

# Tropic responses

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## What you need to know

Tropic responses come up on nearly every paper. Papers 1 and 2 ask one-mark multiple choice (which response is which, what a seedling looks like after a few days, and on Paper 2 where auxin goes); Papers 3 and 4 build a question round an investigation with a seedling in a box, on its side or on a rotating clinostat. Outcomes marked **Extended only** are tested on Papers 2 and 4 only. By the end of this topic you should be able to:

### Core

1. **Describe gravitropism:** a response in which parts of a plant grow **towards or away from gravity**.
2. **Describe phototropism:** a response in which parts of a plant grow **towards or away from the direction of the light source**.
3. **Carry out and describe experiments on shoots and roots:** say, draw and explain which way a shoot and a root grow when light comes from one side, when they are kept in the dark, laid on their side or turned on a rotating platform.
4. **Extended only: Explain why a shoot bends** towards light and upwards: both responses are growth controlled by a **plant hormone**.
5. **Extended only: Use auxin to explain how a shoot grows**, using just four facts:
  - the **tip** of the shoot makes it;
  - it spreads down from the tip by **diffusion**;
  - **light and gravity** make it collect on one side;
  - it makes cells **grow longer**.

Photosynthesis and the uses of water are from Plant nutrition and Transport in plants; this note uses them only to explain why tropic responses help a plant.

## Understand it

### A plant can't move, but it can grow

An animal that needs food walks to it. A plant is rooted to one spot, so it responds to its surroundings by **growing** in a particular direction instead. A growth response whose **direction** depends on the **direction of a stimulus** is a **tropic response** (a **tropism**).

Two stimuli matter in this topic:

| Stimulus                               | Name of the response                                                       |
|----------------------------------------|----------------------------------------------------------------------------|
| <b>light</b> coming from one direction | <b>phototropism</b> ("photo" = light)                                      |
| <b>gravity</b>                         | <b>gravitropism</b> (older books and some mark schemes call it geotropism) |

Growth can be **towards** the stimulus or **away** from it. Growth towards the stimulus is called **positive**; growth away from it is **negative**.

|              | Response to light                                   | Response to gravity                                             |
|--------------|-----------------------------------------------------|-----------------------------------------------------------------|
| <b>Shoot</b> | grows <b>towards</b> light: positive phototropism   | grows <b>away from</b> gravity (upwards): negative gravitropism |
| <b>Root</b>  | grows <b>away from</b> light: negative phototropism | grows <b>towards</b> gravity (downwards): positive gravitropism |

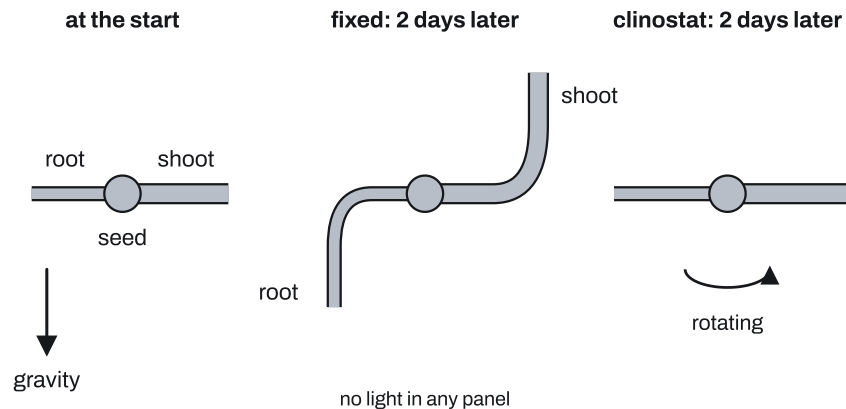
So "shoots up, roots down" in the dark is **gravitropism**, and "shoot bends towards the window" is **phototropism**. Phototropism is a response of **parts** of a plant; it is not "all parts of the plant grow towards light", because roots grow away from it.

