CHAPITRE 03 :

DEVELOPMENT

2nd year agronomy

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PLAN OF COURS

1.Seed formation

2.Germination

3.Growth

4.Flowering

5.Fructification

- The meaning of the terms growth, differentiation and development
- Three terms routinely used to describe various changes that a plant undergoes during its life cycle are growth, differentiation, and development.
- **Growth** is an irreversible increase in volume or size
- Growth is a quantitative term, related only to changes in size and mass. For cells, growth is simply an irreversible increase in volume. For tissues and organs, growth normally reflects an increase in both cell number and cell size

Differentiation

- Differentiation is the process in which the cells specialize into morphologically and physiologically different cells. Mature cells can divide and differentiate again, and this is known as

Development

The development includes all the changes that take place during the life cycle of a plant. There are different pathways followed by plants in response to the environment and form different structures.

The leaves of a young plant have different structures as compared to the mature plant.

- Development is the sum of growth and differentiation
- Development is an umbrella term, referring to the sum of all of the changes that a cell, tissue, organ, or organism goes through in its life cycle.
- Development is most visibly manifested as changes in the form of an organ or organism, such as the transition from embryo to seedling, from a leaf primordium to a fully expanded leaf, or from the production of vegetative organs to the production of floral structures.
- Growth, differentiation, and development are closely related events. A plant cannot develop if the cells do not grow and differentiate.

The development, maturation, and germination of seeds

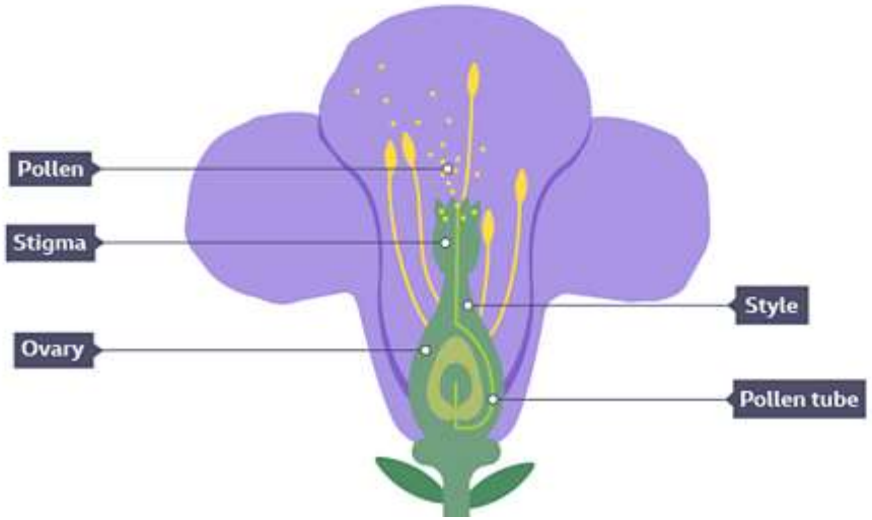
- The life of an individual plant begins when an egg nucleus in the maternal organs of a flower is fertilized by a sperm nucleus to form a **zygote**.
- Growth and differentiation of the zygote produces an embryo contained within a protective structure called a seed. Under appropriate conditions, the embryo within the seed will renew its growth and will continue to develop into a mature plant.

Seeds bearing embryos are formed in the flowers

- Flowers appear to vary enormously in structure, yet all flowers follow the same basic plan. A generic flower consists of four whorls or circles. The two outermost whorls
- The sepals and petals → are vegetative structures;
- and the two innermost **the stamens** and **pistil** → are the male and female reproductive structures, respectively.
- At the base of the pistil, or female structure, is the ovary, which contains one or more ovules

SEED FORMATION

- Seed formation begins with the combination of a male and female gamete: a process known as fertilization.
- Fertilization, can occur when both male and female gametophytes are fully mature.
- This usually occurs in a dual fusion process known as ***double fertilization***.
- Mature pollen grains are shed from the anthers and carried to the stigmatic surface of the pistil by insects, wind, or some other vector. Once the pollen grain lands on the stigmatic surface – an event called pollination
- The pollen grain takes up water and sends out a pollen tube that grows down the style of the pistil toward the ovule.



