ROOTS AND S.T.E.M.

A GREENHOUSE SCIENCE CURRICULUM

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INTRODUCTION

How do I design a winter greenhouse curriculum for our high-school aged after-school internship program at Urban Roots that will be highly engaging, increase scientific understanding, and make our interns better farmers?

I am lucky enough to be the Market Garden Education Manager at Urban Roots, a small youth development and leadership non-profit on the east side of St. Paul. Each year we employ 60 youth interns and reach over 4000 people through our volunteering, service learning, and outreach programs. Our mission is to connect people with healthy food and nature. We have a strong internship program with our youth in the spring, summer, and fall (during the growing season), but always struggle to have meaningful content during the winter when we are inside. This year renovation of a greenhouse immediately adjacent to Urban Roots began. This greenhouse will be called the GROW-IT (Gateway for Research, Outreach, Workforce development, Innovation, and Teaching) center and is the result of four years of work and partnership between Metropolitan State University, Urban Roots, and other community partners. This curriculum was created for use in this new GROW-IT center. This curriculum is also intended to give our youth interns more confidence in science, more understanding of the work we do on our urban farm, and become more engaged in STEM and agriculture.
The result is a sixteen-week, inquiry and experiential-based curriculum, designed to be delivered in one three-hour lesson per week. This pacing allows for plant growth between the lessons. The intended audience is high-school aged youth interns in an after-school urban farm setting. The curriculum could be adapted for use in the classroom, one-time community education classes, as well as for adults or middle-school aged students. The curriculum does not have to be delivered in its entirety, lessons could be chosen a la carte. All lessons include links to the printable documents and slideshows needed to execute the lesson.

The curriculum was created using the *Understanding by Design* model (Wiggins & McTighe, 2006). First both long and short term desired results were established, then the evidence needed to show those results was determined, and finally the learning plan created (see Table 1).

*Table 1:* Curriculum outline. This figure outlines the desired results, evidence required by the students, and learning plan of the curriculum.

<table>
<thead>
<tr>
<th>Desired Results</th>
<th>Evidence</th>
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| **Long-term:** Give youth more background, knowledge and experience in the fields of both agriculture and biology so that they do better in school science classes, demonstrate more confidence and competence as farmers, and become more invested in our spring, summer, and fall programming. | 1. Growing vegetable plants using methods they learn throughout the unit  
2. An improved rating of their own confidence and understanding of the scientific method and factors affecting plant growth.  
3. Designing experiments using the scientific method throughout the unit. |
| **Short-term:** 1. Youth will be able to design and conduct their own experiments testing a variety of factors on plant germination and growth.  
2. Youth show increased confidence, understanding, and affinity to/in the following topics, as evidenced by a pre- and post- survey rating their comfort and interest in the topics of a. The scientific method, b. Factors affecting plant growth, c. Farming, and d. Working in greenhouses. | |
Learning Plan

Each of the lessons below (except seed germination, which will be one class period per variable) would take approximately one week of class time, but all need time to run, so weeks later in the unit will be filled with data collection and analysis, while earlier weeks will be learning background, setting up experiments and then caring for plants and tending to experiments.

1. **Introduction to Greenhouses**
2. **Nutrient deficiencies** - Tomato hydroponics - nutrient deficiency experiment
3. **Propagating plants**
   a. Basics
   b. Propagating plants from the grocery store challenge
4. **Photoperiodism** - Tricking house plants to bloom or grow
6. **Seed Germination**
   a. Effects of seed age
   b. Variety
   c. Light
   d. Water/humidity
   e. Soil medium
6. **Winter veggie growing** - Grow-a-salad competition
7. **Crop Expert Project** - Summative Project
8. **Greenhouse Plan** - using math and knowledge from seed germination experiment to make a plan for spring starts

Each lesson then came to be by exploring and establishing the big ideas, enduring understandings, essential questions, and standards that could be unpacked for each of those big ideas (see Table 2).

*Table 2. Big Ideas Table. This table outlines the big ideas, enduring understandings, essential questions, and standards uncovered in each topic.*

<table>
<thead>
<tr>
<th>Big Ideas</th>
<th>Enduring Understandings</th>
<th>Essential Questions</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouses</td>
<td>1. Greenhouses work because of the “greenhouse effect.”</td>
<td>1. Why do greenhouses work?</td>
<td>9.1.3.1.3</td>
</tr>
<tr>
<td></td>
<td>2. There are several different designs of greenhouses, each with different benefits.</td>
<td>2. Are all greenhouses the same?</td>
<td>9.1.3.4.2</td>
</tr>
<tr>
<td></td>
<td>3. There are certain procedures we must follow and tools we must use to keep ourselves and our plants safe and healthy in a greenhouse.</td>
<td>3. How do we manage a greenhouse?</td>
<td>9.4.4.1.1</td>
</tr>
<tr>
<td></td>
<td>4. What are we doing in this unit?</td>
<td>4. What are we doing in this unit?</td>
<td></td>
</tr>
</tbody>
</table>
### Plant Nutrients
1. Plants need certain nutrients in order to survive.
2. Hydroponics is a method we can use to test this claim.
3. The scientific method is an organized way of doing experiments.

### Ideal Growing Conditions (Crop Expert Project)
1. Different crops require different growing conditions.
2. How to design an experiment to test for one variable.

### Winter Greenhouse Veggies (Salad Contest)
1. Certain veggies grow better in the winter in the greenhouse than others.
1. What veggies can I grow in 2.5 months in the winter in a greenhouse to make a salad?
2. If we ever do a winter CSA, what could we grow for it?

