Stage of the Instructional Model	The BSCS 5E Instructional Model What the Teacher Does	
	That is consistent with this model	**That is inconsistent with this model**
Engage	▪ Creates interest ▪ Generates curiosity ▪ Raises questions ▪ Elicits responses that uncover what the students know or think about the concept/topic	▪ Explains concepts ▪ Provides definitions and answers ▪ States conclusions ▪ Provides closure ▪ Lectures
Explore	▪ Encourages the students to work together without direct instruction from the teacher ▪ Observes and listens to the students as they interact ▪ Asks probing questions to redirect the students' investigations when necessary ▪ Provides time for the students to puzzle through problems ▪ Acts as a consultant for students	▪ Provides answers ▪ Tells or explains how to work through the problem ▪ Provides closure ▪ Tells the students that they are wrong ▪ Gives information or facts that solve the problem ▪ Leads the students step-by-step to a solution
Explain	▪ Encourages the students to explain concepts and definitions in their own words ▪ Asks for justification (evidence) and clarification from students ▪ Formally provides definitions, explanations, and new labels ▪ Uses students' previous experiences as basis for explaining concepts	▪ Accepts explanations that have no justification ▪ Neglects to solicit the students' explanations ▪ Introduces unrelated concepts or skills
Elaborate	▪ Expects the students to use formal labels, definitions, and explanations provided previously ▪ Encourages the students to apply or extend the concepts and skills in new situations ▪ Reminds the students of alternate explanations ▪ Refers the students to existing data and evidence and asks: What do you already know? Why do you think…? (Strategies from Explore apply here also)	▪ Provides definitive answers ▪ Tells the students that they are wrong ▪ Lectures ▪ Leads students step-by-step to a solution ▪ Explains how to work through the problem
Evaluate	▪ Observes the students as they apply new concepts and skills ▪ Assesses students' knowledge and/or skills ▪ Looks for evidence that the students have changed their thinking or behaviors ▪ Allows students to assess their own learning and group-process skills ▪ Asks open-ended questions such as, Why do you think…? What evidence do you have? What do you know about x? How would you explain x?	▪ Tests vocabulary words, terms, and isolated facts ▪ Introduces new ideas or concepts ▪ Creates ambiguity ▪ Promotes open-ended discussion unrelated to the concept or skill

Stage of the instructional model	The BSCS 5E Instructional Model What the Student Does	
	That is consistent with this model	**That is inconsistent with this model**
Engage	▪ Asks questions, such as Why did this happen? What do I already know about this? What can I find out about this? ▪ Shows interest in the topic	▪ Asks for the "right" answer ▪ Offers the "right" answer ▪ Insists on answers or explanations ▪ Seeks one solution
Explore	▪ Thinks freely, but within the limits of the activity ▪ Tests predictions and hypotheses ▪ Forms new predictions and hypotheses ▪ Tries alternatives and discusses them with others ▪ Records observations and ideas ▪ Suspends judgment	▪ Lets others do the thinking and exploring (passive involvement) ▪ Works quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) ▪ "Plays around" indiscriminately with no goal in mind ▪ Stops with one solution
Explain	▪ Explains possible solutions or answers to others ▪ Listens critically to others' explanations ▪ Questions others' explanations ▪ Listens to and tries to comprehend explanations that the teacher offers ▪ Revisits initial explanations and can revise them to reflect new understandings ▪ Refers to previous activities ▪ Uses recorded observations in explanations	▪ Proposes explanations from "thin air" with no relationship to previous experiences ▪ Brings up irrelevant experiences and examples ▪ Accepts explanations without justification ▪ Does not attend to other plausible explanations
Elaborate	▪ Applies new labels, definitions, explanations, and skills in new but similar situations ▪ Uses previous information to ask questions, propose solutions, make decisions, and design experiments ▪ Draws reasonable conclusions from evidence ▪ Records observations and explanations ▪ Checks for understanding among peers	▪ "Plays around" with no goal in mind ▪ Ignores previous information or evidence ▪ Draws conclusions from "thin air" ▪ In discussion, uses only those labels that the teacher provided
Evaluate	▪ Answers open-ended questions by using observations, evidence, and previously accepted explanations ▪ Demonstrates an understanding or knowledge of the concept or skill ▪ Evaluates his or her own progress and knowledge ▪ Asks related questions that would encourage future investigations	▪ Draws conclusions, not using evidence or previously accepted explanations ▪ Offers only yes-or-no answers and memorized definitions or explanations as answers ▪ Fails to express satisfactory explanations in his or her own words ▪ Introduces new, irrelevant topics

Tool 4 Template Example – 5E Learning Sequence Outline

Unit: *Ecosystems: Interactions, Energy and Dynamics*
Instructional Sequence: *1-Wolves in Yellowstone*

Guiding Question: *What happens when a predator comes back into an environment?*
Resources: *Yellowstone food web cards and data sheet*

What science (and engineering) content will be developed during this learning sequence? **Note**: This information comes from Tool 1	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts and Connections**
	Constructing Explanations: Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	**MS LS2.A:** Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns**: Patterns can be used to identify cause and effect relationships.
What connections will be made? **Note**: This information comes from Tool 1	**Engaging in Argument from Evidence**: Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**MS ESS3.C:** Typically as human populations ~~and per-capita consumption of natural resources~~ increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause & Effect**: Cause and effect relationships may be used to predict phenomena in natural or designed systems. (**Connections to Engineering, Technology and Applications of Science**): All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. (**Connections to the Nature of Science**): Science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.
Performance Expectations **Note**: This information comes from Tool 1	**MS-LS2-2** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-ESS3-4** Construct an argument supported by evidence for how increases in human population ~~and per-capita consumption of natural resources~~ impact Earth's systems.		

Tool 4 Template Example – 5E Learning Sequence Outline

What prior knowledge is crucial as a foundation for the learning sequence? **Note**: Review the previous grade band(s) for core idea	**LS2 A.** From K-2: Plants depend on water and light to grow; plants depend on animals for pollination or to move their seeds around. From 3-5: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals each the animals that eat plants. **LS1 C.** From K-2: All animals need food in order to live and grow. They obtain their food from plants and from other animals. **LS4 D.** From K-2: There are many different kinds of living things in any area, and they exist in different places on land and in water. From 3-5: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.
Common Student Ideas **Note**: These ideas come from your experience teaching the topic, and the research on student ideas in science. Sources may include: *Atlas of Science Literacy*, AAAS *Making Sense of Secondary Science*, Driver	Students may think plants are dependent on humans, rather than humans (and all other animals) are dependent on plants. They may think predator and prey populations are similar in size OR that the relative sizes of predator prey populations have no bearing on the size of the other. Students may think varying the population size of a species may not affect an ecosystem because some organisms are not important. They may think that ecosystems are not a functioning whole but simply a collection of organisms instead of thinking that ecosystems include not just the organisms but also the interactions between organisms and between the organisms and their physical environment.

Tool 4 Template Example – 5E Learning Sequence Outline

Engage: The teacher or a curriculum task helps students become engaged by a natural phenomenon through the use of short activities that promote curiosity and elicit prior knowledge about the phenomenon and associated concepts. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of activities in the instructional sequence.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts DCI , CCC, PE
At the beginning of the lesson ask students to briefly describe what animals and plants need in order to live and grow. To generate interest in the topic, invite students to think about a local environment near their school. Facilitate students charting their responses, and have groups compare their lists to other groups' lists. Show a video about the reintroduction of wolves in Yellowstone National Park (National Geographic Video – wolves, bison and ranchers in Yellowstone). Show students Interactive Map: Where Yellowstone Wolves Roam (website from PBS Nature). Asks students if they think the wolves stay within park boundaries. Ask students to consider whether people should be allowed to hunt wolves, and whether people should act to restore wild ecosystems. Chart students' questions about the interactions between animals and people in Yellowstone.	Student response: living things need food, air and water. Students work in groups to consider what they know about a local environment near their school (such as a playground, park, or garden). They list the possible interactions among the living and non-living things and share their ideas with the class (**SL.8.1**). Students watch video and read two paragraphs of text to learn story that all the wolves were gone from the park by 1930 due to overhunting, but that these animals were reintroduced into the park in 1995. **Construct an explanation that includes qualitative relationships between variables that predict and describe phenomena** In pairs, students discuss how reintroducing the wolves might affect the park and the tourists, cattle ranchers, and local residents who live nearby. They list other animals that live in Yellowstone based on what they saw in the video, and discuss how the wolf presence might affect the numbers and distribution of these other animals (**SL.8.1**). Student Response: Animals such as wolves, grizzly bears, moose and deer will not likely remain within the park boundaries. **Construct an oral argument supported by scientific reasoning to support or refute a solution to a problem** Students argue about whether people should be allowed to hunt wolves, and whether people should act to restore wild ecosystems. Student Response: Wolves should not be hunted since there are only about 100 within the park or wolves should be hunted since they can post a threat to cattle and people outside the park boundaries.	**Anchor Phenomenon:** Wolves were reintroduced to Yellowstone Park in 1995 and since then the numbers of several different organisms have been affected with some populations increasing and some decreasing. **Guiding Question:** *How do living things, including humans, interact with each other and with non-living things in an environment?* Animals and plants live in variety of environments; humans are part of and can affect that environment. Animals need air, water and food - they eat plants and other animals. Plants also need food, which they make from air, water and sunlight.

