ***Mating & Cloning*** (~45 minutes), Grades 5–8
- **Card Hike** (50+ minutes), Grades 5–8

2.9 Thought Swap & Reflection (~10-30 minutes) [CORE]

2.1 Materials & Preparation

MATERIALS

For the instructor

- 1 manila folder, large sheet of paper, or portable whiteboard
- marker, large

For each student

- journal
- pen or pencil

PREPARATION

1. Print this script. Print this script to carry with you as you lead the field experiences.

2. Prepare definition signs. On a manila folder or pieces of paper, write in English (and any other language(s) that are primary for your students), the following definitions to hold up as you introduce the definitions to students. :

- "Organism = any living thing"
- "Adaptation = inheritable behaviors and structures that help a group of organisms survive in their habitat"

3. Make a copy of the Structure and Function Crosscutting Concept Poster. (Print a free copy at: https://johnmuirlaws.com/product/crosscutting-concept-poster)

4. Read individual BEETLES activity write-ups, gather other materials you will need for these, and print the Field Cards for each one.

- Each BEETLES activity referenced in this theme field experience sequence includes its own list of materials and preparation steps, an Instructor Support section outlining key concepts and content knowledge, and (a) Field Card(s) to print and carry with you in the field.
- At the beginning of each section in this theme field experience sequence, links to the activity write-ups are included.

2.2 Introduction to Adaptations Theme (~45-52 minutes) **[CORE]**

Thought Swap (~10 minutes) **[CORE]**

Beginning your day. Begin the field experience with your preferred practices for tone-setting, checking in with students, and preparing logistically for the day.

Starting with *Thought Swap* (formerly known as Walk & Talk). Starting with this routine supports social engagement, teamwork, and inclusion, and helps establish a culture of group learning and discussion. Once students know the structure, they can drop into the routine easily throughout the rest of your sessions (as is suggested in this write-up).

Note: See the BEETLES *Thought Swap* activity write-up to lead this activity. (http://beetlesproject.org/resources/for-field-instructors/thought-swap/)

1. **Introduce the *Thought Swap* routine** (as described in the BEETLES student activity write-up).

Adapting Thought Swap to your situation. The moving version of *Thought Swap* works well if you are moving from one location to a different location where you plan to lead the session. If not, use the stationary version. If it's a very short distance between activity sites, arrange students in pairs, and direct them to discuss questions with that one partner. Younger students can struggle with the rotation procedure, so consider always pairing them with no rotation when using this routine.

2. **Lead *Thought Swap* as you move to your first activity site.** Use some of the following questions as an "invitation" to the field experiences theme. This will help students access their prior knowledge about structure, function, and adaptations.
    - *What are different ways animals protect themselves?*
    - *What are different ways plants protect themselves?*
    - *What colors do you think might help animals in this area survive?*
    - *What are different ways animals have of moving around?*
    - *What do deer need to survive?*
    - *What does that tree need to survive?*
    - *If this habitat were to become much dryer, what behaviors or body structures might help some organisms survive better than others?*
    - *What are different ways plants reproduce?*

Avoiding repeating the same questions. Some of the questions listed in this script are the same as those listed in individual field activity write-ups. Simply skip any repeats that may come up.

3. You may choose to use "*Thought Swap*" at any other point in your field experiences when beginning or ending a session, and when moving between activity sites. Use questions included in each individual activity write-up, improvise some questions, or use any included in the Additional Thought Swap Questions category on page 21. It's a great way to keep students thinking about the theme of the sequence throughout their field experiences.

Introduction to **Organisms & Adaptations** (~5 minutes) **[CORE]**

1. **Offer that there are amazing, interesting things everywhere, if we pay attention.**
2. **Hold up the sign with the definition of the word "organism."**
    - Offer to students that "organism" is a word that describes *any* living thing. Ask them to brainstorm names of organisms (eg: organisms can be animals, including slugs, insects, birds, whales, raccoons, crabs, sea anemones, lizards and frogs; plants or organisms like plants, like moss, trees, ferns, flowers, and algae; fungi such as mushrooms, and bacteria).

Using "hard" words. It takes about seven exposures to a word for it to become part of a learner's vocabulary. Ideally, students should hear, speak, read, and write the word. Define the words "organism" and "adaptation" the first few times you use them, and hold up the cards showing their definition. This will help students have a better chance of remembering the word and developing understanding of the concept. "Adaptation" is a trickier concept than "organism," so students will benefit from repeated exposure and reminders throughout your field experiences. When introducing a new word like "organism," it can be useful to use it at first along with the term, "living things," to help students remember what it means, then gradually shift to just using "organism."