### Reading the set-up

In every tropism question, first ask: **which stimulus can the plant detect from one side only?**

- **In the dark** (in a light-proof box, or in soil), there is **no light** to respond to, so the only possible response is **gravitropism**. Phototropism can't happen in the dark.
- **Light from one side** (a hole in a box, a window, a lamp): the shoot shows **phototropism** and bends towards the light.
- **Light from all directions**, or a plant **turned round and round**: light reaches every side equally, so there is no bending towards light.
- **A plant on its side**, not rotating: gravity acts on its lower side, so the shoot curves **up** and the root curves **down**.
- **A plant on its side on a rotating clinostat**: each side takes its turn at the bottom, so gravity acts on **all sides equally** and the shoot and root grow **straight on**, horizontally, in the direction they started.

A **clinostat** is a slowly rotating platform or disc. Rotating a plant **cancels out** a one-sided stimulus (gravity if it is turned about a horizontal axis, light from one side if the platform spins flat). It is used as a **control**: a rotated plant is compared with a fixed one to show that the fixed plant's bending was caused by the one-sided stimulus.



## Why tropisms help the plant

Growing the right way puts each part where it can do its job:

- **Shoots** grow **up** and **towards light**, so the leaves **receive more light** for **photosynthesis** (and reach the air, for carbon dioxide). A plant that makes more glucose can grow and respire more. Tall shoots also hold flowers where insects or wind can pollinate them.
- **Roots** grow **down** into the soil, **towards gravity** and **away from light**, so they grow deeper to reach **water** and **mineral ions**, and **anchor** the plant.
- A seed buried in the dark soil still "knows" which way is up: its shoot grows up to the surface and its root grows down, by gravitropism.

## Auxin controls the growth

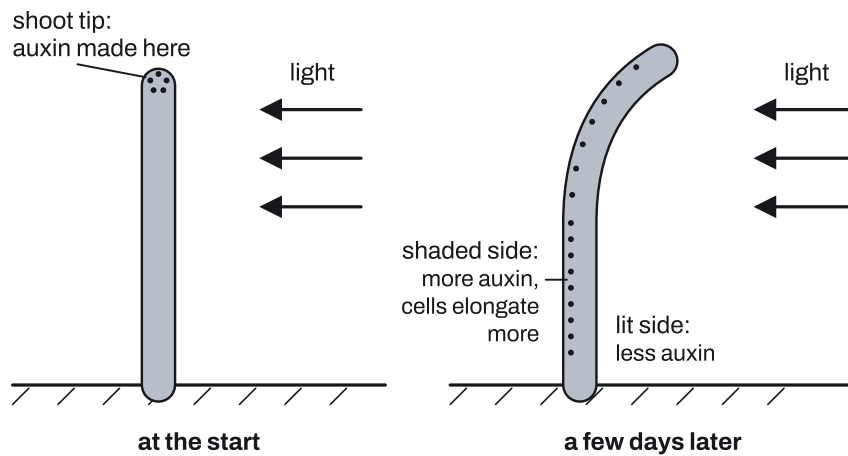
**Extended only:** Tropisms are **chemical control** of growth. The chemical is a plant hormone called **auxin**.

Four facts explain everything:

1. **Auxin is made in the shoot tip** (the very end of the shoot), not along the whole stem.
2. **Auxin diffuses** down the shoot **from the tip**, to the region just below it where the cells are growing. It moves by **diffusion**, not by osmosis.
3. **Auxin is unequally distributed in response to light and gravity:** it collects on one side of the shoot.
4. **Auxin stimulates cell elongation:** cells with **more auxin grow longer**.

**Extended only:** The side with more auxin grows faster, so the shoot **bends away from that side**.

**Extended only: Phototropism in a shoot.** With light from one side, auxin moves to the **shaded side**. Cells on the shaded side elongate **more** than cells on the lit side, so the shaded side becomes longer and the shoot curves **towards the light**.



