Curriculum development was supported by the USDA National Institute of Food and Agriculture.

Kansas Foundation for AGRICULTURE IN THE CLASSROOM
KFAC

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Course:	Biology 9-12	**Unit:**	Vertical Gardening - Agriculture Careers
Lesson Title:	Experimental Design and Careers in Crop Production		
Estimated Time:	3 class periods of 40 minutes		

Objectives:

1) Define and give examples of quantitative and qualitative observations
2) Design an experimental procedure to test variables on plant growth following proper experiment development guidelines
3) Identify careers in the field of agriculture

Equipment Needed:

Electronic device/projector or paper copies of Lesson 4 Slides

Supplies Needed:

Paper or device for bell ringer

Paper copies of Experiment Design Template. (if needed)

Paper copies of Create a Journal template (1 per student)

Paper copies of Class vertical garden data (if needed)

Potting mix, sand, peat moss, clay pebbles, rock wool, perlite, vermiculite, or other growing media that students may use for planting their seeds

Seeds for students to plant that they chose in Lesson 2

Accessibility Options

Students can access information visually through online videos with subtitles and auto-translations.

Utilize Speech-to-Text and text-to-speech add-ons for reading/listening/writing support (Updated 7/17/23)

For more suggestions, please visit:
https://www.washington.edu/doit/equal-access-science-and-students-sensory-impairment

Instructor Directions & Estimated Time	Procedures
Day 1 40 minute period	Plan experiment
Day 2 40 minute period	Research and plan Agriculture careers
Day 3 40 minute period	Present Agriculture careers

No.	9-12 Next Generation Science Standards		
HS-LS 1-3	Structure and Function: Plan and investigate to provide evidence that feedback mechanisms maintain homeostasis		
	Disciplinary Core Ideas	Science and Engineering Practices	Cross-Cutting Concepts
	LS1.A: Structure and Function	Planning and carrying out investigations	Stability and change

No.	9-12 National Agriculture Literacy Outcomes
T1. 9-12 f&h	f. Evaluate the various definitions of “sustainable agriculture,” considering population growth, carbon footprint, environmental systems, land and water resources, and economics h. Understand the natural cycles that govern the flow of nutrients as well as the the way various nutrients (organic and inorganic) move through and affect farming and natural systems
T2. 9-12 b	b. Compare similarities and differences between organic and inorganic nutrients (i.e., fertilizer) on plant growth and development; determine how their the application affects plant and animal life

Vocabulary	
Biomass	the amount of living matter (as in a unit area or volume of habitat)
Quantitative	measuring something in terms of the quantity or number of
Qualitative	measuring something by its characteristics rather than the amount
Control	In reference to an experiment, this is the aspect of it that stays constant or is the standard throughout the entirety of the experiment
Variable	any factor, trait, or conditions that are altered during the experiment to test a different result

Careers Mentioned	
Climatologist	Perform hands-on research such as water and soil samples, then analyze and report the data. They also present research at seminars or conferences or provide analysis of other research to employers, government officials, or other interested parties.
Conservationist	Responsible for improving, protecting, and managing the earth's natural resources.
Environmental scientist	Applies knowledge of natural sciences to develop ways to save the environment and protect human health.

Day 1

Day 1: Design, create a model, and write a procedure

Essential Question: How does our experiment design affect plant growth?

1) Bellringer- Use the Lesson 4 Slides and have students complete the Measurement review bellringer on slide 1. (2 minutes)
2) On slide 2, discuss what types of measurements students will take during their experiment. Possible answers should include:
-Plant growth (height)
-Root growth (length)
-Biomass (grams)
-The number of leaves
-The length of leaves

These are all examples of **quantitative** observations. Review the difference between quantitative and qualitative data on slide 3. Ask students, " What **qualitative** observations will we make as our plants grow?" (To help students remember the difference, use the mnemonic: Quantitative has an "N" like "number" while Qualitative has an "L" like "color".) (3 minutes)

3) Students will work in small groups to design their experiment. They will compare their group results to the results from the class vertical garden (Tower garden is optimal). Students should discuss which of the following aspects will be the same for all groups (the control) and which will vary (the variable). Each group (or individual student) will complete this Experiment Design Template. (20-30 minutes)

4) If there is time, students can share their experiment design with other groups and get feedback at the end of class.

