

SeedPop! Teacher's Guide



General Description

The SeedPop! Project is a teacher-led programme consisting of five sessions designed to introduce young students to the science of plants and food crops. The programme places these topics within the context of a rapidly changing environment and the growing need for more sustainable agricultural solutions.

Through our hands-on SeedPop! Toolkit, you will give your students the opportunity to become plant scientists. The sessions will help them understand how environmental factors, such as salinity caused by drought, is a harmful environmental stress faced by farmers and has a detrimental effect on plants. The learning will focus on seeds, a cornerstone of our agricultural and food systems. Students will also explore how science can drive the development of environmentally friendly solutions to secure future food production.

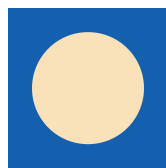
Using hands-on activities, children will explore seeds, germination, seed priming, and the scientific methods used to study them — as well as why this research matters in agriculture and everyday life.

On completion of the SeedPop! Toolkit, your students will;

Understand the biological processes underlying seed germination	Have hands-on experience observing the effects of environmental stress, such as high salt, on plant growth
Have gained knowledge of sustainable agricultural practices that support improved crop performance	Understand the role that scientists have in helping to solve big world issues such as climate change and food security

To gain this knowledge, students will set up an experiment to germinate seeds and observe root growth, mirroring real laboratory methods used by scientists. They will study root development in normal seeds and explore how 'priming' — a specific method of preparing seeds for germination — can improve this process. They will also observe the difference that salinity can make to the growth of roots.

The SeedPop! toolkit includes all resources needed to set up the experiment, including materials for observation, data recording, analysis, and presentation of results. As part of the SeedPop! Project, your class will also have the opportunity to meet a scientist, increasing their awareness of STEM careers and providing an opportunity to ask questions of relatable role models.



Learning Objectives & Outcomes

The SeedPop! project has been designed for students in 5th/6th class- a key transition period when learners begin forming long-term attitudes toward science and STEM. This age group is also especially receptive to real-world learning through exploration and hands-on activities.

The project also supports you, the teacher with a fully-resourced, low-prep kit aligned with the Science, Technology, Engineering, and Mathematics (STEM) Education curriculum. To bring the SeedPop! experience to your classroom, you will receive guidance and training from a dedicated project manager, helping to support this experience of delivering STEM education.

Learning Objectives

By the end of this series of activities, students will;

- Understand the biological processes underlying seed germination.
- Understand how to observe the effects of environmental stress of seed growth.
- Apply the scientific method through a hands-on experiment.
- Understand sustainable innovations for agriculture

Learning Outcomes

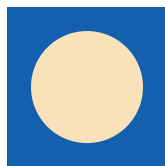
By the end of this series of activities, students will be able to;

- Explain the process of seed germination
- Explain the role of priming in plant growth
- Explain why priming is important in agriculture
- Explain the role of agriculture in food security
- Explain the impact of climate change on agriculture
- Conduct a germination experiment using the scientific method (forming a research question, setting up the experiment, observing, recording root growth, and analysing results)
- Analyse, discuss, and present their scientific findings

Expected Impact on Science-Related Attitudes

Beyond scientific knowledge, this toolkit aims to;

- Broaden children's perception of who can be a scientist.
- Develop an understanding of how scientists contribute to solving real-world problems.



Curriculum Connections

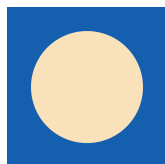
The SeedPop! Science Learning Toolkit has been designed to support the Science, Technology, Engineering and Mathematics (STEM) education curriculum for primary school students. It provides opportunities for students to develop their curiosity, STEM skills, conceptual and procedural understanding, critical thinking, and capacity to communicate ideas using disciplinary language.