Linking question from Engage to Explore: What patterns do we see in the ways organisms interact with each other?

Tool 4 Template Example – 5E Learning Sequence Outline

Explore: Experiences in the Explore phase provide students with a common base of activities within which students wrestle with their current conceptions about a natural phenomenon through the science and engineering practice identified in the performance expectation. Learners may complete activities that help them use prior knowledge to generate new ideas, explore questions, and/or design and conduct an investigation.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts DCI , CCC, PE
Ask students to brainstorm and review the list of Yellowstone organisms they had generated in the previous lesson. As animal interactions are described, draw food chain, and then a food web on the board (based on student ideas). Distribute Yellowstone cards for bison, beaver, coyote, elk, cowbird, bear, snowshoe hare, and winter tick. After students have had time to predict the food web, give students an information sheet that lists what the various organisms in the food web eat. Key Questions: • Which organisms play a similar role? Describe these roles. • What do you predict would happen to the food web if all the plants died? Give students the Gray Wolf food web card.	**Use a model (a food web) to describe phenomena** Students receive Yellowstone Food Web cards for certain organisms and are asked to sort the cards into groups and explain their groupings to each other. Students arrange the cards into a food web, and predict what each animal might eat, and record it in their science notebooks. They compare their food webs with those of other groups and reflect on similarities and differences. Using the information sheet, students revise their food webs, according to the new information and record their revisions. In their groups they discuss the patterns of interaction among the organisms in the food web (**SL.8.1**). Ideal Student Responses: • The beaver, the elk, the hare and the bison all eat plants • If all the plants died, animals like the hare wouldn't have food, and then animals like the coyote, that eat small animals like the hare, might also die. **Construct an explanation that includes qualitative relationships between variables that predict and describe phenomena** Students think about the reintroduction of the wolf and how it will affect the food web by adding the wolf card to their model, and discussing/predicting which interactions it might affect. The also add bacteria, humans and cattle to think about how they might affect the food web too.	**Anchor Phenomenon:** The population of wolves in Yellowstone affects the population of many other organisms, not just the ones they eat. **Guiding Question**: *What impact can an organism have on the interactions between other organisms in a food web?* Food webs can represent patterns of feeding relationships among organisms in an environment. Cause and effect relationships represented in a food web may be used to predict phenomena.

Tool 4 Template Example – 5E Learning Sequence Outline

Key Questions: ● Which animals eat other animals for food? ● Which animals compete for the same food? ● What is an example of a helpful relationship between two animals? ● What effect do you think restoring wolves had on the elk? The small animals? The plants? Note: questions should help students describe the patterns of interactions. Discuss the local environment from the previous lesson with students.	Ideal Student Responses: ● Cowbirds, coyote, bear, and wolves eat other animals. ● Beaver, elk, bison and hare compete. The bear, coyote and wolf compete. ● The cowbird eating winter ticks is helpful to the animals the tick lives on, like bison. ● The wolves might cause the elk and the hares to go down since that is a food source for them; since wolves eat the plant-eaters, this might indirectly lead to *more* plants Students construct a food web of the organisms in their local environment (from the previous lesson).	

Linking question from Explore to Explain: What similar patterns are there between how the organisms interact in the Yellowstone food web and how the organisms interact in your local environment?

Tool 4 Template Example – 5E Learning Sequence Outline

Explain: During the Explain phase students are provided opportunities to demonstrate their conceptual understanding and use of science and engineering practices. In this phase teachers or instructional materials employ sense-making strategies and introduce academic language. An explanation from the teacher or other resources may guide learners toward a deeper understanding, which is a critical part of this phase.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts **DCI , CCC, PE**
Ask students to share some examples of Yellowstone food web interactions from the previous lesson. Show three videos about patterns of interactions between organisms: • Video 1 from PBS - *predator-prey* • Video 2 from National Geographic - *competition* • Video 3 from Untamed Science - *symbiosis* (including *mutualism*, *commensalism* and *parasitism*). After each video, have students record definitions of the terms onto a note-taking sheet, and list the organisms from the video. Give students a reading with information similar to what was in the videos, and allow students to revise their definitions and list additional examples of organisms that follow each pattern of interaction (model an example of how to review the definition for predator-prey). Give students matching activity to identify relationships using this new terms. Ask students to identify the patterns of relationships from the Yellowstone food web using the new scientific terms (create a chart for them to fill out together). Ask them to explain how humans interact with other organisms in predator-prey, competitive, and mutualistic relationships.	Example student response: wolves and coyotes eat elk and bison. Students use graphic organizer (worksheet) to take notes about organism relationships in the videos. In groups they create their own definitions based on the videos and provide examples from of each type of interaction Then students work with their partner to read the text. With their group they revise their definitions. **(SL.8.1)** Ideal Student Responses: *predator-prey* (feeding relationship where one animal kills and the other is killed; ex. bear eats a fish) *competition* (two or more species require the same limited resources; ex. European green crabs and native green crabs compete for food) *symbiosis* (*commensalism* - helps one species and doesn't help or harm the other, *mutualism* - helps both species involved, *parasitism* - benefits one species (parasite) and harms the other (host); ex. tapeworms are parasites that live inside the intestine of an animal host Students are given a list of organisms and descriptions of their relationships, and have to match each example with a pattern of interaction from their graphic organizer (ex. "mountain lions eat deer" is matched with *predator-prey*). Students revisit the Yellowstone food web and identify different types of interactions that include how humans interact in the food web.	**Anchor Phenomenon:** Wolves and coyote have a relationship, even though neither one of them eats the other. **Guiding Question**: *What types of interactions occur between organisms?* While the individual organisms in different environments may vary, the patterns of interactions (relationships) between organisms are consistent across different environments. These relationships between organisms, including humans, can be predatory, competitive or mutually beneficial.

Tool 4 Template Example – 5E Learning Sequence Outline

Key Questions: Complete the Chart

Pattern of Interaction	Example in Yellowstone	Example of how humans interact with another species
Predator-Prey		
Competition		
Mutualism		

Wrap-up lesson with discussion about Yellowstone before and after the reintroduction of the wolves.

Key Question:

Explain the impact of humans on the food web in and near Yellowstone National Park during each of the following time periods. Use the scientific terms you learned in this lesson to explain the interactions between humans and other organisms.

a. From late 1800s to 1994

b. From 1995 to the present

Ideal Student Responses:

Pattern of Interaction	Example in Yellowstone	Example of how humans interact with another species
Predator-Prey	wolf and beaver	Humans are predators that eat prey such as fish
Competition	elk and bison	Humans compete with other predators such as wolves for prey such as bison; they also compete with other organisms for space
Mutualism	cowbird and bison	Humans raise bees for honey and bees pollinate important commercial crops

Construct an explanation that includes qualitative relationships between variables that predict and describe phenomena.

Critically read scientific texts adapted for classroom use to determine the central ideas and obtain scientific information to describe patterns in and evidence about the natural world.

Ideal Student Response:

a. Yellowstone was established in 1872, which led to increases in some organisms in the food web such a bison. People were not harmed or helped while the protected animals were helped. This was commensalism. At the same time people competed with wolves and bears for animals such as deer and also killed wolves and bears. By 1930 there were no wolves in the park.

b. Wolves were re-introduced into the park; this helped the wolf population to recover. This probably caused their prey populations to decrease.

Linking question from Explain to 2nd Explore: What data can we analyze in order to better understand these patterns of interactions between populations?

Tool 4 Template Example – 5E Learning Sequence Outline

Explore Experiences in the Explore phase provide students with a common base of activities within which students wrestle with their current conceptions about a natural phenomenon through the science and engineering practice identified in the performance expectation. Learners may complete activities that help them use prior knowledge to generate new ideas, explore questions, and/or design and conduct an investigation.

What **teacher** is doing (including a brief description of the activity and key questions)	What students are doing (including ideal student response to selected questions/tasks) Identify SEP as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts DCI , CCC, PE
Tell students that they will shift from thinking about individual organisms to thinking about populations of organisms. Engage students in a review of interactions among organisms in Yellowstone. Key Question: • What kinds of data might help us learn more about the patterns of interactions they were studying in the previous lesson? • What do you predict that the data will show? Provides students with data, which they plot on graph paper. SOURCE: National Park Service. (2015). *Winter Count of Northern Yellowstone Elk.* Prompt students to think about what may have caused the fluctuations they see (the *overall* pattern does show the trend they may have predicted, but the data is more complex than that). Share with students that another factor may have affected the elk population--snow accumulation. Discuss with students how snow may have affected the elk – ask them to make a prediction before presenting the data to them. Students briefly discuss what they expect to see in the data and then graph the snow data with the elk population data. Help students make sense of the data; ask them what may have caused these patterns and trends to occur. Tell students they will continue to think about the impact of wolves in Yellowstone in the next lesson.	Students review the Yellowstone Food Web and their notes from the previous lesson. Ideal Student Response: • Wolves and elk have a predator-prey interaction. We would want to see information about the quantity of each species in the park over time. • We predict we will see an increase in wolves over time and we expect to see a decrease in the elk since 1994. **6.SP.B.5 (Summarize and describe distributions)** **Summarize numerical data sets in relation to their context.** **Analyze and interpret data to provide evidence for phenomena** Students analyze Wolf and Elk data in Yellowstone to look at the pattern of interaction in a predator-prey relationship. Students analyze snow accumulation and Elk population data in Yellowstone to look at the impact of a non-living factor on a population. Students write a paragraph (exit slip or homework) summarizing how their graphs helped them understand how living and non-living factors affect populations.	**Anchor Phenomenon:** Snow affects elk populations, which then affects wolf populations. **Guiding Question**: *How do living and non-living factors affect populations?* Patterns consistent with predator-prey relationships can be observed in population data. Non-living factors can also affect populations.

