

Conditions needed for germination

Investigate and describe the environmental conditions that affect germination of seeds, limited to the requirement for: water, oxygen and a suitable temperature

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). 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 food store. **Germination** is when a seed begins to grow into a new plant. The seed needs three conditions to germinate: **water**, **oxygen** and a **suitable temperature**.

The seed absorbs water and swells, and its enzymes become active and break down the stored food so that it can be used for growth. Oxygen is needed for aerobic respiration, which releases energy for growth. Enzymes work best at a suitable temperature: too cold and reactions are too slow, and too hot and enzymes are denatured. Light is not needed for most seeds to germinate.

To show that a condition is needed, take it away from one set of seeds and keep everything else the same. The tube with all three conditions is the **control**. It shows that the seeds can germinate, so that failure in the other tubes can be linked to the missing condition. Light is kept the same for every tube by keeping them all in the dark, because the inside of a refrigerator is dark.

Hypothesis

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

Variables

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

Equipment

- 4 boiling tubes (150 mm × 25 mm) and a test-tube rack
- 40 mustard (or cress) seeds of the same type
- Cotton wool
- Water and a dropping pipette

- 250 cm³ beaker, heat source and heatproof mat to boil water (with a lid or cover to cool it)
- Vegetable oil
- Marker pen or glass-marking pencil for labelling the tubes
- Dark cupboard at room temperature (about 20 °C)
- Refrigerator (about 4 °C), dark inside
- Thermometer, -10 °C to +110 °C
- Hand lens (at least ×6) for checking small roots

Risk assessment

Hazard	Risk	Precaution
Boiling water	Scalds when boiling the water or pouring it	Let the water cool before it is used, 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

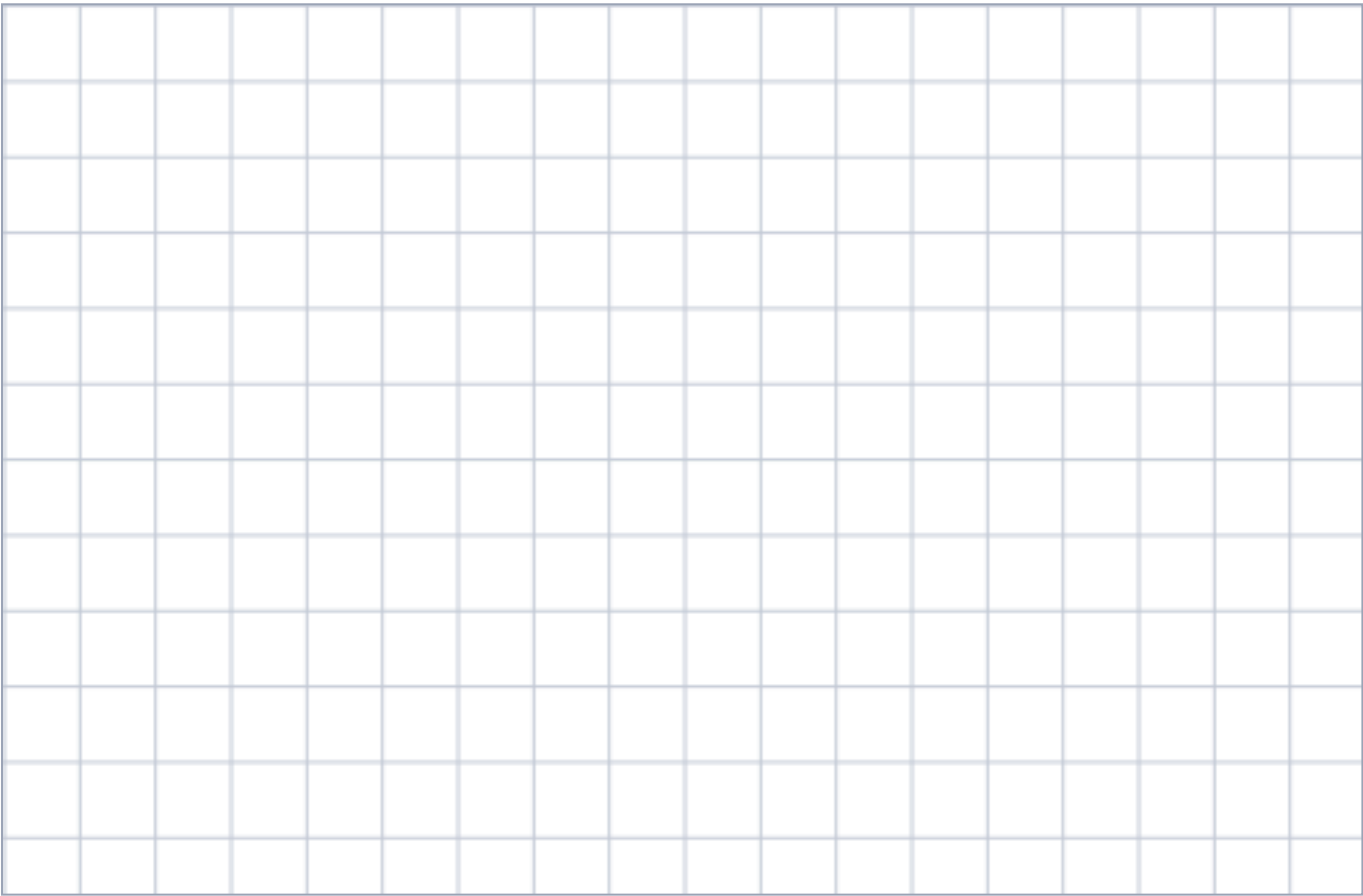
1. Label four boiling tubes A, B, C and D with the marker pen.
2. Put a pad of cotton wool in the bottom of tubes A, B and D.
3. Use a dropping pipette to add water to the cotton wool in tubes A and D until it is damp but not dripping. Leave the cotton wool in tube B dry.
4. Place 10 seeds on the cotton wool in each of tubes A, B and D.
5. Boil some water, then let it cool completely in a covered beaker. 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 (about 20 °C). Check the temperature with a thermometer.
9. Put tube D in a refrigerator, which is dark inside, at about 4 °C.
10. Check the tubes each day. Add a few drops of water if the cotton wool in tube A is drying out, and keep the cotton wool in tube B dry.
11. After 5 days, take out each tube and count the seeds that have germinated (a root or shoot is visible). Use a hand lens to check any small roots.
12. Record the number germinated in each tube and calculate the percentage of seeds that germinated. Wash your hands.

