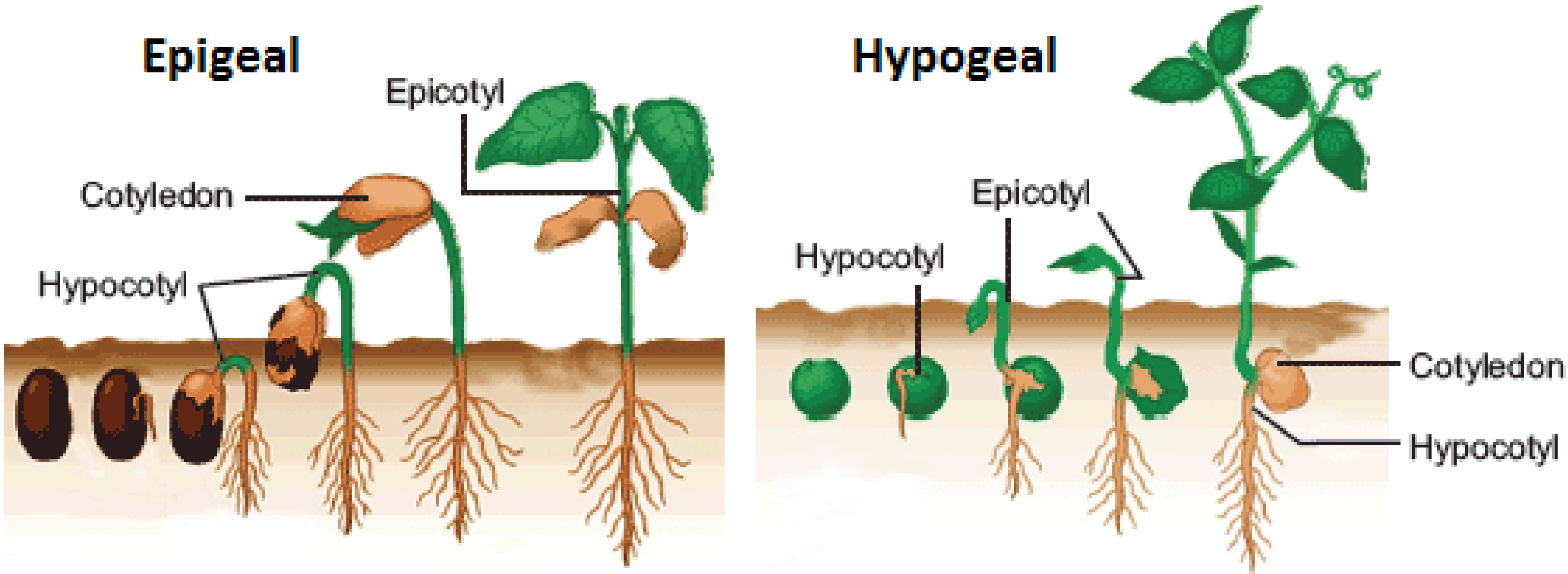
Plant Growth

Seed Germination and Dormancy

Germination is the process by which an organism grows from a seed or spore. The term is applied to the sprouting of a seedling from a seed of an angiosperm or gymnosperm, the growth of a sporeling from a spore, such as the spores of fungi, ferns, bacteria, and the growth of the pollen tube from the pollen grain of a seed plant.


Epigeal
Epicotyl
Cotyledon
Hypocotyl
Hypogeal
Epicotyl
Hypocotyl
Cotyledon
Hypocotyl