Linking question from 2nd Explore to 2nd Explain: What evidence-based claims can we make about the overall impact a predator has on an ecosystem?

Tool 4 Template Example – 5E Learning Sequence Outline

Explain: During the Explain phase students are provided opportunities to demonstrate their conceptual understanding and use of science and engineering practices. In this phase teachers or instructional materials employ sense-making strategies and introduce academic language. An explanation from the teacher or other resources may guide learners toward a deeper understanding, which is a critical part of this phase.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts DCI , CCC, PE
Ask students to summarize the story of the wolves in Yellowstone. Provide a reading about the growing population of wolves in the greater Yellowstone region, and the concern about the wolves eating not just elk but also deer, moose, bison and sometimes even livestock and pets. The reading introduces the terms *ecosystem*, *biotic* and *abiotic.* Post question, "Does reducing a predator population have a positive or negative impact on an ecosystem?" Ask students to discuss what additional data would be helpful to address this question. Provide students with data that show the increase in population of some of the other organisms in the Yellowstone food web (various bird species, trees and other plants, etc.). Key Question: Why do you think the bird and plant populations increased? Share a graph that displays four sets of data: the estimated wolf population from 2004-2014, the wolf population at the end of each year, the total number of wolf deaths caused by humans, and the total number of livestock and pets killed by wolves. SOURCE: Northern Yellowstone Cooperative Wildlife Working Group. (2013). *Annual Report*. SOURCE: U.S. Fish and Wildlife Service. (2014). *Rocky Mountain Wolf Recovery 2014 Interagency Annual Report.*	Students turn and talk to a partner; they describe the story of the wolves in Yellowstone. Ideal Students Response: Humans killed the wolves due to concerns about their effect on wildlife, pets and human safety and by 1930 they were all gone; after the wolves were reintroduced in 1995 they increased in number; their predator-prey relationship with the elk caused an overall decrease in the elk population. Students list the type of data that would help them including population data for other organisms in the Yellowstone food web, as well as information about humans. Ideal Student Response: Populations of birds such as the flycatcher increased as their home, the Aspen trees, grew more abundant. This increase in the plant population was due to the decrease in the elk (observed in the data from the previous lesson). Next students will look at the data on the distribution of wolf packs, cattle ranchers and human populations in the greater Yellowstone ecosystem, number of wolf deaths caused by humans, and the number of livestock and pets killed by wolves. **6.SP.B.5 (Summarize and describe distributions)** **Summarize numerical data sets in relation to their context.** Students work in groups to summarize what the data is showing.	**Anchor Phenomenon:** Humans have killed wolves at one time in history and reintroduced them to Yellowstone at another point in history. **Guiding Question**: *Does reducing a predator population have a positive or negative impact on an ecosystem?* Humans can disrupt the patterns of interactions between predator-prey populations and affect ecosystems.

Tool 4 Template Example – 5E Learning Sequence Outline

Post the argument question in the front of the room: "Did wolf deaths caused by humans (ranchers, hunters and park rangers) have a positive or negative impact on the greater Yellowstone ecosystem?" Post the positive claim on one side of the room and the negative claim on the other. Facilitate "Walking Debate." Support students with using Accountable Talk throughout the discussion. Remind students to consider which evidence best supports their side of the argument. Point out to students that as they critique each other's evidence, that this is reasoning – using their science concepts to think about which evidence is stronger. Debrief the experience with students; ask them to reflect on how engaging in argument helped them understand what happened to the ecosystem in Yellowstone.	**Construct an oral argument supported by empirical evidence and scientific reasoning to support or refute an explanation for phenomena.** **RST.6-8.1, WHST.6-8.1, WHST.6-8.9** Students engage in an argument. They participate in a Walking Debate in which they move to the side of the room with the claim they think is best supported by the evidence; they are allowed to switch sides at any time. After the debate students write a summary of the best lines of evidence they heard during the walking argument activity.	

Linking question from 2nd Explain to Elaborate: How might the reintroduction of a predator into a different ecosystem affect the patterns of interactions among organisms there?

Tool 4 Template Example – 5E Learning Sequence Outline

Elaborate: Teachers or instructional materials challenge and extend students' conceptual understanding and use of science and engineering practices during the Elaborate phase. Through new experiences, the students develop deeper or broader understanding by applying their understanding or practice in a new context. During the Elaborate phase teachers may emphasize the crosscutting concept in the foreground of the instructional sequence.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts **DCI , CCC, PE**
Share with students that people are considering reintroducing the wolf into the northeastern United States. Ask students what information they would need to answer the question, "What is the impact of reintroducing a predator in an ecosystem that also includes humans?" Provide students with data that shows the population of white-tail deer over time in the U.S. Also provide additional reading about how humans have affected the deer population, and the variety of negative impacts that increased populations of deer are having on the ecosystem (both biotic and abiotic factors). SOURCE: U.S. Fish and Wildlife Service: *Northern Rocky Mountain Wolf Recovery Program 2014 Interagency Annual Report* Introduce students to the Explanation Tool. Provide sentence stems for each of the components on the tool to help students get started. After students have completed the Tool for their explanation about deer, select a few students to share out their responses on the document camera – provide feedback.	Ideal Student Response: To learn about a predator's impact on an ecosystem we need background knowledge about the ecosystem, data about existing populations including humans, and more information about the patterns of interactions among those factors. **6.SP.B.5 (Summarize and describe distributions)** **Summarize numerical data sets in relation to their context.** Students gather in pairs to discuss the deer population data and the reading. **Construct an explanation that includes qualitative and quantitative relationships between variables that describe phenomena** They construct a scientific explanation using the Explanation Tool (a graphic organizer that provides a scaffold for students to write Claims, Evidence and Reasoning) about the effect of large populations of deer on the forest ecosystem in the Adirondacks using quantitative evidence from the reading. Ideal Student Response: We are investigating the question: What is the effect of large populations of deer on ecosystems? My claim is that when a population of deer becomes too large, it can cause damage to an ecosystem. The evidence for this is based on studies showing that large deer populations cause overgrazing of plants, which can cause a reduction in the populations of some birds. These relationships are explained by the role of deer as consumers and by the concept of competition between organisms. These concepts lead me to reason that too many deer harm both the plants and other organisms that need the plants for food or shelter.	**Anchor Phenomenon:** Scientists are considering reintroducing wolves into the Adirondacks, but think that they will affect the ecosystem in different ways than in Yellowstone. **Guiding Question**: *What impact can reintroducing a predator have on an ecosystem that includes humans?* By examining both the natural and human-caused patterns of interactions between populations in an ecosystem, predications can be made about the effect of reintroducing a predator in an ecosystem.

Tool 4 Template Example – 5E Learning Sequence Outline

Provide students with the Explanation Tool again; ask them to identify patterns of interaction in the Adirondack ecosystem using the reading and the data, and to identify the cause and effect relationships that help them predict the impact wolves might have on the deer *and* human populations in the Adirondack ecosystem. Ask students to reflect on how the scaffold supported them in constructing their explanations. Also, ask students to reflect on how thinking about the patterns helped them explain the phenomena.	**Construct an explanation that includes qualitative relationships between variables that predict phenomena** **RST.6-8.1, WHST.6-8.2, WHST.6-8.9** The second part has them construct an explanation, using the Explanation Tool again, that predicts the impact that the reintroduction of wolves in the Adirondacks might have on an ecosystem that includes humans. They apply their knowledge about patterns in ecosystems that they learned from studying the organisms in Yellowstone. They make predictions about what the reintroduction of wolves in the Adirondacks would do to the ecosystem (including the impact on both the deer and human populations). Ideal Student Response: If wolves are reintroduced into the northeastern United States, they will help reduce the deer population, which will then be less harmful to the ecosystem. The deer population is large and is harming the ecosystem by destroying plants, which serve as a home for bird populations. Wolves are predators of deer. Increasing the predator population (wolves) can lead to a new balance in the number of deer, which will reduce the damage that the deer cause. The prediction is that the same pattern seen in Yellowstone in the elk population data due to wolves would be seen in the Adirondacks (wolves increase, elk/deer decrease). While there is evidence that wolves can cause damage to pets and livestock, the reintroduction of wolves to Yellowstone allowed for both other plants and animals to increase in population, so it can be expected that a similar balance would be restored to the Adirondacks.	

Linking question from Elaborate to Evaluate: What patterns do we see in the way organisms interact across ecosystems and how do humans affect those patterns?

Tool 4 Template Example – 5E Learning Sequence Outline

Evaluate: Experiences in the Evaluate phase encourage students to assess their conceptual understanding and use of the practices. The experiences allow teachers to evaluate student progress toward achieving the performance expectation(s). No new ideas are introduced during the Evaluate.