STEM Education Strands	STEM Education Elements	Key Competencies
Nature of STEM — Identify and appreciate the key features of the Nature of Science, Technology, and Engineering. Explore and discuss topical STEM issues in Ireland and globally	Exploring and understanding	Being an active citizen
Living Things — Demonstrate an awareness of how learning about living things connects to the wider field of Biology and related 'Bio' disciplines.	Creative and critical thinking	Being an active learner
	Applying and problem-solving	Being a communicator and using language
	Evaluating and communicating	

Real-World Connections

Completing the SeedPop! activities helps students develop skills and knowledge relevant to everyday life, including:

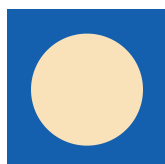
- A better understanding of how to grow plants and the science of agriculture.
- Awareness of how plant science connects to global challenges such as climate change and food security.



General Organisation

The SeedPop! Science Learning Toolkit is structured across five sessions, each lasting between 20 and 60 minutes.

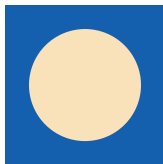
Session	Topics to be Explored	Duration
Session 1	Understanding seed germination, the impact of climate change on crop growth (drought and salinity) and understanding the ways scientists are working to address the challenge of climate change on agriculture (priming)	40 mins
Session 2	Introduction to the Scientific Method, learning how to form a research question, and establishing a hypothesis for the experiment	40 mins
Session 3	Seed priming experiment setup & root measurements	60 mins + 20 min seed check x 3
Session 4.1	Graphing results and analysing data	60 mins
Session 4.2	Presenting your research findings	40 mins
Session 5	Scientific Conference with visiting scientists	60 mins



Resources Provided

The SeedPop! toolkit is a compact, ready-to-use classroom resource containing;

- Consumables for a seed germination experiment
- Digital access to;
 - Teacher Guide, Lesson Plans & Theory Manual
 - Powerpoint slides for each Session to guide your class through the project
 - Student Handbook containing all worksheets and experiment templates
 - Evaluation tools and surveys



SeedPop! Lesson Plans

The SeedPop! toolkit has been designed as to take place across five learning sessions, each with their own hands-on activities, learning objectives and learning outcomes.

Ranging in duration from 50-60 minutes, the toolkit can be explored in the classroom over a 2-3 week period. (Note that the experiment, which takes place during Session 3 requires 7 days – this allows for root growth, observation and measurement of data.) Session 5 is an opportunity to have scientists visit your classroom and run a ‘Scientif Conference’ that allows your students to present their work.

Session 1

Understanding seed germination, the impact of climate change on crop growth, priming - a method scientists are working on to address the challenge of climate change on agriculture

To begin their exploration of the SeedPop! Toolkit, students will be presented with the foundational learning material that underpins the hands-on experiment.

Duration

40 minutes

Topics to be explored in this session;

- Understanding Seed Germination
- Climate Change & its impact on crop growth – learning about drought and salinity
- Priming of seeds - a method scientists are working on to address climate change challenges

Learning Outcomes

- Understand the seed germination process
- Discover the impact of environmental stresses, particularly climate change, on plant growth
- Define seed priming

Resources Provided

- SeedPop! Session One slides
- Student Handbook containing;
 - Handout – graphic illustration of the seed germination process with key terms clearly labelled

- Worksheet – graphic illustration of the seed germination process with missing pieces that the students must fill in to complete the full process.
- Optional:
 - Samples of seeds
 - Two cards games that can be used for the students to explore a range of seeds and their uses.

Lesson Structure

Segment	Action	Duration
SeedPop! Session One Slides	Start the lesson with the powerpoint.	30 mins
Handout	Found in the Student Handbook. Read through key points, including; • the three stages of seed germination • conditions required for seeds to germinate	10 mins
Worksheet	Found in the Student Handbook. Encourage students to fill in the blanks to complete the diagram of the seed germination process, working from memory first, before reviewing with the Germination Handout.	10 mins

Advanced preparation required

- Download Session 1 Slides
- Distribute Student Handbook
- Have Card game and real seed samples ready to distribute



Session 2

Getting to know the Scientific Method, how to form a research question, and establishing a hypothesis