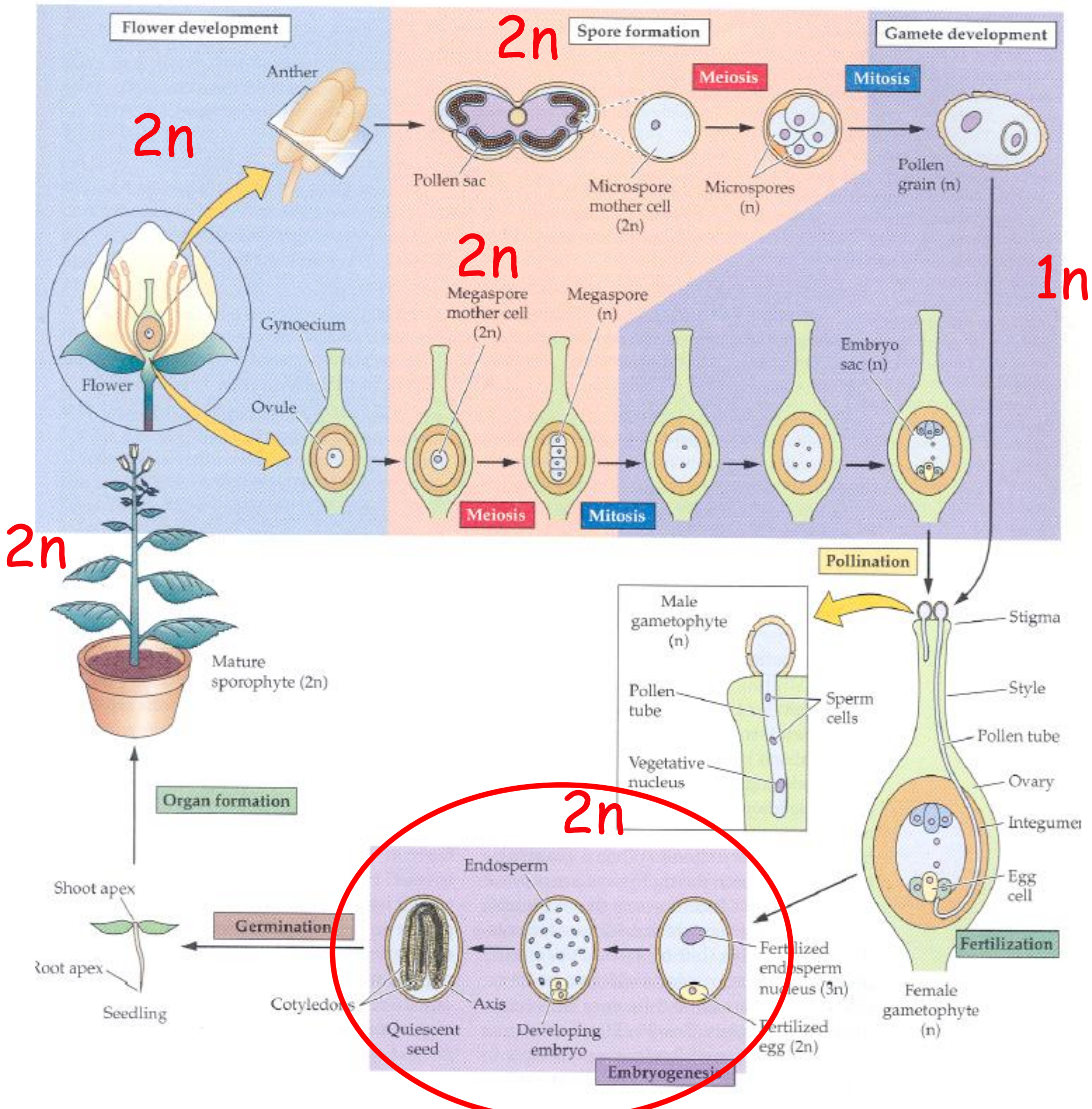
Types of germination

1. **Epigeal germination** (Ancient Greek [*epígaios*] 'above ground', from [*epí*] 'on' and [*gê*] 'earth, ground') or **Epi:** Above + **Geo:** Earth ------ is a botanical term indicating that the germination of a plant seed takes place **above the ground**. An example of a plant with epigeal germination is the common bean (*Phaseolus vulgaris*).

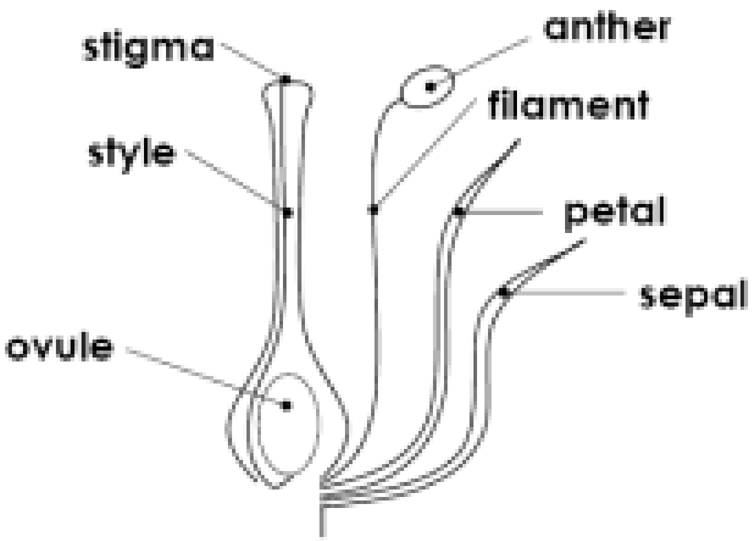
2. **Hypogeal germination** (from Ancient Greek [*hupógeios*] 'below ground', from [*hupó*] 'below' and [*gê*] 'earth, ground') is a botanical term indicating that the germination of a plant seed takes place **below the ground**. An example of a plant with hypogeal germination is the pea (*Pisum sativum*). The opposite of hypogeal is epigeal (above-ground germination).

3. what above or below meaning?!!!!!!