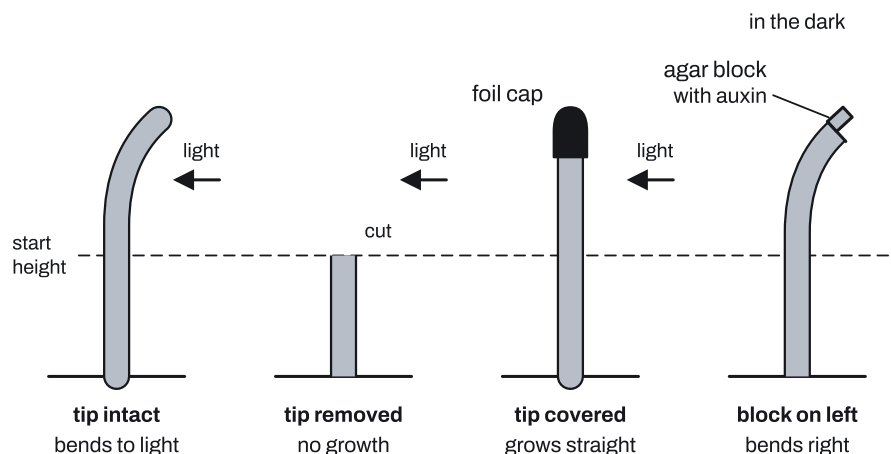
**Extended only: Gravitropism in a shoot.** In a shoot lying on its side, auxin collects on the **lower side**. The lower side elongates **more** than the upper side, so the shoot curves **upwards**, away from gravity (the fixed seedling in the first diagram).

**Extended only:** If auxin is **evenly distributed** (light from all sides, or a plant on a clinostat), both sides elongate equally and the shoot grows **straight**.

**Extended only:** The syllabus asks you to explain auxin only in **shoots**. For a root, describe the response (it curves **down**, towards gravity) and, unless a question asks about auxin in the root, keep your auxin explanation to the shoot.

## Experiments with shoot tips

**Extended only:** Because auxin is made in the tip and diffuses down, removing, covering or replacing the tip gives predictable results. With light from one side:



**Extended only:** what each experiment shows:

| What was done                                                                  | Result                                         | Why                                                                                           |
|--------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Tip left on, light from one side                                               | grows and <b>bends towards the light</b>       | auxin collects on the shaded side                                                             |
| <b>Tip removed</b>                                                             | <b>no growth</b> , no bending                  | no tip, so no auxin is made: evidence that auxin is <b>made in the tip</b>                    |
| <b>Tip covered with a light-proof cap</b>                                      | grows <b>straight up</b>                       | the tip can't detect the direction of light, so the auxin that diffuses down is spread evenly |
| Tip removed, <b>agar block</b> with auxin placed <b>over the whole cut end</b> | grows <b>straight up</b>                       | auxin diffuses evenly out of the block and down the stem                                      |
| Tip removed, agar block with auxin on <b>one side</b> of the cut end           | bends <b>away from the side with the block</b> | only that side gets auxin and elongates                                                       |

**Extended only:** Agar blocks can collect auxin: stand a shoot tip on a block split into two halves, with light from one side, and the half under the **shaded** side collects **more** auxin. A decapitated shoot given the block with more auxin grows **taller** than one given the block with less.

## Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt.

| Formula                                                                                                    | Status   |
|------------------------------------------------------------------------------------------------------------|----------|
| Gravitropism: growth towards or away from gravity                                                          | Learn it |
| Phototropism: growth towards or away from the direction of the light source                                | Learn it |
| Positive = towards the stimulus; negative = away from it                                                   | Learn it |
| Shoots: positive phototropism, negative gravitropism; roots: negative phototropism, positive gravitropism  | Learn it |
| In the dark only gravitropism can happen                                                                   | Learn it |
| Clinostat: rotation makes a one-sided stimulus act equally on all sides; a control                         | Learn it |
| <b>Extended only:</b> auxin is made in the shoot tip and diffuses down from it                             | Learn it |
| <b>Extended only:</b> auxin collects on the shaded side (light) and on the lower side (gravity) of a shoot | Learn it |

| Formula                                                                                        | Status   |
|------------------------------------------------------------------------------------------------|----------|
| <b>Extended only:</b> auxin stimulates cell elongation, so the side with more auxin grows more | Learn it |
| Percentage change = (new value – original value) ÷ original value × 100                        | Learn it |