5) Students will need to have their experimental design approved by the teacher before planting their seeds for their project.

Create a journal template for recording data, drawing, and labeling with vocabulary. Each class can use this class's Vertical Garden Data to compare results each week.

Days 2 and 3

Day 2 & 3 Essential Questions: What careers are related to plant nutrition and growth? Who has made a significant impact on the field of agriculture?

1) After the teacher has signed off on students' experimental designs from the previous class period, students may plant their seeds by either planting them directly into their vertical growing systems or by starting the seeds in seed-starting pods. (15 min.)

2) Ask students to take out their career mind map from Lesson 1, Day 3. Give them 3-5 minutes to add any careers they have learned about in the last 3 lessons. They can list them, draw related pictures, and add a short description of their responsibilities and skills.

3) People in Agriculture Personality Portrait. This can easily be shortened based on the amount of information that you want students to investigate. The bottom of the document contains a list of suggested sources. (30 minutes)

4) Students present their Ag Personality Portraits to the class. Peers will fill out a listening chart while their classmates present. (30 minutes)

5) Discuss: How did these individuals overcome adversity? What impact did this person's work have on the world? (10 min)

Main topics teachers should know:

It is important to know the different factors and key components of the experimental design when experimenting. A control is the baseline group in an experiment that does not have any experiments on it or changing variables. The control group helps compare the results so they can be visually seen and understood. A variable is any factor that changes and affects the experiment's outcome. There are two different types of variables: Independent and dependent. The independent variable is deliberately changed. For example, the amount of fertilizer that gets applied to the soil. The dependent variable is a factor that is measured or observed like plant height or yield. As researchers, these variables make it easy to change specific conditions to see the effects on the plant.

There are two ways to explain the measurements or observations in an experiment; Quantitative and Qualitative. Quantitative data refers to the numerical measurement that can be counted or measured with an exact number. This could include plant height, leaf count, biomass, or nutrient content. This type of data allows for more statistical comparisons in experiments. Qualitative data involves descriptive observations that are not numerical. This could be the colors, texture, or general appearance of the plant. While quantitative data is more precise than qualitative it can give more insight into the health and condition of the plant. Both of these types of data are important and making a successful experiment. A way that scientists measure the total mass of all living parts of a plant is called biomass. This includes the stems, leaves, roots, and any fruit or flowers. Biomass is an important indicator of plant growth and health. By measuring the biomass, scientists can determine how well a plant is growing under specific conditions.

Climatologists, conservationists, and environmental scientists are integral to experimental designs in agriculture and vertical farming, as their expertise helps researchers understand and mitigate environmental impacts. Climatologists study weather patterns and climate conditions, which are essential for designing experiments that test plant responses to temperature, humidity, and light changes. Their work ensures that controlled environments in vertical farming mimic optimal conditions for growth while preparing for potential climate-related challenges. Conservationists focus on sustainable practices and the preservation of natural resources, helping researchers design experiments that minimize environmental degradation. They may guide the use of renewable resources and the reduction of waste in vertical farming systems. Environmental Scientists analyze the broader impacts of agricultural experiments on ecosystems, including soil health, water quality, and carbon emissions. They contribute to designing experiments that evaluate the sustainability and environmental footprint of new farming techniques. Together, these professionals ensure that experimental designs in vertical farming not only maximize productivity but also align with ecological and environmental goals.

- Biomass explained - U.S. Energy Information Administration (EIA)
- Qualitative vs. Quantitative Data in Research: The Difference | Fullstory.
- Variables, Constants, and Controls When it comes to conducting a scientific experiment there are three components that are very
- Experimental Design - an overview | ScienceDirect Topics.

Suggestions for instruction:

When designing experiments, the Tower Garden could be used as the control and students could also test one other factor in their vertical garden, such as nutrients, light, watering, plant species, and growing media. If testing another factor, it is beneficial to design the vertical gardens in a way that allows other factors to be tested by having two pots per level for example.

