



AGRICULTURE AND ECOSYSTEMS

LESSON PLAN

Overview

Estimated lesson time: 125 minutes

Before this module, we recommend students become familiar with the [vocabulary definitions](#) for this module. Refer to [vocabulary builders](#) for suggested activities. We also suggest students become familiar with the material covered in [History of Food](#).

10 min **Introduction**

Brainstorm and discussion

Students will brainstorm responses to essential questions (see below).

10 min **Tracing food to soil**

Brainstorm and discussion

Students will trace the ingredients of a meal back to their origins in the soil.

20 min **Food, agriculture and ecosystems**

Graphic organizer and lecture

Students will brainstorm facets of ecosystems that are essential to our food supply and record their responses in graphic organizers. The lecture that follows will cover the relationships between food, agriculture and ecosystems.

20 min **Problems in agriculture**

Lecture

The lecture will cover some of the health, environmental, social and economic problems facing agriculture. Before this section, it is recommended that students cover the industrialization of the U.S. food system in [History of Food](#).

30 min **Assessing and addressing problems**

Group activity and presentations

Working in groups, students will assess the problems facing agriculture and devise plans to address them.

20 min **Alternative farming systems**

Lecture and discussion

The lecture will cover alternatives to the prevailing industrial agricultural model, including the organic and sustainable agricultural movements.

15 min **Reflection**

Discussion and think-pair-share

Students will discuss essential questions and respond to quotes about agriculture, ecosystems and health.

Essential questions

Essential questions¹ point to the big ideas of a module. They can be discussed, written on the board and posed on essays and exams.

- Where does our food come from? How is our food supply dependent on ecosystems?
- How do current agricultural practices affect public health, social justice, the environment and the economy?
- What can be done to address the current problems facing agriculture?
- How does an industrial approach to agriculture compare with organic and sustainable approaches?
- If the prevailing practices in agriculture continue, what kind of food system can we expect in the future? What kind of agriculture *should* we strive toward, and how will we get there?

Learning objectives

Students will be able to:

- Reflect on the connections between the food they eat, agriculture and ecosystems;
- Describe the health, environmental, social and economic problems in agriculture;
- Work collaboratively to assess the problems facing agriculture and suggest plans to address them;
- Compare and contrast industrial, organic and sustainable approaches to agriculture.

Materials

Available on the [Teaching the Food System](#) website:

- Background reading, intended to brief educators on the concepts covered in this module but also suitable as a reading assignment for students
- Slides
- Student handouts:
 - *Food and ecosystems*
 - *Assessing problems*
 - *Addressing problems*

10 min Introduction

Brainstorm and discussion

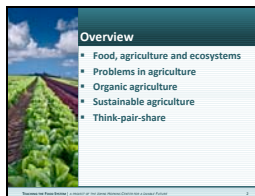
Students will brainstorm responses to essential questions.

Note: Instructions to the educator are written in italics; talking points to students are written in plain font. Talking points are not intended to be delivered verbatim—we expect educators will adapt them to best suit their audiences.



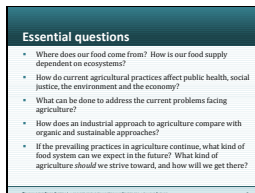
Title slide

- **Agriculture** is the production of food and goods through farming. It is the source of most of the world's food supply.²
- Agriculture depends on parts of **ecosystems**—communities of organisms interacting with each other and with their physical environment.³
- In this lesson, you will:
 - Trace the ingredients of a meal back to their origins in the **soil**;
 - Reflect on the connections between food, agriculture and ecosystems;
 - Assess some of the challenges facing agriculture and devise plans to address them;
 - Discuss organic and **sustainable** approaches to agriculture.