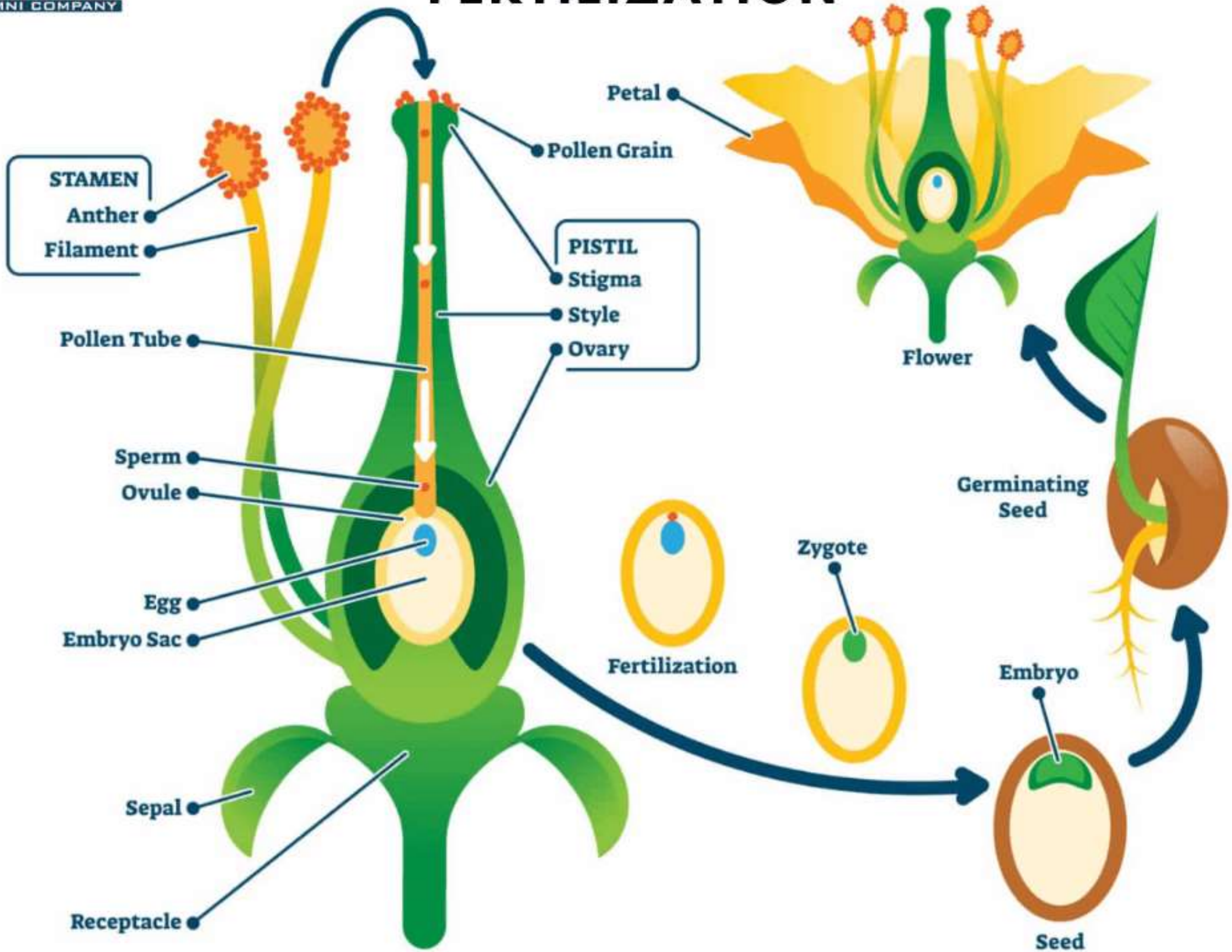
Within each ovule, a single large diploid cell, called the megaspore mother cell, undergoes mitosis to produce four (4) megaspore cells.

Only one megaspore cell survives and that cell undergoes meiotic division to produce an embryo sac with eight haploid nuclei.

The tube nucleus soon degenerates, but the two pollen sperm cells enter the embryo sac, to form a diploid (2N) ***zygote***, or fertilized egg.