3. **Hold up the sign with the definition of the word "adaptation."**
    - Depending on your students' prior experiences, break down the words used in the definition, or guide students in doing so.
    - Tell students that they will spend a sequence of sessions observing organisms/living things, and exploring their adaptations - their behaviors and structures - to figure out how these help the organism survive.
    - They'll also be thinking about how organisms/living things change over time to survive in their habitats, much like scientists would.
    - It's a fun and cool way to look at the world!
    - It also means we're going to need to work as a team, sharing observations and ideas so we can all learn together.

4. **Invite students to look around from where they're standing, notice the organisms that surround them everywhere, and describe one to a partner.**
    a. Look around us! There are amazing, interesting things everywhere!
    b. Take a moment to notice some organisms/living things with a partner, and describe one to a partner.

Keep it moving. Keep this introduction to the theme fairly brief and fast-paced. The point is *not* to tell students everything about adaptations, but to give them a frame for the activities to come.

Getting kids pumped. The idea of exploring and making discoveries about how things work can be exciting for students. Use it to get them pumped up to start the theme field experience.

Whacky Adapty (~10 minutes)
(http://beetlesproject.org/resources/for-field-instructors/whacky-adapty/) **[CORE]**

1. **Lead the name game, *Whacky Adapty* to connect to and help introduce the theme of adaptations, structure, and function.**
2. **After the game be clear about inaccuracies in the game.** When debriefing the activity, remind students that the context of the game is different from the natural world. Even though as players they could choose a different "tool" to make the game easier, individual organisms in the real world can't choose to alter their body structures to be able to survive better. Adaptations are behaviors or structures that are inherited—which means they are passed down from parents to offspring. Individuals who survive pass on their traits that helped them survive, so structures and behaviors can change in populations over generations.
3. **If your students already know each other's names.**
    - If your students already know each other's names well, it's still a fun game to play, as well as a light-hearted introduction to the adaptations theme.
    - If students are able to say names too quickly for the person in the center to tag someone, consider asking each student to choose an organism name instead of their own for the game. This should make it more challenging.
    - If you choose to do this, before starting the game, go around the circle asking each student to share their chosen organism.
    - Ideally each student should have a different organism (and there are so many to choose from!), so if there are duplicates, consider asking some students to choose a different organism.

[Optional] *Mind Pie* (~7 minutes)
Note: See the BEETLES *Mind Pie* activity write-up to lead this activity.
(http://beetlesproject.org/resources/for-field-instructors/mind-pie-2/)

This activity will help prepare students for the kind of learning they'll focus on during the field experiences, and will give you a sense of students' perceptions of their understanding of key concepts, and skills. Lead the activity as written, and include statements from the Adaptations and Evolution category, as well as a few from the Science Practices category.

Suggested prompts related to Adaptations:

- I can explain how an organism's adaptations help it survive in its habitat.
- I can explain how changes in a habitat can cause changes in adaptations.
- I can explain how types of living things evolve over deep time.
- I can explain how all organisms are related and how they are different.

- I can explain how the shape of an organism's body part (like a beak) shows what it's used for.

Suggested prompts related to Science Practices:

- I can participate in a scientific discussion.
- I like exploring outside.
- I can make an explanation based on evidence.

Keeping the momentum. Keep everything you do in the introduction quick and connected to the theme to keep the momentum going and to keep students excited about exploring nature. An introduction is important to frame the experience and set the tone, but it's also important that students get a chance to do something in nature fairly soon.

2. **Introduce and lead the *Mind Pie* activity** (as described in the BEETLES activity write-up).

Using Mind Pie to assess student understanding. This activity helps students access their prior knowledge on the topic, gives them an idea of what to expect during the field experiences, and gives the instructor some information about the group that they can use to make instructional decisions.

Foundational tools for exploring nature. It's important to lead an activity such as *I Notice, I Wonder, It Reminds Me Of* toward the beginning of field experiences because it gives students tools to engage with and explore nature through wonder, curiosity, and a scientific mindset. Those are important and foundational attitudes that will make all the other activities on your field experiences more successful. NSI: Nature Scene Investigators is another BEETLES activity that provides these tools. Students can keep using these tools to explore nature on their own outside of the field experiences.

Adaptation Intro—Live! (~20 minutes) **[CORE]**

(http://beetlesproject.org/resources/for-field-instructors/adaptation-intro/)

Lead the activity as written. Listen to students' statements about what is an adaptation and what is not. Assess their understanding. The concept of inheritance can be particularly tricky. If necessary, put more focus on this idea, to help students continue to build understanding of the concept of adaptation.