## How to do it

We tagged 58 questions for this topic (2021–2025, Papers 1–4; one multiple-choice question appeared on six papers in November 2021). 10 of them mix types, so the counts add up to 75.

| Question type                                   | Questions |
|-------------------------------------------------|-----------|
| Name or describe a tropic response              | 31        |
| Predict or interpret growth in an investigation | 19        |
| Explain the role of auxin                       | 17        |
| Explain why a tropic response is an advantage   | 4         |
| Interpret experiments on shoot tips             | 3         |
| Calculate a percentage change in growth         | 1         |

### 1. Name or describe a tropic response (31 questions)

- Find the stimulus that comes from one direction:** light (from a window, a lamp or a hole in a box) or gravity (in the dark, or a plant on its side).
- Name it:** light → **phototropism**; gravity → **gravitropism**. Spell it exactly: "phototropism", "gravitropism".
- Say which way the part grew:** towards the stimulus (positive) or away from it (negative).

#### Variations you will meet:

- Definitions** (as multiple choice or 1–2 marks): phototropism is **growth** of part of a plant **towards or away from the direction of light**; gravitropism is **growth towards or away from gravity**. It is **directional growth**, not photosynthesis, not "absorbing water", and not a reflex.
- "Which is an example of phototropism?"** A shoot growing towards light. "A root growing towards the centre of the Earth" is gravitropism.
- Tables of + and –** for a root or a shoot: root = gravitropism +, phototropism –; shoot = gravitropism –, phototropism +. On a diagram, the part below ground (or pointing down) is the root.
- "In the dark, shoots grow up and roots grow down. What causes this?"** Gravitropism only (no phototropism). The same for a seedling in a **dark box**: both root and shoot show **gravitropism**.
- A seedling underground:** the shoot growing up and the root growing down are both **gravitropism**; there is no light in the soil.

- **"A plant near a window: the shoot grows towards the window."** Growth towards the light source and, as it grows up, away from gravity.
- **Gap-fills:** growth towards light is **phototropism**; the growth is the **response**; light is the **stimulus**.
- **"Which factors affect the growth of plants?"** Gravity, light **and** temperature.
- **The scape (flower stalk) or stem grows towards sunlight:** phototropism.

## 2. Predict or interpret growth in an investigation (19 questions)

1. **Read every condition:** light or dark? Light from one side or all sides? Plant upright, on its side, or rotating?
2. **Decide the stimulus** (as in type 1) and **predict:** shoot towards light and up; root away from light and down.
3. **Draw or choose** the result: curve the **shoot** upwards or towards the light and the **root** downwards, starting from where they were. Don't redraw the plant in a new position.
4. **Explain** in terms of the stimulus acting on one side. **Extended only:** add that auxin collects on that side.

### Variations you will meet:

- **A seedling on its side in the dark** (on a board, a card or in a Petri dish): shoot curves **up**, root curves **down**. Seedlings pinned facing different ways all end up the same: every root down, every shoot up.
- **A pot turned on its side** in the dark: the shoot turns and grows upwards; the roots turn and grow downwards.
- **Rotating clinostat or disc** (on its side): gravity acts **equally on all sides**, so the shoot and root grow **straight on**, horizontally. **When the rotation stops**, the root curves **down** (towards gravity) and the shoot **up**.
- **"Explain the reason for rotating plant A":** to cancel the effect of gravity on one side, so it acts equally on all sides; plant A is a **control** to compare with the fixed plant. **Extended only:** add that auxin is then evenly distributed.
- **A box with a hole and a turntable:** the fixed plant bends **towards the hole** (phototropism); the rotated plant grows **straighter**, because every side receives light in turn.
- **Light from one side and on its side together:** the shoot grows up and towards the light; the root grows down and away from the light.
- **"Which stimuli have the seedlings responded to?"** In the dark: gravity only. With light from one side and a seedling on its side: gravity and light.
- **"Describe the pattern of growth":** say what **all** the roots did (grew downwards, whichever way they faced at the start) and what **all** the shoots did (grew upwards).

