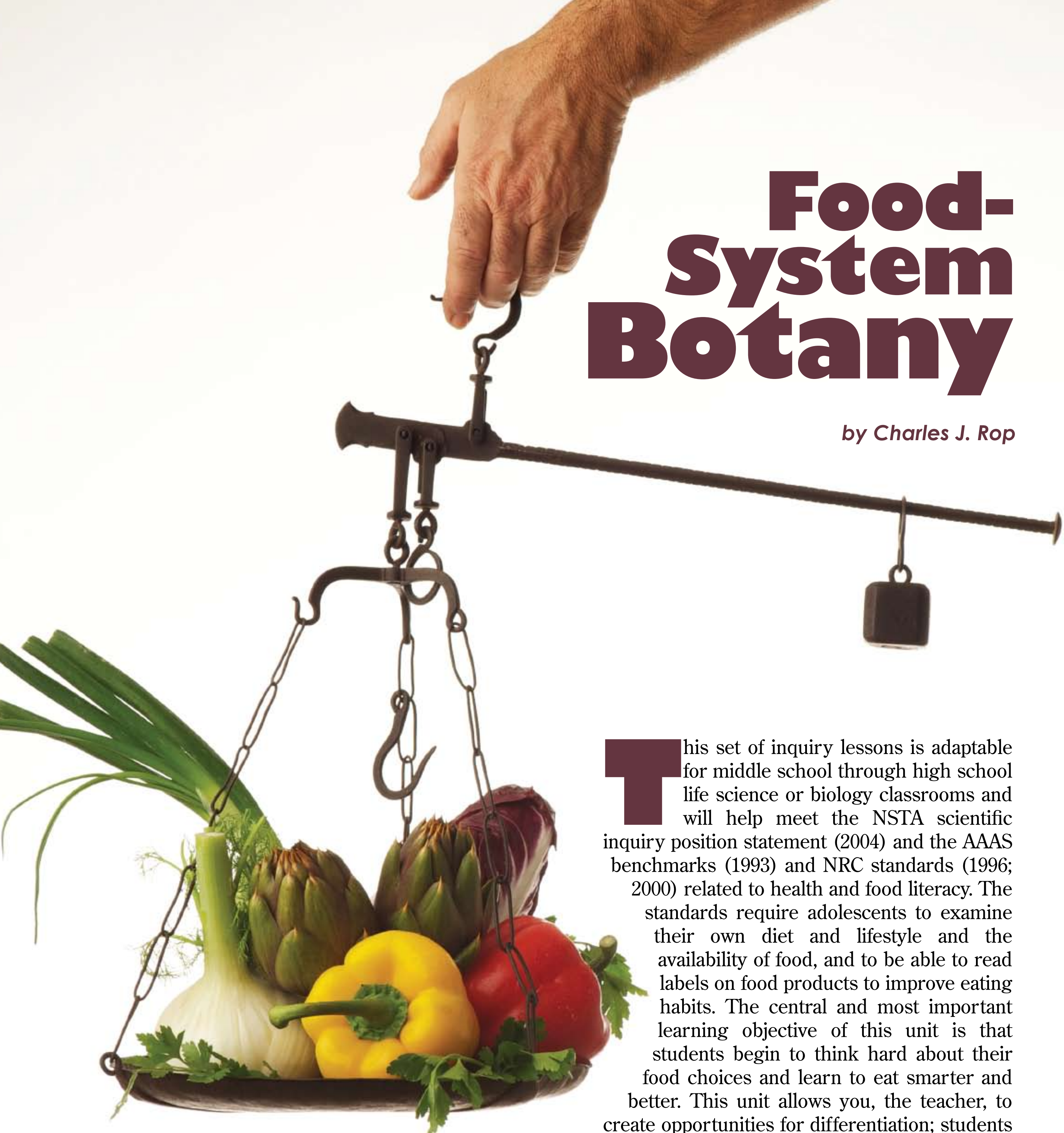

Food-System Botany

by Charles J. Rop

This set of inquiry lessons is adaptable for middle school through high school life science or biology classrooms and will help meet the NSTA scientific inquiry position statement (2004) and the AAAS benchmarks (1993) and NRC standards (1996; 2000) related to health and food literacy. The standards require adolescents to examine their own diet and lifestyle and the availability of food, and to be able to read labels on food products to improve eating habits. The central and most important learning objective of this unit is that students begin to think hard about their food choices and learn to eat smarter and better. This unit allows you, the teacher, to create opportunities for differentiation; students bring their own ethnic and cultural food traditions to the discussion. Your class discussions about the data will create opportunities to share family traditions and make the learning specifically relevant to your particular school environment and constituency. This relevancy is highly motivational and will serve as your anticipatory set.

