



OLLSCOIL NA
GAILLIMHE
UNIVERSITY
OF GALWAY



Taighde Éireann
Research Ireland



STUDENT HANDBOOK

Name:

School:

Class:

WELCOME TO SEEDPOP!

In this project you'll be learning about seed **germination**, **plant stress** caused by **climate change**, and a process call seed **priming** which can help plants grow, even in **stressed conditions**.

This is your Lab Notebook, the place where you'll find lots of information, worksheets that you'll be using during the project, a guide on how to run the experiment, and more.

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We hope you enjoy taking part in the SeedPop! project!

GLOSSARY OF TERMS

Here are the definitions of some new words you will learn during the SeedPop! project.

Activate: To make something (for example, a seed) ready to begin a process.

Analysis: Looking closely at your results to understand what they mean.

Climate change: Long-term changes in the Earth's climate. Today's climate change usually refers to more extreme weather conditions.

Conditions: The surroundings or circumstances that can affect an experiment or an organism.

Concentration of salt: How much salt is mixed into a certain amount of water. The more salt there is in the same amount of water, the higher the concentration.

Data: Information collected through measurements and observations during an experiment.

Dormant seed: A seed that cannot germinate.

Drought: A long period with much less rain than usual. Drought makes it difficult for plants to get enough water and can cause salt to build up in the soil.

Food security: Making sure everyone has enough safe and nutritious food.

Germination: A process that allows a seed to grow into a new plant.

Hypothesis: An idea or possible explanation that can be tested through an experiment.

Observations: Information gathered by carefully using your senses (such as sight, hearing or touch) or scientific tools, such as a ruler, magnifying glass or thermometer.

Photosynthesis: How plants make their own food and other chemicals using light.

Plant stress: Anything that acts negatively on a plant.

Priming: A method to improve a seed's ability to germinate and grow, even when stressed. There are many ways to prime a seed. In SeedPop!, we use seeds that have been primed by soaking them in a chemical solution.

Protocol: A detailed set of step-by-step instructions explaining how to do an experiment.

Radicle: the first small root to emerge from a seed during germination.

Resilience: To be able to resist a stress.

Stress memory: The ability to remember a previous stress to resist better a second one.

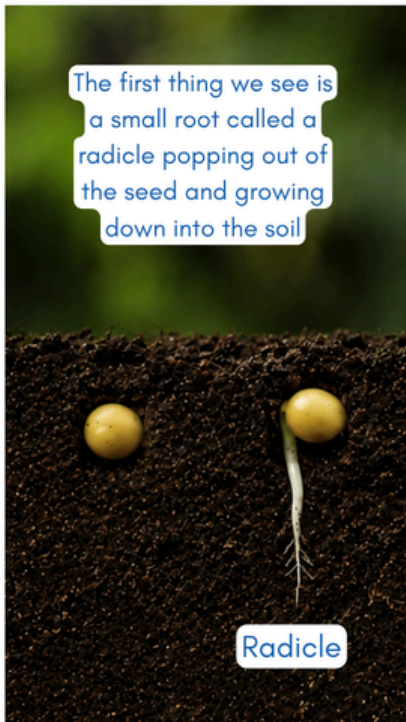
Stress-response: What a plant or animal does to protect itself against a stress.



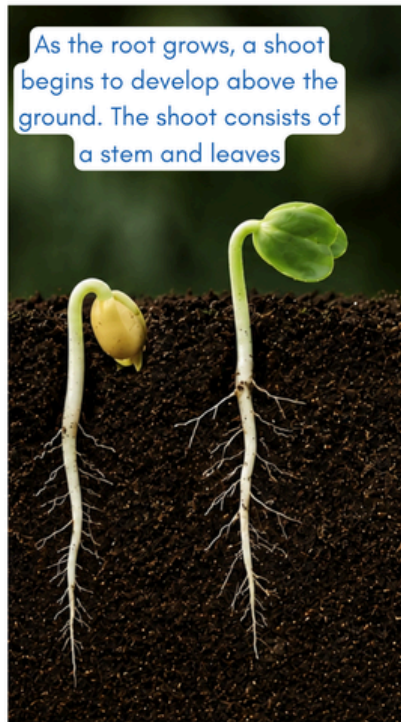
SEED GERMINATION

Seed germination allows a dormant seed to transform into a growing plant. It requires the right combination of water, light, warmth and oxygen to activate the seed and initiate root and shoot growth.