What **teacher** is doing (including a brief description of the activity and key questions)	What **students** are doing (including ideal student response to selected questions/tasks) Identify **SEP** as appropriate Identify CCSS (ELA/literacy and math) as appropriate	Anchor Phenomenon Guiding Question Science Concepts DCI , CCC, PE
Part 1: Provide students with a series of six written scenarios and six graphs showing qualitative trends (not quantitative). Explain to students their task as a group is to match the scenario to the pattern in the graph, and that for the biotic relationships they need to label the pattern of interaction with the correct term. Scenarios are taken from real-world examples: 1. Freshwater Lake Fish (Rainbow smelt in Crystal Lake eliminated yellow perch) SOURCE: University of Wisconsin-Madison's Center for Limnology – *Crystal Lake Mixing Project: Smelt* (website) 2. Marine Worms and Ocean Temperatures (scaleworms live on sea stars in shallow ocean water in the Pacific northwest; the population of worms is affected by seasonal temperature changes – when winter temperatures drop, worm populations increase and the opposite occurs in the summer) 3. Insect Fields and Orchards (insects are pests in crop fields and other farmland; evidence suggests the introduction of a wasp can cause the levels of certain pests in farm fields to decline) SOURCE: Cornell University College of Agriculture and Life Sciences' Biological Control: *Beneficial Insects Introduction Research* (website) 4. Phosphorus and Algae Growth (when phosphorus, an essential nutrient for plans/algae, rises in water due to sewage waste, population of algae increases) 5. Canadian Lynx and Snowshoe Hare (in northern Canada, the lynx's preferred diet is the snowshoe hare but when the hare population decreases, the lynx kittens are often unable to survive) SOURCE: Duke University's Dept. of Math: *Predator-Prey Models* (website) 6. Oxygen and Fish Populations (investigations of a fish population in a lake showed as the oxygen levels drop, the population decreased rapidly) Provide students with Explanation Tool to support their writing a scientific explanation about one of the phenomena in the scenarios.	Part 1: Students work in groups (**SL.8.1**) to identify the patterns of interaction in a variety of scenarios. They explain the impact of one population on another (including *predator-prey*, *competition* and *symbiosis*), and the impact of abiotic factors on a population. Ideal Student Responses: 1 – Competition (Graph C) 2 – Abiotic (Graph A) 3 – Parasitism (Graph E) 4 – Abiotic (Graph F) 5 – Predator is Lynx, Prey is Hare (Graph B) 6 – Abioitc (Graph D) **Construct an explanation that includes qualitative relationships between variables that predict and describe phenomena** **RST.6-8.1, WHST.6-8.2, WHST.6-8.9** Students select one of the six scenarios and use the Explanation Tool (C-E-R scaffold) to construct a written explanation for the phenomena presented. Ideal Student Response: My claim is that Graph A best matches scenario 2, which is the interaction between an abiotic factor (water temperature) and a population of worms that increases in cold water. The evidence that supports my claim is that the graph shows the worm population increasing in winter, when the graph shows the water temperature is decreasing. The opposite happens when the water temperature goes	**Anchor Phenomenon:** Data and patterns can show the relationships in ecosystems clearly enough to predict which scenario the data matches, even when the graphs are not labeled. **Guiding Question**: *What are the patterns of interactions between biotic and abiotic factors that affect ecosystems?* Consistent patterns of interactions show relationships among organisms (competition, predation, and mutualism) and between organisms and abiotic components. These patterns of interaction predict similar phenomena across multiple ecosystems. Increases in human populations impact ecosystems.

Tool 4 Template Example – 5E Learning Sequence Outline

	up—then the worm population goes down. The concept that supports this evidence is the interaction of a population with an abiotic factor. The reasoning that links the evidence to the concept of interaction of a population with the abiotic factor is the pattern every year showing that whenever the water temperature changes, the worm population changes in the opposite direction.	
Part 2: Lead students in argument discussion – post the claim "Humans impact ecosystems," on the board. Ask students evaluate the evidence they learned about across their lessons that supports this claim using science concepts and reasoning. Support students with using Accountable Talk. Engage students in a reflection about their own learning and understanding about the patterns of interactions in ecosystems; also help them reflect on how modeling, analyzing data, constructing explanations and engaging in argument helped them learn what they now understand. Give students written performance task with a scenario and data that asks students to apply their science knowledge to answer a series of questions. **(SEE TOOL 5)**	Part 2: Students are presented with the claim "Humans impact ecosystems." They use science concepts and reasoning from their previous lessons to evaluate the evidence that supports this claim. **Construct an oral argument supported by empirical evidence and scientific reasoning to support or refute an explanation for phenomena.** **RST.6-8.1, WHST.6-8.1, WHST.6-8.9** After the discussion, students reflect with a partner on how their thinking about interactions ecosystems has changed since the first lesson. They reflect on each of the practices they engaged in across the 5E learning sequence to think about how that practice helped them learn. To prepare for performance task, students review together what they had written in their science notebooks and scaffolds throughout the lessons, as well as what they had recorded from the various activities done during the unit. Students take written performance task individually **(SEE TOOL 5)**.	

Engage Analysis Guide

Part I. Overview

1. What is the major concept to be developed in this 5E sequence? (See "Big Idea" in Tool 1 Unit Blueprint)

2. What is the concept to be developed in this phase of the 5Es? (See Conceptual Flow in Tool 3)

What is the source of the activity?		**What is the activity to be analyzed?**	

3. What is our decision about using this activity? (Note: You may make this decision at any point in the process.)

Decision	**Reasoning**	✓
Keep it	• Matches the concept • Allows students to consider natural phenomena or engineering problems • Meets all or many of the characteristics for an Engage	
Tweak it	• Includes a few distracting ideas that could be eliminated • Context could be revised • Could allow students to consider natural phenomena or engineering problems in a way more closely related to the concept • Students could take part in the activity in a different way • Could include additional characteristics for an Engage	
Toss it	• Too many distracting ideas • Does not allow students to consider natural phenomena or engineering problems related to the concept • Not sufficient to engage students • Does not fit with the characteristics of an Engage	

Adapted from BSCS, 2014

Part II. Identify Key Characteristics of the Activity **ENGAGE**

1. What is the major concept *actually* developed in this activity?

2. Read all parts of the activity before beginning this section.

Does the activity fit characteristics of an Engage?	Yes	No	Evidence (e.g., page/question #) & Ideas for improvement)
a. The activity asks students to consider or generate questions or to identify engineering problems that directly align with the major concept of the unit?			
b. The activity elicits many responses that uncover what students currently know or think about think about natural phenomena or problems related to the concept.			
c. The activity creates interest or generates curiosity.			
d. The activity does *not* require correct answers or conclusions.			
e. The activity reminds students that their ideas may change, grow, or expand as they gather evidence or test solutions in the unit so they may revisit their ideas at a later time.			
f. The activity provides appropriate support for students' use of science and engineering practices.			
g. The activity includes opportunities for students to reflect on their use of science and engineering practices.			
h. The activity includes a guiding question appropriate for the Engage activity. ***Note:*** *If students can answer the guiding question of the activity correctly, then it should show that they understand the main concept of the activity. In an Engage activity, this may mean that students are able to share ideas related to the concept, even if their ideas are not fully formed or correct.*			

Note: *While an Engage activity does not have to meet all of the characteristics of an Engage, it should fit with at least several of the criteria listed above.*

If you think the activity is still worth considering, go on to Part III

Adapted from BSCS, 2014

Part III. Analyze Student Thinking **ENGAGE**

Step	Questions to Consider	Findings
1. Try It Out	What is the ideal student response to the guiding question?	
Note: *A key purpose of an Engage is for students to make their* ***current*** *thinking visible. Therefore, the actual student responses may include misconceptions, naïve conceptions, or correct ideas.*		
2. Check against the Concept	• What knowledge or experience is accessed by this activity? • What common misconceptions might students have related to this activity?	
Note: *A key purpose of an Engage is for students to make their* ***current*** *thinking visible. Therefore, the activity should uncover experiences and misconceptions, naïve conceptions, or correct ideas.*		
3. Consider the Big Picture	How does this activity help students focus on a natural phenomenon or engineering problem?	
Note: *Consider this question in light of the characteristics of an Engage (from part 2). For example, at this point, students might become curious about and share their current understanding of a phenomenon or problem, but should not be expected to create an accurate explanation or solution.*		

Part IV. Revise the Activity Based on Notes from Parts I, II, and III

Questions to Guide Revisions	Action(s) to Take
• What distracting ideas should be eliminated? • Where are those ideas in the activity?	
• What context would better help students understand the concepts in the activity? • Where should the context be introduced?	
• How could students consider natural phenomena or engineering problems in a way more closely related to the concept? • What aspects of the activity should change to allow closer connections to the concept?	
• How might students take part in the activity in a different way? For example, is there a way to make the activity more student-centered or a better order to the parts of the activity? • What parts of the activity need to change to accomplish this?	