### Bulb Forcing
1. Bulbs are a food storage organ for plants.
2. Bulbs can be forced to grow out of season with the proper techniques.
1. Why do plants have bulbs?
2. How can we get bulbs to grow flowers for valentines day?

### Plant Propagation
1. Just like animals, plants have organs that work together to maintain homeostasis.
2. Many of these organs can be used to propagate new plants via mitosis.
1. Do plants have organs? Can you name them?
2. Is a seed the only part of a plant that can be used to grow new plants?

### Seed Germination (Part 1)
1. Germination is the process of seeds growing into plants.
2. Seed variety and age can affect germination rate.
3. Soil medium can affect germination rate.
1. How do seeds work?
2. Will different varieties of the same species germinate at different rates? Will our seeds from last year grow as well as our new seeds?
3. What is the best soil medium to use for germination?

### Seed Germination (Part 2-Photosynthesis)
1. Reactants for photosynthesis are CO2, H2O and light. Products are O2 and sugar.
2. Amount of light/day can affect germination rate.
3. Watering technique and amount can affect germination rate.
4. Because plants are green, they absorb blue and red light best.
1. What do plants need for photosynthesis?
2. What is the best amount of light for germination?
3. What is the best way to water our seeds?
4. How much light do our seeds need?
5. If photosynthesis is happening in plants, will...
there be more oxygen nearer to the plants?

**Spring Seed Start Plan**

1. Math is needed in order to figure out how many plants are needed for a farm.
2. More calculations are needed to figure out what resources are needed to grow the desired number of plants.
3. A timeline must be carefully devised in order for plants to be ready for start dates.
4. The conclusions we drew in the seed starting experiment will inform this plan.

1. How do we figure out how many of each plant we need?
2. How do we figure out what we need to grow those plants?
3. How do we figure out when to plant what?
4. How do we apply what we learned to do the best possible job of seed starting?

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Week</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Intro to Greenhouse</td>
<td>9</td>
<td>Seed Germination</td>
</tr>
<tr>
<td>2</td>
<td>Plant Nutrients (Tomato Hydroponics)</td>
<td>10</td>
<td>Seed Germination/Photosynthesis</td>
</tr>
<tr>
<td>3</td>
<td>Salad Contest</td>
<td>11</td>
<td>Seed Starting Plan (math)</td>
</tr>
<tr>
<td>4</td>
<td>Crop Expert Project</td>
<td>12</td>
<td>Seed Starting Plan (math)</td>
</tr>
<tr>
<td>5</td>
<td>Propagating Plants</td>
<td>13</td>
<td>Bulb forcing/ Salad Contest</td>
</tr>
<tr>
<td>6</td>
<td>Plant Nutrients</td>
<td>14</td>
<td>Propagating plants</td>
</tr>
<tr>
<td>7</td>
<td>Propagating plants challenge</td>
<td>15</td>
<td>Seed Germination</td>
</tr>
<tr>
<td>8</td>
<td>Bulb Forcing</td>
<td>16</td>
<td>Crop Expert Project</td>
</tr>
</tbody>
</table>

Finally, each lesson was written with a title (big idea), a primary essential question, objectives (similar to our enduring understandings but written as an action statement: “students will be able to…”), evidence (what students will show to prove mastery of the topic), materials, and finally the learning plan. Each part of the learning plan includes a time estimation to help teachers with pacing the lesson. Below Table 3 is a pacing guide intended to help teachers pace the entire unit.

*Table 3. Pacing Guide. Titles and pacing of all lessons.*
1- Greenhouse Basics

Objectives:

- Students will be able to explain why greenhouses work and the difference between greenhouse shapes.
- Students will be able to keep a log of important greenhouse conditions.

Evidence:

- Students will explain the greenhouse effect in their growing journals after doing an experiment.
- Students will present the benefits of the different shaped greenhouses to each other.
- Students will set up Greenhouse Log in their growing journal.

Essential Question/s:

- What do I need to know about greenhouses to get started?
- What are we doing in this Winter Greenhouse unit?

Materials:

For pre-assessment

- Assessment

For starting seeds for tomato hydroponics experiment (session 3):

- 20 seed packets of annual veggies that grow in your growing zone
- 1 flat with at least 10 cells per lab group
- Seed starting soil medium

For greenhouse effect demo:

- Two thermometers
- A clear container, such as a jar
Learning Experiences

1. (15 min) Before anything else begins youth must choose a lab partner. They will need to work with a different partner for each experiment we do. Next they need to choose a crop with that lab partner for their “Crop Expert” project. They won’t know anything about what’s coming, except that they need to start these plants. Have about 20 seed packets of annual vegetable plants that grow in the summer in your growing zone. The best choices are varieties that would germinate in a fairly short time frame. Avoid the parsley and onion family. Lab pairs should start about 10 plants each in growing medium and plastic cells.

2. (15 min) Do pre-assessment. Assessment
3. (2 min) Hook: Ask youth if they have ever opened their car on a sunny day and felt the overwhelming heat pour out. Ask them if they have ever wondered why that happens. Ask if anyone knows and can explain. Tell them we are going to dedicate the next 8 weeks of our time together to greenhouses so let’s begin with understanding how they work.

4. (10 min) Do Greenhouse Effect Demo.
   
a. Use the following link as a guide on how to set up the experiment, but in the interest of time, set it up 20 min before class and explain to students how you did it. Just have students record final difference in temperature.  
   
   
b. Explain that like scientists, we are first going to collect data to support the claim that spaces inside glass retain heat better than spaces not inside glass, then we will talk about why it happens.
   
c. Greenhouses work because light energy, in the form of photons, can pass through glass, then when light hits any matter it absorbs that light and then emits it again as infrared light, or heat. The heat is then trapped inside the greenhouse, because it cannot pass back through the glass.
   
d. Pass out growing journals (spiral bound notebooks). Have youth skip the first three pages and then date the third page and title it “Intro to Greenhouses”. They should record the final difference in temperature from the Greenhouse Effect Demo on this page.
e. When the Greenhouse Effect experiment is complete youth should write in their journals the answer to this question: “Why do greenhouses work?”