Duration

40 minutes

Topics to be explored in this session;

- Introduction to the Scientific Method
- How scientists conduct experiments in the lab
- Forming a scientific research question

Learning Outcomes

- Understand the scientific method
- Understand the scientific hypothesis and how to form a question as a hypothesis

Resources Provided

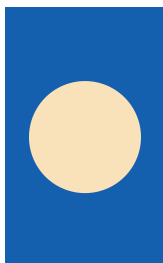
- SeedPop! Session Two Slides
- Student Handbook containing;
 - Worksheet – forming a hypothesis
 - Handout- an at-a-glance diagram of the Scientific Method

Lesson Structure

Segment		Action	Duration
SeedPop! Session Two Slides		Start the lesson with the powerpoint.	25 mins
Handout		Found in the Student Handbook. Read through the 6 steps of the Scientific Method that scientists follow in research	5 mins
Worksheet		Found in the Student Handbook. Students can work in pairs to complete the worksheet which will guide them in forming a hypothesis for the experiment. *Note that there is a point in the Slides where you will be cued to pause and have students complete the worksheet	10 mins

Advanced preparation required

- Download Session Two Slides



Session 3

Seed Priming Experiment

Duration

60 minutes. (Day 0); 20 mins each (Days 3, 6 & 7)

Topics to be explored in this session;

- Setting up & starting your SeedPop! Experiment – Day 0
- Measuring root growth – Days, 3, 6 & 7

Learning Outcomes

- Understand how to set up a scientific experiment
- Implement the seed priming experiment with brassica seeds
- Observe the differences between primed and unprimed seeds under varying conditions
- Develop data measurement skills
- Record data

Resources Provided

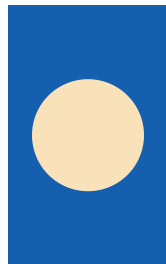
- SeedPop! Session Three Slides – a detailed explanation of how to set up and conduct the experiment as well as measuring root growth on days 3,6 and 7.
- Experiment kit – to include all materials required for the experiment.
- SeedPop! Experiment Booklet (within the Student Handbook) – a checklist of all materials needed for the experiment, a graphic illustration of each step in the experiment process (as seen in the video), worksheets for recording measurements

Lesson Structure

Segment	Action	Duration
SeedPop! Session Three Slides	Start the lesson with the powerpoint.	15 mins
Materials Setup	Distribute the materials needed for the experiment to each group of students. We recommend that students work in pairs or groups of three, to be certain that everyone will be able to play an active role	5 mins
Germination Protocol Demonstration	Guide the students through the protocol using the Germination Protocol located in the Student Handbook. This will include the following; • Labelling: Instruct students to label the lids of their petri dishes (Water & Salt) and mark sections for unprimed (UP) and primed (P) seeds • Filter paper setup: show them how to properly insert and moisten the filter paper. • Preparing Solutions: Demonstrate how to dissolve the salt in the saline solution and distribute it on the filter paper.	10 mins
Seed Placement	Instruct the students to place the primed and unprimed seeds on the filter paper according to the protocol. Ensure they follow proper spacing and sealing of the petri dishes with rubber bands and plastic bags to maintain moisture.	10 mins
Final Setup and Placement	Remind the students to place their petri dishes in a well-lit area (preferably near a window) for germination. Discuss the importance of keeping the setup undisturbed for optimal growth conditions.	5 mins
Root Measurement and Data Recording (20 minutes for each measurement date, on Days 3, 6 & 7	Instruct the students to place the string following the root shape to cover the whole root, and hold the start and end points on the string with their hands. Show them how to determine the root length by measuring the distance between the start and end points of the strong after stretching the string. Remind them to record each measurement in the table included in the Booklet or in their copy book	20 mins

Advanced preparation required

- Download Session Three Slides
- Distribute experiment toolkit materials



Session 4.1

Graphing measurements and analysing data

Duration

60 minutes

Topics to be explored in this session;