When students plant their seeds, make sure they do not plant them too deeply. A good rule of thumb is to plant as deep as two to three times the width of the seed. When planting seeds in rock wool, make sure to cover the seeds with vermiculite and water with just water, not nutrient solution. The salt in the nutrient solution could kill germinating seeds. Make sure the rock wool stays moist by keeping the water level ⅓ to ½ way up the side of the rock wool. Keep the seedlings in a bright window or provide supplemental lighting. You will need supplemental lighting when growing garden plants in a classroom. Seedlings planted in rock wool will need to grow for 2 to 3 weeks before being transferred to a hydroponic system such as the Tower Garden. Have students take notes on their plants in their vertical gardens and on plants in the Tower Garden each week. This can be done on paper or in a digital format.

When students are creating their Ag Personality Portrait, allow them to be creative with the project by including pictures of the actual person or other visuals. Providing students the option to complete the project on paper may also be beneficial.

Agriculture Extension & Research in Kansas

At Kansas State University, the College of Agriculture and K-State Research and Extension is committed to its role as a premier agricultural research institution. Research teams of students, faculty, and staff work together to address scientific and economic challenges; promote innovation; and educate a new generation of researchers ready to assume leadership roles in agricultural-related fields.

These research teams collaborate with government agencies, businesses industries, and communities to deliver the solutions and the skilled workforce they need to thrive. The interdisciplinary research strengths are organized around these five strategic areas:

- Animals and Animal Systems
- Food Science, Food and Feed Safety, and Grain Science
- Plants and Plant Systems
- Sustainability, Profitability, and Management
- Workforce Development

K-State Research and Extension connects people across the state with the knowledge and science of Kansas State University by offering practical, research-based education. K-State Research and Extension improves Kansans' lives, livelihoods, and communities through education, research, engagement, and leadership. With scientists, educators, and volunteers in each of the state's 105 counties, K-State Research and Extension professionals strive to make the university's scientific improvements and discoveries accessible and relevant to every household. What they do, though, is not contained within state borders. Their work with regional, national, and international organizations creates positive impacts around the world.

Careers:

Climatologist:

Description: The job of a climatologist is varied and exciting. Depending on the position, a climatologist might be called upon to wear many different hats. A climatologist might do hands-on research such as taking water or soil samples, then analyze and report on the data. They may make presentations on their research at seminars or conferences, or provide an analysis of other research to employers, government officials, or other interested parties. Climatologists can also be problem solvers, applying the research to address local climate issues or to determine how to best work under different climate conditions. For example, they can work with or as weather forecasters, working to improve accuracy through developing new measurement tools and statistical models; conducting simulations; and translating findings into more easily understood terms for the general public.

Education: A bachelor's degree in meteorology or climatology, or in a closely related field with courses in climatology/meteorology, is the minimum educational requirement; a master's degree is necessary for some positions, and a Ph. D. is required for most research positions.

Salary: According to the Bureau of Labor Statistics, in 2020 the median annual salary for atmospheric scientists, including climatologists, was $99,740, with a salary range between $52,350 and $153,150.

Links:
https://www.dnr.sc.gov/education/pdf/Climatologist.pdf
https://www.environmentalscience.org/career/climatologist

Conservationist:

Description: A Conservationist is responsible for improving, protecting, and managing the earth's natural resources. To do so, they work closely with private landowners and federal, state, and local governments. Conservationists also frequently meet with farmers to consult them on the best practices for their land and how to increase their productivity while keeping the environment safe. A conservationist may have the following job responsibilities: research or study conservation management practices to provide sustained production of forage, livestock, and wildlife, develop technical standards and specifications used to manage, protect and improve the natural resources of conservation, maintain soil stability and vegetation for non-grazing uses, such as wildlife habitats and outdoor

recreation, manage forage resources through fire, herbicide use, or re-vegetation to maintain a sustainable yield from the land, plan and direct construction and maintenance of conservation improvements such as watershed research and soil-erosion control structures, or study forage plants and their growth requirements to determine varieties best suited to particular area.