5. (40 min.) Do greenhouse structure expert activity.
   a. Split the youth up into 5 groups. Each group is to become an “expert” on one of the following shapes of greenhouses:
      i. Gable, A-frame, Gothic Arch, Quonset, Lean-to
   b. Their task is to look up information on the internet about their shape greenhouse and then make a 5 minute poster that includes the following:
      i. A drawing of the shape
      ii. 1-3 advantages of their shape
      iii. 1-3 disadvantages of their shape
   c. The groups will then go around and present about their greenhouse shape. Youth should take notes in their growing journals about the 5 structures.

6. (10 min) Share Intro to Greenhouses Slideshow that outlines the goals, objectives, and lessons for this winter curriculum. Stop at the “Enjoy, Engage, Grow!” slide.

7. (40 min) Make growing journal.
   a. Give students a composition notebook and tell them that this will be their “Growing Journal” for this winter greenhouse session. This is the place they will draw and record what they see, write what they think, and take notes on what they are learning. Give them 20 minutes to decorate the front cover of their growing journal with cutouts from old seed catalogs,
markers and tape. This is really important so that they own and connect with these journals.

b. Have them write their names on the inside covers and “My Growing Journal” on the first page. Have students leave the next 2 pages for a “Table of Contents.” Have students number the pages.

8. (40 min) Setting up greenhouse log

   a. Continue Intro to Greenhouses Slideshow to teach basic greenhouse operations. Have youth take notes for further reference.

      i. Temperature- 80-85 degrees

          1. Too cold?- Turn up heat

          2. Too hot? -Vent or shade

      ii. Humidity- There should be no moisture buildup on the leaves. Note this in Greenhouse Log. If you have access to a hygrometer, also record percent humidity. For vegetable growing, humidity should read 80-90% during the day and 65-75% at night. High humidity and low temperature promotes mold, low humidity and high temperature may affect growth. If humidity is too high opening windows, reducing watering, or a dehumidifier are ways of remedying it. If humidity is too low, add a humidity tent, increase watering, or decrease ventilation. Extreme humidity causes plants to be unable to exchange oxygen and carbon dioxide.

      iii. Ventilation- make sure air is moving. If the air is not moving it can increase chances for disease and decrease respiration due to oxygen buildup.
iv. Pests- check all plants for pests both before they are brought into the greenhouse and every day. If pests are found, address it right away, either by squishing the pests, removing affected plants, introducing a biological control, or other method.

v. Disease- check all plants for signs of disease. If youth notice anything abnormal, first try to determine if it is due to lack of water, ventilation, temp, humidity, or fertility. If it is determined that the abnormality is due to a disease, treat it if possible, otherwise get rid of that plant so that the disease doesn’t spread.

vi. Cleanliness- The best way to spread disease or invite pests is to leave our greenhouse a mess. Make sure everything is tidy and in its place. Make sure floors are swept if applicable.

b. Print 2 copies of the Greenhouse Log for each youth. Have them fold it them in half and tape them to the last 2 pages of their Growing Journal.

Go to greenhouse and check each of the basic greenhouse operations factors. Record in notebook.

9. (5 min) Do growing journal reflection.

a. What are you excited about during this winter greenhouse session?

b. Why do greenhouses work?

c. What is one thing we will be checking to maintain our greenhouse.

   Explain why it is important.
2- Plant Nutrients, Tomato Hydroponics

Objectives:

- Students will be able to explain what happens to plants when are lacking an essential nutrient.
- Students will be able to use the scientific method to set up an experiment.

Evidence:

- Students will do a guided lab write-up in their growing notebooks.
- Students will set up tomatoes growing hydroponically and carry out plant nutrient experiment.
- Students will make predictions about what will happen to each of the plants when they are lacking a specific nutrient.

Essential Question:

- What happens to plants when they don’t get all their nutrients?

Materials:

It should be noted that this experiment is a bit more extensive and expensive than the rest and takes quite a few materials and preparation. It is also very rewarding. This lesson could be adapted by simply using the School Specialty hydroponics kits and introducing different variables (as opposed to the nutrient variability).

- !!Tomato starts that should be about 4-6 weeks old!!!
- Batch of homemade cookies (all ingredients necessary)
- Tomato Hydroponics slideshow
- Scientific Method slideshow
- Copies of Lab Report Form for each student
- One lab kit for every 8 students (if they are working in pairs) Order lab kits here through School Specialty:
Learning Experiences:

1. (5 min.) Hook: Make a batch of cookies ahead of time. Divide the batch into 4 equal parts and leave out one essential ingredient in 3 of those parts, one part add all the ingredients (this will require some planning and calculating). Let the youth taste each of those cookies. Draw the parallel that in a cookie recipe there are essential ingredients that each have a job and are necessary for the cookie to turn out tasting good. In plants and animals, we have essential nutrients that are required for our organs to work properly. Things start to fail if we don’t consume these nutrients.

2. (20 min) Show Tomato Hydroponics slideshow. This slideshow has 2 parts:
   a. The first section is about what Ca, K, P, N do in plants. Don’t show pictures of what a plant that is deficient in these nutrients looks like. This is the piece they are going to predict.
      i. After each slide, have youth make predictions about what a plant with deficits in each of the above nutrients will look like, based on the knowledge about what each of those nutrients do for a plant, as well as their practical garden knowledge. You may want to help talk them through the science.
b. The second section is about growing plants hydroponically and why it works.

