Sustainable Agriculture Garden Module

Materials Needed:

- Sustainable Agriculture Garden at San José State University
- “Sustainable” food item (supplied by student)
- White board, white board pens, & eraser (provided)
- Paper & writing implement (supplied by student)
- Handouts (pdfs, websites, & Word documents posted on CLL website)
  - Examples of Organic Certifiers – Labels (Word document)
  - Santa Clara County Master Gardener planting chart ([http://mastergardeners.org/pdf/warm_cool_veg_planting_charts.pdf](http://mastergardeners.org/pdf/warm_cool_veg_planting_charts.pdf))
- Resealable plastic bags containing seed packets & seeds
- Articles on GMOs from the scientific literature (links found within lesson content)

Student Learning Objectives:

- **All Campuses: GE Area B2, Student Learning Objective 1:** Students should be able to use the methods of science and knowledge derived from current scientific inquiry in life or physical science to question existing explanations
- **SJSU Only: SJSU Studies Area R, Student Learning Objective 2:** Within the particular scientific content of the course, a student should be able to distinguish science from pseudo-science

Key Concepts:

- Students will learn about closed-loop materials cycles in nature and how these apply to the human food system.
- Students will learn how biodiversity and species interactions apply to human food systems.
- Students will learn definitions of sustainability.
• Students will learn basic principles of sustainable agriculture, with focus on it being a closed-loop system.
• Students will learn the definitions of conventional, organic, and genetically modified food in context that highlights their differences and varying environmental impacts.
• Students will learn how to decode food labels and ingredient lists and determine which may be genetically modified.
• Students will learn how to gauge sustainability of a food item, with emphasis on where and how it was grown.
• Students will learn what types of food can be grown in Santa Clara County and how to read seed packets to determine this information.
• Students will learn how to distinguish between unbiased, objective articles and clearly biased ones in the academic, scientific literature.

Lesson Location:
• Brief introduction in classroom week prior to field trip
• Main content and activity presented in the Sustainable Agriculture Garden at San José State University

Lesson Duration:
• Approx. 1 hour 15 minutes, with options to increase.

Lesson:

Lesson Introduction (to be done during class meeting prior to field trip)
1. Next class meeting, we’re going to visit San José State University’s Sustainable Agriculture Garden to not only learn about the garden itself but also about what makes food sustainable.

2. We will learn how to evaluate and analyze sources of information regarding the sustainability of food, finding out how it shapes our opinions of healthiness and sustainability.

3. We will learn how to determine a food item’s sustainability based upon its packaging, label, and ingredient list.

4. We will find out what types of food can grow in our area and how to glean information from a packet of seeds.

5. **In preparation for our next class, please bring with you to class a relatively small, fruit-, vegetable-, or grain-based food item that you feel is healthy and/or sustainable.**
   a. Please no large or perishable items (i.e. jumbo bag of Kettle Chips or cup of blueberry-flavored Greek yogurt), as you will have to carry this item to and from the field trip.
6. Instruct students to sit down at the tables & benches and to get out their note-taking materials.
   a. They don’t need to take out their food item yet.

7. Position white board so all students can see it.

8. Before we talk about sustainable agriculture, let’s start at the beginning:
   a. **What is sustainability?**
      i. Ask for volunteers to define what it means for something to be sustainable.
      ii. Write responses on board.
   b. **Often hard to define.**
      i. Different fields use the term differently.
      ii. Sometimes it’s often hard to define within the same field.
      iii. The definition in terms of **economics/business** usually pertains to whether a venture is viable or if a person can support his/her family.
      iv. In terms of the **environment**, it can be defined as resources that are used and managed in ways in which they are preserved/available for future generations.
      v. At the **local, national, and global scale**, sustainability can incorporate or be defined in terms of the 3 E’s: environment, economy, and (social) equity.
      vi. Using nature as a model, sustainability means that no materials ever go to waste and that natural processes such as species interactions sustain the system.

