9 SURVIVING WINTER IN THE DUST BOWL (FOOD CHAINS AND TROPHIC LEVELS)

In the 1930s, the states of Kansas, Oklahoma, Colorado, and Texas suffered from a severe drought that lasted for almost a decade. Many farmers struggled because of lack of rain, high temperatures, and high winds. These conditions were made even worse by frequent insect infestations and huge dust storms (see Figure 9.1). The dust storms were so bad and happened so often that these states came to be known as the dust bowl. The farmers who stayed on their land were forced to make difficult choices in order to survive in the face of these hardships (see Figure 9.2).

Figure 9.1. A Dust Storm Approaches Stratford, Texas, in 1935

Figure 9.2. A Farmer and His Sons Walking in the Face of a Dust Storm in Cimarron County, Oklahoma

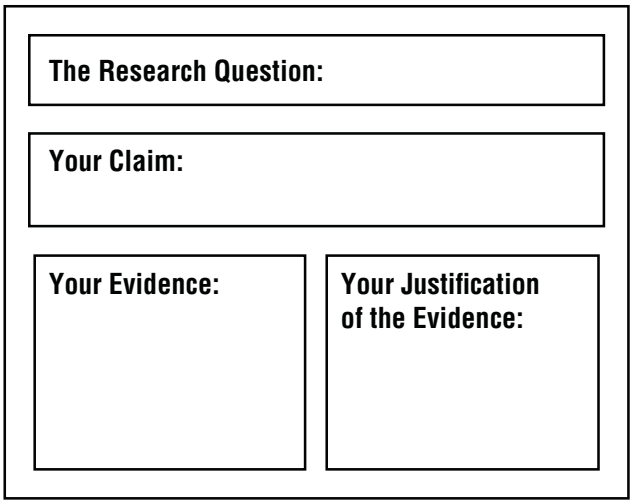
Imagine that you and the other members of your group are a family of wheat farmers living in Oklahoma, and it is October 15, 1934. It was a very dry year (less than 10 inches of rain fell from January 1, 1934 to October 1, 1934, compared to the average of approximately 42 inches per year), and your crops did not grow well. You and your family planted spring wheat in April and harvested the crop in mid-September. Unfortunately, you were only able to harvest 500 bushels of wheat (1 bushel = 60 pounds), which is much less than 2,800 bushels that you were expecting to harvest (you planted 80 acres of wheat, and you normally are able to harvest 30 to 35 bushels per acre). You only have 500 gallons of potable water left, and you have no way of knowing when it will rain again. You also have a female jersey cow and male bull on your farm, both of which need food and water in order to survive.

9 SURVIVING WINTER IN THE DUST BOWL

You and the rest of your family decided to use the last of your savings in September to buy the seed and equipment needed to plant a crop of winter wheat. You won't be able to harvest the crop of winter wheat, however, until June (assuming that it grows at all). You therefore need a plan to make sure you and the rest of your family have the food you need to make it through the winter. You have several options:

- Eat the bull. Keep the cow alive but don't feed it. Drink the cow's milk. Eat the cow when the milk production ceases, and then eat the wheat.
- Eat the bull. Keep the cow alive, feed it, and drink the milk. Eat the rest of the wheat.
- Share the wheat with the bull and cow, and keep them alive until the wheat runs out. Then eat the bull and the cow.
- Eat the bull and the cow, and then eat the wheat.

Figure 9.3. Components of the Whiteboard



Given all these options (and there are many others), you might be wondering: **What should your group do in order to survive the winter?**

With your group, develop a claim that best answers this research question. Once your group has developed your claim, prepare a whiteboard that you can use to share and justify your ideas. Your whiteboard should include all the information shown in Figure 9.3.

To share your work with others, we will be using a round-robin format. This means that one member of the group will stay at your workstation to share your group's ideas while the other group members go to the other groups one at a time in order to listen to and critique the arguments developed by your classmates.

Remember, as you critique the work of others, you need to decide if their conclusions are valid or acceptable based on the quality of their claim and how well they are able to support their ideas. In other words, you need to determine if their argument is *convincing* or not. One way to determine if their argument is convincing is to ask them some of the following questions:

- How did you analyze or interpret your data? Why did you decide to do it that way?

