Flavors and Phytochemicals

Purpose and Content of Lesson:
Fresh fruits and vegetables, herbs, and spices have a long history in medicine as well as in cuisine. Numerous epidemiological studies demonstrate that a diet rich in fruit and vegetables offers health benefits to humans, including a reduced risk of developing many forms of cancer (lung, prostate, pancreas, bladder, and breast) and a reduced risk of cardiovascular diseases. Current research is focused on defining the physiological effects that explain the epidemiological evidence, with a focus on phytochemicals. Plants produce a large variety of chemicals that are not directly involved in primary metabolism like growth and reproduction. These phytochemicals, also called secondary metabolites, protect the plant against bacteria, fungi, viruses, and UV light, and deter herbivores. When we eat the plants, these chemicals may have health-promoting effects. Much research remains to be done to demonstrate the specific physiological effects of these phytochemicals in humans.

Terms and definitions:
herbs: the dried, leafy parts of a plant
spice: pungent or aromatic part of a plant made by drying the bark, seed, fruit or root
antioxidant: chemical that protects against harmful oxidation reactions, often more potent when plant is cooked
phytochemical and secondary metabolite: both terms refer to an unusual chemical made by a plant that is not involved in the making of food, reproduction, or other primary processes.

Secondary metabolite is used when referring to chemicals from the plant’s point of view. Thus, chemicals that are beneficial to the plant may be harmful to those eating the plant, including chemicals that interfere with the nervous system, such as nicotine, caffeine, and pyrethrum, for example.

Next Generation Science Standards (NGSS):
http://www.nextgenscience.org/search-standards
Disciplinary Core Ideas
LS4.C: Adaptation
Natural selection leads to adaptation of a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (High School-LS4-3, 4)

LS1.B: Growth and Development of Organisms
Plants reproduce in a variety of ways, often depending on animal behavior and specialized features for reproduction. (MS-LS1-4)
 Genetic factors as well as local conditions affect the growth of the adult plant. (Middle School-LS1-5)

Lesson Objective:
Students will hopefully become interested in sampling fresh fruits, greens, and other vegetables to experience the variety of flavors and health benefits they offer, especially from plants growing in the Tower Garden.

Learners will conduct research to explain the relevance of flavors, colors, and phytochemicals to the survival of the plant species as well as their role in human health, medicine, and cuisine.

1http://www.ipfn.ie/introduction/phytochemicals.html
2http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals
Distribute a variety of fresh herbs and other flavorful plants for students to smell and taste. Be sure these foods have been thoroughly washed and that there are no food allergies to any of the samples. This lesson is best taught when the plants growing in the Tower Garden® serve as samples. Examples may include fresh basil, cilantro, thyme, oregano, dill, mint, Swiss chard, spinach, mustard greens, strawberries, chives, pakchoi, endive, and kale.

List the names of each sample. After tasting, smelling and observing the color, each student rates each one:
1. like it, interesting, and would try it again
2. interesting, but wouldn’t try it again
3. don’t like it.

Compare the ratings and draw some conclusions about the nature of the flavors from the class results. Think about the possible physiological effects of these samples based on the experience of tasting them. Discuss cultural preferences and specific uses for certain foods, herbs, and spices as well as having “acquired tastes over time vs. having a new tasting experience.”

Begin the PowerPoint slideshow titled FLAVORS and PHYTOCHEMICALS.

1. Why do plants make all these interesting flavors? Come up with as many ideas as possible, since scientists haven’t pinned it down. Present reasons for your ideas.

2. What are some examples of plants or secondary metabolites that have physiological effects in humans, especially on the nervous system?

(Some examples are: caffeine, nicotine, digitalis, and chemicals found in tea, coffee, tobacco, chocolate, nightshade, pokeweed, and many herbs. [https://faculty.unlv.edu/landau/psychoactiveplants.htm](https://faculty.unlv.edu/landau/psychoactiveplants.htm)

Plant flavors are chemicals in a category called secondary metabolites. These are chemicals that are not involved in making food or reproduction or other primary processes. These secondary metabolites protect the plant against bacteria, fungi, viruses, and UV light, and deter herbivores. Some of these secondary metabolites, often called phytochemicals (phyto means “plant”) may be responsible for the health-promoting effects that have been demonstrated when people eat more fresh fruits and vegetables.

Particular families of plants make particular kinds of chemicals (chemical families). For example, the mustard family, including cabbage and radishes, makes a chemical that irritates the tongue and sinuses; chili peppers sting; the onion family makes eyes tear; the citrus family and the mint family are both refreshing.