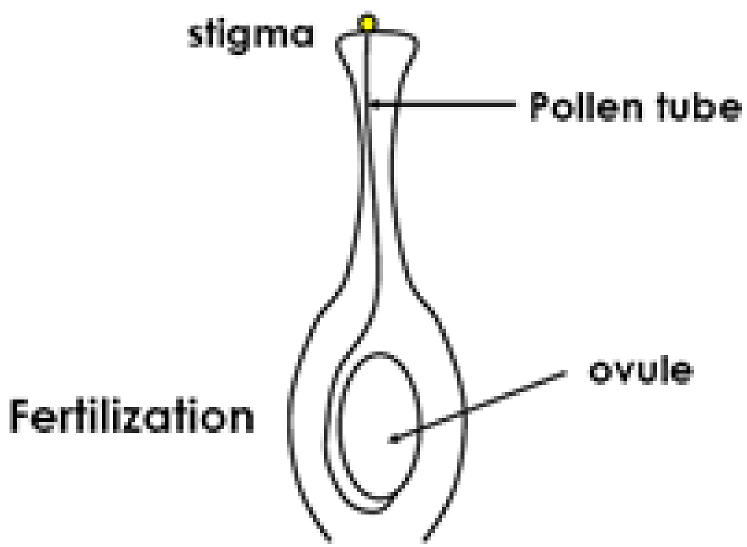
Life cycle of a flowering seed plant



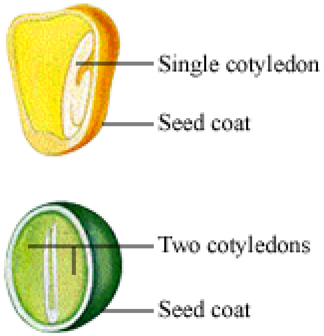
Flower

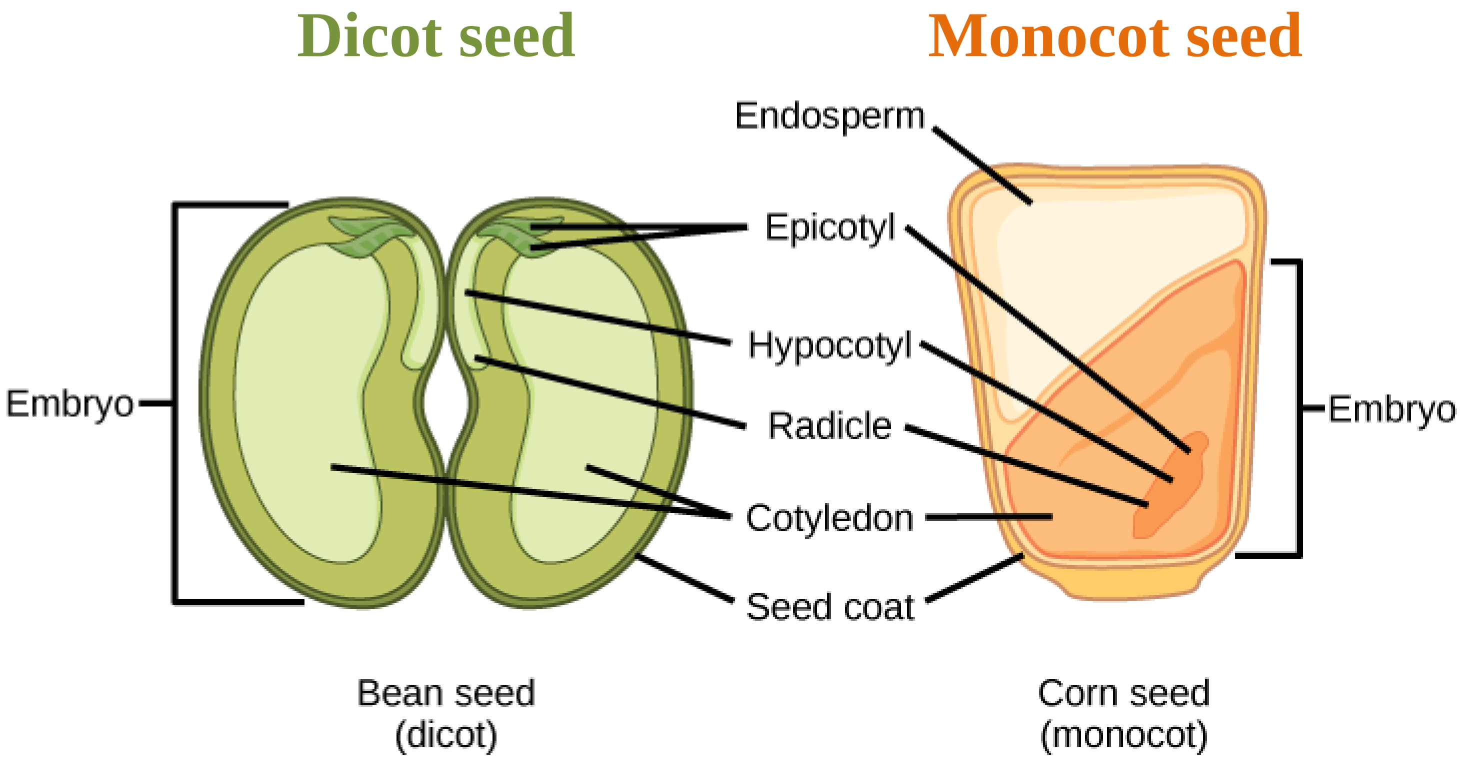


Fertilization



Seed anatomy





I. Seed Structure and Function:-

A. Seed Function:-

1. Propagation of plant.
2. Mechanism for offspring dispersal.
3. Protect immature plant in adverse conditions.

B. Definitions:-

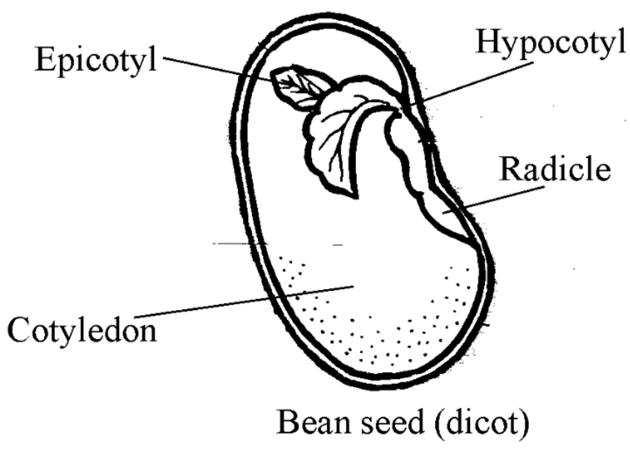
1. A fancy botanical definition for a seed: a ripened ovule.
2. Steve’s simplistic definition: a baby in a suitcase carrying its lunch.

C. Parts:

1. The Baby → [Embryo]

1. The embryo is essentially an immature, undeveloped plant
2. derived from zygote
3. The main parts of the embryo are:-

A. Radicle (develops into the root).
B. Epicotyl (develops into the shoot).
C. Hypocotyl (embryonic stem connecting radicle and epicotyl).
D. Cotyledons (seed" leaves" - usually for food storage).



2. Suitcase → [Seed coat]

This represents the outer protective layer, derived from the integuments of the ovule.

3. Lunch → [Stored reserves]

A. Provide nutrients for the germinating seedling.

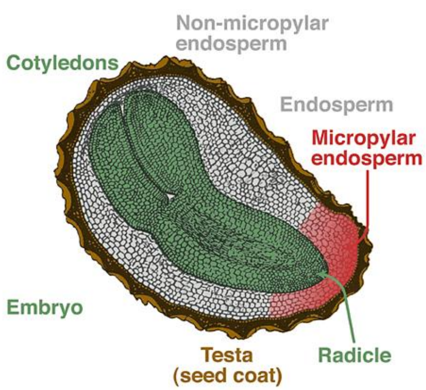
B. Various kinds of reserves depending upon the plant: starch (cereals), Fats & oils (nuts, soybean), protein (legumes).