9. So what do we mean by “**no materials ever go to waste**”?
   a. **All natural products are recycled**, meaning there is no “waste” in nature, but how is this possible?
   b. **Properly functioning ecosystems are closed-loop systems.**
      i. Has anyone ever heard this term before? In what context?
      ii. Example: (Draw on board, with arrows linking steps; see image below for inspiration)
         • Think of a forest. What components do we have? Trees, bushes, animals (prey & predator examples), soil, stream, etc.
         • Leaves fall from branches, fruit is partially eaten by a squirrel and discarded, a carcass from a small mammal is left by its predator, etc. **What happens to these plant and animal remains?**
         • This “waste” is **not waste** at all. It is broken down by insects, fungi, microbes, and other detritivores (decomposers).
         • Nutrients from this process are put back into the soil where they can be taken up by other organisms that will grow, reproduce, and die (or get eaten), and thus repeating the process/cycle again.
         • There are no “outside” inputs that need to be added in order for the process to work in a fully functioning ecosystem.
a. The environment does not naturally receive new inputs of nutrients.


10. For this closed-loop system to work, it **needs to be supported by a variety of species interactions**. In a functioning ecosystem, each species (from microbe to mammal) **plays a role in that system** (from decomposer to top predator). The **more species in a system**, the **higher the biodiversity** is of that system.
   a. **Biodiversity** generally refers to both species and genetic diversity.
      i. There needs to be a good **flow of genes** within a species.
      ii. Why? **So the population of a species** in a system does not become inbred, which could make them more susceptible to disease or more likely to have mutations.
   b. An ecosystem will generally support as much biodiversity as the system can **physically allow** – in terms of food, water, shelter, and other resources.
   c. The **interactions between different species/the roles of those species** are what support all natural systems (i.e. our forest example) and **all plants**, including human food plants.

11. Keeping all of this in mind, now let’s talk about **sustainability** in terms of **food**.

Lesson
12. Let’s first talk about **unsustainable food growing practices**. These fall under **“conventional agriculture.”** What is **conventional agriculture**?
   a. Erase board/make room for new topic. Ask for suggestions and write answers on board in bullet form.
      i. **Alternative**: Venn diagram can be used to contrast organic or sustainable agriculture vs. conventional agriculture.
   b. Basically, **conventional agriculture is not sustainable and is not a closed-loop system**.
c. Crops are often grown in **monocultures** (1 crop), which reduces genetic diversity and biodiversity, making for a **less-healthy ecosystem**.
   i. Where have you seen fields with just 1 crop? What was the crop?

d. Generally **relies heavily on off-farm inputs**, such as (synthetic) fertilizers.

e. Often uses powerful pesticides, herbicides, and fungicides that are also toxic to non-target species as well as the people that apply them.

f. Continually using synthetic fertilizers, pesticides, herbicides, and fungicides actually ends up creating (super) pest organisms (i.e. insects and weeds) that are **immune to the toxins**, thus creating the need for even more applications of more toxic chemicals.

g. May **not use most efficient irrigation strategies**, increasing amount of run-off (which can carry away soil as well as applied chemicals into waterways).

h. **Key crops** (i.e. corn, soy, rice, cotton, and wheat) are **subsidized by the US government**, as a sort of safety net in case of crop failure.
   i. Can be genetically modified.

13. **What is a genetically modified organism** (GMO)?
   a. Ask for definitions first.
   b. **A plant or animal that is created through the splicing and transfer of genes from one organism to another.**
      i. Also called GM (genetically modified), GE (genetically engineered), and transgenic, among others.
      ii. Made-up, very simplified example: You want to make a new variety of apple that is really round. You’ve found a variety of tomato that is absolutely spherical. You find the gene that makes the tomato round, cut it out of the tomato’s genetic material and insert it (ideally) into the genetic material of the apple. If all goes well, round apples will be produced.