Additional Thought Swap Questions

Included here are a few questions you might want to use for further discussion, for moving between locations, or if you have time between activities, and if you think your students would be interested in discussing them:

- *Look around at some of the plants. Notice and describe different leaf shapes and structures to the people next to you.*
- *There are structures in living things that we can't see, because they're very small, or inside their bodies! What are some less visible structures inside of a [deer, mouse, bird, etc.] that help it to survive?*
- *Remember, adaptations are inheritable body structures or behaviors. Look around at some structures. Discuss with your partner whether or not you think they are inheritable. For example, I might say "look, that branch looks broken. That's not inheritable. But the color and texture of the bark, yeah, that's inheritable."*

Listen to students' responses to get a sense of their understanding of these concepts.

2.3 *I Notice, I Wonder, It Reminds Me Of* field activity

(~45-65 minutes). **[CORE]**

Note:

- *If you have already presented this activity with your students, feel free to move on to the next activity.*

See the BEETLES *I Notice, I Wonder, It Reminds Me Of* activity write-up, which comes with a short video, to lead this activity.
(http://beetlesproject.org/resources/for-field-instructors/notice-wonder-reminds/)

1. **Introduce *I Notice, I Wonder, It Reminds Me Of,* and tell students they will learn observation skills that will help them learn about organisms they find.**
2. **Lead the activity as described in the BEETLES activity write-up.**
3. **Afterwards, offer to students that the observation tools they've learned will help them better understand any organisms.**
4. **Remind students to use tools from the activity throughout the field experiences.**
    a. For example, when you come across something interesting, remind students to use the prompts out loud in pairs—for example, "Call out what you notice" or "Use your observation tools."
    b. Or, during an Exploration phase of one of the activities, remind students before you send them out to observe to use these tools during their explorations.

2.4 *Structures & Behaviors* field activity (~45 minutes). Grades 3-8. Adaptable for younger or older students. **[CORE]**

http://beetlesproject.org/resources/for-field-instructors/structures-and-behaviors-2/

- Lead the activity as written. This is an opportunity for students to focus on one organism through the lens of structure, function, and adaptations.
- Use the large-group discussion as an opportunity to get a sense of students' conceptual understanding of adaptation. For example-
    - When students point out a structure and make an explanation of how it functions as an adaptation, are they connecting that explanation to evidence, and the environmental pressures of the organism's habitat?
    - Are the behaviors they are identifying as adaptations inheritable behaviors?
- Use this information to shape your instruction: do students need additional opportunities to apply these concepts, or are they ready to move on to other ideas?

Most Successful Organism Discussion **(7-20 minutes)** Grades 3-8. Adaptable for younger or older students. **[OPTIONAL]**
(http://beetlesproject.org/resources/for-field-instructors/most-successful-organism/)

This is a fun, casual "mini discussion" that can be used to get students generating and sharing ideas in a low-stakes setting, and to help build a culture of discourse and develop discussion skills within a group. It's an interesting and fairly easy topic for students to think about and participate in. Students tend to love talking about the "most," "least," and "how many" facts within nature. The very broad category of "organism" means all students will probably have something to contribute to the discussion. Engaging in this kind of talk can help prepare a group to participate in similar or more involved discussions later, and it can "run in the background" while the group is eating lunch or a snack, or whenever they seem ready to sit and chat.

- Lead the activity as written.

2.5 *Discovery Swap* field activity (~60 minutes) **[CORE]**

(http://beetlesproject.org/resources/for-field-instructors/discovery-swap-2/)
Note: the write-up comes with a short video to help you prepare to lead the activity.

• **Discovery Swap** (~60 minutes)
This flexible, student-centered Exploration Routine gives students an opportunity to search for, observe, research, and share discoveries about organisms. *Discovery Swap* can be used to focus on any type of organism (or even parts of organisms) you choose, such as macroinvertebrates in streams or ponds, plants, insects, under-log organisms, insects caught with nets, seeds, mushrooms, etc.. First, students explore an ecosystem in pairs, collecting and examining many organisms. Then, each pair chooses one organism to study through drawing and recording observations and questions in writing. Students also use tools such as field guides or identification keys (if you have them) to

identify and further research their organisms. Then, in a “Cool Organism Convention”, one member of each pair stays with their organism, while the other member circulates to check out the other organisms. Students discuss their discoveries, questions, and ideas with one another and then, after a few minutes, pairs swap roles so everyone has a chance to look at other organisms and to share about their own.

1. Choose the types of organisms you want your students to focus on during *Discovery Swap* (see examples above).
2. Gather appropriate tools to observe those organisms.
3. To engage students in a search for organisms and then an in-depth study of one particular organism, lead *Discovery Swap* as written in the activity write-up.
4. Integrate the crosscutting concept of Structure & Function into the activity, as described, to better support the group’s understanding of adaptations. Include all the “optional” steps in the session write-up that address Structure & Function.