Education: A bachelor's degree in natural resources, crop science, soil science, biology, or a related field, such as horticulture, plant physiology, or environmental science is required. Positions that are research-focused require a master's or doctorate degree.

Salary: According to the U.S. Bureau of Labor Statistics (BLS), conservation scientists earned an annual average salary of $69,020 in 2020.

Links:
https://www.agcareers.com/career-profiles/conservationist.cfm#:~:text=A%20Conservationist%20is%20responsible%20for,%2C%20state%2C%20and%20local%20governments.

https://learn.org/articles/Conservationist_Your_Career_and_Salary_Questions_Answered.html

Environmental Scientist:

Description: An Environmental Scientist, or Environmental Specialist, applies their knowledge of natural sciences to develop ways to save the environment and protect human health. Their main duties include collecting and analyzing samples of food, soil, air, and water; building plans to fix and prevent common environmental issues, and educating organizations and the public on potential environmental health hazards. Their job responsibilities may include: collecting and scientifically analyzing soil, air, and water samples to determine the level and cause of environmental contamination, developing solutions to control, fix, or prevent environmental problems, conducting environmental research projects, and preparing reports and presentations on their findings, or advising governmental organizations, businesses and the public on potential environmental hazards and health risks.

Education: A bachelor's degree in environmental science or a science-related field (biology, chemistry, or engineering) is needed for an entry-level job such as a field analyst or research assistant. For more advanced positions, such as project leader or program manager, a master's degree is often required. Further degrees can open opportunities as researchers or faculty at colleges and universities. Most colleges offering environmental science programs include an internship that enables students to gain field experience prior to entering the workforce.

Salary: The median annual wage for environmental scientists and specialists was $76,530 in May 2021.

Links:
https://www.bls.gov/ooh/life-physical-and-social-science/environmental-scientists-and-specialists.htm#:~:text=Collect%20and%20compile%20environmental%20data,as%20land%20or%20water%20pollution

https://www.energy.gov/eere/wind/career-map-environmental-scientist

Take a look at the Career Glossary to find other related careers!

Career Map: Environmental scientist. Office of Energy Efficiency and Renewable Energy. (n.d.). https://www.energy.gov/eere/wind/career-map-environmental-scientist

Conservationist. AgCareers. (n.d.). https://www.agcareers.com/career-profiles/conservationist.cfm#:~:text=A%20Conservationist%20is%20responsible%20for,%2C%20state%2C%20and%20local%20governments

Conservationist: Salary and Career Facts. Learn.org. (2024). https://learn.org/articles/Conservationist_Your_Career_and_Salary_Questions_Answered.html

Mizell, H. (n.d.). *Climatologist*. South Carolina Department of Natural Resources. https://www.dnr.sc.gov/education/pdf/Climatologist.pdf

U.S. Bureau of Labor Statistics. (2024, September 30). *Environmental Scientists and Specialists*. U.S. Bureau of Labor Statistics. https://www.bls.gov/ooh/life-physical-and-social-science/environmental-scientists-and-specialists.htm#:~:text=Collect%20and%20compile%20environmental%20data,as%20land%20or%20water%20pollution

What are variables?. Science Buddies. (n.d.). https://www.sciencebuddies.org/science-fair-projects/science-fair/variables

What is a climatologist?. EnvironmentalScience.org. (2024). https://www.environmentalscience.org/career/climatologist

Name Date Class Partners

Experiment Design for _____

1) What is the title of your experiment?

2) What is the goal of your experiment?

3) What are the materials you are using?
a) What plants?
b) What media?
c) What nutrient solution?

4) What is your control? (What is the same for every group?)

5) What is your variable? (What are you changing?)

6) What are your hypotheses? Write 2.

Hypothesis 1: When we _____ we will see_____

Hypothesis 2: When we _____ we will see_____

7) Create a data table for quantitative and qualitative observations (at least 2 of each). Write the titles but do not fill in the data, you haven't collected it yet.
(Examples of quantitative observations: **height**, **length, time, # of times**)
(Examples of qualitative observations: **color, smell, actions, sounds, texture**)

8) Write a 3 to 5 step procedure. Assign each person in your group a responsibility. Include the s**pecific quantities of materials** you will use .
Bad example: We will put seeds into the dirt
Good example: We will plant 2 lettuce seeds into 200mL of growing medium.