- Analysing data collected during experiment
- Learning how to create visual representations of your results – creating a graph

Learning Outcomes

- Analysing data
- Understanding how to create a graph

Resources Provided

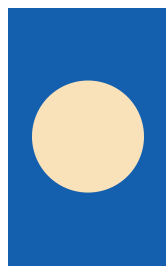
- SeedPop! Session Four Slides – an explanation of how to create a graph from your data and ways to analyse data
- Student Handbook – with instructions on how to create a graph

Lesson Structure

Segment	Action	Duration
SeedPop! Session Four Slides	Start the Lesson with the powerpoint. These include a step-by-step guide on how to create graphs from the root measurements taken in Session 3.	20 mins
Graphing the Results	Guide students on how to create graphs using the Root Measurement Graph template Graph the three measurements taken on different dates (Day 3, 6 and 7) to build the graph. The time of the measurement should be on the x-axis and the root length on the y-axis. Connect the points with a ruler, differentiating primed and unprimed seeds by using two different colours.	30 mins
Analysing Data	The slides will also prompt students on how to use the graphs and their observation notes to analyse the results and draw conclusions	10 mins

Advanced preparation required

- Download Session 4 Slides



Session 4.2

Presenting your research findings

Duration

60 minutes

Topics to be explored in this session;

- Preparing a scientific research poster

Learning Outcomes

- Learn how to demonstrate acquired knowledge using a research poster
- Understand the importance of present results to peers

Resources Provided

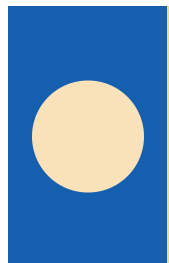
- SeedPop! Session 4.2 Slides – instructions on creating a research poster
- Student Handbook – with instructions on how to create a graph

Lesson Structure

Segment	Action	Duration
SeedPop! Session 4.2 Slides	Start the Lesson with the powerpoint. These are an explanation of the importance of sharing research findings.	20 mins
Creating a Scientific Poster	A guide and template are included in the Student Handbook that students can use to complete their poster	40 mins

Advanced preparation required

- Download Session 4.2 Slides



Session 5

Scientific Conference

Duration

60 minutes

Topics to be explored in this session;

- Sharing experiment findings with classmates and visiting scientists

Learning Outcomes

- Demonstrate acquired knowledge using a research poster
- Present results to peers
- Meet Scientists and hear what it is like to work as a scientist

Resources Provided

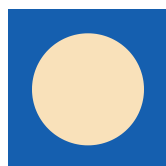
- SeedPop! Session Five Slides - with prompts to guide the Scientific Conference format

Lesson Structure

Segment	Action	Duration
SeedPop! Session Five Slides	Scientific Conference	60 mins

Advanced preparation required

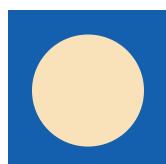
- Download Session Five Slides



Theory Manual

This theory manual is designed to remind you of the key learning concepts that will become relevant as you take your students through this kit. The topics covered here are the basics of;

1. Seed germination
2. Environmental stress
3. Priming & Seed Treatment
4. The importance of Brassica in agriculture



Topic 1: Seed Germination

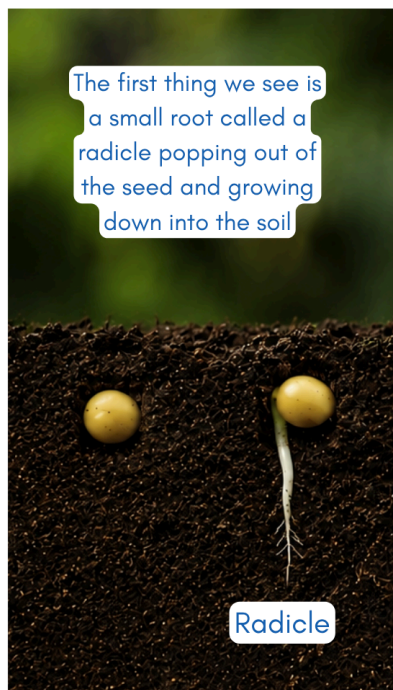
Seed germination is a pivotal process in agriculture, marking the transition from a dormant seed to a vigorous seedling capable of sustained growth. Germination unfolds in several phases; water uptake softens the seed coat, allowing the radicle to emerge and establish the root system. Subsequently, the shoot emerges, forming the initial leaves for photosynthesis. These phases mark the seed's transformation into a seedling, priming it for growth into a mature plant.



