Balance of Hormones regulate growth and development

Environmental factors regulate hormone levels
  - light - e.g. phototropism
  - gravity - e.g. gravitropism
  - temperature

Mode of action of each hormone
1. Signal perception by a receptor on or in target cells.
2. Signal transduction and amplification via
   - \( R \rightarrow \text{ messengers} \rightarrow \text{ modify/activate protein} \)
   - \( R \rightarrow \text{ gene expression} \)
3. Response: change protein activity and/or gene expression
   \( \rightarrow \) growth/development response

Balance of IAA: cytokinin
Explain the effect on pith tissue
Hormones are used to regenerate transgenic plants.

21-13. Shoot and root development depend on ratio of IAA/CK

Auxin \( \rightarrow \) rooting

Cytokinin

shoot

21-4 Taiz. Tumour induction by cytokinin.
[Agrobacterium-mediated transformation - introducing new gene into plants]

Box 21-1 Taiz. Regenerating whole plants from transgenic cells or tissues.

Balance of hormones regulate growth and development
1. Shoot and root development depend on ratio of Auxin IAA: cytokinin
2. Leaf abscission depends on auxin and ABA
3. Seed development and germination depends on relative amount of ABA and GA

Effect depends on
  - Type of hormones
  - Concentration
  - Balance of hormones
19-27. Light causes redistribution of auxin to shaded side in phototropism.

Environmental signals regulate hormone levels via transport

**Figure 1** Auxin response during differential hypocotyl growth. a–d, Expression of the DR5::GUS reporter in hypocotyl of untreated (a, c) or auxin efflux inhibitor (NPA)-treated (b, d) wild-type seedlings upon stimulation by light (a, b) or gravity (c, d). Insets show details of DR5::GUS expression. Scale bars, 400 µm. e, Asymmetric expression of DR5::GUS reporter in the apical hook of an etiolated seedling. Scale bar, 50 µm.


Auxin level changes in response to light and to gravity are due to auxin transport.

**Figure 2.** pin3 mutants. 

b, c, pin3 hypocotyls are defective in gravitropic (b) as well as phototropic (c) responses.

d, pin3 mutants are defective in root gravitropism


19-33 Taiz. Gravitropism depends on distribution of hormones

What is the sensor for gravity?

19-30. Taiz. Root cap cells are important for sensing gravity

Amyloplast
Gravity may be sensed by a root cap cell according to the distribution of starch-storing plastids.

Mode of Action of hormones

1. Signal perception by a receptor in/on target cell
2. Signal transduction and amplification
3. Responses:
   - early gene expression
   - late gene expression
   - proteins activated
   - repressor removed

What causes cell elongation?
Acid pH causes wall extension.

Wall protein expansins are required for acid growth.

How does auxin stimulate cell elongation?
• Auxin induce H⁺ extrusion
• Ion uptake → osmotic water uptake
• Turgor pressure builds up
• Wall loosens, allowing cell wall to expand

How does auxin stimulate H⁺ extrusion?
• Activate the PM H⁺-pumping ATPase
• Increase synthesis of new PM H⁺ pumps
19-18. Model of auxin-induced H⁺ extrusion and cell expansion

19-31. Many SAUR (small auxin upregulated RNA) are transcription factors

Auxin induces expression of early and late genes

**Early genes** - [primary response genes]
- expressed in 5-60 min after adding auxin
- include transcription factors
- have roles in intercellular communication
- stress adaptation

19-41. IAA induce changes leading to degradation of proteins that repress early genes.

20-33. GA and barley seed germination
- Activate vegetative growth
- Mobilize stored food
- Q? How does GA stimulate amylase activity?
- What is the signal transduction pathway?
GA-Myb is an early response gene that regulates expression of α-amylase.

How is GA signal sensed?
How is that signal transmitted to increase amylase synthesis and secretion?