Overview

- *Briefly indicate some of the topics that will be covered.*



Essential questions

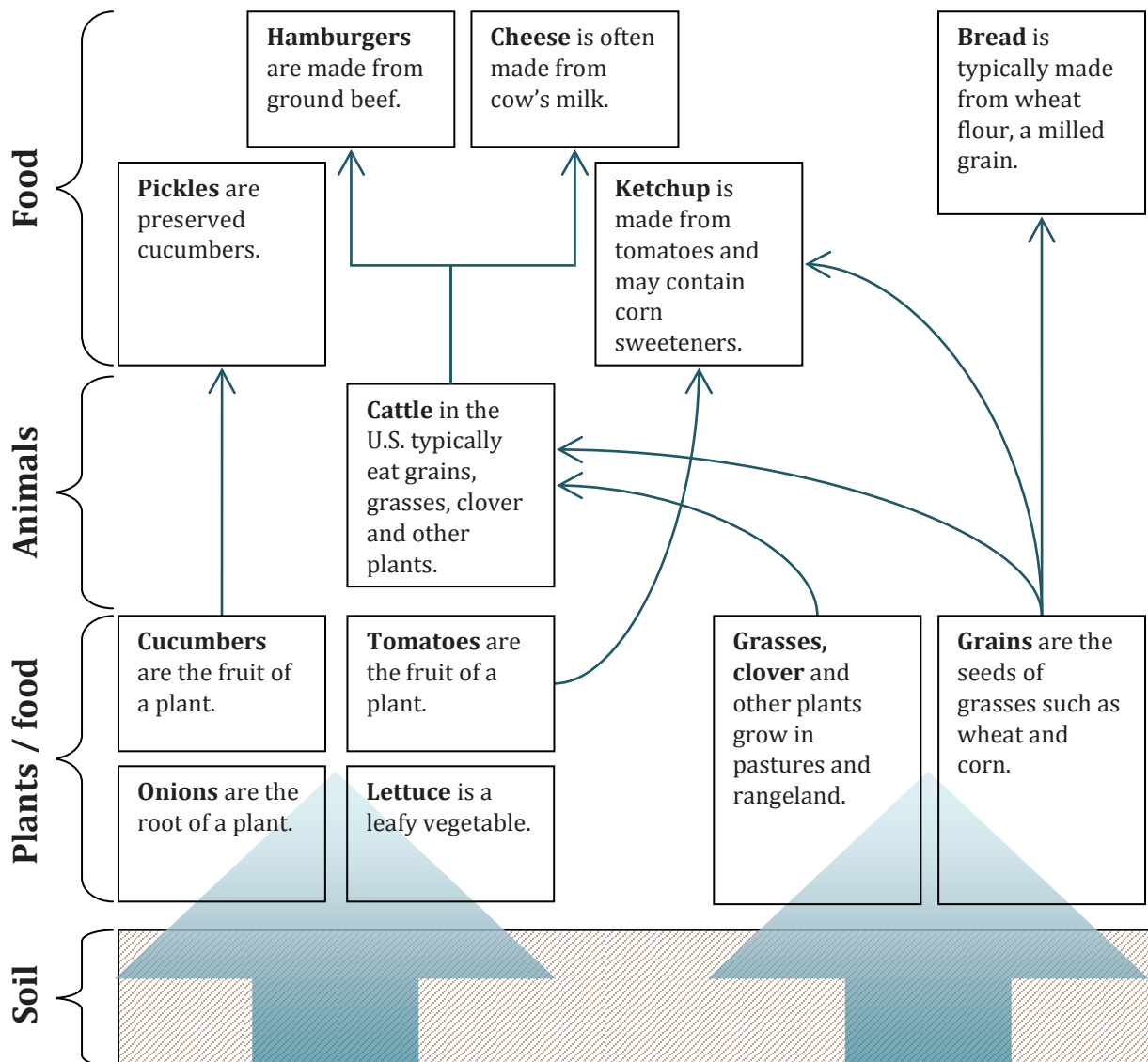
- These questions point to the big ideas of this module.
- *Give students a few moments to read the essential questions. Notify them that they may be used after the lesson as exam or essay questions.*
- *Leave this slide on display during the remainder of the introduction.*
- *Before discussing essential questions, ask if students are familiar with current agricultural practices in the U.S., how they changed over recent decades and why. This should be a review for students familiar with [History of Food](#).*
- *Brainstorm responses to essential questions. Students may not yet have enough content knowledge to respond to the question comparing industrial, sustainable and organic approaches.*
- *Students can respond aloud and/or in writing. List students' responses on the board. Their responses don't need to be correct—this activity is designed to solicit their initial conceptions and to prime their curiosity.*
- *Students will revisit some of these questions after the lesson.*

10 min Tracing food to soil

Brainstorm and discussion

Students will trace the ingredients of a meal back to their origins in the soil.

- List the ingredients of a hamburger on the board.
- Ask students where each ingredient comes from. If they respond with retail places (supermarket, cafeteria, etc.), ask where the ingredient comes from before that. Most ingredients, including animal products, can be traced to plants that grow in soil.
- As students divulge the origins of each ingredient, recreate the diagram below on the board.
- Why is soil important to our food supply?
- Most of our food supply originates in soil. Soil provides plants with water, **nutrients** and support for their roots. Fertile soil is teeming with billions of organisms, many of which help plants grow.
- This activity can be repeated for any number of other foods, though some of the ingredients in highly processed foods may be difficult to trace to their plant/soil origins.



Adapted, with permission, from Robinson C. Dr. *Dirt's K-12 Teaching Resources*. 2009.¹

20 min Food, agriculture and ecosystems

Graphic organizer and lecture

Students will brainstorm facets of ecosystems that are essential to our food supply and record their responses in graphic organizers. The lecture that follows will cover the relationships between food, agriculture and ecosystems.