Stage One



Stage Two



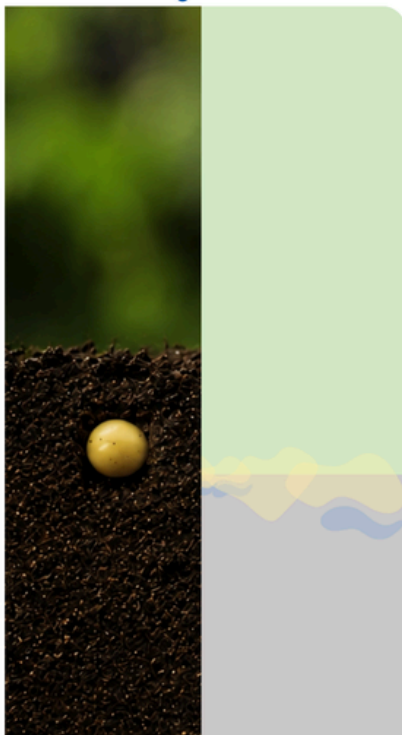
Stage Three



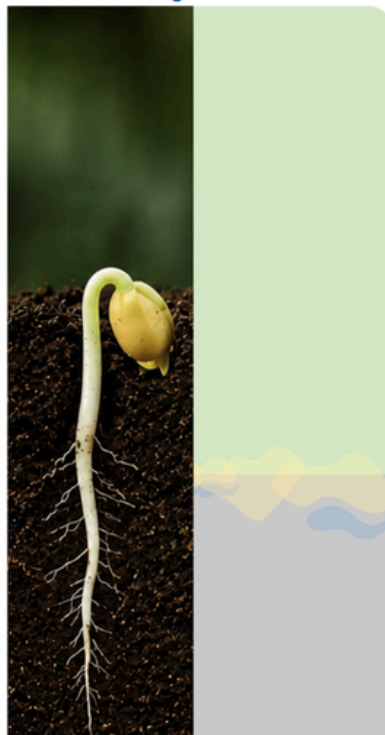
FILL IN THE BLANKS

The images below show the first part of each stage of germination. Can you draw what happens next in each stage and label the different parts of the plant?

