LECTURE 2

DORMANCY AND GERMINATION IN SEEDS

In developed seeds metabolic activities are generally very slow, but at the time of germination, the metabolic activities in seeds increase and they grow into new plants under favorable conditions of growth, this is called **seed germination**.

Seed germination is the return of metabolic activities and growth by the seed tissue to give rise to a new plant by the development of the embryo.

Some seeds do not germinate immediately after dispersal even if suitable conditions of growth are provided. In this period growth of the seeds remains suspended and it is said to be in the rest or dormant stage. This phenomenon is called **dormancy of seeds**.

It may occur due to immature embryo**,** hard or impermeable seed coat, and presence of inhibitors like abscissic acid.

Types of Seed Germination

In flowering plants two types of germination are found. They are:

(a) Epigeal germination
(b) Hypogeal germination.

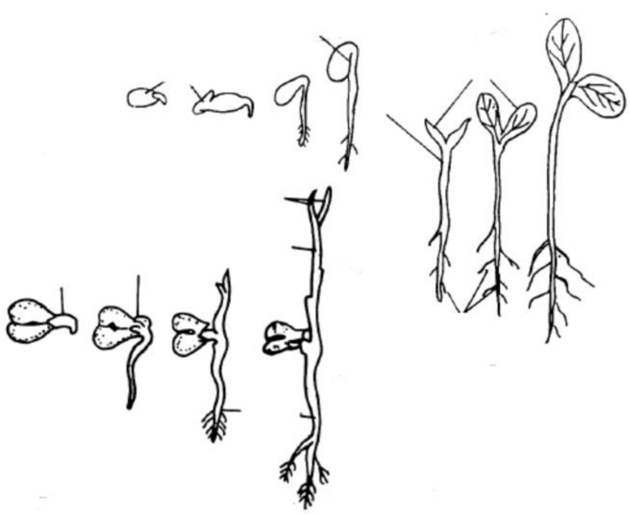


Figure 1. Epigeal Germination and Hypogeal Germination Vivipary.

(a) Epigeal Germination
In epigeal (*epi* - above; *geo* - soil) germination hypocotyl elongates and cotyledons come out above the soil surface. Examples: seeds of pumpkin, mustard, tamarind and French bean.

(b) Hypogeal Germination
In hypogeal (hypo = below, geo = earth) germination the epicotyl elongates and *cotyledons remain below the soil surface*. Examples: Most monocots seed like rice, wheat, maize, and coconut.
Some plants, which grow in marshy places show a special type of germination called **Vivipary**. Here the seed germinates inside the fruit while it is attached to the parent plant. The weight of the seed increases because of germination and seedling separates from the plant and falls down into the mud. Then roots develop to fix it in the soil. These plants are called viviparous plants. For example, *Rhizophora* and *Sonneratia*.

Figure 2. Viviparous Germination

Mechanism of Seed Germination
In seed germination, the first step is the imbibition or absorption of water by seed. Then the seed swells and the seed coat ruptures or ripping. Through the ruptured seed coat the radicle comes out from one end of embryonic axis.

