



# **Soilless Growing Systems**

*A Hydroponics Curriculum for  
High School 4-H Clubs*

**Leader Guide**

# Soilless Growing Systems

## A Hydroponics Curriculum for High School 4-H Clubs

### **Authors**

Natalie Bumgarner, Ph.D.

Catherine Virden, Student Assistant

James Swart, Graduate Assistant

Daniel Sarver, Extension Specialist

Carrie Stephens, Ph.D.

Jennifer Richards, Ph.D.

Alexis Hall, Student Assistant

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# Life Skills

Code	Grade	Life Skill	Outcome	Indicator	Activity
9.HT.1	9th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Judge the value of information for a given purpose.	1, 2, 3, 4, 5, 6, 7, & 8
9.HT.2	9th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Be able to break down information about a given problem into parts.	1, 2, 3, 4, 5, 6, 7, & 8
9.HT.3	9th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Apply information to problem solving and to helping others.	1, 2, 3, 4, 5, 6, 7, & 8
9.HM.1	9th	Head Managing	Wisely use resources to achieve a purpose.	Budget income; engage in comparison shopping.	1 & 3
9.HM.2	9th	Head Managing	Wisely use resources to achieve a purpose.	Enter the information for accounting on a specific project and any explanation.	1 & 3
9.HM.3	9th	Head Managing	Wisely use resources to achieve a purpose.	Practice good interpersonal relationships by actively participating as a group or team member.	1, 2, 3, 4, 5, 6, 7, & 8
9.HR.1	9th	Heart Relating	Establish connections with others that are wholesome and meaningful.	Interact with others and behave in the accepted manner or customs of the society in which they live.	1, 2, 3, 4, 5, 6, 7, & 8
9.HR.3	9th	Heart Relating	Establish connections with others that are wholesome and meaningful.	Interact effectively with others.	1, 2, 3, 4, 5, 6, 7, & 8
9.HW.1	9th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Demonstrate the ability to learn, reason, think creatively, make decisions, and problem solve.	1, 2, 3, 4, 5, 6, 7, & 8

9.HW.3	9th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Acquire, communicate, organize, use and evaluate information.	1, 2, 3, 4, 5, 6, 7, & 8
9.HW.4	9th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Share accomplishments related to group efforts.	1, 2, 3, 4, 5, 6, 7, & 8
9.HB.1	9th	Health Being	Consistently demonstrate characteristics of healthy well-being.	Build interpersonal skills for emotional health.	1, 2, 3, 4, 5, 6, 7, & 8
10.HT.1	10th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Consider risks and appraise alternatives to a given problem.	1, 2, 3, 4, 5, 6, 7, & 8
10.HT.2	10th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Compare and select the best alternative for a given problem.	1, 2, 3, 4, 5, 6, 7, & 8
10.HM.2	10th	Head Managing	Wisely use resources to achieve a purpose.	Use information to make a determination, decision, or judgment.	1, 2, 3, 4, 5, 6, 7, & 8
10.HR.3	10th	Heart Relating	Establish connections with others that are wholesome and meaningful.	Act together for a common purpose of mutual benefit.	1, 2, 3, 4, 5, 6, 7, & 8
10.HW.1	10th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Demonstrate the ability to learn, reason, think creatively, make decisions, and problem solve.	1, 2, 3, 4, 5, 6, 7, & 8
10.HW.3	10th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Acquire, communicate, organize, use and evaluate information.	1, 2, 3, 4, 5, 6, 7, & 8
10.HW.4	10th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Design or improve systems related to a given problem.	3 & 8
10.HB.1	10th	Health Being	Consistently demonstrate	Gain acceptance among peers by actively engaging in	1, 2, 3, 4, 5, 6, 7, & 8