Graphic organizer

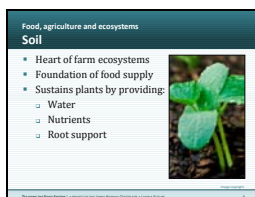
- Break students into groups of 3-5.
- Provide each student with a copy of the handout *Food and ecosystems*.
- Soil is the foundation of farm ecosystems. What are some other parts of ecosystems that might be important to agriculture?
- In groups, students will brainstorm parts of ecosystems that are essential to our food supply, such as freshwater, beneficial organisms (pollinators, earthworms, etc.) and a stable climate. Students will write their responses on their graphic organizers.
- Students will consider the function that each part of ecosystems serves in supporting our food supply. Students will write their responses on their graphic organizers.
- Students will revisit their graphic organizers after the following lecture.

Lecture



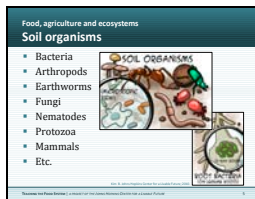
Overview: Food, agriculture and ecosystems

- Food and agriculture are rooted in ecosystems.
- An endless number of organisms, including humans, crop plants, livestock, insects, bacteria and fungi, are essential to our food supply.
- Physical facets of ecosystems that affect agriculture include soil, **climate** and water.



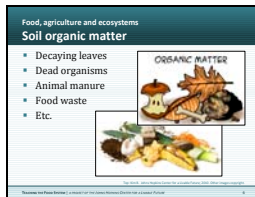
Soil

- Soil is the foundation of farm ecosystems; we depend on it for most of our food supply.²
- Partly because much of the American Midwest has deep, fertile soil, the region, along with parts of Europe and China, produces most of the world's grain.⁴
- Among other benefits, soil provides plants with water, nutrients and support for their roots.



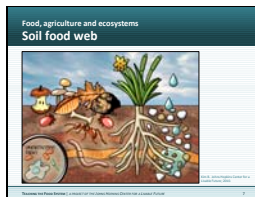
Soil organisms

- Although it may be mistaken for lifeless dirt, fertile soil is actually teeming with living organisms. A single teaspoon of soil can contain as many as a billion bacteria.⁵
- Some beneficial bacteria inhabit the roots of legumes, such as bean and peanut plants. These root bacteria capture nutrients from the atmosphere and make them available to the plants.
- Arthropods, earthworms, fungi, nematodes and protozoa also inhabit soil.



Soil organic matter

- Soil organisms are sustained by the energy and nutrients contained in dead **organic matter**, such as decaying leaves and other plant and animal materials.⁵
- **Compost** is a collection of decomposing or decomposed organic matter that is often added to soil to enhance its fertility.



Soil food web

- The interactions between living organisms and nonliving organic matter form a soil ecosystem called the **soil food web** because every organism becomes food for another.⁵
- The soil food web offers many services that promote an abundant food supply and human health:
 - Organisms break down dead plant and animal materials, cycling nutrients into forms that crops can use. Earthworms, for example, eat decaying leaves and release valuable nutrients in their waste.⁵
 - The soil food web stores nutrients, releasing them slowly over time;⁵
 - It stores water;⁵
 - It suppresses certain plant diseases;⁵
 - In some cases, it purifies water by breaking down certain pollutants.⁵



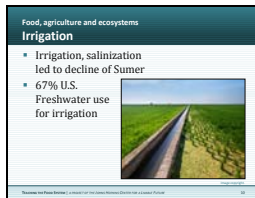
Climate

- A region's climate is the temperature, precipitation, humidity and other weather conditions over a long period, whereas weather refers to the conditions at a particular time.
- Like soil, climate contributes to the suitability of the land for agriculture.
- The favorable climate of the American Midwest, for example, is essential to the immense productivity of agriculture in the region.⁴
- In contrast, Europe's climate between 1430 and 1850 shifted into a "Little Ice Age," which led to shortened growing seasons, reduced crop yields and less arable land (land that could be farmed), contributing to severe food shortages among the poor.⁴
- Today, a warming global climate—driven by human activities such as burning fossil fuels⁶—similarly threatens **food security** among the world's poor.^{7,8}



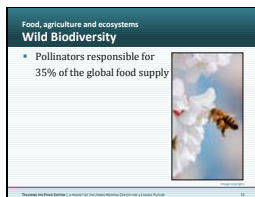
Freshwater

- Agriculture depends on a reliable supply of **freshwater** (water that is not salty) from streams, rivers, underground aquifers and other sources.