Here is a great resource for teachers to read about the basics:

https://www.fullbloomhydroponics.net/hydroponic-systems-101/ Order your hydroponics kit here:

https://www.schoolspecialty.com/delta-education-hydroponics-kit-080-1790?gclid=EAIaIQobChMIyOCWy9Hc4AIVD7nACH2WfwhpEAQYAiABEGK-ZPD_BwE. Only use the nutrient solution in this kit for your control. Use the mixes in the 4-way hydroponics nutrient kit for the variables:

https://www.carolina.com/hydroponics/lamotte-hydroponics-4-way-kit/FAM_653204.pr Read these directions very carefully before attempting to explain the experiment to students.

3. (15 min.) Show the Scientific Method slideshow while youth take notes in their notebooks.

4. (20 min.) Explain the experiment in detail in scientific method format.
   a. Hand out the Lab Report Form sheet.
   b. Use this to guide students through the scientific method in setting up the experiment in their notebooks. Walk them through each step of the experiment for this first encounter with the scientific method.
   c. Here is where you’ll go into detail with explaining the procedure from the lab manuals that came with the kits.
   d. Tape the Lab Report Form into notebook using folding method. Make sure youth are keeping their table of contents up to date.
5. (80 min) Go to greenhouse and set up experiment! Note: pH is influential in hydroponics, be sure to keep constant.

6. (35 min) Check all factors in the greenhouse that students learned about last week (temp, ventilation, humidity) and record in Greenhouse Log.

7. (5 min) Reflection question: Why do different plants need different nutrients?
3-Salad Contest

Objectives:

- Students will be able to experiment with growing a variety of veggies in the winter in a greenhouse in MN.

Evidence:

- Students will grow ingredients for a salad in 2.5 months after researching which veggies will grow best in a MN greenhouse in the winter.

Essential Question:

- What veggies can I grow in 2.5 months in a greenhouse to make a salad?
  - If we ever had a winter CSA, what could we grow for it in the greenhouse?

Materials:

- Salad Contest slideshow
- Salad Contest Planning Sheet
- Seeds for about 20 common winter greenhouse crops (most of these can be left over from the Crop Expert lesson)
- Flats or 4 in pots
- Seed starting mix

Learning Experiences:

1. (5 min.) Hook: Ask youth what the best salad they ever had was. Talk about why they loved it. What flavors, textures, food groups were incorporated? Tell them that we are going to have, not a salad-making, but a salad-growing contest. The best salad according to blind taste-testers will win a prize. On the day they harvest, they will also make a
dressing that can be an original recipe or a recipe they get from somewhere else. No other outside ingredients are allowed. We want our veggies to shine.

2. (20 min) Show Salad Contest slideshow about growing zones. Explain that the catch with the above challenge is that when you’re truly eating local, the best dish might not be the one that you dream up, but rather the one with the freshest, most well-grown ingredients.

3. (2 hrs.) Have youth choose a new lab partner. Their instructions for planning are both on the slideshow and below. Hand out the Salad Contest Planning Sheet to youth and have them get started! Once finished, one youth should tape planning sheet in their notebook.
   a. Research veggies to come up with a list that meet our criteria of veggies we predict would grow well in a greenhouse.
   b. Narrow that list down to 4-5 veggies that you think would taste great in a salad together.
   c. Get list approved by instructor (make sure seeds are available!)
   d. Make a growing plan for those crops.(some youth will plant today and some they will not)
   e. Go to greenhouse and set up!

4. Have youth leave a page blank in their growing journals in this section for taking notes and observations on growth.

5. (10 min) Do Greenhouse Log.

6. (20 min) Check on, maintain, and record observations for all ongoing projects.

7. (5 min) Reflection question: Explain why you chose the crops you did for the salad contest.
5- Propagating Plants

Objectives:

- Students will be able to identify the flowers, fruit, leaf, petriole, terminal bud, axillary bud, node, stem, and root of a plant.
- Students will be able to propagate plants asexually using different plant parts.

Evidence:

- Students will label a diagram of a flowering plant.
- Students will successfully propagate 4 different plant species.

Essential Question:

- Besides using seeds, what other parts of a plant can we use for reproduction?

Materials:

- Plant Propagation Slideshow
- Plant Diagram print one for each youth
- Mature plant of each of the following:
  - Geranium plant- into 4 inch pots
  - Snake plant - into 4 in. pots
  - Spider plants
  - An herb (your choice: basil, thyme, peppermint, thyme, rosemary, stevia, oregano, lemonbalm, chives)
    - Rex Bagonia
- 1 flat for each pair
- 1 humidity tent for each pair
- Scissors
- 4 inch pots
- Peat moss
- Sand
- Potting soil (for spider plant- all others should first go into the Peat/Sand mix)
- Plastic bags
- Pebbles
Learning Experiences:

1. (5 min.) Hook: what plant parts can you name?

2. (20 min) Teach about plant anatomy. Show slide 2 of Plant Propagation Slideshow about plant parts. While doing this have label the plant diagram. Tape diagram into notebook using the folding method.

3. (20 min) Teach about plant propagation. Show slides 2-10 of Plant Propagation Slideshow about propagation featuring sexual (meiosis) and asexual (mitosis) reproduction. There are five different kinds of asexual plant propagation: cuttings, layering, division, budding and grafting.