1st
2nd

3rd
4th
5th

9) Draw a picture of your experiment before and after you collect data. Use labels and color.

Results, Conclusions and Future Directions for _____Experiment

Data Analysis-Explaining your Results
Directions: Look at your completed data table from your experiment. Explain your results in sentences.

1) The quantitative data shows:_____

This means _____ did/did not happen.

2) The qualitative data shows:_____

This means _____did/did not happen.

Conclusions
Directions: Use your data analysis to make conclusions about your hypotheses.

3) Rewrite Hypothesis 1:_____

This hypothesis was/was not correct because_____

4) Rewrite Hypothesis 2:_____

This hypothesis was/was not correct because_____

Future Directions

Directions: Look at the questions you wrote in your data table. Choose 2 and write them below.
5) Question 1:

6) Question 2:

*Now choose one of those questions and use it to redesign your experiment. Choose a variable you will change and explain why.

7) We will change _____ because we think if we do this we will see_____

_____

Reflection
8) Do you think your experiment was successful? Why or why not?

Potted vs. Hydroponic Plant Growth Weekly Data

Name: _____ Planting Date: _____ Plant Variety: _____

Potted Plant Data

Date	Plant Height	Number of Leaves	Color	Other Notes

Hydroponic Plant Data

Date	Plant Height	Number of Leaves	Color	Other Notes

Harvest Data Date: _____

Plant	Plant Height	Number of Leaves	Aboveground Biomass	Other Notes
Potted Plant				
Hydroponic Plant				

Name Date

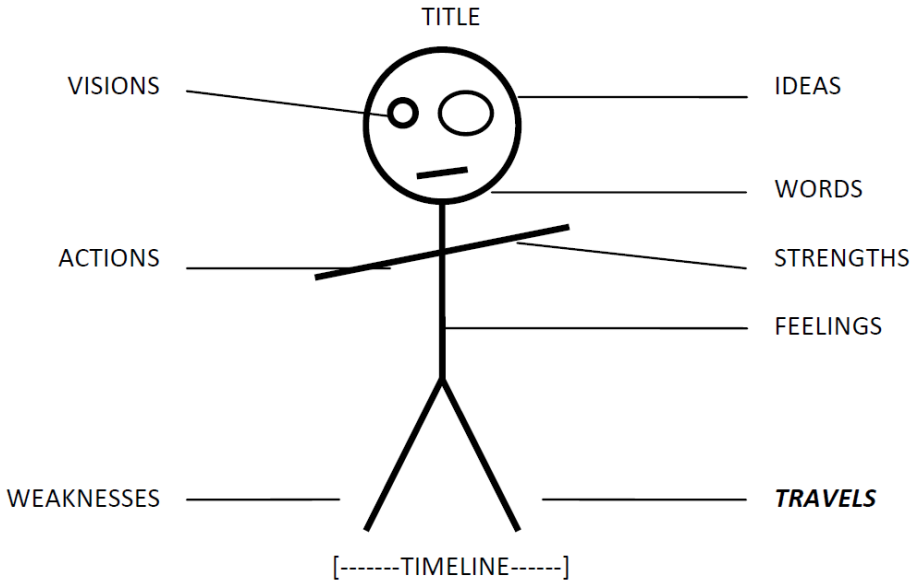
People in Agriculture Personality Portrait

Objective:
To research and report on the life and ideas of someone working in Agriculture. They can be from anywhere in the world. Learn more about someone from your culture OR a culture that is different from yours.

Assignment:
Create a personality portrait poster that provides the rest of the class with the important details of the person you chose.

This "stick figure" format is useful in providing a variety of information about people while allowing for creativity, design, humor, and artistic expression within this form of communication.