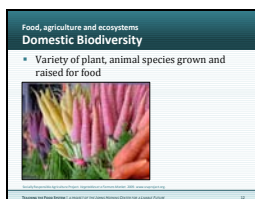
Irrigation

- Where rainfall is inadequate, farmers use **irrigation** to deliver water to fields. In the United States, 67 percent of freshwater use is for irrigation.³
- If poorly managed, irrigation can be catastrophic.
- The Sumerians were among the earliest human societies; they prospered for a time, but their food supply declined from 3000 to 1000 BCE—along with their civilization—largely because they mismanaged their freshwater and soil.⁴
- Sumerian farmers relied on groundwater to irrigate their fields of wheat, but the water contained a hidden risk: When it evaporated, it left behind deposits of dissolved salt.⁴ As the growing population demanded increasingly aggressive agricultural production, continued unchecked irrigation eventually “salted the earth” to the point where crops could no longer be grown.⁴
- Today, in many parts of the world, irrigation depletes freshwater supplies faster than they can be replenished.⁹



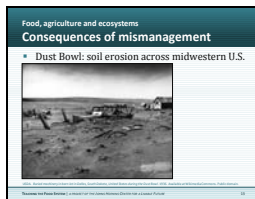
Wild biodiversity

- **Biodiversity**—the variety of organisms living in an ecosystem—plays a crucial role in agriculture.
- Can you name some organisms that help our food supply?
- Farmers depend upon a varied assortment of bees, birds, butterflies and other pollinators that tend to 35 percent of the global food supply.¹⁰
- Greater biodiversity within soil ecosystems may enhance the beneficial services offered by soil food webs.⁵



Domestic biodiversity

- Diversity among the plant varieties and animal breeds we cultivate is another essential genetic resource.
- What could happen if every farmer in America raised only one variety of chicken or grew only one variety of potato? *An example of this scenario is given below.*
- Building our food supply upon a greater variety of species allows farmers to increase productivity and better adapt to changing conditions.¹¹
- With a greater variety of plant and animal species to choose from, farmers are able to produce the crops and livestock that are best suited to their region.¹¹
- Some species, for example, are more tolerant of certain weather conditions or resistant to certain **pests**.¹¹



Consequences of mismanagement

- How well farmers care for soil, climate, water, biodiversity and other facets of ecosystems can greatly influence a nation's food supply.
 - In certain parts of the world throughout every era, overplowing, deforestation and other forms of soil mismanagement have turned fertile land to arid wasteland.⁴
 - Farming practices that erode fertile soil persist to this day, even after the **Dust Bowl** (pictured) caused massive crop failures, hunger and poverty across the Midwestern United States less than a century ago.⁴
 - These sobering realities remind us that even after over 10,000 years of practicing agriculture, farmers still struggle to foster healthy ecosystems while providing a stable food supply.
- *Students will compare their graphic organizers to the concepts covered in this lecture.*
 - Were there any concepts that you included in their graphic organizers but were not covered in the lecture?
 - Were there any concepts covered in the lecture that were new to you?
 - Are there other valuable services that ecosystems can offer, besides supporting agriculture?

20 min Problems in agriculture Lecture

The lecture will cover some of the health, environmental, social and economic problems facing agriculture.

- During the following lecture, instruct students to take notes on each problem. They will refer to their notes during the activity that follows.



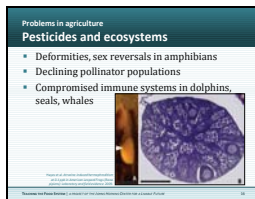
Overview: Problems in agriculture

- The industrialization of agriculture brought enormous changes to how food is grown.
- Partly as a result, agriculture boomed: From 1950 to 2000, production on U.S. farms more than doubled, with a fraction of the human labor.¹²
- It has been said that U.S. agriculture has become the “most efficient in the world, at least in terms of the dollar and cent costs of production.”¹³
- Many of the practices that arose from industrialization, however, negatively impact health, ecosystems and social **equity**, and may have consequences for farmers and their long-term capacities to provide a stable food supply.
- Many of these problems are related; for example, impacts to ecosystems very often affect health.¹⁴



Fertilizers and aquatic ecosystems

- Heavy reliance on agricultural chemicals is one route by which the practices associated with industrial agriculture can impact aquatic and terrestrial ecosystems.
- To provide crops with nutrients, some farmers apply chemical **fertilizers**, **manure** or **treated** sewage sludge to fields.¹⁴
- When these nutrients exceed plant needs, or are applied shortly before it rains, the excess can leach down into groundwater or be carried by **runoff** into nearby waterways.¹⁴⁻¹⁶
- Nutrient pollution in aquatic ecosystems contributes to harmful **algal blooms** that deplete oxygen from water, creating underwater regions that are devoid of most aquatic life.^{17,18} These **dead zones** are common in the Gulf of Mexico, Chesapeake Bay and other coastal regions.^{17,18}
- Globally, synthetic nitrogen fertilizers and increased intensity of meat production are among the greatest contributors to nutrient pollution.¹⁷



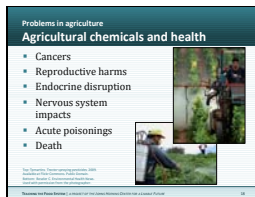
Pesticides and ecosystems

- Agricultural **pesticides** can also impact surrounding ecosystems.
- Among other harms, pesticide use has been implicated in deformities and sex reversals in amphibians,¹⁹⁻²¹ declining pollinator populations²² and compromised immune systems in dolphins, seals and whales.¹⁵
- Image:* Cross section of testes from a male frog exposed to atrazine, a common herbicide known to cause reproductive abnormalities in wildlife. The three spherical structures are egg cells.²¹



The treadmill effect

- Over time, many target species, including insects and plants, develop resistance to the pesticides used against them.¹⁵
- Chemical fertilizers can degrade soil fertility over the long term.²³
- These adverse effects can create a “treadmill effect,” where farmers continually need to apply more chemicals to achieve the desired result,^{24,25} worsening the harms posed by their use.