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



Brassica species, such as *Brassica rapa* (included in the kit), exhibit unique germination characteristics influenced by genetic and environmental factors. Brassica seeds are renowned for their rapid germination rates and uniform seedling emergence, making them ideal candidates for educational studies on seed biology. Understanding Brassica germination is essential for optimizing seedling establishment, ensuring uniform crop stands, and maximizing yield potential.

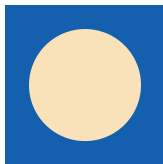


Topic 2: Environmental Stress

Climate change exerts significant environmental effects on plants, altering temperature and precipitation patterns, which in turn affect plant growth, reproduction, and distribution. Increased frequency of extreme weather events such as droughts, floods, and heatwaves further stresses plant populations, potentially leading to shifts in ecosystems and biodiversity loss.

Salt stress, resulting from high soil salinity, poses a significant threat to agricultural productivity worldwide. Excess salts disrupt cellular ion balance, leading to osmotic stress, ion toxicity, and oxidative damage in plants. Salt-affected soils limit water uptake by crops, impair nutrient absorption, and compromise growth and development.

By simulating salt stress in the germination kit, students gain firsthand experience in observing the detrimental effects of salinity on Brassica seed germination and seedling growth. Understanding salt stress is crucial for developing resilient crop varieties, implementing soil management practices, and limiting the impact of salinity on agriculture.

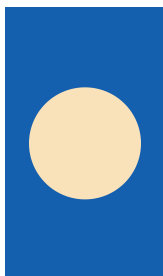


Topic 3: Priming & Seed Treatment

Osmopriming, or priming, is a method used to enhance seed vitality and their ability to withstand environmental stresses. It involves soaking seeds in solutions containing substances like polyethylene glycol (PEG), which prepares the seeds by activating their stress-response genes.

This treatment accelerates germination, improves seedling growth, and enhances the plant's performance even under challenging conditions such as drought or high salt content in the soil. This not only leads to more vigorous and uniformly grown plants but also increases overall crop productivity.

By incorporating osmoprimed seeds into a germination kit, students can observe the effects and importance of advanced seed treatment technologies in agriculture.



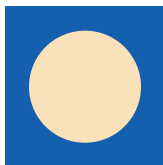
Topic 4: The importance of Brassica in agriculture

Brassica is a key genus within the Brassicaceae family, including several important crops that play significant roles in agriculture and cuisine. Species such as *Brassica rapa*, *Brassica napus*, and *Brassica juncea* are grown for their edible parts like leaves, roots, and seeds.

Vegetables from this group, including broccoli, cabbage, and kale, are highly nutritious, offering vitamins, minerals, and antioxidants that are crucial for a healthy diet. Additionally, Brassica oilseeds, like canola and mustard, are essential for producing edible oils, biodiesel, and livestock feed.

Brassica crops also serve as cover crops, providing benefits such as preventing soil erosion, suppressing weeds, and recycling nutrients, thus enhancing the sustainability and resilience of farming systems.

The diverse uses and adaptability of Brassica crops make them vital for global food security, economic growth, and environmental sustainability.

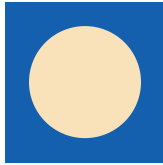


Topics for Discussion

Here are a few suggested topics that could prove useful in leading a class discussion as you explore the learning material included in the toolkit.