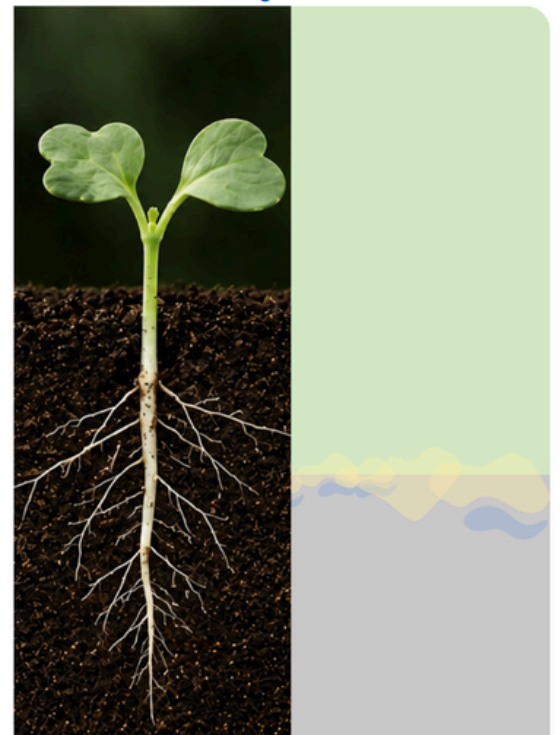
Stage One



Stage Two



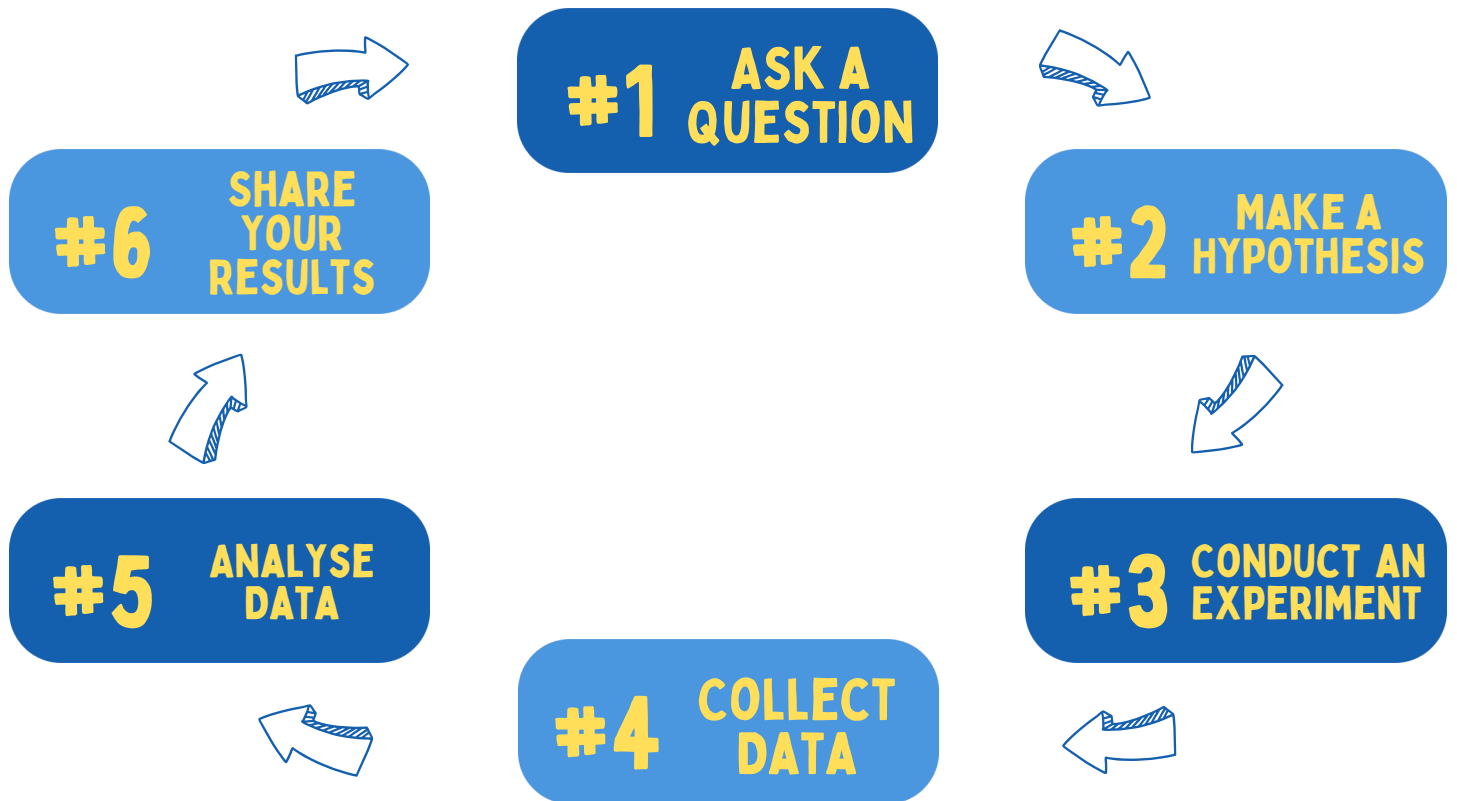
Stage Three



Q: Why do roots grow down towards soil and the shoot goes up?

A: Because plants can sense gravity and know which way is up and which way is down.

THE SCIENTIFIC METHOD



When you think like a scientist, you learn from your mistakes and try again.

By doing experiments, scientists often discover that their hypothesis is wrong- but that is not a bad thing- every failure teaches us something, and helps us move forward until we solve a problem.

FORMING A HYPOTHESIS



A hypothesis is your best idea about the answer to a scientific question. You test it with an experiment to find out if it is correct.

The easiest way to write a hypothesis is to use this "fill-in-the-blanks" sentence.

IF [I do this action]...

THEN [this specific thing will happen]...

BECAUSE [this is the scientific reason why].

Here is an example:

Question:

"What happens to a seedling when light comes from only one side?"

Hypothesis:

"***IF*** a seedling receives light from only one side,

THEN it will grow towards the light,

BECAUSE plants need light to grow."

Now you give it a try with these questions:

Question 1:

"What happens to seeds if they do not receive any water?"

Hypothesis:

IF

THEN

BECAUSE

Question 2:

"How does salty water affect seed germination and growth compared with fresh water?"

Hypothesis:

IF

THEN

BECAUSE

Now let's write a ***hypothesis*** for the experiment you'll be doing in class. Think back to the questions you came up with.

We are trying to figure out if primed seeds might help Liam and Lisa grow a strong crop of rapeseed plants on their farm, even drought conditions when soil becomes salty.

Your research question: Does priming help rapeseed seeds germinate and grow, especially in salty conditions?

Complete your hypothesis:

IF

THEN

BECAUSE

How will we test our hypothesis?

We need to make two comparisons:

- **Water & salt water:** to check whether salt affects seed germination and growth.
- **Primed & unprimed seeds:** to test whether priming affects how seeds germinate and grow in each condition.

Complete the table to create the **four experimental conditions**.

"Primed seeds + water" has been completed as an example.

	Water	Salt water
Primed seeds	Primed seeds + water	
Unprimed seeds		

Now think about the comparisons:

- What can we learn by comparing seeds grown with water and seeds grown with salt water?
- Why do we compare primed and unprimed seeds in both water and salt water?