Agricultural chemicals and health

- People can be exposed to pesticides through inhalation, direct skin contact, contaminated drinking water or residues on or inside foods.¹⁵
- Depending on the pesticide, the potential long-term effects of exposure may include elevated risks of certain cancers and disruption of the body’s reproductive, immune, endocrine and nervous systems, among other harms.¹⁵
- Agricultural workers in the United States may face health risks from occupational exposures to pesticides, including acute poisonings and in some cases death.^{26,27} These occupational risks are disproportionately shouldered by minority and immigrant workers.¹⁵



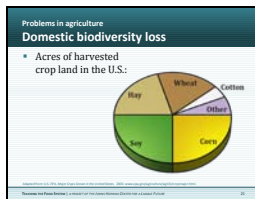
Wild biodiversity loss: Insecticides

- The heavy application of insecticides (a type of pesticide intended to control insect pests) and other agricultural chemicals can have unintended impacts on biodiversity.
- Insecticide use can have harmful impacts to beneficial organisms, including pollinators and predators of pests.^{15,22,28}
- Recently, bee populations have been in dramatic decline. Scientists are uncertain as to the exact combination of causes,²⁹ though pesticide use is a suspected contributor.^{10,15,30}



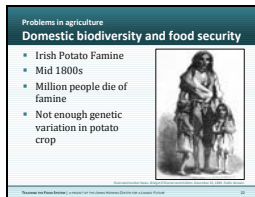
Wild biodiversity loss: Monocultures

- The specialized **monocultures** characteristic of U.S. industrial agriculture also contribute to the loss of wild biodiversity.
- Growing monocultures replaces biodiverse habitats with fields of genetically uniform organisms.¹⁵
- In places where monocultures are grown in place of a variety of flowering plants, pollinators may be left without enough forage (nectar) to survive.³⁰



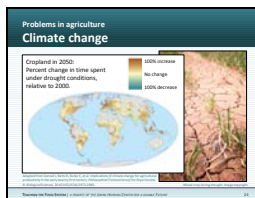
Domestic biodiversity loss

- The extent to which U.S. agriculture specializes in producing a narrow range of crops and animals has lessened the genetic diversity of our food supply (domestic biodiversity).³¹
- Roughly half of U.S. cropland, for example, is dedicated solely to growing corn and soybeans.³²
- Globally, 90 percent of the food supply is derived from only 15 plant and eight animal species.³³



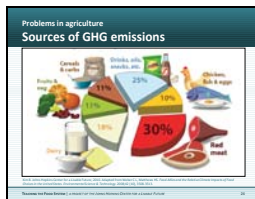
Domestic biodiversity and food security

- With farmers relying on only a few crop varieties, the stability of our food supply is more susceptible to pest invasions and other shocks.¹⁵
- The Irish potato famine of the mid-1800s illustrates these dangers. Ireland's poor (one-third of its population) depended on a genetically uniform food source—potatoes—for the bulk of their sustenance.³⁴ This set the stage for a devastating food crisis. The plant disease *P. infestans* wiped out potato crops, crippling the food supply and contributing to the deaths of an estimated 1 million people.³⁴



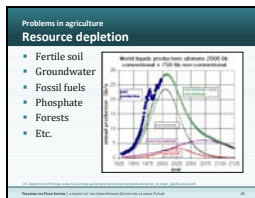
Climate change

- Agriculture has always been affected by, and has contributed to, **climate change**.
- Based on some projections, changes in temperature, rainfall and severe weather events are expected to reduce crop yields in many regions of the developing world, particularly sub-Saharan Africa and parts of Asia. Many parts of these regions already struggle with a lack of food security.^{7,8,35}
- *Ask students to interpret the map depicted on the slide.*
 - Although this image depicts a worse-case scenario, the climate model that this map is based on consistently predicts an increase in the time spent under drought conditions in most crop-growing regions of the world.³⁵
- Recent studies suggest that rising global temperatures since 1980 have already dampened global corn and wheat yields.³⁶
- Some of these losses may be partially offset by rising levels of atmospheric carbon dioxide, a common greenhouse gas (GHG) that is essential to plant growth.^{7,35}
- It is difficult to measure the net long-term global effect of climate change on agricultural productivity, and the effects are expected to vary widely by region.³⁵
- Despite these uncertainties, climate change is generally viewed as a major threat to **public health**, equity, food security, freshwater supplies and ecosystems. It is predicted to increase the frequency and severity of droughts, heat waves, flooding, hurricanes and other weather events, with far-reaching effects on human populations. Immediate action to reduce human sources of greenhouse gas emissions may lessen some of these impacts.^{6-8,37,38}



