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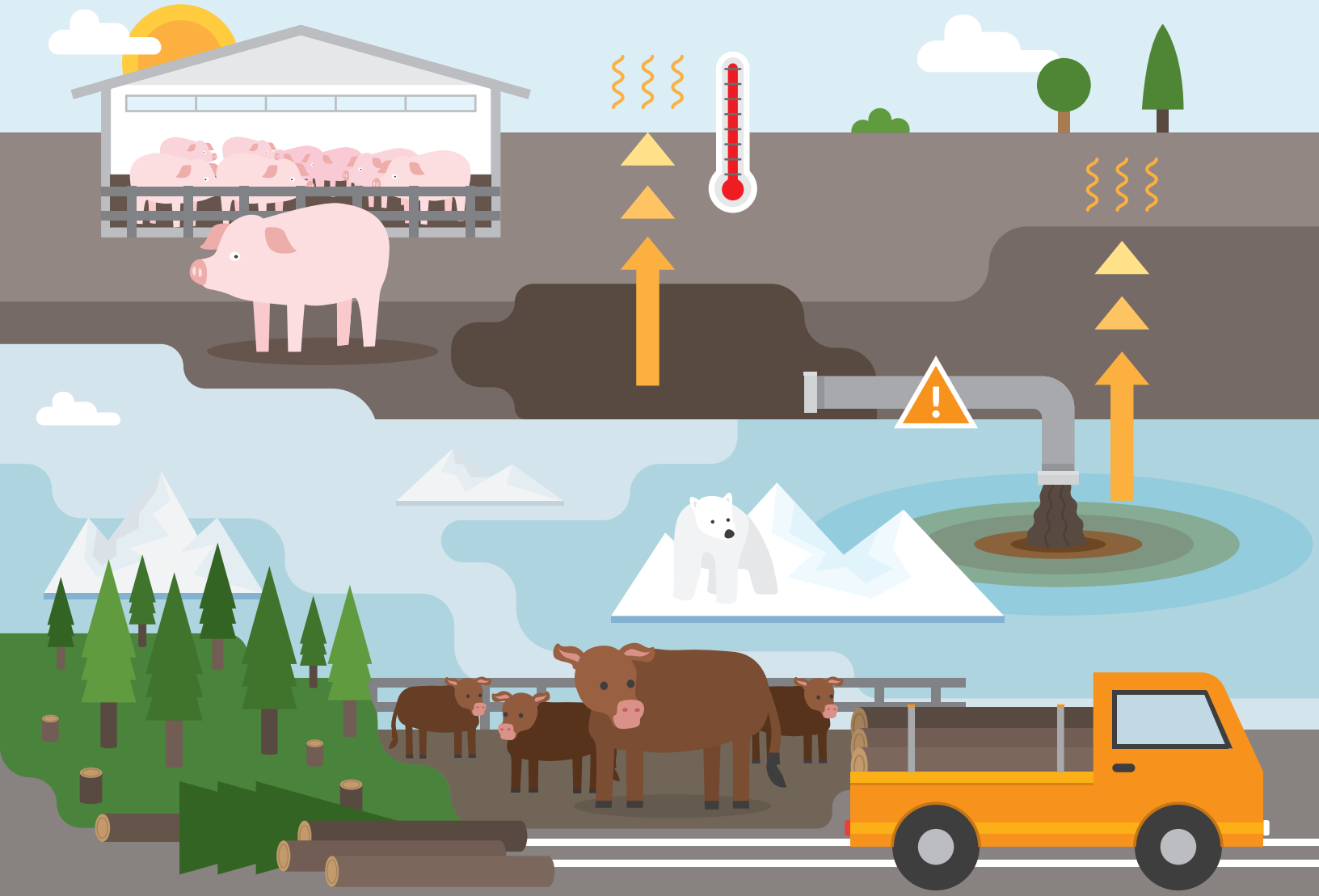
HS Environmental Science Lesson 1 - Section 1

Food Production & CO_2 Equivalents: Creating a Computational Simulation

> *"For the first time [in history], we concluded anthropogenic warming has had an influence on many physical and biological systems."*
> **— Cynthia Rosenzweig, NASA's Goddard Institute for Space Studies**



Overview

Global warming can be attributed to an increase in greenhouse gas production. Many people assume that this increase primarily results from the burning of fossil fuels, for instance from cars, but the agricultural industry is actually a major contributor. In this lesson, students will compare the carbon footprint of different types of foods to explore where greenhouse gases are coming from and which foods produce the most emissions.

- Students will use carbon dioxide equivalents (CO_2e) to compare the amount of greenhouse gases released from different processes during food production.
- Students will use a spreadsheet to graph data in order to compare the CO_2e for plant-based and animal-based food production.
- Students will then use a formula to calculate the number of miles driven by a typical car for 1 kg of different types of food.

Essential Questions:

- How can we compare how much greenhouse gas emissions are created by different processes, specifically in food production?
- How does the production of different foods impact global warming?

Lesson Time:

Section 1 = 50 minutes
Section 2 = 50 minutes
Section 3 = 50 minutes

Student Learning Objectives:

Students will be able to...

- Interpret data relating plant-based farming and animal farming with corresponding CO_2 equivalents
- Identify the differences in amount of CO_2e produced during plant-based and animal-based food production
- Investigate the relationship between farming and global warming
- Simulate the equivalent number of miles driven to produce 1 kg of different types of foods
- Consider ways to reduce CO_2e emissions related to food production

Resources:

- **Article:** How Feed Production and Manure Generate Greenhouse Gases and Harm the Environment
- **PowerPoint:** Sources of Greenhouse Gases https://www.dropbox.com/s/exy0zojdwwhv0oo/Sources%20of%20Greenhouse%20Gases.ppt?dl=0
- **Student Handout:** Food Production and CO_2 Equivalents
- **Student Handout:** How Feed Production and Manure Generate Greenhouse Gases and Harm the Environment
- **Student Handout:** Sources of Greenhouse Gases
- **Student Handout:** Terms and Definitions
- **Teacher Key:** Food Production and CO_2 Equivalents
- **Teacher Key:** Sources of Greenhouse Gases
- **Video:** *Causes and Effects of Climate Change* - National Geographic (3:04): https://www.youtube.com/watch?v=G4H1N_yXBiA

Materials:

- An object or objects that are about 1 kg (examples: a 1 kg weight, a pineapple, a liter of water, or a small laptop)
- Access to YouTube**

** If Internet access in school is not available, YouTube Red is a great resource that allows you to download a video when you have WiFi/Internet access and then be able to play the video when you do not have WiFi/Internet access.

Website: www.youtube.com/red/freetrial

Next Generation Science Standards

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

Activities: Section 1

Evaluate
Elaborate
Explain
Explore
Engage

Engage: Where do greenhouse gas emissions come from? (15 minutes)

Show students the video, *Causes and Effects of Climate Change* - National Geographic (3:04):
https://www.youtube.com/watch?v=G4H1N_yXBiA

As a group, ask the class the following questions and record their responses on the board:

1. What are three examples of greenhouse gases?

   Answers may include: carbon dioxide, chloro-fluorocarbons, methane, nitrous oxide, and water vapor.

2. An increasing amount of greenhouse gases in the atmosphere does what to the earth's temperature?

   More greenhouse gases in the atmosphere increases the atmosphere's temperature and causes global warming.

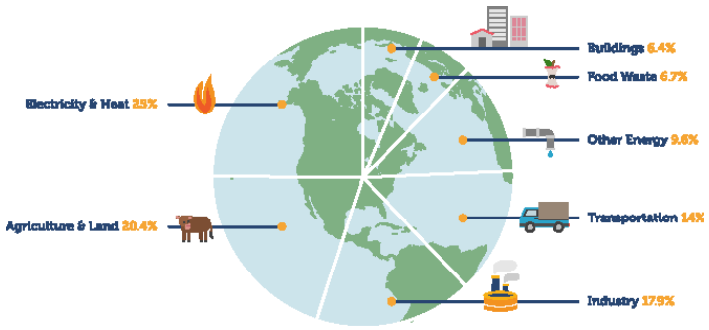
3. What are three effects of global climate change?

   Answers may include: Ice sheets continuing to melt causing sea levels to rise, higher temperatures mean more extreme weather, longer and more frequent droughts, growing crops may become more difficult in certain regions, regions where animals can live will shift, warmer temperatures in urban areas mean increased levels of smog which can lead to more health issues like asthma, heart disease, and lung cancer.

Next, give students the handout, **Sources of Greenhouse Gases.**

1. In pairs or alone, students will try and identify what sources go with each segment of the pie chart.

   Sources include:
   - Agriculture and Land
   - Buildings
   - Electricity and Heat
   - Food Waste
   - Industry
   - Transportation
   - Other Energy



2. After 5 minutes, ask a few students to share their answers.

3. Now, students should correct their own work as you share with them the correct sources associated with each segment of the pie chart. The teacher key for this handout is also entitled **Sources of Greenhouse Gases**. Optional: The teacher key, **Sources of Greenhouse Gases**, is available in PowerPoint format so that students can view the completed infographic on a projector screen. The link to the PowerPoint slide can be found on page 2 of this section's lesson plan.