Adapted from BSCS, 2014

Explore Analysis Guide

Part I. Overview

1. What is the major concept to be developed in this 5E sequence? (See "Big Idea" in Tool 1 Unit Blueprint)

2. What is the concept to be developed in this phase of the 5Es? (See Conceptual Flow in Tool 3)

What is the source of the activity?		**What is the activity to be analyzed?**	

3. What is our decision about using this activity? (Note: You may make this decision at any point in the process.)

Decision	**Reasoning**	✓
Keep it	• Matches the concept • Allows students to explore natural phenomena or engineering problems • Meets all or many of the characteristics for an Explore	
Tweak it	• Includes a few distracting ideas that could be eliminated • Context could be revised • Could allow students to explore natural phenomena or engineering problems in a way more closely related to the concept • Students could take part in the activity in a different way • Could include additional characteristics for an Explore	
Toss it	• Too many distracting ideas • Does not allow students to explore natural phenomena or engineering problems related to the concept • Not sufficient to engage students • Does not fit with the characteristics of an Explore	

Part II. Identify Key Characteristics of the Activity

1. What is the major concept *actually* developed in this activity?

2. Read all parts of the activity before beginning this section.

Does the activity fit characteristics of an Explore?	Yes	No	Evidence (e.g., page/question #) & Ideas for improvement)
a. The activity provides a common experience that "levels the playing field" among students with different background knowledge.			
b. The activity asks students to make a prediction or pose a question about a phenomenon or to consider a problem related to the main concept of the unit.			
c. The activity allows students to manipulate materials and make observations.			
d. The activity asks students to think critically about data (their own or other).			
e. The activity encourages students to work collaboratively.			
f. The activity allows enough time for students to puzzle about a problem.			
g. The activity allows students to use the practice that is the focus on the performance expectation associated with this 5E sequence.			
h. The activity provides appropriate support for students' use of science and engineering practices.			
i. The activity includes opportunities for students to reflect on their use of science and engineering practices.			
j. The activity includes a guiding question appropriate for the Explore activity. ***Note:*** *If students can answer the guiding question of the activity correctly, then it should show that they understand the main concept of the activity. In an Explore activity, this may mean that students are able to begin forming explanations of a phenomenon based on their work but do not yet have a complete understanding.*			

Note: *While an Explore activity does not have to meet all of the characteristics of an Explore, it should fit with at least several of the criteria listed above.*

If you think the activity is still worth considering, go on to Part III

Part III. Analyze Student Thinking

Step	Questions to Consider	Findings
1. Try It Out	What is the ideal student response to the guiding question?	
Note: *In an Explore activity, the ideal student response should represent the work students have done thus far in the unit and may not represent a complete explanation. The actual student responses may include misconceptions, naïve conception, or correct ideas.*		
2. Check against the Concept	• What knowledge or experience is accessed by this activity? • What common misconceptions might students have related to this activity?	
Note: *A key purpose of an Explore is for students to have a common experience focused on the phenomenon or problem and to help them be ready for the introduction of scientific terminology during the Explain. In addition, the Explore should include a focus on the practice that is emphasized by the performance expectation associated with this 5E sequence.*		
3. Consider the Big Picture	How does this activity help students focus on a natural phenomenon or engineering problem?	
Note: *Consider this question in light of the characteristics of an Explore.(from part 2). For example, at this point, students might begin exploring a phenomenon or problem through investigation, but should not be expected to create a complete explanation or solution.*		

Part IV. Revise the Activity Based on Notes from Parts I, II, and III

Questions to Guide Revisions	Action(s) to Take
• What distracting ideas should be eliminated? • Where are those ideas in the activity?	
• What context would better help students understand the concepts in the activity? • How and where should the context be introduced?	
• How could students explore natural phenomena or engineering problems in a way more closely related to the concept? • What aspects of the activity should change to allow closer connections to the concept or Science and Engineering Practice?	
• How might students take part in the activity in a different way? For example, is there a way to make the activity more student-centered, to better sequence the parts of the activity, or for students to use one or more Science and Engineering Practices? • What parts of the activity need to change to accomplish this?	

Explain Analysis Guide

Part I. Overview

1. What is the major concept to be developed in this 5E sequence? (See "Big Idea" in Tool 1 Unit Blueprint)

2. What is the concept to be developed in this phase of the 5Es? (See Conceptual Flow in Tool 3)

What is the source of the activity?		**What is the activity to be analyzed?**	

3. What is our decision about using this activity? (Note: You may make this decision at any point in the process.)

Decision	**Reasoning**	✓
Keep it	• Matches the concept • Allows students to explain natural phenomena or propose solutions to engineering problems • Meets all or many of the characteristics for an Explain	
Tweak it	• Includes a few distracting ideas that could be eliminated • Context could be revised • Could allow students to explain natural phenomena or propose solutions to engineering problems in a way more closely related to the concept • Students could take part in the activity in a different way • Could include additional characteristics for an Explain	
Toss it	• Too many distracting ideas • Does not allow students to explain natural phenomena or propose solutions to engineering problems related to the concept • Not sufficient to engage students • Does not fit with the characteristics of an Explain	

Part II. Identify Key Characteristics of the Activity

1. What is the major concept *actually* developed in this activity?

2. Read all parts of the activity before beginning this section.

Does the activity fit characteristics of an Explain?	Yes	No	Evidence (e.g., page/question #) & Ideas for improvement)
a. The activity provides students with an opportunity to construct a scientific explanation or propose solutions.			
b. The activity allows students to examine currently accepted science ideas as they construct their own explanations or solutions.			
c. The activity formally introduces definitions and terminology for the first time in the 5E sequence.			
d. The activity encourages students to explain science concepts in their own words.			
e. The activity asks students to justify their ideas.			
f. The activity offers opportunities for students to challenge or confirm their experiences or solutions, particularly if their preliminary thinking was not aligned with current science ideas. Students have opportunities to make sense of important science ideas.			
g. The activity provides appropriate support for students' use of science and engineering practices.			
h. The activity includes opportunities for students to reflect on their use of science and engineering practices.			
i. The activity includes a guiding question appropriate for the Explain activity. ***Note:*** *If students can answer the guiding question of the activity correctly, then it should show that they understand the main concept of the activity. In an Explain activity, students should show some understanding of science ideas as they explain the phenomenon they are investigating or the problem they are solving.*			

Note: *While an Explain activity does not have to meet all of the characteristics of an Explain, it should fit with at least several of the criteria listed above.*

If you think the activity is still worth considering, go on to Part III

Part III. Analyze Student Thinking **EXPLAIN**

Step	Questions to Consider	Findings
1. Try It Out	What is the ideal student response to the guiding question?	
Note: *In an Explain activity, the ideal student response should include science terminology; however, students should communicate science ideas in their own words.*		
2. Check against the Concept	• What knowledge or experience is accessed by this activity? • What common misconceptions might students have related to this activity?	
Note: *A key purpose of an Explain is for students to make connections among important science or engineering ideas to develop conceptual understanding. The product of the Explain may or may not be a scientific explanation as described in the NGSS Science and Engineering Practices.*		
3. Consider the Big Picture	How does this activity help students focus on a natural phenomenon or engineering problem?	
Note: *Consider this question in light of the characteristics of an Explain (from part 2). At this point, students should be able to make connections among science ideas. One way to do this is by constructing an explanation or solution to a problem using a model or appropriate evidence, terminology, and science or engineering ideas.*		

Part IV. Revise the Activity Based on Notes from Parts I, II, and III

Questions to Guide Revisions	Action(s) to Take
• What distracting ideas should be eliminated? • Where are those ideas in the activity?	
• What context would better help students understand the concepts in the activity? • How and where should the context be introduced?	
• How could students explain natural phenomena or engineering problems in a way more closely related to the concept? • What aspects of the activity should change to allow closer connections to the concept?	
• How might students take part in the activity in a different way? For example, is there a way to make the activity more student-centered, to better sequence the parts of the activity, or for students to use one or more Science and Engineering Practices? • What parts of the activity need to change to accomplish this?	

Elaborate Analysis Guide

Part I. Overview

1. What is the major concept to be developed in this 5E sequence? (See "Big Idea" in Tool 1 Unit Blueprint)

2. What is the concept to be developed in this phase of the 5Es? (See Conceptual Flow in Tool 3)

What is the source of the activity?		**What is the activity to be analyzed?**	

3. What is our decision about using this activity? (Note: You may make this decision at any point in the process.)

Decision	**Reasoning**	✓
Keep it	• Matches the concept • Allows students to consider natural phenomena or engineering problems • Meets all or many of the characteristics for an Elaborate	
Tweak it	• Includes a few distracting ideas that could be eliminated • Context could be revised • Could allow students to consider natural phenomena or engineering problems in a way more closely related to the concept • Students could take part in the activity in a different way • Could include additional characteristics for an Elaborate	
Toss it	• Too many distracting ideas • Does not allow students to consider natural phenomena or engineering problems related to the concept • Not sufficient to engage students • Does not fit with the characteristics of an Elaborate	

Part II. Identify Key Characteristics of the Activity

1. What is the major concept *actually* developed in this activity?

2. Read all parts of the activity before beginning this section.

Does the activity fit characteristics of an Explain?	Yes	No	Evidence (e.g., page/question #) & Ideas for improvement)
a. The activity provides opportunities to transfer understanding, skills, and abilities developed in the sequence to a new context.			
b. The activity allows students to study the main concept in a deeper or broader context.			
c. The activity asks students to consider another scientific question or problem related to the major concept.			
d. The activity provides opportunities for students to use data, think critically about the data, and make sense of the data.			
e. The activity asks students to consider alternative explanations or solutions.			
f. The activity helps students make connections to the Cross-cutting Concept associated with the 5E sequence.			
a. The activity provides appropriate support for students' use of science and engineering practices.			
b. The activity includes opportunities for students to reflect on their use of science and engineering practices.			
c. The activity includes a guiding question appropriate for the Elaborate activity. ***Note:*** *If students can answer the guiding question of the activity correctly, then it should show that they understand the main concept of the activity. In an Elaborate activity, the answer to the guiding question should represent an understanding of the concept in a new context or in a context that allows students to explore the concept more broadly or deeply. This may include the introduction of a limited number of new ideas.*			