Results

Results table: germination after 5 days			
tube	condition missing	number of seeds germinated out of 10	seeds germinated / %
A	none (control)		
B	water		
C	oxygen		
D	suitable temperature		

Graph

Bar chart: tube (A to D) on the x-axis, label 'tube', and seeds germinated / % on the y-axis from 0 to 100 (2 cm per 20%). Draw bars of equal width that do not touch, because the x-axis shows separate categories.



Exam questions 10 questions · 26 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, cooled and then covered with a layer of oil. Explain why each of these steps was done. **[3 marks]**

3 Tube A contained damp cotton wool and was kept at about 20 °C. Explain why tube A was needed. **[2 marks]**

4 In a repeat of the investigation, 7 out of the 10 seeds in tube A germinated. Calculate the percentage of seeds that germinated. **[2 marks]**

Answer =

5 Very few seeds germinated in tube D, which was kept at about 4 °C. Explain why. **[3 marks]**

6 All four tubes were kept in the dark. Explain why this was done. **[2 marks]**

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

8 Explain why a seed needs water for germination.

[3 marks]

9 A student wants to find the best temperature for the germination of mustard seeds.
Describe an investigation the student could carry out. Include one way of making it a fair test.

[4 marks]

10 Explain why a germinating seed needs oxygen.

[3 marks]

Teacher answers

Practical skill 15: Conditions needed for germination. The example results are practice data, not real measurements.

Example results

Example results (practice data)			
tube	condition missing	number of seeds germinated out of 10	seeds germinated / %
A	none (control)	9	90
B	water	0	0
C	oxygen	1	10
D	suitable temperature	1	10

Conclusion

In the example results 90% of the seeds germinated in tube A, which had water, oxygen and a suitable temperature. None germinated without water (tube B), only 10% germinated without oxygen (tube C) and only 10% germinated at 4 °C (tube D). This supports the hypothesis that seeds need all three conditions. Water is needed so that the seed swells and its enzymes become active, breaking down the stored food. Oxygen is needed for aerobic respiration, which releases energy for growth. At 4 °C, enzymes work very slowly, so few seeds germinate in 5 days. Because the seeds in tube A germinated, the failure in the other tubes can be linked to the missing condition. The one seed that germinated in tube C shows that the oxygen was probably not completely removed from the water.

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 germinate and the need for 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 in each tube.
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 is the control / it has all three conditions (1)
- to show that the seeds are able to germinate, so failure in the other tubes is due to the missing condition (1)

4. [2]

- $7 \div 10 \times 100$ (1)
- 70% (1)
- correct answer with no working scores 2

5. [3]

- the temperature was too low / not a suitable temperature (1)
- enzymes work very slowly at low temperature (1)
- so there is too little respiration / release of energy / growth for the seed to germinate (1)

6. [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)

7. [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 fail to germinate by chance (1)

8. [3]

- the seed absorbs water and swells (1)
- enzymes in the seed become active (1)
- they break down the stored food so it can be used for growth (1)

9. [4]

- put the same number of seeds on damp cotton wool in several tubes (1)
- keep each tube at a different temperature, for example 5, 15, 25, 35 and 45 °C, in incubators or water baths, in the dark (1)
- keep the amount of water, type and number of seeds, light and time the same (1)
- after a set time (for example 5 days) count the number of seeds that have germinated in each tube (1)
- repeat and calculate a mean / percentage germination for each temperature (1)
- the best temperature is the one with the most germination (1)
- Max 4

10. [3]

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

Exam tips

- Change only one condition at a time. Say which condition is missing in each tube and keep everything else the same, including light.
- Explain what the control is for: it shows that the seeds can germinate, so the failure in the other tubes is due to the missing condition.
- Link each condition to its job. Water activates enzymes, oxygen is for aerobic respiration, and a suitable temperature lets enzymes work well.
- 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. In a table, put the unit in the heading, as in 'seeds germinated / %'.