## 3. Explain the role of auxin (17 questions)

**Extended only:** write one fact per mark, in this order:

1. **Auxin** (a plant hormone) is **made in the shoot tip**.
2. It **diffuses** down the shoot **from the tip**.

3. It is **unequally distributed**: it collects on the **shaded side** (light from one side) or the **lower side** (shoot on its side).
4. Auxin **stimulates cell elongation**.
5. So cells on that side **elongate more** than the other side.
6. The shoot **grows** (bends) **towards the light**, or **upwards, away from gravity**.

**Extended only:** variations you will meet:

- **Multiple-choice statements:** true: made in the shoot tip; collects on the lower side of a horizontal stem; collects on the **shaded** side; stimulates elongation; unequally distributed. False: made in all cells; made only on the shaded side; more on the **lit** side; moves by **osmosis**; **inhibits** elongation; elongates cells **in the tip** itself; acts only where it is made.
- **"Which side has the lowest auxin concentration?"** The side **facing the light**. Auxin is **produced** at the **tip**.
- **Diagrams of auxin distribution:** pick the one with auxin on the side **away from** the light.
- **A seedling on its side:** auxin collects on the **lower** surface of the shoot and **promotes** elongation there; conclusion: a **high** concentration stimulates elongation on the **lower side of the shoot** (not the root).
- **Light from one side plus a seedling on its side:** auxin collects in the **lower** part of the shoot, and the shoot grows up and towards the light.
- **Clinostat gap-fills** about a root (the one exam case that brings auxin into roots): the answers expected are that auxin is made in shoot and root **tips**; it travels by **diffusion**; rotation makes the effect of **gravity** equal on all sides; auxin is **equally** distributed; auxin stimulates cell **elongation**, so the root grows straight on (horizontally).
- **Comparing a fixed and a rotated shoot:** fixed: more auxin on the lower side → lower side elongates more → shoot grows up; rotated: auxin equal on both sides → equal elongation → grows straight.

#### 4. Explain why a tropic response is an advantage (4 questions)

1. **Shoot:** grows towards light / up → leaves **receive more light** → more **photosynthesis** → more **glucose** for growth and respiration. Reaching the air gives **carbon dioxide** for photosynthesis; flowers held up are easier to **pollinate**.
2. **Root:** grows down / away from light → deeper into the **soil** → absorbs more **water** and **mineral ions**; **anchors** the plant.

**Variations you will meet:**

- **"How do tropic responses allow roots to absorb more water?"** Name the responses (positive gravitropism, negative phototropism), say which way roots grow (towards gravity, away from light), then link to reaching **more water deeper in the soil**.
- **Seedlings** that come up from underground: the shoot reaches light before its food store runs out; the root reaches water.

## 5. Interpret experiments on shoot tips (3 questions)

**Extended only:** these experiments test the auxin facts.

1. **Tip removed** → no auxin → **no growth** and no bending. Two shoots, one with a tip and one without, in even light: the evidence shows that **auxin is made in the tip**.
2. **Tip covered** (foil cap) → can't detect light direction → auxin even → grows **straight up**.
3. **Agar block**: auxin diffuses from a tip into agar and from agar into a cut stem. More auxin in the block → **more growth**. A block over the **whole** cut end → straight growth; a block on **one side** → bends **away** from that side.
4. A tip on a split agar block with light from one side: the half under the **shaded** side collects **more** auxin.