3. How might these secondary metabolites be useful to the plant that makes them? (They deter animals that try to eat the plant.)

4. Examples of other secondary metabolites that taste bitter are found in coffee, tea, and tobacco. Of what use might these be to the plant? How is this consistent with their effects on humans? (These are toxins to small mammals and insects but have a less toxic effect on humans. They affect the nervous system.)

Some of these secondary metabolites, often red or yellow in color, are antioxidants that scavenge highly reactive oxygen. They help the plant cope with the toxic effects of free oxygen that is a by-product of photosynthesis. Antioxidants are also considered helpful for human health by protecting against cancer. Antioxidant content in food is often increased by cooking. What do you think might be the benefit of antioxidants to the plants? (protect against oxygen made during photosynthesis)

Fruits and vegetables, especially leafy greens, are considered health promoting. Choose four such plants that you like, and research their medicinal or health-promoting characteristics.

5. Compare the flavor and nutritional value of a particular vegetable that is raw vs cooked. Find out how heating (cooking) affects the nutritional value of this food.

6. What did you learn about the scientific basis for the dietary advice “Eat more fruits and veggies?”

Create grading criteria to evaluate research question responses.
Create a FOOD FAIR as a class, incorporating real food samples and knowledge about nutritious foods and interesting flavors.

- Groups prepare a list of edible plants to bring in for a healthy-food tasting fair.
- Consider how the nutritional value of these foods is optimized, and wash, cut, cook (if needed), and display your selected foods in an appetizing and attractive manner for others to taste.
- Each group must present four foods in quantities large enough for everyone to have a small serving.
- Each dish will be accompanied by a one-page, typed report that relates the following information:
  1. Name of plant
  2. Where it was grown and where it was obtained (if bought)
  3. Health benefits and nutritional value
  4. How it is best or typically served
  5. Phytochemicals and antioxidants in this food and what you learned about them
  6. Historical and cultural uses as food and/or medicine
  7. How varieties of the plant have been developed and modified

Food Fair Presentation:
On the day of the food fair, share what you learned about your plant and encourage others to taste it.

Be sure to tell them about the highlights of your research findings.

**Additional Applications**

**Phytochemicals** http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals

**Herbs and Spices** http://blog.fooducate.com/2011/10/19/whats-the-difference-between-herbs-and-spices/


**Micronutrients** http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals

**Herb flavor wheel** http://www.tasteofherbs.com/fe/57799-flavor-wheel

**Antioxidants** http://www.preparedfoods.com/articles/108500-antioxidants-and-flavor-masking

**Book:** *Plant Secondary Metabolites: Occurrence, Structure and Role in the Human Diet* / edited by Alan Crozier, Michael N. Clifford, Hiroshi Ashihara.

**Scientific American article by Ferris Jabr:** “Reclaiming the Lost Flavor of Heirloom Produce—without GMOs,” 2014.

Making modern supermarket fruits and vegetables grow big and hardy drained a lot of their flavor. Scientists now have the technology to restore those flavors — and it doesn't involve genetic engineering.

Use the information in the references below to complete the table below them.

1. **Leafy Green Vegetables**  

2. **Video**  

3. **Phytochemicals**  
   [http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals](http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals)

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Worksheet for student responses to questions in lesson is attached (next page). Students will need access to the Internet in class. A Powerpoint presentation accompanies this lesson.

PLANT FLAVOR QUESTIONS

1. Why do plants make all these interesting flavors? Come up with as many ideas and reasons as possible.

2. What are some examples of plants or secondary metabolites that have physiological effects in humans, especially effects on the nervous system? (examples: caffeine, tobacco)

3. How might these secondary metabolites be useful to the plant that makes them?

4. Examples of other secondary metabolites that taste bitter are found in coffee, tea, marijuana, poppy, and tobacco. Of what use might these secondary metabolites be to the plant?

5. Fruits and vegetables, especially leafy greens are considered health promoting. Choose four such plants that you like, and research their medicinal or health-promoting characteristics.

6. Compare the flavor and nutritional value of a particular fruit and vegetable (from your chart) that is raw vs. cooked. Find out how heating (cooking) affects the nutritional value of this food, and write your findings.