   c. **What are some common facts you hear about GMOs?**
      i. Ask students to work in their groups for approximately 5 minutes to come up with a list.
      ii. Compile facts on board.

   d. **Ask students from what source they heard their information.**
      i. It’s important to **consider where you get your “scientific” information from**. Some sources are more credible than others. Some sources may claim to be or appear to be scientific but are actually not. Later on, as part of our assignment, we’ll use a rubric to help us determine whether “scientific” articles are in fact sound science or if they are pseudoscience.
      ii. In terms of GMOs, we need to acknowledge that there is pseudoscience mixed in with actual scientific fact. Let’s discuss some of those common facts you hear about GMOs and see if we support or dispel them. (See Appendix for extra GMO common “facts”)

   e. First of all, **why should we be concerned about GMOs?** What’s the big deal about them? Why are they so controversial, especially from an environmental/biodiversity standpoint? What are the environmental risks of GMOs?
      i. Ask for ideas.
ii. **Pollen from GM crops can spread** into fields with non-GM crops.
   - These non-GM crops are now contaminated and can no longer be considered non-GM or organic.

iii. Can **reduce biodiversity**.
   - GM crops are often grown in monocultures, which in turn lessens species diversity of plants, insects, and other organisms that, under diverse conditions, would interact and contribute to a fully functioning (agro)ecosystem. Genetic diversity is also lessened, which can lead to increased susceptibility to pests and diseases.
     a. Remember these pitfalls from earlier when we discussed conventional farming?

iv. GM-seeds are often **1-time-use only** and cannot be saved, thus causing farmers to rely on GM seed companies.

v. **Unknown health effects**.
   - Just not enough long-term evidence to make sound conclusions.

vi. **NOT required to be labeled!**
   - People are not allowed to make educated choices.
   - Any other problems associated with no labeling?

vii. **Genetic engineering increases yield**.
   - Not really. There is little data to support this claim. Oftentimes the GM crop falls prey to insect infestation or disease, despite the efforts of Round-Up Ready or Bt seed.
     a. Round-Up Ready seed has been programmed to withstand the application of the herbicide Round-Up.
     b. Bt seed has had the insect-resistant bacteria *Bacillus thuringiensis* incorporated into its genetic material.
     c. Result: Super weeds and pests that are immune to pesticides and herbicides are created, thus actually reducing yield.

viii. **Genetic engineering reduces the amount of pesticides/herbicides applied.**
    - Not necessarily, especially if pests/weeds become immune to the pesticides/herbicides in the seed. More toxic chemicals have to be applied topically, oftentimes more frequently.

ix. **Genetic engineering can increase the nutrition of the food item.**
    - No nutritionally enhanced GM foods are commercially available.
    - Most famous example: “Golden Rice”
      a. Enriched with beta-carotene and intended for use in countries where vitamin A deficiencies are prevalent, generally caused by a lack of variety in the diet.
      b. Instead of helping these countries plant foods that would give them beta-carotene (often not possible because viable farming land has been taken over by big corporations), efforts are still being put into a crop that after more than 10 years, the rice is still not available.

x. **Genetic engineering can help cure world hunger.**
    - World hunger is largely a distribution problem.
a. Food waste = approximately 30-40% of the world’s calories
b. Between now and 2050, 1/3 of future food demand will come from population growth while the other 2/3 will be due to a richer population that desires diets laden with more animal products.

- Currently no GM crops available that actually increase yield or are better than non-GM crops at tolerating challenging conditions.
- Cropland is being used to grow biofuels, instead of food.
  a. Most GM crops have nothing to do with meeting basic hunger/nutrition needs.
  b. Most GM crops are grown for biofuel, animal feed, and are ingredients in processed foods.

A great, general, peer-reviewed review article of pros/cons and relation to agrobiodiversity. Can mine it for other sources, more research, etc. (good technique for students to learn).]