			characteristics of healthy well-being.	teams and group activities.	
11.HT.1	11th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Given a specific problem and set of solutions, choose an alternative to implement.	3, 5, 6, & 8
11.HT.2	11th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Generate alternatives for a given problem.	3, 5, 6, & 8
11.HT.3	11th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Consider alternative responses and opposing viewpoints: Based on what I know, is the statement true?	1, 2, 3, 5, 6, & 8
11.HM.2	11th	Head Managing	Wisely use resources to achieve a purpose.	Use information to make a determination, decision, or judgment.	1, 2, 3, 4, 5, 6, 7, & 8
11.HG.1	11th	Hands Giving	Demonstrate social responsibility and citizenship through organizing, giving, and action.	Assist the group in meeting its goals by showing or directing along the way.	1, 2, 3, 4, 5, 6, 7, & 8
11.HG.2	11th	Hands Giving	Demonstrate social responsibility and citizenship through organizing, giving, and action.	Work well with people and groups; understand group processes/functioning.	1, 2, 3, 4, 5, 6, 7, & 8
11.HW.1	11th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Demonstrate the ability to learn, reason, think creatively, make decisions, and problem solve.	1, 2, 3, 4, 5, 6, 7, & 8
11.HW.3	11th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Acquire, communicate, organize, use and evaluate information.	1, 2, 3, 4, 5, 6, 7, & 8
12.HT.1	12th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Evaluate the results of the implementation of a solution to a given	3

				problem: Is the problem solved?	
12.HT.2	12th	Head Thinking	Learn to form ideas, make decisions, and think critically.	Integrate parts of information from different sources to form a whole.	1, 2, 3, 4, 5, 6, 7, & 8
12.HM.2	12th	Head Managing	Wisely use resources to achieve a purpose.	Use information to make a determination, decision, or judgment.	1, 2, 3, 4, 5, 6, 7, & 8
12.HR.2	12th	Heart Relating	Establish connections with others that are wholesome and meaningful.	Build and maintain trust with others.	1, 2, 3, 4, 5, 6, 7, & 8
12.HW.1	12th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Demonstrate the ability to learn, reason, think creatively, make decisions, and problem solve.	1, 2, 3, 4, 5, 6, 7, & 8
12.HW.3	12th	Hands Working	Use skill, effort, or ability to accomplish a goal.	Acquire, communicate, organize, use and evaluate information.	1, 2, 3, 4, 5, 6, 7, & 8

**Source:** Richards, J. (2017) TIPPs for 4-H: Tennessee's Innovative Programming Priorities. *University of Tennessee Extension*. Retrieved from [tiny.utk.edu/TIPPS](http://tiny.utk.edu/TIPPS).

# Science Standards

Code	Standard	Activity
HS-LS1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	1
HS-LS2-5	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	1
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	2
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.	2
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	2
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	3
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	3
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	3
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	3
HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.	4
HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.	5
HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	6
HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	7
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	8

**Source:** Next Generation Science Standards. (2018). Retrieved from [nextgenscience.org](http://nextgenscience.org)



# Plant System Standards

Code	Standard	Activity
AG-PL-1	Develop and implement a crop management plan for a given production goal that accounts for environmental factors.	1-8
AG-PL-2	Apply the principles of classification, plant anatomy and plant physiology to plant production and management.	2-8
AG-PL-3	Propagate, culture and harvest plants and plant products based on current industry standards.	2-8

**Source:** Common Career Technical Core. (2014). Retrieved from [https://cte.careertech.org/sites/default/files/CCTC\\_Standards\\_Formatted\\_2014.pdf](https://cte.careertech.org/sites/default/files/CCTC_Standards_Formatted_2014.pdf)

# Chapter 1

## Introduction to Soilless Growing Systems

### Activity 1

This initial lesson introduces the idea of growing plants without using soil and shows students what soilless production looks like and an overview of how the industry has developed.

- Define hydroponics and soilless production
- Outline the history of growing vegetables using hydroponics
- Research common plants grown in hydroponic growing systems
- Understand the need for evolution in growing practices related to hydroponics

### Activity 2

The second lesson in this module covers climate and the environmental conditions that are needed to produce vegetable crops. Contrasts are made between CEA and outdoor growing environments.

- List the major fruiting crops grown in soilless growing systems
- List the major leafy crops grown in soilless growing systems
- Draw conclusions based on the influence of climate and population on the location of CEA operations
- Analyze the growing conditions needed for the major fruiting crops grown in soilless growing systems
- Group vegetable crops based on general temperature preferences and their production region in the United States- compare outdoor and CEA production locations
- Understand how soilless growing systems in controlled environments can alter the growing location for many vegetable crops

### Activity 3

The final lesson in the module becomes provides a practical introduction to the most common types of soilless growing systems and provides context on why different systems are used for specific crops and situations.

