'You haven't much experience in plant conservation, have you Winthorpe?'
I. Plant Hormones - A compound produced by one part of the plant

Hormones - A compound produced in one area of an organism and has an affect on another area.

A. Plants grow toward the light

1. Phototropism - growth toward or away from the light
2. Shoot toward light = positive
3. Differential growth of cells on opposite side of shoot
4. Cells on opposite side elongate faster
<table>
<thead>
<tr>
<th>Hormone</th>
<th>Where Produced or Found in Plant</th>
<th>Major Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxin (IAA)</td>
<td>Embryo of seed, meristems of apical buds, young leaves</td>
<td>Stimulates stem elongation (low concentration only), root growth, cell differentiation, and branching; regulates development of fruit; enhances apical dominance; functions in phototropism and gravitropism; promotes xylem differentiation; retards leaf abscission</td>
</tr>
<tr>
<td>Cytokinins</td>
<td>Synthesized in roots and transported to other organs</td>
<td>Affect root growth and differentiation; stimulate cell division and growth; stimulate germination; delay senescence</td>
</tr>
<tr>
<td>Gibberellins</td>
<td>Meristems of apical buds and roots, young leaves, embryo</td>
<td>Promote seed and bud germination, stem elongation, and leaf growth; stimulate flowering and development of fruit; affect root growth and differentiation</td>
</tr>
<tr>
<td>Brassinosteroids</td>
<td>Seeds, fruit, shoots, leaves, and floral buds</td>
<td>Inhibit root growth; retard leaf abscission; promote xylem differentiation</td>
</tr>
<tr>
<td>Abscisic acid</td>
<td>Leaves, stems, roots, green fruit</td>
<td>Inhibits growth; closes stomata during water stress; promotes seed dormancy</td>
</tr>
<tr>
<td>Ethylene</td>
<td>Tissues of ripening fruit, nodes of stems, aging leaves and flowers</td>
<td>Promotes fruit ripening, opposes some auxin effects; promotes or inhibits growth and development of roots, leaves, and flowers, depending on species</td>
</tr>
</tbody>
</table>
B. Coordination of growth and development - 5 major classes of hormones

- Auxins (IAA)
- Cytokinins
- Gibberellins (GA)
- Abscisic acid
- Ethylene
Auxin

(a) Before exposure to light. A dark-grown potato has tall, spindly stems and nonexpanded leaves—morphological adaptations that enable the shoots to penetrate the soil. The roots are short, but there is little need for water absorption because little water is lost by the shoots.

(b) After a week’s exposure to natural daylight. The potato plant begins to resemble a typical plant with broad green leaves, short sturdy stems, and long roots. This transformation begins with the reception of light by a specific pigment, phytochrome.
• 1. Auxin- promotes elongation of young shoots (Indoleacetic acid)

  • a. The major site of auxin production is apical meristem
  • b. Affects secondary cell growth by inducing vascular cambium and secondary xylem
  • c. Promotes fruit growth
1. Reception
   - Cell wall
   - Light
   - Phytochrome activated by light
   - Plasma membrane

2. Transduction
   - Second messenger produced
   - cGMP
   - Specific protein kinase 1 activated
   - Specific protein kinase 2 activated
   - Ca²⁺ channel opened
   - Ca²⁺

3. Response
   - Transcription factor 1
   - Transcription factor 2
   - Transcription
   - Translation
   - De-etiolation (greening) response proteins
Excised tip placed on agar block

Growth-promoting chemical diffuses into agar block

Agar block with chemical stimulates growth

Control (agar block lacking chemical) has no effect

Offset blocks cause curvature
Flourescent tag used to show auxin location in a plant

EXPERIMENT
To investigate how auxin is transported unidirectionally, researchers designed an experiment to identify the location of the auxin transport protein. They used a greenish-yellow fluorescent molecule to label antibodies that bind to the auxin transport protein. They applied the antibodies to longitudinally sectioned Arabidopsis stems.

RESULTS
The left micrograph shows that the auxin transport protein is not found in all tissues of the stem, but only in the xylem parenchyma. In the right micrograph, a higher magnification reveals that the auxin transport protein is primarily localized to the basal end of the cells.

CONCLUSION
The results support the hypothesis that concentration of the auxin transport protein at the basal ends of cells is responsible for polar transport of auxin.
2. Cytokinins - stimulates cytokinesis
   a. Cell division and cytokinesis
      1. Moves in xylem sap
      2. Stimulates RNA and protein synthesis
      3. Works in conjunction with auxin
   b. Apical dominance
      1. cytokinins and auxin are antagonistic- auxin from terminal bud causes shoot to 
         lengthen.
      2. Cytokinins from roots stimulate axillary bud
      3. Auxin stimulates lateral root formation cytokinins restrain it.
   c. Anti-__aging - slows leaf deterioration
Plant b has apical bud removed so axillary buds grow.
3. Giberellins- 80 different kinds
   a. Stem elongation- produced in the roots and young leaves
      1. stimulate cell division, growth of leaves
      2. causes bolting- rapid growth of floral stems
   b. Fruit growth- controlled by Giberellins and auxin
      1. Grapes are sprayed to grow bigger
   c. Germination- signals seeds to break dormancy
Grapes on the right treated with gibberellins
• 4. First isolated from *Brassic* pollen in 1979, brassinosteroids are steroids chemically similar to cholesterol and the sex hormones of animals.
  
