PLANT SIGNALLING

Content Statements:

C3.1.17 Observation of tropic responses in seedlings

C3.1.18 Positive phototropism as a directional growth response to lateral light in plant shoots

C3.1.19 Phytohormones as signalling chemicals controlling growth, development and response to stimuli in plants

C3.1.20 Auxin efflux carriers as an example of maintaining concentration gradients by phytohormones

C3.1.21 Promotion of cell growth by auxin

C3.1.22 Interactions between auxin and cytokinin as a means of regulating root and shoot growth

C3.1.23 Positive feedback in fruit ripening and ethylene production

PHYTOHORMONES

Phytohormones are signalling molecules produced by plants to control growth and development processes. Changing the concentrations and distributions of phytohormones allow plants to respond dynamically to external and internal stimuli. Examples of phytohormones include *auxins* (primary and directional growth), *cytokinin* (cell division), *ethylene* (ripening), *gibberellin* (germination) and *abscisic acid* (stomatal closure).

Gibberellin	Auxins	Ethylene	Abscisic Acid	Cytokinin

Phytohormones are signalling molecules produced by plants to control growth and development

PLANT GROWTH

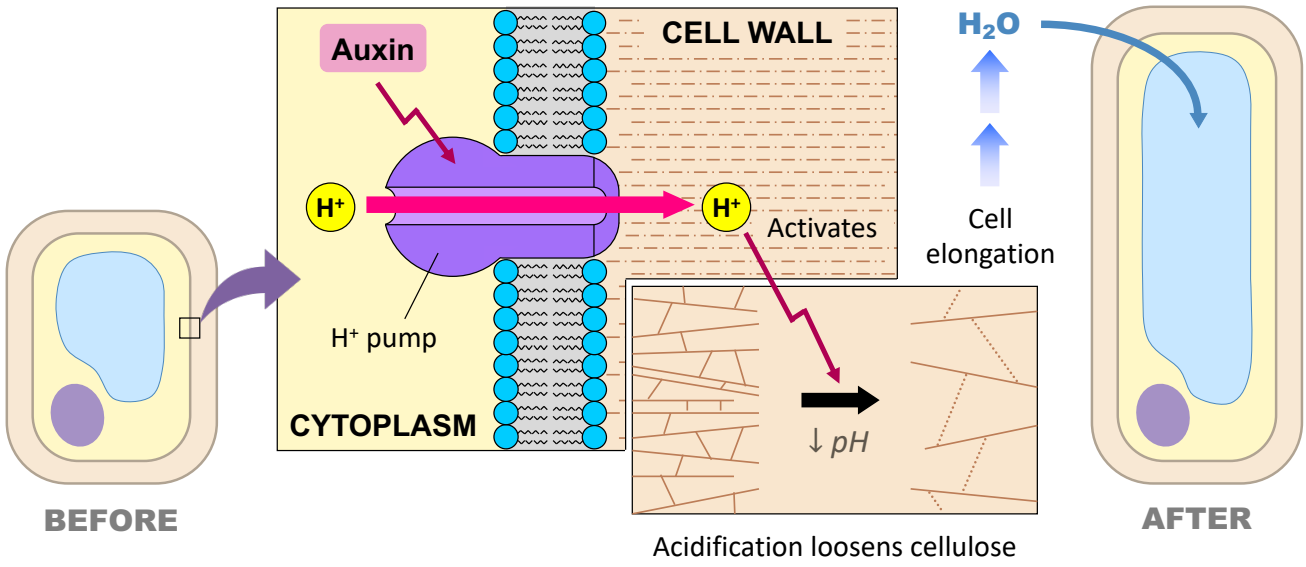
Apical growth refers to the growth that occurs at the tips of the shoots and roots and is controlled by two phytohormones – auxin and cytokinin. **Auxin** is produced in the *shoot tips* and is transported towards the roots (via phloem). **Cytokinin** is produced in the *roots* and is transported towards the shoots (via xylem). Both hormones are required for growth and must be transported to the region of the plant where they are not produced. Interactions between auxin and cytokinin are *synergetic* or *antagonistic* depending on their relative concentrations. A high ratio of auxin : cytokinin promotes root formation, while a low ratio induces shoot growth. Varying the concentrations of the hormones will allow plants to adapt to diverse conditions.

TROPISMS

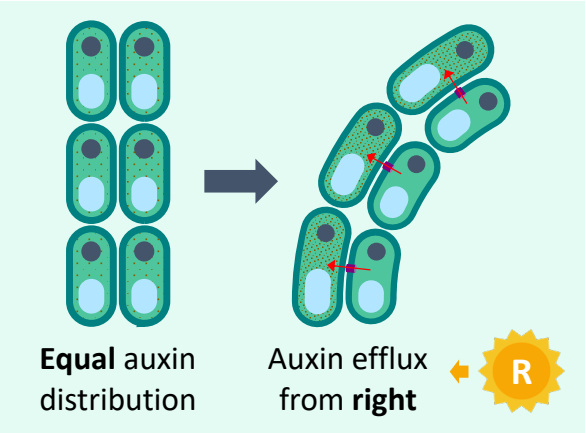
Tropisms describe the growth or turning movement of a plant in response to a directional external stimulus. A tropic response can be either *positive* (growth towards the stimulus) or *negative* (growing away from the stimulus). Tropisms can be determined by qualitative observations or quantitative measurements (e.g. angle of curvature). Examples of tropic responses include **phototropism** (light), geotropism (gravity), hydrotropism (water) or thigmotropism (contact).

PHOTOTROPISM

Auxins are a group of plant hormones that can increase the flexibility of the cell wall to promote growth via **cell elongation**. Auxin activates a proton pump in the cell membrane which causes the secretion of H^+ ions into the apoplast. The resultant acidification of the cell wall causes cellulose fibres to loosen. Additionally, auxin upregulates the expression of **expansins**, which similarly increase the elasticity of the cell wall. With the cell wall now more flexible, potassium channels are opened to trigger an influx of potassium ions into the cytoplasm. This lowers the water potential inside the cell, drawing in water via osmosis. This increases the pressure within the cell, causing the cytoplasm to expand and the cell wall to stretch (i.e. cell growth).



Auxin efflux carriers establish concentration gradients of auxin in plant tissues to control the growth of cells in the different areas of plants. Plants can position auxin efflux carriers on particular sides of a cell to create distribution patterns. Light receptors (**phototropins**) in plant shoots trigger the redistribution of the efflux carriers to *shaded sides* of a plant. This causes the shaded side of plants to become longer relative to the illuminated side (as auxin promotes cell elongation). This results in a bending of a shoot tip towards the source of light (**+ phototropism**).



RIPENING

Ethylene is a phytohormone involved in the maturation and ripening of certain types of fruits. Ethylene is a gas which can be released from one plant to influence the growth of another plant (*allelopathy*). Ethylene release causes a **positive feedback loop** which will synchronise the ripening of all fruit on a plant. Ethylene is released as the fruit begins to ripen, which triggers the ripening of other fruit (which in turn forms more ethylene gas). The production of high amounts of ethylene functions to ensure the ripening process is rapid (not prolonged). Ethylene is also involved in flowering and leaf shedding.