4. (20 min) Teach about propagation techniques. Show slide 11 in Plant Propagation Slideshow. We will propagate geraniums (stem cuttings in soil), snake plant (leaf cuttings), spider plants (division), an herb (water cuttings), Rex Bagonia (leaf cuttings). Have youth write down these 5 plants in their notebook with room to take notes after each of them. Have youth watch the four youtube videos on the slideshow and take notes on how to plant each of the 5 above. You will want to watch it ahead of time to understand how we will set up the experiments.

5. (1 hr) Set up experiment. Use propagation trays and seed starting soil for all soil based cuttings and cover with a humidity tent. Go set up propagation tray and water jar for herbs.

- Mason jars
- Rooting hormone (optional)
a. Youth should make a data table in their notebooks for recording observations.

6. (10 min) Fill out greenhouse log.

7. (40 min) Check on, maintain, and record data for all ongoing projects.

8. (5 min) Reflection question: Describe how you set up your propagation chamber.
6- Tomato Hydroponics Conclusion

Objectives:

- Students will be able to describe what happens to plants when they are deficient in each of four major macronutrients: Ca, N, P, K.
- Students will be able to make a plan for caring for their ongoing experiments over break.

Evidence:

- Students will create a short slideshow showing what happened to their tomato plants.
- Students will make a plan to care for their plants over break.

Essential Question:

- What happens to plants when they are deficient in each of four major macronutrients?

Materials:

- Access to computers
- Projector and screen

Learning Experiences:

1. (5 min) Hook: Ask youth to talk about how they feel if they haven’t had any protein in awhile, fat, carbs, certain veggies? Can they tell that their body is missing something? Connect this to how the plants react to these nutrient deficiencies.

2. (20 min) Youth will go collect their last data and take photos of the final product. They will clean up the experiment and head back to the youth room (our classroom).

3. (10 min) Do greenhouse log.
4. (30 min) Maintain and record data for all ongoing experiments.

5. (1 hour) Students will have the next hour to create a short slideshow sharing the following:
   a. Hypothesis
   b. Data
   c. Before and after pictures
   d. Conclusion, CEE format- why do you think each nutrient deficiency had the effect it did?
      i. **Claim:** The “answer” to your experiment question.
      ii. **Evidence:** 2-3 pieces of data (usually #'s) from your experiment that supports your claim.
      iii. **Explanation:** Using your background knowledge and science vocabulary, write why you think your claim is true.

6. (50 min) Students will share their slideshows.

7. (5 min) Reflection question: What is one unexpected result you found? Why do you think you got that result?
7- Propagating Plants Challenge

Objectives:

- Students will be able to make an informed hypothesis about which vegetable from the grocery store may be able to be propagated.

Evidence:

- Students will go to the grocery store and buy a fruit or vegetable and attempt to propagate it.

Essential Question:

- How can we propagate vegetables from the grocery store?

Materials:

- Optional: Plant Propagation Slideshow
- Transportation to grocery store
- Enough money to buy one vegetable per lab pair
- Open flats
- Seed starting mix
- Humidity tent
- Knives

Learning Experiences:

1. (1 min) Hook: Have you ever seen your potato, garlic, or onion that you left in the cupboard too long start to sprout? That plant was trying to propagate! Those aren’t the only veggies from the grocery store that can grow into new plants!
2. (10 min) Talk about what parts of plants propagate well. You may want to pull up the slideshow from before break again or mention the basal plate in onions (from the Valentine Bulbs lesson which they will not have gotten to yet). What might be some things you could look for when trying to find a plant that might propagate? What things wouldn’t work? Brainstorm together.

3. (1 hour) Go to the grocery store and have each pair of lab partners buy one vegetable they will attempt to propagate.

4. (30 min) Go back to the greenhouse and have youth set up their experiment.

5. (20 min) Record a drawing or description in their notebooks about their set-up. Include a one paragraph rationalization describing why they made their choice.

6. Youth should leave a page for observations of the Grocery Store Challenge in their notebooks and record each session.

7. (10 min) Record in their greenhouse logs.

8. (40 min) Check on, maintain, and record data for all other ongoing experiments.

9. (5 min) Reflection question: What other vegetable would you like to try to propagate besides the one you picked, and why?
8- Seed Germination

Objectives:

● Students will be able to design and carry out an experiment to test whether seed variety, seed age, or soil medium have an effect on germination rate.

Evidence:

● Students will design and carry out an experiment testing one of the three following variables: seed age, seed variety, and soil medium.

Essential Question:

● How do we design an experiment to test how germination rate is affected by either seed age, seed variety, or soil medium?

Materials:

● Variety of seeds with interesting shapes/smells for Hook
● 1-2 varieties of seeds with a new packet and a packet that is one year old, and another packet that is two years old
● Seeds of 3-4 varieties of a single crop (ie. beets)
● A variety of soil medium
● 100 cell flats- 4 per lab pair
● Seed Germination Lab Report Form (copy for each youth)

Learning Experiences:

1. (5 min) Hook: Bring in a variety of seeds. Have students observe and describe them.

   Remind students to notice shape, smell, and texture. Have students guess what plant
produces those seeds. Marvel for a moment of how amazing it is that those tiny seeds have all the information (DNA) they need to grow into a plant.

2. (40 min) Introduce seed germination. Tell youth that we have arrived at what is potentially our most important lesson of this course: seed germination. This is what we will be using our greenhouse for most often as the years go by, so it is important that we learn best practices in how to germinate seeds. Show video about plant propagation using seeds: [https://www.youtube.com/watch?v=qq_2gRNnG9e](https://www.youtube.com/watch?v=qq_2gRNnG9e) . Have youth take notes on this video about things they want to remember/that will help them be better farmers. It gets very specific between about 20-25 min. But there is good information on caring for sprouts in the last 5 min, so good to push through.

