

Light, gravity and the growth of seedlings

Investigate the effect of light or gravity on the growth of newly germinated seedlings.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** This practical is not in Combined Science. Teacher answers start on a new page.

Name

Date

Aim

To find how light from one side and gravity affect the direction and length of growth of newly germinated seedlings.

Background

Plants respond to their environment. A growth response to light is **phototropism**. A growth response to gravity is **gravitropism** (also called geotropism).

These responses are controlled by the plant hormone **auxin**. Unequal distribution of auxin causes unequal growth rates in shoots and roots. In a shoot lit from one side, auxin builds up on the shaded side, cells there elongate more and the shoot bends **towards the light**.

In a root lying sideways, auxin builds up on the lower side, but it slows down growth there. The upper side grows faster, so the root bends **downwards**, in the direction of gravity. In a shoot lying sideways, auxin on the lower side makes cells there elongate more, so the shoot bends upwards, away from gravity.

The spec asks for results to be recorded as both **length measurements** and as careful, labelled **biological drawings** to show the effects. The spec asks for light **or** gravity, so you may do just one. This sheet covers both as two separate tests, each with its own control: compare dish A only with dish B, and dish C only with dish D.

Hypothesis

Shoots will grow towards a light source and away from gravity, and roots will grow in the direction of gravity, because unequal distribution of auxin causes unequal growth.

Variables

Independent	The direction of the light (one side or even light all round) or the position of the seedlings (upright or on their side in the dark)
Dependent	Direction of growth of the shoots and roots (angle of bend in degrees) and the length of the shoots (mm)
Control	• Same species and age of seedling (for example cress, 2 days after germination) • Same number of seedlings in each dish • Same temperature • Same volume of water on the cotton wool or filter paper • Same time period (for example 48 hours) • For the gravity test, no light from any direction (keep the dishes in the dark)

Equipment

- Cress seeds (or mustard seeds), about 20 per dish
- 4 Petri dishes or small plastic pots with damp cotton wool or filter paper
- Cardboard box with a slit (about 1 cm wide) cut in one side
- Dark cupboard or a box wrapped in black card or foil
- Ruler (mm)
- Protractor
- Water and a dropper or spray bottle
- Sticky tack or tape to hold dishes in position
- Sharp pencil and plain paper (for drawings)
- Lamp (optional, if there is not a window available)

Risk assessment

Hazard	Risk	Precaution
Seeds and seedlings	Allergic reaction or harmful microbes if swallowed	Do not eat any seeds or seedlings. Wash hands after handling seedlings and the damp cotton wool.
Damp surfaces and spills	Slipping on spilled water	Wipe up spills straight away.
Mould on damp cotton wool	Spores can cause allergic reactions	Do not open dishes with obvious mould. Tell the teacher and do not sniff them.
Lamp (if used)	Electrical hazard near water; hot surface	Keep the lamp and cable dry, use an LED lamp and do not touch it when on.

Method

1. Put damp cotton wool or filter paper in four Petri dishes. Sprinkle about 20 cress seeds evenly on each and keep them in a warm place for 2–3 days, until they have germinated and the shoots are 15–25 mm long.
2. Label the dishes A (one-sided light), B (even light), C (gravity, dish on its side) and D (control for gravity, dish upright).
3. Measure the length of five shoots in each dish with a ruler to the nearest mm. Record the start length and calculate a mean for each dish.
4. Make a careful, labelled drawing of one typical seedling from each dish at the start.
5. Dish A: place in the cardboard box so that light enters from the slit on one side only. Put the box next to a window or in front of a lamp.
6. Dish B: place in similar conditions with light coming from all around, for example uncovered in even light, or turned slowly on a turntable.
7. Dish C: pack the cotton wool firmly so the seedlings cannot slide, tape the lid on, and fix the dish with sticky tack so it stands on its edge with the shoots and roots pointing sideways. Put it in a dark cupboard.
8. Dish D: leave upright in the same dark cupboard.
9. Leave all dishes for 48 hours. Keep damp, adding a little water if needed, without moving the dishes.
10. Observe the direction of growth of the shoots and roots. Use a protractor to measure the angle between the shoot and the direction it pointed at the start (vertical for dishes A, B and D, horizontal for dish C).

- L1 . Measure the length of the same five shoots in each dish and calculate the mean length and the increase.
- L2 . Make a second careful labelled drawing of a typical seedling from each dish to show the direction of growth. Draw with a sharp pencil, use clear single lines and label each part.
- L3 . Compare the treated dishes (A and C) with their controls (B and D) and write down the effects on direction and length.

Results

Growth of cress seedlings after 48 hours (mean of five seedlings)					
Dish and treatment	Mean shoot length at start (mm)	Mean shoot length after 48 h (mm)	Increase in length (mm)	Direction of shoot growth	Angle of bend from the starting direction (°)
A: light from one side					
B: even light all round					
C: on its side, in the dark					
D: upright, in the dark					

Graph

Bar chart of mean increase in shoot length in mm (y-axis, labelled 'Increase in shoot length (mm)') for each dish A-D (x-axis). Bars of equal width with gaps, because the dishes are categories. Use more than half the grid and equal scale steps. Add the labelled biological drawings next to the table.



