Cambridge Assessment International Education

Skills Pack

Investigating the effect of sodium chloride concentration on the growth of germinated seeds

Cambridge IGCSE®

Biology

0610

This *Skills Pack* can also be used with the following syllabuses:
- Cambridge IGCSE® (9–1) Biology **0970**
- Cambridge IGCSE® Combined Science **0653**
- Cambridge IGCSE® Coordinated Science **0654**
- Cambridge O Level Biology **5090**

Version 1.0

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Skills Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Skills Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Investigating the effect of sodium chloride concentration on the growth of germinated seeds

This *Skills Pack* focuses on an investigation into the effect of changing the concentration of sodium chloride, or common salt, on the germination of mung beans, a type of seed.

In many parts of the world, low-lying fields used to grow crops are flooded by seawater after heavy rains and extreme weather events. The lower water potential of the surroundings can have significant effects on young plants as they develop and grow.

This experiment has links to the following syllabus content (2023 – 2025 Syllabus):

- **3.2.5.** Investigate and describe the effects on plant tissues of immersing them in solutions of different concentrations.
- **3.2.8.** Explain the effects on plant cells of immersing them in solutions of different concentrations by using the terms: turgid, turgor pressure, plasmolysis, flaccid.
- **8.2.1.** Identify in diagrams and images root hair cells and state their functions.
- **8.2.3.** Outline the pathway taken by water through the root, stem and leaf as: root hair cells, root cortex cells, xylem, mesophyll cells.
- **16.3.8.** Investigate and describe the environmental conditions that affect germination of seeds, limited to the requirement for: water, oxygen and a suitable temperature.

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- make and record observations, measurements and estimates.
- interpret and evaluate experimental observations and data.
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- **3.2.2.** State that water diffuses through partially permeable membranes by osmosis.
- **3.2.3.** State that water moves into and out of cells by osmosis through the cell membrane.

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners about plant reproduction.

Briefing lesson: Plants as model organisms

Resources	• Teacher instructions 1 • Worksheets A and B • Cotton wool • Mung beans • Petri dish
Learning objectives	By the end of the lesson: • **all** learners will be able to outline how sodium chloride is likely to affect the growth of germinated seeds. • **most** learners will be able to select equipment and describe how sodium chloride concentration is likely to affect the growth of germinated seeds. • **some** learners will be able to evaluate, using specific terminology, an approach that can be used to investigate the effect of sodium chloride concentration is likely to affect the growth of germinated seeds.

Timings	Activity
10 minutes	**Starter/Introduction** Learners must be familiar with lots of key terms important to this series of lessons. To reinforce this knowledge, make a 'loop activity' using some or all the terms. Type some or all the terms with their definitions into a spreadsheet. Now, move all the terms down by one cell so that term and definition no longer match. Type START against the first definition and END against the last term (see diagram below; an example is provided in **Teacher Instructions 1**). START definition term 1 Term 1 definition term 2 Term 2 definition term 3 Term 3 END Print the spreadsheet onto stiff card and cut up so that each piece of card has a term and a definition. Shuffle the cards and then hand one to each member of the class. The student with the 'START' card reads out the definition and the person with the matching term identifies themselves, reads out the term and then reads the definition on their card. This continues until it reaches the 'END' card. The cards can be shuffled, and the loop activity repeated to see if the students can do it faster the second time.
40 minutes	**Main lesson** Learners study a micrograph of the tip of a root. Also show a photomicrograph showing part of a transverse section of a root. You may wish to display this on the board or provide photocopies. First, ask learners to suggest what roles are played by, for example, the root cap and the root hairs. Provide learners with the definition of a root and discuss whether the information that has been discussed during this