3. (1 hour) Design the experiment.
   a. This week we will be starting by asking these three questions:
      i. Do last year’s seeds grow as well as new seeds?
      ii. Will different varieties of the same species germinate at different rates?
      iii. What is the best soil medium to use for germination.
   b. Have youth find a new lab partner. With that lab partner they should choose one of the above three questions to answer.
   c. Youth should fill out the [Lab Report Form](#) up to the procedure in order to design their experiment.
   d. Once youth arrive at the procedure, stop them and focus the discussion. Their main objective is to discover % germination rate. Facilitate a discussion about
how they could test for this. When they have some ideas, have youth write a procedure.

4. (30 min) Go to greenhouse and set up experiment! Let youth know that photos are a great compliment to recorded data.

5. (40 min) Fill out greenhouse log and maintain all other experiments.

6. (5 min) Reflection Question: Tell how you will calculate % germination rate.
9- Seed Germination (Part 2- Photosynthesis)

Objectives:

● Students will be able to name reactants and products of photosynthesis.

● Students will be able to design and carry out an experiment to test one of the following variables: type of light, amount of light, watering technique, amount of water, or ventilation.

Evidence:

● Students will write the photosynthesis equation by memory.

● Students will design and carry out an experiment to test one of the following variables: type of light, amount of light, watering technique, amount of water, or ventilation.

Essential Question:

● If we change the amount of light, water, and ventilation seeds get, how will that affect germination?

Materials:

● Paper
● Colored pencils or markers
● Photosynthesis Slideshow
● Seed starting mix
● 100 cell flats- about 4 per lab pair
● Seeds of any variety
● Other materials youth will decide on to carry out experiment. Things you may want to have on hand:
  ○ Fans
  ○ Humidity tent
  ○ Different types of watering vessels (watering can, different hose nozzles etc.)
Different bulbs for grow lights

Learning Experiences:

1. (5 min) Hook: Draw everything you know about photosynthesis on a piece of paper.
   (Provide markers or colored pencils to make it fun)

2. (30 min) Introduce photosynthesis in more depth. Show Photosynthesis Slideshow.
   Emphasize how this is the bread and butter of plant growth. They cannot grow if they are not doing photosynthesis. Therefore, it is extremely important as the stewards of these plants that we are making sure they are receiving their optimal amount of these photosynthesis “ingredients.”

3. (1 hour) Design Lab.
   a. With lab partner they picked for this Seed Germination Project youth should choose the variable they will test for this Part 2. Lab partners should choose one of the following variables to test:
      i. type of light
      ii. amount of light
      iii. watering technique
      iv. amount of water
      v. Ventilation
      vi. Something else related to photosynthesis?

   b. Youth should fill out a second seed germination Lab Report Form to complete designing their experiment.
4. (40 min) Go to the greenhouse and set up the experiment!

5. (40 min) Fill out the Greenhouse Log and check on all other ongoing experiments!

6. (5 min) Reflection question: What is the formula for photosynthesis?
10-Bulb Forcing for Valentines Day

Objectives:

● Students will be able to explain what purpose bulbs serve in plants.
● Students will be able to force hyacinth bulbs when they are not in season.

Evidence:

● Students will force hyacinth bulbs for valentines day
● Students will explain what purpose bulbs serve in plants.

Essential Question:

● How can we get hyacinth bulbs to bloom for Valentines Day?

Materials:

● Pre-potted and chilled bulbs

● Bulb Forcing Slideshow

Learning Experiences:

!!! THIS LESSON MUST HAPPEN 3 WEEKS BEFORE YOUR DESIRED BLOOMING DATE. ADJUST ACCORDINGLY. BULBS MUST BE CHILLED AT 35-45 DEGREES IN TOTAL DARKNESS BEGINNING AT 13-18 WEEKS PRIOR TO THE DATE OF THIS LESSON- exact amount of time depends on hyacinth variety !!! Tips for potting can be found in slideshow.
*This lesson is on the shorter side to allow time to care for all the ongoing experiments.

Optional extension if that time is not needed is at the bottom.

1. (5 min) Hook: Ask youth, “What’s a funny valentines memory from elementary school?”
   (Think, Pair, Share) Explain that it’s only January but we have to start thinking about valentines day in the growing world because plants take time! Share that we are going to force beautiful flowers for valentines day that youth can take home and give as a gift to their valentine (which should be their mom).

2. (20 min) Teach about forcing bulbs. Show Bulb Forcing Slideshow to teach about bulbs and the purpose they serve in plants. Use slideshow to explain how bulbs that live in cold climates need to overwinter to stimulate growth, but that we can trick them into thinking they overwintered by putting them in a cooler in the dark for at least 13 weeks. All it takes is timing and some basic materials.

3. (10 min) Take potted bulbs out of cooler and plastic bags and put in a cool area with partial sun. Water all bulbs well and check for disease, premature growth, or any other problems. Bulbs should be warmed up slowly. After one week they can go in full sun and be warmed up to room temperature. Great resources to learn more about this whole process: https://www.gardeners.com/how-to-grow-bulbs-indoors/5158.html
   https://aggie-horticulture.tamu.edu/newsletters/hortupdate/hortupdate_archives/2005/jan05/QuestAbBu.html

4. (10 min) Do Greenhouse Log
5. (1 hour) Check on, maintain, and record data for all ongoing projects.

6. (5 min) Reflection question: How are bulbs important for a plant and how do they know when to grow?