- The steps involved in seed germination
- Ways that changes to the climate can have a negative impact on the agricultural sector

- The potential of seed treatment techniques even under stressful conditions
- The Scientific Method and the way it embraces and learns from mistakes- the fail-forward mindset



References

Nadeem, M.; Li, J.; Yahya, M.; Wang, M.; Ali, A.; Cheng, A.; Wang, X.; Ma, C. Grain Legumes and Fear of Salt Stress: Focus on Mechanisms and Management Strategies. *Int. J. Mol. Sci.* **2019**, *20*, 799. <https://doi.org/10.3390/ijms20040799>

Munns R. & Tester M. Mechanisms of Salinity Tolerance. *Ann. Review Plant Biol.* **2008**, *59*: 651-681 <https://doi.org/10.1146/annurev.arplant.59.032607.092911>

Laemke, Joern & Bäurle, Isabel. Epigenetic and chromatin-based mechanisms in environmental stress adaptation and stress memory in plants. *Genome Biology.* **2017**, *18*. [10.1186/s13059-017-1263-6](https://doi.org/10.1186/s13059-017-1263-6)



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;

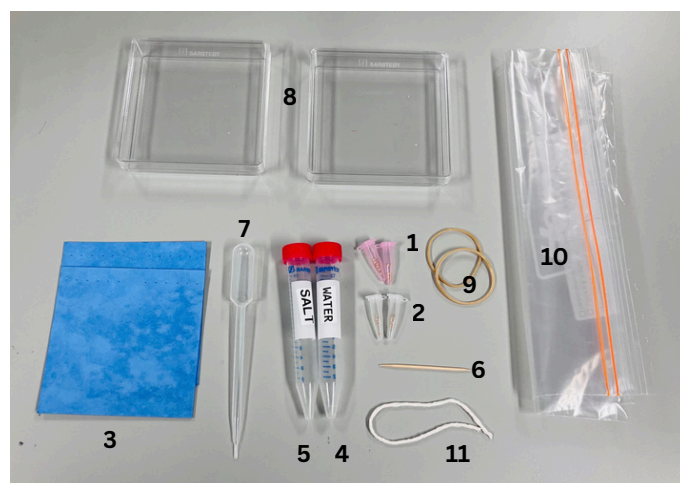
1. Materials Checklist
2. Experiment Procedure - Step by Step Instructions
3. Measuring Root Growth - Step by Step Instructions



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.

Students should have a ruler in their pencil case and you can provide 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.

Setting Up and Beginning Your Experiment: DAY 0

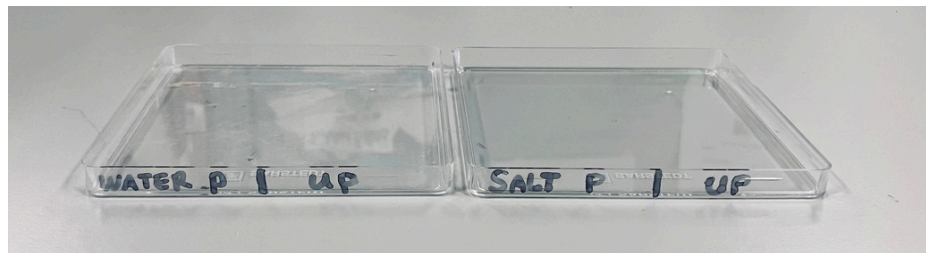
Step One

Using a permanent marker, label **the lid** of one petri dish lid as "Water" and the other as "Salt."

- *This helps us remember which dish has regular water (the control for this experiment) and which one has salty water (causing stress to the plants).*

On each lid, draw **a line down the middle**. Label one half "**P**" for primed seeds and the other half "**UP**" for unprimed seeds

- *This helps us remember which side has the unprimed control seeds and which side has the primed seeds.*



Step Two

Pour 12 mL of water into both tubes. Shake the "salt" tube until the salt fully dissolves and disappears. This makes the saline solution.