- In the final stage, the elongating pollen tube enters the ovule by growing through the micropyle (the space between the ends of the surrounding integuments) and releases the two sperm nuclei into the embryo sac. Ultimately, one of the two sperm nuclei enters the egg cell and fertilizes the egg cell nucleus to form the zygote.
- The second sperm nucleus enters the large central cell and fuses with the two polar nuclei to form a triploid (3n) endosperm nucleus. The involvement of two sperm nuclei in this way is called double fertilization, a characteristic unique to the flowering plants or angiosperm

FERTILIZATION

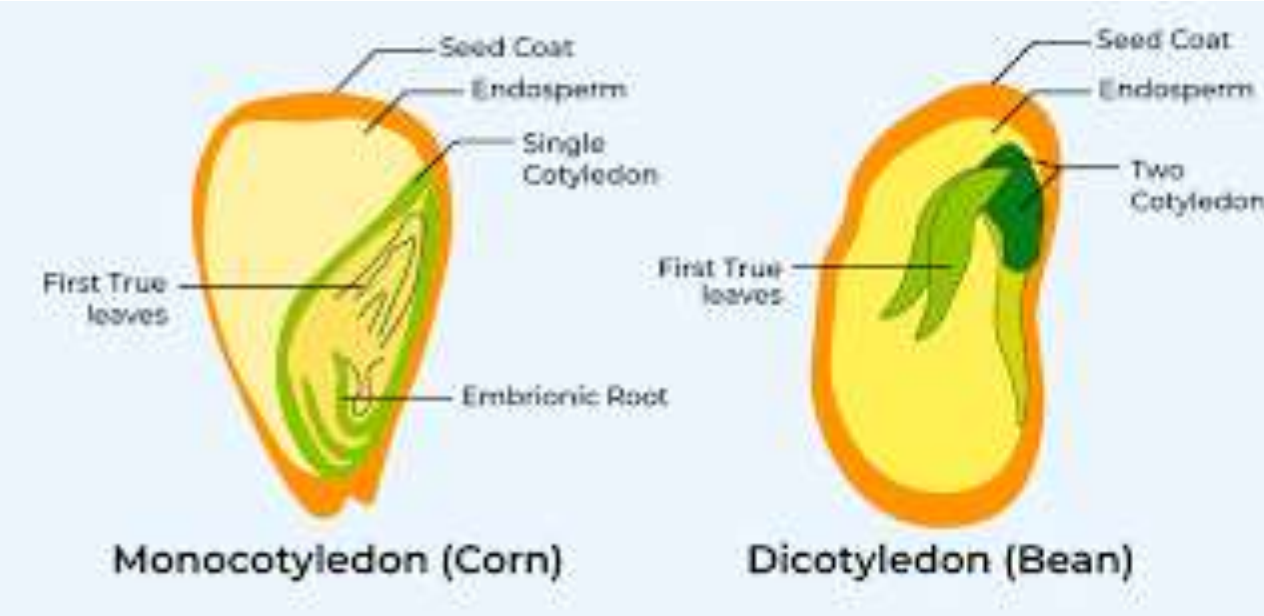


- Seed development is characterized by extensive cell divisions
- The development of a seed begins with the fertilized ovule, or zygote. The early stage of seed development is characterized by extensive cell divisions that form the embryo and, in endospermic seeds, the tissues that store nutrients that will support the eventual germination of the seed and seedling development.
- The first division of the zygote is usually transverse and immediately establishes polarity of the embryo.

- The upper cell is destined to become the embryo itself while the lower cell produces a stalk-like suspensor that anchors the embryo at the base of the embryo sac. The typical dicot seed will then pass through several recognizable stages. During the early stages of embryo development, cell division occurs throughout the entire cell mass but at the heart-shape stage both the shoot and root apical meristems begin to organize as centers of cell division.

