

Conditions needed for seed germination

investigate the conditions needed for seed germination

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. Teacher answers start on a new page.

Name

Date

Aim

To find out whether water, oxygen and a suitable temperature are needed for seeds to germinate.

Background

A seed contains an embryo plant and a store of food. It stays dormant until conditions are right.

Germination is the start of growth of the embryo: the root and then the shoot emerge from the seed coat.

Germination needs **water** to rehydrate the seed so that enzymes can work, **oxygen** for aerobic respiration to release energy for growth, and a **suitable temperature** so that the enzymes work quickly enough. Seeds do not need light or soil to start germinating, because they use their own food store until the leaves grow and begin to photosynthesise.

To show that a condition is needed, you take it away from one set of seeds while keeping everything else the same. A tube with all three conditions is the **control**, which shows that the seeds are able to germinate.

Hypothesis

Seeds will germinate only when they have water, oxygen and a suitable temperature, because water activates enzymes and oxygen is needed for respiration to release energy for growth.

Variables

Independent	The condition provided: water, oxygen or warmth (one tube lacks each in turn)
Dependent	The number of seeds that have germinated (a root or shoot is visible) out of 10, shown as a percentage
Control	• Type, age and source of the seeds (for example mustard or cress) • Number of seeds in each tube (10) • Amount of cotton wool and volume of water used • Light: all tubes kept in the dark, because the inside of a refrigerator is dark • Time the seeds are left (5 days)

Equipment

- 4 test tubes and a test-tube rack
- 40 cress or mustard seeds of the same type
- Cotton wool
- Water and a dropper
- Kettle or beaker and heat source to boil water, and a heatproof mat
- Vegetable oil
- Labels or a marker pen
- Dark cupboard at room temperature (about 20 °C)
- Refrigerator (about 4 °C)
- Hand lens for checking small roots (optional)

Risk assessment

Hazard	Risk	Precaution
Boiling water	Scalds when boiling the water or pouring it	Let the water cool before it is added to the seeds, use a heatproof mat and do not carry hot water across the room.
Seeds (some are treated with fungicide)	Skin irritation or harm if swallowed	Do not put seeds in the mouth, and wash hands after handling them.
Spilt water or oil	Slipping on the floor	Mop up spills straight away.

Method

1. Label four test tubes A, B, C and D.
2. Put a pad of cotton wool in the bottom of tubes A, B and D.
3. Add enough water to dampen the cotton wool in tubes A and D. It should be damp, not dripping. Leave the cotton wool in tube B dry.
4. Place 10 seeds on the cotton wool in each of tubes A, B and D.
5. Boil some water, then let it cool completely in a covered container. Boiling removes the dissolved oxygen.
6. Place 10 seeds in the bottom of tube C, with no cotton wool. Fill the tube with the boiled, cooled water so that the seeds are covered.
7. Pour a thin layer of vegetable oil on top of the water in tube C. This stops oxygen from the air dissolving in the water again.
8. Put tubes A, B and C in a dark cupboard at room temperature.
9. Put tube D in a refrigerator.
10. Check the tubes each day. Add a few drops of water to keep the cotton wool in tube A damp, and keep the cotton wool in tube B dry.
11. After 5 days, count the seeds in each tube that have germinated (a root or shoot is visible) and record the number.
12. Calculate the percentage of seeds that germinated in each tube. Wash your hands.

Results

Results table: germination after 5 days			
Tube	Condition missing	Seeds germinated (out of 10)	Seeds germinated (%)
A	None (control)		
B	Water		
C	Oxygen		
D	Warmth		

Graph

Bar chart: tube (A to D, or the condition missing) on the x-axis and seeds germinated (%) on the y-axis from 0 to 100. Leave gaps between the bars because the x-axis is categoric.



Exam questions 9 questions · 25 marks

- 1** State the independent variable and the dependent variable in this investigation. [2 marks]

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- 2** The water in tube C was boiled and cooled and a layer of oil was added. Explain why each of these was done. [3 marks]

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- 3** Tube A was the control. Explain why it was needed. [2 marks]

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- 4** In tube A, 9 out of the 10 seeds germinated. Calculate the percentage of seeds that germinated. **[2 marks]**

Answer =

- 5** Very few seeds germinated in tube D, which was kept in the refrigerator. Explain why. **[3 marks]**

- 6** Explain why a germinating seed needs oxygen. **[3 marks]**

- 7** Tubes A, B and C were kept in a dark cupboard. Explain why this was done. **[2 marks]**

- 8** Suggest one change to the investigation that would make the results more reliable, and explain why it would help. **[2 marks]**

9 A student wants to find the best temperature for the germination of mustard seeds. **[6 marks]**
Describe an investigation the student could carry out. Include how you would make it a fair test.