	activity is satisfied by it. Then reveal the nature of the investigation that they will undertake. Through a class discussion, remind learners of the difference between qualitative measurements and quantitative measurements. Provide learners **Worksheet A**. Ask them to explain if the table shows quantitative or qualitative data. Agree that although the table shows numerical data (sample times, temperature) the recorded data are observations not measurements, so the data is qualitative. Arrange the class into groups of 3–4. Give each group **Worksheet B**, which includes a range of laboratory equipment. Tell learners that in their next lesson they are going to investigate the effect of sodium chloride concentration on the growth of germinated seeds. Explain that they need to use what they have learned so far in the course to help them devise a method to follow. Learners should be provided with at least 5 minutes to discuss their thoughts, and then should be provided with a piece of A3 paper to produce a rough labelled diagram. During this activity, circulate to provide support and guidance. If learners find it difficult to make a start, provide some hints. Questions will vary depending on the choices learners make. Show learners some key items of equipment that they will use in the investigation – especially some information about how to prepare diluted solutions and especially the Petri dishes.
10 minutes	**Plenary** Encourage learners to use as many key terms as possible to write a summary of the method they will use to investigate this research question. List of key terms to be provided at second draft stage.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher Instructions 2 • Worksheets C and D • 100 mung beans that have been allowed to germinate for one day so that early roots (radicals) are beginning to emerge. • 150 cm^3 distilled water. • 200 cm^3 sodium chloride solution (0.2 mol dm^{-3}) • 5 Petri dishes with lids • beakers • marker pen or labels • measuring cylinder (50 cm^3) • pair of forceps • ruler with millimetre measurements
Learning objectives	By the end of the lesson: • **all** learners will be able to outline how sodium chloride is likely to affect the growth of germinated seeds. • **most** learners will be able to select equipment and describe how sodium chloride concentration is likely to affect the growth of germinated seeds. • **some** learners will be able to evaluate, using specific terminology, an approach that can be used to investigate the effect of sodium chloride concentration is likely to affect the growth of germinated seeds.

Timings	Activity
10 minutes	**Starter/Introduction** Review the content from the Briefing lesson and ask learners why plants made useful model organisms for scientific investigations and host a brief discussion.
45 minutes	**Main lesson** Give each learner **Worksheet C**, which can be completed to produce a method they will use in the practical lesson. They are asked to identify the activity that should be undertaken in each step, or the rationale for taking a step. Learners should attempt this individually. Ask them to compare their answers with a partner once they have finished. They should discuss how they could ensure that the method improves the likelihood of obtaining valid, reliable and accurate data and then answer the questions at the bottom of the worksheet. **Safety** Always circulate the classroom during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.
5 minutes	**Plenary** After discussion, provide **Worksheet D**, which provides a prompt to help learners design a table for homework. Learners should be directed to consider this in advance of next lesson.

Teacher notes

Watch the video (teacher version) and read these notes.

Each group will require:

- 100 mung beans that have been allowed to germinate for one day so that early roots (radicals) are beginning to emerge
- 150 cm^3 distilled water
- 5 Petri dishes with lids
- 200 cm^3 sodium chloride solution (0.2 mol dm^{-3})
- beakers
- marker pen or labels
- measuring cylinder (50 cm^3)
- pair of forceps
- ruler with millimetre measurements

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
mung beans	allergen	

How to make the stock solutions of sodium chloride

The stock solution of 0.2 mol dm^{-3} sodium chloride solution can be prepared by putting 2.35 g of sodium chloride in 100 cm^3 of distilled water and making up to 200 cm3 with distilled water.

Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 2–4 learners)
- the amount of equipment/chemicals required.

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
To prepare the first dilution, 25 cm3 distilled water is put into a measuring cylinder using the water bottle.	It is important to produce a range of solutions of different sodium chloride solutions that represent a wide range to represent the conditions that seeds might encounter in fields contaminated with saltwater.
This is poured into a beaker labelled with the first diluted concentration of sodium chloride.	N/A.
Next, 25 cm3 sodium chloride solution of the highest concentration is poured into the measuring cylinder from the stock beaker.	N/A.
This is poured into the beaker containing the distilled water measured previously. The solution, which is now half as concentrated as the stock solution, is gently swirled to mix.	N/A.
To prepare the second dilution, 25 cm3 distilled water is put into the rinsed measuring cylinder using the water bottle in the same way as before.	N/A.
This is poured into a beaker labelled with the second diluted concentration of sodium chloride.	N/A.
Next, 25 cm3 sodium chloride solution with the concentration prepared previously is poured into the measuring cylinder from the stock beaker.	N/A.
This is poured into the beaker containing the distilled water measured previously. The solution, which is now half as concentrated as the solution prepared previously, is again gently swirled to mix.	This process, called serial dilution, is repeated to form another solution of sodium chloride, of the lowest concentration for this investigation.
Enough of the stock solution of sodium chloride is poured onto cotton wool in a Petri dish to ensure that it is saturated. 20 seedlings with noticeable early roots, called radicals, are equally spaced apart on	Pour enough solution onto the cotton wool so that it is sodden to the touch.

cotton wool in a Petri dish, labelled with the highest concentration of sodium chloride.	Try to place the seeds an equal distance from each other.
The seedlings are kept undisturbed at room temperature for three days.	After 3 days, the seedlings are ready for data collection.
Next, the seedlings are observed. It is important to note whether the seedling has a plumule, or early shoot. A ruler can be used to measure the length of the root.	N/A.