**Extended only:** variations you will meet:

- **"Which statement is supported by the evidence?"** Only choose what the experiment shows. In even light, nothing shows unequal distribution in response to light; nothing shows osmosis.

## 6. Calculate a percentage change in growth (1 question)

1. **Read both values** from the graph or table, at the times asked.
2. **Percentage increase** = (later value – earlier value) ÷ earlier value × 100.
3. **Round** as asked, for example to two decimal places.

For example, a root that grows from 18 mm to 45 mm has increased by  $\frac{45 - 18}{18} \times 100 = 150\%$ .

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## Worked examples

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The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

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### Example 1

**Core.** A student placed a young bean seedling on its side on a damp card inside a light-proof box. The shoot pointed to the right and the root pointed to the left.

- (a) Describe the appearance of the root and the shoot after three days. **[2]**
- (b) State the name of the response shown. Explain your answer. **[2]**

(c) The student repeated the experiment with a second seedling, but fixed the card to a clinostat that rotated slowly. Predict the appearance of this seedling after three days, and explain why the student set up this seedling. [3]

(a) The shoot has curved **upwards B1**; the root has curved **downwards B1**.

(b) Gravitropism **B1**; the box let in no light, so the seedling could only respond to gravity **B1**.

(c) The shoot and root have both grown straight on, horizontally **B1**. The rotation makes gravity act equally on all sides **B1**. It is a control, to show that the bending of the first seedling was caused by gravity **B1**.

## Example 2

**Extended only:** A potted plant was kept in a room where light came only through a window on its left.

(a) State the name of the response shown by the shoot after a week. [1]

(b) Explain how auxin causes this response. [4]

(c) Explain how this response is an advantage to the plant. [2]

(a) (Positive) phototropism **B1**.

(b) Any four of: auxin is made in the shoot tip **B1**; it diffuses down the shoot from the tip **B1**; it collects on the shaded (right-hand) side of the shoot **B1**; auxin stimulates cell elongation **B1**; so cells on the shaded side elongate more than on the lit side, and the shoot bends towards the window **B1**.

(c) The leaves receive more light **B1**, which is needed for photosynthesis, so the plant can make more glucose **B1**.

## Example 3

**Extended only:** Two groups of maize seedlings, P and Q, were grown with light from one side for four days. In group P a foil cap was placed over each shoot tip; in group Q the shoot tips were cut off.

| Group               | Mean length at the start / mm | Mean length after four days / mm |
|---------------------|-------------------------------|----------------------------------|
| P (foil cap on tip) | 30                            | 42                               |
| Q (tip removed)     | 30                            | 31                               |

(a) Calculate the percentage increase in mean length for group P and for group Q. Give your answers to two decimal places. [3]

(b) Explain why the shoots in group P grew much more than those in group Q. [3]

(c) Predict the direction of growth of the shoots in group P, and explain your prediction. [2]

(a) P:  $\frac{42 - 30}{30} \times 100 = 40.00\%$  **M1 A1**. Q:  $\frac{31 - 30}{30} \times 100 = 3.33\%$  **A1**.

(b) Auxin is made in the shoot tip **B1**. In group P the tips were still there, so auxin diffused down the shoot and stimulated cell elongation **B1**. In group Q there was no tip, so no auxin was made and the cells hardly elongated **B1**.

(c) The shoots grew straight up **B1**: the cap stopped the tip detecting the direction of the light, so auxin was evenly distributed and both sides elongated equally **B1**.

