

LESSON: Converting Water into Food

Summary: Using unit conversions, students estimate the amount of water it takes to produce 1 pound of corn and 1 pound of beef. Then they identify assumptions and factors that potentially affect the estimates.

Lesson Type: Data Analysis —Students read and interpret data.

EHP Article: “How Much Water Did Your Food Require?”
EHP Student Edition, April 2007, p. A23
<http://www.ehponline.org/docs/2007/115-1/forum.html#beat>

Objectives: By the end of this lesson, students should be able to

1. estimate the amount of water it takes to produce 1 pound of corn and 1 pound of corn-fed beef;
2. calculate unit conversions; and
3. identify potential factors affecting estimates of the amounts of water used to produce grain or beef.

Class Time: 1 hour

Grade Level: 9–12

Subjects Addressed: General Science, Mathematics, Environmental Science, Biology, Agricultural Science

► Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Download the entire April 2007 *EHP Student Edition* at <http://www.ehponline.org/science-ed/>, or download just the article “How Much Water Did Your Food Require?” at <http://www.ehponline.org/docs/2007/115-1/forum.html#beat>.
2. Review the Background Information, Instructions, and Student Instructions.
3. Decide whether you want students to work in pairs or individually.
4. Make copies of the Student Instructions and the article.

MATERIALS (per student):

- 1 copy of the April 2007 *EHP Student Edition* or 1 copy of “How Much Water Did Your Food Require?” preferably in color
- 1 copy of the Student Instructions

VOCABULARY:

- World Health Organization

BACKGROUND INFORMATION:

The amount of water it takes to produce the food we eat is a matter of contention between special interest groups. The website BeefFromPasturetoPlate.com states “Considering all factors in beef cattle production including direct consumption, irrigation of pastures and crops, and carcass processing, it takes 435 gallons of water to produce a pound of boneless beef, according to the CAST [Council for Agricultural Science and Technology, made up primarily of university agricultural researchers] 1999 *Animal Agriculture and Global Food Supply Report*” (see <http://www.beeffrompasturetoplate.org/mythmeatproductioniswasteful.aspx>). But according to the website GoVeg.com, “It takes 5,000 gallons of water to produce 1 pound of meat, while growing 1 pound of wheat only requires 25 gallons” (cited from the book *The Food Revolution* by John Robbins). There are so many factors that go into estimating the amount of water (or other resources) used to produce our food that special interest groups can pick “extreme” examples to make their point.



This lesson has students use data from less biased organizations like the U.S. Department of Agriculture (USDA), the U.S. Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA) to estimate the amount of water it takes to produce 1 pound of corn and 1 pound of beef. The lesson also has students identify assumptions and potential errors in their estimates. This should help them understand the complexities and differences between the estimates they calculate and those provided by the World Health Organization (WHO), which are cited in the article.

If the students are not familiar with the WHO, you can inform them that this is the health agency for the United Nations and consists of experts and representatives from 193 different world states/countries. Although every agency or organization is potentially subject to bias, federal agencies such as the USGS and world agencies such as the WHO have checks, balances, and safeguards to minimize bias. These organizations typically assemble data from multiple sources and consider it from various perspectives and contexts in an attempt to find the most accurate representation to make informed decisions.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, <http://ehp.niehs.nih.gov/>. Choose Agriculture/Farming, Food Safety

USDA, Water use, <http://www.ers.usda.gov/Briefing/WaterUse/>

USDA, Water facts, <http://ct.water.usgs.gov/education/waterfacts.htm>

U.S. Embassy, Structure of the beef industry, <http://tokyo.usembassy.gov/e/p/tp-20041112-80.html>

U.S. EPA, Use of water for crops, <http://www.epa.gov/oecaagct/ag101/cropmajor.html>

USGS, *Estimated Use of Water in the United States in 2000*, <http://pubs.usgs.gov/circ/2004/circ1268/>