7. What did you learn about the scientific basis for the dietary advice “Eat more fruits and vegetables?”
Flavors and Phytochemicals

DEVELOPED BY: Debra Zinicola, Ed.D., Seton Hall University, Chair, Department of Educational Studies, and Marian Glenn, Ph.D., Seton Hall University, Professor, Department of Biological Sciences
Some terms and definitions:

- **Herbs** – the leafy parts of a plant
- **Spice** – pungent or aromatic part of a plant made by drying the bark, seed, fruit or root
- **Antioxidant** – a chemical that protects against harmful oxidation reactions, often more potent when plant is cooked
- **Phytochemical and secondary metabolite** – both terms refer to an unusual chemical made by a plant, that is not involved in making food, or reproduction, or other primary processes.
- **Phytochemical** – a term used primarily for chemicals deemed to have a beneficial effect on human health.
- **Secondary metabolite** – expresses the plant’s point of view. Chemicals that are beneficial to the plant may be harmful to those eating the plant, including chemicals that interfere with the nervous system, such as caffeine, opium, pyrethrum, for example.
Thinking about plants as food:

Now that we have tasted and rated some of our Tower Garden plants, let’s learn about why they may taste different, some more appealing than others.

Why do you think plants make all these interesting flavors?

Come up with as many ideas and rationales as possible.

1. ____________________________________________
2. ____________________________________________
3. ____________________________________________
4. ____________________________________________
5. ____________________________________________
6. ____________________________________________
Thinking about plants as food:

What are some examples of plants you know (or secondary metabolites) that have physiological effects in humans, especially effects on the nervous system?

Two examples are stimulants and tobacco.

1. _________________________________
2. _________________________________
3. _________________________________
4. _________________________________
5. _________________________________
6. _________________________________
Fruit and vegetables are good for you but why?

A diet rich in fruit and vegetables offers health benefits:
- reduced risk of cancer (lung, prostate, pancreas, bladder and breast)
- reduced risk of cardiovascular disease

Plants produce phytochemicals, also called secondary metabolites.
- These chemicals can protect the plant against bacteria, fungi, viruses, UV light, and deter herbivores.
- When we eat the plants, these chemicals may have health-benefits.

Much research is needed to demonstrate the specific physiological effects of phytochemicals in humans.
Particular families of plants make particular kinds of chemicals.

- Mustard family, including cabbage and radishes, makes a chemical that irritates the tongue and sinuses.
- Chili peppers sting.
- Onion family makes eyes tear.
- Citrus family and the mint family are refreshing

How might these secondary metabolites be useful to the plant that makes them?
Bitter tasting plants:

Secondary metabolites that taste bitter are found in:
- coffee
- marijuana
- poppy
- tobacco
- cacao

Of what benefit does having a bitter taste help the plant?
How is your answer consistent with their effects on humans?
Antioxidants are phytochemicals.

Antioxidants:
- are often red or yellow.
- scavenge highly reactive oxygen produced by photosynthesis.
- are believed to protect people against cancer.
- have a presence in food that is often increased by cooking.

What do you think might be the benefit of antioxidants to the plants?
Learn more about plants:

Fruits and vegetables, especially leafy greens are considered health-promoting.

Choose four such plants that appeal to you and research their medicinal or health-promoting characteristic for display in a chart. (next slide)

WebMD
Leafy greens
WebMD eat more veggies
Phytochemicals
Flavors and Phytochemicals

Plant chart:

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Additional research questions:

Compare the flavor and nutritional value of a particular vegetable that is raw vs. cooked. Find out how heating (cooking) affects the nutritional value of this food.

Phytochemicals and phytonutrients are marketed as health-promoting supplements, such as beta carotene, and phytoestrogens, especially as a substitute for eating vegetables.

Use this website or other sources to find information about one of the phytochemicals identified in your chart.

WebMD phytonutrients
Additional questions:

Explain the pros and cons of taking a supplement vs. eating the food itself.

What did you learn about the scientific basis for the dietary advice, “Eat more fruits and veggies?”
Food fair:

In your groups, prepare a list of some of the edible plants you researched (the legal ones) to bring in for a healthy food tasting fair.

• Consider how the nutritional value of these foods is optimized and wash, cut, cook (if needed) and prepare your selected foods in an appetizing and attractive manner for others to eat.

• Each group must present four foods in quantities large enough for everyone to have a small serving. Each dish will be accompanied by a one page sheet, typed, sources cited, that relates the following information: (next slide)
Flavors and Phytochemicals

Food fair research:

• Name of plant;
• Where it was grown and where it was obtained (if bought);
• Health benefits and nutritional value;
• How it is best or typically served;
• Phytochemicals and antioxidants in this food and what you learned about them;
• Supplements sold to substitute for eating this food;
• Historical and cultural uses as food and/or medicine;
• How varieties of the plant has been developed and modified.

Food Fair Presentation:

You will talk about your plant and encourage others to try it. Be sure to tell them about the highlights of your research findings.