2.6 *Blending In & Standing Out* field activity [CORE]

(45-60 minutes) Grades 2–8. Adaptable for younger or older students (http://beetlesproject.org/resources/for-field-instructors/blendinginstandingout/)
Colors and patterns in nature are a great entry point to understand adaptations. Students tend to be fascinated by colors and patterns of organisms, and by thinking and learning about these and other adaptive structures and behaviors. This activity focuses on how organisms’ patterns and colors help them stand out or blend in with their environment, and how this helps them survive. Students observe the main colors in the landscape, then search for plastic animals hidden there, noticing which blend in with their surroundings and which stand out. Then, students discuss what made the animals blend in or stand out, construct explanations for how blending in or standing out could help the animals survive. Through discussion they will further their understanding of four categories of color and pattern adaptations: camouflage, mimicry, warning, and attraction. Students apply these concepts as they search for real organisms in the area, then discuss how patterns and coloration might help the organisms survive in their habitat.

This activity builds towards beginning to think about natural selection, and how populations of organisms change over time to have colors beneficial for survival in their habitats.

1. **Lead *Blending in & Standing Out* as written in the activity write-up.**

Note: The next section describes a variety of activities you might choose to lead with your students. Other than *Interview an Organism*, which can be done with any organisms, each activity focuses on a specific type of organism: lichen, fungi, spiders, or birds. Which activities you choose will depend on your site and what organisms are readily available, the time you have, and the interests of your students. For example, if you have lots of fungi present at your

site at the time of year when you plan to present, then you might choose to lead *Fungi Exploration*, but if not, you're probably better off choosing a different activity. Spiders and lichen tend to be present at most sites. *Interview an Organism* can be done with any kinds of organisms. For *Bird Language*, you need an area where students can hear a variety of bird calls.

If you're not going to lead any of those activities, skip to the Thought Swap & Reflection section on page 28, and wrap up the field experiences.

2.7 More Focused Exploration field activities

Additional BEETLES Activities to Explore Different Organisms (40-60 minutes each) **[OPTIONAL]**

1. Lead one or more additional BEETLES activities, to focus on and further explore adaptations in different types of organisms.

• **Lichen Exploration** (~45 minutes) Grades 5-8. Adaptable for younger or older students. (http://beetlesproject. org/resources/for-field-instructors/lichen-exploration-2) Lichen is an interesting example of how a relationship between organisms can be an adaptation to survive. To engage students in studying lichen and discussing the unique relationship between the two organisms that make up lichen (fungi and algae), lead *Lichen Exploration* as written in the activity write-up.

• ***Fungi Exploration*** (~60 minutes) Grades 4-8 (http://beetlesproject.org/resources/for-field-instructors/fungi-exploration/) To engage students in investigating fungi and discussing adaptations of fungi, lead *Fungi Exploration* as written in the activity write-up, with the following exceptions: Skip the Optional: Small Group Discussion of Fungal Impacts on Ecosystems, and instead, lead a discussion about interesting fungi adaptations, how they benefit fungi, and how they might have come to be over time, while using these two provided cards: Turn insects into zombies & Protect then digest leaves.

• ***Spider Exploration*** (~60 minutes) Grades 3-8. (http://beetlesproject.org/resources/for-field-instructors/spider-exploration/) An interesting example of how spiders' ability to build a structure that serves as an extension of their body is an adaptation. Many students are squeamish about spiders. But when you spray spider webs with a water mister, they are easy to see and gorgeous, and just about anyone can get caught up in exploring them! Students explore webs, then learn about different web types, then use a key to identify different kinds of webs. They also make explanations about how the structures of the webs they find function to catch different kinds of prey. Lead *Spider Exploration* as written in the activity write-up.

• ***Bird Language Exploration*** (~60 minutes) Grades 3-8. (http://beetlesproject.org/resources/for-field-instructors/bird-language-exploration/) Bird calls are an interesting example of how the sounds an animal makes can be adaptations. In this activity, students pay attention to bird calls around them. Students think about how bird calls are adaptations to fill needs birds have, and discuss the different messages birds might communicate, then they individually watch and listen to birds from a Sit Spot. When the group gathers again, students compare their observations and make a large map of the bird vocalizations and behaviors they observed. Lead *Bird Language Exploration* as written in the activity write-up.

• ***Interview an Organism*** (~40 minutes) Grades 5-8. (http://beetlesproject.org/resources/for-field-instructors/interview-an-organism/) To focus students on deep observations of a single organism and how it interacts with living and nonliving things in its surroundings, lead *Interview an Organism* as written in the activity write-up.

2. When introducing any of these optional activities, make clear connections to the theme of adaptations, structure, and function.