Clean-up

After the experiment learners should:

- clean all glassware.
- tidy up their work space.
- ensure any spillages have been mopped up.
- return all equipment and any unused chemicals to you.

The Petri dishes should be disposed of and sealed in bin bags.

Lab lesson: Option 2 – virtual experiment

Resources	• Teacher Instructions 2 • Worksheets C and D
Learning objectives	By the end of the lesson: • **all** learners will be able to outline how sodium chloride is likely to affect the growth of germinated seeds. • **most** learners will be able to select equipment and describe how sodium chloride concentration is likely to affect the growth of germinated seeds. • **some** learners will be able to evaluate, using specific terminology, an approach that can be used to investigate the effect of sodium chloride concentration is likely to affect the growth of germinated seeds.

Timings	Activity
10 minutes	**Starter/Introduction** Ask learners to swap their completed **Worksheet C** with a partner. Then hand out **Worksheet D**. Ask learners how their tables compare with the actual table that they will be using. It is likely that learners have put the independent and dependent variables in inappropriate columns and/ or did not include a control or repeated data.
40 minutes	**Main lesson** Challenge learners to identify the activity that should be undertaken in each step of the method, or the rationale for taking a step. Learners should attempt this individually. Ask them to compare their answers with a partner once they have finished. They should discuss how they could ensure that the method improves the likelihood of obtaining valid, reliable and accurate data. **Safety** Always circulate the classroom during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.
10 minutes	**Plenary** Provide pairs of learners with sample data tables and ask them to record the mean root length on a common class spreadsheet (e.g. a shared *Google sheet*) or on the whiteboard. **Teacher Instructions 2** provides sample data tables that can be cut out and distributed if necessary.

Debriefing lesson: Improving an investigation

Resources	• Teacher Instructions 3 • Worksheet E
Learning objectives	By the end of the lesson: • **all** learners should be able to understand the importance of some considerations in an experiment to the quality of the data. • **most** learners should be able to explain why some considerations in an experiment enhance the quality of the data. • **some** learners will be able suggest new considerations in an experiment to enhance the quality of the data.

Timings	Activity
10 minutes	**Starter/Introduction** Ask learners to write down possible solutions that they could employ to the problems they encountered when they did their investigation. This will be a useful reminder of what they previously covered but will also begin to develop their evaluative skills and prepare them for the upcoming task in this *Debriefing Lesson*.
40 minutes	**Main lesson** Divide learners into groups of three. Provide each learner **Worksheet E**, which is a task that is based on a student plan that has been written to investigate a similar research question to their own. During the activity, provide learners with an opportunity to seek support if they encounter difficulty This can be done by producing a series of 'clue cards', available on request. If a learner feels they need support, they can request a card from you. Each card provides a 'hint' that is intended to give the learner just enough information to help them move on with their work. In addition, this activity provides a good opportunity to pair learners of different abilities with each other, with mutual benefits for each learner.
10 minutes	**Plenary** Ask the learners to get back into their original groups and discuss each of the other plans that they've learned about. Summarise the lesson by highlighting the most important points, before asking learners to evaluate their own plan.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
Teacher Instructions 1: Revision dominoes	**15**	**N/A**
A: Qualitative and quantitative data	**20**	**25**
B: Choosing equipment	**21**	**N/A**
For use in *Lab lesson:*		
Teacher Instructions 2: Sample data tables	**17**	**N/A**
C: Designing a data table	**22**	**N/A**
D: Data table	**23**	**N/A**
For use in the *Debriefing lesson:*		
E: Critiquing a report	**24**	**26**