The guided investigations and extensions explained here are adaptations of those I have used in middle school and high school biology classes. They require very little equipment and can be used with modest adaptation in any school setting from grades 5 through 12. This set of investigations is designed to help you develop your students' understanding of (1) the concept of biodiversity and its importance in maintaining healthy ecosystems, (2) the strongly monocultural agriculture that produces the American food supply, (3) the dangers to a food supply posed by a lack of biodiversity, and (4) the potential power and safety of biodiverse food systems. It will stimulate discussions about place, local foodsheds, and healthy food choices.

In addition to learning about biodiversity and sustainable agriculture, students will also practice scientific reasoning and habits of mind as they do original (to them) scientific inquiry as described in the national standards (AAAS 1993; NRC 1996). These propensities, attitudes, actions, and the related scientific habits of mind that are involved in designing and carrying out original experiments are important aspects of vital science instruction.

The teaching unit described here is designed to take 10 to 12 interdisciplinary lessons that provide opportunities to team teach across the curriculum. The investigations incorporate discussions about socioeconomic factors related to food systems, quantification and analysis of data (graphing, deriving formulas, means, averages, patterns, etc.), history of human civilization from agrarian to urban civilization, scientific writing as genre, the poetry of Wendell Berry, and other botany-related topics.

FIGURE 1 Weekly eating log

Record everything you eat for _____days. If you prefer, record every other day. Try to be very specific and measure or estimate the mass (g) or volume (L) as accurately as you can. In the last column, record prepared-food ingredients as they are listed on the package. If there is not enough room, create another table or method for recording ingredients.

Name:

Day	Breakfast	Lunch	Dinner	Snacks	Notes
Mon.	• Corn flakes • Skim milk	• Hot dog • Hot dog bun • Ketchup	• Hamburger • Bun • Ketchup • Pickle • French fries	• Orange • Potato chips • Snickers	Record additives, ingredients such as sugar, salt, etc.
Wed.					
Fri.					
Sun.					

FIGURE 2 Class data chart for weekly food consumption

Class data for Lessons 1 and 2

Food type	Total mass or volume for our class (g)	Average mass per individual per week (g)	Average mass per individual per day (g)	% of total mass of weekly food consumed (g)	Calculate total mass per individual, per year (g)
Oats					
Corn					
Corn product					
Pickle					
Ground beef					
Salt					
Sugar					

Debriefing sessions should be conducted after each inquiry. Without them, you or your students may not know what was learned or how much is understood. Each debriefing session also points ahead to the next inquiry and gives students power over and ownership of the questions and particulars of their next experience. Debriefing sessions therefore serve as a postassessment of learning outcomes as well as a preassessment for the next investigation. The lessons that follow are written so that you can adapt them accordingly to meet your particular student needs.

Lesson 1: Introduction and collecting baseline data

This lesson is preparation for beginning the unit, and should be completed during the week before Lesson 2. Students keep a record of everything they eat in order to collect baseline data as they make the learning personal, contextual, and relevant. Inform students that the class will be looking at plants in their diet. (To encourage honest recording, emphasize that this is not an examination of the quality of their eating habits.) It is suggested that teachers participate by logging their own food to model the process.

Have students record data for a minimum of three full days. I found it helpful to post a data chart (see Figures 1 and 2) during progress checks so students could construct the data set together. Figure 1 is a personal data chart students fill out on their own and bring to class during progress checks. Students should then use the data recorded there to fill in Figure 2, the class data chart, during class time. Either post the class data chart on a wall or on an overhead projector slide so students can see it and have access

FIGURE 3 Glossary of terms with working definitions

Biodiversity: Much of the credit for this concept is given to E.O. Wilson and his important book *Biodiversity* (1988). It literally means that there is a wide variety of living organisms in a healthy ecosystem and that the health of a system depends on this variety. Every type of native plant or animal contributes something important to the entire system, and the system would not be the same without that organism.