NOW THAT YOU'VE WRITTEN YOUR HYPOTHESIS AND DESIGNED YOUR EXPERIMENT, YOU'RE READY TO SET IT UP AND CARRY IT OUT. REMEMBER: EVEN IF YOUR RESULTS DO NOT MATCH YOUR HYPOTHESIS, THE DATA YOU COLLECT WILL STILL TEACH YOU SOMETHING IMPORTANT!



SeedPop! Experiment Protocol



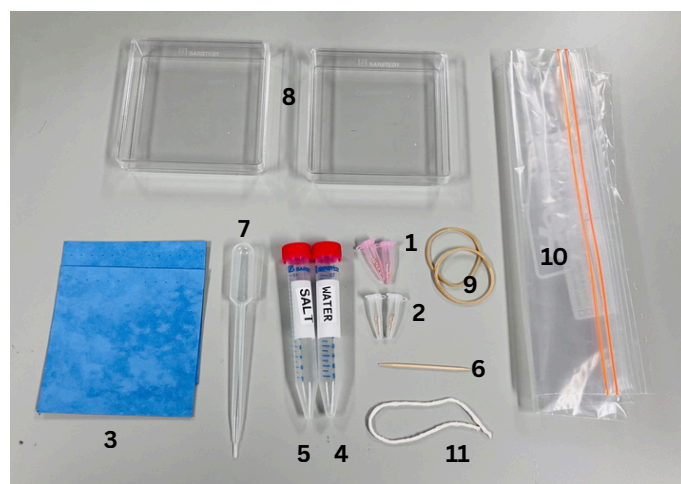
This protocol will guide you through the experiment, setting it up, measuring the roots, collecting and analysing the data and sharing your results with others. It contains the following sections;

1. Materials Checklist
2. Experiment Procedure - Step by Step Instructions
3. Measuring Root Growth - Step by Step Instructions

Materials Checklist

Here is a list of all of the items you will need to conduct your experiment. Take a moment to make sure you have everything listed here.

1. 2 small tubes with 5 primed seeds (pink tube marked with P)
2. 2 small tubes with 5 unprimed seeds (transparent tube marked with UP)
3. 2 square blue filter paper sheets
4. 1 empty tube (15 mL)
5. 1 tube with salt (15 mL)
6. 1 toothpick
7. 1 transfer pipette
8. 2 square petri dishes
9. 2 rubber bands
10. 1 plastic bag
11. 1 measuring string



Also needed, but not included in your kit are the following;

- Ruler (minimum 10 cm)
- Permanent Marker,
- Cup/jug of water.

You should have a ruler in your pencil case and your teacher will have a permanent marker pen for you all to use.

Experiment Procedure

Key Things to Note:

- Label the **petri dish lid**, not the base.
- Complete **one step at a time** before moving on to the next.
- This experiment is about **comparing** the plants in the two petri dishes.
- Take the time to **carefully note the differences** between signs of germination and root growth on days 3, 6 & 7
- Place the two petri dishes side by side on each **observation** day to make it easy to spot the **differences**. Write down what you see.

Step One

- Using a permanent marker, label **the lid** of one petri dish lid as "**Water**" and the other as "**Salt**."
- On each lid, **draw a line down the middle**. Label one half "**P**" for primed seeds and the other half "**UP**" for unprimed seeds

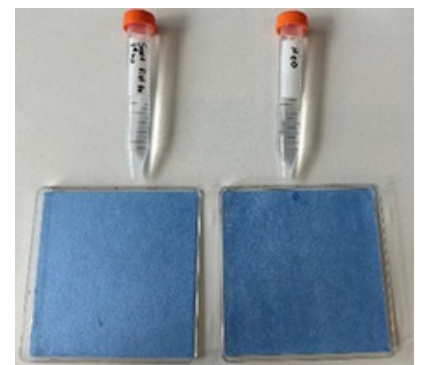


Step Two

- Using the **transfer pipette**, pour **12 mL of water** into both tubes.
- **Shake the "salt" tube** until the salt fully dissolves and disappears. This makes the saline solution.

Step Three

- Insert the blue filter paper into **the lid** of the square petri dishes.
- Gently **spread the water** all over the blue filter paper in the lid labelled "**water**".
- Gently **spread the saline solution** all over the blue filter paper in the lid labelled "**salt**".

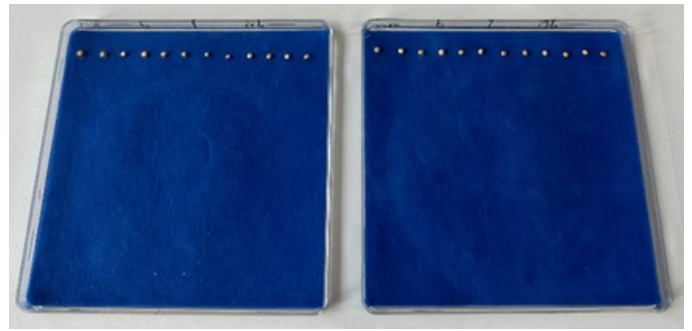


Step Four

- Make sure there are no air bubbles under the blue filter paper by gently smoothing its surface with your finger.