Teacher instructions 1: Revision dominoes

START	substance that can be dissolved in a solvent
cortex	in a plant stem or root, a tissue made of typical plant cells (usually, however, without chloroplasts)
xylem	long hollow tubes made up of dead, empty cells with lignified walls, which transport water in plants and help to support them
spongy mesophyll tissue	the tissue beneath the palisade layer in a leaf; it is made up of cells that contain chloroplasts and can photosynthesise, with many air spaces between them
palisade mesophyll tissue	the upper mesophyll layer in a leaf, made up of rectangular cells containing many chloroplasts
germination	the breaking of dormancy in a seed.
turgid	describes a plant cell that has become firm owing to water retention
flaccid	

	a term used to describe a cell that has lost a lot of water, becoming soft
turgor pressure	exerted by a plant cell cytoplasm on the plant cell wall
water potential	a measure of the tendency for water to move out of a solution; the more water in the solution, the greater its water potential
partially permeable	allowing some molecules to pass through, but not others
osmosis	the diffusion of water molecules from a region of high water potential to a region of lower water potential, through a partially permeable membrane
root hair cell	cell on the surface of a plant root; it has a very large surface area to volume ratio for the absorption of water and mineral ions
vacuole	fluid-filled space inside a cell
solute	**END**

Teacher Instructions 2: Sample data tables

seedlings grown in distilled water		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

seedlings grown in sodium chloride solution, **0.025 mol dm^{-3}** concentration		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

seedlings grown in sodium chloride solution, **0.05 mol dm^{-3}** concentration		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

seedlings grown in sodium chloride solution, **0.1 mol dm^{-3}** concentration		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

seedlings grown in sodium chloride solution, **0.2 mol dm^{-3}** concentration		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

Worksheet A: Qualitative & quantitative data

Read the five research questions provided in the table below.

	research question: how does changing the…
1	How does changing the temperature of a room affect the time taken for yeast cells to divide?
2	How does changing the light intensity affect the volume of oxygen produced by a plant?
3	How does changing the colour of light affect the volume of oxygen produced by a plant?
4	How does changing the pH affect the time taken for protein to be digested?
5	How does changing the hours of daylight per day affect the species of plants identified?

List the numbers of the experiments that are likely to give **qualitative** data, and which are likely to give **quantitative** data. Use the space below the table to reflect on whether more experiments in Biology give qualitative or quantitative data, and in which experiments the most accurate data can be obtained.

Qualitative	Quantitative
Experiment numbered: _____	Experiment numbered: _____

.....

.....

.....

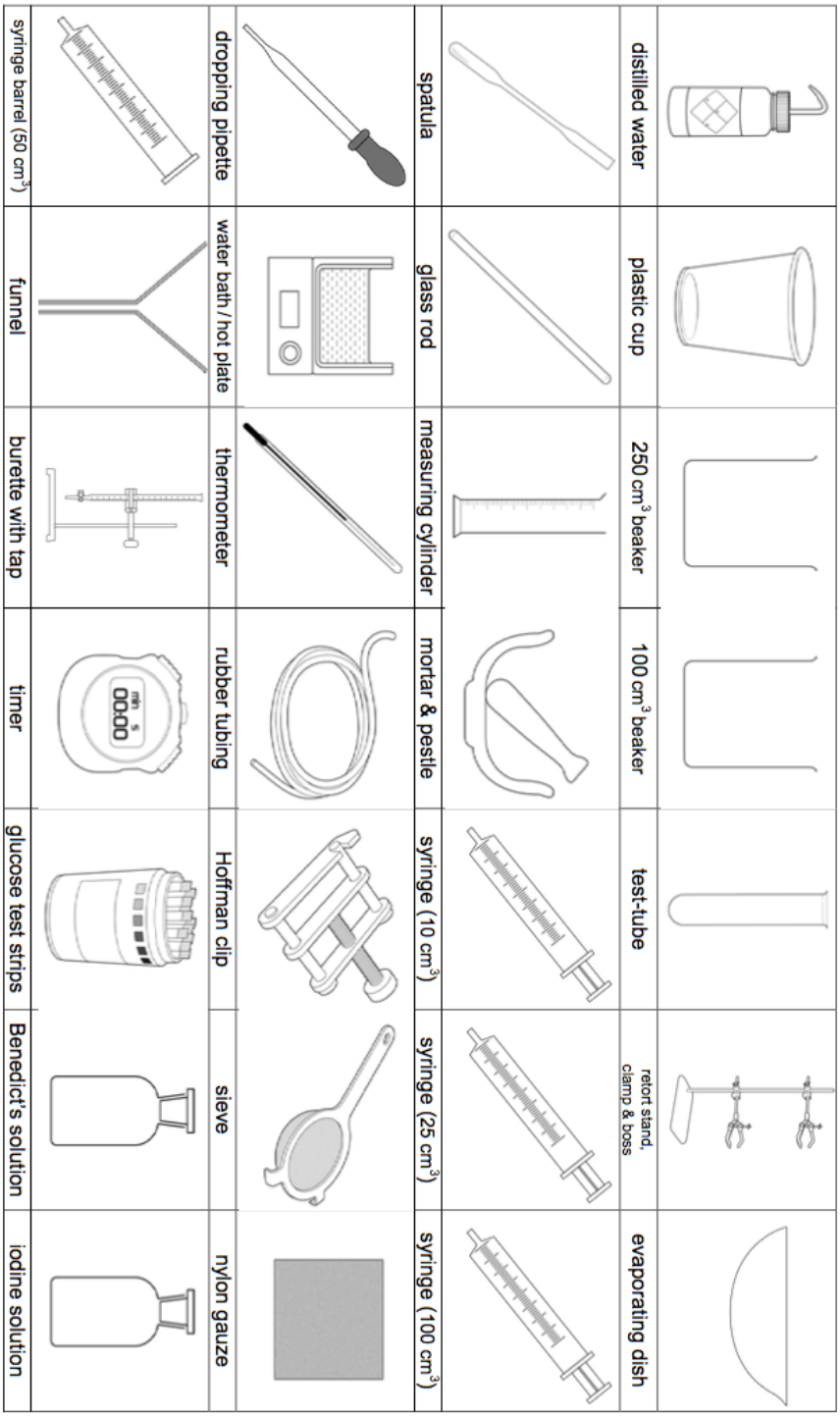
.....