Carbon miles: The number of miles food or any other product is transported from where it is produced or processed to where it is consumed or used. It is a term that is related to global warming and the assumption that burning fossil fuels to transport goods puts carbon dioxide and other greenhouse gases into the air. Fewer carbon miles are better for global health.

Debriefing: This is a pedagogic tool common in experiential and outdoor learning. Basically, it is a discussion session usually led by the instructor that follows an activity or investigation. The instructor uses this discussion to summarize what has been learned, as well as to assess student learning. A lesson is never done until the debriefing session is complete.

Foodshed: This term is used in the local-food movement and is a way of applying some of the principles of watershed ecology to urban food systems. To study a foodshed, one would look at the agricultural land surrounding a city and learn about the farmers who tend the crops, their practices, the type of food they grow, and what it would take to bring their products to city people. The idea is to determine what local food is available and how to make it flow like a river into the city to supply the nutritional needs of people living there.

Monoculture: This term literally means one culture. It refers to the common farming practice of using chemicals or other means to ensure only one kind of plant grows in a field. Any plant other than the desired plant (e.g., corn or soybeans) is considered a weed that affects productivity. It takes a lot of energy, chemicals, and work to maintain a monoculture, because natural systems, if left alone, always move toward biodiversity. Monocultures also naturally draw opportunistic insects and other herbivores because of the rich concentration of available food.

Nice green suburban lawns are also monocultures of plants often not very well adapted to the climate. Homeowners need to constantly tend lawns and use water and chemicals to keep them alive and keep weeds and pests at bay.

Polyculture: This term literally means variety in culture. In agriculture, it refers to a more natural situation where the land is covered by a variety of plants. Some farmers plant between rows or let different crops grow in the same field at the same time. This practice can conserve water and reduce the amount of fertilizers and pesticides needed (see *monoculture*), but it can also be more labor intensive, because the farmer can't use some of the machinery designed for monocultures or rely on chemicals as much.

Scientific inquiry: For this article, I adopted the National Research Council description of scientific inquiry: "Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries" (1996, p. 23).

Sustainable agriculture: The agricultural practices that are often associated with the slow-food and local-food movements. Farmers try to conserve and protect clean water and good soil, reduce dependency on chemicals, support biodiversity, and contribute to social good by changing the way people get their food and what they eat.

FIGURE 4 Group presentation grading criteria

Names of group members:

Title of presentation:

Learner outcomes	Self-evaluation	Peer comments	Teacher comments
Gave a good introduction • Defined terms • Identified focus or thesis • Got our interest			
Slide preparation • Used technology well • Followed an outline • Well-organized			
Raised good questions • Did not just tell us • Made us think • Challenged us			
Good conclusion • Brought us back to thesis • Appealed to our interest • Good closure			
Content focus We know • more about food choices • more about sustainability • more about healthy eating • about where to get good food • more about plants • more about the importance of variety in plant systems • more about biodiversity			

to it. Of course, you could use a SMART Board or a computer with a projector, as well. I record questions as they come up and solve problems with students as they appear. This also helps me model the kind of record keeping expected of participants.

The procedures are simple. In a food log or data table, students record everything they eat by mass before they eat it. For packaged individual servings, the net mass of the food will be written on the package. Show students how to read food labels and help them distinguish plant materials from other ingredients. This is an opportunity to directly address one of the standards for health and food literacy (AAAS 1993; NRC 1996, 2000). Because actually measuring the mass of food items is not possible in most cases, have students make estimates. You will have to use examples to show students how to do this. For prepared or fast-food meals, the mass should be on the package or in the nutritional information vendors provide. At the end of the investigation, have students bring their data tables and food logs to class. Pool class data and averages of foods consumed (see Figure 2).

