Seed Germination

Seed Germination types and Physiological process

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SEED GERMINATION

- **Definition:**

"The process that begins with the water uptake by the dry seed and ends with the emergence of the embryonic axis, usually the radicle, from its surrounding tissue".

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SEED GERMINATION

- **Activation Of Embryo**

Seed germination is a mechanism, in which morphological and physiological alterations result in activation of the embryo

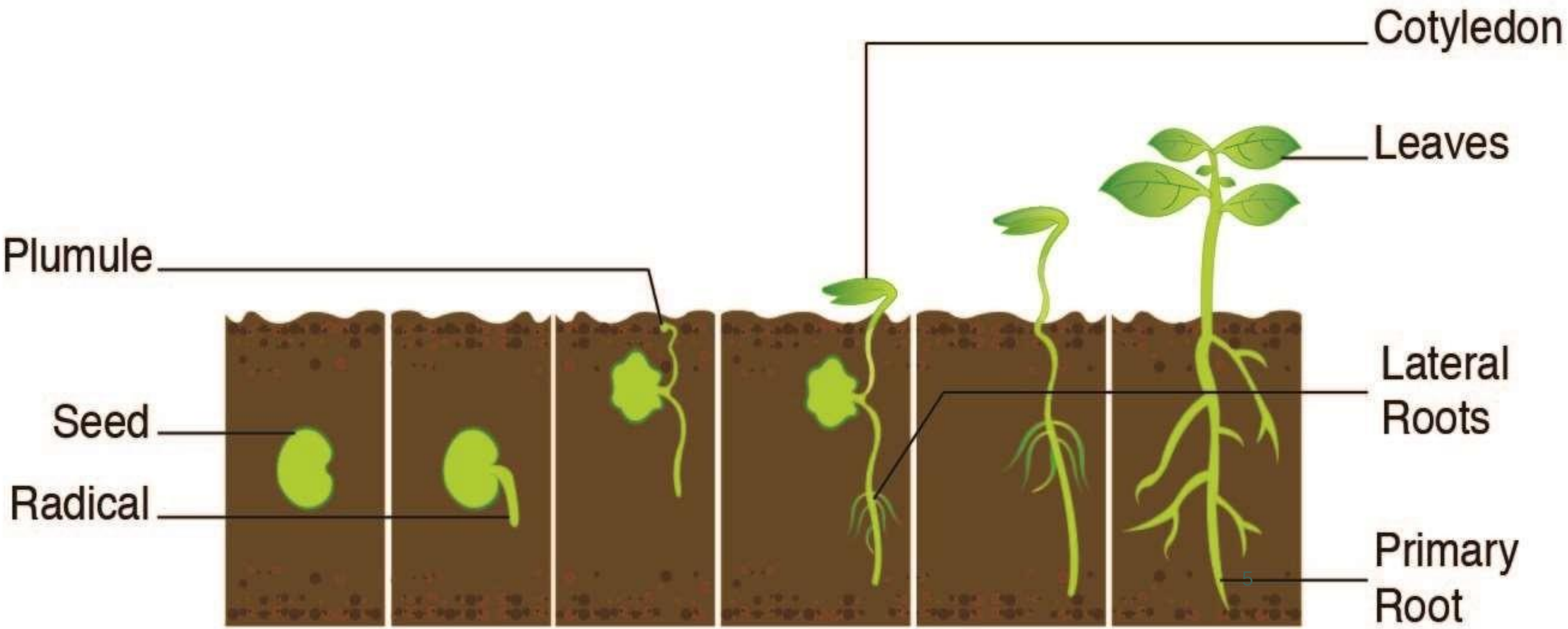
- **Elongation:**

Before germination, seed absorbs water, resulting in the expansion and elongation of seed embryo.

- **Emergence of Radicle.**

When the radicle has grown out of the covering seed layers, the process of seed germination is completed (Hermann et al., 2007)

Germination of a Seed



Seedling Establishment and Post Germination Process

Strictly speaking, germination does not include seedling growth after radicle emergence, which is referred to as

seedling establishment.