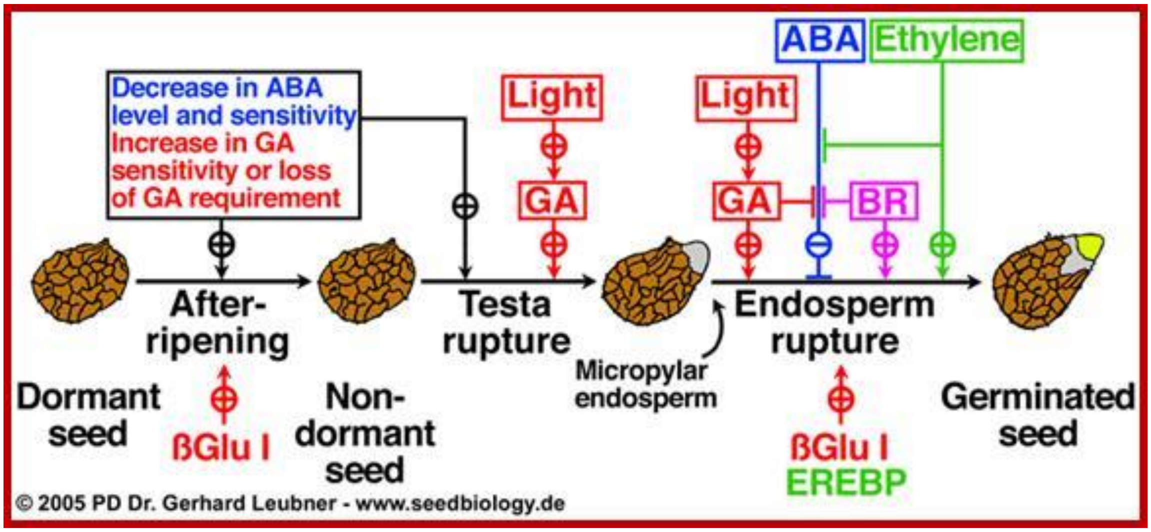
This radicle gives rise to root system. From the other end of embryonic axis the plumule elongates and develops as the shoot of the plant.

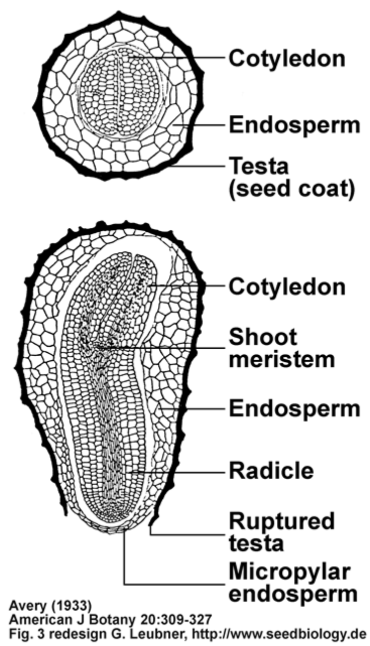
Factors Affecting Seed Germination

Seed germination requires five factors: water, temperature, oxygen, light and growth hormones.

- **Water:** The seed must swell up to rupture its seed coat. A ripe seed contains Heredity very low quantity of water. So for swelling to cause rupture of seed coats supply of adequate water is essential. Biochemical reactions required for growth and development of the seedling require water.
- **Temperature:** For germination of seeds a particular temperature is required. The degree of temperature required varies from species to species. Warmth accelerates chemical reactions inside.
- **Oxygen:** Oxygen is required in breaking down reserve food of seed and release energy for metabolism of growth of the embryo.
- **Light:** In most of the seeds light is not an essential factor for germination. But in some cases like lettuce and tobacco light is absolutely essential.
- **Hormone:** Besides the above external factors, hormones also control germination of seeds. Some roles played by hormones are as follows.

  Gibberellins can induce germination in some cases even in complete darkness.
  Auxin, Cytokinins and Ethylene can break dormancy in many seeds and initiate germination.
  In some seeds Abscissic acid inhibits germination process.





Seed Dormancy and its regulation

Seed dormancy is an innate property of plant seed that defines the environmental conditions, in which the seed is able to germinate, in this period the seeds cannot germinate even under optimal environmental conditions. Seed dormancy is determined by genetics with a substantial environmental influence which is mediated, at least in part, by the plant hormones abscisic acid (ABA) and gibberellins. The status of dormancy is influenced by the environmental factors that exist at the time of seed maturation. Even after shedding of seed, the status of dormancy is determined by the ambient environment. As dormancy exists throughout the higher plants in all major climatic regions, several adaptations have occurred in diverse responses to the environment. Through this adaptation, germination is timed to avoid unfavorable weather for subsequent plant establishment and reproductive growth.

Dormancy is determined by both morphological and physiological properties of the seed. Five classes of seed dormancy are physiological (PD), morphological (MD), morphophysiological (MPD), physical (PY) and combinational (PY + PD).