Guiding questions

- If you go outside your home or outside the school building, where would you expect to find a polyculture? (See Figure 3 for a glossary of terms.)
- Have you ever seen a monoculture? When and where?
- Do monocultures ever exist in nature without human intervention? Are they sustainable?
- What prevents monocultures in nature?
- Some families spend time and money sustaining a nice, green lawn. What would happen to this lawn if it was left alone for a couple of years? Would this be good or bad? From whose perspective?

Extension opportunities

After you and your students have discussed the answers to the guiding questions, some students might want to further explore these ideas in groups or as individuals. For example, students can check if there are any local ordinances about lawn care or letting one's property go natural. Students can research the Irish potato famine, black wheat rust blight, or the common practice of planting American elm, American chestnut, or white ash trees along city streets. Students might then report on whether or not they think human efforts to create monocultures had anything to do with related historical and current events. For example, the famous Irish potato famine of the 1840–50s was likely caused by or at least exacerbated by monocultural agriculture practices.

Lesson 2: Agricultural diversity as represented by our eating habits

This lesson is designed to analyze the data collected during Lesson 1. Help your students pool class data and count how many different plants are represented in students' recorded eating history (see Figure 2). Look for patterns, exceptions, and discrepant cases. Record questions students would like answered as they proceed.

Guiding questions

- How many different plants were consumed by each student?
- What plants are most frequently represented in the data?
- What plants represent the most biomass consumed by the class?
- What range of quantities are represented?
- Are our class results typical of the American diet?
- Are our class results representative of other students in other parts of the world?
- What proportion of our food is processed in some way by the food industry?

Extension opportunities

In groups, have students research a plant found in their data and trace it to its source. How far was it transported, and what was done to the original plant on its way to their table? Calculate the food miles (carbon miles) it traveled from farm to table. What resources are used in this transportation? What are the implications of this resource use?

Lesson 3: Thought experiment—Alien invasion

Present the following scenario to students:

The inhabitants of a distant planet left their homeworld because their population increased so rapidly that they ate all the available food. Their diet is so specialized that they eats only one thing—a plant called Zea mays. *The aliens have been traveling the universe looking for planets with sources of this needed food. On every planet, they eat every bit of this food and then move on. When they* *came to planet Earth, they found a great supply in North America. Very soon, the aliens had to move again.*

Procedure

Students examine the data from the previous investigations and predict how our food system would be different after the alien invasion. This will require examining the ingredients list for the foods consumed, which can be found on corporate websites if the actual product is not at hand. (After the alien invasion there would be no corn or anything else that comes from or depends on corn. This means no corn-fed beef, fish, poultry, or pork; no dairy products or eggs from factory farms or feedlots; no processed foods that contain corn; and no beverages that contain corn syrup.)

Guiding questions

- What foods would be left on our list and charts if corn were not available?
- How dependent are we on monocultures of corn?
- What if you substitute a new pesticide- and herbicide-resistant pathogen for the hungry aliens?
- Can you think of circumstances in which the effects of this imaginary scenario could become real?

Extension opportunities

With your students, make a list of all the corn products or places corn appears in our diet. Have student groups research one or more of the corn products they found in their diet. What is done to corn kernels to make this product? By whom? What is the physical process like? What machines are used, and where is it done? What chemicals are added to the corn to make the product? How much water is used, and what waste products are generated?

Lesson 4: Expanding on the thought experiment

This inquiry expands on the thought experiment as it brings students to the grocery store to examine their local food system. It is best done in small groups of three or four students and with adult supervision. I always look for ways to encourage parental involvement in my students' science education; field trips are excellent opportunities.

Procedure step 1: Get the lay of the land

Students go to their own grocery store with parents or adult guardians. On graphing paper, students sketch the layout of the store to scale, giving estimated dimensions of the entire floor space. Next, students sketch the aisles and displays, recording which types of products are available in each aisle (e.g., canned fruit and vegetables, canned meals and soup, soft drinks, fresh produce, frozen vegetables, frozen prepared meals, snacks, dairy products, etc.). Your class can decide on categories and how to best represent them. Students will find it useful to take digital pictures to represent findings to the class. Help students calculate the percentage of the floor space dedicated to each category of food.