Similarly, the rapid mobilization of stored food reserves that fuels the initial growth of the seedling is considered a

post germination process.

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Requirements for Germination.

- Water
- Gases
- Temperature
- Light
- Nitrates

❑ Gases

- Air is composed of about 20% oxygen, 0.03% carbon dioxide, and
- about 80% nitrogen gas oxygen is required for germination of most species.
- Carbon dioxide concentrations higher than 0.03% retard germination.
- while nitrogen gas has no influence.

❑ Temperature.

- Seed germination is a complex process involving many individual reactions and phases, each of which is affected by temperature.
- The optimum temperature for most seeds is between 15 and 30o C. The maximum temperature for most species is between 30 and 40o C.
- The response to temperature depends on a number of factors, including the species, variety, growing region, quality of the seed, and duration of time from harvest.

❑ water

- water is the most essential factor.
- The water content of mature, air-dried seeds is in the range of 5 to 15%,
- well below the threshold required for fully active metabolism.
- In addition, water uptake is needed to generate the turgor pressure that powers cell expansion, the basis of vegetative growth and development.

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TYPES OF SEED GERMINATION

- Based on the fate of the cotyledons, two kinds of seed germination occur, and neither appears to be related to seed structure.
- These two types are illustrated by the germination of bean and pea seeds.
- Although these seeds are similar in structure and are in the same taxonomic family, their germination patterns are quite different

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TYPES

Epigeal Germination

- Epigeal germination is characteristic of bean and pine seeds and is considered evolutionarily more primitive than hypogeal germination.
- During germination, the cotyledons are raised above the ground where they continue to provide nutritive support to the growing points.

Hypogeal Germination

- Hypogeal germination is characteristic of pea seeds, all grasses such as corn, and many other species.
- During germination, the cotyledons or comparable storage organs remain beneath the soil while the plumule pushes upward and emerges above the ground.

