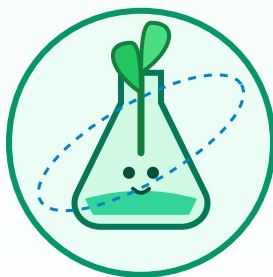




Sammy the Seed & The Science of Hydroponics

Plant Life Cycles, Controlled Environment Agriculture & Student Research Guide



Lead Investigator (Student): _____

Research Laboratory (Classroom):

Science Advisor (Teacher): _____

Investigation Date: _____

 **Next Generation Science Standards: 3-LS1-1 (Life Cycles) & 3-5-ETS1 (Engineering Design)** 

Scientist Name: _____

Date: _____

Unit 1: The Mindset of a Scientist

Exploring Scientific Inquiry, Controlled Variables, and Evidence-Based Reasoning

Key Concept: Scientists do not just memorize facts—they ask testable questions, make systematic observations, collect quantitative data, and construct explanations supported by evidence.

THE FOUR CORE PRACTICES OF A FIELD SCIENTIST

1. Questioning & Hypothesizing

Scientists make observations about natural phenomena and form a **Hypothesis**: a testable, predictive statement structured as "If [action], then [result] because [scientific reason]."

2. Fair Test Investigation (Variables)

Scientists only change **one single condition** (Independent Variable), measure the outcome (Dependent Variable), and keep everything else identical (Controlled Variables).

3. Quantitative & Qualitative Data

Observations require **precise measurements** (plant height in mm, leaf counts, pH levels) rather than vague guesses like "it looks bigger."

4. Communication & CER

Scientists share findings using the **CER Framework**: Make a **Claim**, cite numerical **Evidence**, and explain the underlying biological **Reasoning**.

SCIENTIST'S REFLECTION & IDENTIFICATION CHECK

Q1: Why is it critical for an agricultural scientist to test only ONE variable at a time when comparing plant growth in a vertical hydroponic system versus soil?

Q2: Classify the following data points as either **Quantitative (Qn) or **Qualitative (Ql)** :**

[] The lettuce leaf is vibrant emerald green.

[] The seedling produced 6 true leaves in 10 days.

[] The root system measures 14.5 centimeters.

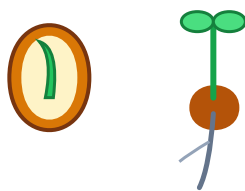
[] The stem feels firm and hydrated.

Unit 2: Plant Anatomy & The 4 Life Cycle Stages

NGSS 3-LS1-1: Developing Models of Organism Growth, Development, and Reproduction

Scientific Modeling: Plants undergo distinct life cycle stages: *Dormancy* → *Germination* → *Vegetative Growth* → *Maturity / Flowering / Seed Dispersal*. Label the anatomical diagrams and match the scientific functions.

Stage 1 & 2: Seed Anatomy & Germination



Key Structures: Seed Coat (Testa), Endosperm (Food Reserve), Radicle (Primary Root), Cotyledon (Seed Leaf).

Stage 3 & 4: Vegetative Growth & Maturity



Key Structures: True Leaves (Photosynthesis), Xylem/Phloem (Vascular Transport), Roots (Water/Nutrient Uptake).

ANATOMICAL FUNCTION MATCHING MATRIX

Plant Structure	Primary Biological Function	Hydroponic Advantage
Cotyledon	Provides initial stored glucose & starch until true leaves emerge.	Starts clean inside Rockwool cubes.
Xylem Vessels	Vascular tissue that pulls water and dissolved minerals upward.	Rapid capillary flow without soil resistance.
Stomata (Leaves)	Microscopic pores that exchange CO ₂ gas and release O ₂ & water.	Optimized by indoor airflow and fans.
Root Hairs	Maximize surface area for mineral absorption & oxygen intake.	Bathed directly in oxygenated nutrient solution.

Investigation Challenge: Why does a seed not require sunlight during the initial stage of germination, but cannot survive without light once its true leaves unfold?

Scientist Name: _____

Date: _____

Unit 3: Informational Text — What is Hydroponics?

Cross-Curricular Science & Technical Reading Comprehension

The Ancient & Modern Science of Soil-Free Agriculture: For centuries, humans believed that plants required rich soil to grow. However, plant physiologists discovered that soil acts primarily as a physical anchor and a sponge to hold minerals. The word **hydroponics** originates from two Greek words: *hydro* (meaning water) and *ponos* (meaning labor or work). In modern hydroponic and aeroponic systems—such as vertical Tower Gardens and Flex Acre grow walls—crops are cultivated entirely without soil.