- Define soilless growing systems
- Compare and contrast the advantages of each of the common growing systems
- Identify the crucial components needed for a successful hydroponic growing system
- Develop a basic layout for a hydroponic system

# Plants Can Grow Without Soil?



## An Introduction to Soilless Growing Systems Chapter 1, Activity 1

### Learner Outcomes

- Define hydroponics and soilless production
- Outline the history of growing vegetables using hydroponics
- Research common plants grown in hydroponic growing systems
- Understand the need for evolution in growing practices related to hydroponics

### Standards Supported

NGSS: HS-LS1-5, HS-LS2-5  
CCTC: AG-PL-1

### Concepts/Terms

Hydroponic, Hydroculture, Soilless, Aquaponic, Aeroponic, Controlled Environment Agriculture, Greenhouse Production

### Life Skills

9.HT.1, 9.HT.2, 9.HT.3, 9.HM.1, 9.HM.2, 9.HM.3,  
9.HR.1, 9.HR.3, 9.HW.1, 9.HW.3, 9.HW.4  
9.HB.1, 10.HT.1, 10.HT.2, 10.HM.2, 10.HR.3, 10.HW.1,  
10.HW.3, 10.HB.1, 11.HT.2, 11.HT.3, 11.HM.2,  
11.HG.1, 11.HG.2, 11.HW.1, 11.HW.3, 12.HT.2,  
12.HM.2, 12.HR.2, 12.HW.1, 12.HW.3

### Time

90 Minutes

### Materials

Before the lesson, the leader will purchase a selection of vegetables from the grocery store.

Suggestions include:

- Loose Slicing Tomatoes (2)
- Slicing Tomatoes Labeled as "Greenhouse" (2)
- Tomatoes on Vine (2 clusters)
- Cucumbers (2)
- Long English Cucumbers (Plastic Wrapped) (2)
- Head of Iceberg Lettuce (2)
- Head of Bibb Lettuce (Purchased in Crisper) (2)

*Did you know that plants can grow without soil? In this lesson, students will learn about the basics of the soilless production industry.*

### Overview

This lesson introduces students to soilless vegetable production. Learners view and taste vegetables to identify similarities and differences between crops grown in soil and crops grown without soil. The leader introduces students to soilless growing systems and the crops they produce for grocery stores. Students will learn key terms and history to explain how much these systems have improved over time, and they will identify advantages and disadvantages of the systems. Learners will understand that food production efficiency will continue to improve, but that agriculture will most likely need a mix of production systems to feed the world in the future.

### Intro

In the classroom, unwrap the produce and ask students to guess where the crops were grown. They might guess particular states or countries, but then ask if they think the vegetables were grown outdoors, in a greenhouse, or some other structure.

Say, **"We cannot tell where a crop was grown just by looking at it, but once you understand the systems of production, you can see some clues that provide insight. Let's talk about some of the information we can gain from the crops themselves and the packaging."**

# An Introduction to Soilless Growing Systems

## Chapter 1, Activity 1

### Experience

Guide students through the process of cutting the vegetables, or give them samples that you cut before the lesson. Instruct them to observe the samples before trying all the samples. After eating, ask students if they can tell any differences between the types of vegetables. After they respond, explain each product's origin:

- Loose tomatoes are generally grown in a field. They may not be visually different from greenhouse grown, but they probably have the calyx (stem) removed to prevent puncture as they are handled. They were probably picked, packed, and transported multiple layers deep. If it is a plum tomato (roma type), it was likely field grown and picked mechanically. Field tomatoes might be green when they are picked. Ask students, **"What characteristics might a fruit need to be shipped like this?"** *They need a firm texture and a slow ripening process.*
- The loose slicing tomatoes labeled as greenhouse grown may not be visually different, but they probably have the calyx intact. This is an industry indicator that they were picked, packed and transported in a box that was probably only one layer deep. Greenhouse tomatoes were picked by hand rather than mechanically. While they may have been shipped, ripening was almost complete when they were picked. Ask, **"Which type of tomatoes have the shortest storage time?"** *Greenhouse grown slicing tomatoes.*
- Iceberg lettuce is field grown. The outer leaves are removed, and it is packed tightly in a box. Ask students, **"Why can we pack and ship the iceberg lettuce in a simple way without much damage?"** *The head of lettuce is dense.*
- Bibb lettuce often has a small head, but it is not as dense. The leaves are more tender. Ask the students, **"Why do we pack the bibb lettuce in a plastic crisper? Wouldn't it be slower to harvest and pack, and wouldn't it take up more room in shipping?"** *The tender leaves would lose water and quality without protection*
- Ask, **"Do you notice how the field cucumber has a thick skin? What does it taste like?"** *Some tissue around the skin may be bitter. "How are the long English cucumbers different?"* *They have a thinner skin with no bitterness. "Why do we wrap this product in plastic?"* *Its thin skin loses water much more quickly.*