Optional Extension:

Forcing Forsythia, Crabapples, Redbuds, Pussy Willow or Magnolias

Materials:

- Clippers
- Youtube showing capabilities
- Vases with water

1. (20 min) Under the same principles that allow bulb forcing to be possible, branches of flowering trees can be tricked into blooming early too. Plants in a cold climate need to undergo a period of being cold before they will bloom. This is why we chilled the bulbs before trying to grow them, and why cutting branches in November wouldn’t have worked. Late January might be a little early in Minnesota, but it’s worth the try. Plants then need a combination of warmth and longer days to begin blooming again. Cutting branches and bringing them inside in a vase, will achieve this. Show Forcing Branches to Bloom Indoors Video to explain technique. Forsythia, Crabapples, and Redbuds are mentioned in the video. Pussy Willows or Magnolias are other great options.

2. (20-40 min- depending if you need transportation) Go outside and cut branches of one of the above trees for forcing.
3. (20 min) Come inside and trim the branches and arrange in a vase. Just like the bulbs, don’t warm them up too fast. First put them in a cool place with partial sun. Then a few days later move them to full sun and regular room temperature.
11 & 12 - Seed Starting Plan
(with optional plant sale extension)

Objectives:

- Students will be able to make calculations needed in order to make a plan for spring seed starting.

Evidence:

- Students will create a greenhouse plan for spring planting.

Essential Question:

- What materials, how much space do we need, and when should we begin to grow our starts in the greenhouse this spring?

Materials:

- Computers for each pair of youth
- Make an electronic copy of Seed Starting Plan Spreadsheet- share with all youth via Googledocs
- Paper copies of Seed Starting Calculations for each pair

Learning Experiences:

I have allotted two lessons for this because, in my experience this takes youth a long time. The lesson is designed to be repeated both weeks and likely to be done by the second. If you have youth that move quickly through this, you could either just take one week and move on to the next lesson or do the optional extension below.
1. (5 min) Hook: It’s always exciting to me when I come across real world applications of math. Tell a personal story about when you got to use math in real life. Then ask the youth, “What’s a real-life math story you have?”

2. (15 min.) Give youth instructions about how to do calculations for the Seed Start Plan.

   a. The youth’s goal for this project is to create a usable seed starting plan for the greenhouse using math. The overarching question they need to answer is:

   What materials, how much space do we need, and when should we begin to grow our starts in the greenhouse this spring?

   b. This question can be broken down and achieved by doing calculations and following instructions on the Seed Starting Calculations. A paper copy of this should be made for each student. Make an electronic copy of the Seed Starting Plan Spreadsheet. Share it with all youth via Google Drive. Have each pair of youth make a copy and begin recording their calculations directly on the spreadsheet.

   c. Some of the youth’s calculations will be recorded on the first tab and some on the second. Materials list and special instructions go on the second tab. Youth should enter their calculations on the “Seed Starting Plan” spreadsheet and then check in with other youth to see if their calculations match.

   d. Youth will submit the “Seed Starting Plan,” calendar, and materials list to the Farm Manager for review.

3. (2 hours) Youth will work on Seed Starting Plan!
4. (45 min) When 30-45 min is left each day, go to greenhouse to fill out Greenhouse Log and check on all other ongoing projects.

5. (5 min) Reflection question Day 1: What is something that surprised you about this process?

6. (5 min) Reflection question Day 2: Discuss your results. Did you error on the side of too many plants, not enough? Was it difficult to figure out anything? What else would you like to include in your report that isn’t said in numbers?

Optional extension: Plant Sale Plan. If your youth move through this lesson quickly, they could plan a plant sale in a similar fashion. They may be able to skip some steps if they now understand the process. They should keep in mind that the plant sale would be all from greenhouse starts and not include outdoor bed space. They can use some of their knowledge from the plant propagating lessons to grow houseplants, or seed germination to grow vegetables. They should calculate cost in versus potential earnings and decide if the endeavor would be worth it. It would be entirely possible to carry out the plant sale plan in March and April if you have the greenhouse time and space.
13 - Salad Contest/Bulb Forcing Conclusion

Objectives:

- Students will be able to make a recommendation for veggies to grow in a winter greenhouse.
- Students will be able to take home flowers grown from bulb forcing for Valentines Day and explain to their valentine how they grew them.

Evidence:

- Students will write an official recommendation for our Farm Manager about which varieties to grow in a winter greenhouse for a winter CSA share or wholesale.

Essential Question:

- Which veggies should we grow in the greenhouse if we were ever to have a winter CSA?

Materials:

- Harvesting knives
- Bowls or crates for harvesting veggies into
- Access to kitchen for salad prep
- Ingredients for dressing (choose a few basic recipes and ingredients you’d like to offer the youth)
- Bowls and forks for eating
- Access to computer and projector
- Salad Contest- Veggie Recommendation Spreadsheet
Learning Experiences:

1. (15 min) Hook: Sell your salad to us in 1 min. Have each pair talk about what delicious greens and veggies we will be trying and what types of salad dressing they will be making to accent the flavors in their salad. Give youth 5 minutes to come up with a basic idea of what type of dressing they want to make. Make sure you tell them which ingredients are available first.

2. (30 min) Go to greenhouse and harvest salad ingredients! Clean up materials from experiment.

3. (30 min) Fill out Greenhouse Log and check on all other ongoing experiments.

4. (5 min) Collect forced valentines bulbs.

5. (30 min) Go to kitchen and make dressings and assemble salad.
   a. As youth are sampling each veggie, they should take notes on flavor in their growing journals.

6. (10 min) Save one perfect sample of each salad to give to an unbiased third party to decide on who wins the salad contest for the best tasting salad. Bring little valentines treats for prizes.