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## Common mistakes

- **Answering "phototropism" when the plant is in the dark.** Examiner reports in 2021 and 2023 said many candidates did this. In a light-proof box or underground there is no light, so the response is **gravitropism**. Check the diagram for "box to exclude light" before you answer.
- **Saying "positive gravitropism" for a shoot.** A shoot grows away from gravity: **negative** gravitropism. If unsure, just write "gravitropism" (the name is what the mark is for).
- **Writing "tropism", "gravity" or a misspelling.** Name the response exactly: **phototropism**, **gravitropism**. Examiners stress spelling these keywords correctly, especially where a misspelling could be confused with another word ("photo trophic" was seen in 2025).
- **Extended only: Putting auxin on the lit side.** Auxin collects on the **shaded** side, so that side grows more and the shoot bends **towards** the light.
- **Extended only: Saying auxin inhibits growth or moves by osmosis.** Auxin **stimulates cell elongation** and moves by **diffusion**.
- **Extended only: "Auxin elongates the cells in the shoot tip" or "auxin is made where it acts".** It is **made** in the tip and **acts** below it, after diffusing down.
- **Extended only: Saying the shoot "bends" without growth.** Say the cells **elongate** and the shoot **grows** towards the light or upwards.
- **Extended only: Explaining roots when the question asks about the shoot.** Read which part the question names; the syllabus's auxin explanation is for shoots.
- **Misreading a clinostat set-up.** If light comes from **every** direction, the investigation is about gravity, not light. Rotation makes a stimulus act equally on all sides.
- **Advantages that stop at "light for photosynthesis".** Add more linked points: more glucose, carbon dioxide from the air, flowers reached by pollinators; for roots, water and mineral ions and anchorage.
- **Drawing a new root and shoot, or drawing them still horizontal.** Continue the shoot and root already drawn, **curving** up and down from where they end.

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## How to get the marks

- **"State the name":** one word, spelt correctly: phototropism, gravitropism (**Extended only:** auxin). Give one answer only; a second, wrong answer can cancel the right one.
- **"Describe" a tropism:** say **growth**, the **part** (shoot or root) and **towards or away from the stimulus** (light or gravity).

- **Extended only: "Explain" with auxin:** a chain of separate points, each a mark: made in the **tip** → **diffuses** down → collects on the **shaded / lower** side → stimulates **cell elongation** → that side **grows more** → shoot grows **towards light / upwards**. Four marks need four different points.
- **"Predict":** say which way each part will grow; if asked to explain, name the stimulus acting on one side.
- **"Complete the diagram":** one mark for the shoot (up or towards the light) and one for the root (down), both drawn from the original seed.
- **"Suggest"** an advantage: apply what you know (light → photosynthesis; soil → water and ions).
- **Controls:** a rotated or unrotated plant is there **to compare** with. **Extended only:** so is a shoot with its tip intact.
- **Calculations:** show the working, and round to the number of decimal places asked (for example 3.33).

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## Quick check

1. State what is meant by gravitropism.
2. A bean seed germinates deep in the soil. State which way the root grows and which way the shoot grows, and name the response.
3. **Extended only:** A shoot is lit from its left side. State which side of the shoot has the most auxin, and explain why the shoot bends.
4. **Extended only:** A shoot tip is removed and replaced by an agar block containing auxin, placed on the right half of the cut end only. The shoot is kept in the dark. Predict which way it grows.
5. A root was 12 mm long at the start and 30 mm long two days later. Calculate the percentage increase in length.

## Answers

1. A response in which parts of a plant grow towards or away from gravity.
2. The root grows down (towards gravity) and the shoot grows up (away from gravity); this is gravitropism (there is no light underground).
3. The right side (the shaded side). Auxin made in the tip diffuses down and collects on the shaded side; it stimulates cell elongation, so the right side grows longer and the shoot bends towards the light on the left.
4. It bends to the left: auxin diffuses down the right side only, so the right side elongates more.
5.  $\frac{30 - 12}{12} \times 100 = 150\%$ .

## Past questions to try

- **0610/42/M/J/23 Q6:** seedlings in fixed and rotating Petri dishes, naming the response and explaining it with auxin (Extended).
- **0610/41/M/J/21 Q4:** a clinostat as a control, auxin and the advantages of the response (Extended).
- **0610/31/M/J/24 Q5:** a plant on a rotating platform with light from one side, and why tropisms help (Core).
- **0610/42/F/M/24 Q3:** the response of a shoot in the dark, auxin, and a percentage increase in root length (Extended).