Step Five

- Use the **toothpick** to carefully place **5 unprimed seeds** and **5 primed seeds** on the blue filter paper **in each of the dishes**, spacing them evenly.



Step Six

- Place the bottom of the dish on the lid so it slightly touches the seeds. Use a rubber band to keep it closed.



Note: Do not squash the seeds with the lid. Place it gently on top of them.

Step Seven

- Place both assembled petri dishes in one provided plastic bag. Fold any extra plastic behind the dish to keep it neat.
- Write your names on the plastic bag.



Step Eight

- Place the setup in an upright position near a window.

Observing Changes (Days 3, 6 & 7)

Now that you have set up your experiment it is time to **observe the differences between your two petri dishes**.

On each of the three days, you should:

- Take your experiment away from the window and bring them to your desk.
- Place the two dishes side by side.
- Look for differences between the two dishes. Have some seeds germinated, and others have not? Are some roots longer than others?
- Take the time to find as many differences as you can.
- Take notes to record what you see. The more detail you can include the better!

Note: *Three days after setting up your experiment, measure the roots for the first time (Day 3) using the 10-centimeter string provided. Measure again on Day 6 and Day 7. You will take 3 measurements in total. Write down the measurements on the Root Measurement Table provided.*

Measuring the Root Growth (Day 3, 6 & 7)

Day 3 of your experiment is the first time you will make observations and try to measure any root growth.

Important things to Note:

- **Roots on Day 3 may be very short**, or just beginning to emerge.
- Some seeds will may not even have germinated - this is expected! If any of the seeds have root growth, you can attempt to measure it using the string.
- If there are no roots to measure, **record your observations in the notes section of the measurement table**.

DO NOT LIFT THE LID OF YOUR PETRI DISHES WHEN MEASURING ROOTS

When roots begin to emerge from the seeds, chances are they will not grow in a straight line. It is very difficult to measure something curvy with a straight ruler! This is why we have included a short length of string in your toolkit.

To take a measurement;

- **Place the string next to the root** from the seed to the tip.
- **Mark the spot where the root ends (Figure 1)** by grasping the string tightly between your fingers at the root end.
- Keep a tight hold of the string and bring it to the ruler
- **Hold the string up to the ruler (Figure 2)** to see how many millimeters the length is from the top of the string to the point where you are grasping it.
- Write that measurement down on your root measurement table
- Repeat these steps for every seed in your petri dishes, one after the other.
- You will do the same task again on Day 6 and for the final time on Day 7.



Figure 1.

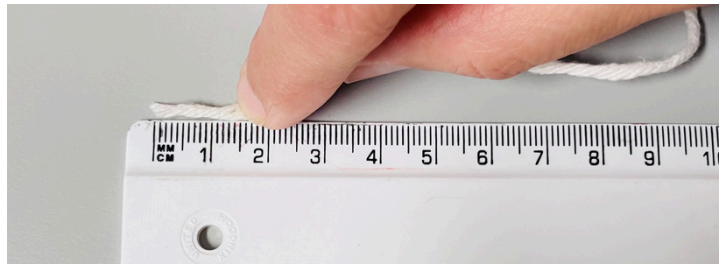


Figure 2.

Note: as you are observing changes and measuring the root growth of your seeds, think about your research questions and hypothesis.

ROOT MEASUREMENTS:

WATER – UNPRIMED SEEDS



Use this table to write down the **length of the roots** emerging from each seed on **Day 3, 6 & 7**. Be as **precise** with your measurements as possible. You can also note your **observations**—look closely to see **differences** between the two dishes!

Do your observations match your hypothesis? Do you need to double check any measurements?

Day	Seed 1	Seed 2	Seed 3	Seed 4	Seed 5	Average
3 Measurement						
	Notes					
6 Measurement						
	Notes					
7 Measurement						
	Notes					

ROOT MEASUREMENTS: WATER – PRIMED SEEDS



Use this table to write down the **length of the roots** emerging from each seed on **Day 3, 6 & 7**. Be as **precise** with your measurements as possible. You can also note your **observations**—look closely to see **differences** between the two dishes!

Do your observations match your hypothesis? Do you need to double check any measurements?