Type of dormancy:

1. **Physiological dormancy (PD):** PD is the most abundant form. It is found in seeds of gymnosperms and all major clades of angiosperms. This is major form of dormancy in model species used in the laboratory. PD can be divided into three levels: deep, intermediate and non–deep.

   Embryos excised from seeds with PD deep, either do not grow or will produce abnormal seedlings. GA treatment does not break their dormancy and several months of cold (subtype a) or warm (subtype b) stratification are required before germination can take place. Examples: *Acer platanoides* (PD deep) and *Acer pseudoplantanus* (PD intermediate).

   The great majority of seeds have non-deep PD. Embryos excised from these seeds produce normal seedlings. GA treatment can break this dormancy.

2. **Morphological dormancy (MD):** MD is evident in seeds with embryos that are underdeveloped (in term of size), but differentiated (e.g. into cotyledons and hypocotyl–radicle). These embryos are not (physiologically) dormant, but simply need time to grow and germinate. Example: Celery (*Apium graveolens*).

3. **Morphophysiological dormancy (MPD):** MPD is also evident in seed with underdeveloped embryos, but in addition they have physiological components to their dormancy. These seeds therefore require a dormancy–breaking treatment, e.g. a defined combination of warm and cold water stratification which in some cases can be replaced by GA application. There are eight known levels of MPD. Examples: *Fraxinus excelsior*, *Trollius*.
4. **Physical dormancy (PY):** PY is caused by water–impermeable layers of palisade cells in the seed or fruit that control water movement. Mechanical and chemical scarification can break PY dormancy. Examples: *Melilotus* and *Trigonella* (Methi).
5. **Combinational dormancy (PY + PD):** PY + PD is evident in seeds with water–permeable coats (as PY) combined with physiological embryo dormancy (PD). Examples: *Geranium* and *Trifolium*.

Regulation of seed dormancy

Physiological and molecular biological work has provided insight into mechanisms of non-deep physiological dormancy. Embryo dormancy and coat dormancy are components of PD; their sum and interaction determine the degree of 'whole seed' PD. At molecular level, very little is known about MD, MPD, PY, PY + PD and deep PD. Embryo dormancy is characterized by a block that inhibits extension growth, and therefore excised embryo do not grow. Coat dormancy is characterized by a block that is conferred by the covering layers. 'Coat' is used in a loose sense and can be any embryo–covering structure, for example testa, endosperm and/or pericarp.

ABA is an important positive regulator of both the induction of dormancy and the maintenance of the dormant state in imbibed seeds following shedding. ABA deficiency during seed development is associated with absence of primary dormancy in the mature seed. Over expression of ABA biosynthesis genes can increase seed ABA content and enhance seed dormancy or delay seed germination. A lasting dormancy is imposed by ABA produced by seed itself during its development. ABA application during seed development does not induce lasting seed dormancy. ABA biosynthesis in the embryos and that in the endosperm both contribute to the induction of seed dormancy. Seed dormancy in strongly dormant *A. thaliana* ecotype cvi exhibited that dormancy depend on an intrinsic balance of GA and ABA biosynthesis and catabolism. The net result of the dormant state is characterized by increased ABA biosynthesis and GA degradation. ABA induces dormancy during maturation, and GA plays key role in release of dormancy and hence in the promotion of seed germination. It has been shown that the dormant state of embryo has transcription of genes with an overrepresentation of ABA–responsive elements (ABRE) in their promoters and of genes for transcription factors that bind to the ABRE. The ABRE–binding transcription factors appear to be master regulators that mediate ABA responses in seeds, including the regulation of dormancy.

Plant hormones/ phytohormones/ Growthregulators: Plant hormones are chemically diverse substances produced in minute quantity and they involve in most of the plant cell activities. They regulate the growth process both by promoting and inhibiting growth. They are produced in certain parts of the plant and transported to other tissues where their action is shown. Based on their promontory and inhibitory activity they have been classified into growth promoters and growth inhibitors.