World Health Organization, <http://www.who.int/en/>

► Implementing the Lesson

INSTRUCTIONS:

1. Distribute the Student Instructions and the article to the class.
2. Review unit conversions as needed. Remind student they need to show units and cancellations in their calculations. Doing this will help them keep track of the units. You may need to remind students that the units will tell them whether to multiply or divide (i.e., which figure goes on the top and which goes on the bottom in the conversion). Another helpful tip for unit conversions is to have the students identify which unit they will end up with in their answer and then work backward from there, setting up the cancellations such that only the units they want remain.
3. As a group, discuss the students' responses to Steps 2 and 5. This will help students understand the challenges and complexity of making estimates.

NOTES & HELPFUL HINTS:

1. The lesson can be expanded to include a discussion about the use of information to promote an agenda (e.g., vegetarian lifestyle or the beef industry), as well as reliable sources of information (e.g., the USDA versus a special-interest group). The Background section of this lesson provides information to begin such a dialogue.
2. Students could research and calculate the amount of water it takes to raise other animals (such as chickens) and/or other plant crops (such as soybeans). They could also investigate the nutritional impact or value of a pound of grain versus a pound of beef or other meat

► Aligning with Standards

SKILLS USED OR DEVELOPED:

- Classification
- Communication (note-taking, oral, written—including summarization)
- Comprehension (listening, reading)
- Computation
- Critical thinking and response
- Manipulation
- Unit conversions



SPECIFIC CONTENT ADDRESSED:

- Water use
- Agriculture
- Resource consumption

NATIONAL SCIENCE EDUCATION STANDARDS MET:**Science Content Standards****Unifying Concepts and Processes Standard**

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement

Science as Inquiry Standard

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Life Science Standard

- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Science in Personal and Social Perspectives Standard

- Natural resources

▶ Assessing the Lesson

Step 1: a) Amount of water to produce 1 pound of corn for direct human consumption.

$4,000 \text{ gallons of water/bushel} \times 1 \text{ bushel}/70 \text{ pounds} = 4,000 \text{ gallons}/70 \text{ pounds corn} = \mathbf{57 \text{ gallons of water/pound of corn}}$

b) Amount of water to produce 1 pound of beef from a cow that ate only corn.

$57 \text{ gallons of water/pound of corn} \times 25 \text{ pounds of corn/day} \times (365 \text{ days} + 90 \text{ days}) = 57 \text{ gallons of water} \times 25/\text{day} \times 455 \text{ days} = 648,375 \text{ gallons of water}/758\text{-pound cow} = \mathbf{855 \text{ gallons of water/pound of beef}}$

c) How many more times the amount of water does it take to produce 1 pound of beef compared to 1 pound of corn? Show your calculations.

$855/57 = \mathbf{15 \text{ times more water}}$

Step 2: Do you think your calculation of the amount of water it takes to produce 1 pound of beef is an overestimate or an underestimate? Explain your reasoning and be sure to discuss any assumptions made in the calculations.

Student answers will vary. Explanations should be clear and logical. Some possible explanations include:

Underestimate: The mass of the animal we used included the bones, not just the usable meat; we did not account for the excess crop eaten by the mother cow when lactating; we did not include the additional water used for direct consumption of the animal, cleaning, slaughtering, and processing of the animal; we assumed the animal ate only corn, and other feed crops may require more water; we assumed the animal would be slaughtered at age 1 year and 3 months of age, although if it lived longer it would consume more water.

Overestimate: We assumed the animal ate only corn, and other feed crops may require less water; the animal may be able to use the entire corn stalk and ear, while humans consume only the kernels on the ear; types of corn used for humans versus livestock may differ in their water needs; this calculation assumes grain feeding the entire time, but the animal could have grazed part of the time; the animal does not eat corn during the first 4 months of its life; we assumed the animal would be slaughtered at age 1 year and 3 months, but if it were killed sooner it would consume less water.



