

SCIENCE ON THE FARM

TARGET AUDIENCE

Middle school students in science and environmental science classes

PROGRAM OBJECTIVES

- Educate students about scientific technologies used in 21st century farming
- Raise awareness of principles farmers use to make sure cows are well cared for
- Explore environmentally beneficial techniques used in modern agriculture
- Examine efforts to make food more nutritious

PROGRAM COMPONENTS

- This teacher's guide
- Three student activity sheets that align with NGSS and CCSS ELA standards
- Access a Virtual Farm Tour at <https://www.wisconsin dairy.org/Youth-and-Schools/Dairy-Education/Farm-Tour>
- Microsite with downloadable standards chart, answer keys, and more materials and ideas at ymiclassroom.com/WisconsinDairy
- Comment online at ymiclassroom.com/feedback-WisconsinDairy



Farm Technology

Ask students to think about ways they use technology to make work easier or to live more comfortably.

Their examples may include computers, Bluetooth, and GPS maps. Tell students that technology is also used on farms to help produce the food we eat.

Have students read the activity introduction, and discuss how it may have changed their ideas about what it means to be a farmer. Then have students go to https://youtu.be/_-4_IlgABMM?si=z2ogZjf82crEyZvZ to watch a video about how robotics have improved cow care and milk production. Afterwards, have students respond to the focus questions in writing or in a class discussion.

For Part 2, view the video about harvesting technology at <https://youtu.be/kd6XtYvszEU>. Then, divide students into groups and assign each team one of the technologies mentioned: drones, GPS, GIS, robots. Provide time for research, then bring the groups together to share what they learned.



Farm Ecology

Advances in technology and bioscience help farmers produce better crops, but without a healthy growing environment, those crops

are doomed to fail. Explain to students that farmers use practices that protect and nurture the environment. This is called *sustainable agriculture*. These practices help conserve energy and water, minimize pollution, and build soil health.

Have the students read about the sustainable agriculture practices in the first column on the activity sheet, and then decide if that practice helps conserve energy, conserve water, minimize pollution, and/or build soil health. Then ask students to think of a way they can help achieve

the same environmental goals at home.

Answers: 1: A, B, C, D; 2: C; 3: A, B, C; 4: B, C, D; 5: C; 6: A, C; 7: C. For more detailed information, download the Answer Key at ymiclassroom.com/WisconsinDairy.



Farm Biology

This activity explores how advances in bioscience have helped improve farming practices and provide a

scientific perspective on the GMO debate. Begin by discussing how species evolve through natural selection. Organisms with genetic mutations that help them adapt to their environment are most likely to reproduce and pass their beneficial genes on to their offspring.

Remind students that farms are the original biotech labs. It was experiments with selective breeding of pea plants that led Gregor Mendel to discover the underlying rules of genetics.

Explain how farmers have used selective breeding to create new kinds of food. Ancient wheat farmers, for example, would select plants with larger kernels of grain as seed for their next crop. Farmers have also used cross breeding — mating organisms that display a desired genetic characteristic to create a new hybrid, such as seedless watermelon.¹

Since the 1990s, genetic engineering has provided another way to improve crop yield and quality. By adding a new gene to a plant's DNA, scientists have created crops that can resist insect pests and weeds without being harmful to humans. This genetic engineering has allowed farms to reduce herbicide and pesticide use, thereby reducing impacts on the environment.²

Animals and plants created through genetic engineering are sometimes called GMOs — genetically modified organisms. Some people worry that GMOs have unknown consequences. However, the benefits of GMOs are improving agriculture around the world.³ Golden rice, for example, has the potential to prevent blindness in children. Genetically engineered crops can also help conserve soil and water. The cost savings help make nutritious foods more affordable for consumers.

Have each student compare genetic engineering with selective breeding by weighing the pros and cons of each method based on the examples provided. Then ask them to write a paragraph explaining the subsequent nutritional benefits to families.