Day	Seed 1	Seed 2	Seed 3	Seed 4	Seed 5	Average
3 Measurement						
6 Measurement						
7 Measurement						

ROOT MEASUREMENTS:

SALT WATER – UNPRIMED SEEDS



Use this table to write down the **length of the roots** emerging from each seed on **Day 3, 6 & 7**. Be as **precise** with your measurements as possible. You can also note your **observations**—look closely to see **differences** between the two dishes!

Do your observations match your hypothesis? Do you need to double check any measurements?

Day	Seed 1	Seed 2	Seed 3	Seed 4	Seed 5	Average
3 Measurement						
6 Measurement						
7 Measurement						

ROOT MEASUREMENTS: SALT WATER – PRIMED SEEDS



Use this table to write down the **length of the roots** emerging from each seed on **Day 3, 6 & 7**. Be as **precise** with your measurements as possible. You can also note your **observations**—look closely to see **differences** between the two dishes!

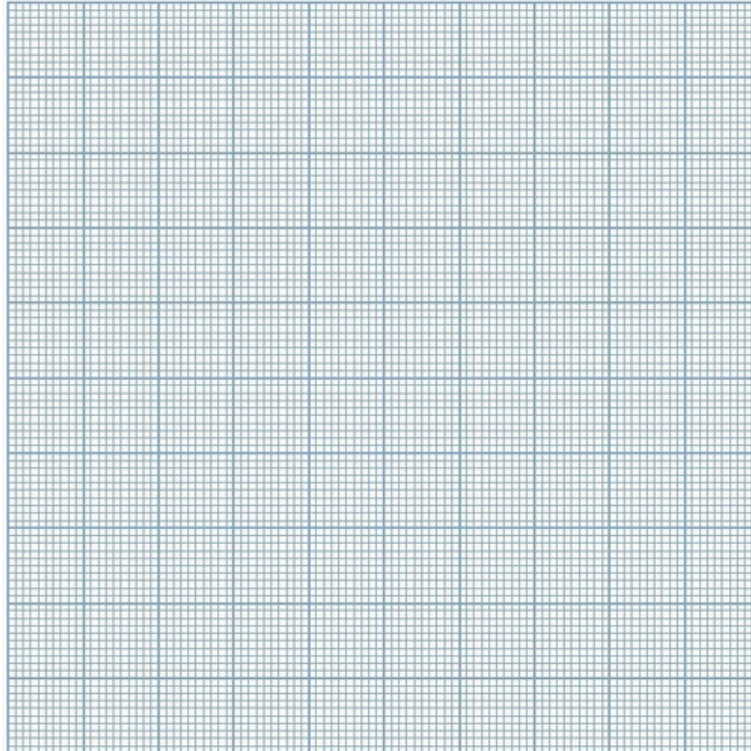
Do your observations match your hypothesis? Do you need to double check any measurements?

Day	Seed 1	Seed 2	Seed 3	Seed 4	Seed 5	Average
3 Measurement						
6 Measurement						
7 Measurement						

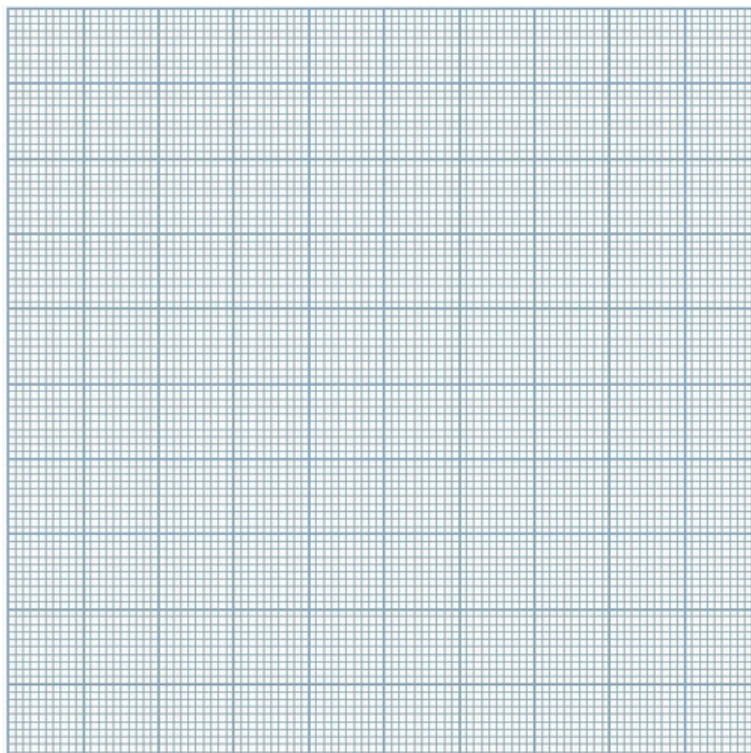
AVERAGE ROOT GROWTH IN WATER

Graphs help us present our data clearly, spot patterns and make sense of our results. Use the two grids to draw line graphs showing the average root measurements for primed and unprimed seeds grown in water.