Not peer-reviewed but contains peer-reviewed sources. Boils information down very well.


f. Top GM crops in the US:
  i. Ask for any guesses, then pass out “Adoption of Genetically Engineered Crops in the United States, 1996-2013” chart.
  • Takeaway points: 93% of soybeans, 85% of corn, and 82% of cotton grown in the US are GM.
• HT = herbicide-tolerant, Bt = insect-resistant because of *Bacillus thuringiensis*

ii. Pass out “GMO FAQs” and draw their attention to the section titled “Which foods might be GMO?” Ask if any of the items on the list are surprising to the students.

• This brochure is from the Non-GMO Project. While the information in the brochure is indeed true, it is important to recognize that the organization definitely and clearly favors one side of the GMO debate.

• Some basic info about the Non-GMO Project from: [http://www.nongmoproject.org/about/who-we-are/](http://www.nongmoproject.org/about/who-we-are/)
  a. “The Non-GMO Project is a non-profit organization committed to preserving and building the non-GMO food supply, educating consumers, and providing verified non-GMO choices. We believe that everyone deserves an informed choice about whether or not to consume genetically modified organisms.”
  b. “The Non-GMO Project is governed by a Board of Directors. We also work with a collaborative network of technical and communications advisers from all backgrounds and sectors.”

• Now focus on the ingredient lists under the boxes. These are ingredients that can often contain GMOs or be genetically modified themselves.

14. Now let’s get out the food we brought and check out their ingredient lists for any of these potentially genetically modified items.
   a. Give students a few minutes, then bring the class back together, and go around the class asking what they found out.

15. Other information to consider:
   a. GM crops in the works:
      • Apples, barley, bell peppers, cabbage, carrots, cauliflower, cherries, chili peppers, coffee, cranberries, cucumber, flax, grapefruit, kiwi, lentils, lettuce, melons, mustard, oats, olives, onions, peanuts, pears, peas, persimmons, pineapple, popcorn, radishes, strawberries, sugar cane, sunflower, sweet potatoes, tomatoes, walnuts, and watercress
   ii. See Appendix for information on GM animals in the works.

16. So then, how does sustainable agriculture differ from conventional agriculture? From existing knowledge you have, what is sustainable agriculture? What are its components?
   a. Ask for examples. Either make another bulleted list or use Venn diagram alternative.
b. Words often associated with sustainable agriculture include “agroecology” and “agroecosystem.”
   i. Both of these highlight the essence of sustainable agriculture – that the agricultural system is treated like a functioning ecosystem.
   ii. This system should be a closed-loop system (remember from earlier?), like what is found in nature.
      • Nothing is lost or wasted; everything is reused and recycled.
      • Properly functioning nutrient cycles (carbon, phosphorus, & nitrogen) are vital for ecosystems.
      • A closed-loop agroecosystem functions essentially the same way.

c. Elements of sustainable agriculture/an agroecosystem:
      • Does not depend on external purchased inputs
      • Makes extensive use of locally available, renewable resources
      • Emphasizes recycling of nutrients
      • Has beneficial or minimal negative impacts on both the on- and off-farm environment
      • Is adapted to or tolerant of local conditions, rather than dependent on massive alteration or control of the environment
      • Is able to take advantage of the full range of microenvironmental variation within cropping system, farm, and region
      • Maximizes yield without sacrificing the long-term productive capacity of the entire system and the ability of humans to use its resources optimally
      • Maintains spatial and temporal diversity and continuity
      • Conserves biological and cultural diversity
      • Relies on local crop varieties and often incorporates wild plants and animals
      • Uses production to meet local needs first
      • Is relatively independent of external economic factors
      • Is built on the knowledge and culture of local inhabitants

   ii. Evident how 3 E’s of sustainability are linked here.
   iii. Some common practices:
      • Genetically modified seed is not allowed
      • Efficient irrigation methods that reduce run-off (i.e. drip irrigation instead of rain birds)
      • Crop rotation and use of cover crops, compost, and green manures (spent crop material) to help return nutrients to the soil
      • Use of trap crops to draw pests away from desired crop and also to attract pest predators
      • Use of hedgerows to reduce effects of wind and also to bring in more pollinators
      • Use of mulches to prevent soil erosion, keep down weeds, and keep in moisture
• Use of intercropping: planting a variety of crops that have different height, sun, and moisture requirements yet complement each other
  a. i.e. 3 sisters: corn, beans, and squash
  b. Also increases biodiversity and genetic diversity

d. Has anyone seen a large-scale example of sustainable agriculture? Where and what crops were being grown?