The stick figure format should include as much of the following information as possible: ideas, vision, words, actions, strengths, feelings, weaknesses, and travels; as well as a timeline of key events in their lifetime and major world or regional events related to their legacy. **Please record your findings in the Research Chart.**



Assessment:25 points (This will include a self-reflection on the last day of class)

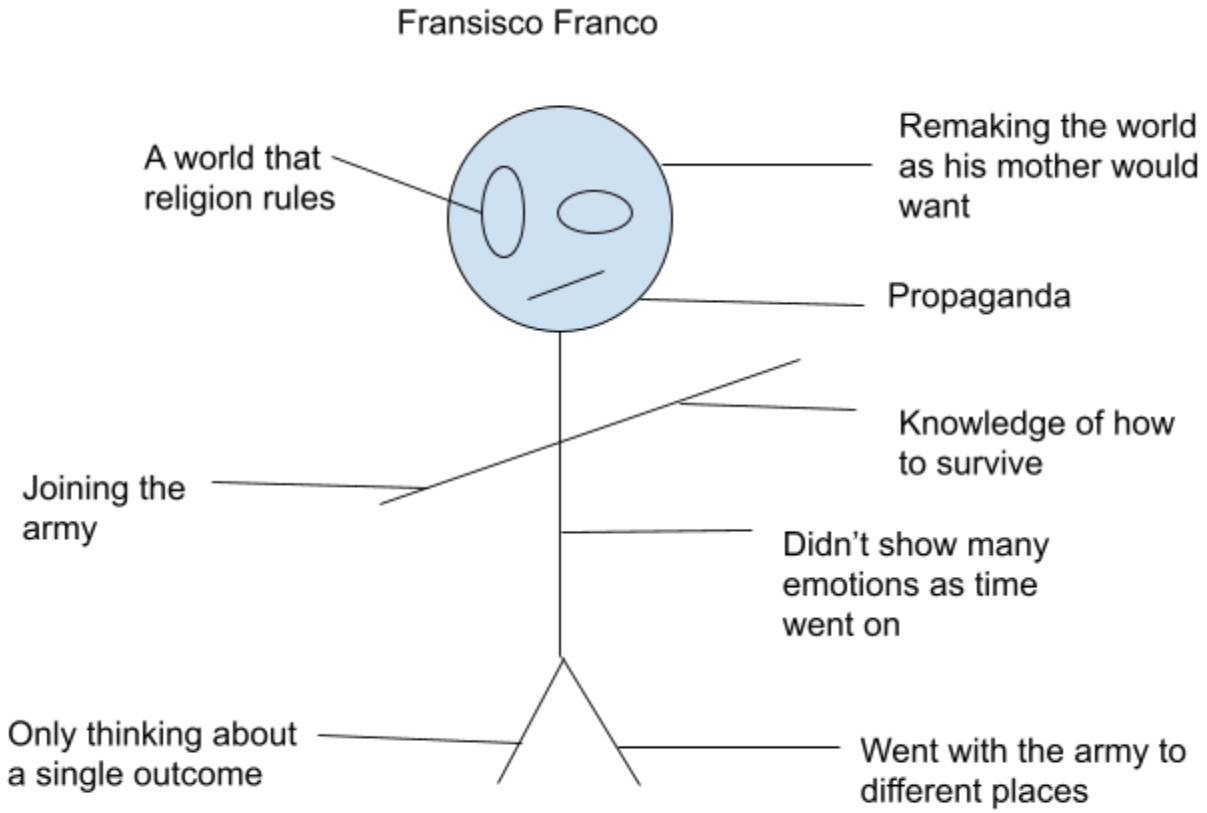
Your poster will be evaluated on the following:
____ Quality and Quantity of Research. (5 points)
o How much time and effort has gone into investigating the life and times of this person?
- Uses 2 or more reliable sources
- Evidence that sources were actively read

____ Design and Execution of the Poster. (10 points)
o Is it evident that you put thought, time, and effort into the construction of your poster? Is it colorful and easy to read? Is it appropriate for your audience? Do you use multiple methods to inform a variety of stakeholders? (Pictures, text, additional resources, multilingual, etc?) Are names and keywords spelled correctly? Do you use appropriate capitalization and punctuation?

