



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 cow pedometers and collars (sensors) benefit farmers?

They help by collecting data or information about each cow to then help the farmer care for them better. The farmer will use the information to make the best decisions about how to care for their cows.

2. What information do these sensors collect about each cow?

They record how many steps a cow takes, if cows are lying down, how long a cow chews her food, and how much milk she produces.

3. Why would a cow's number of daily steps change?

If they are in heat, or it is time to be bred, cows' steps will increase significantly. If they are not feeling well and spending more time lying down, they will decrease significantly.

4. How would a farmer use the information collected by a sensor?

Sensors give farmers information about each cow in real time so the farmers can see when changes occur. This allows the farmer to identify those cows and give them extra attention. It also allows the farmer to monitor the herd's performance as a whole.

PART 2

Precision farming is the use of science and technology 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 (continued)



FARM BIOLOGY

Selective Breeding and Genetic Engineering

Similarities: Both processes produce offspring that have different or desired genetic traits to improve the health or production of the animal.

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.



SCIENCE ON THE FARM



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.)

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SCIENCE ON THE FARM



FARM ECOLOGY ANSWER KEY (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>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>

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SCIENCE ON THE FARM



FARM ECOLOGY ANSWER KEY (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.		Use the reverse side of printed papers for note-taking instead of a fresh sheet. 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



DAIRY ECOSYSTEMS ANSWER KEY (CONTINUED)

Dairy and the Environment

(Source: Excerpt from www.americandairy.com/sustainability/dairy-and-the-environment)

The paragraphs are numbered below. References to the words featured in the puzzle are underlined.

Sustainability Is the Goal

1. Dairy (#17 Down) farmers (#12 Across) contribute to a sustainable (#18 Across) food system. They support practices that make economic (#1 Down) sense, help the environment (#9 Across) and are socially responsible to our communities (#2 Down) and our world.
2. The latest research shows that the U.S. dairy industry accounts for only about 2 percent of U.S. greenhouse gas emissions (#6 Down). Still, dairy farmers are working on ways to reduce that figure even more: Over a recent 10-year period, dairy farming used about 21% less land (#19 Down), 30.5% less water (#5 Down), 20% less fuel (#15 Across), and 17% less feed. Their work continues as the dairy industry has committed to becoming greenhouse gas neutral (#10 Down) by 2050.
3. More milk is produced today with only 9 million cows than with 26 million cows in 1944. While providing a supply of healthy milk for consumers and protecting the environment, dairy farmers oversee some of the most efficient (#7 Down), productive cows in the world!

Manure Management and Waterway Protection

4. All dairy farms must meet state and federal standards for manure storage, handling and recycling. Dairy farmers recycle (#4 Down) manure according to detailed nutrient management plans that help conserve (#11 Across) soil and protect (#13 Across) local streams,

rivers and estuaries (#16 Down) like the Chesapeake Bay. Cow manure is used to fertilize (#12 Down) crops, part of a sustainable cycle that allows dairy farmers to make nutritious foods available to people. In fact, manure can even be used to create clean, comfortable cow beds.

Other Sustainable Dairy Farming Practices

5. Farmers also use many other best management practices such as no-till farming, energy conservation, solar panels and streambank protection. For example, E-Z Acres, Reinford Farms and Twin Birch Dairy were highlighted as environmental stewards by the Innovation Center for U.S. Dairy.
6. Some dairy farms are using technology that has environmental benefits. Methane digesters, for example, allow dairy farms to produce renewable (#8 Down) energy. A digester collects methane (#14 Across) gas released from cow manure and other materials and converts it to electricity that can power the dairy farm and other homes in the community.
7. Dairy farmers continuously work with government and university experts to find even more ways to conserve natural resources. For example, they have found creative ways to recycle water and other materials, and prevent soil erosion (#3 Down) — activities that help ensure their farms remain economically viable.



SCIENCE ON THE FARM



DAIRY ECOSYSTEMS

Teachers: Please feel free to photocopy and distribute this article to your students to assist them in completing this bonus activity.

Dairy and the Environment

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