17. What elements of sustainability can you spot in this garden? Take a few moments to explore. As students point out different features, draw the class’ attention to it or ask for volunteers to share what they saw once students are back seated at the tables.
   a. Drip irrigation
   b. Rainbarrels
   c. Intercropping
   d. Mulching
   e. ...

18. Now, we’ve all likely heard of the term “organic,” but what does it mean and how is it different from conventional agriculture?
   a. Ask for initial comments, then pass out “USDA Labeling Organic Products” and “CCOF Understanding Organic Labels: What Does Organic Mean?” (only the 1st page).
   b. Give students a few moments to read over the two handouts.
   c. Both the USDA and CCOF (California Certified Organic Farmers) are certifiers of organic foods. There are other certifiers such as Oregon Tilth and Quality Assurance International. Farms/crops have to be certified in order to be labeled organic at grocery stores and farmer’s markets.
      i. Show label examples (see document: Examples of Organic Certifiers – Labels on website).
         • Websites are provided for more information about each of the 4 certifier examples.
   d. So what is organic?
      i. Using handouts, students should provide examples that are written on the board.
      ii. It’s different from conventional agriculture because toxic pesticides/herbicides/fungicides, synthetic fertilizers, and GMOs are not used or allowed.
   e. Is food grown organically also sustainable?
      i. Ideally, yes. Organic should be incorporated along with the elements we already discussed. However, organic farms are not always entirely sustainable. For example, farmers may grow crops as monocultures or may use irrigation methods that are not as efficient as they could be.
   f. Price differences are often cited as a main reason why people claim they cannot buy organic food.
      i. The Food and Agricultural Organization of the United Nations (FAO) provides the basics of why organics tend to cost more on the shelf than conventional foods
19. When considering the sustainability of a food item, it is vital to know where it was grown, in addition to knowing how it was grown. The more locally grown an item is, the better. The fewer the number of inputs (i.e. processing, travel, distribution) were needed in getting it from the field to your table, the better.
   a. How would you define local?
   b. Tough to define local. Some say local can mean < 500, or < 300, or < 100 miles away. Some farmer’s markets and grocery stores put a mileage limit on what can be considered local.

20. Let’s look at our food items again.
   a. Who can tell me where their food was grown? How many of you cannot determine this? As consumers, shouldn’t we have the right to know?
   b. How many of you have an organic item or one that contains organic ingredients?

21. Time to get up and explore the garden some more.
   a. Walk students over to the garden beds. What is growing in the beds?
      i. Can contact the Department of Environmental Studies prior to fieldtrip to find out.
      ii. How many of you have ingredients in your food item that is currently growing in these beds?
   b. Of your ingredients, what ingredients could be grown here?
      i. Don’t know? That’s ok!
      • What factors do we need to consider if we want to grow food?
         a. Amount of space, water, light, length of time to germinate, and days to harvest
      • How can we find out the specifics for what we want to grow?
         a. Pass out Santa Clara County Master Gardener planting chart.
            i. What could we start now? What wouldn’t work?
         b. Seed packets can also tell us a ton of information. Pass around bags containing seed packets and seeds.
            i. What information can we glean just from looking at the seed packets?
         c. Based upon the conditions around you (think mainly light, space, weather, and time of year) and the information on the packets, what crops could we start right now?
      • Collect planting charts and bags.