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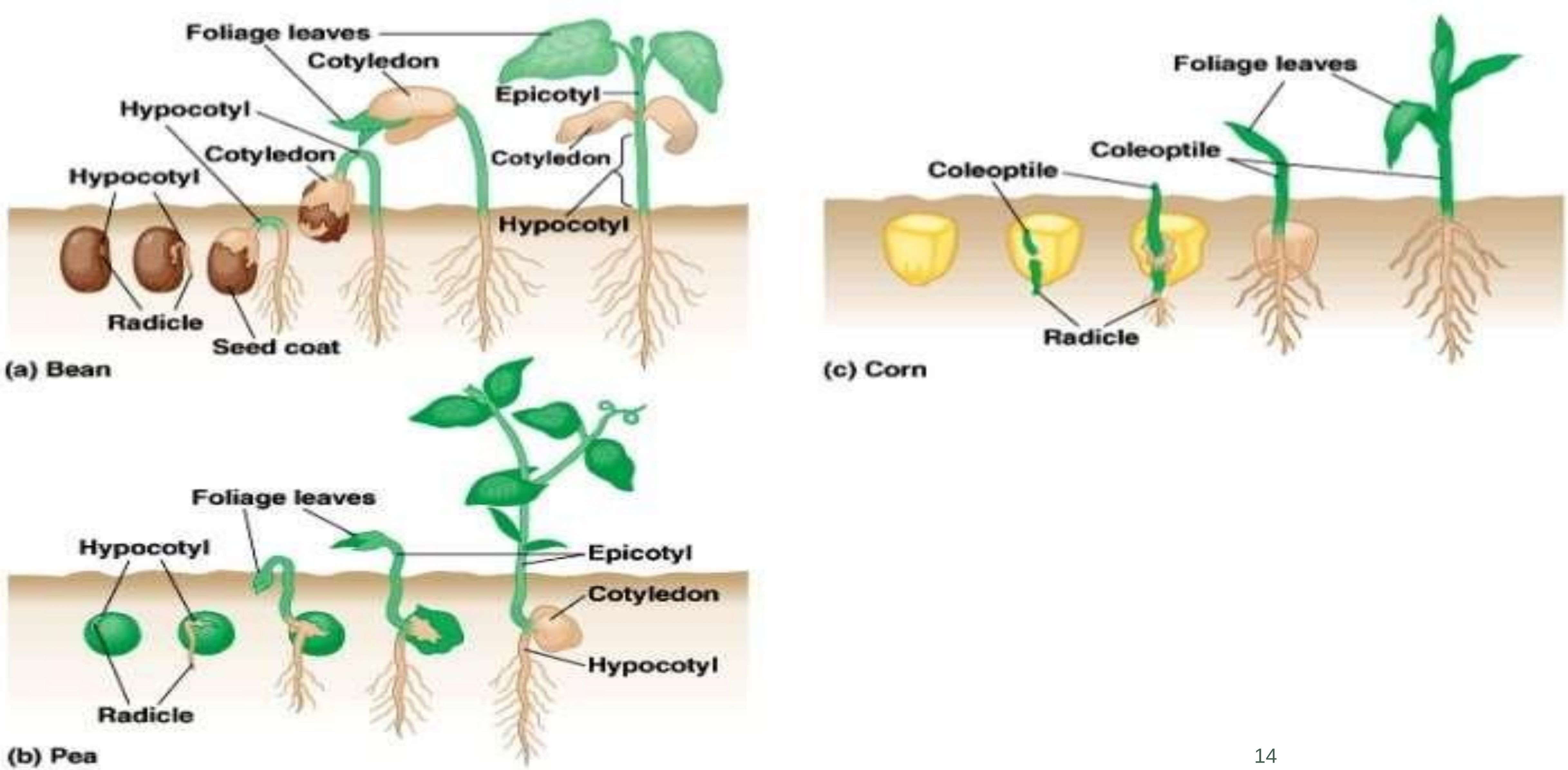
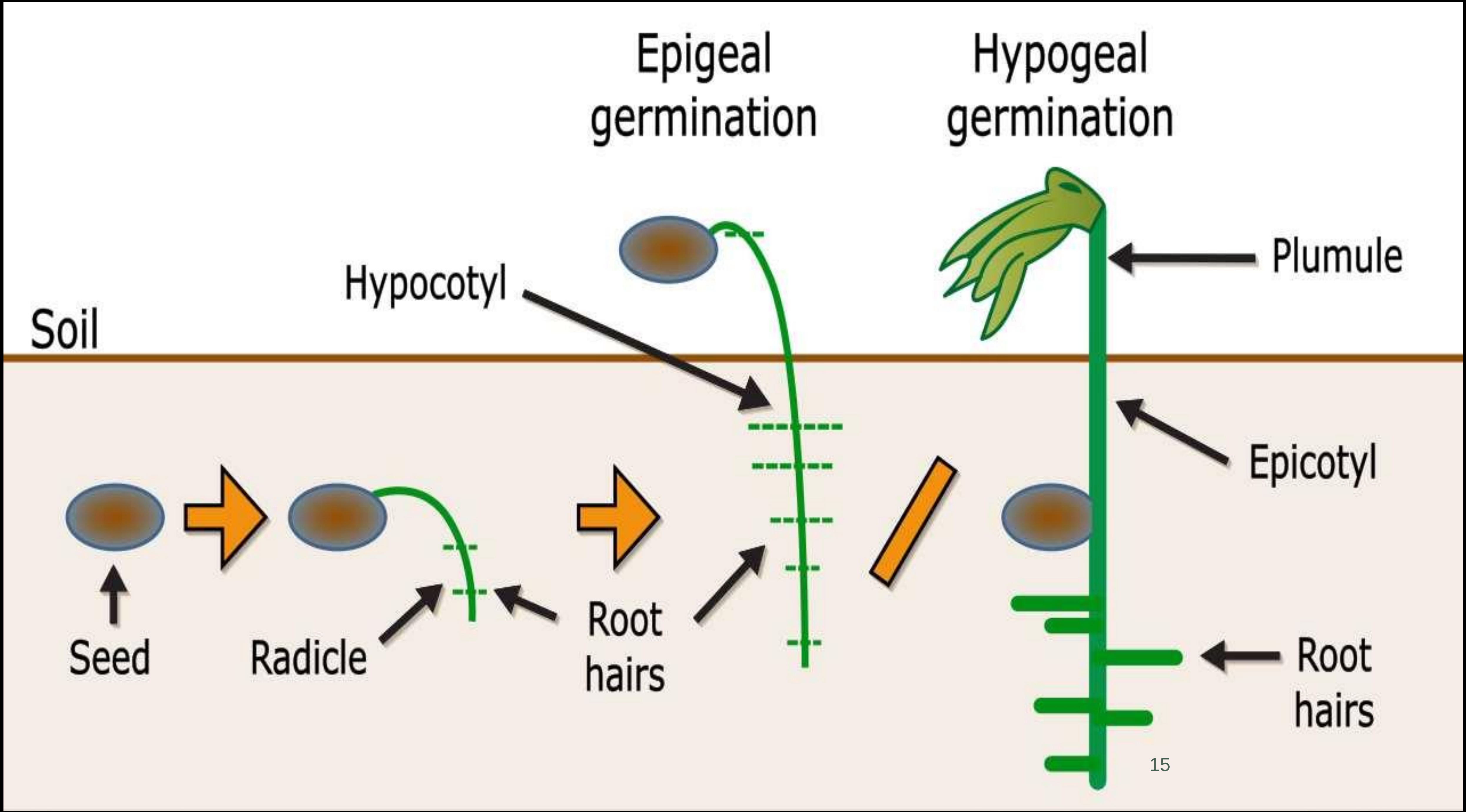
Types