3. Hold up the Adaptation sign and offer:

- When looking at an organism, think about it's adaptations that help it survive in its habitat.

4. Hold up the Structure & Function poster and offer:

- Looking at structure and function is a way of thinking that scientists often use to understand things.
- Knowing how [lichen, fungi, spiders, etc.]'s structures and behaviors help them survive can give us a deeper understanding of the organism, and of organisms in general.

5. At the end of each activity, tie it back into the theme of adaptations, structure, and function.

Look at the *Thought Swap* questions included at the end of the activity. Make sure there is at least one question that addresses the theme. Do this either by using an existing question, adjusting an existing question, or adding a new question.

2.8 Deeper Content Field Activities for Older Students [OPTIONAL]

Note: If you have students grades 5+, the next section describes 3 optional activities. If you're not going to lead those activities, skip to the Adaptations Thought Swap and Reflection section on pg. 28, and wrap up the field experiences.

Related & Different and/or Mating & Cloning

The activities in this section take the content to deeper levels. To support the Adaptations, Structure & Function Theme, do one or all three of these activities, depending on how much time you have, and the interest and conceptual understanding of your students. In *Related & Different*, students explore genetic relationships between organisms they find, and learn how these are represented on a "Tree of Life Diagram." In *Mating & Cloning*, students explore reproductive strategies in plants. In *Card Hike*, students follow a trail of cards "solo." Each card prompts the reader to do and/or think about something related to adaptations.

Related & Different (~40 minutes). Grades 5–8. Adaptable for younger or older students. (http://beetlesproject.org/resources/for-field-instructors/related-and-different/)

Are you related to a lizard? This Adaptations Activity gives students insights into how very different organisms are actually related (distantly). Students search for two somewhat closely related organisms (like two kinds of insects, or a spider and an insect) to compare, using Venn diagrams. Then they debate which two organisms studied by a team are most closely related, supporting their ideas with evidence and reasoning. Finally, they interpret a "Tree of Life" diagram to see how living things on Earth share common ancestors. This activity helps students develop a foundation for understanding key ideas about evolution. Lead the activity as written, and begin by letting students know they'll learn about what some of the differences in organisms' structures might tell them about the relatedness of those organisms.

Mating & Cloning (~45 minutes) Grades 5–8. Adaptable for older or younger students. (http://beetlesproject.org/resources/for-field-instructors/mating-cloning/)

Understanding inheritance and adaptation can give students a new lens through which to see the diversity of life around them. This activity brings to life the concept of inheritance through observation and rich discussion, and builds towards beginning understandings of adaptation and natural selection. Students use a "Field Guide to Mating in Flowering Plants, Conifers, Ferns & Mosses" to find and explore flowers, seeds, berries, cones, and spores (evidence of plant reproduction). They realize that there are plants mating all around them! A final discussion focuses on advantages and disadvantages of sexual (mating) and asexual (cloning) reproduction.

Card Hike (50+ minutes) Grades 5–8. Adaptable for younger or older students. (http://beetlesproject.org/resources/for-field-instructors/card-hike/)

Lead *Card Hike* (see write-up) with the Adaptations Cards. Lay them out for your students, set up the *Card Hike* protocol, and tell students there will be some cards that help them to think about how adaptations come to be, and are passed on. Let students know the goal isn't for them to memorize everything on the cards but to react to the information, and think about it, along with what else they have learned during the day.

There are more cards related to adaptations available in the *Card Hike* write-up than you'll likely need. There may also be some that your students might find confusing, depending on their prior experiences. Choose those that you think are most appropriate for your group and situation. Be aware that some of these cards build upon each other conceptually, so don't break up "sets" of cards. For example, mutation is a theme that builds conceptually throughout many cards.

1. **As you wrap up any of these activities, help students connect what they learned to the theme, by asking them to reflect on their understanding.**

Boxed feature:

Optional Adaptations Application Discussion Questions

At some point in instruction, consider offering one or two of the questions below to students to discuss, first in pairs, and then in the large group. When students share their answers, ask them for their reasoning, and encourage respectful agreement and disagreement among members of the group.

- *The Rough-Skinned Newt and the California Newt are slow and easy to catch, but they are so poisonous to eat that one could kill 20 people. Yet common Garter Snakes can eat these newts and survive. Why and how might newts have become so poisonous?*
- *Some banana slugs are bright yellow. Some are greenish-yellow with black spots. Do you think banana slug coloration is for camouflage or for warning? How do you think banana slug populations became these colors over time?*

Note: The goal of these discussions is not to find the "right" answer. In fact, these are questions that are still somewhat puzzling to scientists. It is worthwhile for students to discuss these ideas because it will help them to better understand the idea of adaptations, and specifically how it relates to coloration. This will help them to apply the knowledge they've gained, and will begin to build foundational knowledge and curiosity, about how adaptations (behaviors and body structures) develop over time.