Sources of GHG emissions

- Globally, agriculture contributes an estimated 14 percent of total anthropogenic (human-caused) GHG emissions.⁶ Deforestation and land use, including clearing forests for crops and livestock, contribute an additional 19 percent.⁶
- Studies suggest that on average, GHG emissions associated with production through retail in the U.S. **supply chain** are predominantly from food production (83 percent), with smaller contributions from transporting food and food ingredients (11 percent) and food retail (5 percent).³⁹
- Image:* Nearly half of total GHG emissions from production through retail in the U.S. are from red meat and dairy production.^{39,40}
- Major sources of GHG emissions from U.S. agriculture include synthetic fertilizers, cattle belching, livestock waste and fossil fuels for farm machinery.^{39,41}



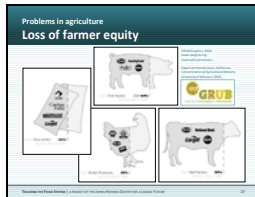
Resource depletion

- Natural resources, including fertile soil,^{2,42} groundwater,^{43,44} fossil fuels⁴⁵ and phosphate⁴⁶ (a mineral used in the manufacture of some chemical fertilizers), are being depleted at rates faster than natural processes can restore them.
- Many of these resources are nearing or have passed the point at which their rate of extraction begins to decline, prompting the use of terms like **peak oil**⁴⁵ and peak phosphorous.⁴⁶
- In its current form, agriculture is dependent on all of these resources and is a major contributor to their decline.^{2,44-46} The possibility that they may no longer be easily acquired raises concerns about the long-term price and availability of food, which may disproportionately impact the poor.^{2,44-46}
- Graph:* Projected liquid petroleum production. Many authorities believe we are at or near peak oil—the point at which oil production begins to decline.⁴⁵



Loss of farmland

- Arable land is another natural resource that calls for conservation efforts.
- Every minute, more than an acre of American agricultural land is lost to sprawling suburbs and other developments.⁴⁷
- Paving over farmland diminishes natural ecosystems, local economies, scenic and cultural landscapes, and the nation's ability to supply ourselves and other nations with food.⁴⁸
- Well-managed agricultural land can offer many ecosystem services, including providing habitats for wildlife, helping to control flooding and maintaining air quality.⁴⁸



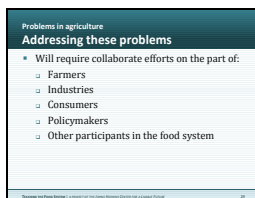
Loss of farmer equity

- Decisions about what food is produced, how it is produced and who produces it are shifting away from farmers and into the hands of a small number of influential corporations.⁴⁹
 - More than half of the U.S. corn seed market, for example, is controlled by only two corporations.⁵⁰
 - On the **food processing** side, more than half of the flour milling industry is controlled by three corporations.⁵⁰
 - Similar trends exist in food animal production.
- This trend is called **industry concentration**⁵¹ because the majority of the sales of a product or service are concentrated under the ownership of only a few corporations.
- The concentration of agricultural and related industries can leave farmers with fewer choices about where to acquire supplies, such as seeds and chemicals, and where to process their products.⁴⁹
- They may be pressured into following the practices dictated by the dominant industries, potentially leading to a loss of skills and knowledge, heavier debts, greater specialization and a loss of crop and animal biodiversity.⁴⁹
- The crucial point is that industrialization and market concentration can force farmers to compromise on what they believe is best for their land, animals and labor.⁴⁹
- *For more on market concentration, refer to [History of Food](#), [Food Animal Production](#) and [Food Processing](#).*



Industrial food animal production

- There are many additional challenges in agriculture that relate to the way animal products are produced in the United States. These are discussed in [Food Animal Production](#).



Addressing these problems

- Agriculture faces no shortage of challenges. In many cases, problems facing agriculture are related.
- Climate change, for example, is expected to worsen biodiversity loss⁶ and freshwater availability.⁴³
- The adoption of agricultural practices that conserve resources and protect health may depend on farmers having greater autonomy.⁴⁹
- Addressing these problems will require a collaborative effort on the part of farmers, industries, consumers, policymakers and other participants in the **food system**.

30 min **Assessing and addressing problems**

Group activity and presentations

Working in groups, students will assess the challenges facing agriculture and devise plans to address them.

- Break students into groups of 3-5.
- Provide each group with one copy of the [Assessing problems](#) and [Addressing problems](#) handouts.

Assessing problems

- Students will work as a group to respond to the questions in [Assessing problems](#).

Addressing problems

- Assign each group one of the problems covered in the prior lecture. These are listed on the [Assessing problems](#) worksheet.
- Each group will devise a plan to address their assigned challenge. They will respond to the questions in [Addressing problems](#).

Presentations and discussion

- Select several groups to present their responses to the class. Invite other students' critiques.