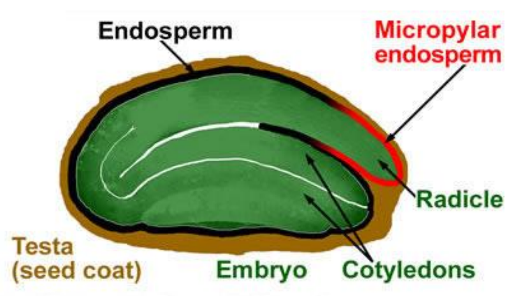
C. Amount of stored reserves varies (lots in cereals, legumes) to little (Orchids provide virtually no reserves, which means the seedlings rely on a symbiotic relationship with fungi immediately on germination to support the seeds).

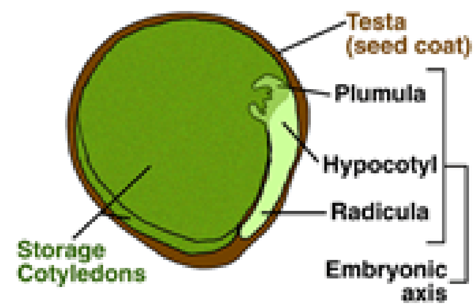
D. Seed Types :-

There are three major kinds based on embryo structure and how metabolize endosperm. Note that there are many variations and intermediate forms.

I. Monocot (cereal).
II. Eudicot with endosperm.
III. Eudicot without endosperm (endosperm is metabolized and stored in cotyledons, i.e., beans).





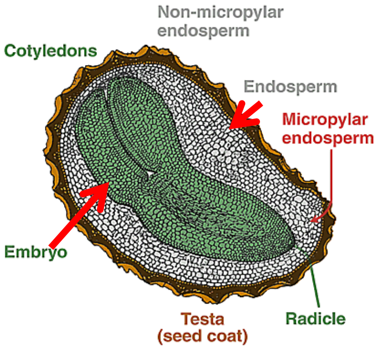


Morphological variation of endosperms

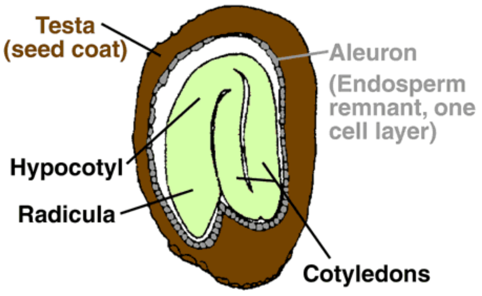
Monocots

Eudicot with endosperm
Dicots

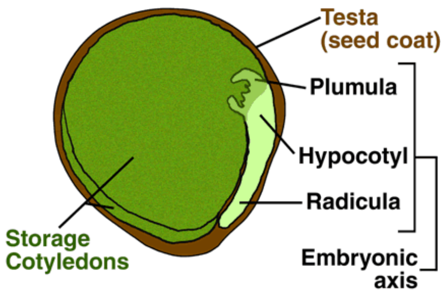
Eudicot without endosperm
Dicots



Tobacco



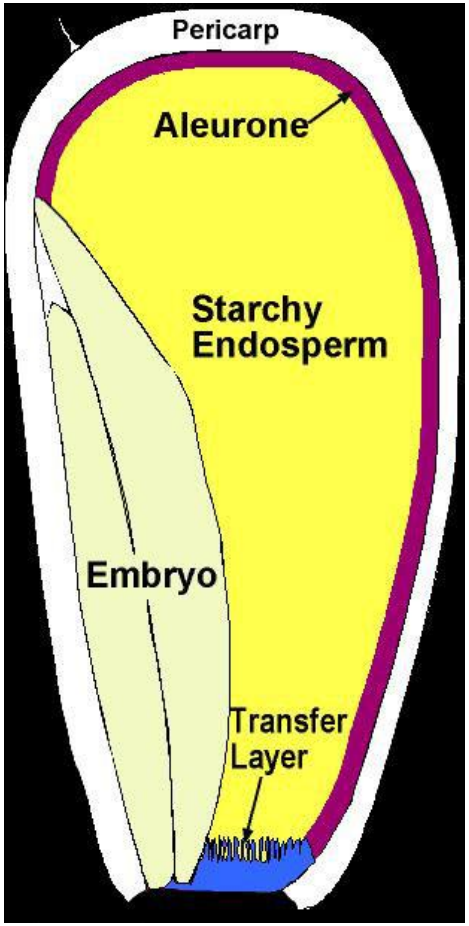
Arabidopsis thaliana



Pisum sativum

Most dicots have <u>large Cotyledons</u> and <u>Small Endosperms</u>

Endosperms are prominent in most monocots



Three parts:-

1. Basal transfer layer: nutrient uptake from the mother plant during seed development.
2. Starchy endosperm: major storage site for starch and proteins.
3. Aleurone: digestive tissue, secretes amylase into the starchy endosperm causing breakdown of the stored starch.

II. Seed Formation

Seed formation is initiated upon pollination/fertilization.

The general pattern of activities: embryo formation→ reserves stored→ water loss

1. Embryo formation is the first stage. The zygote develops into the embryo. During this stage there is lots of cell division, synthesis of DNA, RNA and proteins, and endosperm formation.
2. Once the basic embryo forms, growth stops and then reserves accumulate. Growth inhibitors synthesized during latter part of the phase
3. Dehydration - seed looses water, mature seeds with less than 10% water; seed coat sclerifies (becomes hard & dry) for added protection

III. Dormancy

A. Definition

1. Dormant - suspended animation; doesn't germinate even if conditions are favorable (innate dormancy).
2. Quiescence (enforced dormancy) – doesn't germinate because conditions aren't favorable. (i.e., missing one of the requirements for germination such as water).

