# AGRICULTURE, HYDROPONICS & THE ENVIRONMENT:

## Topic: Botany

## Grade Level: High School

## ABSTRACT\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

This unit can be easily modified to fit anywhere within a Botany class. For the Botany class at Holt High School, this unit will fall between the Plant Nutrition and Health unit and the Plant Pathology unit. Students will first identify major events leading to agricultural methods and techniques seen today. Next, students will analyze how such large scale agricultural systems meet the requirements for plant growth (sunlight, water, air, nutrients and space) just as small scale systems do. Students will also evaluate the implications of such systems as they explore developing alternative methods. Hydroponics will be explored in depth as students examine the mechanisms and variations in such systems. Students will also have the opportunity to develop and construct their own hydroponic system using common house-hold materials. Later, students will use this information as they investigate issues that may arise with crop production and plant growth especially in relation to plant pathology.

## BIG IDEAS:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Plants are found worldwide in a variety of environments ranging from deserts to tropical forests. Some plants have been harnessed by humans to use for consumption. Agriculture refers to the production of crops and livestock for human consumption. Since the beginning of agriculture nearly 10,000 years ago, agricultural methods and techniques have adapted to the ever-changed demands of both local and global environments and populations. In the modern world, alternatives to traditional soil-based agriculture are in development. They take into consideration the impact agriculture has on local and global economy and environment. Aquaponics is one alternative that grows plants in a nutrient solution rather than soil. This system uses less water than the traditional method and can support a variety of plants. The size of such a system can be modified to fit the needs of surrounding population as well. An ecological footprint measures the impact an individual, group, business or farm has on the environment. It takes into consideration inputs (money, resource usage, labor) compared to the outputs (product quality/quantity, profits, greenhouse gas emission). Many alternative agricultural methods are deemed more ecologically friendly because they use fewer resources and require less money for start-up and for continued use. They also produce high quality, high quantity yield, low greenhouse gas emissions and high profit.

## DRIVING THEORY #1:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Plants are found worldwide in a variety of environments ranging from deserts to tropical forests. Some plants have been harnessed by humans to use for consumption. Agriculture refers to the production of crops and livestock for human consumption. Because of variations in climate (temperature, amount of rainfall, soil type, etc.) and in population demands (small and large scale) there is variability in farming methods. Crops and livestock are sometimes specific to location but can be transported far distances to people across the globe.*

## Observations, experiences, data, or examples:

* Students can investigate the different kinds of agriculture that is seen around the world including ranches, irrigated farming, multi-crop farming and permaculture.
* Students can identify the major crops that supply food and nutrition for the global population
  + http://www.epa.gov/oecaagct/ag101/printcrop.html#major
* Students can compare and contrast the imports and exports of food crops from countries of the Eastern Hemisphere and of the Western Hemisphere.

## DRIVING THEORY #2:\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Since the origin of agriculture nearly 10,000 years ago, agricultural methods and techniques have adapted to the ever-changed demands of both local and global environments and populations. Agricultural methods and techniques had to improve in response to changes in environment and in population demands. Such improvements were irrigation techniques, fertilizers and pesticides, greenhouses and the exchange of crops between global hemispheres.*

## Observations, experiences, data, or examples:

* Students can identify and explain how agriculture has changed over time by investigating the implications of inventions and methods
* Domestication of wheat, formation of farming communities, irrigation methods, row cultivation, Medieval Green Revolution, Columbian Exchange, greenhouses, British Agricultural Revolution, crop rotation, chemical fertilizers, Mendelian genetics, industrial agriculture, the organic movement, and genetically modified plants and organisms (GMO’s).

## DRIVING THEORY #3: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*In the modern world, alternatives to traditional soil-based agriculture are in development. They take into consideration the impact agriculture has on local and global economy and environment. Agriculture’s use of non-renewable resources (i.e. petroleum), chemicals (fertilizers and pesticides) and copious amounts of water in addition to the benefits of holistic living, methods of agriculture have turned more towards sustainability.*

## Observations, experiences, data, or examples:

* Students can compare and contrast the simplistic method of agriculture to modern, alternative methods such as Biointensive farming, Biodynamic farming, Permaculture and Aquaponics.
* Students can read media reviews of modern methods of agriculture and their sustainability efforts
  + http://www.contextnet.com/120420%20Global%20Crop%20Production%20Systems.pdf

