VEGETABLE SEED GERMINATION

Seed maturation
- Takes place in the fruit on the parent plant
- **Endospermous seeds**: Retain the endosperm tissue, which eventually dies but it is surrounded by a layer of living cells, the aleurone layer.
- **Non-endospermous seeds**: The endosperm tissue is absorbed by the cotyledons. These then become the food reserve for the seed.

Dormancy
- Metabolism falls
- Number of organelles per cell falls
- Dehydration – water content falls
- Vacuoles in cells deflate
- Food reserves become dense crystalline bodies

Maintaining dormancy
- Physical barriers
  - The seed coat (testa) is waxy = **waterproof** and **impermeable to oxygen**
  - Physical state – dehydrated
- Chemical **inhibitors** present e.g. salts, mustard oils, organic acids, alkaloids
- Growth promoters **absent**

Breaking Seed Dormancy
- **Scarification**
  - Overcomes physical seed dormancy
    - (Seed coat is impermeable to water)
  - Three methods
    - Mechanical abrasion
    - Hot water (170-212°F)
    - Acid treatment (concentrated sulfuric acid)
      - (Seed coat is impermeable to water)
- **Stratification**
  - Overcomes physiological seed dormancy
    - (Embryo dormancy, internal dormancy)
    - Moistened, cold storage
      - Storage at 32°F for 1-9 months

Seed viability
- **Viability**: When a seed is capable of germinating after all the necessary environmental conditions are met.
- Average life span of a seed 10 to 15 years.
- Some are very short-lived e.g. willow (< 1 week)
- Some are very long-lived e.g. mimosa 221 years
- Conditions are very important for longevity
- **Cold, dry, anaerobic conditions**
- These are the conditions which are maintained in seed banks
Germination: The breaking of dormancy

The growth of the embryo and its penetration of the seed coat

Break down of barriers
- Abrasion of seed coat (soil particles)
- Decomposition of seed coat (soil microbes, gut enzymes)
- Cracking of seed coat (fire)

Change in physical state - rehydration

Destruction and dilution of inhibitors
- Light, temperature, water

Production of growth promoters

STAGE | EVENTS
--- | ---
PREGERMINATION | (a) Rehydration – inhibition of water.
(b) RNA & protein synthesis stimulated.
(c) Increased metabolism – increased respiration.
(d) Hydrolisis (digestion) of food reserves by enzymes.
(e) Changes in cell ultrastructure.
(f) Induction of cell division & cell growth.

GERMINATION | (a) Rupture of seed coat.
(b) Emergence of seedling, usually radicle first.

POST GERMINATION | (a) Controlled growth of root and shoot axis.
(b) Controlled transport of materials from food stores to growing axis.
(c) Senescence (aging) of food storage tissues.

Stages leading to cell division

Respiration
- Initially anaerobic
- Later aerobic
- Mitochondria reconstituted

Soluble sugars
- RNA activated
- Translational reaction (polysomes)
- Protein synthesis (0.5h)
- Enzymes (proteins)
- DNA synthesis (45h)
- Mitosis (70h)

The control of food reserve hydrolysis

- Control by growth promoters such as gibberellin and growth inhibitors such as abscisic acid
- These directly affect the genes for enzyme synthesis or the activity of the enzymes themselves
- The growth substances are affected by environmental factors (e.g. light, temperature, humidity)

The mobilisation of food reserves

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Starches (amylopectin &amp; amylose)</th>
<th>Amylases</th>
<th>Maltose and glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>e.g. Zein</td>
<td>Proteases</td>
<td>Amino acids</td>
</tr>
<tr>
<td>Lipids</td>
<td>Oils</td>
<td>Lipases</td>
<td>Fatty acids &amp; glycerol</td>
</tr>
</tbody>
</table>

- The food reserves are stored as large insoluble macromolecules
- They are hydrolysed using enzymes to smaller soluble molecules for transport

The control of food reserve hydrolysis

- Negative feedback control of enzymes
- The action of the enzyme also limited by substrate
- Once all the starch in an amyloplast is hydrolysed the enzyme stops work

Therefore, the release of the stored food is adjusted to suite the demand
DICOT GERMINATION. The RADICLE (embryonic root) is the first organ to emerge from the germinating seed. A hook forms in the HYPOCOTYL, and growth pushes the hook with the attached COTYLEDONS and EPICOTYL above ground. This action protects the delicate shoot tip as it emerges from the soil.

Stages of Germination

We have already learned that seeds contain embryonic roots, stems, and leaves, and enough food to keep the plant growing until it has the ability to produce its own food through photosynthesis.

Epicotyl (will become the shoot-stems and leaves)
Radicle (embryonic root)
Hypocotyl (connection between cotyledon and radicle)
Cotyledon (seed leaf)

Note: If the seed has one cotyledon, it is a monocot. Corn is a monocot. If it has two, it is a dicot. A Mung bean is a dicot.

Once germination requirements have been met, these embryonic plant parts begin to grow. Botanists are still debating whether cell expansion or cell division is responsible for this growth. Either way, the following process takes place:
1) The radicle pushes through the seed coat into the soil.

2) Primary roots begin to develop and the hypocotyl forms a hook that straightens out, pulling the cotyledons above ground.

3) The emergent seedling begins to straighten out, taking the cotyledons with it.

4) The primary leaves begin unfolding and the stem elongates.

5) The true leaves completely emerge and the cotyledons eventually fall off.
Germination Temperatures for Vegetables and Special Crops

<table>
<thead>
<tr>
<th></th>
<th>Minimum (°C)</th>
<th>Preferred (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>beans</td>
<td>8-10</td>
<td>16-30</td>
</tr>
<tr>
<td>beet</td>
<td>4</td>
<td>10-30</td>
</tr>
<tr>
<td>cabbage</td>
<td>4</td>
<td>7-35</td>
</tr>
</tbody>
</table>

Germination: the development of a seed from its embryonic form to the birth of a new plant.

Cotyledon: lobe contained within the seed.

Young stem: immature plant.

Seed coat: the hard outer shell of the seed.


Radicle: part of the plant from which the root originates.

Secondary roots: divisions of the primary root.

Hypocotyl: part of the plantlet beneath the cotyledons.

Seed Priming (Osmoconditioning)

- Controlling seed hydration to trigger pre-germination metabolic activities while preventing radicle emergence
- Used for flower and vegetable seeds for uniform and vigorous germination

Two Different Types of Germination

- **Epigeous Germination**
  - Cotyledons are exposed above ground
  - Epicotyl and hypocotyls are also visible
  - radish

- **Hypogeous Germination**
  - Cotyledons are buried in the ground
  - Only epicotyl are visible
  - pea
Germination of Angiosperm Seeds

Irregularities in seed germination, poor quality seeds

Germination of Primed Seeds

Uniformity in the germination of primed seeds