Water - Primed Seeds



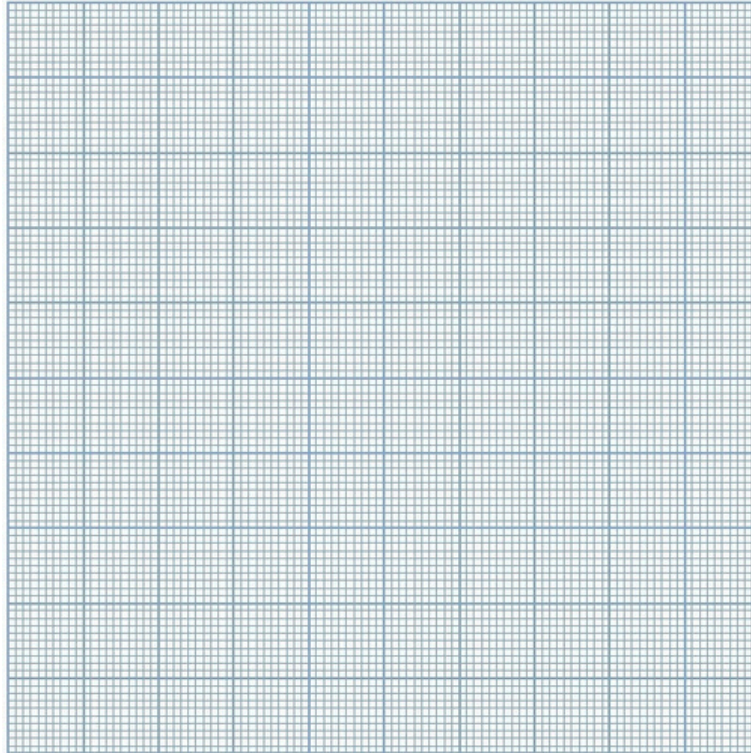
Water - Unprimed Seeds



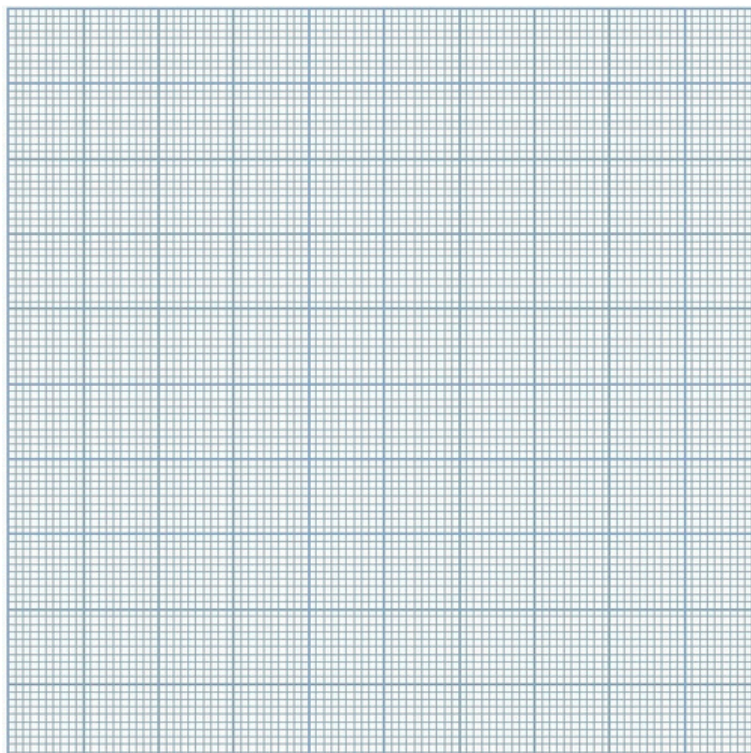
AVERAGE ROOT GROWTH IN SALT WATER

Graphs help us present our data clearly, spot patterns and make sense of our results. Use the two grids to draw line graphs showing the average root measurements for primed and unprimed seeds grown in salt water.