## DRIVING THEORY#4:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Aquaponics is one alternative that grows plants in a nutrient solution rather than soil. This system uses less water than the traditional method and can support a variety of plants. The size of such a system can be modified to fit the needs of surrounding population as well. Aquaponics uses water as the growth medium rather than soil. Because the system is enclosed and the water is recycled over and over again, total water usage is great reduced. Also, nutrients are manually added to the water and the need for chemical fertilizers is diminished. Instead of requiring more land, aquaponics systems can be grown vertically (up rather than out) and can be designed for homes or for large scale systems.*

## Observations, experiences, data, or examples:

* Students can investigate, model and explain how an aquaponics system works(http://aquaponics.com/) (http://en.wikipedia.org/wiki/Aquaponics)
* Students can analyze the pros and cons of using a hydroponics system by reading media reviews of such systems
  + <http://www.backyardaquaponics.com/Travis/CostBenefitAnalysisofAquaponicSystems.pdf>
  + <http://www.resilientcommunities.com/how-much-food-and-income-can-an-urban-farm-produce/>
* Students can collect a list of all of the materials that would be needed in order to create an aquaponics system and modify them to scale down the system or scale up.
  + <http://www.theaquaponicsgarden.com/aquaponics_fact_sheet.htm>
  + <http://www.aquaponicshowto.com/how-much-space/page/60/>

## DRIVING THEORY #5:\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Aquaponics leaves a smaller ecological footprint than the traditional, soil-based method we use today. An ecological footprint measures the impact an individual, group, business or farm has on the environment. It takes into consideration inputs (money, resource usage, labor) compared to the outputs (product quality/quantity, profits, greenhouse gas emission).*

## Observations, experiences, data, or examples:

* Students can interpret and review the pros and cons to using soil based agriculture compared to hydroponics or aquaponics using John Foleys’ TED Talk “The Other Inconvenient Truth”
  + http://www.ted.com/talks/jonathan\_foley\_the\_other\_inconvenient\_truth
* Students can investigate and compare and contrast soil based agriculture and aquaponics based on:
  + how much space is needed for one system
  + how much will initial set up and maintenance cost for one year
  + how much water will be required
  + how much energy will be required
  + what fertilizers and pesticides will be used and any secondary effects
  + any greenhouse gas emissions
  + total, yearly crop production

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## STUDENTS’ PRIOR KNOWLEDGE:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Accurate examples or ideas to build on:

* Students should have a basic understanding of what agriculture is.
* Students should have a basic understanding of ways humans can impact the environment.

## Common Misconceptions:

* Students will not know about the ecological impacts agriculture, specifically, has on the environment. When asked to compare the new alternative methods to traditional methods, they will assume that they are the same.
* Students will think that they can grow any kind of crop in a hydroponics system.
* Students will think that the water in a hydroponics system must be constantly refreshed but in reality it is simply recycled and ‘topped off’ when evaporation occurs.
* Students may come to believe that all greenhouse gases are bad for the Earth but in reality, without some of them the Earth would be too cold for us to live in.

## OBJECTIVES FOR STUDENT LEARNING:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Michigan State Objectives** |
| **E1.1g** *Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.* |
| **E1.2B** *Identify and critique arguments about personal or societal issues based on scientific evidence.* |
| **E1.2D** *Evaluate scientific explanations in a peer review process or discussion format.* |
| **E1.2g** *Identify scientific tradeoffs in design decisions and choose among alternative solutions.* |
| **E1.2K** *Analyze how science and society interact from a historical, political, economic or social perspective.* |
| **E2.4d** *Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal and pollution.* |
| **B2.2g** *Propose how moving an organism to a new environment may influence its ability to survive and predict the possible impact or this type of transfer.* |
| **B2.3C** *Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.* |
| **L3.p3C** *Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen and nitrogen). (prerequisite).* |
| **B3.4E** *List the possible causes and consequences of global warming.* |

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| **Disciplinary Core Ideas** | |
| **ESS2.A** *Feedback effects exist within and among Earth’s systems.* | |
| **ESS3.A** *Resource availability has guided the development of human society and use of natural resources has associated costs, risks and benefits.* | |
| **ESS3.C** *Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies and regulations.* | |
| **Science and Engineering Practices** | **Cross Cutting Concepts** |
| **Practice 2** *Developing and Using Models* | *Systems and System Models* |
| **Practice 4** *Analyzing and Interpreting Data* | *Energy and Matter in Systems* |
| **Practice 8** *Obtaining, Evaluating and Communicating Information* | *Structure and Function* |