I. Primary – dormant immediately at harvest
II. Secondary (induced dormancy) – can germinate initially, but if exposed to adverse conditions (cold, low oxygen, high temp) will become dormant

Seed Dormancy

Primary dormancy

Seed coat
- Prevention of water uptake
- Mechanical constraints
- Gas exchange

Scarification

Chemical
- Inhibitors or
- Inhibitor production

Developmental
- Immature embryo

Physiological
- Brief exposure to light, dehydration or chilling

Deep dormancy

Stratification

Double dormancy

Secondary dormancy

Post-imbibation conditions
- Water stress
- Prolonged dark or light
- Anoxia or hypoxia
- Drought

B. Are seeds alive?

* Inactive metabolism, unable to detect, viable vs. dead?

Germination Percentage = # seeds germ/total * 100

Germination Rate %germ vs. time (quicker better – sooner to photosynthesize, shorter growing time, uniform stand vs. uneven crop).

Viability Tests: (a) sow, (b) tetrazolium, (c) float, (d) cut open embryo.

C. Function

A. Withstand environmental extremes (e.g., cold, heat, radiation, microwaves), loose water during development (dry to less than 10% moisture), *prevents ice formation, *inactivates metabolism.

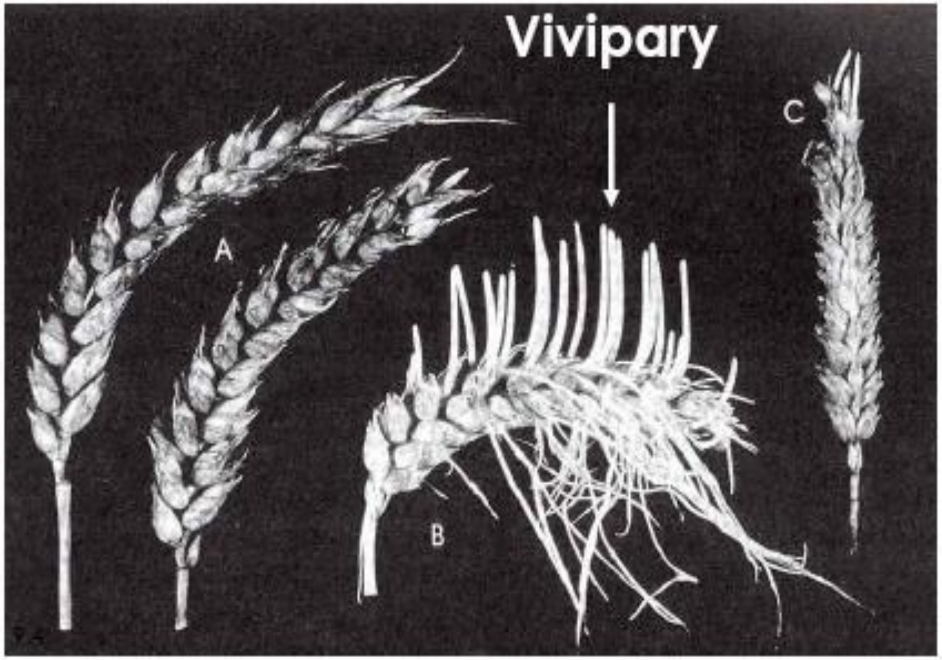
B. Increase longevity - variable storage survival rates – few months to many years (10,000 arctic lupine); longest lived seeds with hard heavy coat or weeds; crops generally short viability.

C. Provides time for dispersal.

D. key feature distinguishes plants and animals - animals have no dormant period, undergo continuous development.

F. Viviparous – a few wit.

Viviparous Seeds

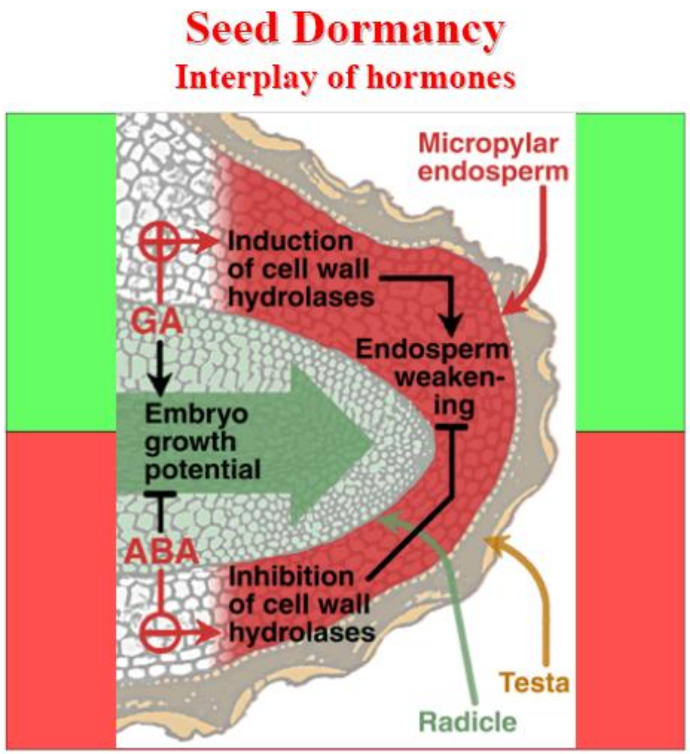


Developing wheat seeds

D. Dormancy Mechanisms:-

1. Mechanical *(*<u>heavy impervious seed coat</u>*)* – scarification to break ,acid, rotating drum with sandpaper. (e.g., honey locust, morning glory).

2. Chemical (<u>inhibitors</u>) – removed by washing out, chilling (e.g., ABA in ash other seeds, citric acid in tomatoes).