- *This step is important because it makes the saline solution that we need for the seeds to test how they grow under salty stress condition.*

Step Three

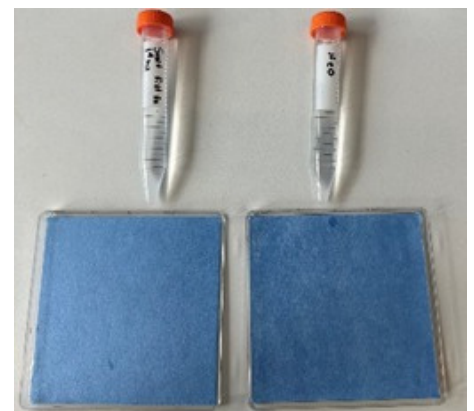
Insert the blue filter paper into the lid of the square petri dishes.

- *Blue filter papers absorb the solution and keeps the seeds moist. It also helps us see the seeds and their tiny growing roots more easily.*

Gently spread the water all over the blue filter paper in the lid labelled "water".

- *This makes sure all the seeds on the paper get enough water to help them grow.*

Repeat the previous step but in this case, use the saline solution and filter in the lid marked "salt".



Step Four

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

- *Avoiding air bubbles is important because they can block water from reaching the seeds, making germination more difficult.*

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.

- *This is important so the seeds have room to grow.*



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.

- *This is important so the seeds stay in place and can grow without getting mixed up.*



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.

- *This step is essential to retain moisture during the germination process.*

Fold any extra plastic behind the dish to keep it neat.

Write your names on the plastic bag so your experiment doesn't get mixed up with anyone else's.



Step Eight

Place the setup in an upright position near a window.

- *This is done so germinating seeds get natural light. You can use a book or other heavy material to place behind the plate so that it does not fall.*



Observing Changes - Days 3, 6 & 7

As this experiment is based on germinating **2 types of seeds** (primed and unprimed) under **different conditions** (one with salty water, one with unsalty water), **observing the differences between your two petri dishes is very important.**

On each of the three days that you examine your experiment and take measurements, take the time to make observations that compare the differences between the two petri dishes first. Take notes to record what you see. The more detail you can include the better!

Place the two petri dishes side by side to allow you to easily compare the differences in germination and root growth between the two conditions.



Measuring Root Growth

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 attempt to measure any root growth that may have begun. **Roots on Day 3 may be very short**, or just beginning to emerge. Some seeds 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 however 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. THIS MAY DISTURB YOUR SEEDS AND ALTER THEIR GROWTH.

Step One

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 measure curvy roots, you can use the string **by placing the string next to the root from the seed to the tip**. Hold the string tightly between your fingers to **mark the spot where the root ends (Figure 1).**



Figure 1.

Step Two

Then, hold the string up to the ruler to see how many centimeters that length is.
Check the root length by placing the string next to a ruler and reading the number (Figure 2).



Figure 2.

Step Three

Write the measurement down on your Root Measurement Table. Be as precise as possible!

Repeat these three 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.

Use this table to write down the length of the roots emerging from each seed on Day 5, 6 & 7. Be as precise with your measurements as possible. You can also note your observations—look closely to see differences between the seeds!

Salt | Unprimed Seeds

Day	Seed 1	Seed 2	Seed 3	Seed 4	Seed 5	Seed 6	Average
3							
Notes							
6	0	0	0.1 cm	0.6 cm	0.25	0.7 cm	0.475 cm
Notes	Nothing	Nothing	tiny bit radicle no leaves	Small Radicle	Small Radicle and its opened up	Small Radicle	
7	0	0	0.2	0.4 cm	0.7	0.9 cm	0.55 cm
Notes	Still no growth	No growth yet	really tiny, still no leaves	Shrink	Small radicle but grew baby leaves	Grew, radicle is putting on the top	

Example root growth measurements from Pilot 1

Note: This example uses an earlier template with space for six seeds. In this activity, you will measure five seeds