Note: *While an Elaborate activity does not have to meet all of the characteristics of an Elaborate, it should fit with at least several of the criteria listed above.*

If you think the activity is still worth considering, go on to Part III

Part III. Analyze Student Thinking

Step	Questions to Consider	Findings
1. Try It Out	What is the ideal student response to the guiding question?	
Note: *In an Elaborate activity, the ideal student response should include science ideas and terminology as students show their understanding of the concept or solutions to a problem. This activity is the last opportunity to introduce new ideas in the unit, so students should have a good understanding of concepts at this point.*		
2. Check against the Concept	• What knowledge or experience is accessed by this activity? • What common misconceptions might students have related to this activity?	
Note: *A key purpose of the Elaborate is to increase the depth or breadth of understanding. One way to deepen or broaden understanding is to help student make connections to the Cross-cutting Concept associated with the sequence. Given that the activity may include the introduction of a new context or a limited number of new ideas, it's important that we think about possible misconceptions.*		
3. Consider the Big Picture	How does this activity help students focus on a natural phenomenon or engineering problem?	
Note: *Consider this question in light of the characteristics of an Elaborate (from part 2). For example, at this point, students might expand the breadth or depth of their understanding by applying what they learned in the Elaborate to a new context, making connections between the ideas developed in the Elaborate and a limited number of new ideas, or making connections to the Cross-cutting Concept.*		

Part IV. Revise the Activity Based on Notes from Parts I, II, and III

Questions to Guide Revisions	Action(s) to Take
• What distracting ideas should be eliminated? • Where are those ideas in the activity?	
• What context would better help students understand the concepts or practices in the activity? • How and where should the context be introduced?	
• How could students consider natural phenomena, engineering problems, Science and Engineering Practice, or Cross-cutting Concept in a way more closely related to the concept? • What aspects of the activity should change to allow closer connections to the concept?	
• How might students take part in the activity in a different way? For example, is there a way to make the activity more student-centered, to better sequence the parts of the activity, or for students to use one or more of the Science and Engineering Practices? • What parts of the activity need to change to accomplish this?	

Evaluate Analysis Guide

Part I. Overview

1. What is the major concept to be developed in this 5E sequence? (See "Big Idea" in Tool 1 Unit Blueprint)

2. What is the concept to be assessed in this phase of the 5Es? NOTE: NO new concepts are developed in the Evaluate phase! (See Conceptual Flow in Tool 3)

What is the source of the activity?		**What is the activity to be analyzed?**	

3. What is our decision about using this activity? (Note: You may make this decision at any point in the process.)

Decision	**Reasoning**	✓
Keep it	• Matches the concept • Allows students to demonstrate their understandings and abilities related to the Performance Expectation • Meets all or many of the characteristics for an Evaluate	
Tweak it	• Includes a few distracting or new ideas that could be eliminated • Context could be revised • Could allow students to demonstrate their understandings and abilities related to the Performance Expectation • Students could take part in the activity in a different way • Could include additional characteristics for an Evaluate	
Get rid of it	• Too many distracting or new ideas • Does not allow students to consider natural phenomena or engineering problems related to the concept and Performance Expectation • Not sufficient to engage students • Does not fit with the characteristics of an Evaluate	

Part II: Identify Key Characteristics of the Activity

1. What is the major concept actually assessed in this activity?

2. Read all parts of the activity before beginning this section.

Does the activity fit characteristics of an Evaluate?	Yes	No	Evidence (e.g., page/question #) & Ideas for improvement)
a. The activity does *not* introduce any new concepts or ideas.			
b. The activity includes authentic contexts for assessment.			
c. The activity allows students to answer open-ended questions using observations, data, evidence, and previously accepted explanations or solutions.			
d. The activity allows students to demonstrate their understanding and abilities related to the major concept of the 5E sequence.			
e. The activity provides an opportunity for students to demonstrate their understanding of concepts from each of the previous activities.			
f. The activity provides opportunities for self-assessment, peer assessment, and teacher assessment.			
g. The activity includes opportunities for students to reflect on their use of science and engineering practices.			
h. The activity links to the Performance Expectation and Evidence of Learning Specifications developed as part of Tool 2.			
i. The activity includes a guiding question appropriate for the Evaluate activity. ***Note:*** *If students can answer the guiding question of the activity correctly, then it should show that they understand the main concept of the activity. In an Evaluate activity, the answer to the guiding question is often the final product from the activity. It should allow students to show an understanding not only of the main concept in the 5E sequence but also the concepts developed in previous activities.*			

Note: *While an Evaluate activity does not have to meet all of the characteristics of an Evaluate, it should fit with at least several of the criteria listed above.*

If you think the activity is still worth considering, go on to Part III

Part III. Analyze the Student Thinking **EVALUATE**

Step	Questions to Consider	Findings
1. Try It Out	What is the ideal student response to the guiding question?	
Note: *In an Evaluate activity, the ideal student response should include science ideas, data, evidence, and proper terminology as students show their understanding of all of the concepts in the unit.*		
2. Check against the Concept	• What knowledge or experience is accessed by this activity? • What common misconceptions might students have related to this activity?	
Note: *The Evaluate should provide students with opportunities to demonstrate their understanding of the Performance Expectation and uncover evidence of student learning as defined in the Evidence of Learning Specifications developed as part of Tool 2.*		
3. Consider the Big Picture	How does this activity help students focus on a natural phenomenon or engineering problem?	
Note: *Consider this question in light of the characteristics of an Evaluate (from part 2). For example, at this point, students should show their understanding of all the concepts they have learned throughout the 5E sequence.*		

Part IV. Revise the Activity Based on Notes from Parts I, II, and III

Questions to Guide Revisions	Action(s) to Take
▪ What distracting or new ideas should be eliminated? ▪ Where are those ideas in the activity?	
▪ What context would better help students demonstrate their understanding of the concepts? ▪ How and where should the context be introduced?	
▪ How could students demonstrate their understandings and abilities of natural phenomena, engineering problems, Science and Engineering Practices, and Crosscutting Concepts in a way more closely related to the Performance Expectation? ▪ What aspects of the activity should change to allow closer connections to the performance expectation?	

Activity 1.2

Explore: Ecological Interactions

Scientists use diagrams to show the feeding relationships within an ecosystem. These relationships can be shown as a single chain (Figure 1a) or as a web that provides a more complete picture (Figure 1b). Arrows point from the organism that is eaten to the organism that eats it. For example, in the chain in Figure 1a, the arrow from the grass to the grasshopper shows that the grasshopper eats the grass.

Figure 1a.
Food Chain

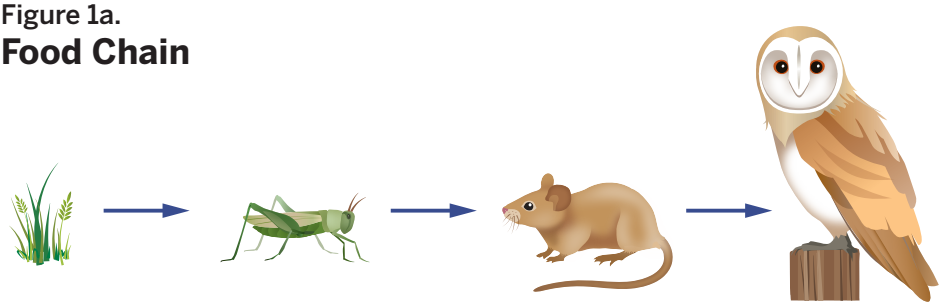
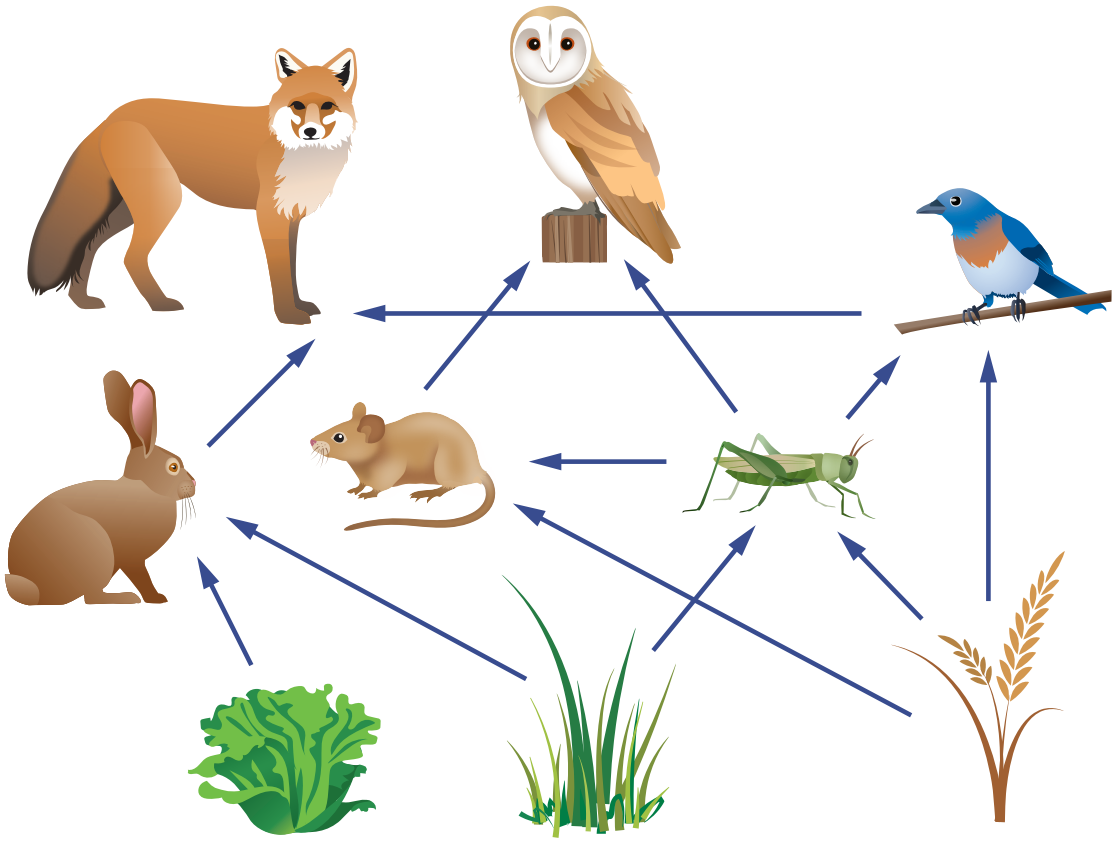


Figure 1b.
Food Web



Guiding Question

What effect did the reintroduction of wolves have on the food web in Yellowstone National Park?