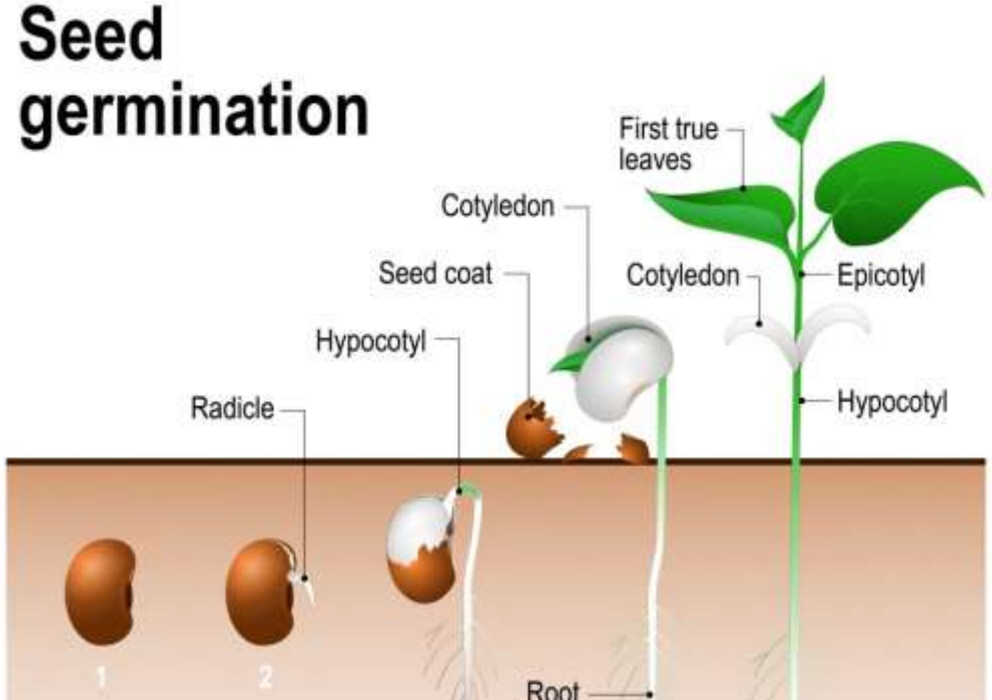
GERMINATION

- **Anatomy Of A Seed**
- The seed is made up of three parts:
- The Embryo – gives rise to the new plant.
- The Endosperm – nourishes and provides food for the seedling.
- The Seed Coat – the hard outer covering that protects the embryo. Some seed coats are hard (peas and corn), while some are comparatively soft (tomatoes and peppers)



The process by which a seed transforms into a plant (seedling) in optimum sunlight, air, and water is called germination. Seed germination is the **initial step in the life cycle of plants, which begins when the inactive dry seed imbibes water and is completed with the protrusion of the radicle from the seed coat**

The seed can grow within its range of minimum and maximum temperatures. Any temperature above this range can either damage the seeds or make them dormant.



germination, the sprouting of a seed, spore, or other reproductive body, usually after a period of dormancy. The absorption of water, the passage of time, chilling, warming, oxygen availability, and light exposure may all operate in initiating the process.

- In the process of seed germination, water is absorbed by the embryo, which results in the rehydration and expansion of the cells. Shortly after the beginning of water uptake, or imbibition, the rate of respiration increases, and various metabolic processes, suspended or much reduced during dormancy, resume. These events are associated with structural changes in the organelles (membranous bodies concerned with metabolism), in the cells of the embryo.

- **Seed dormancy**

- Dormancy is brief for some seeds—for example, those of certain short-lived annual plants. After dispersal and under appropriate environmental conditions, such as suitable temperature and access to water and oxygen, the seed germinates, and the embryo resumes growth.

- the seeds of many species do not germinate immediately after exposure to conditions generally favourable for plant growth but require a “breaking” of dormancy, which may be associated with change in the seed coats or with the state of the embryo itself. Commonly, the embryo has no innate dormancy and will develop after the seed coat is removed or sufficiently damaged to allow water to enter.
- Germination in such cases depends upon rotting or abrasion of the seed coat in the gut of an animal or in the soil. Inhibitors of germination must be either leached away by water or the tissues containing them destroyed before germination can occur. Mechanical restriction of the growth of the embryo is common only in species that have thick, tough seed coats. Germination then depends upon weakening of the coat by abrasion or decomposition.