  – a. Brassinosteroids induce cell *elongation* and division in the stem
  
  – b. They also retard leaf *abscission* and promote xylem differentiation
5. Abscisic Acid- helps prepare plants for winter by suspending growth
   a. inhibits cell division in vascular cambium
   b. onset of seed dormancy
   c. stress hormone - closes stomata
Without abscisic acid the mutant corn seed sprouts
6. Ethylene - Gaseous hormone - induced by high auxin, inhibits growth

   a. Senescence - aging, fruit ripening and leaf abscission

   b. Fruit ripening - aging cells release more ethylene

       1. Spreads from fruit to fruit

       2. Leaves lose pigment

   c. Leaf abscission - prevents dessication

       1. Leaf nutrients are sent to storage

       2. Short days and cool temperature
The triple response to an obstacle induces ethylene production.
<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Ethylene added</th>
<th>Ethylene synthesis inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wild-type</strong></td>
<td><img src="image" alt="Wild-type control" /></td>
<td><img src="image" alt="Wild-type added" /></td>
<td><img src="image" alt="Wild-type inhibitor" /></td>
</tr>
<tr>
<td><strong>Ethylene insensitive (ein)</strong></td>
<td><img src="image" alt="Ein control" /></td>
<td><img src="image" alt="Ein added" /></td>
<td><img src="image" alt="Ein inhibitor" /></td>
</tr>
<tr>
<td><strong>Ethylene overproducing (eto)</strong></td>
<td><img src="image" alt="Eto control" /></td>
<td><img src="image" alt="Eto added" /></td>
<td><img src="image" alt="Eto inhibitor" /></td>
</tr>
<tr>
<td><strong>Constitutive triple response (ctr)</strong></td>
<td><img src="image" alt="Ctr control" /></td>
<td><img src="image" alt="Ctr added" /></td>
<td><img src="image" alt="Ctr inhibitor" /></td>
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The change in balance of auxin and ethylene causes abscission.
II. Plant Movement
A. Tropism- growth toward stimuli
1. Phototropism- see early note
2. Gravitropism- orientation of plant in response to gravity
   a. roots down, stems up
3. Thigmotropism- response to **touch**- may be increased ethylene
Phototropism
QuickTime® and a YUV420 codec decompressor are needed to see this picture.
Gravitropism

(a) (b)

Statoliths

20 μm
QuickTime? and a YUV420 codec decompressor are needed to see this picture.
Thigmotropism
QuickTime® and a YUV420 codec decompressor are needed to see this picture.
Far red light inhibits germination while red light enhances it.

**EXPERIMENT**
During the 1950s, USDA scientists briefly exposed batches of lettuce seeds to red light or far-red light to test the effects on germination. After the light exposure, the seeds were placed in the dark, and the results were compared with control seeds that were not exposed to light.

**RESULTS**
The bar below each photo indicates the sequence of red-light exposure, far-red light exposure, and darkness. The germination rate increased greatly in groups of seeds that were last exposed to red light (left). Germination was inhibited in groups of seeds that were last exposed to far-red light (right).

**CONCLUSION**
Red light stimulated germination, and far-red light inhibited germination. The final exposure was the determining factor. The effects of red and far-red light were reversible.
A phytochrome consists of two identical proteins joined to form one functional molecule. Each of these proteins has two domains.
Synthesis $\rightarrow$ $P_r$ $\xrightarrow{\text{Red light}}$ $P_{fr}$ $\rightarrow$ Responses: seed germination, control of flowering, etc.

$\xleftarrow{\text{Far-red light}}$ $\xrightarrow{\text{Enzymatic destruction}}$ Slow conversion in darkness (some plants)
Sleep movements
(a) “Short-day” plants

(b) “Long-day” plants
III. Control of daily and Seasonal responses

A. Biological clocks - circadian rhythms- plants have sleep movements and opening and closing of stomata.

1. Circadian rhythm- physiological cycle (24hrs)
   a. most are cued to dark and light
   b. Once off it could take days to reset (jet lag)

B. Photoperiodism- plants response to day length

1. Photoperiodism and flowering- control
   a. short- day= light shorter than critical period (late summer, fall, winter)
   b. long-day= light period longer than a critical period (late spring/summer)
   c. day-neutral= unaffected by day length.
Flowering signal (florigen)
1. Wounding
2. Signal transduction pathway
3. Synthesis and release of volatile attractants
4. Recruitment of parasitoid wasps that lay their eggs within caterpillars
examination

• Q1. 請說明光合作用色素之組成 (主要色素及輔助色素)，舉例說明植物適應光強及光質改變之色素變化 (25%)
• Q2. 說明質體 (plastid) 的演化過程 (25%)
• Q3. 說明Auxin (生長素) 之酸性生長 (25%)
• Q4. Ethylene 是一種氣態植物荷爾蒙，說明triple response (25%)