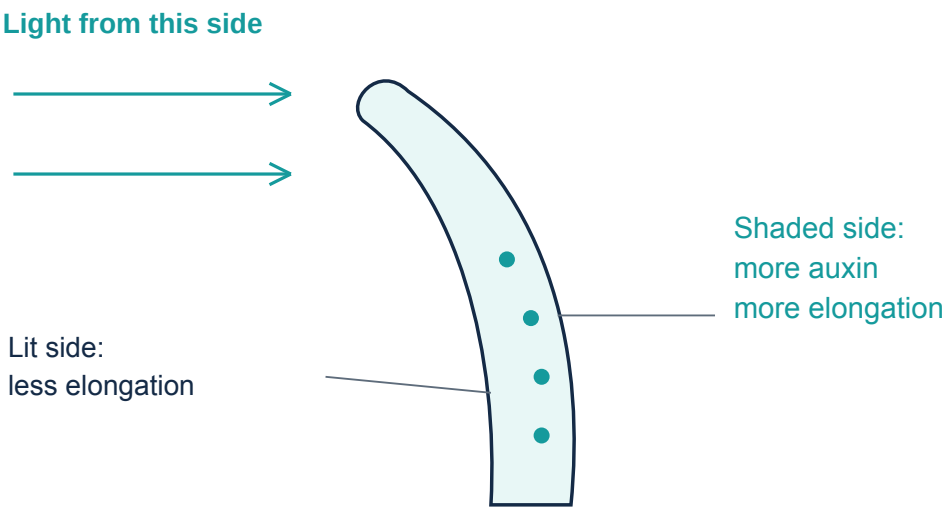
# Unequal growth bends a shoot

A tropism is growth whose direction depends on a stimulus. Positive means towards the stimulus; negative means away. Auxin is a hormone, not the stimulus itself.

## 1. SHOOT PHOTOTROPISM




The longer shaded side pushes the tip towards the light.

## 2. FROM LIGHT TO CURVATURE

In a young shoot, directional light changes auxin distribution. More auxin reaches the shaded side of the elongation region. Cells there extend faster, producing a bend towards the light: positive phototropism.

## 3. THE GROWING REGION MATTERS

Auxin, including indole-3-acetic acid (IAA), is produced in young tissues such as shoot tips. Regulated transport carries signals to responsive cells. Bending involves differential cell elongation, not the whole plant walking or the shaded side simply making more cells.

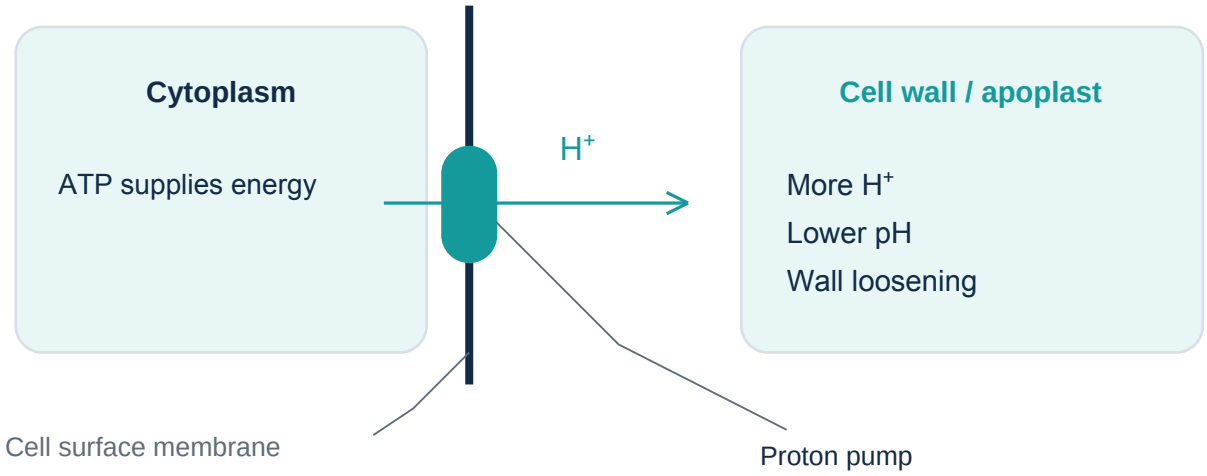
Directional responses and auxin: OpenStax, Biology 2e 30.6.
Auxin and cell-wall expansion: Majda & Robert (2018).

Scope: 9700 section 15.2, outcome 2, p. 40; tropisms are lesson context.

# Auxin promotes acid growth

The key syllabus mechanism is proton pumping into the cell wall region. A more extensible wall can yield to internal pressure, allowing the cell to elongate.

## 1. ACIDIFY THE WALL, NOT THE CYTOPLASM




| | |
|---|---|
| A. Activate | Auxin signalling increases plasma-membrane $H^+$-ATPase activity. |
| B. Acidify | ATP-driven pumps export $H^+$ into the wall region, lowering its pH. |
| C. Loosen | Acid conditions promote wall-loosening proteins such as expansins. The wall becomes more extensible. |
| D. Extend | Water uptake and turgor allow the loosened wall to yield. Cellulose organisation helps constrain expansion into elongation. |

Loosening is not digestion of the entire wall. The cell wall remains present and continues to support the growing cell.

Proton-pump activation: Takahashi, Hayashi & Kinoshita (2012).
Acid growth and wall extensibility: Majda & Robert (2018).

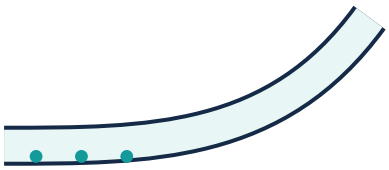
Scope: 9700 section 15.2, outcome 2, p. 40; tropisms are lesson context.

# Same signal, different responses

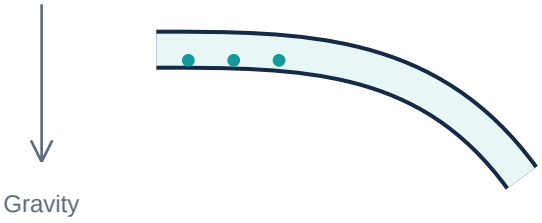
When an organ is placed horizontally, auxin redistribution towards its lower side can produce opposite curvature in shoots and roots.

## 1. GRAVITROPISM: COMPARE THE SIDES

### Shoot bends up



Lower side: more auxin.
Faster elongation.




### Root bends down

Lower side: more auxin.
Slower elongation.

Teal dots indicate relatively more auxin on the lower side. Schematics show the resulting bend, not measured concentrations.

## 2. ROOTS ARE MORE SENSITIVE TO AUXIN

In roots, increased auxin inhibits lower-side elongation. The upper side extends faster, bending the root down: positive gravitropism. In shoots, lower-side elongation is faster, bending the shoot up: negative gravitropism.

## 3. DO NOT USE AN ALWAYS RULE

Auxin effects depend on concentration, tissue and developmental stage. A level that promotes shoot elongation can inhibit root elongation. The useful distinction is the response of each side of the organ, not "more auxin always means more growth".

Root auxin transport and differential inhibition: Luschnig et al. (1998).
Shoot and root gravitropism: OpenStax, Biology 2e 30.6.

Scope: 9700 section 15.2, outcome 2, p. 40; tropisms are lesson context.