- certain period of time has lapsed. The time may be required for continued embryonic development in the seed or for some necessary finishing process—known as afterripening—the nature of which remains obscure.

The processes involved in seed germination can be categorized into three prominent stages

• Phase I, rapid imbibition of water by the dry seed;

•Phase II, metabolism reactivation, including mobilization of food reserves and protein synthesis; and

• Phase III, radicle protrusion.

Water imbibition by the seeds hydrate matrices including reserve polymers and cell walls within the cell (Bewley, 1997). Water uptake by dry seeds during

the first phase of germination is rapid, while resumption of phase II is more gradual (Nonogaki et al., 2010). Rapid water uptake stimulates the embryo to produce phytohormones, *

especially GA, which disseminate to the aleurone layer to resume a biochemical cascade leading to the synthesis of hydrolytic enzymes including α-amylase (Bewley, 1997).

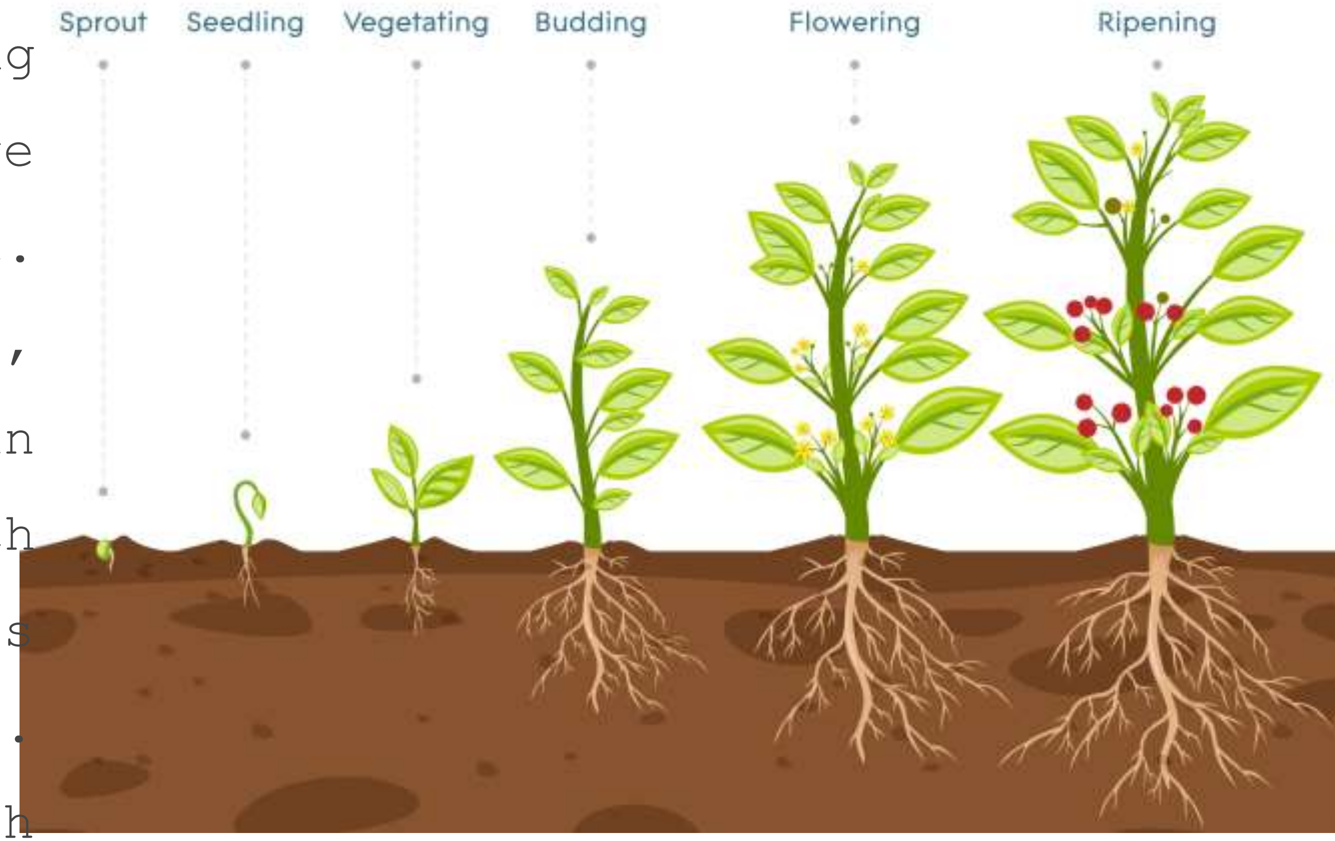
Seed germination is a complex process, which involves several signals and is influenced by both intrinsic and extrinsic factors. Intrinsic factors include seed dormancy and available food stores while water, temperature, oxygen, light, relative humidity, chemicals in the seed environment, and substrate used constitute extrinsic factors. The germination process plays a key role in the domestication of crops as lack of uniform seed germination can result in poor stand establishment, which affects overall crop yield. Germination is largely affected by the balance of phytohormones, especially the abscisic acid (ABA) and gibberellins (GA) ratio (Miransari and Smith, 2014). The processes involved in seed germination can be categorized into three prominen