4. Finally, ask students if any of the categories surprise them. Most students (and consumers) are not aware that agriculture is a major producer of greenhouse gases. Tell students that in this lesson they will look into some of the reasons why agriculture is a major producer of greenhouse gases.

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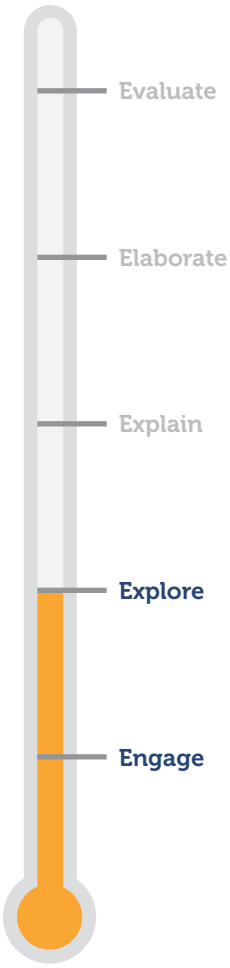


Explore: How does agriculture produce greenhouse gases? (20 minutes)

Provide each student with a copy of the handouts: **Food Production and CO_2 Equivalents** and **Terms and Definitions**.

In addition to the teacher key entitled **Food Production and CO_2 Equivalents**, the following text acts as directions and provides a portion of the answer key for the accompanying student handout.

The introductory question asks students to brainstorm all the ways food production (of vegetables, grains, meat, and anything else we eat) might result in greenhouse gas emissions (the emissions of carbon dioxide, methane, and other greenhouse gases).

- If students get stuck, ask them to think about ways in which energy might be used, as energy use often results in CO_2e production. For example, driving a vehicle burns fuel and that gives off CO_2 equivalents. Give students 1 minute.
- Now, ask students to share their ideas with 1-2 neighbors, and add to their list. Give them 2 more minutes.
- Finally, as a class, have students share their ideas.

Answers to the introductory question may include the following:

- Using farm equipment (tractors) to plant food
- Using farm equipment (combines) to harvest food
- Electricity needed for buildings and running factory farms (lighting, heating, cooling)
- Energy needed to transport food to the consumer (trucks, trains, cars)
- Methane produced by ruminants (cows, sheep, and goats)
- Nitrous oxide and methane produced by waste (manure lagoons)
- Nitrous oxide produced by fertilizer used in the production of animal feed (corn, soy, and other grains)

Now, distribute the article from the Environmental Working Group, **How Feed Production and Manure Generate Greenhouse Gases and Harm the Environment**, and the student handout that accompanies this article to each student. Students should read the article on their own and then work with a partner to answer the handout's questions. Once students have answered the questions, take a moment to go over the answers as a class.

1. How does producing food for farm animals generate greenhouse gases and harm the environment?

Fertilizer, fuel, and pesticides are required to grow feed, and industrial nitrogen fertilizer is energy intensive. Manure fertilizer and industrial fertilizer used on feed crops for animals have environmental impacts in that both can release nitrous oxide. Manure fertilizer can also serve as a source of antibiotic resistant bacteria to the environment. Pesticides and fertilizers end up in our rivers, lakes, and oceans. Irrigation pumps, tractors, and other farm equipment release carbon dioxide. Water is also needed to raise animals for food and grow plants that are fed to farm animals, which results in a substantial carbon footprint.

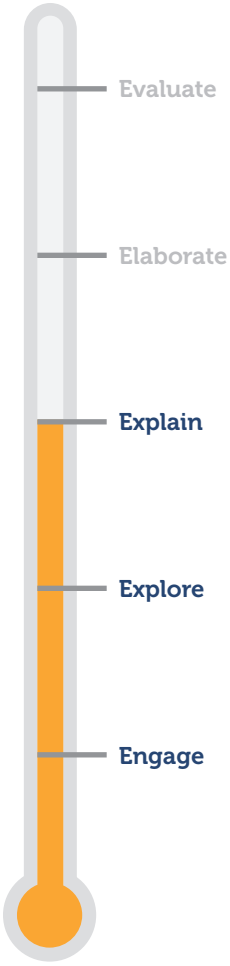
2. How does animal waste generate greenhouse gases and harm the environment?

Animal waste releases nitrous oxide, hydrogen sulfide, ammonia, and methane and pollutes our water and air.

3. What is the fastest growing major source of methane?

Manure

Notes:



Explain: Understanding Carbon Dioxide Equivalents (15 minutes)

Returning to their **Food Production and CO_2 Equivalents** worksheet, students should begin by reading the "Background Information" and answering questions 1 and 2.

1. How many miles would you have to drive a typical car to give off 1 kilogram of CO_2?

> Driving for 2.43 miles gives off 1 kg of CO_2 (1 kg CO_2 x 1 mile/0.411 kg CO_2 = 2.43 miles).

Pass around a 1 kg weight or an object that is approximately 1 kg to give students an idea of how that might feel. Objects that are about 1 kg include a pineapple, a liter of water, or a small laptop. For the volume of CO_2 as a gas, it's harder to imagine, but 1 kg of CO_2 would fill roughly two bathtubs or the trunk of a large car.

2. What is the relationship between the release of CO_2 and other greenhouse gases into the atmosphere and global warming?

> An increase in greenhouse gases, like CO_2, in the atmosphere increases the atmosphere's temperature causing global warming.

After going over the answers to the two questions, read the "Background Information Continued" section out loud to the class which explains the concept of carbon dioxide equivalents (CO_2e).

Note: Students should not turn to page 2 of their handout at this time.

The carbon dioxide equivalent (CO_2e) is a way of expressing greenhouse gas emissions as a single number in order to show their global warming potential (Center for Sustainable Systems, University of Michigan, 2018). One way to compare how much CO_2 is given off by certain processes, like driving a car, to other processes, like food production, is to calculate the number of miles one would have to drive a car to produce the kilograms of CO_2e created by a type of food.

A Look Ahead:
Without turning to page 2 of their handout, tell students that the next activity will have them explore the amount of CO_2e given off when we farm different kinds of food.

Ask students how much CO_2e they think is produced by growing or processing the following foods:

1 kg of tomatoes | 1 kg of cheese | 1 kg of beef

Students won't have any way of knowing the correct answers, so any guesses are fine. The purpose of this exercise is to see if students think there is a difference between how much CO_2e is produced by plant-based versus animal-based foods.

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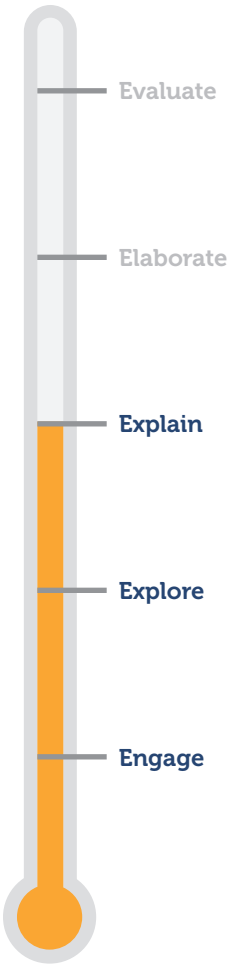

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HS Environmental Science Lesson 1 - Section 2

Food Production & CO_2 Equivalents: Creating a Computational Simulation

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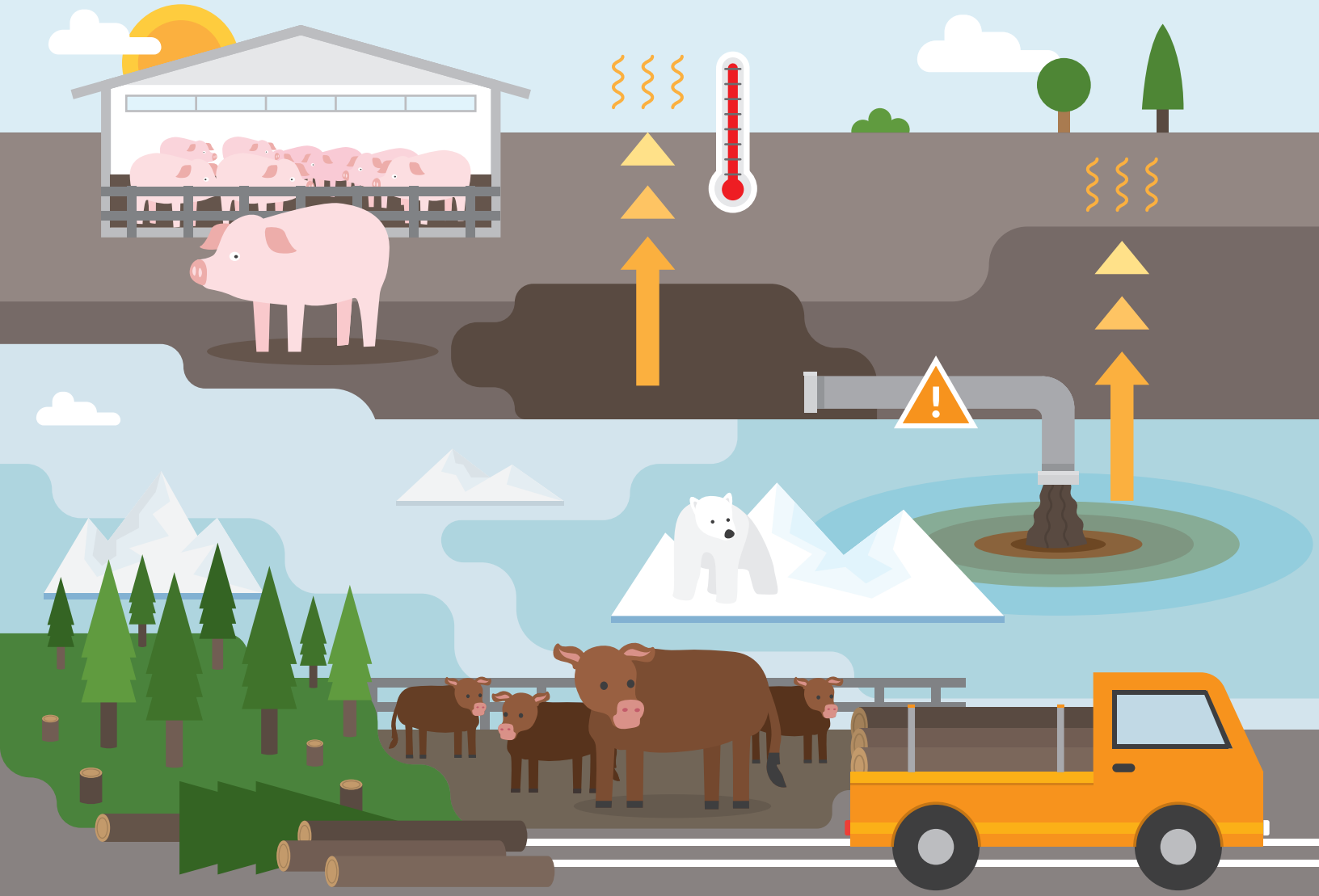