- During root establishment, the hypocotyls begins to elongate in an arch that breaks through the soil, pulling the cotyledon and the enclosed plumule though the ground and projecting them into the air.
- Afterwards, the cotyledons open, plumule growth continues and the cotyledons wither and fall to the ground.

- In hypogeal germination, the epicotyl is the rapidly elongating structure.
- Regardless of their above-ground or below-ground locations, the cotyledons or comparable storage organs continue to provide nutritive support to the growing points throughout germination

Seed germination




Epigeal germination
Hypogeal germination
Plumule
Hypocotyl
Soil
Epicotyl
Seed
Radicle
Root hairs
Root hairs


hypocotyl
cotyledon
Roots

Trigger and germination Agents

- At some point, the seed becomes sensitive to the presence of “trigger” agents.
- A “trigger” agent can be defined as a factor that elicits germination but whose continued presence is not required throughout germination.

- A “trigger” agent such as light or temperature alterations shift the balance of inhibitors to favor promoters such as gibberellins.

Trigger and germination Agents

- In contrast, a "germination" agent is a factor that must be present throughout the germination process.
- An example is gibberellic acid.
- The major sequence of events leading to germination is imbibition, enzyme activation, initiation of embryo growth, rupture of the seed coat and emergence of the seedling.

Pattern of seed germination

Maintenance Phase

- Most seeds undergo a specific sequence of events during germination.
- **Prior to germination**, seeds are in a **“maintenance” phase.**
- It is often characterized as **dormancy** being imposed by **ABA,** metabolic blocks or some other agent hindering the transition to germination.
- **Seed dormancy:** is a mechanism by which seeds can inhibit their germination in order to wait for more favorable conditions (secondary dormancy) (Finkelstein et al., 2008).
- However, primary dormancy is caused by the effects of abscisic acid during seed development.

Pattern of seed germination

- Germination can be divided into three phases corresponding to the phases of water uptake

- ❑ Phase I.
- ❑ Phase II.
- ❑ Phase III.

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PHASE I : IMBIBATION

- The dry seed takes up water rapidly by the process of imbibition.
- It is the first key event that moves the seed from a dry, dormant organism to the resumption of embryo growth.
- The extent to which water imbibition occurs is dependent on three factors:

(1) composition of the seed

(2) seed coat permeability

(3) water availability

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PHASE II: LAG PHASE

- Water uptake by imbibition declines and metabolic processes, including transcription and translation, are reinitiated.
- The embryo expands, and the radicle emerges from the seed coat.