2.9 Thought Swap & Reflection (~10-30 minutes) **[CORE]**

1. **Tell students they've been doing some deep thinking and observing about very complex ideas!**
    - Appreciate your students' ability to engage in scientific discussion, and to make observations and explanations about the world around them.
    - Point out that these are transferable skills - that students can look at any living thing and think about how it might survive in its habitat, or how its structures came to exist over many generations.

2. **Highlight Structure and Function as a "big idea" students can apply anywhere.**
   • Remind students that all types of scientists think about the "big idea" of structure and function, not just those who study nature.
   • Challenge students to start thinking about structure and function wherever they go, whatever they're looking at - even things like their desks, toys, or tools around the house or kitchen, can be thought and learned about from this perspective.

3. **Lead a *Thought Swap*, using a few of the following questions to reflect back on the whole sequence of outdoor science sessions:**

Adaptations-related questions:

- *Everybody check out X organism over there. Describe to your partner any adaptations you think it may have.*
- *How might the adaptations (including coloration) of organisms be different in order to survive in an environment like [name a very different environment, like desert, beach, mountain, etc.]?*
- *Whales have a thick layer of blubber. How could this extra layer help them survive in the ocean?*
- *What do you have in common with all organisms? What makes you unique from all other organisms?*

General questions:

- *What were some interesting things we experienced?*
- *Talk about things you enjoyed.*
- *What are some questions you have about organisms or anything else we saw?*
- *Did you learn anything that surprised you? If so, what?*
- *What were some ideas that made you think in different ways?*
- *Think quietly to yourself about things you did that make you feel proud, as well as things you could do better.*
- *Did you notice anyone else doing something that impressed you?*
- *What are some examples of how people treated each other well?*
- *What helped you to learn?*
- *Describe some things you learned.*
- *Describe some things you learned that are not facts. Like different ways to look at or think about things.*
- *If you were to take a family member to this site or one like it, what are some organisms you could show them? What could you show them and teach them about how to observe, think and learn in nature?*
- *Pretend you are talking to a younger person, like a sibling, cousin or friend. Describe to them how to make observations in nature.*
- *Think of some places near your home where you could do these sorts of explorations.*
- *Describe some of the funniest moments.*

4. **[Optional] Return to *Mind Pie*.** If desired, lead *Mind Pie* again, and ask them to consider whether they feel more solid about certain parts of the pie than they did at the beginning of the experience.

3. Instructor Support

FOR ADDITIONAL BACKGROUND, SEE THE INSTRUCTOR SUPPORT SECTIONS OF INDIVIDUAL ACTIVITIES.

3.1 Teaching Knowledge

Multiple exposures make for stickier learning. It's hard to hold onto information you only engage with once. That's one reason why an experience like this theme field experiences sequence, which gives students opportunities to go deeply into content and to apply concepts in new contexts, can be so valuable.

Vocabulary. A themed field experience offers students multiple opportunities to use a related set of words. It takes about seven exposures to a "hard" word for students to fully adopt it. Words are concepts (in general), and students can't learn a concept just by learning the definition of a word. A word without an understanding of what it means isn't very useful. Giving students opportunities to develop an understanding of a concept, then introducing the word for it, and also giving them opportunities to keep using it can help it stick. Ideally, students should be hearing, saying, reading, and writing the word *in context*. Introducing too many hard words at the same time can be counterproductive. Too many such words, especially when only used once or twice, can be confusing for students. It's best to choose just a few hard words to focus on during a sequence of field experiences, offering students opportunities to develop understanding of the concepts, using the words multiple times yourself, and encouraging students to use them. Vocabulary related to the content in the adaptations field experience sequence include: *structure, function, organism, adaptation, habitat, inherit; individual, population, generation; evolve,* and *mutation*. Useful vocabulary related to the science practices students engage in include *evidence, explanation,* and *observation*.

Engaging students in discussion. Discussion is central to meaning-making, and to the activities in this field experience. For students to be able to engage in productive discussion, it's important to set up a culture of discourse in your group, and to give students opportunities to talk in pairs and small groups before participating in a whole-group discussion. To establish a culture of discourse, create and nurture an atmosphere of respect and intellectual curiosity by responding equitably to students' ideas as a facilitator, and by facilitating—*not* dominating—the discussion. When you respond to students, do so in a neutral, accepting manner, then probe their thinking with follow-up questions. Encourage respectful agreement and disagreement, and establish that, when there is disagreement about ideas, students will not be ridiculed for giving the "wrong" answer. Emphasize that sharing ideas as a group is an important part of the learning process. And keep the discussions interesting! Be on a constant lookout for ideas that may be of interest to your students, as well as perspectives that may help them shift their thinking. Shift between pair talk, small-group talk, and whole-group talk to encourage participation and interest. For more on how to specifically create an equitable learning culture

for discussion, see the BEETLES website-
http://beetlesproject.org/resources/integrating-discussion-instruction/.

