

LESSON:

Soy: Filling in the Gaps

Summary: Students read an in-depth article on scientists' emerging understanding of the active components of soy foods, research and define terms from the article, and make recommendations about how to consume soy to maximize benefits and minimize potential dangers.

Lesson Type: Focus article lesson.

EHP Article: "The Science of Soy: What Do We Really Know?"
EHP Student Edition, September 2006, p. A352–A358
<http://www.ehponline.org/members/2006/114-6/focus.html>

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

1. describe the possible benefits of soy as part of the diet and as a dietary supplement;
2. identify various chemical components believed to be active in soy;
3. discuss the limitations of our current knowledge about soy; and
4. make dietary recommendations based on the information presented in the article.

Class Time: 2 hours

Grade Level: 10–12

Subjects Addressed: Health, Nutrition, Environmental Health, Biochemistry

► **Prepping the Lesson (15 minutes)**

INSTRUCTIONS:

1. Download the September 2006 *EHP Student Edition* at <http://www.ehponline.org/science-ed/>, or download just the article "The Science of Soy: What Do We Really Know?" at <http://www.ehponline.org/members/2006/114-6/focus.html>.
2. Review the Background Information, Instructions, and Student Instructions.
3. Make copies of the Student Instructions.

MATERIALS (per student):

- 1 copy of the *EHP Student Edition* article "The Science of Soy: What Do We Really Know?"
- 1 copy of the Student Instructions

VOCABULARY:

- adenocarcinoma
- agonists
- angiogenesis
- antioxidants
- cultivar
- daidzein
- epidemiology
- equol
- estrous cycle
- genistein
- glycitein
- hydrolyzed
- *in vitro*
- *in vivo*
- infertility



- isoflavones
- kinases
- microflora
- miso
- nutraceuticals
- nonnutritive
- pharmacokinetics
- phytic acid
- phytoestrogens
- protease inhibitors
- saponins
- tempeh
- topoisomerases

BACKGROUND INFORMATION:

The article provides a good review of the issues associated with bioactive compounds in soy. There are numerous examples of healthy foods from which active chemicals have been isolated and marketed as supplements. One recent example of this has been lycopene, a substance extracted from cooked tomatoes. Although there is a general understanding among health professionals as to what constitutes a healthy diet, it is difficult to get people to change their dietary habits, even in the face of disease arising from poor diet. Food choices are heavily influenced by culture, income, region, and family, not to mention habit. By creating supplements, marketers hope to attract people to an easier way to improve their diet than making broad changes to their eating patterns. Although supplements can be a good “insurance policy” against occasional deficiencies of nutrients, a balanced diet of whole foods remains the best way of ensuring health.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, <http://ehp.niehs.nih.gov>. Choose Diet and Nutrition, Endocrine Disruptors, Herbal Medicine

Setchell KDR. 2006. Assessing risks and benefits of genistein and soy. *Environmental Health Perspectives* 114:A332–A333; <http://www.ehponline.org/docs/2006/114-6/editorial.html>

Isoflavones.info (a commercially sponsored website providing extensive information about various isoflavones, including those in soy), <http://www.isoflavones.info/>

Nutrition and Health Info-sheet: Soy, UC Davis,

<http://nutrition.ucdavis.edu/InfoSheets/ANR/soyfact.pdf>

Phytochemicals.info (a commercially sponsored website providing information about various phytochemicals mentioned in the article), <http://www.phytochemicals.info/>

Saponins, Cornell University,

<http://www.ansci.cornell.edu/plants/toxicagents/saponin.html>

Soy and Cardiovascular Disease: Cholesterol Lowering and Beyond; *The Journal of Nutrition*, web address the same, <http://jn.nutrition.org/cgi/content/full/130/3/6625>

► Implementing the Lesson

INSTRUCTIONS:

1. Have students read the article “The Science of Soy: What Do We Really Know?”
2. Hand out the Student Instructions and assign students particular statements to research (e.g., half the class researches statements A–C and half researches D–F, or count off students A–F so each gets one statement). Allow time for research. Note that not all of the vocabulary words are defined in the article, so inform students that they may need to conduct additional research to answer their questions in Step 2.
3. As a class read the statements aloud and have the students explain the meaning and significance of their assigned statement with respect to the main idea of the article.

NOTES & HELPFUL HINTS:

- This article likely contains many new vocabulary words for students. This lesson is loosely based on a strategy in which students use the context to make guesses about the word meanings in question and then verify these guesses by looking the words up and writing down how their new knowledge deepens their understanding of the original text.



- If you are allotting more time to the exercise or have an advanced class, you may assign all statements to each student. In this case, the class discussion may not be necessary.
- This lesson can be extended by asking students to bring in soy-based products for taste testing or by having students compile a booklet of soy-based recipes.

▶ Aligning with Standards

SKILLS USED OR DEVELOPED:

- Communication (note taking—oral, written)
- Comprehension (listening, reading)
- Critical thinking and response
- Research

SPECIFIC CONTENT ADDRESSED:

- Nutrition
- Chemical components of foods
- Dietary recommendations
- Food science

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
- Form and function

Science as Inquiry Standard

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

Science in Personal and Social Perspectives Standard

- Personal and community health

History and Nature of Science Standard

- Science as a human endeavor
- Nature of scientific knowledge

▶ Assessing the Lesson

Step 1: The main idea of the article could be described as follows: “Although many studies have indicated that soy diets have health benefits, scientists have not yet explored the various active ingredients in soy, and recent research has indicated that some of these ingredients in pure form may have harmful effects on animals.”

Step 2: Following are sample answers for each statement:

A. Soybeans and soy foods contain a variety of bioactive components including saponins, protease inhibitors, phytic acid, and isoflavones [p. A354].