Resources

- **Virtual Dairy Farm Tours** www.wisconsin dairy.org/Youth-and-Schools/Dairy-Education/Farm-Tour
- **"Apple Breeding, Genetics and Genomics"** nyshs.org/wp-content/uploads/2015/10/Brown-Pages-from-NYFQ-Book-Fall-2015.pdf
- **Agricultural Biotechnology** www.fda.gov/food/consumers/agricultural-biotechnology

1. Learn more about selective breeding of watermelon: <https://www.watermelon.org/the-slice/where-does-seedless-watermelon-come-from/>
 2. <https://www.tandfonline.com/doi/full/10.1080/21645698.2020.1773198>
 3. For more on the debate over GMOs, students can watch the film "Food Evolution," available at <https://foodevolutionmovie.com/>.

DEAR EDUCATOR,

Feeding the world is an honor and privilege but is not an easy task, and it is something Wisconsin dairy farmers focus on every day while tending to their farms. Ensuring the product moves from the farm to the table as safe, fresh, and affordable as possible is a complex process that starts at the farm.

Do your students know the role that technology plays on today's dairy farms? Modern farmers use smartphones, GPS, drones, and robots all along the supply chain. Precision farming, coupled with the latest research, allows 21st century dairy farms to improve animal care, sustainability, and nutrition continually.

This free educational program from Dairy Farmers of Wisconsin and the curriculum specialists at Young Minds Inspired will introduce your students to the important roles that technology and bioscience play in modern farming, and help them understand how these advances in agricultural practices contribute to the health of our environment, the animals farmers care for, and our families.

Please photocopy and share these materials with other teachers in your school. Let us know your opinion of this program by commenting at ymiclassroom.com/feedback-WisconsinDairy.

Sincerely,

Tina Peterson, Director
Dairy Farmers of Wisconsin

Dr. Dominic Kinsley
Editor in Chief
Young Minds Inspired



Questions? Contact us toll-free at 1-800-859-8005 or by e-mail at feedback@ymiclassroom.com.



Adapted from a program developed by American Dairy Association North East.

FARM TECHNOLOGY

Technology has made modern farming more **productive**. On dairy farms, it also keeps cows healthier and more comfortable. Some farmers milk cows on their farm using **robots**!



Part 1 Robotic milking systems allow cows to choose when they want to be milked and provide farmers with valuable information on the health and habits of each animal. To see how, watch the video at https://youtu.be/_-4_lgABMM?si=z2ogZjf82crEyZvZ. Think about how robotic milking systems help farmers take better care of their livestock. Then, answer the questions below.

1. How do robotic milking machines benefit farmers? _____

2. What kind of information do the sensors collect about each cow? _____

3. Why do the cows choose to be milked? _____

4. How do robotic milking machines help farmers take better care of each cow? _____

Part 2 Modern farmers also use other types of technology and data to care for their farms, solve problems, and improve their results. This is a precision farming approach to farm management. For example, some farmers use satellite and sensor technologies like GIS (Geographic Information Systems) to collect information about their soil, crops, livestock, and even the weather. They use GPS (Global Positioning Systems) to map fields, guide tractors, and check crops, even at night. Drones and robots can be used to disperse chemicals, plow fields, plant seeds, weed, irrigate, and harvest the crops. See how one dairy farmer uses technology in the video at <https://youtu.be/ki6XtYvszEU>. These tools save time and money. For dairy farmers, it means more time spent caring for the cows themselves.

Choose one of the technologies listed in the paragraph above. Research how it is used on modern dairy farms and write down 3-4 benefits it offers to animals, farms, the environment, and families. Write your list on the back of this sheet.





FARM ECOLOGY



Wisconsin dairy farmers are committed to recycling and maintaining ecological balance throughout all aspects of their farms.

Today's dairy farmers use sustainable farming practices to protect the environment by conserving energy and water, reducing pollution, and building soil health. Soil health refers to the soil's ability to function as an ecosystem that can support plants, animals, and humans.

