Cellular Communication In Plants

Plasmodesmata

Etiolation

Tropisms

Photoperiodism and Flowering
Plasmodesmata in Plant Cells

• **Plasmodesmata** are channels that perforate plant cell walls

• Through plasmodesmata, water and small solutes (and sometimes proteins and RNA) can pass from cell to cell
Figure 6.31

Interior of cell

0.5 µm

Plasmodesmata

Plasma membranes

Cell walls

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Concept 39.1: Signal transduction pathways link signal reception to response

• A potato left growing in darkness produces shoots that look unhealthy, and it lacks elongated roots
• These are morphological adaptations for growing in darkness, collectively called etiolation
• After exposure to light, a potato undergoes changes called de-etiolation, in which shoots and roots grow normally
Figure 39.2

(a) Before exposure to light

(b) After a week’s exposure to natural daylight
• A potato’s response to light is an example of cell-signal processing
• The stages are reception, transduction, and response
Figure 39.3

1. Reception
2. Transduction
3. Response

Relay proteins and second messengers

Activation of cellular responses

Plasma membrane
Reception

- Internal and external signals are detected by receptors, proteins that change in response to specific stimuli.
- In de-etioloation, the receptor is a phytochrome capable of detecting light.
Transduction

- **Second messengers** transfer and amplify signals from receptors to proteins that cause responses
- Two types of second messengers play an important role in de-etiolation: Ca$^{2+}$ ions and cyclic GMP (cGMP)
- The phytochrome receptor responds to light by
  - Opening Ca$^{2+}$ channels, which increases Ca$^{2+}$ levels in the cytosol
  - Activating an enzyme that produces cGMP
Figure 39.4-1

Reception

CYTOPLASM

Plasma membrane

Phytochrome

Cell wall

Light
Figure 39.4-3

1 Reception
   - Plasma membrane
   - Cell wall
   - Light

2 Transduction
   - Phytochrome
   - Ca^{2+} channel
   - cGMP
   - Protein kinase 1
   - Protein kinase 2

3 Response
   - Nucleus
   - Transcription
   - Translation
   - De-etiolation (greening) response proteins
   - Transcription factor 1
   - Transcription factor 2
Response

- A signal transduction pathway leads to regulation of one or more cellular activities
- In most cases, these responses to stimulation involve increased activity of enzymes
- This can occur by transcriptional regulation or post-translational modification
TROPISMS
TROPISM:
Plant growth in response to a stimulus
("tropo" - "turn")

There are many types of tropisms:

- Phototropism
- Geotropism
- Thigmotropism
- Hydrotropism
- Chemotropism
- Thermotropism

*Can be positive or negative

3 main types
**GEOTROPISM**

(“Geo” – Earth)

*Geotropism* is the growth of a plant in response to gravity.

*Positive Geotropism*
It is the growth of a plant towards the center of the earth-down with gravity.
Ex. roots growing down

*Negative Geotropism*
It is the growth of a plant away from the center of the earth-opposite from the pull of gravity.
Ex. stems grow up
IMPORTANCE OF GEOTROPISMS

• Pulls roots down to anchor a plant

• Roots can get needed water and minerals if they stay in the soil
PHOTOTROPISM

("Photo" – light)

The growth response of a plant in response to light direction is called phototropism.

Ex. Stems growing toward the window to get to the light
IMPORTANCE OF PHOTOTROPISMS

Enables leaves to be in the best position possible to receive adequate light for photosynthesis

http://www.darienps.org/teachers/otterspoor/botany/tropisms/Gravitropismwlight.jpg
THIGMOTROPISM
("Thigmo" - "touch")

Thigmotropism is the growth of a plant in response to touch/contact.

Tendrils on a sweet pea

Vines growing on a wall or fence
HYDROTROPISM
("hydro" - "water")

Hydro tropism is the growth in response to water. Ex. roots growing toward moisture.

THERMOTROPISM
("Therm" - "heat")

Thermotropism is the tendency of plants or other organisms to bend toward or away from heat.
Ex. curling of Rhododendron leaves in response to cold temperatures.

CHEMOTROPISM
("chemo" - chemical)

Chemotropism is movement caused by chemical stimuli. Ex. Growth of a pollen tube is always towards the ovules so that reproduction can occur.
CORN TROPISM LAB

http://www.youtube.com/watch?v=iFCdAgeMGOA&feature=related
Photoperiodism and Control of Flowering

• Some processes, including flowering in many species, require a certain photoperiod.

• Plants that flower when a light period is shorter than a critical length are called **short-day plants**.

• Plants that flower when a light period is longer than a certain number of hours are called **long-day plants**.

• Flowering in **day-neutral plants** is controlled by plant maturity, not photoperiod.
• Phytochromes exist in two photoreversible states, with conversion of $P_r$ to $P_{fr}$ triggering many developmental responses
• Red light triggers the conversion of $P_r$ to $P_{fr}$
• Far-red light triggers the conversion of $P_{fr}$ to $P_r$
• The conversion to $P_{fr}$ is faster than the conversion to $P_r$
• Sunlight increases the ratio of $P_{fr}$ to $P_r$, and triggers germination
Figure 39.19

Synthesis

$P_r$

Red light

Far-red light

Slow conversion in darkness (some plants)

$P_{fr}$

Enzymatic destruction

Responses: seed germination, control of flowering, etc.
The Effect of Light on the Biological Clock

- Phytochrome conversion marks sunrise and sunset, providing the biological clock with environmental cues
Photoperiodism and Responses to Seasons

- Photoperiod, the relative lengths of night and day, is the environmental stimulus plants use most often to detect the time of year
- **Photoperiodism** is a physiological response to photoperiod
• Some plants flower after only a single exposure to the required photoperiod
• Other plants need several successive days of the required photoperiod
• Still others need an environmental stimulus in addition to the required photoperiod
  — For example, **vernalization** is a pretreatment with cold to induce flowering