- **Seedling emergence**
- Active growth in the embryo, other than swelling resulting from imbibition, usually begins with the emergence of the primary root, known as the radicle, from the seed, although in some species (e.g., the coconut) the shoot, emerges first. Early growth is dependent mainly upon cell expansion, but within a short time cell division begins in the radicle and young shoot, and thereafter growth and further organ formation (organogenesis) are based upon the usual combination of increase in cell number and enlargement of individual cells.
- Until it becomes nutritionally self-supporting, the seedling depends upon reserves provided by the parent sporophyte. In angiosperms these reserves are found in the endosperm in the ovule, or in the body of the embryo, usually in the cotyledons.

- Since reserve materials are partly in insoluble form—as starch grains, protein granules, lipid droplets, and the like—much of the early metabolism of the seedling is concerned with mobilizing these materials and delivering, or translocating, the products to active areas. Reserves outside the embryo are digested by enzymes secreted by the embryo and, in some instances, also by special cells of the endosperm.
- In some seeds (e.g., castor beans) absorption of nutrients from reserves is through the cotyledons, which later expand in the light to become the first organs active in photosynthesis. When the reserves are stored in the cotyledons themselves, these organs may shrink after germination and die or develop chlorophyll and become photosynthetic.

GROWTH

Growth is a characteristic of a living organism. It is a permanent change which increases the size of the plant. Just like other living organisms, plants also show growth. Growth is an essential property of plants which helps them gain nutrients from places which are far from their position. Growth helps plants compete with each other and also protect their important organs.



- **Phases of Plant Growth**
- These are the phases of plant growth:
- **Formative Phase**
- During the formative phase of growth, growth is dominated
- by cell division. Cell division leads to a rise of new daughter
- cells from pre-existing parent cells. Plant cells divide by the
- process of mitosis, where identical cells are created. It is carried out in two steps:
- Division of Nucleus or Karyokinesis
- Division of Cytoplasm or Cytokinesis
- In higher plants, the division of cells begins in the meristematic region.

- **Cell Enlargement and Differentiation**
- During this stage, the newly formed cells grow in size, which results in the growth of the tissues and organs. The growth in the size of the cells is due to various factors such as absorption of water, formation and growth of vacuoles and the thickening of the cell wall.”
- **Cell Maturation**
- During the maturing process, the cells take a definite shape and structure for a specialised function. This growth leads to the differentiation of the tissues

- **Factors Affecting Plant Growth**

- The important factors affecting the growth of plants include:

1. **Temperature**: Growth is accelerated with the increase in temperature.
2. **Light**: Light intensity, duration of light and the quality of light influence many physiological processes occurring in a plant.
3. **Water**: Water is an essential factor for plant growth. They grow well in a sufficient amount of water. They even respond to the scarcity of water.
4. **Soil Nutrients**: Plants require an adequate amount of nutrients for proper growth. The quality and quantity of nutrients affect plant growth.
5. **Plant Growth Regulators**: Various plant growth regulators such as auxin, cytokinin, gibberellins, etc. are added to plants to regulate their growth.