Overview

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- Students will use carbon dioxide equivalents (CO_2e) to compare the amount of greenhouse gases released from different processes during food production.
- Students will use a spreadsheet to graph data in order to compare the CO_2e for plant-based and animal-based food production.
- Students will then use a formula to calculate the number of miles driven by a typical car for 1 kg of different types of food.

Essential Questions:

- How can we compare how much greenhouse gas emissions are created by different processes, specifically in food production?
- How does the production of different foods impact global warming?

Resources:

- **Student Handout:** Food Production and CO_2 Equivalents
- **Student Handout:** Terms and Definitions
- **Teacher Key:** Food Production and CO_2 Equivalents

Lesson Time:

Section 1 = 50 minutes
Section 2 = 50 minutes
Section 3 = 50 minutes

Materials:

- Access to a computer spreadsheet program (such as Excel or Google Sheets)

Student Learning Objectives:

Students will be able to...

- Interpret data relating plant-based farming and animal farming with corresponding CO_2 equivalents
- Identify the differences in amount of CO_2e produced during plant-based and animal-based food production
- Investigate the relationship between farming and global warming
- Simulate the equivalent number of miles driven to produce 1 kg of different types of foods
- Consider ways to reduce CO_2e emissions related to food production

Next Generation Science Standards

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

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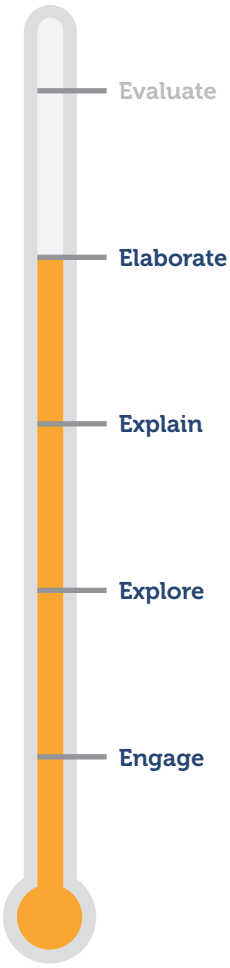


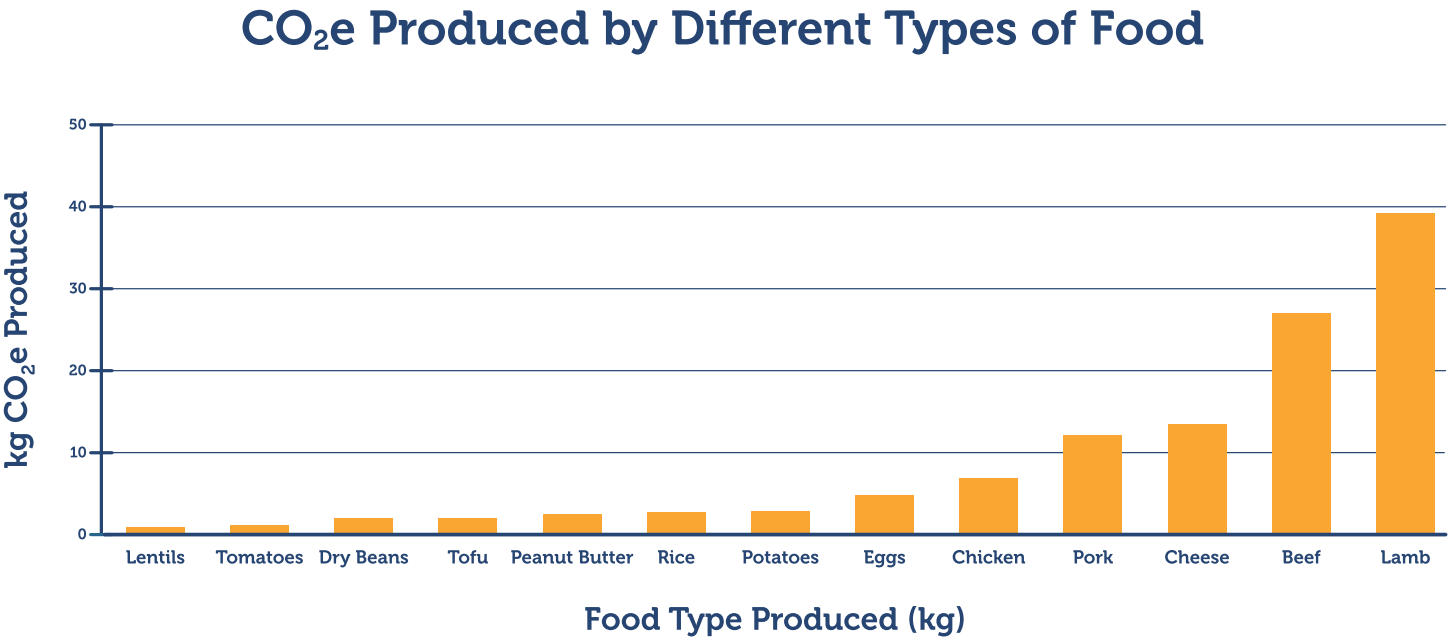
Activities: Section 2

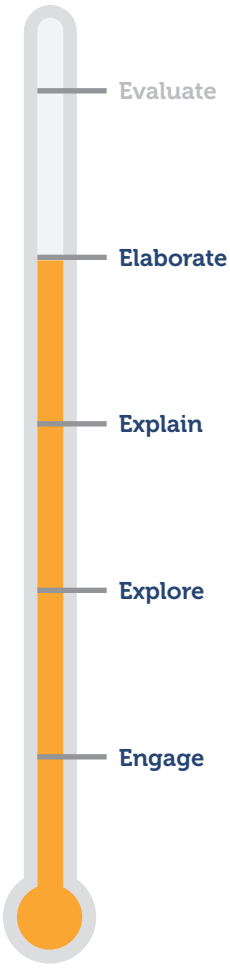
Elaborate: What foods are responsible for the most CO_2 emissions?
(20 minutes)

Tell students that they will find a data table with the amount of CO_2 equivalent (CO_2e) associated with the production of different foods on the second page of their **Food Production and CO_2 Equivalents** handout. They will then use a spreadsheet program, such as Excel or Google Sheets, to create a graph that will enable them to compare the CO_2 footprints of different foods (see sample bar graph below).

Note: Refer to the teacher key, **Food Production and CO_2 Equivalents**, for answers to the calculation and graphing portion of the student handout.

1. Students should open up a spreadsheet in Excel, Google Sheets, or another graphing program.
2. Students will then copy and paste (or type in) the two columns of data from Data Set 1, comparing kg CO_2e released per 1 kg of consumed food.
3. Students will then sort the data to see a trend. (Students may try sorting by one column and then the other to see which makes more sense. In this case, sorting by kg CO_2e is more appropriate.)
4. Students should then determine the best type of graph to represent their data. (They will do this by selecting their data and creating a chart or graph. In Google Sheets, charts or graphs can be located under the insert tab.) In this case, a bar graph is most appropriate.
5. Students should come up with an appropriate title for their bar graph.





Conclusions
(25 minutes)

After students have completed their graphs, they should move on to the conclusions section of their handout.

1. What foods release the least CO_2e? Which foods release the most CO_2e? How much of a difference is there? Compare lamb, beef, tofu, and tomato.

   - Animal-based foods release the most CO_2e. Plant-based foods release the least CO_2e.
   - Almost 24x more CO_2e is released for beef than for a tomato.
   - 13x more CO_2e is released for beef than for tofu.
   - Approximately 36x more CO_2e is released for lamb than for a tomato.
   - Approximately 20x more CO_2e is released for lamb than for tofu.