Name Date

____ **Quality of Presentation.** (10 points)
o You will either present this in person or create a screencast. Is it evident that you prepared for the presentation? Do you speak clearly and slowly? Is your tone appropriate for your intended audience?

Example



Research Chart- Please turn this in with your finished poster.	
Questions	**Actively read information with sources (Pictures, videos, text, etc)**
1) Which scientist are you researching?	
2) IDEAS: What are some of their thoughts and/or beliefs?	
3) VISION: What sort of future do they have in mind? What are some of their goals?	
4) WORDS: Give a notable quote.	

Name Date

(What is something this person wrote or said?)	
5) ACTIONS: What are some significant things that they did?	
6) STRENGTHS: What are some of their skills?	
7) WEAKNESSES: What do/did they have problems with or need to improve? What challenges or controversy have they faced? Why?	
8) FEELINGS: What emotions have they expressed in relation to their goals? This might include love, hate, frustration, envy, joy, sorrow, etc.	
9) TRAVELS: Where are they from originally? Where did they go?	
10) TIMELINE: What are 4 or more important events in their life?	

Optional sources (These can give you some ideas. You can use your own sources as well)

Person	Resources
Dr. George Washington Carver (USA- Peanuts)	PBS Video with English subtitles Website
Dr. Norman Borlaug (USA-Wheat)	Website
Dr. Michael Kotutwa Johnson (Hopi Reservation, USA- Indigenous Agriculture)	Website
Dr. Maria Andrade (Cape Verde- Sweet Potatoes)	Website

Name Date

Dr. Evangelina Villegas (Mexico- Maize)	Website
Dr. Tempel Grandin (USA- Animal Welfare)	Website
Dr. Yuan Longping (China- Rice)	Youtube Video with multilingual subtitles Website
Dr. Ismahane Elouafi (Morocco- Underutilized crops)	Youtube Video with multilingual subtitles Website

Student Name:
Experiment Name:
Date:

Control Treatment:

	Quantitative Data			Qualitative Data		
Plant #	**Number of leaves**	**Plant Height**	**Plant Width**	**Color**	**Shape**	**Appearance**
Plant 1						
Plant 2						
Plant 3						
Plant 4						

Other Observations:

Experimental Treatment:

	Quantitative Data			Qualitative Data		
Plant #	**Number of leaves**	**Plant Height**	**Plant Width**	**Color**	**Shape**	**Appearance**
Plant 1						
Plant 2						
Plant 3						
Plant 4						

Other Observations:

Class Vertical Garden Data

Directions: Work with your partners to complete the table below. On the last page is a space for you to write down any questions you have as you compare your data with those of other groups.

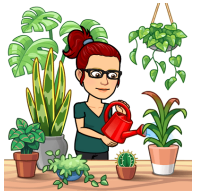


Table 1: Initial measurements and observation from date:_____

	Group 1	Group 2	Group 3	Group 4
Name of Seed (English and other languages)				
Seed/plant image				
Height (cm)				
Length (cm)				
Mass (g)				
Description (color, shape, texture)				

Table 2: Measurement of plant growth- Height above growing medium

	Group 1	Group 2	Group 3	Group 4
Name of Seed				
Height 7 days after planting				
Height 14 days after planting				
Height 21 days after planting				
Height 28 days after planting				

Table 3: Measurement of plant growth- Biomass

	Group 1	Group 2	Group 3	Group 4
Name of Seed				
Biomass 7 days after planting				
Biomass 14 days after planting				
Biomass 21 days after planting				
Biomass 28 days after planting				

Group Claims (Opinions), Evidence and Reasoning

Group Names	**Claim**: We think our plants are___	**Evidence**: Based on our observations we saw…..	Reasoning: This shows that our vertical garden design is ____ because…..

Research questions- What did you wonder as you started comparing data?

Ag Personality Profile Listening Chart

Name: _____

Speaker	Famous Scientist	What they did	Something interesting you learned	Questions you still have about this person
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				

Speaker	**Famous Scientist**	**What they did**	**Something interesting you learned**	**Questions you still have about this person**
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				
Name: _____ Proficiency: Developing:				