Exploration leads to curiosity. All individual BEETLES activities give students a chance to explore before diving into content. If you plunge straight into content, you're skipping the phase where students touch, feel, smell, and wonder about the organisms they're exploring. They need to become curious and develop a real desire to understand the organisms they're investigating. Exploration primes students for the deeper meaning-making they do later in each activity.

3.2 Conceptual Knowledge

The following information is meant as background to help you better understand adaptations, structure, function, and other key concepts that relate to this field experience. They are *not* talking points for a lecture, nor lists of concepts students should understand.

Adaptations are the result of evolution in a species, not in a single individual. An organism does not decide to produce adaptations. A species can't develop adaptations over the course of a few months or years. Species do not develop adaptations because they want or need them. Certain genetic changes help organisms survive and reproduce, and to pass on these changes to future generations. These characteristics then become new adaptations of the species. *Populations* can be said to adapt as a result of changes in habitat, or changes in the adaptations of other species in their habitat. This is because the conditions for survival have changed, and as a result, different variants in the population of the species are more successful in reproducing.

An important distinction for understanding both the mechanisms for heredity and its role in evolution is the idea of acquired versus inherited characteristics. Inherited characteristics are the result of the genes in the individual. Acquired characteristics come from its experience and interactions with its environment. For example, injuries like a broken bone, learned skills like riding a bicycle and temporary changes, like a haircut, are all characteristics that don't affect a person's genes. These are examples of acquired characteristics. Some characteristics are harder to categorize because they may be partially inherited and partially acquired. Language in humans is a good example of this. Human brains are genetically engineered to process and produce language (inherited), but one must be taught the specific words and symbols used in one's cultural group to be able to speak a language and be understood (acquired).

Not all characteristics of a species are considered to be adaptations. Adaptations are only those characteristics that have evolved through the process of natural selection that provide a survival advantage to the population. Other characteristics exist just because they are carried over from past generations, and don't provide a survival advantage. For example the wings of flightless birds are not considered adaptations in those species, because they no longer help the animal to survive, and therefore cannot be "selected."

Natural selection is the process by which the organisms with the most favorable genetic adaptations out-compete other organisms in a population, and displace the less-adapted organisms. It's easy to imagine how the environmental factors in a habitat, such as the temperature or the types of predators, can influence which individuals of a species survive. Due to random genetic variation within a species (from reproduction or mutations), some individuals may have characteristics that enable them to survive better to reproduce in the particular set of conditions in a habitat. For example, those with thicker fur might survive decreasing temperatures, or those with thicker skin might survive bites from a predator better. Over many generations, these individuals with characteristics more suited to survival in the habitat will reproduce more successfully. Over time this causes a shift in the population toward individuals that have the adaptive characteristics (e.g., thicker fur or skin). The driving force behind adaptation and evolution is not the desire or needs of individuals or species, but a combination of evolutionary processes; genetic variation, natural selection and the inheritance of genetically determined characteristics.

The process of natural selection can be misunderstood. It's tempting to think of it as a force driving species to become more advanced or perfected. The truth is that species do not need to be perfect to survive. Think about the genetic diseases that humans have or how certain plants are susceptible to particular types of pests. Realistically, natural selection should not be called "survival of the fittest", but survival of the "good enough to pass on their genes."

Students should understand that the processes of evolution do not have a goal and do not produce "better" organisms over time. Some students may even think that the purpose for the development of new species through adaptation was to eventually produce humans. Generally, life tends to evolve from less complex to more complex (i.e., from single-celled to multi-cellular organisms). So it is true that human body processes are more complex at the cellular level than in their ancestors, but, biologically speaking they are not more advanced than any other living organism. There is no aim to evolution. It happens automatically as certain organisms are able to have more offspring that survive in particular habitats. To quote one educational resource, "Evolution is a tinkerer, not an engineer."

A basic understanding of inheritance and the role of genes is an important part of understanding mechanisms for evolution. Knowing that characteristics are passed from parents to young through genes will help students understand how adaptive traits are passed onto future generations. Understanding that new variations of organisms are often formed through reproduction, helps lay a foundation for understanding that natural selection can only take place when there are new characteristics introduced into populations. This idea also helps combat the common misconception that variations occur as a response to changes in the environment. The variation is always there, but selective pressures, such as changes in the environment, can select for certain traits to be more successful. This series of field experiences doesn't take students deep enough to fully understand how variation occurs through mutation, but the most extended version, which includes the *Card Hike* activity, will begin to expose students to that idea.