Materials

For each group of four students:

- 1 set of 12 Yellowstone Food Web cards
- 1 additional Yellowstone Food Web card: Gray Wolf

For each student:

- Handout 1.2-1, "Yellowstone Food Web Data"

Process & Procedure

Part One: Investigating the Yellowstone Food Web in 1990

1. Work with your group to examine the 12 Yellowstone Food Web cards in your set. Consider which organisms are familiar to you and which are not.
2. Think about what the organisms on the Food Web cards might eat.
3. Work with your group to sort the cards into groups. Explain how you decided to group the cards.
4. As a group, choose three cards that make a simple food chain. Record your food chain in your science notebook.
5. Work with your group to create a food web using *all* of the cards in your set.

Hint

Put organisms with similar eating patterns on the same row of your food web to make it easy to read (see sample food web in the introduction).

6. Record your food web in your science notebook. Use a full page of paper to draw your food web. Leave space around the name of each organism so that you have room to draw in arrows. Then draw arrows from the eaten organism to the animal that eats it.
7. Share and discuss your food web with another group of students. How similar or different are your ideas?
8. Obtain a copy of Handout 1.2-1, "Yellowstone Food Web Information," from your teacher. Use the information on the handout to revise your food web.

9. Record your revised food web in your science notebook.

10. Discuss with your group the patterns of interaction among the organisms in your food web:
    - Which organisms play a similar role in the food web? Describe these roles.
    - What do you predict would happen to the food web if all of the plants died?

Part Two: Reintroducing the Gray Wolf in 1995

11. Your teacher will give you another Yellowstone Food Web card: the Gray Wolf.

12. Add the wolf to your revised food web.

13. Discuss with your group how the reintroduction of this species affected your food web.

14. Your teacher will introduce another organism into the food web: bacteria. Discuss the role this organism plays in the ecosystem and where to add it to the food web.

Analysis

1. Describe the patterns of interaction among the organisms in your food web:
    - **a.** Which animals eat other animals for food?
    - **b.** Which animals compete for the same food source(s)?
    - **c.** What role did the winter tick play in the food web?
    - **d.** What role did the bacteria play in the food web?
    - **e.** Look again at your food web and Handout 1.2-1. Find an example of a helpful relationship between two animals.

Hint

They do not have to be directly connected in your food web.

2. How did the wolf affect your food web?

3. **a.** Add humans and cattle to your food web diagram.
   b. Describe how humans and cattle change the food web.

4. What effect do you think restoring wolves to the Yellowstone food web had on each of the following populations in the park? Explain your ideas.
   - **a.** Elk
   - **b.** Small animals
   - **c.** Plants

5. People often think of grizzly bears as carnivores. Grizzlies are omnivores, eating plants, insects, and other animals. More than 80% of their diet comes from seeds, nuts, and other vegetation. Does a food web address the importance of different food sources in an organism's diet? Explain.

6. Review the list of organisms in a familiar ecosystem that you developed for Part One of Activity 1.1.
   - **a.** Construct a food web for that area.
   - **b.** What similarities do you see between the food web you drew for question 6a and the Yellowstone food web?

Figure 1.4 △

What role do fungi play in a food web?

1.2 Plants, Animals, and Other Organisms Make Up a Food Chain

Organisms play various roles in the web of life. The green plants use light energy to make food. Because they make their own food, they are called **producers**. Animals cannot make their own food, so they eat plants or other animals or both. Organisms that are unable to make their own food are called **consumers**. During the process of decay, consumers that break down the bodies of dead plants and animals are called **decomposers**. Bacteria and fungi, such as those shown in Figure 1.4, are examples of decomposers. The producers, consumers, and decomposers that live and interact in one area form a **community**.

Let's see how a community works. Not far from the spider's web discussed in Section 1.1 is a raspberry bush. Underneath the bush, a rabbit (see Figure 1.5) finds shelter and a place to hide from animals that may kill it. The bush is an ideal place to hide because its thorns can dig into the flesh of larger animals, and its low-hanging red fruit provides the rabbit with food. A small bird feasts on insects that hover near the top of the bush. Because rabbits usually do not eat raspberry leaves, the rabbit ventures out to look for grasses to eat once the berries are gone. Its movement is spotted by a hungry fox, which slinks forward and suddenly makes a leap for the rabbit. The rabbit looks up just in time, and a wild chase begins. This time, the rabbit reaches safety in another raspberry bush.

Not far from the rabbit's bush is the fox's den (see Figure 1.6). The fox had carried last week's rabbit to the den and eaten most of it. What he did not eat, he buried. **Microorganisms** (organisms too small to be seen with the unaided eye, such as bacteria) began to break down the remains, causing them to decay.

The raspberry bush, the rabbit, the fox, and the microorganisms can be connected in a **food chain**, a pathway that tells what eats what. Several food chains are shown in Figure 1.7. We might look at the food chain labeled path a: the fox eats the rabbit, and the rabbit eats the berries from the bush. Path b illustrates another food chain: the bird eats insects that

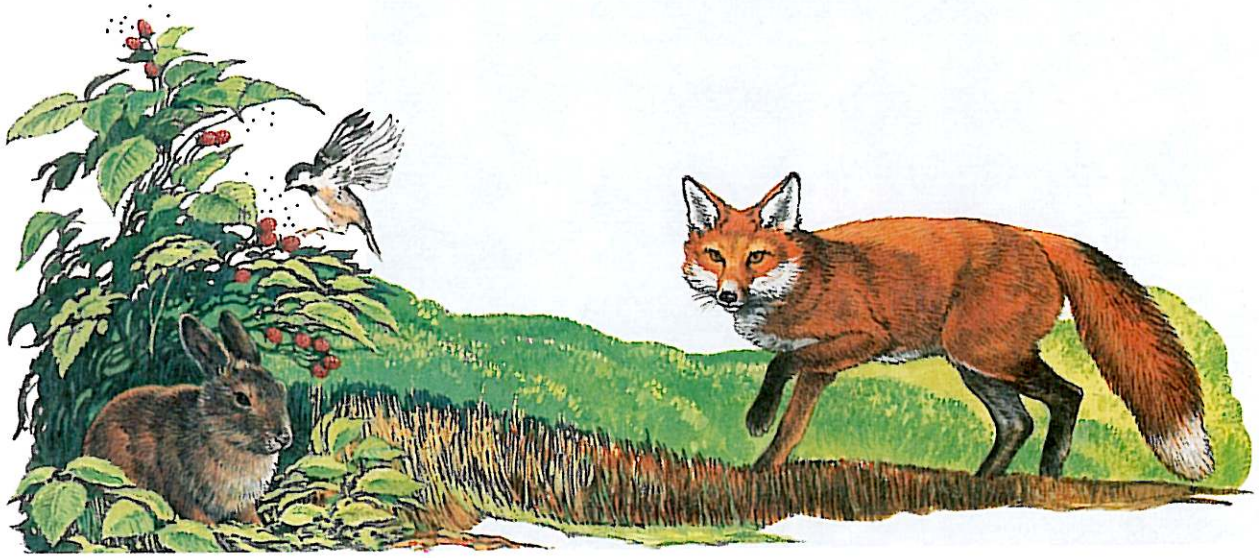


Figure 1.5 △

Describe all the relationships you see among the plants and animals and their environment.