Look at the chart below. Read about the sustainable farming practices in the first column, and then decide if that practice helps conserve energy, conserve water, reduce waste and pollution, or build soil health by putting an "X" in the correct box. You may mark more than one box for each sustainable practice. Then, fill in a way you can help achieve those same environmental goals at home.

Sustainable Farming Practice	A. Conserves Energy	B. Conserves Water	C. Reduces Waste and Pollution	D. Builds Soil Health	E. What I Can Do
1. Cow manure is used in place of commercial fertilizer to improve soil quality.					
2. Methane digesters use the gas given off by cow manure as fuel to generate electricity.					
3. Some dairy farmers use a device called a plate cooler to cool the milk as it comes from a cow. Cold water passes right from the well through the plate cooler, and absorbs heat from the warm milk. Farmers then re-use this water in different ways: as drinking water for cows (who prefer warm water); to cool the cows with a fine spray when it is hot; to wash farm equipment and clean the barn floor.					
4. Field cover crops keep soil and nutrients in place and reduce runoff.					
5. Solar panels on barn roofs generate electricity for use on the farm.					
6. Recycled materials such as shredded waste paper, dried manure solids, and even sand (which can be reused time and again) are used as bedding for the cows.					
7. Orange peels, cotton seeds, and other leftovers are mixed with grain to provide nutritious cow feed.					





FARM BIOLOGY

Farms are the first biotech labs. Since ancient times, farmers have used *selective breeding* to make the foods we eat more widely available and nutritious. Today, scientific developments have enabled the transfer of specific genes from one organism to another. This process is called *genetic engineering*.

The chart below shows the impact of selective breeding and genetic engineering on modern farming, including examples that improve our food supply. Discuss the chart with your class and then use the space below and the back of the sheet to compare and contrast the two methods.



Wisconsin dairy farmers track their cows' genetic history.

Part 1

Selective Breeding	Genetic Engineering
Choose parents with traits you want. These will be passed on to the offspring.	Add the gene for the trait you want into the DNA of the organism so it can be passed on to the offspring.
Examples	Examples
<p>1. Disease-resistant wheat is created by breeding hardy wheat plants with wheat plants that have a high yield. As a result, families have better access to nutritious grains for a lower cost.</p> <p>2. The amount of protein in milk is improved by breeding dairy cows to bulls that have high levels of protein production.</p> <p>3. Hardy snacking apples are created when a sweet variety of apple is grafted onto the trunk of a fungus-resistant variety. This gives the benefit of higher-producing sweet apple trees that are fungus-resistant. This means more fruit for more families.</p>	<p>1. Scientists have engineered dairy cows to produce human antibodies for viruses such as influenza and ebola. This could allow for treatment of a large number of people in a short time frame.¹</p> <p>2. Scientists have created a special type of soybean that produces oil with more “healthy” fat and no trans fat, reducing cholesterol and the risk of heart disease.</p> <p>3. When scientists added the genes that produce Vitamin A in carrots to white rice DNA, they created “golden rice” — a food rich in Vitamin A for countries where Vitamin A deficiency causes childhood blindness.</p>
Similarities:	
Differences:	

Part 2 Dairy farmers use many other types of biotechnology to improve food production. How does biotechnology on dairy farms support people’s nutritional needs? Write your answer on the back of this sheet.

1. <https://www.technologyreview.com/2016/10/04/107551/cows-engineered-with-human-genes-could-stop-our-next-disease-outbreak/>





SCIENCE ON THE FARM ANSWER KEYS



Use these answer keys to guide discussion when reviewing student responses to the activity questions.

FARM TECHNOLOGY

PART 1

1. How do robotic milking machines benefit farmers?

Robotic milking machines allow cows to be milked at regular intervals with little human labor, saving the farmers time to focus on other tasks and greatly reducing their labor costs. The machines are more efficient, so they increase overall milk yield.

2. What kind of information do the sensors collect about each cow?

The sensors track data such as how much food each cow is eating, how often they are milked, how long they are milked, and their preferred milking pace. Sensors on the milking machine detect the location of the teats to make sure they latch on comfortably.