3. After-ripening (immature undeveloped embryos) – require growth period after being shed from plant (e.g., carrots).

4. Physiological inhibition:-

A- Light: Stimulates many (small seeds) or inhibits (uncommon) or no effect. Acts via phytochrome, red light absorbing pigments, alternates between two forms)

B- Ethylene: larger seeds

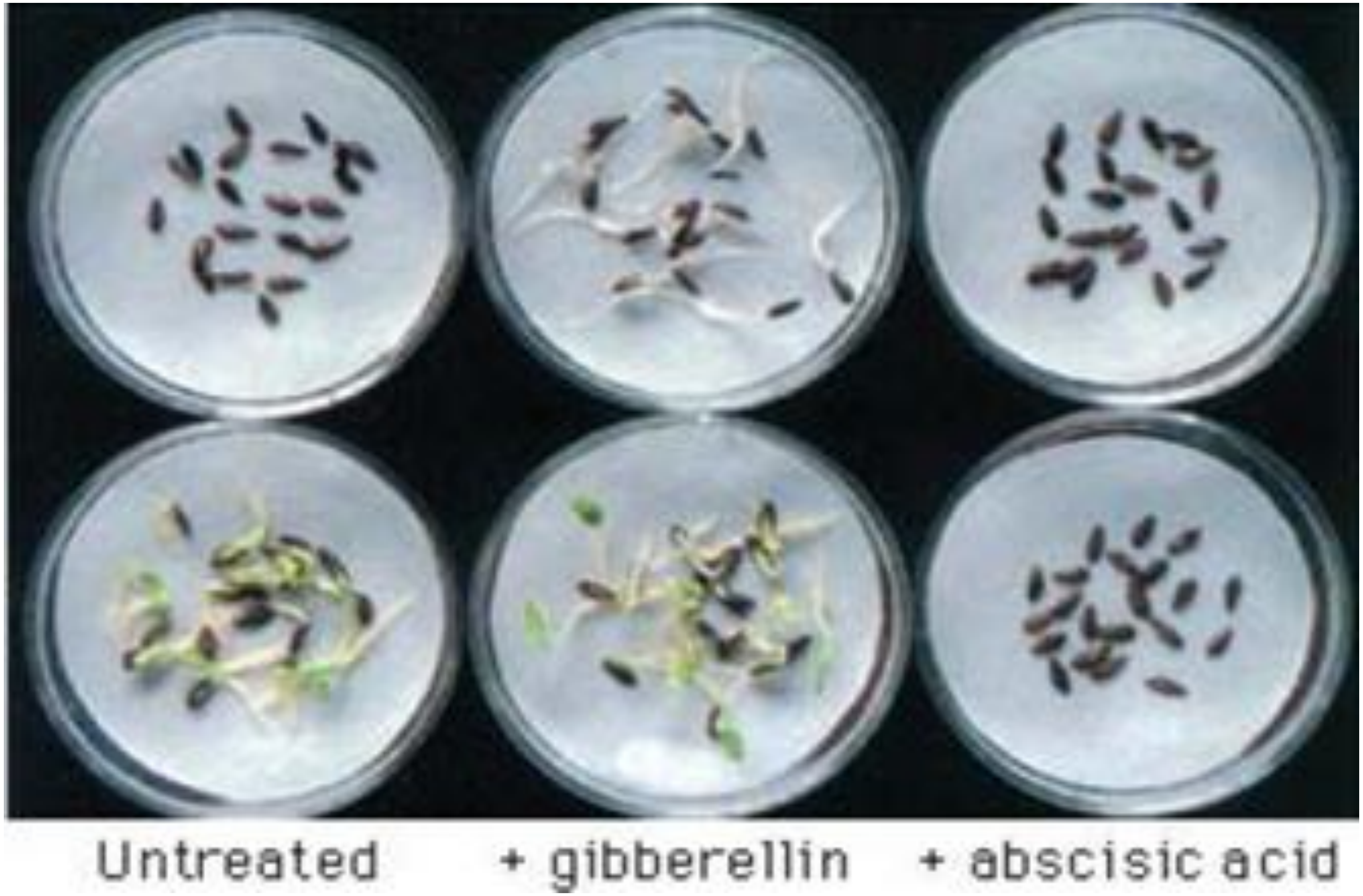
C- Cold: stratification, e.g., apples

D- Heat treatments: for desert and winter annuals (germinate after warm summer)

E- Alternating temperatures - hot/cold: e.g., evening primrose, tobacco; mechanical change in seed coat or other mechanism; epicotyl dormancy - root emerges in warm temp, epicotyl requires cold, gives time for root to develop before epicotyl, e.g., wild ginger, waterleaf.

5. Fire - increases light by reducing competition, destroy inhibitors in soil, charred remains stimulate, smoke stimulates - habitats that are seasonally dry and adapted to periodic burning (e.g., chaparral in CA, prairie in MN)

Figure shows the effect of light on germination of seeds



Light –induced germination of lettuce seeds. **The seeds in top row were placed in darkness, and the seeds in the bottom row were placed in light.**

IV. Germination

A. Requirements

1. Water :-

a. Absorption of water is called imbibition. Seeds can absorb up to 200% of its weight and more than double its volume. Initially quick, slows, then followed by more rapid absorption; too fast damages cells, no time for 'repair'.

b. Embryo expansion provides force to rip open seed coat (which swells less). Generates lots of force (used to be used to quarry stone).

c. Water uptake is passive - due to affinity of water for seed components (adhesion/cohesion) and water potential gradients.

d. Function of water:

1) softens seed coat;
2) provides force to open;
3) activates dormant enzymes and stimulates synthesis of new ones;
4) solubilizes seed components;
5) dilutes inhibitors;
6) provides force for cell growth.

2. Oxygen:-

a. Oxygen uptake very slow initially, then rapidly after imbibition's.

b. Required for oxidative reactions *(i.e.*, respiration & ATP production).

c. Switch from anaerobic to aerobic metabolic key regulatory step during germination.