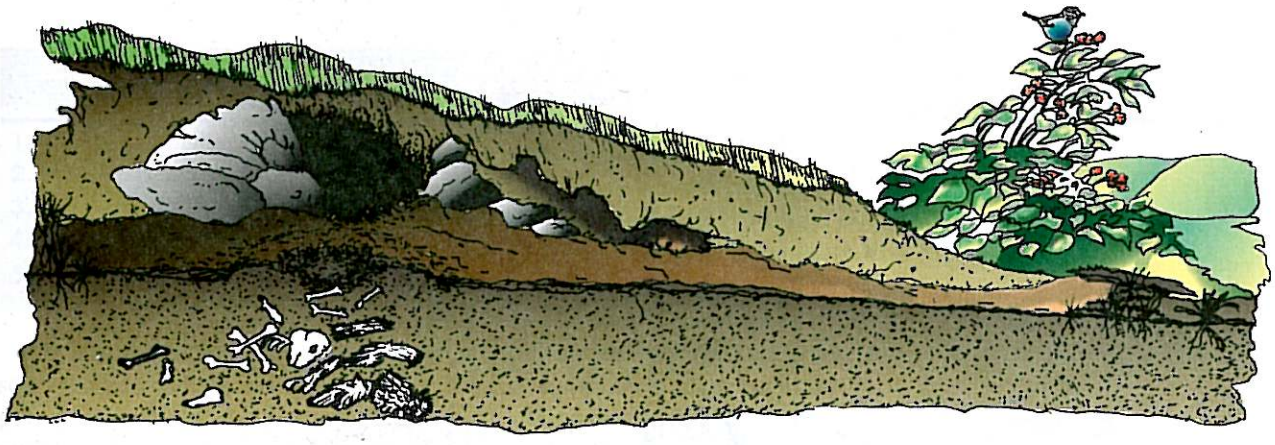


Figure 1.6 △
What role do decomposers play in the food web?

hover over the raspberry bush. These two food chains are connected by the raspberry bush. Section 1.1 described a food chain in which a spider ate a grasshopper that ate a plant (path c). When the bird eats the spider, two food chains are connected (path d). Figure 1.7 does not include all the plants a rabbit might eat, all the animals that might eat a rabbit, or any decomposers.

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When all the food chains in a community are connected to each other, a **food web** is formed. What would the web look like if there were two

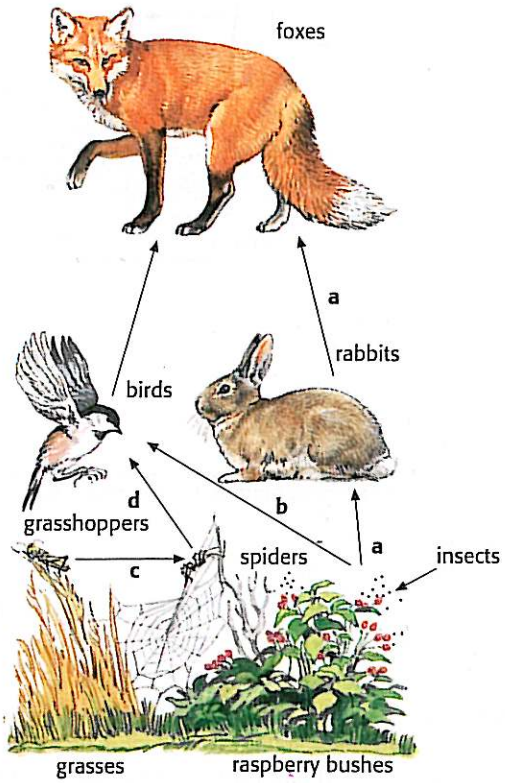

Figure 1.7 △
There is more than one food chain here. How many can you find?

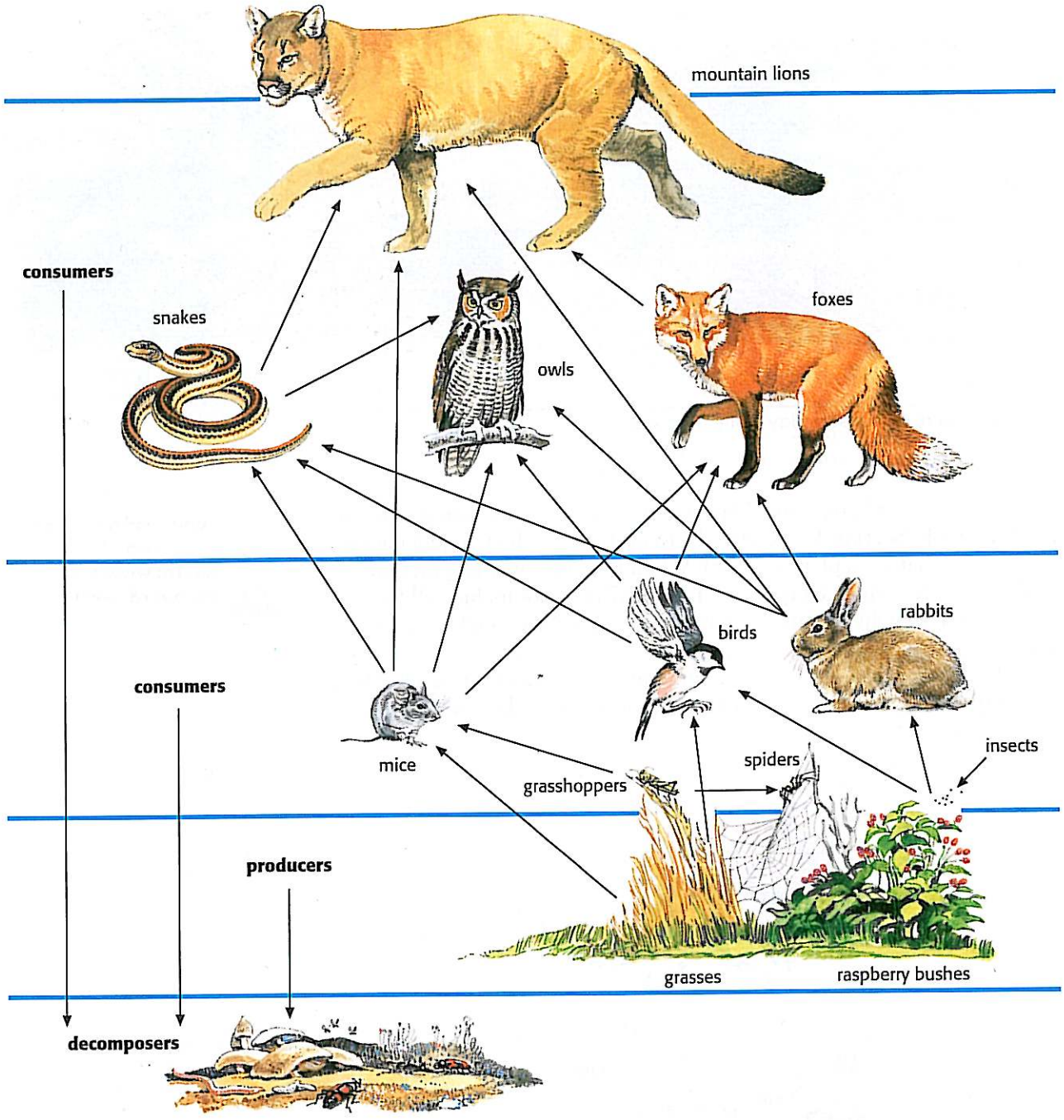

Figure 1.8 △

This complex food web expands the community shown in Figure 1.7. What other relationships can you find?

spiders instead of just one? Figure 1.8 shows a larger food web that includes the organisms discussed in this chapter. You can see that a food web can be large and complex.

Food webs and food chains tend to keep the numbers of living organisms in balance. The rabbits live off the green plants, and many other animals, including humans, live off the rabbits. This might appear to be hard on the rabbits, but rabbits produce many offspring in a short time. Imagine how many rabbits there would be if they reproduced without control. They

CONCEPT REVIEW

1. What parts of the environment does an ecologist study?
2. How do producers differ from consumers?
3. How is a food chain related to a food web?
4. Explain how reproduction and death are part of the balance of nature.
5. In what way do decomposers differ from other consumers

soon would be so numerous that they would eat all the plants. Without the plants, the rabbits would starve. Foxes and other animals that eat rabbits may help keep the rabbit population in balance. Disease or lack of food also may help keep the rabbit population from growing too large. These controls, or checks, apply to all living organisms, including humans, and are just one part of the balance of nature. Investigation 1.2 may help you understand your place in the web of life.

Matter and Energy— The Foundations of Life

1.3 All Biological Activity Requires Energy

GUIDEPOST

Where do organisms obtain the matter and energy they require?

Food chains and food webs are based on the cycling of matter from one organism to another organism and the flow of energy through the food web. The details of this cycling and flow are developed throughout this course. Here, you will look at just the broad outline.

All of an organism's activities require energy. Imagine the runners shown in Figure 1.9a trying to run without having eaten energy-rich foods. An activity does not have to be very intense to require energy; even the

a

b

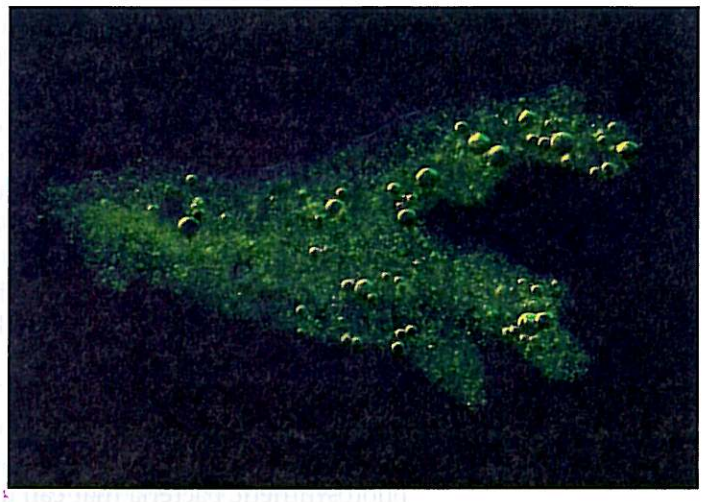

Figure 1.9 ▲

Where do these organisms get their energy?