2. How does this compare to driving a car? In other words, how many miles would you need to drive to give off the same amount of CO_2e produced by different foods? (Students will be simulating the equivalent number of miles one would drive a typical car to release the amount of CO_2 produced by different foods.)

   Producing 1 kg of lentils is like driving a car almost 2.2 miles; producing 1 kg of beef is like driving 63.3 miles! The difference is 61.1 miles.

3. Why do you think producing animal-based foods releases so much more greenhouse gases than producing plant-based foods? Give two reasons.

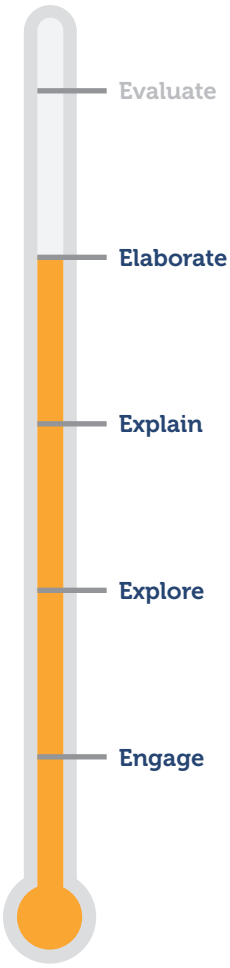
   Answers may include: Ruminant animals, such as cows, produce methane during digestion. Fertilizer used to produce animal feed emits nitrous oxide. Animal waste produces methane.

4. Now have students look at Table 1 on page 4 of their handout. Have them underline all the items in Column 1 that have to do specifically with growing plants and circle all of the items that have to do specifically with producing animal-based foods like meat, dairy, and eggs. (Note: Some items will be circled AND underlined.)

   Students should understand that while some of the items in column 1 are needed to grow plants, ALL of the items in column 1 are needed to produce animal-based foods (because animals must also eat plants).

   Students should conclude that the raising and slaughtering of animals for food requires many more steps and much more energy than growing plants for food. (Note: Table 1 does not account for the carbon dioxide and methane that is produced by animals which further increases the greenhouse gas emissions produced when raising animals for food.)

Notes:



Breaking Down the Data
(5 minutes)

1. Ask students, is there a difference between producing food from plants and producing food from animals?

   The difference is that animal-based food production releases dramatically more CO_2 than plant-based food production.

2. What is the relationship between animal-based food production and global warming?

   Global warming is a result of an increase in the amount of greenhouse gases, like CO_2, in the atmosphere. Animal-based food production requires a lot of energy and produces a large amount of greenhouse gases, therefore contributing to the warming of the planet.

References:

Center for Sustainable Systems, University of Michigan. 2018. "Carbon Footprint Factsheet." Pub. No. CSS09-05.

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HS Environmental Science Lesson 1 - Section 3

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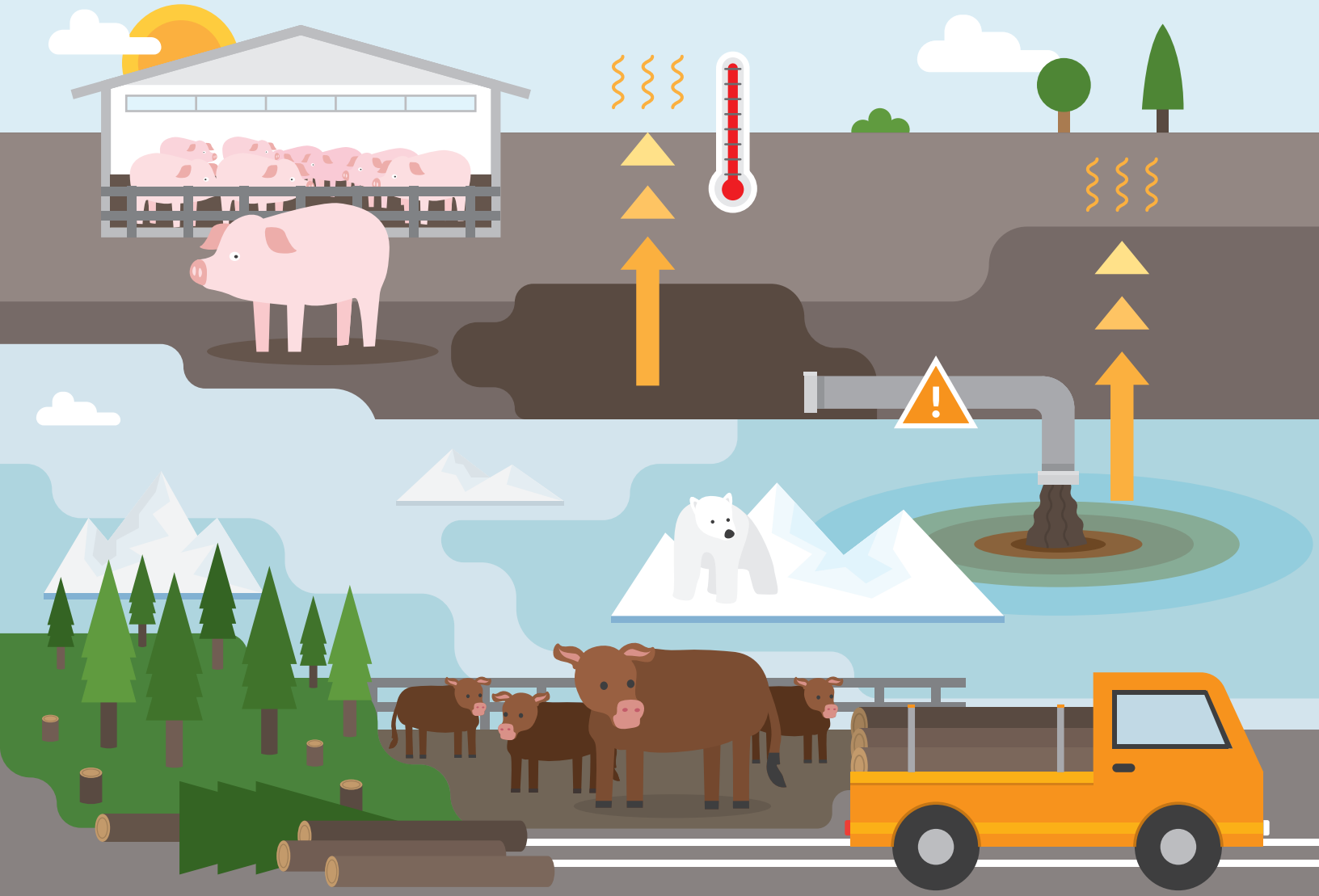

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Resources:

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  https://www.cnet.com/news/impossible-foods-ramps-up-production-of-its-lab-grown-hamburger/
- **Article:** Less Beef, Less Carbon: Americans Shrink Their Diet-Related Carbon Footprint by 10 Percent Between 2005 and 2014 (Pages 1 & 2 only)
  https://www.nrdc.org/sites/default/files/less-beef-less-carbon-ip.pdf
- **Article:** Millennials are Driving the Worldwide Shift Away from Meat
  https://www.forbes.com/sites/michaelpellmanrowland/2018/03/23/millennials-move-away-from-meat/#3e253cdaa4a4
- **Student Activity:** Sticky Note Exercise
- **Student Handout:** Impossible Foods to Supersize Production of Lab-Grown Burger
- **Student Handout:** Less Beef, Less Carbon: Americans Shrink Their Diet-Related Carbon Footprint by 10 Percent Between 2005 and 2014
- **Student Handout:** Millennials are Driving the Worldwide Shift Away from Meat
- **Student Handout:** Terms and Definitions

Materials:

- Sticky notes, one for each student

Next Generation Science Standards

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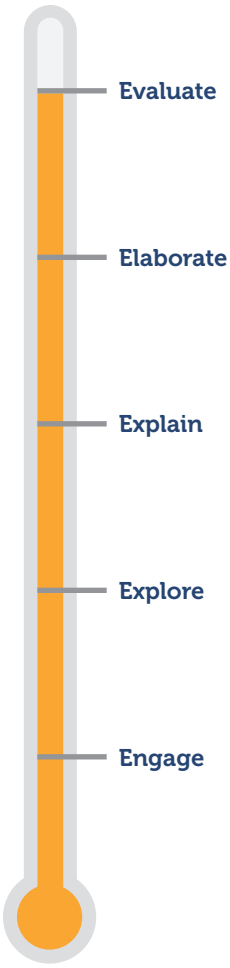


Evaluate: What are some solutions?
(40 minutes)

One solution to the problem of global warming is eating less or no meat. Give each student a copy of **Less Beef, Less Carbon: Americans Shrink Their Diet-Related Carbon Footprint by 10 Percent Between 2005 and 2014** (pages 1 & 2 only), a report conducted by the Natural Resources Defense Council (NRDC), as well as a copy of the accompanying handout. Give students seven minutes to read the article and answer the questions before going over the answers as a class. (Note: Students may reference their **Terms and Definitions** handout as they read each article for this lesson.)