- Step 4:** a) Convert the article's estimates from quarts to gallons (1 quart = 0.25 gallon) for water used for grain and meat. Show your calculations and unit cancellations. Show the range for grains.

$$500 \text{ quarts/pound of meat} \times 0.25 \text{ gallon/quart} = \mathbf{125 \text{ gallon of water/pound of meat}}$$

$$2 \text{ quarts/pound of grain} \times 0.25 \text{ gallon/quart} = \mathbf{0.5 \text{ gallon of water/pound of grain}}$$

$$20 \text{ quarts/pound of grain} \times 0.25 \text{ gallon/quart} = \mathbf{5 \text{ gallons of water/pound of grain}}$$

0.5 to 5 gallons of water/pound of grain

- b) According to the estimates provided in the article, how many more times the amount of water does it take to produce 1 pound of meat compared to 1 pound of grain? Show your calculations.

$$125/0.5 = 250$$

$$125/5 = 25$$

25 to 250 times the amount

- Step 5:** Provide at least one possible explanation for any differences between the estimated water use you calculated for beef and corn and the estimated water use for producing meat and grains described in the article.

Student answers may vary. Look for clear logical answers. One possible explanation is that the article could have used calculations for other crops (e.g., soy, hay, wheat, etc.) and other forms of meat (e.g., chicken, pork, fish, etc.) that could use less water. The article also could have used estimates for production in countries other than the United States, or averaged rates for production across the world.

Students may note that the cow/corn example estimated that it takes 15 times the amount of water to produce 1 pound of beef, which is comparable to, but less than the range of 25 to 250 times the amount estimated in the article.

Students may also note the large range presented in the article. Considering that our example estimated 15 times (close to the lowest number in the range), they may wonder how the upper limit of the range (250 times) was determined.

► Authors and Reviewers

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.



STUDENT INSTRUCTIONS: Converting Water into Food

Step 1: Using the unit conversions below, calculate how many gallons of water were used to produce 1 pound of corn for direct human consumption and 1 pound of beef from a cow that ate only corn. Show your work and unit conversions. NOTE: These conversions are averages and can vary.

- 4,000 gallons of water are used per bushel of corn.
- There are 70 pounds of corn per bushel.
- Each cow/bull eats 25 pounds of corn per day.
- The average weight of a cow/bull when slaughtered is 758 pounds (this is the entire animal, not just the usable meat).
- The average age at slaughter is 1 year and 3 months. Assume 30 days per month. NOTE: Calves begin eating solid food at around age 4 months and continue to drink milk from their mother for up to 8 months. Lactating, or milk-producing, cows eat more when they are lactating than when they are not. For this activity, we use the same corn consumption rate, so assume the animal is eating 25 pounds of corn per day for 15 months.

a) Amount of water to produce 1 pound of corn for direct human consumption.

b) Amount of water to produce 1 pound of beef from a cow that ate only corn.

c) How many more times the amount of water does it take to produce 1 pound of beef compared to 1 pound of corn? Show your calculations.

Step 2: Do you think your calculation of the amount of water it takes to produce 1 pound of beef is an overestimate or an underestimate? Explain your reasoning and be sure to discuss any assumptions made in the calculations.



Step 3: Read the article “How Much Water Did *Your* Food Require?”

Step 4: The article provides an estimate of the amount of water in quarts it takes to produce 1 pound of grain and 1 pound of meat. Answer the following questions.

a) Convert the article’s estimates from quarts to gallons (1 quart = 0.25 gallon) for water used for grain and meat. Show your calculations and unit cancellations. Show the range for grains.

b) According to the estimates provided in the article, how many more times the amount of water does it take to produce 1 pound of meat compared to 1 pound of grain? Show your calculations.

Step 5: Provide at least one possible explanation for any differences between the estimated water use you calculated for beef and corn and the estimated water use for producing meat and grains described in the article.