3. Temperature:-

a. Affects rates of chemical reactions.
b. Dry seeds withstand broad range of temperatures.
c. Hydrated seeds (after imbibition occurs) can tolerate only a narrow range.
d. Species vary in response to temp (minimal temp, maximal temp, optimal temp) for germination.
e. Temperature also influences things other than reaction rates. For example, if treat lima beans at 5^{o}C for first half hour of imbibition, it depresses respiration and the embryo dies with 5 days - due to temp sensitivity of membranes. Cold makes them leaky, cold tolerant species don't leak.

4. Suitable stored reserves (foodstuffs):-

a. Provide:-
   1- Carbon skeletons,
   2 -Fuel source for respiratory energy (ATP).

b. Germination is initially heterotrophic. Food reserves in polymeric form requires conversion to monomeric form and then transported to sites of need.

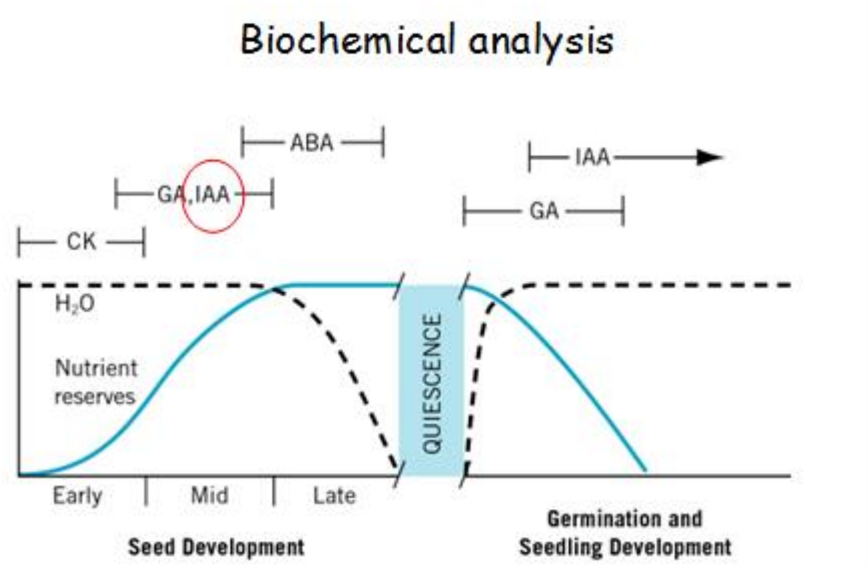
c. Hydrolytic enzymes activated or synthesized.

5. Dormancy broken (chemical treatments to encourage seeds; e.g. GA, potassium nitrate).

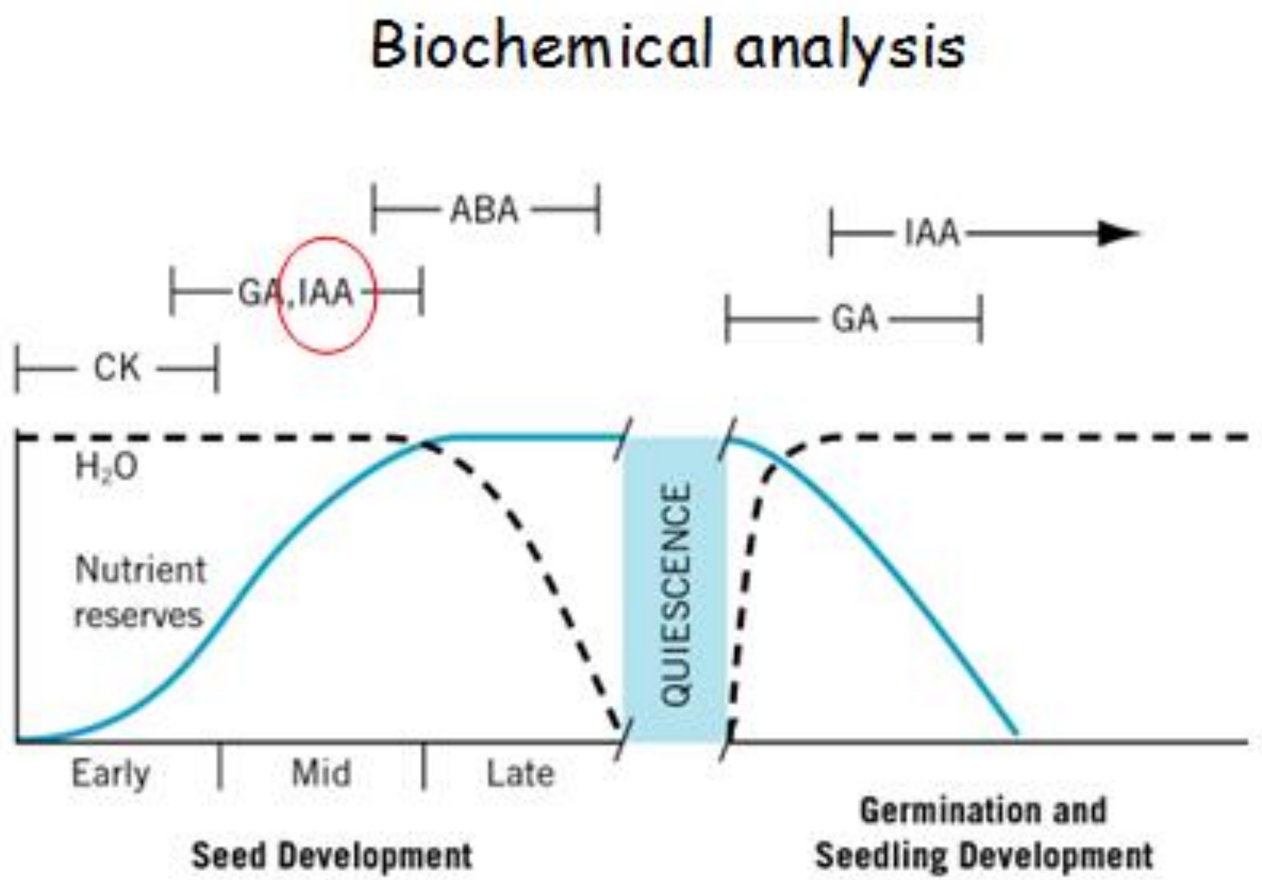
6. Suitable substrate – no inhibitors or *allelopathic* agents present; medium contains sufficient moisture, oxygen, etc.