1. Between 2005 and 2014, the amount of beef that Americans cut out of their diet brought down carbon emissions equivalent to the annual tailpipe emissions for how many cars?

39 million cars

2. How could pollution (carbon emissions) be reduced even more?

If Americans decreased their consumption of other carbon-intensive products including other meats, milk, cheese, butter, and yogurt, pollution could be further reduced.

3. What food in the American diet contributes the most to climate-warming pollution?

Beef

Next, have students read the article, **Impossible Foods to Supersize Production of Lab Grown Burger**, which discusses how people's desire to reduce how much meat they consume has inspired a growing market in the development of meatless, plant-based foods that mimic the taste of meat and other animal-based foods.

Note: The term, lab-grown meat, is also used to describe the production of meat through the process of dividing muscle cell tissues from an animal in a lab environment. This article speaks to a plant-based burger, not a burger that is grown from the cells of a cow.

Give students ten minutes to read this article and answer the questions on the accompanying handout before going over the answers as a class.

1. What "secret ingredient" is in these burgers to make them seem more like meat?

"Heme" (leghemoglobin) is what makes animal blood red, and it's found in all living things, including plants. When Impossible Burgers cook in a pan, they secrete a pinkish juice that resembles blood, and they also give off the smell of charred meat.

2. How are plant-based hamburgers better for the environment than burgers that come from cows?

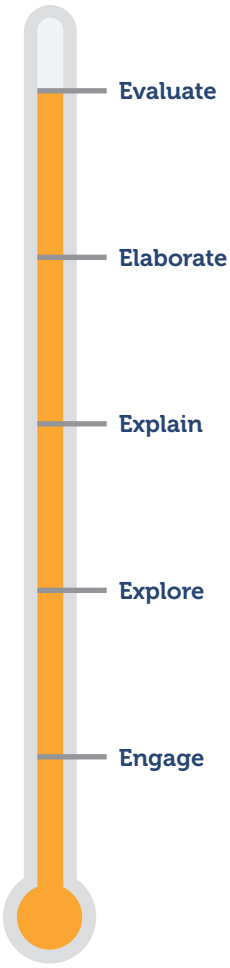
Impossible Foods says producing one of its burgers requires only a quarter of the water and 5 percent of the land that making a burger from a cow requires. Also, the process to produce the Impossible Burger emits only 13 percent of the greenhouse gases that the production of a burger from a cow emits.

3. If your favorite burger restaurant offered the Impossible Burger, would you eat it? Why or why not?

Answers will vary.

Note: Hampton Creek (referred to in article) is now called Just.

Notes:



Now distribute a copy of the article, **Millennials are Driving the Worldwide Shift Away from Meat** to each student, and give students another ten minutes to read this article and answer the questions on the corresponding handout before going over the answers as a class.

1. What three things do millennials often think about when they choose what to eat?

   The source of their food, animal welfare issues, and environmental impacts

2. Name one health concern associated with eating processed meats like bacon and ham.

   Answers may include: Processed meats (like bacon and ham) have been linked to cancer. Animal products are linked to an increase in the risk of heart disease.

3. Name two things that companies are doing as a result of the growing demand for plant-based food options.

   Answers may include: Companies like Cargill are investing in more plant-based food options. Start-up companies are working on lab-grown meat production. Retailers like Walmart are demanding more plant-based foods from food suppliers to sell in their stores.

Finally, as a class, ask students: Given what you now know about the production of animal-based foods and plant-based foods, what are some ways humans could reduce the amount of carbon dioxide we release when producing food for the world?

Students may list:
- Eating no meat (following a vegetarian or vegan diet), which would result in the highest reduction of CO_2 by far
- Eating less meat (Meatless Mondays*)
- Other ideas


Final Activity: Sticky Note Exercise

Purpose: Identify key student learning to assess session effectiveness

1. Requirements

Time
5-10 minutes at most/session

Materials
• One sticky note for each student
• Thin-line markers (such as sharpies) or pens

Board or Wall Space
A place where students can post the sticky notes and the class can gather around to view them

2. Introduction

Tell the class, "We're going to end by seeing what stood out for you in our lesson the past couple days. **Please write 1-2 sentences on the sticky note about what you think is the most important thing you learned. Do not write your name on the sticky note.**"

3. Individual Work Time (1-2 minutes)

4. Posting Sticky Notes (2 minutes)

Tell the class:
• "Now we're going to post all the sticky notes on the board/wall. The purpose is to see what the class learned as a whole."
• **"You do not have to post your sticky note if you prefer not to do so."**
• "Please remain standing by the board/wall."

5. Themes (up to 5 minutes)

Now, ask the class, "As you look at what everyone wrote, do you see any similar ideas?" Encourage a brief discussion.
Time permitting: Have the students group together sticky notes with similar ideas. Then ask students to come up with a title to describe each group of sticky notes. Finally, add titles to the groups of sticky notes using another sticky note.

Conclude by taking a photo of the sticky notes, checking that each sticky note is legible in the photo. In addition to the photo, you may choose to keep the sticky notes for your records or recycle them.

farmsanctuary

Page 5

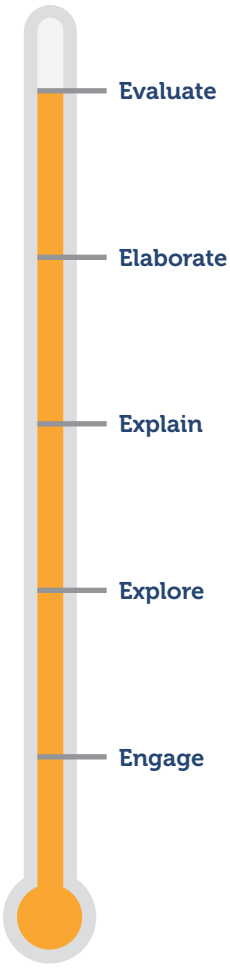
* Meatless Monday is a non-profit initiative started in 2003 by the Monday Campaigns and the Center for a Livable Future (CLF) at the Johns Hopkins Bloomberg School of Public Health. The initiative's goal is to reduce meat consumption to improve personal health and the health of the planet. For more information: https://www.meatlessmonday.com/

Closure: Student Sticky Note Exercise (5-10 minutes)

Please refer to **Student Activity: Sticky Note Exercise** for detailed instructions. Each student will write 1-2 sentences on a sticky note about what they consider to be the most important thing they learned in this lesson. The sticky notes should be completed anonymously. Students will then post their sticky notes on a board or wall and engage in a brief class discussion.

Time Permitting: Have the students group together sticky notes with similar ideas. Then ask students to come up with a title to describe each group of sticky notes. Finally, add titles to each group of sticky notes using an additional sticky note.

Conclude by taking a photo of the sticky notes, checking that each sticky note is legible in the photo. Please email the photo of the anonymous student sticky notes to Farm Sanctuary's Humane Educator Maddie Krasno at mkrasno@farmsanctuary.org.



Teacher Survey and Student Feedback

Teachers who have implemented one complete lesson plan from Farm Sanctuary's Sustainable Future Curriculum are eligible for a **$50 Amazon gift card** by completing our teacher survey and submitting a photo of the anonymous student sticky notes to Farm Sanctuary. Please e-mail Maddie Krasno at mkrasno@farmsanctuary.org for the survey and to submit the photograph of the student sticky notes.

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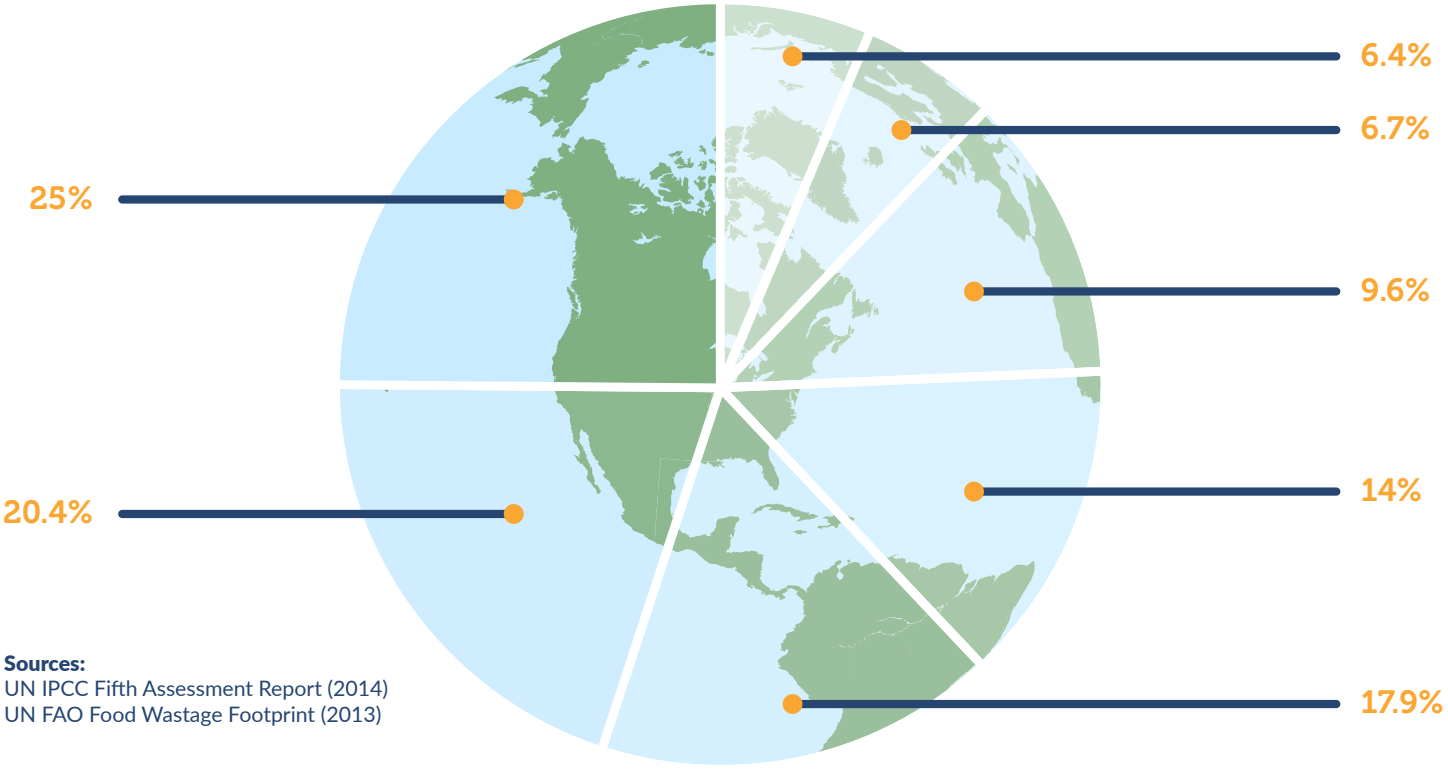
Notes:

Sources of Greenhouse Gases

Name: _____

Date: _____

Which source is responsible for each percentage of greenhouse gas emissions created on our planet? Fill in the blanks.



Sources:
UN IPCC Fifth Assessment Report (2014)
UN FAO Food Wastage Footprint (2013)


Agriculture and Land


Buildings


Electricity and Heat


Food Waste


Industry

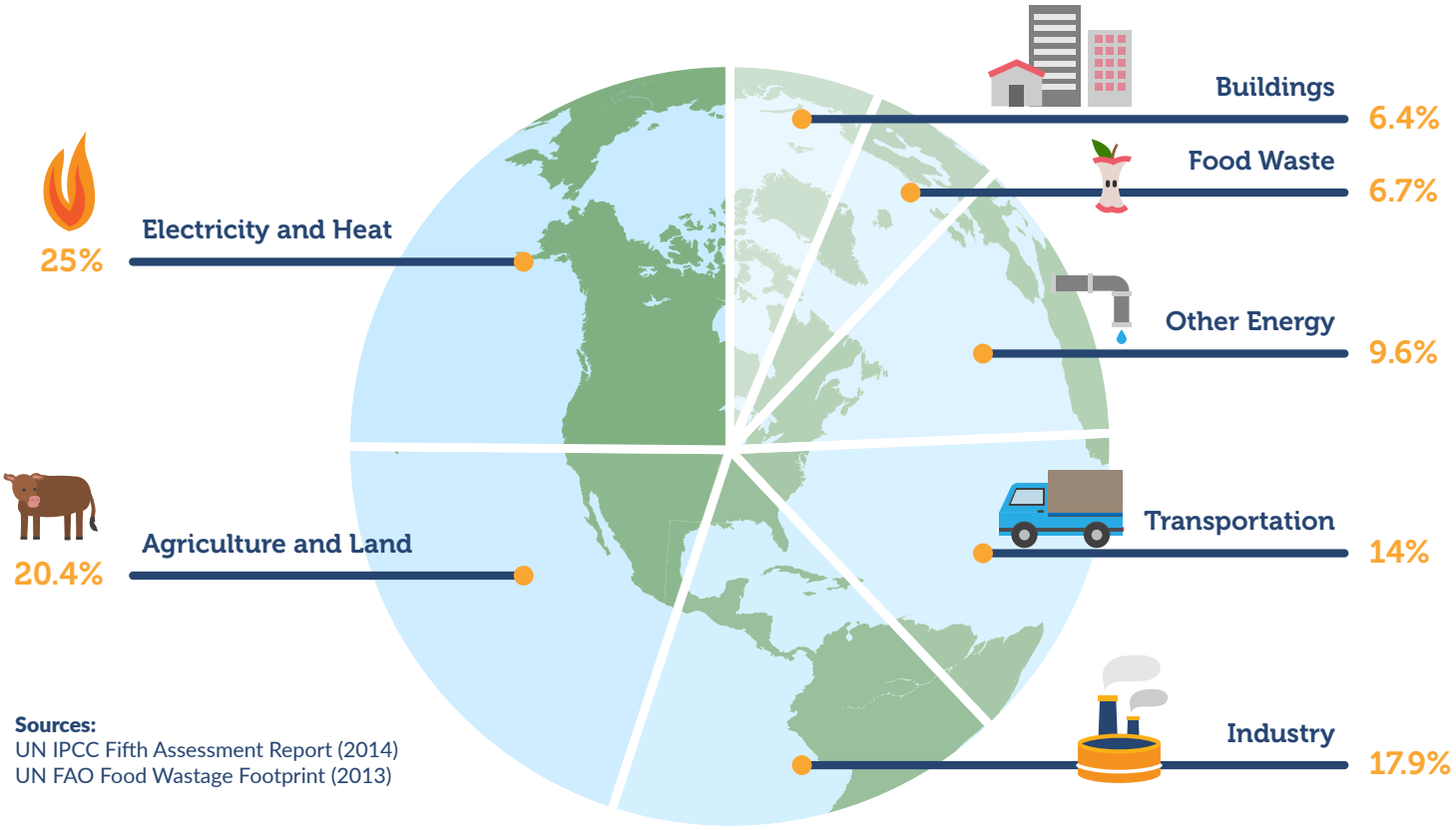

Transportation


Other Energy

Teacher Key

Sources of Greenhouse Gases

Which source is responsible for each percentage of greenhouse gas emissions created on our planet? Fill in the blanks.



Sources:
UN IPCC Fifth Assessment Report (2014)
UN FAO Food Wastage Footprint (2013)

Food Production and CO_2 Equivalents

Name: _____

Date: _____

Introductory Question

Make a list of the different ways that the growing and production of food could release greenhouse gases such as carbon dioxide (CO_2) or methane (CH_4).

Background Information

Carbon dioxide and other greenhouse gases are produced by various processes, one of which is by burning gasoline when you drive a car. To know how much CO_2 is given off by driving a car, you can calculate how many kilograms of CO_2 are produced for X number of miles driven.

For example, a typical car releases 0.411kg of CO_2 for each mile you drive it. More efficient cars will give off less CO_2; less efficient cars will give off more CO_2.

1. **How many miles would you have to drive a typical car to give off 1 kilogram of CO_2?**
   (Hint: Use the conversion factor of 1 mile/0.411 kg CO_2).

2. **What is the relationship between the release of CO_2 and other greenhouse gases into the atmosphere and global warming?**

Background Information Continued

The carbon dioxide equivalent (CO_2e) is a way of expressing greenhouse gas emissions as a single number in order to show their global warming potential (Center for Sustainable Systems, University of Michigan, 2018). One way to compare how much CO_2 is given off by certain processes, like driving a car, to other processes, like food production, is to calculate the number of miles one would have to drive a car to produce the kilograms of CO_2e created by a type of food. This is your next activity.

Graphing Activity

In Data Set 1, you are given data for the CO_2 equivalent produced by different foods.

1. Open up a spreadsheet in Excel, Google Sheets, or another graphing program.
2. Copy and paste (or type in) Data Set 1, comparing kg CO_2e released per 1 kg of consumed food.
3. Sort the data to see a trend. (Which column should you sort by?)
4. Determine the best type of graph to represent your data. Select your data and create a chart or graph. In Google Sheets, charts or graphs can be located under the insert tab.
5. Come up with an appropriate title for your graph.

Data Set 1.

1 kg Consumed Food	kg CO_2e Produced by 1 kg of Consumed Food
Beef	27.0
Cheese	13.5
Chicken	6.9
Dry Beans	2.0
Eggs	4.8
Lamb	39.2
Lentils	0.9
Peanut Butter	2.5
Pork	12.1
Potatoes	2.9
Rice	2.7
Tofu	2.0
Tomatoes	1.1

Source:

Meat eater's guide to climate change & health. (2011).

Retrieved from:

https://static.ewg.org/reports/2011/meateaters/pdf/methodology_ewg_meat_eaters_guide_to_health_and_climate_2011.pdf

Conclusions

1. **Which foods release the least CO_2e? Which foods release the most CO_2e? How much of a difference is there? Compare lamb, beef, tofu, and tomato.**

2. **How does this compare to driving a car? In other words, how many miles would you need to drive to give off the same amount of CO_2e produced by different foods? You can determine this using your spreadsheet.**

- Make a new column entitled "Comparative Miles Driven".
- Use the following conversion factor: the kg CO_2e for a specific food multiplied by the conversion factor of 1 mile/0.411 kg CO_2. Notice how the kg CO_2e cancels out to give you an answer in miles.
- Select the first data square in your new column. What formula could you type in to calculate the miles you would drive for each type of food? Use this formula for each food type.
- How many miles of driving difference is there between producing 1 kg of lentils vs. 1 kg of beef?