3. Why do the cows choose to be milked?

Cows enjoy the more flavorful feed available in the milking stall. Also, frequent milking is more comfortable for cows.

4. How do robotic milking machines help farmers take better care of each cow?

Farmers have more time to spend interacting with the cows and managing their health. They can use the information collected from the transponders to understand each cow's unique needs and to track any changes that might indicate a change in the cow's health.

PART 2

Precision farming is the use of digital technologies to improve farm management. The tools listed below can help increase efficiency and accuracy in all steps from planning through harvest.

Students should note that all these tools cut costs for the farmers, which leads to lower prices at the grocery store – so, they ultimately provide greater access to nutritious foods for more families. Precision farming also reduces the environmental impact of farming because more accurate measurements of soil health allow farmers to use fewer pesticides, commercial fertilizers, and chemicals across the board, and only where needed. Students should also provide examples, such as:

Global Positioning Systems (GPS)

Used to help farmers map their fields, guide farm equipment in the field, and check crops.

- Reduce labor costs and enable work to be done on off-hours or when labor is unavailable
- Help maximize and better plan usage of fields
- Help farmers plan for and protect against weather events
- Allow for direction of crop dusters and aircraft sprayers without human “flaggers” needing to be present

Geographic Information Systems (GIS) & Sensor Technology

Used to help farmers analyze soil conditions, estimate their harvest, and determine where and how much fertilizer and/or pesticide they need to apply. Students can read more here: <https://smallfarms.cornell.edu/2017/04/use-of-gis/>.

- Reduce costs of irrigation, fertilizer, and/or pesticides used by pinpointing specific areas where they are needed
- Reduce environmental impact by minimizing tilling and pesticide use
- Increase profits through better estimation of harvest times and yield, and faster remediation of issues like erosion and insect outbreaks
- Help farmers plan which crops to grow, and where, in order to best maintain the soil
- Allow for more effective planning by providing projections of current and future fluctuations in precipitation, temperature, and crop output

Drones/Robots

Used for milking and feeding cows and to plant seeds, weed, irrigate, and harvest crops.

- Reduce costs and reliance on labor for tasks that are time-intensive
- Provide greater efficiency in feeding cows and harvesting crops, and more evenly disperse water and seeds
- Increase health of crops by providing real-time, accurate data about soil health



SCIENCE ON THE FARM ANSWER KEYS



FARM ECOLOGY

Sustainable Farming Practice	A. Conserves Energy	B. Conserves Water	C. Reduces Waste and Pollution	D. Builds Soil Health	E. What I Can Do
1. Cow manure is used in place of commercial fertilizer to improve soil quality.	Energy is needed to manufacture commercial fertilizers and transport them to farmers. Using manure from the farm reduces energy consumption and costs.	Many commercial fertilizers need to be mixed with water, but cow manure contains water that helps fertilize the fields.	Using manure to fertilize crops makes it a resource rather than a waste product.	Cow manure is a natural fertilizer that feeds crops. Manure application also provides carbon and nutrients to the soil, and increases soil productivity.	Compost at home and use that compost to fertilize your garden, trees, shrubs, etc.
2. Methane digesters use the gas given off by cow manure as fuel to generate electricity.			When released to the atmosphere, methane is a potent greenhouse gas. But when methane is used to generate electricity, it produces water and carbon dioxide, a less potent greenhouse gas. In addition, methane does not produce many of the potentially harmful pollutants released by other energy sources, such as coal and oil.		Conserve energy at home. Turn off lights and appliances when not in use, use energy efficient light bulbs, etc. (See https://www.alliantenergykids.com/UsingEnergyWisely/SavingEnergyAtHome for numerous other suggestions.)