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| **Synthesized Unit Objectives** |
| Students will identify major events in agricultural history and explain their impacts on the advancement of the field. |
| Students will explain how plant growth requirements are consistently met despite variations in agricultural methods. |
| Students will collaborate in groups to develop and construct a functional hydroponics system using household materials. |
| Students will explain how changing physical, chemical and environmental factors may affect crop production in a variety of agricultural methods. |
| Students will compare and contrast the inputs (resources, materials, labor and costs) and outputs (crop yield, profits) of a variety of agricultural methods. |
| Students will collaborate in groups to evaluate the advantages and disadvantages of various agricultural methods upon their analysis of conclusions from prior scientific studies. |
| Students will discuss the consequences of global warming on crop production as it relates to varying agricultural methods. |

# Assessment and Activities:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Students will identify major events in agricultural history and explain their impacts on the advancement of the field.

* **Formative Assessment:** Journal Questions - “Past, Present and Future: The History of Agriculture”
* **Major Activity:** “Timeline of Events: The History of Agriculture” - In groups, students will create advertisements for assigned inventions/events from the history of agriculture. Using provided handouts, students will include what the invention/event was, who was involved, when it occurred and its impact on agriculture. The students will pitch their invention/event to their classmates, who will act as skeptical agriculturists.
* **Summative Assessment:** “Hydroponics Quiz” - Match each of the following events/inventions in agricultural history with their respective effects on the agricultural field.

1. Students will explain how plant growth requirements are consistently met despite variations in agricultural methods.

* **Formative Assessment:** Journal Questions - “Hydroponics: What is it? How does it work?”
* **Major Activities:**
  + “Hydroponics: An Overview” - Students will follow along with a Power Point presentation that introduces what hydroponics is and what the components of a system are.
  + “Hydroponics: Identifying Mechanisms of a Variety of Hydroponic Systems” ***-*** In groups, students will look at diagrams and pictures of five different hydroponics systems. They will work together to identify the LAWNS components as well as the overall mechanism of the system.
* **Summative Assessments:** 
  + “Agriculture: What’s coming next?” - Students will research four alternative agricultural methods (biointensive farming, biodynamic farming, permaculture, aquaponics)and will either write a paragraph summary, write bullet points, or will draw a picture of it.
  + “Hydroponics Quiz” - Hydroponics is plant growth without soil. Explain what each of the following components of a hydroponics system is: [Light, Air, Water, Nutrients, Support]. In the following diagram, explain the overall mechanism of this hydroponics system. Be sure to include the LAWNS factors we talked about previously.

1. Students will collaborate in groups to develop and construct a functional hydroponics system using household materials.

* **Formative Assessment:** Journal Questions - “Hydroponics: Debriefing – What are the Components of Hydroponics Systems”
* **Major Activities:** “Hydroponics: Constructing a Hydroponics System” - Students will be provided a wide range of household and crafting materials and will design a hydroponics system. They will first draw their design and answer guiding questions followed by the actual construction. Tomato plants will be provided for planting.

1. Students will explain how changing physical, chemical and environmental factors may affect crop production in a variety of agricultural methods.

* **Major Activity:** “Agriculture: What’s coming next?” - Students will research four alternative agricultural methods (biointensive farming, biodynamic farming, permaculture, aquaponics)and will either write a paragraph summary, write bullet points, or will draw a picture of it.
* **Summative Assessment:** “Hydroponics Quiz” - Identify two issues farmers today face and provide a way that they can counteract each of these issues.

1. Students will compare and contrast the inputs (resources, materials, labor, costs, etc.) and outputs (crop yield, profits, etc.) of a variety of agricultural methods.
2. Students will collaborate in groups to evaluate the advantages and disadvantages of various agricultural methods upon their analysis of conclusions from prior scientific studies.
3. Students will discuss the consequences of global warming on crop production as it relates to varying agricultural methods.
   * **Formative Assessment:** “John Foley’s TED Talk Calls Agriculture ‘The Other Inconvenient Truth’” - Students will read a post from a blog that summarizes an online seminar discussing agriculture’s ecological footprint. They will answer associated questions.
   * **Major Activity:** “Agriculture’s Footprint: Comparing and Contrasting Traditional and Alternative Agricultural Methods” - In groups, students will analyze press releases, data from scientific studies, discussion posts and other resources to answer a series of driving questions regarding the ecological footprint of aquaponics systems. They will use these answers to compare and contrast agricultural systems ecological footprints and to determine which is more environmentally friendly.
   * **Summative Assessment:** “Hydroponics Quiz” – You have been hired to convince a farmer to switch farming styles. Choose one of the following agricultural methods listed below and explain how it is different and better than the traditional method.