3. **Why do you think producing animal-based foods releases so much more greenhouse gases than producing plant-based foods? Give two reasons.**

4. **Look at Table 1 on the next page. Underline all the items in column 1 that have to do specifically with growing plants. Circle all of the items in Column 1 that have to do specifically with producing animal-based foods like meat, dairy, and eggs. Explain how this exercise might help to answer question #3.**

Table 1. Sources of Primary Greenhouse Gas Emissions

Item (Input/Output) Considered	Processes Included in Assessment	Sources of GHG Emissions for Inputs and Outputs
Fertilizer for cover crops, plant-based foods and animal feed	Production; transportation of fertilizer to farm; application to field	Electrical plant; natural gas for production; fuel combustion during transport
Pesticides for cover crops, plant-based foods and animal feed	Production; transportation of pesticide to farm; application to field	Electricity and fuel for production; fuel combustion during transport
Lime, gypsum, sulfur and other soil additives - for cover crops, plant-based foods and animal feed	Production; transportation of lime to farm; (application to field is included in feed category)	Electricity and fuel for production; fuel combustion during transport
Irrigation water	Withdrawal and distribution	Electricity
Harvested crop	Harvesting and decomposition	Fuel for farm equipment; N_2O from post-harvest crop residues left on fields; N_2O from legumes (nitrogen fixation) and crop residues.
Animal feed (corn, soybean, alfalfa, etc.), rice and other crops	Production (pre- and post-harvest for plant-based feeds); transportation to farm	CO_2 from urea (fertilizer); N_2O from nitrogen-fertilizer emissions emanating from soil and water; CO_2 from lime application on soil; methane from rice production
Other on-farm inputs	Other on-farm activities to raise animals or grow crops	Electricity and fuel combustion
Growing plants	Plant growth	Carbon storage in the biomass of perennial species such as nut trees during growth and at maturity
Maturing animal (during grazing and at the feedlot)	Enteric fermentation (digestive process of ruminants) and manure management	CH_4 from enteric fermentation (adjusted for different kinds of feed); N_2O and CH_4 emissions from manure management
Slaughtered animal	Transport of animal to slaughter facility; slaughter	Electricity used in slaughter process
Packaged food	Transportation of food to packaging facility; production of packaging materials; packaging process	Fuel for transport and electricity used in production of packaging materials as well as actual packaging of the food

Food at retail	Transportation from packaging facility to retail; freezing and refrigeration during transport and at retail	Electricity; hydrofluorocarbons leaked from refrigeration systems at retail
Cooked food	Cooking	Natural gas used for cooking
Wasted food	Transportation from home/ restaurant to landfill; food deposited in landfill	Fuel; CH_4 from food waste in landfills
Aquaculture	Electricity, water, feed, fertilizer (in some cases); transportation of inputs; fuel for boats	Electricity, water pumping, feed production, and transport

Table 1: Copyright © Environmental Working Group, www.ewg.org.
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Meat eater's guide to climate change & health. (2011).
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https://static.ewg.org/reports/2011/meateaters/pdf/methodology_ewg_meat_eaters_guide_to_health_and_climate_2011.pdf

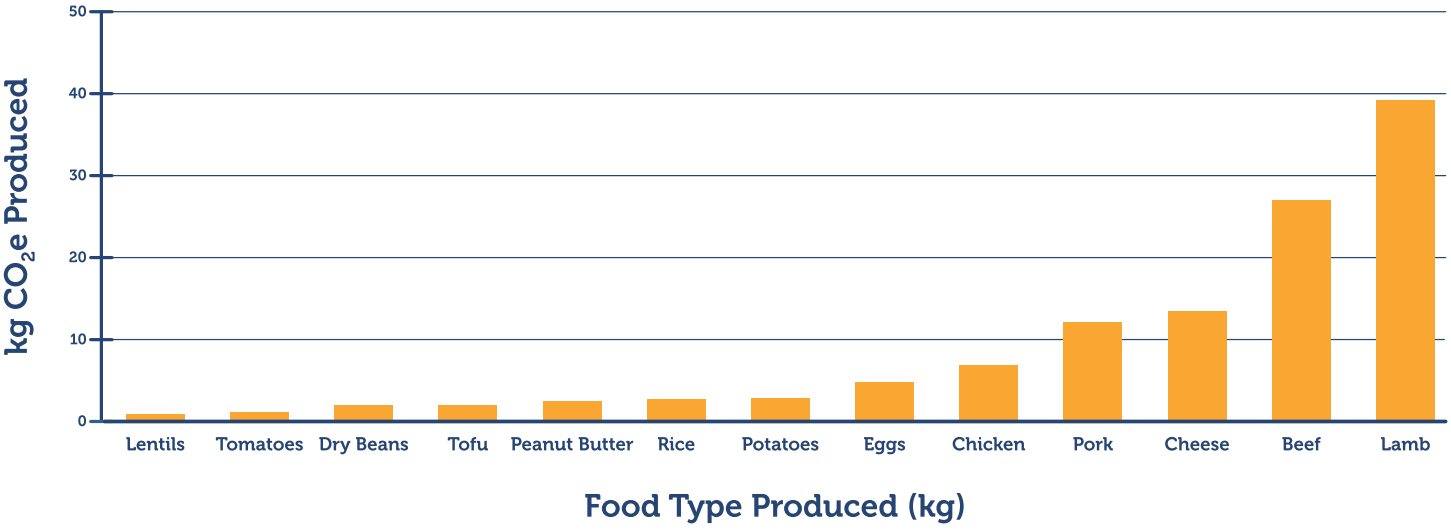
Teacher Key

Food Production and CO_2 Equivalents

	A	B	C
1	**1 kg/2.2 lbs of Consumed Food**	**kg CO_2e**	**Comparative Miles Driven***
2	Lentils	0.9	2.19
3	Tomatoes	1.1	2.68
4	Dry Beans	2	4.87
5	Tofu	2	4.87
6	Peanut Butter	2.5	6.08
7	Rice	2.7	6.57
8	Potatoes	2.9	7.06
9	Eggs	4.8	11.68
10	Chicken	6.9	16.79
11	Pork	12.1	29.44
12	Cheese	13.5	32.85
13	Beef	26	63.26
14	Lamb	39.2	95.38

*The formula for Comparative Miles Driven is the data from Column B (kg CO_2e) multiplied by the conversion factor of 1 mile/0.411 kg to cancel out the kg CO_2e. This is the same as dividing the data in Column B by 0.411. Example: for the first row, the formula would be B2/0.411. For the second row, the formula would be B3/0.411, and so on.

CO_2e Produced by Different Types of Food



Terms and Definitions

General Lesson:

Term	Definition
Atmosphere	The mixture of gases that surrounds the earth[6]
Atom	The smallest particle of a chemical element that can exist[6]
Carbon Dioxide	A gas breathed out by people and animals from the lungs or produced by burning carbon[6]
Cesspool	A container for the temporary storage of liquid waste and sewage[6]
Climate	The regular pattern of weather conditions of a particular place[6]
Climate Change	Changes in the earth's weather, including changes in temperature, wind patterns and rainfall, especially the increase in the temperature of the earth's atmosphere that is caused by the increase of particular gases, especially carbon dioxide[6]
Concentration	A lot of something in one place; the amount of substance in a liquid or in another substance[6]
Deforestation	The act of cutting down or burning the trees in an area[6]
Emit	To send out something such as light, heat, sound, gas, etc.[6]
Emission	The production or sending out of light, heat, gas, etc.[6]
Export	To sell and send goods to another country[6]

Factory Farm	A type of farm in which animals are kept inside in small spaces and are fed special food so that a large amount of meat, milk, etc. is produced as quickly and cheaply as possible[6]
Fossil Fuels	Fuel such as coal or oil, that was formed over millions of years from the remains of animals or plants[6]
Global Warming	The increase in temperature of the earth's atmosphere, that is caused by the increase of particular gases, especially carbon dioxide[6]
Greenhouse Effect	A phenomenon where gases allow sunlight to enter Earth's atmosphere but make it difficult for heat to escape[3]
Hydrogen Sulfide	A colorless, poisonous, flammable gas[6]
Industry	The production of goods from raw materials, especially in factories[6]
Manure	The waste matter from animals[6]
Methane	A gas without color or smell that burns easily and is used as fuel; natural gas consists mainly of methane[6]
Microbe	An extremely small living thing that you can only see under a microscope and that may cause disease[6]
Molecule	The smallest unit, consisting of a group of atoms, into which a substance can be divided without a change in its chemical nature
Phenomenon	A fact or an event in nature or society, especially one that is not fully understood[6]
Regurgitate	To bring food that has been swallowed back up into the mouth again[6]
Ruminant	Animals, such as cows and sheep, bring back food from their stomachs and chew it again[6]

Article:
How Feed Production and Manure Generate Greenhouse Gases - Environmental Working Group