Procedure step 2: Analysis

Refer to the scale drawing and assign different study groups to different sections of the store. Have each group choose three to five examples of foods representing their section of the store and record the name of each product with all of the ingredients listed. Students tabulate their data on a chart and bring it to class. The outcome of this analysis includes these questions: In our thought experiment, an alien invasion eliminated all corn on Earth. What food is left in our grocery store? What does this tell you about our food system?

Extension opportunities

On a class data chart, record each of the ingredients in the group data charts. Help your students record the number of times each ingredient appears in the data and create a histogram of the results. How is plant biodiversity represented in the data?

What percentage of food eaten is traceable to source? Help your students compute food miles where possible (how many miles or kilometers each food item was transported). Discuss the implications for sustainability of our food system (fossil fuels, carbon footprint, climate change).

Help your students make a list of all the chemical additives represented in the class data. Which is the most commonly used, and which is used in the greatest amounts? Either individually or in groups, students could research each of these to find out what the additives are made from and the purpose they serve in the production of the food.

Lesson 5: Debriefing discussion

This lesson will help you and your students refocus on the learning outcomes and provide closure to the unit. The following questions and problems will help guide this discussion.

Guiding questions

- What problems have these activities revealed?
- Are there alternatives to this type of food system?
- Suppose you are a land owner and want to grow field corn. Would you attempt to create a monoculture in your field? Is this the only way to grow corn? Would this be sustainable?
- Imagine that you are a European corn borer moth (*Ostrinia nubilalis*) flying around, looking for a good place to lay your eggs (do research online to find out about these moths). Would you look for a monoculture or polyculture to find the best place to lay your eggs and the best chance for your offspring to survive? (Remember that a moth's behavior should be considered for the good of the species, not the individual.)
- What are the health effects of a diet so predominantly made up of corn?
- Which part of the grocery store was still intact after the invasion?
- What does this suggest about a healthier, safer food system?
- Create an imaginary meal that comes from sources other than this food system.
- What resources are there in our community for food other than the grocery store?

One of the intended lessons of these inquiries is about the place of corn in the American industrial food system. Corn is found either directly (as an additive in processed food or the oil used to fry food) or indirectly (fed to animals, which we then eat) in many foods. There are health implications associated with this. For example, there is a connection between corn products and heart disease, obesity, diabetes, and the body's use of insulin. There are also implications for sustainability that relate closely to the science of botany. If we continue the current agricultural practices we have become accustomed to, how will other species of plants be affected in the near and extended future? What will happen to our food system as fossil fuels become more expensive and carbon loading of the atmosphere gets more extreme? Seek curiosity-driven questions from your students that reflect their understanding of the basic principles of botany and ecology and our dependence on arable land and clean water.

Unit assessment

For assessment of student learning, have each inquiry group prepare electronic slide presentations of their findings and lead a brief discussion of the implications. I find it helpful to use a grading criteria. Figure 4 is an example of how a checklist of criteria might be constructed. You will undoubtedly make adaptations during the unit and will need to modify and personalize the grading criteria. ■

References

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy*. New York: Oxford University Press.

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

National Research Council (NRC). 2000. *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academies Press.

National Science Teachers Association (NSTA). 2004. Position statement: Scientific inquiry. *www.nsta.org/about/positions/inquiry.aspx*.

Wilson, E.O., ed. 1988. *Biodiversity*. Washington, DC: National Academies of Sciences/Smithsonian Institution.

Resources

The following movies may be useful just before, during, or after Lesson 5, because they may help students identify the content of the unit and help them focus their discussions. They should not be used earlier than Lesson 5, because they could give some of the answers away prematurely and negatively influence the inquiry.

Fast Food Nation. 2006. Fox Searchlight—*www.foxsearchlight.com/fastfoodnation*

Food, Inc. 2008. Magnolia Pictures—*www.foodincmovie.com.*

King Corn. 2007. Mosaic Films—*www.kingcorn.net.*

Supersize Me. 2004. Sony Pictures—*http://super-size-me.morganspurlock.com*

Charles J. Rop (*crop@utoledo.edu*) is an associate professor of science education in the Department of Curriculum and Instruction at the University of Toledo in Toledo, Ohio.