Wrap-Up & Evaluation (Assignment)

22. Sustainability, especially the sustainability of food encompasses many different components but essentially boils down to how and where the item was grown or produced – What are the ingredients? Where was it grown? How many steps did it take for the item to reach your table? Where did you buy the item- farmer’s market or grocery store? Was the item grown by a small family farm or giant corporation? What were the labor conditions like for the people who grew, picked, and processed the item?
23. If you want to support local, organic, and sustainable agriculture - what do you do? Where do you go?
   a. Grow your own food
   b. Help close the loop (i.e. by composting)
   c. Participate or volunteer at community gardens or with urban agriculture projects
   d. Shop at farmer’s markets
   e. Read labels and signage at the grocery store
   f. Research local farms, labor conditions, sustainable brands

24. As a wrap-up to today’s lesson, please take out a piece of paper and answer this free-write prompt:
   a. You brought your food item thinking it was sustainable. Based on what you have learned and what you can determine from the labeling/packaging, how sustainable is your food item actually and how do you come to that conclusion? What information do you not have?
      i. Give students time to answer these questions or have them answer it as a homework assignment. If time, share aloud, otherwise just turn in.
   b. Alternative: Can give as homework assignment
      i. Potential additional questions:
         • How can you (specifically) eat more sustainably? It can be a big change, so what steps can help you get there?
         • What effect has today’s lesson had on you? Will you make any changes to your food purchases?
         • What side of the fence are you on regarding GMOs? Have your opinions changed at all after today’s discussion? Why or why not?
         • What part(s)/element(s) of the sustainability of food is the most important to you and why?

25. Evaluation assignment:
   a. It is important to recognize the differences between what is good, objective science and what is pseudoscience, as we mentioned earlier. Using the rubric, read ______ (number of) articles and determine whether the content is unbiased, sound science or whether it is pseudoscience and explain why. Also include if or how the content influenced/changed your views on the potentially good or bad environmental impacts of GMOs.
      i. Go over rubric.
      ii. Articles to consider:
            a. Can inspire discussion about review articles and how to use them properly.
• Other articles:

iii. (Idea: Can have students pick one other article in addition to Jacobsen et al. (2013) and write it up. Then during the following class, students can get into groups based upon the article they chose and can walk through the assignment, assessing the quality of the science and information in the article.)

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For scheduling time in the garden or to find out what’s growing in the garden ahead of your field trip, please contact the Department of Environmental Studies: (408) 924-5450
Appendix

Additional common facts about GMOs/reasons to be concerned:

Genetic engineering is a precise process.
- It is not. Current technology is still quite imprecise. It takes a while to isolate the gene and is difficult to insert the gene (2 common methods: with the help of a manufactured virus or gene gun) into the nucleus of the cell. There also might be unforeseen/unintended consequences of the insertion, making the development process a long one.

Genetic engineering is the same as natural breeding.
- Scientists and farmers have worked to create better varieties of crops for centuries but they did so by breeding the plants, not by slicing up the genetic material and inserting the desired genes into another specimen.

GM animals in the works:

**AquAdvantage Salmon:** growth hormone genes from Chinook salmon so it will grow at twice the rate of natural salmon & antifreeze genes from an eelpout
- Handout “Food safety fact sheet: Genetically engineered fish”
- FDA in process of approving, though has not yet.
- Environment Canada (similar to US’s EPA) recently came to the conclusion that it is not harmful to human or environmental health (when produced in contained facilities).
- What are some problems you can foresee with this?
  - Main one: infiltration/escape into wild population

**Male olive flies with “female-killing gene” in Spain**
- Reason: olive flies devastate olive crops
- Genetically modify male flies, then release them into the wild to mate with wild females.
- Female offspring will die as a result, thus reducing the olive fly population.
- Potential problems?
  - i.e. Environmental ramifications of reducing the olive fly population: what ecological role does the olive fly play?

Thoughts about genetically modifying animals? Any different from your opinion regarding the genetic modification of plants?