.....

.....

Worksheet B: Choosing equipment

Here is some typical laboratory apparatus available to you. Note that you will not need to use all items.



Worksheet C: Designing a data table

A good table:

- Contains an appropriate number of columns and rows.
- Is drawn with ruled lines and has a full border.
- Places the independent variable (the factor that is changed) into the left-most column.
- Includes units only in the headings of the table, and never in the table body.
- Contains numerical values that have the same number of decimal places.
- Has a column that records the mean values of repeated data.

For homework, use the space below to prepare a table in advance of the *Lab lesson*. Use the information above to help you.

Worksheet D: Data table

Use the table below to record your data during this investigation:

seedlings grown in sodium chloride solution, x **mol dm^{-3}** concentration		
seedling number	plumule present? Y/N?	root length / mm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
mean radical length / mm:		

If you finish collecting your data before other members of your class, consider the **graph** that you will plot:

- Bar chart or line graph? Why?
- Which labels (and units) should be on the x- and y-axes?
- What the most common mistakes regarding presentation that students make when drawing such a graph?

Worksheet E: Critiquing a report

The plan below was written by a student in response to the question:

"How could the method used in this investigation be used to determine the effect of incubation temperature on the growth of germinated seeds?"

The student has access to the same equipment you used in your investigation.

In my investigation, I would make five solutions of salt of the same concentration but heat them to different temperatures. I would pour these into five different dishes and put the same amount of cotton wool in each, followed by 5 mung bean seeds. I would then pour the solutions in, and then incubate the dishes for two days. After this time, I would measure the length of the roots of the five seeds in each dish and calculate a mean value.

Worksheet A: Answers

Qualitative	Quantitative
Experiment numbered: **3 and 5**	Experiment numbered: **1, 2 and 4**

Worksheet E: Answers

Here is the student's plan.

In my investigation, I would make five solutions of salt of the same concentration but heat them to different temperatures. I would pour these into five different dishes and put the same amount of cotton wool in each, followed by 5 mung bean seeds. I would then pour the solutions in, and then incubate the dishes for two days. After this time, I would measure the length of the roots of the five seeds in each dish and calculate a mean value.

Suggested changes to the plan are provided below.

- There is no need to use salt solutions in this investigation; it would be best to grow the seeds in water with no salt added, to investigate the effect of temperature on their germination.
- The values of the temperatures used are not listed. These should be of a range that can be tolerated by the plant seeds and should be separated by increments that are large enough for a graph to be drawn that could show an accurate trend.
- The application of the solution to the seeds at a particular temperature at the start of the investigation would not ensure that the temperature remains at that temperature for the remainder of the investigation. Instead, the student should use a series of thermostatically-controlled water baths or rooms of different temperatures.
- Just using five mung bean seeds is insufficient. The mean that would be calculated from this data would be unreliable.

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