Term	Definition
CAFO	A concentrated animal feeding operation[6]
Confined	(Of a space or an area) Small and surrounded by walls or sides[6]
Decompose	To be destroyed gradually by natural chemical processes[6]
Degraded	To degrade something is to make something become worse, especially in quality[6]
Federal	(Within a federal system, for example the US and Canada) Connected with national government rather than the local government of an individual state[6]
Fertilizer	A substance added to soil to make plants grow more successfully[6]
Generate	To produce or create something[6]
Irrigation	The practice of supplying water to an area of land through pipes or channels so that crops will grow[6]
Pesticide	A chemical used for killing pests, especially insects[6]
Reservoir	A natural or artificial lake where water is stored before it is taken by pipes to houses, etc.[6]
Runoff	Rain, water or other liquid that runs off land into streams and rivers[6]
Subsidized	To subsidize somebody/something is to give money to somebody or an organization to help pay for something; to give a subsidy[6]

Article:
Impossible Foods to Supersize Production of Lab-Grown Burger - CNET

Term	Definition
Cohort	A group of people who share a common feature or aspect of behavior[6]
Faux	Artificial, but intended to look or seem real[6]
Lab-Grown Meat	Cultured meat, also called clean meat, synthetic meat, or in vitro meat, is meat grown from in vitro animals' cell culture instead of from slaughtered animals[1]
Secrete	Secrete something (of part of the body or a plant) to produce a liquid substance[6]
Undiscerning	Unable to show good judgement about the quality of somebody/ something[6]

Article:
Millennials are Driving the Worldwide Shift Away from Meat – Forbes.com

Term	Definition
Blistering	Done very fast or with great energy[6]
Combat	To struggle against or to strive to reduce or eliminate[5]
Conscious	Aware of something; noticing something[6]
Cruelty-Free	Developed or produced without testing on animals[4]
Diversify	To develop a wider range of products, interest, skills, etc. in order to be more successful or reduce risk[6]
Entitlement	A government system that provides financial support to a particular group of people[6]
Environmental (Ecological) Footprint	A measure of the amount of the earth's resources used by a person or a population that lives in a particular way[6]
Flexitarian(ism)	A person who sometimes eats meat or fish although they do not usually do so[6]
Heart Disease	An abnormal condition of the heart or of the heart and blood circulation[5]
Lab-Grown Meat	Cultured meat, also called clean meat, synthetic meat, or in vitro meat, is meat grown from in vitro animals' cell culture instead of from slaughtered animals[1]
Meat-Free	Food that is free of meat (animal flesh)
Millennial	A person born in the 1980s or 1990s[5]

Organic	Produced or practiced without using artificial chemicals[6]
Pivot	To turn on a central point[2]
Plant-Based	A diet based on foods derived from plants, including vegetables, whole grains, nuts, seeds, legumes, and fruits, but with no animal products
Plant-Centric	A diet centered around foods derived from plants, including vegetables, whole grains, nuts, seeds, legumes, and fruits
Processed	A method of doing or making something, especially one that is used in industry[6]
Secular	Not connected with spiritual or religious matters[6]
Sustainable	Involving the use of natural products and energy in a way that does not harm the environment[6]
Vegan	A person who does not eat any animal products such as meat, milk, or eggs. Some vegans do not use animal products such as silk or leather[6]

Article:

Less Beef, Less Carbon: Americans Shrink Their Diet-Related Carbon Footprint by 10% Between 2005 and 2014 – NRDC

Term	Definition
Carbon Footprint	A measure of the amount of carbon dioxide that is produced by the daily activities of a person or company[6]
Cumulatively	In a way that increases in strength or importance each time something more or new is added[6]
Impactful	Having a major impact or effect[6]
Pollutant	A substance that pollutes something, especially air and water[6]
Scrutiny	Careful and thorough examination[6]

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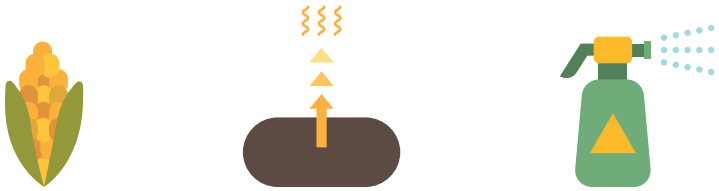
How Feed Production and Manure Generate Greenhouse Gases and Harm the Environment



Feed Production

Most U.S. livestock are fattened on fishmeal, corn, soybean meal and other grains. Grain production, in particular, requires significant quantities of fertilizer, fuel, pesticides, water and land. It takes 149 million acres of cropland, 76 million kilos (167 million lbs) of pesticides and 7.7 billion kilos (17 billion lbs) of nitrogen fertilizer to grow this feed. Fertilizer applied to soil generates nitrous oxide (N_20), which has 300 times the warming effect of carbon dioxide. Irrigation pumps, tractors and other farm equipment also release carbon dioxide, but in relatively small amounts. Pesticides and fertilizers often end up in runoff that pollutes rivers, groundwater and oceans. Feed crops are heavily subsidized by taxpayers through the federal Farm Bill, to the tune of $45 billion over the past 10 years. Fertilizer and pesticide production requires a significant amount of energy, but our model found that together they account for just 12 percent of the emissions from growing feed. The biggest impact is from the nitrous oxide emissions resulting from fertilizer application.

Manure

Animal waste releases nitrous oxide and methane and pollutes our water and air, especially when it is concentrated. In 2007, U.S. livestock in confined feeding operations generated about 500 million tons of manure a year, three times the amount of human waste produced by the entire U.S. population (EPA 2007). Manure is the fastest growing major source of methane, up 60 percent from 1990 to 2008 (EPA 2010). While manure is a valuable nutrient for plants, it can leach pollutants – including nitrogen, phosphorus, antibiotics and metals – into groundwater when storage facilities leak or too much is spread on farm fields. More than 34,000 miles of rivers and 216,000 acres of lakes and reservoirs in the U.S. have been degraded by waste from confined feeding operations (EPA 2009). Decomposing waste releases dust, smog odors and toxic gases, including ammonia and hydrogen sulfide, which degrade air quality and can cause itching, dizziness and discomfort to workers and nearby residents.

Climate and environmental impacts. (n.d.)
Retrieved from:
https://www.ewg.org/meateatersguide/a-meat-eaters-guide-to-climate-change-health-what-you-eat-matters/climate-and-environmental-impacts/

Article Worksheet

Name: _____

Date: _____

Article: How Feed Production and Manure Generate Greenhouse Gases and Harm the Environment

Author: Environmental Working Group

1. How does producing food for farm animals generate greenhouse gases and harm the environment?

2. How does animal waste generate greenhouse gases and harm the environment?

3. What is the fastest growing major source of methane?

Article Worksheet

Name: _____

Date: _____

Article: Less Beef, Less Carbon: Americans Shrink Their Diet-Related Carbon Footprint by 10 Percent Between 2005 and 2014

Author: NRDC

1. **Between 2005 and 2014, the amount of beef that Americans cut out of their diet brought down carbon emissions equivalent to the annual tailpipe emissions for how many cars?**

2. **How could pollution (carbon emissions) be reduced even more?**

3. **What food in the American diet contributes the most to climate-warming pollution?**

Article Worksheet

Name: _____

Date: _____

Article: Impossible Foods to Supersize Production of Lab-Grown Burger

Author: Dara Kerr, CNET

1. What "secret ingredient" is in these burgers to make them seem more like meat?

2. How are plant-based hamburgers better for the environment than hamburgers made from cows?

3. If your favorite burger restaurant offered the Impossible Burger, would you eat it? Why or why not?

Article Worksheet

Name: _____

Date: _____

Article: Millennials are Driving the Worldwide Shift Away from Meat

Author: Michael Pellman Rowland, Forbes.com

1. What three things do millennials often think about when they choose what to eat?

2. Name one health concern associated with eating processed meats like bacon and ham.

3. Name two things that companies are doing as a result of the demand for plant-based options.

Final Activity: Sticky Note Exercise

Purpose: Identify key student learning to assess lesson effectiveness

1. Requirements

Time

5-10 minutes
at end of session

Materials

- One sticky note for each student
- Thin-line markers (such as sharpies) or pens

Board or Wall Space

A place where students can post the sticky notes and the class can gather around to view them

2. Introduction

Inform the class that the final activity will have them reflect upon what they have learned throughout the lesson. **Ask each student to write 1-2 sentences on a sticky note about what they think is the most important thing they learned. Students should not write their names on the sticky notes.**

3. Individual Work Time (2 minutes)

4. Posting Sticky Notes (2 minutes)

Students should now post their sticky notes on the board/wall so that they can see what their fellow classmates learned as a whole. Inform the students that they do not have to post their sticky note if they prefer not to do so. Students should remain standing by the board/wall once they have posted their sticky notes.

5. Themes (up to 5 minutes)

Now, ask the class if they see similar concepts, facts, or comments referred to on the sticky notes. Encourage a brief discussion.

Time Permitting: Have the students group together sticky notes with similar ideas. Then ask students to come up with a title to describe each group of sticky notes. Finally, add titles to each group of sticky notes using an additional sticky note.

Conclude by taking a photo of the anonymous sticky notes for your records, checking that each sticky note is legible in the photo. You may choose to keep the sticky notes or recycle them. Please e-mail this photo to Farm Sanctuary's Humane Educator Maddie Krasno at mkrasno@farmsanctuary.org.