20 min Alternative farming systems

Lecture and discussion

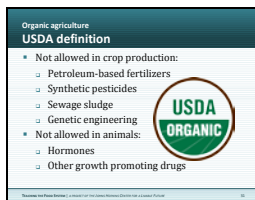
The lecture will cover alternatives to the prevailing industrial agricultural model, including the organic and sustainable agricultural movements.

- In recent decades, a movement toward alternative approaches to agriculture has gained momentum. These alternatives attempt to reduce the health, environmental, social and economic costs associated with the prevailing industrial model.
- While not an exhaustive discussion of alternative farming systems, the following briefly covers some of the more established approaches.

Organic agriculture

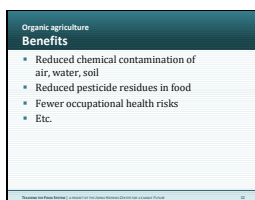


Overview: Organic agriculture



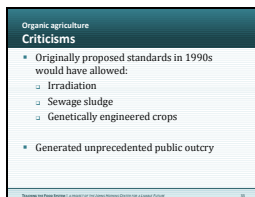
USDA definition

- As defined by the U.S. Department of Agriculture (USDA), organic farming practices generally prohibit the use of petroleum-based fertilizers, synthetic pesticides, sewage sludge and genetic engineering.⁵²
- Animals raised under organic practices must be given organic feed and allowed access to the outdoors, and cannot be given hormones or other growth-promoting drugs (refer to [Food Animal Production](#)).⁵²
- Since 1990, organic production in the United States has more than doubled (sales have increased over fivefold).⁵³ Despite these gains, only 1 percent of U.S. farmland was certified organic in 2005.⁵³



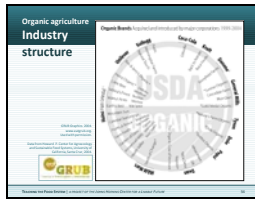
Benefits

- USDA organic practices can offer many ecological and health benefits, including reduced chemical contamination of air, water and soil, as well as a reduction in pesticide residues in food.⁵⁴



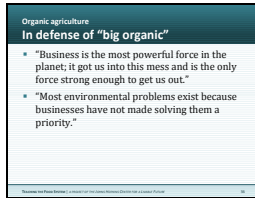
Criticisms

- Despite these benefits, the USDA organic certification program has come under some criticism since it was first introduced in the 1990s.^{54,55}
- The originally proposed standards allowed for the use of debated practices such as irradiation, use of sewage sludge as fertilizer and genetically engineered crops.⁵⁴ The public responded in outrage. After receiving an unprecedented volume of negative comments, the USDA revised the standards to resemble their current form.⁵⁴



Industry structure (2 slides)

- Today, parts of the organic food industry are characterized by large, industrial-scale farms and global product distribution to distant supermarkets,^{54,55} while many organic brands have come under the ownership of some of the world's largest corporate food manufacturers.⁵⁴⁻⁵⁸
- The industrial nature of the current organic food industry has been criticized for moving away from the movement's original ideals of small-scale production, **local** distribution and community engagement.^{54,55}



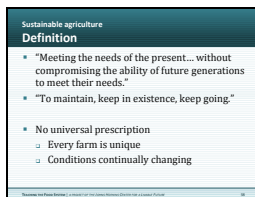
In defense of “big organic”

- In defense of “big organic,” the CEO of a large-scale organic dairy producer argues that globalization is not inherently harmful, and that large-scale capitalism can be leveraged to create sustainable change.⁵⁹ In his words:
 - “Business is the most powerful force in the planet; it got us into this mess and is the only force strong enough to get us out.”⁵⁹
 - “Most environmental problems exist because businesses have not made solving them a priority.”⁵⁹
- Do you agree or disagree with these statements? Why or why not?
- Refer to [Marketing and Labeling](#) for more on the USDA Organic label.

Sustainable agriculture



Overview: Sustainable agriculture



Definition

- Sustainability has been described as “meeting the needs of the present generation without compromising the ability of future generations to meet their needs.”⁶⁰
- Literally, “to sustain” means “to maintain,” “to keep in existence” or “to keep going.”⁶¹
- Unlike the set of required and prohibited practices for USDA organic agriculture, a prescription for sustainable agriculture remains elusive. Some argue that this is rightly so because each farm is unique, not standardized like a factory; what is sustainable on a farm in North Dakota may be dysfunctional in California.⁶²
- Sustainable agriculture has also been described as a “moving target”; one must continually anticipate change and adapt accordingly.⁶²



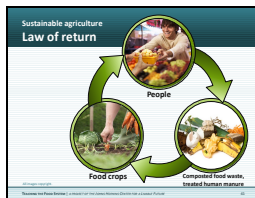
Themes

- Although lacking a set of definitive rules, sustainable agriculture does have several themes that describe it.
- *Before defining each of the following themes, ask students to share their own interpretations.*
- Ecologically sound,^{62,63} practiced in ways that minimize harms to the natural environment;
- Economically viable, allowing farmers to make an adequate living and produce sufficient food supplies;
- Socially just.⁶³