B. Chronology of Events:-

1. Imbibition.
2. Appearance of metabolic activity - early activities: primarily to get seed ready for metabolism & growth, later events involved in utilization of stored reserves for new synthesis.
3. Radicle (root) emergence - now considered a seedling (germination starts at imbibition and ends at radicle appearance).



Chronology of Events:- Seed formation and germination



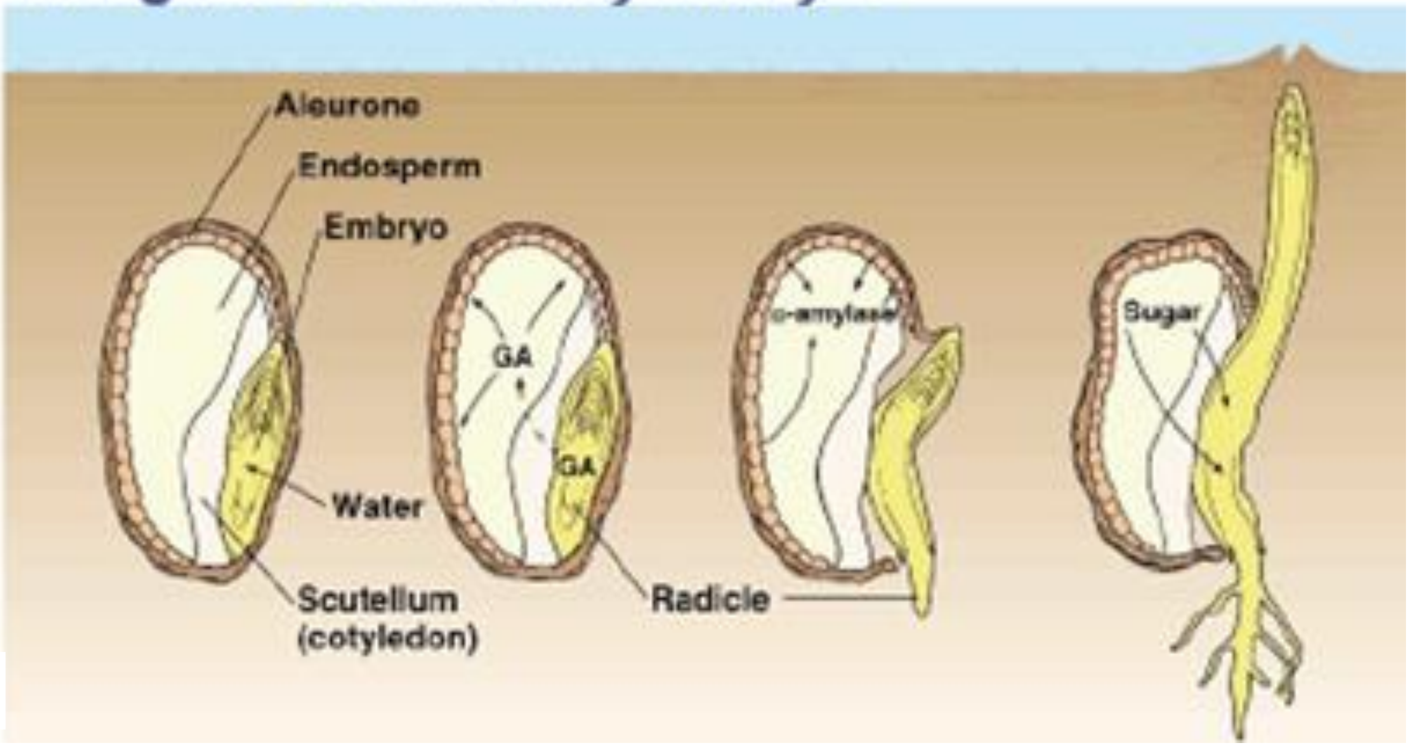
IV. Molecular Biology of Barley Seed Germination:-

- Gibberellic acid (GA), which is one of the plant hormones, is produced by the scutellum (cotyledon) of the embryo _ stimulates the production of amylase by the aleurone layer _ amylase hydrolyzes starch to simple sugars _ absorbed by scutellum and translocated to embryo for growth.

- The production of amylase occurs *de novo*. That is, gibberellin s stimulates transcription.

Mobilization of nutrients

- Seed germination
  1. seed imbibes water
  2. gibberellin release signals aleurone layer
  3. amylase is released which hydrolyzes starch
  4. sugar is absorbed by embryo



V. Planting seeds:-

1. Depth - no deeper than length or 3x the average diameter, shallower is better than deeper.

2. Plant more than you think you need - not all will germinate (can't tell if dead, dormant or quiescent).

3. Thin as necessary - too much competition.
4. Methods - Petri dish, pots, germination paper.

5. Timing – important:-

A. Cool Season (40 – 55 ºF or 4.4. – 13 ºC) – radish, lettuce, spinach, Swiss chard, beet, carrot, onion, cauliflower, cabbage, broccoli, kohlrabi, kale, turnips, rutabagas, peas, snapdragons, pansies.

B. Warm season (> 60 ºF) - tomato, egg plant, pepper, cucumber, squash, watermelon, cantaloupe snap bean, lima bean, sweet corn, marigold, zinnia.

6. Seed bed prepare - uniform eliminate clod to get good contact between seed and soil, free from weeds.

7. When to plant indoors - transplants put out after the average last killing frost (in late May). Tomato require about six weeks, annual flowers 6 – 8 weeks; cool season - sow outside as soon as work soil.

Germination

How does the dicot differ from the monocot?

Dicot

Monocot