(continued)



SCIENCE ON THE FARM ANSWER KEYS



FARM ECOLOGY (CONTINUED)

Sustainable Farming Practice	A. Conserves Energy	B. Conserves Water	C. Reduces Waste and Pollution	D. Builds Soil Health	E. What I Can Do
<p>3. Some dairy farmers use a device called a plate cooler to cool the milk as it comes from a cow. Cold water passes straight from the well through a plate cooler and absorbs heat from the warm milk. Farmers then re-use this water in different ways: as drinking water for cows (who prefer warm water); to cool the cows with a fine spray when it is hot; to wash farm equipment and clean the barn floor.</p>	<p>By using a plate cooler and transferring heat from the milk to the cold water, it takes less energy to heat the water for cleaning equipment and less energy to cool down the milk in the bulk tank.</p>	<p>Water is used over and over instead of drawing fresh water for each activity. By utilizing the plate cooler water elsewhere on a farm, for example for the cows' drinking water, farmers use less water.</p>	<p>As it goes through the barn, the water may pick up things like manure from the barn floor. When applied to fields, the manure in the water serves to fertilize crops, thereby making it a resource rather than a waste product.</p>		<p>How can you conserve water? Turn off the faucet when brushing your teeth, take shorter showers, collect rainwater to water indoor plants.</p>
<p>4. Field cover crops keep soil and nutrients in place and reduce runoff.</p>		<p>Helps keep streams flowing free and clean. Also improves soil health and soil porosity. The soil can hold more rainwater, reducing the need for additional irrigation.</p>	<p>Vegetation and groundcover help to filter pollutants such as pesticides and sediment from field runoff.</p>	<p>Reduced runoff and erosion helps keep nutrients in the field where they belong instead of washing away with rain. This, in turn, increases soil quality for the following season. Also improves soil's ability to retain water and benefits the soil microbial community.</p>	<p>Participate in events organized to plant vegetation along stream banks, lakefronts, etc. Plant native vegetation in your yard, school grounds, etc. Some schools and homeowners construct rain gardens (www.epa.gov/soakuptherain/soak-rain-rain-gardens).</p>



SCIENCE ON THE FARM ANSWER KEYS



FARM ECOLOGY (CONTINUED)

Sustainable Farming Practice	A. Conserves Energy	B. Conserves Water	C. Reduces Waste and Pollution	D. Builds Soil Health	E. What I Can Do
5. Solar panels on barn roofs generate electricity for use on the farm.			Solar power does not emit greenhouse gases or other air pollutants.		Conserve energy at home. Turn off lights and appliances when not in use. Use energy efficient light bulbs, etc. (See https://www.alliantenergykids.com/UsingEnergyWisely/SavingEnergyAtHome for numerous other suggestions.) Consider using solar power for your home.
6. Recycled materials such as shredded waste paper, dried manure solids, and even sand (which can be reused time and again) are used as bedding for the cows.	Using these materials reduces the need to truck in other bedding materials, or at least reduces the number of necessary shipments due to reuse on the farm, thus reducing fuel consumption and costs.		Keeps these materials out of landfills.		How can you recycle beyond what your town may already require? Can you use the back side of printed papers for note-taking instead of a fresh sheet? Can you start a home compost pile with food waste to help feed your garden?
7. Orange peels, cotton seeds, and other leftovers are mixed with grain to provide nutritious cow feed.			Keeps these "leftovers" out of landfills.		Compost "leftovers" at home and use that compost to fertilize your garden, trees, shrubs, etc.



SCIENCE ON THE FARM ANSWER KEYS



FARM BIOLOGY

Selective Breeding and Genetic Engineering

Similarities: Both processes alter the DNA of an organism to create a new organism with different genetic traits.

Differences: Selective breeding operates through natural reproductive and growth processes. Genetic engineering operates by scientific manipulation of an organism's DNA.

How does biotechnology on dairy farms support people's nutritional needs?

Biotechnology allows dairy farmers to grow more feed crops using the same amount of land, water, and other natural resources. These crops make up a large part of the cows' diet, which is carefully designed by nutritionists to keep the cows healthy and productive, while continuing to reduce farmers' costs. The result is that more people have affordable access to nutritionally-rich milk and dairy products.

Follow-Up Activity Idea: To complete this lesson, as a discussion or writing project, have your class brainstorm other nutritional concerns that biotechnology may someday address.