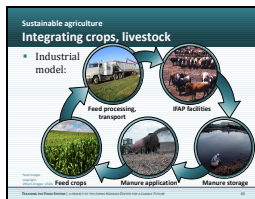
Protecting long-term interests

- In practice, sustainable agriculture gives due consideration to the importance of long-term interests.¹⁵
- *Ask students to share their interpretations of what this means.*
- Long-term interests include preserving fertile soil, biodiversity, freshwater and other resources.¹⁵
- **Soil erosion**, for example, can be minimized by protecting soil from wind and rain.² Crop rotations, cover crops, mulching, no-till farming and **rotational grazing** are farming practices that can reduce erosion.^{2,15}



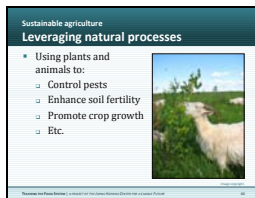
Law of return (2 slides)

- When appropriate, sustainable agriculture mimics natural processes. Among these core principles is “waste equals food.”^{64,65} In nature, the concept of waste does not exist; organic matter and the nutrients within it are continually recycled.
- On a farm, manure, food waste and other forms of organic matter enhance fertility when they are **composted** and put back into soil, where plants incorporate them back into the food supply. This has been called the law of return.⁶⁴
- We can apply this principle by composting our food waste, bringing it to a nearby farm or dropping it off at a collection site.



Integrating crops, livestock

- One way to promote the efficient cycling of organic matter is to combine crops and animals on a farm.⁶² In the words of agriculturalist Sir Albert Howard, “Mother Earth never attempts to farm without livestock.”⁶⁶
- Ask students why they think Sir Howard wrote this.
- The specialized industrial model separates animals and crops, creating enormous quantities of animal waste on the one hand and a need for fertility on the other (refer to *Food Animal Production*).
- Farmer and poet Wendell Berry describes the irony of this approach: “Once plants and animals were raised together on the same farm—which therefore neither produced unmanageable surpluses of manure, to be wasted and to pollute the water supply, nor depended on such quantities of commercial fertilizer. The genius of American farm experts is very well demonstrated here: They can take a solution and divide it neatly into two problems.”⁶⁷



Leveraging natural processes

- In the predominant industrial model of agriculture, technological “quick fix” solutions are often designed to solve a problem by attempting to exert control over nature.⁶⁸ This short-term, reductionist approach often solves one problem while creating several others.⁶⁸ The heavy reliance on chemical pesticides is an example.⁶⁸
- In contrast, more sustainable approaches attempt to work with nature by leveraging existing relationships in an ecosystem,⁶⁸ for instance, managing pests by growing a diversity of crops and rotating them over time,¹⁵ a practice that capitalizes on natural defenses.
- Image: Goats can be used to clear brush.



Informed by current knowledge

- Although *some* pre-industrial cultures farmed in relatively sustainable ways, sustainable agriculture is not a throwback to earlier times.
- It neither shuns nor embraces modern technology, nor does it necessarily reject all of the principles associated with industrialization.
- Rather, it is informed by the latest knowledge among farmers, researchers and policymakers.



Becoming native to places

- Finally, because sustainable agriculture is place-specific, farmers must look to the unique biological, physical, social and economic qualities of their region.¹⁵
- Underscoring this point, author and farmer Wes Jackson has said that farmers must “become native” to the places where they grow food,¹⁴ connecting with local ecosystems as though they were lifelong residents of them.

15 min Reflection

Discussion and think-pair-share

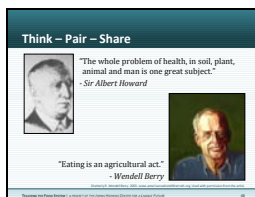
Students will discuss essential questions and respond to quotes about agriculture, ecosystems and health.

Essential questions

- How does an industrial approach to agriculture compare and contrast to organic and sustainable approaches?
 - Note that most farms share qualities of industrial, organic and sustainable models.
- If the prevailing practices in agriculture continue, what kind of food system can we expect in the future? What kind of agriculture *should* we strive toward, and how will we get there?

Think-pair-share

- *Divide the class in two halves, then group students in pairs. Assign each half of the class one of the following questions. The quotes are featured in the slides.*



Think-pair-share

- The English botanist and farmer Sir Albert Howard has been called the “father of modern organic agriculture.” He once wrote, “The whole problem of health, in soil, plant, animal and man is one great subject.” Do you agree with him? Why or why not? Support your answer in 4-7 sentences.
- The farmer, author and poet Wendell Berry once wrote, “Eating is an agricultural act.” Do you agree with him? Why or why not? Support your answer in 4-7 sentences.
- *Students will think about their responses for two minutes, write their responses for three, then discuss their responses with their partner. Ask pairs to share their responses aloud.*

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