7. (30 min) Have a Valentine’s Day salad meal together and practice explaining what bulbs are for and how bulb forcing works. (this is the assessment for bulb forcing lesson)

8. (40 min) After tasting all the salads, have youth prepare to present their thoughts on whether or not they recommend growing each of the veggies they did for a winter CSA. They should be prepared to share a summary of their growing notes, their thoughts on flavor, overall recommendation, and why or why not. Someone should take notes on the
Salad Contest- Veggie Recommendation Spreadsheet in order to collectively make a list of recommended veggies for growing in a winter greenhouse. Submit to Farm Manager.

9. (5 min) Reflection question: What is your biggest take-away from the Salad Contest Project?
14- Propagating Plants Conclusion

Objectives:

- Students will be able to explain successes and failures of their plant propagation experiments.

Evidence:

- Students will make a list recommending plants to propagate for a plant sale, including tips on methods.

Essential Question:

- What were your successes, failures, and recommendations in this plant propagation experiment?

Materials:

- Extra pots and soil for potting up rooted plants
- Plant Propagation Conclusions Spreadsheet
- Access to computer and projector

Learning Experiences:

1. (5 min) Hook: Talk about having a plant sale as a fundraiser and propagating house plants as one piece of the sale. Tell youth that this is a real possibility (and an optional extension to this curriculum) and that today’s goal to is evaluate and record the successes and failures of our propagating experiment so that we could use that information in the event that we would ever want to do a plant sale.

2. (70 min) Go to greenhouse to finish plant propagation experiment.
a. If they haven’t already, youth should pot up all plants that now have roots at least a half inch in length.

b. Youth should make final observation recordings in their notebooks for both their propagation chamber and the grocery store challenge. They should prepare to have a discussion (similar to last session but less formal works well with this experiment) discussing their observations (successes/failures of propagating each plant), growing tips in their opinion, and whether or not they would recommend propagating this particular plant if we were ever to do a plant sale.

c. Youth should clean up Plant Propagation experiment.

3. (40 min) Record Greenhouse Log and tend to all other experiments.

4. (1 hour) Go back to classroom and have discussion about the experiment. Have someone record youth responses on the Plant Propagation Conclusions Spreadsheet to submit to the farm manager.

5. (5 min) Reflection question: Would you propagate any of the grocery store veggies for your own consumption? Why or why not?
15- Seed Germination Conclusion

Objectives:

- Students will be able to make recommendations about which seed varieties, age, soil medium, light and/or watering techniques work best for germinating seeds.

Evidence:

- Students will make a compiled recommendation table with their results.
- Students will adjust their greenhouse plan based on their results.

Essential Question:

- What have you learned about the best way to germinate seeds?

Materials:

- Seed Germination Conclusion Spreadsheet

Learning Experiences:

1. (5 min) Hook: Talk about how the real growing season is approaching! How we will be spending March almost entirely in the greenhouse planting our own starts that we will then be caring for much of, if not all of, the season. Everything they have been learning in this curriculum will help them have success with this, but most particularly this Seed Germination Experiment. Their conclusions here should help us have the most success or failure of any of the experiments we’ve done.

2. (30 min) Finish Seed Germination Experiment.
a. Youth should go the greenhouse and take their last data for their Seed Germination Experiment.

b. Clean up supplies from Seed Germination Experiment. Youth may wish to keep some of the plants for their own use or you may want to plant them in your gardens.

3. (30 min) Youth should fill out Greenhouse Log and check on their Crop Expert experiment.

4. (1 hour) Youth will return to the youth room (classroom) and begin to work on their lab reports for the project. They should write their conclusion in a CEE (Claim, Evidence, Explanation) format.

5. (30 min) Youth will informally share their conclusions and supporting data (photos welcome here) with the group. As they are doing so, someone should be the recorder and record all results on the Seed Germination Conclusion Spreadsheet to submit to the farm manager. Results table should be projected on a screen. Tell youth that, yes, this is a lot of spreadsheets, but this is what farmers do! They love spreadsheets since there is so much data for them to keep track of, so this is real work.

6. (5 min) Using the Seed Germination Conclusion Spreadsheet youth should go back and adjust their Seed Start Plan according to their results.

7. (20 min) Spend a little time reviewing the Greenhouse Log. Talk about trends. Ask what we’ve learned from keeping a close watch on the Greenhouse.

8. (5 min) Reflection question: Is there anything in your experiment you would do differently next time?
16- Crop Expert Conclusion

Objectives:

- Students will be able to write a lab report drawing conclusions about their growing conditions experiment.

Evidence:

- Students will make a poster of their lab report and present their findings to the class.

Essential Question:

- How do we formally share our conclusions about a science experiment?

Materials:

- Poster paper or giant 3M post-it notes
- Access to computers for all youth
- Access to a printer
- Markers

Learning Experiences:

1. (5 min) Hook: Share with youth that huge posters as the final product of science experiments are the norm in college science departments these days. If they tour college campuses, this is what they will likely see. Today, as their final project, youth are going to get to create something like it. We don’t have big fancy printers, but they can use our regular size printers to print pictures and text.

2. (30 min) Finish Crop Expert Project in greenhouse.
a. Youth will take their last data set for their Crop Expert Project (including pictures!).

b. Youth will clean up and put away their Crop Expert Project.

3. (1.5 hours) Youth will go to the youth room (classroom) and make a poster in formal lab report format about their findings. All elements on their Lab Report should be included in their poster. It is recommended that they type up each piece and print it out separately to literally cut and paste on a big poster board. Youth should print pictures they’ve taken, data tables, or graphs they may have made.

4. (30 min) Youth will present their findings to the group and posters displayed for all to see!

5. (5 min) Reflection question: what would you change about your experiment if you did it again?

6. (20 min) Do final assessment survey! **Assessment**
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