[illegible]

Teacher answers

Practical 11: Conditions needed for seed germination. The example results are practice data, not real measurements.

Example results

Example results (practice data)			
Tube	Condition missing	Seeds germinated (out of 10)	Seeds germinated (%)
A	None (control)	9	90
B	Water	0	0
C	Oxygen	0	0
D	Warmth	1	10

Conclusion

In the example results 90% of the seeds germinated in tube A, which had water, oxygen and warmth, but none germinated without water (tube B) or without oxygen (tube C) and only 10% germinated at low temperature (tube D). This supports the hypothesis that seeds need all three conditions. Water is needed for enzymes in the seed to work and to carry substances to the embryo. Oxygen is needed for aerobic respiration, which releases the energy for growth. At the low temperature in the refrigerator, enzymes work very slowly, so there is too little respiration and growth. Because tube A germinated, the failure in the other tubes can be linked to the missing condition.

Errors and improvements

Error	Effect on the results	Improvement
Some seeds may be dead or dormant (random error), and with only 10 seeds one seed changes the result by 10%	The percentage germination may not be representative, so a small difference could be down to chance	Use more seeds in each tube (for example 20) or repeat each tube and calculate a mean.
Oxygen may dissolve back into the boiled water, for example if it cools in an open beaker or the oil layer is broken (systematic error)	Tube C is not fully oxygen-free, so some seeds may germinate and the effect of oxygen is underestimated	Cool the water in a covered container, fill the tube completely, make sure the oil layer is complete and do not shake the tube.
The cotton wool in tube A dries out or the cotton wool in tube B becomes damp from the air	The water condition is no longer controlled, so the results are less valid	Check the tubes each day and adjust the water, and use the same amount of cotton wool each time.
Deciding when a seed has germinated depends on judgement	Different people may count different numbers, so the counts are not consistent	Agree a clear rule beforehand (for example a root at least 2 mm long) and use the same person to count each tube.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- independent variable: the condition provided or taken away (water, oxygen or temperature) (1)
- dependent variable: the number (or percentage) of seeds that germinate (1)

2. [3]

- boiling removes the dissolved oxygen (1)
- it was cooled so that it did not kill the seeds (1)
- the oil layer stops oxygen from the air dissolving in the water (1)

3. [2]

- it shows that the seeds are able to germinate when they have all three conditions (1)
- so that failure to germinate in the other tubes can be linked to the missing condition (1)

4. [2]

- $9 \div 10 \times 100$ (1)
- 90% (1)

5. [3]

- the temperature was too low (1)
- enzymes work very slowly at low temperature (1)
- so there is too little respiration / release of energy / growth for the seeds to germinate (1)

6. [3]

- for aerobic respiration (1)
- to release energy (1)
- for growth / cell division / making new cells in the embryo (1)

7. [2]

- the inside of the refrigerator (tube D) is dark (1)
- so light is kept the same / controlled in all four tubes, so any difference is not due to light (1)

8. [2]

- use more seeds in each tube / repeat each tube and calculate a mean (1)
- to reduce the effect of seeds that are dead or do not germinate by chance (1)

9. [6]

Level 3 5-6	A clear, ordered method with a range of temperatures, how each is maintained, how the result is measured and several control variables named; the answer is detailed and logically ordered
Level 2 3-4	A method with at least two temperatures and a way of measuring germination, and some control variables, but with some detail or ordering missing
Level 1 1-2	A simple or partial method, for example seeds at different temperatures with little detail

Indicative content

- same number of seeds on damp cotton wool in several tubes (or dishes)
- place in different temperatures, for example 5, 15, 25, 35 and 45 °C, in incubators or water baths in the dark
- keep the amount of water, type and age of seeds, number of seeds and the time the same
- after a set time (for example 5 days) count the number of seeds that have germinated in each
- calculate the percentage germination and repeat to calculate a mean
- the best temperature is the one with the highest germination

Exam tips

- Change only one condition at a time. Say which condition is missing in each tube and keep everything else the same.
- Explain what the control is for: it shows that the seeds can germinate, so the failure in the other tubes is because of the missing condition.
- Link each condition to its job. Water activates enzymes, oxygen is for aerobic respiration, and warmth gives the right temperature for enzymes to work quickly.
- Light and soil are not needed for germination. A common mistake is to say that seeds need light.
- The dependent variable is the number or percentage of seeds that germinate, not the length of the shoot.