PLANT GROWTH REGULATORS

- Intercellular intrinsic factors are the chemical substances, called plant growth regulators (PGR). There are diverse groups of PGRs in plants, principally belonging to five groups: auxins, gibberellins, cytokinins, abscisic acid and ethylene. These PGRs are synthesised in various parts of the plant; they control different differentiation and developmental events. Any PGR has diverse physiological effects on plants. Diverse PGRs also manifest similar effects. PGRs may act synergistically or antagonistically. Plant growth and development is also affected by light, temperature, nutrition, oxygen status, gravity and such external factors

FLOWERING

- Flowering is one of the most decisive physiological processes of plants that ensures genetic continuity, variability and ultimately food security.
- The whole process includes four distinctive stages:
- i) transition to flowering,
- ii) development of flowers,
- iii) development of fruits,
- and iv) setting of seeds.
- Among them, the first commitment step, i.e. conversion of meristem to inflorescence or floral meristem is the most crucial one and is result of complex cross-talk between plants and their surrounding environment.

- Multiple environmental stimuli such as light, low and ambient temperature (vernalization and ambient temperature pathway and seasonality determine this commitment step. Hence, perturbation in any one of these environmental conditions may have impact on crop yield. Studies revealed that plants are more susceptible to abiotic stresses during flowering than the vegetative growth period.

TRANSITION FROM VEGETATIVE TO FLORAL STATE

- The process of flowering begins with floral induction, which is a preparatory step. During this phase, certain stimuli from the environment trigger the plant's organs to send a signal to the meristem, instructing it to shift from a vegetative development program to a reproductive one.
- Floral evocation: This is when the dormant meristem is "awakened," and the architecture of the apical meristem changes. This marks the preparation for the differentiation of floral organs. At this stage, there is an acceleration of the plant's metabolism and an increase in mitotic activity.
- Floral initiation: At this point, the primordia (early stages) of the floral parts—both perianth (non-reproductive parts like petals and sepals) and sexual organs (pistil and stamens)—begin to differentiate. In other words, the vegetative bud has now transformed into a floral bud, which causes the bud to swell.
- Flowering: The process continues with the development of the floral organs and culminates in the anthesis, which is the full opening of the flowers and the dehiscence (release) of the anthers, marking the completion of flowering

- Fruits are the result of the transformation of the ovary of a fertilized flower; they contain seeds, which develop from the ovules. The development of the ovary, from its formation within a floral bud to the mature fruit, typically occurs continuously after the flower has been pollinated. However, if the flower is not pollinated, this growth halts abruptly, and the unfertilized flower falls off.
- There are, however, some rare exceptions where plants produce fruit without pollination. This phenomenon is known as parthenocarpy, which results in seedless fruits. This can be observed in some species
- that have been selectively bred and cultivated by humans, such as seedless oranges. Parthenocarpy can occur naturally in some plants or be induced artificially, often through the application of growth regulators or other methods that stimulate fruit development without fertilization.

TYPES OF FRUITS

- Fruits can develop into either succulent structures, leading to fleshy fruits, or evolve into woody structures at maturity, as in the case of dry fruits.
- Fleshy Fruits (Succulent):

These fruits are juicy and tender, typically containing a significant amount of water. Examples include:

- **Berries:** These fruits have a fleshy pericarp and include examples such as grapes, bananas, and tomatoes.
- **Drupes:** These fruits have a single seed surrounded by a fleshy outer layer, such as olives, peaches, and cherries.

Dry Fruits (Lignified):

These fruits become hardened or woody at maturity. Dry fruits can be either dehiscent or indehiscent:

Dehiscent Fruits: These open up when ripe to release their seeds. Examples include:

Follicles: Found in plants like peonies and magnolias.

Legumes (Pods): Seen in peas, beans, and other leguminous plants.

Siliques: Characteristic of plants like cabbage, radishes, and canola.

Indehiscent Fruits: These do not open when mature, and the seeds remain enclosed. Examples include:

Achenes: Seen in sunflowers and buttercups.

Caryopses: Common in grasses, such as wheat and corn.

Samaras: Characteristic of trees like maples and ash, these are winged seeds.

These categories help to distinguish the various types of fruits based on their structure.

REFERNCE

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