- How do you know that your analysis of the data is free from errors?
- Why does your evidence support your claim?
- Why did you decide to use that evidence? Why is your evidence important?
- How does your justification of the evidence fit with accepted scientific ideas?
- What are some of the other claims your group discussed before agreeing on your claim, and why did you reject them?

Information About Nutritional Values and Dietary Needs

Table 9.1. Dietary Needs

Organism	Weight (Pounds)	Calories (Consumed/Day)	Water Intake (Gallons/Day)	Protein (% of Diet)	Carbohydrate (% of Diet)	Fat (% of Diet)
Human Female*	120–180	1200	0.4	10–35	45–65	20–35
Human Male*	150–200	1800	0.4	10–35	45–65	20–35
Female Cow Lactating**	800–1000	44,000	50	10–20	70–80	10–20
Female Cow Dry	800–1000	30,500	40	10–20	70–80	10–20
Bull (Male Cow)	1000–1200	46,000	45	10–20	70–80	10–20

*Humans can survive without food for 4–8 weeks with a minimal activity level (although this is *not* recommended as serious side effects result). However, humans cannot survive more than 3–5 days without potable water.
** A lactating cow produces approximately 6 gallons of milk per day (1 gallon = 128 ounces, 1 ounce of milk = 28.6 grams of milk).

Table 9.2. Nutritional Information

Food	Serving Size (in grams*)	Calories Per Serving	Total Protein (in grams)	Total Carbohydrates (in grams)	Total Fat (in grams)
Wheat	100	339.0	13.7	72.6	1.9
Cow**	453.6	662.0	95.8	0	161.0
Milk	100	497	26.3	38.4	26.7

* 453.6 grams = 1 pound
** Only 41% of a cow's total weight is consumable.

Name_____ Date_____

SURVIVING WINTER IN THE DUST BOWL:
What Is Your Argument?

In the space below, write an argument in order to persuade another biologist that your claim is valid and acceptable. As you write your argument, remember to do the following:

- State the claim you are trying to support
- Include a sufficient amount of genuine evidence
- Provide a justification of your evidence that explains why the evidence is important and relevant by linking it a specific concept, principle, or an underlying assumption
- Organize your paper in a way that enhances readability
- Use a broad range of words including vocabulary that we have learned
- Make sure your writing has an easy flow and rhythm
- Correct grammar, punctuation, and spelling errors

9 SURVIVING WINTER IN THE DUST BOWL
TEACHER NOTES

Purpose

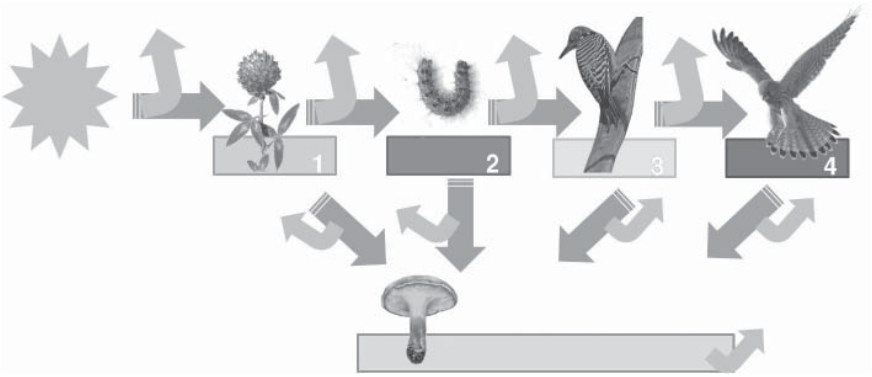
The purpose of this activity is to help students understand food chains, the interactions between trophic levels, the interdependency of organisms, and how energy flows through a system. This activity also helps students learn how to engage in practices such as using mathematics and computational thinking, constructing explanations, arguing from evidence, and communicating information. In addition, this activity is designed to give students an opportunity to learn how to write in science and develop their speaking and listening skills, which are important goals for literacy in science (see Standards Addressed in This Activity for a complete list of the practices, crosscutting concepts, core ideas, and literacy skills that are aligned with this activity).