Saponins: glycosides of steroids present in the waxy coating of the soybean, possibly helpful in controlling cholesterol and aiding digestions and calcium absorption. Some types of saponins found in weeds are also known to be poisonous for some animals.

Protease inhibitors: naturally occurring molecules that inhibit the function of peptidases, enzymes that break peptide bonds in proteins. Developed also as a medicine for treating HIV infection.

Phytic acid: a natural antioxidant found in grains, seeds, and beans. Also the principal store of phosphate in plants, believed to play a role in slowing glucose absorption and possibly having an anticancer effect. Considered nonnutritive, it can also chelate minerals, causing deficiencies.

Significance: Each of these soy components has positive and negative effects depending on the setting and



combination of chemical factors. It's easy to see why soy is a complex food to study, even when individual components are looked at separately.

B. Soy isoflavones are frequently referred to as weak estrogens, and . . . they can act as agonists, partial agonists, or antagonists to endogenous estrogens (such as estradiol) and xenoestrogens (including phytoestrogens) at estrogen receptors [p. A354].

Agonists: chemical substances capable of combining with a receptor on a cell and initiating a reaction or activity.

Antagonists: chemicals that act within the body to reduce the physiological activity of another chemical substance (such as an opiate); especially, one that opposes the action on the nervous system of a drug or a substance occurring naturally in the body by combining with and blocking its nervous receptor.

Endogenous: produced or synthesized within the organism or system.

Xenoestrogens: the prefix xeno- is from the Greek meaning "guest" or "foreigner." Xenoestrogens are estrogens that come from a source outside the body.

The above definitions were taken from Merriam-Webster Online Dictionary (<http://www.m-w.com/dictionary>).

Significance: Isoflavones act as estrogens, which interact in complicated and unpredictable ways on the estrogens produced and taken in by the body.

C. Caution is necessary when predicting in vivo potency from in vitro systems [p. A354].

In vivo: from the Latin meaning "in life"—in a real-life circumstance. Research done within or on living organisms.

In vitro: from the Latin meaning "in glass"—in a lab or test-tube type circumstances. Research done in an artificial environment outside of a living organism.

Significance: Laboratory tests may not provide adequate indicators of the effects of soy in humans, where there are many complex interactions.

D. Key exceptions are fermented products, such as miso and tempeh, which may contain up to 40% free genistein [p. A355].

Fermented: in which organic compounds have been split into more simple forms by chemical processes; for instance, when sugar is split into alcohol and carbon dioxide. Also known as "decay".

Miso: a thick paste made of fermented cooked soybeans, rice, and salt. Used for flavoring soups and sauces in Japanese cooking.

Tempeh: a thick cake-like food made from partially cooked and fermented soybeans. Originally from Indonesia.

Significance: The chemical process of fermentation seems to protect the genistein, while other more-involved forms of processing break the substance down.

E. There is considerable variability in individuals' ability to produce equol, and the metabolic pathways for both genistein and daidzein may vary due to factors such as a person's particular microflora, intestinal transit time, and . . . use of antibiotics or other drugs [p. A356].

Equol: a nonsteroidal estrogen manufactured in some people's gut as a by-product of daidzein, an isoflavone.

Microflora: the microscopic bacteria that colonize the intestine and help break down food products as part of the digestive process.

Significance: Because of factors unique to an individual, soy may have different effects on different people, making it hard to determine the population-wide effects usually sought in nutritional studies.

F. The soy-fed marmosets had comparatively lower testosterone levels and higher numbers of Leydig cells per testis [p. A357].

Marmosets: small clawed monkeys native to the Americas, which are used sometimes for research purposes.

Leydig cells: cells of the interstitial tissue of the testes that secrete testosterone.

Testis: the singular of "testes," the male reproductive organs, which create sperm cells and are suspended in the testicles.

Significance: The animal study showed that although the number of the testosterone cells increased, less testosterone was produced.

Step 3: The article indicates that if people want to get the health benefits associated with soy in earlier studies, they need to consume moderate amounts of whole soy foods, not extracts or supplements, and particularly not unusual quantities of fermented soy products. Infant formula appears to be safe in cases where breast milk or cow's milk-based formulas are not appropriate, at least until further research is completed.

► Authors and Reviewers

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



STUDENT INSTRUCTIONS:
Soy: Filling in the Gaps

Step 1: Read the article “The Science of Soy: What Do We Really Know?” *EHP Student Edition*, September 2006, p. A352–A358. In the space below, write a sentence describing the main idea of the article.

Step 2: Below are six statements from the article with terms and concepts that may be unfamiliar to you. Your teacher will assign you several (or all) of these statements to research. For each statement, first define the underlined words, then explain how the statement relates to the main idea of the article. Use a separate sheet of paper.

A. Soybeans and soy foods contain a variety of bioactive components including saponins, protease inhibitors, phytic acid, and isoflavones [p. A354].

B. Soy isoflavones are frequently referred to as weak estrogens, and . . . they can act as agonists, partial agonists, or antagonists to endogenous estrogens (such as estradiol) and xenoestrogens (including phytoestrogens) at estrogen receptors [p. A354].

C. Caution is necessary when predicting in vivo potency from in vitro systems [p. A354].

D. Key exceptions are fermented products, such as miso and tempeh, which may contain up to 40% free genistein [p. A355].

E. There is considerable variability in individuals’ ability to produce equol, and the metabolic pathways for both genistein and daidzein may vary due to factors such as a person’s particular microflora, intestinal transit time, and . . . use of antibiotics or other drugs [p. A356].

F. The soy-fed marmosets had comparatively lower testosterone levels and higher numbers of Leydig cells per testis [p. A357].

Step 3: Based on your reading, what recommendations do you have for people wanting to maximize the dietary benefits of soy?