Growth promoting hormones: These are involved in growth promoting activities such as cell division, cell enlargement, flowering, fruiting and seed formation. *e.g.*, Auxin, gibberellins, cytokinins.

Growth inhibitor: Involved in growth inhibiting activities such as dormancy and abscission. *e.g.*, Abscisic acid and Ethylene.

Hormones	**Functions**
Auxins	Apical dominance, cell elongation, prevent premature leaf and fruit falling, initiate rooting in stem cutting, as weedicide, induce parthenocarpy.
Gibberellins	Delay senescence, speed up malting process, increase in length of axis (grape stalk), increase in length of stem (sugarcane), bolting in beet, cabbages and many plants with rosette habit.
Cytokinins	Promote cell division, induce cell enlargement, reduce apical dominance, and induce growth in auxiliary bud, chlorophyll preservation, lateral shoot growth,

	adventitious root formation.
Ethylene	Promotes senescence and abscission of leaf and fruits, promotes ripening of fruits, break seed and bud dormancy, initiate germination in peanut, sprouting of potato tuber, promotes root growth and root hair formation.
Abscisic acid	Inhibit seed germination, stimulate closer of stomata, increase tolerance to various stress,induce dormancy in seed and bud, promotes ageing of leaf (senescence).

Growth of movement:

On this basis can divide the movement of plants to:

1. Autonomic movement: like as growth of rhizomes, runners stem, roots, cromes and bulbs.

2. Parasonic movement : Occur as a result of external stimulation, where either be a result of the installation of floral known Nastic movement like as convolution some plants leaves at night and movement leaves of Insectivorous or result of external stimulation known Phototropism, Geotropism, Hydrotropism and Chemotropism.

The plants characterized as localized movement. The movement types are:

1. Open the flower in the light and closed in the dark.
2. Convolution the leaf and expansion in the *Lupinus* plant.
3. Movement of inflorescence of Helianthus all day with sun movement and wilt the leaf of *Mimosa* plant when touch it so movement the *Qensh* insects when any other insects or protein matter touch it.

Tropism:

Is a biological phenomenon, indicating growth or turning movement of a biological organism, usually a plant, in response to an environmental stimulus. In tropisms, this response is dependent on the direction of the stimulus (as opposed to nastic movements which are non-directional responses).

In English, the word tropism is used to indicate an action done without cognitive thought: However, "tropism" in this sense has a proper, although non-scientific, meaning as an innate tendency, natural inclination, or propensity to act in a certain manner towards a certain stimulus.

Type of tropism:

1. Aerotropism: growth of plants towards or away from a source of oxygen.
2. Chemotropism: movement or growth in response to chemicals.
3. Electrotropism: movement or growth in response to an electric field.
4. Exotropism: continuation of growth "outward," i.e. in the previously established direction.
5. Geotropism (or gravitropism): movement or growth in response to gravity.
6. Apogeotropism: negative geotropism.
7. Heliotropism: diurnal motion or seasonal motion of plant parts in response to the direction of the sun, (e.g. the sunflower).
8. Apheliotropism: negative heliotropism.
9. Hydrotropism: movement or growth in response to water. In plants, the root cap senses differences in water moisture in the soil, and signals cellular changes that causes the root to curve towards the area of higher moister.
10. Prohydrotropism: positive hydrotropism.
11. Hygrotropism: movement or growth in response to moisture or humidity.
12. Magnetotropism: movement or growth in response to magnetic fields.
13. Orthotropism: movement or growth in the same line of action as the stimulus.
14. Plagiotropism: movement or growth at an angle to a line of stimulus such as gravity or light.
15. Phototropism, movement or growth in response to lights or colors of light.
16. Aphototropism: negative phototropism.
17. Skototropism: negative phototropism of vines.
18. Thermotropism: movement of growth in response to temperature.
19. Thigmotropism: movement or growth in response to touch or contact.