The Content and Related Concepts

All living organisms need energy, and all living things get their energy from food. Plants get their energy from the Sun, and the processes of photosynthesis allow them to generate their own food. Plants, therefore, are described as producers. All other living things get their food from consuming other living things. The organisms that consume other living organisms are identified as consumers. There are three types of consumers: herbivores (also known as primary consumers), which eat only plants; carnivores, which eat only other animals; and omnivores, which eat both plants and animals. In addition to these classifications of consumers, the carnivores are further classified into two groups. Secondary consumers are carnivores that eat herbivores, and tertiary consumers are carnivores that eat other carnivores. There are also organisms that consume dead and decaying organisms. These organisms are identified as decomposers (e.g., bacteria and mushrooms). The decomposers speed up the decaying process that releases minerals back into the food chain for absorption by plants as nutrients.

The trophic level of an organism is the position it occupies in a food chain. The first trophic level consists of primary producers such as plants. The second trophic level consists of herbivores or primary consumers. The third trophic level consists of carnivores that eat herbivores, and the fourth level consists of carnivores that eat other carnivores. Each trophic level relates to the one below it by absorbing some of the energy it consumes and as a result, is supported by the trophic level below it. At each stage in the chain, or trophic level, energy is lost due to metabolic activity and other factors (see Figure 9.4). Plants, for example, only convert about 1% of the sunlight they receive into chemical energy, and consumers at each level only covert about 10% of the chemical energy available in their food to actual biomass. As a result of this inefficient

Figure 9.4. A Food Chain That Consists of Four Trophic Levels (Darker arrows represent energy transfer at each level, and the lighter arrows represent energy lost due to metabolic activity.)



energy transfer, only about 0.001% of the energy available in sunlight is incorporated into the bodies of tertiary consumers.

In this activity, the students must calculate the amount of energy available in the wheat, and then determine how to best allocate that energy given the amount of energy that is lost at each trophic level. They must also consider dietary needs (i.e., amount of protein, fats, and carbohydrates that need to be consumed) and minimal water intake of the livestock and the members of their family. There is no one best answer to the guiding question, especially since the students will need to take into account the needs of each system and the overall goals of the family (for example, if they decide to eat the cows, they will need to purchase more later). What is important, however, is that the students are able to support their claim using genuine evidence and a rationale that explains why the evidence is important.

Curriculum and Instructional Considerations

Middle School

Students in the middle grades continue to learn about the comparisons of species and their relationships to each other in an ecosystem through food webs and food chains. There are many resources that provide examples of food webs for various ecosystems; however, these often lack the inclusion of the energy that is transferred and needed to support each of the trophic levels. In addition, students are likely to believe that food is not a scarce resource in an ecosystem and that organisms can change their food source at will (Leach et al. 1992). Students

are also likely to have the misconception that organisms at the top of a trophic level will have more energy, misunderstanding the storage and use of energy in living organisms. They may believe that some populations of organisms are larger than others in order to meet the demands of food for other populations (Leach et al. 1992).

High School

Students in the high school grades will focus more of their content on biology and environmental studies than the middle-level students and are therefore more likely to be able to identify connections to the food chains more easily and without much prompting. However, they are not likely to understand the interactions between organisms in a food web that are indirect causal interactions. In addition, high school students may not recognize the concept of matter that is transferred through the chains and are likely to see it as being created and destroyed rather than transferred and conserved, in the same way that energy is transferred and conserved (Smith and Anderson 1986).

This activity would be appropriate as an introduction as well as a summative activity that helps students apply their knowledge to a real-world event. It is an activity that strongly serves as a pre/post activity that will allow students to reflect on the learning. Teachers should allow students to read the activity and discuss their ideas. Then the teacher should provide various lessons related to the food webs, food chains, health and nutrition, and the transfer of energy and matter in the ecosystem. Returning to this activity, students could review their previous responses and develop a more appropriate argument based on the concepts and ideas that they have learned.