How Controlled Environment Agriculture (CEA) Works: In a vertical aeroponic system, seedlings sit suspended in specialized net pots filled with porous rockwool or coconut coir. A submersible pump at the base pushes an aqueous solution enriched with essential ionic minerals (including Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium) up through a central distribution pipe. The nutrient-dense water cascades down directly over the bare root systems, delivering perfectly balanced hydration and high dissolved oxygen.

Environmental Sustainability & Global Food Security: Traditional soil farming requires massive acreage, heavy tractors, and millions of gallons of water. Hydroponic systems recirculate closed-loop water, utilizing up to **95% less water** and **90% less land** while producing harvest yields three times faster. Furthermore, because indoor grow walls utilize high-efficiency LED light spectrums calibrated specifically for chlorophyll absorption, crops can be harvested 365 days a year, free of synthetic pesticides and independent of outdoor weather droughts.

TECHNICAL TEXT ANALYSIS & EVIDENCE-BASED QUESTIONS

1. Based on the text, what is the biological function of soil, and why can water replace it?

2. Calculate the Conservation Factor: If a traditional soil farm uses 100 liters of water to produce a head of lettuce, how many liters would a hydroponic system use if it saves 95%?

Show your math equation: _____ Final Hydroponic Water Usage: [] Liters

3. Vocabulary in Context: Define the term "*Closed-Loop System*" as described in the reading:

Lead Investigator: _____

Date: _____

Unit 4: Engineering & Research Project Protocol

Formulating a Controlled Agricultural Investigation & Variable Matrix

Scientific Method Step 1 to 3: Design your classroom agricultural experiment comparing plant growth parameters. Follow the rigorous scientific framework below.

PART I: RESEARCH QUESTION & FORMAL HYPOTHESIS

Select or Write Your Investigation Question:

Example: "How does LED light exposure duration (12 hrs vs. 18 hrs) affect the leaf production rate of Butterhead Lettuce in a vertical tower?"

Formal Hypothesis (If / Then / Because Structure):

IF we _____
THEN the plants will _____
BECAUSE _____

PART II: THE EXPERIMENTAL VARIABLE CONTROL MATRIX

Variable Category	Experimental Factor	How It Will Be Controlled / Measured
Independent Variable (The ONE factor changed)	-----	Applied systematically to Test Group B only.
Dependent Variable (The outcome measured)	-----	Measured in millimeters (mm) and leaf counts every 48 hours.
Controlled Variables (Keep IDENTICAL in all groups)	1. Water Temperature 2. Nutrient Concentration (ppm) 3. Seed Variety (Sammy's Seed)	Calibrated digital TDS meter & pH sensor checked daily.

PART III: MATERIALS & LABORATORY SAFETY EQUIPMENT CHECKLIST

- ☐ Vertical Hydroponic Tower
- ☐ Digital Caliper / Metric Ruler
- ☐ Mineral Nutrient Solution (A+B)
- ☐ Rockwool Starter Plugs
- ☐ Full-Spectrum LED Lights
- ☐ Digital pH & EC/TDS Probe
- ☐ Sammy's Lettuce Seeds
- ☐ Submersible 12V Water Pump
- ☐ Laboratory Safety Goggles

Lead Investigator: _____

Date: _____

Unit 5: 4-Week Quantitative Observation Log & Graphing

Collecting Metric Data, Recording Observations, and Plotting Growth Trajectories

Scientific Rigor: Record systematic data twice a week. Track average stem height (\$mm\$), true leaf counts, and environmental conditions.

BI-WEEKLY LABORATORY GROWTH DATA LOG

Time	Group A Height (mm) [Soil Control]	Group B Height (mm) [Hydroponics]	Leaf Count (Avg)	Water pH / EC	Qualitative Morphological Notes
Day 1	0 mm	0 mm	0	6.0 pH	Seeds sown in Rockwool & seedling tray.
Day 7					Germination observed; radicle emerging.
Day 14					First true leaves visible; roots entering water.
Day 21					Rapid vegetative growth; vascular canopy.
Day 28					Harvest stage; measuring final biomass.

GROWTH CURVE COORDINATE PLANE (PLOT HEIGHT VS. DAYS)



Lead Investigator: _____

Date: _____

Unit 6: Scientific Argumentation & CER Report

Constructing Explanations and Communicating Scientific Evidence

FINAL CER RESEARCH SYNTHESIS

1. CLAIM (Direct answer to your research question):

2. EVIDENCE (Specific numerical & observational data from your log/graph):

3. REASONING (Scientific principles of plant biology/hydroponics explaining why the evidence supports the claim):

★ SCIENTIFIC MERIT RECOGNITION ★

JUNIOR AGRICULTURAL RESEARCH SCIENTIST

This credential certifies that

has successfully executed controlled experimental protocols, analyzed hydroponic growth dynamics, demonstrated scientific inquiry practices, and mastered 3rd Grade Life Science Standards.

Principal Investigator (Teacher)

Date of Certification