Salt Water - Primed Seeds



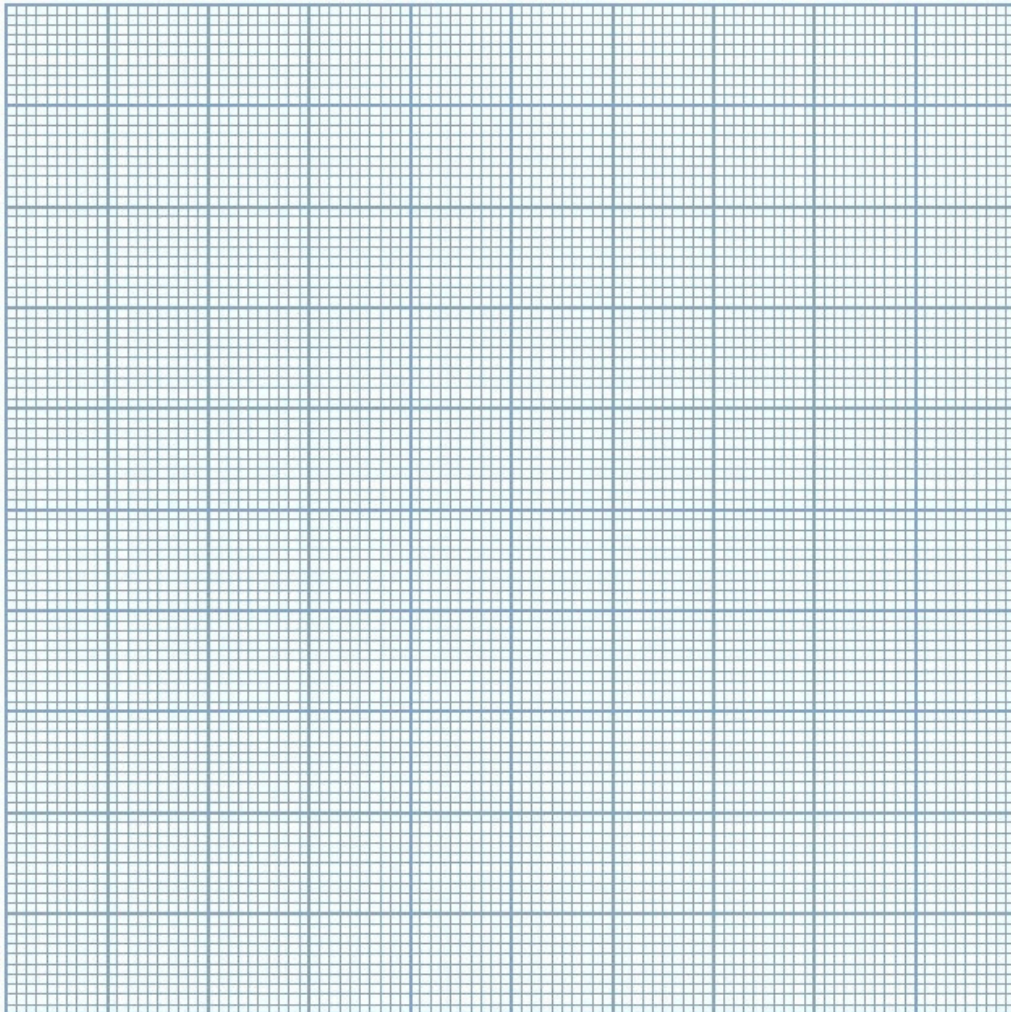
Salt Water - Unprimed Seeds



COMPARING ALL FOUR CONDITIONS

Putting all four conditions on one graph will help you compare the results and spot differences between them.

Plot the **average** root measurements for **all four conditions** on the same grid. **Use a different colour or symbol for each line**, and label each line clearly.



Key: Draw the colour or symbol you used beside each condition

Water + Primed Seeds

Water + Unprimed Seeds

Salt Water + Primed Seeds

Salt Water + Unprimed Seeds





TITLE: GIVE YOUR POSTER AN INTERESTING TITLE

Authors: Your names

INTRODUCTION:

WHY DID YOU DO THE EXPERIMENT?

AIM:

WHAT DID YOU WANT TO FIND OUT?

HOW DID YOU TEST THE HYPOTHESIS?

RESULTS:

WHAT HAPPENED DURING THE EXPERIMENT?

WHAT OBSERVATION DID YOU MAKE WHEN YOU COMPARED YOUR TWO PETRI DISHES?

WHEN LOOKING AT YOUR MEASUREMENTS AND OBSERVATION NOTES, WHAT IS THE ANSWER TO THE QUESTION YOU ASKED?

PROCEDURE:

WHAT DID YOU DO?

HOW DID YOU DO IT?

WHY DID YOU DO IT?

CONCLUSION:

DID YOUR RESULTS PROVE YOUR HYPOTHESIS?

HOW WILL YOUR FINDINGS HELP FARMERS LIKE LIAM AND LISA?



TITLE:

Authors:

School:

INTRODUCTION:

AIM:

RESULTS:

PROCEDURE:

CONCLUSION:

SEEDPOP! SKETCHES & SCRIBBLES

Use this blank page to write down your own thoughts or draw sketches....

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