Almost every cell in the body has a complete set of genes in its DNA, so all cells contain the information needed for the whole body. In species that reproduce sexually, such as humans, an offspring is made from combining the egg cell from the mother (containing copies of half of her DNA) and the sperm cell from the father (containing copies of half of his DNA). This combined set of DNA, from both the mother and the father, produces the full set of genes needed by the new individual. Every time an egg and sperm join, a new combination of genes is created, which means every individual has a unique set of genes. Identical twins are exactly alike genetically, because the same fertilized egg splits into two individuals. Species that reproduce asexually, by cloning or budding, also have identical genes, since they are exact replicas of the parent organism. Sexual reproduction, along with spontaneous genetic mutation, is the primary mechanism for producing variation among species.

What's the difference between "ecosystem," "habitat," and "environment"? It's easy to confuse these terms, because they overlap, but each has a slightly different meaning.

- **Environment** is all the living and nonliving things that surround an organism or an ecosystem. It can refer to nature as a whole, or a specific part of nature.
- **Ecosystem** is all the living and nonliving things that interact with each other in a particular environment. Examples: "desert ecosystem," "tropical rainforest ecosystem," or "coral reef ecosystem."
- **Habitat** is the *home of a particular type of organism*. A habitat is the area that includes all the living and nonliving things that a type of organism needs to survive. Examples: "the chickadee's habitat," or "the rock crab's habitat." The habitat of wolves can be very large. The habitat of a type of bird that migrates can be one place in the summer and a different place in the winter.

MISCONCEPTIONS

If you can help improve students' understandings on a few of the misconceptions listed below, you've done well!

Common Relevant Misconceptions

Misconception. An individual organism can adapt.

More accurate information. This is the most prevalent misconception about adaptations. In common English usage, the word "adapt" does refer to something an individual can do, e.g. "I moved to a new school and I adapted by making new friends." In scientific usage, populations of organisms adapt over generations, but individuals don't. Adaptations are behaviors or structures an organism inherits from its parents that provide a survival and reproductive advantage in its environment. An individual organism can't acquire an adaptation during its' life span - the adaptation is something inherited. If a person works out a lot and develops big muscles, that person's children will not inherit big muscles, so it's not an adaptation. An adaptation must be something an organism inherits, like long legs. If longer legs help organisms run faster, survive

and have more offspring than those with shorter legs, then longer legs may eventually become an adaptation and spread throughout the population.

Misconception. Species that become extinct are failures and those that survive are successes.

More accurate information. In fact, any species that has ever existed was successful at surviving in its habitat, but habitats change. Dinosaurs were the dominant terrestrial vertebrates on Earth for 135 million years, which was a pretty darned good run. Our own species has only been around for a few hundred thousand years.

Misconception. Evolution is a gradual march toward superior species, concluding with humans, the crowning achievement.

More accurate information. Humans are more complex, but no more advanced than single-celled organisms. Each is well-adapted to its own particular niche. In evolutionary terms, single-celled organisms might be considered more successful than humans, considering how long they have been around, as well as sheer numbers.

Connections to the Next Generation Science Standards
Note: Students should have multiple experiences with science and engineering practices, crosscutting concepts, and disciplinary core ideas in order to reach full understanding. Their field experiences should be connected to other in-school activities.

Featured Crosscutting Concepts: Structure and Function, Stability and Change

At the 3-5 and 6-8 level, students should be engaging with Structure and Function at the following level:
Different materials have different substructures, which can sometimes be observed. Substructures have shapes and parts that serve functions; complex natural and designed structures/systems can be analyzed to determine how they function.

At the 3-5 and 6-8 level, students should be engaging with Stability and Change at the following level:
Some systems appear stable, but over long periods of time will eventually change; Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Featured Science and Engineering Practices:

- Asking questions
- Constructing explanations
- Obtaining, evaluating, and communicating information

These activities don't "cover" any of these practices, or fully develop students' ability to use the practices. Students should be using these practices consistentlys to learn science and deepen their understanding of disciplinary core ideas, while they apply crosscutting concepts.

Featured Disciplinary Core Ideas:

- LS3.A Inheritance of traits and LS3.B Variation of traits.
    - 3-5: Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.
    - 6-8: In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.
- LS4.B Natural selection.
    - 3-5: Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing.
    - 6-8: Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.
- LS4.C Adaptation.
    - 3-5: Particular organisms can only survive in particular environments.
    - 6-8: Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.