Share the produce prices with students and ask, **"Why are the prices different for each item? Based on this time of year, could we grow these crops outdoors now? How might the current season affect vegetable prices?"**

### Tips for Engagement

- This lesson is more engaging if students can actively participate as much as possible. Could students be involved with selecting the products at the grocery store? Can they help wash and cut the vegetables? Can they use the Internet to compare prices at various stores?

# An Introduction to Soilless Growing Systems

## Chapter 1, Activity 1

### Share

Guide students through the presentation and ask them to answer the following questions:

- What are hydroponics and soilless growing systems?
- What does hydroponics look like in real life production systems?
- How is hydroponics different from soilless?
- How is hydroponics different from aquaponics?
- What are some common crops in soilless systems?
- How have soilless growing systems changed over time?
- What are some advantages and disadvantages of soilless production?
- Are you willing to pay more for crops grown in a soilless system? Why or why not? What if you owned a restaurant?

### Process

Help students to learn more about some of the largest hydroponic vegetable producers featured in the slideshow (Village Farms, Bright Farms, Gotham Greens, Tantimura and Antle, and Houweling's). Depending on the class size and access to technology, you could divide the students into groups and ask them to each research a different producer, or the entire class could research one together.

Instruct learners to search for photographs of the crops, labels, and packaging. Ask them to find the answers to the following questions: **“What are these businesses growing? How are their crops different from ones grown outdoors? What are some advantages that these businesses have over their outdoor competitors?”** Invite students to share their findings with the group after they complete their research.

### Generalize

Instruct students to visit the grocery store and analyze 7 vegetables using the student handout- “What’s Growing?” Students will record the price of each item and decide where the product was grown (outside locally, outside and shipped in from somewhere else, or grown in a greenhouse or soilless system).

Ask, **“Why do we not see corn or wheat in hydroponic systems? How might food safety be impacted by growing system? What about working conditions for people?”**

### Accommodations and Modifications

- Guide students through the images of real-world growing systems at their own pace and ask questions about how the weather and climate is different from the outdoors. Provide students with a printed copy of the slides.
- Ask students to draw or write responses to questions instead of answering them verbally.
- Give students a choice of working together or alone during the research component.

# An Introduction to Soilless Growing Systems

## Chapter 1, Activity 1

### Apply

Ask, “Does this new knowledge change how you see produce in the grocery store? Do you think that vegetable production is dirty, hot, and low-tech?” Explain that appearances may be deceiving, and we cannot tell how a crop was produced just by looking at it. Production systems are about much more than appearances.

### Resources

- **Practical Hydroponics Article:** <http://www.hydroponics.com.au/issue-94-field-vs-glasshouse-tomatoes/>
- **Transparent Stone and the Romans:** [https://hort.purdue.edu/newcrop/2\\_13\\_Janick.pdf](https://hort.purdue.edu/newcrop/2_13_Janick.pdf)
- **Ascension Island in WWII:** <http://www.ascension-island.gov.ac/wwii-hydroponics/>

### Authors

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### Enrichment

- Ask students to research soilless and hydroponic systems in other countries such as Spain, Mexico, Belgium, Japan, Canada, and the Netherlands. They should consider population, climate, and industry when comparing how different countries grow vegetables in greenhouses.
- Investigate the history of controlled environments and soilless production through topics such as:
- Hanging Gardens of Babylon, Chinampas and the Aztecs, Transparent Stone and the Romans, Emery at UK and the first plastic greenhouses, and Ascension Island in WWII
- Using the article from Practical Hydroponics (located in the Resources section), explain how water use and crop density differ. What elements of this comparison are missing? How much did it cost to build?