Exam questions 10 questions · 26 marks

1 Name the growth response of a shoot towards a light source. [1 mark]

2 Dish B was kept in even light all round. Explain why dish B was included. [2 marks]

3 The dishes in the gravity investigation were kept in the dark. Explain why. [2 marks]

4 Use the sample results to calculate the percentage increase in mean shoot length for the seedlings in dish A (light from one side). Give your answer as a whole number. [3 marks]

Mean shoot length		
Dish	Start (mm)	After 48 h (mm)
A: light from one side	20	34

Answer =

5 Explain why the shoots in dish A bent towards the light. [3 marks]

Teacher answers

Required practical 8: Light, gravity and the growth of seedlings. The example results are practice data, not real measurements.

Example results

Example results (practice data)					
Dish and treatment	Mean shoot length at start (mm)	Mean shoot length after 48 h (mm)	Increase in length (mm)	Direction of shoot growth	Angle of bend from the starting direction (°)
A: light from one side	20	34	14	Bent towards the light	40
B: even light all round	20	36	16	Straight up	0
C: on its side, in the dark	20	44	24	Bent upwards, away from gravity	60
D: upright, in the dark	20	45	25	Straight up	0

Conclusion

Shoots lit from one side bent towards the light (40° from the vertical), while shoots in even light grew straight up. This is **phototropism**: auxin was **unequally distributed**, with more on the shaded side, so cells on the shaded side elongated more and the shoot bent towards the light. In dish C the shoots bent upwards, away from gravity (negative gravitropism), because auxin built up on the lower side and made those cells elongate more. The drawings showed the roots in dish C curving downwards, because auxin on the lower side of the root slows growth there, so the upper side grows faster. In dish D, upright in the dark, shoots grew straight up and roots straight down. The shoots in the dark grew more (an increase of 24-25 mm) than those in the light (14-16 mm).

Errors and improvements

Error	Effect on the results	Improvement
Light leaks into the box or the dark cupboard (a systematic error).	In the gravity test, seedlings respond to light as well as gravity, so the bend is not caused by gravity only.	Check the box is light-tight, cover gaps with black card and keep the dishes in a lightproof cupboard.
Seedlings in the same dish differ in size and age (random error).	Lengths and angles vary, so the mean is not a true value for the treatment.	Measure more seedlings (at least 10) and use seedlings of the same height at the start.
Measuring the length of a bent shoot with a ruler is difficult, and the angle of bend is hard to read exactly.	Measurements are not accurate, so differences between dishes could be missed.	Use thread laid along the shoot and then measured with a ruler, or take photographs and measure on screen.
Seedlings dry out or get too warm near a lamp.	Growth is slower for reasons that are not the treatment.	Keep cotton wool damp in all dishes and use a window or cool LED lamp at the same distance.

Mark scheme

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

1. [1]

- phototropism (1)

2. [2]

- it is a control / to compare with dish A (1)
- to show that the bending in A was due to the light from one side and not another factor (1) allow so that the only difference is the direction of light

3. [2]

- so that light from one side does not affect the direction of growth (1)
- so that any bending is caused by gravity only (1)

4. [3]

- increase = $34 - 20 = 14$ (mm) (1)
- $14 \div 20 \times 100$ (1)
- = 70 % (1)

5. [3]

- auxin is unequally distributed / more auxin on the shaded side (1)
- cells on the shaded side elongate / grow more than on the lit side (1)
- so the shoot bends towards the light (1)

6. [3]

- auxin builds up on the lower side of the root (1)
- this slows (inhibits) growth of the cells on the lower side (1)
- so the upper side grows faster and the root bends downwards, towards gravity (1)

7. [2]

- to calculate a mean / reduce the effect of random variation between seedlings (1)
- to identify anomalous results / make the results more repeatable (1)

8. [2]

- sharp pencil / clear continuous lines with no shading or sketching (1)
- labels drawn with straight lines that do not cross / title or scale (1) allow drawn large and in proportion

9. [2]

- shoots grow upwards and roots grow downwards (1)
- because shoots grow away from gravity and roots grow towards gravity / auxin is evenly distributed so growth is even (1)

10. [6]

Level 3 5-6	A clear and logical plan with the independent variable (light from one side), a suitable control (even light), the dependent variable (direction of growth and / or length), at least three control variables, repeats or several seedlings, and results recorded as both measurements and labelled drawings. The plan could be followed by another person.
Level 2 3-4	A plan with most key steps, but one or two features missing, such as the control, control variables or the recording of results.
Level 1 1-2	A few simple points, for example 'shine a light on one side of seedlings', with little detail.

Indicative content

- germinate the same number of seedlings of the same age and species on damp cotton wool
- set up a box with a slit so light enters from one side; control set in even light
- control temperature, water, time, type and age of seedling
- leave for a set time (for example 48 hours) and then measure the angle of bend / length of shoot
- make labelled biological drawings at the start and the end
- use several seedlings, calculate a mean, compare with the control

Exam tips

- Always say that auxin is unequally distributed, then say which side has more and what that does to growth on that side.
- Do not say 'auxin makes the shoot bend'. Say that more auxin on the shaded side makes cells there elongate more.
- In a root, the lower side has more auxin and slower growth. This is the opposite of a shoot, so check which part of the plant the question asks about.
- AQA expects results as both measurements and careful, labelled drawings. A drawing needs a sharp pencil, clear lines, no shading and labels.