Recommendations for Implementing the Activity

This activity takes approximately 100 minutes of instructional time to complete, but the amount of time devoted to each stage of the activity varies depending on how a teacher decides to spend time in class. For more information about how to implement the activity, see Appendix E on page 369.

Table 9.3 provides information about the type and amount of materials needed to implement this activity in a classroom with 28 students with groups of four and groups of three.

Table 9.3. Materials Needed to Implement the Activity in a Classroom of 28 Students

Material	Amount Needed With …	
	Groups of 3	Groups of 4
Whiteboards (or chart paper)[+]	10	7
Whiteboard markers (or permanent if using chart paper)[+]	20	14
Copy of Student Pages (pp. 113–116)[*]	28	28
Copy of Student Page (p. 117)[*]	10	7
Copy of Appendix B (p. 366)[*]	28	28

[+] Teachers can also have students prepare their arguments in a digital medium (such as PowerPoint or Keynote).
[*] Teachers can also project these materials onto a screen in order to cut down on paper use.

Assessment

The rubric provided in Appendix B (p. 366) can be used to assess the arguments crafted by each student at the end of the activity. To illustrate how the rubric can be used to score an argument written by a student, consider the following example. This sample argument, which was written by a seventh-grade student, is an example of an argument of moderate quality.

> We think that we should keep the bull alive long enough to allow it to breed with the cow. **If we do that, then the cow can have a baby for future food for us. In the time to allow them to breed we would eat very little and we would do little exercise or things that take lots of energy. The wheat we eat and the milk from the cow would provide us with enough energy since the wheat is on the bottom of the food chain. Even though the cow is not the bottom of the food chain it is close and the amount of protein from the milk, combined with the wheat should help us survive.** The problem will be how long we should keep the bull alive to breed with the cow. We will have to think about how long that would be and it depends on how much water we actually have. The bulls and cows need a lot of water and that will be a problem. If the bull is not going to mate within about a week, then we will have to kill him and not try to get her pregnant. We would need to figure out how long the wheat would last for us and the cow before she gives birth. Once she is pregnant, we could kill the bull and let the cow have the wheat while she was pregnant so that her baby would be healthy. By the time she gives birth, the wheat is likely to be nearly gone and we would have to make a decision to either kill the cow or kill the baby. The thing about killing the baby and eating it is that by keeping the cow we would still have milk. But is there still wheat to feed the cow?

The content of the example argument is poor for several reasons. The student's claim (underlined) is sufficient (1/1) but inaccurate (0/1), because it would likely lead to a shortage of food. The student does not use genuine evidence to support the claim because she does not include data (0/1), an analysis of the data (0/1), or an interpretation of the data (0/1). Instead, the author provides a series of reasons as support for the claim (in bold). The justification of the evidence is insufficient, because the author never explains why the "evidence" is important (0/1) nor attempts to link the evidence she uses to an important concept or principle (0/1). However, the author uses scientific terms correctly (1/1) and also uses phrases that are consistent with the nature of science (1/1). The writing mechanics of the sample argument are good. The organization of the argument is appropriate because the arrangement of the sentences does not distract from the development of the main idea (0/1). Finally, there are no grammatical (1/1) or punctuation errors (1/1) in the argu-

ment. The overall score for the sample argument, therefore, is 5 out the 12 points possible.

Standards Addressed in This Activity

This activity can be used to address the following dimensions outlined in *A Framework for K–12 Science Education* (NRC 2012):

Scientific Practices

- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Crosscutting Concepts

- Cause and effect: Mechanism and explanation
- Systems and system models
- Energy and matter: Flows, cycles, and conservation

Life Sciences Core Ideas

- From molecules to organisms: Structures and processes
- Ecosystems: Interactions, energy, and dynamics

This activity can be used to address the following standards for literacy in science from the *Common Core State Standards for English Language Arts and Literacy* (NGA and CCSSO 2010):

Writing

- Text types and purposes
- Production and distribution of writing
- Research to build and present knowledge
- Range of writing

Speaking and Listening

- Comprehension and collaboration
- Presentation of knowledge and ideas

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