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PHASE III: MOBILIZATION OF RESERVE FOOD

- Water uptake resumes due to a decrease in ljl as the seedling grows, and the stored food reserves of the seed are fully mobilized.

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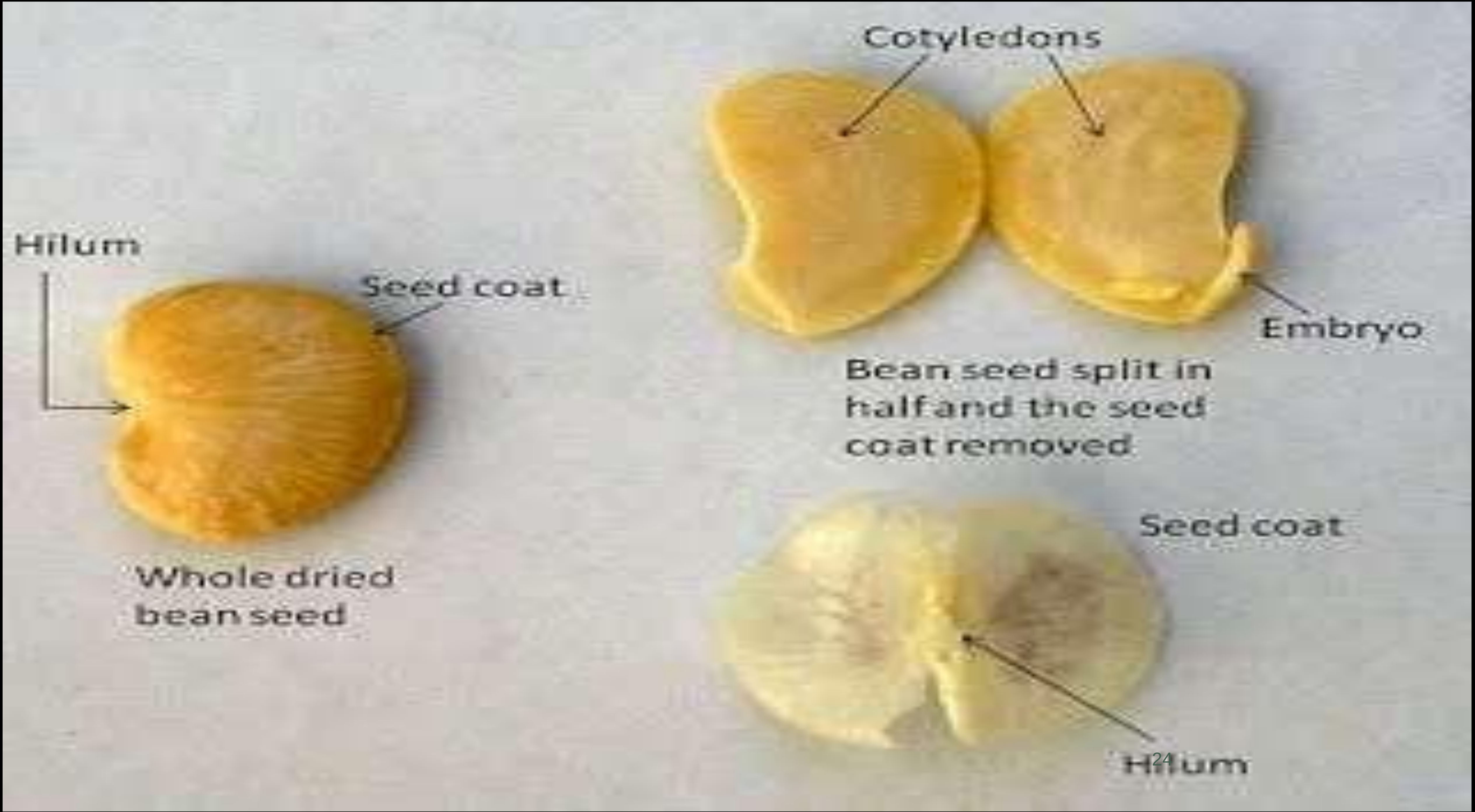
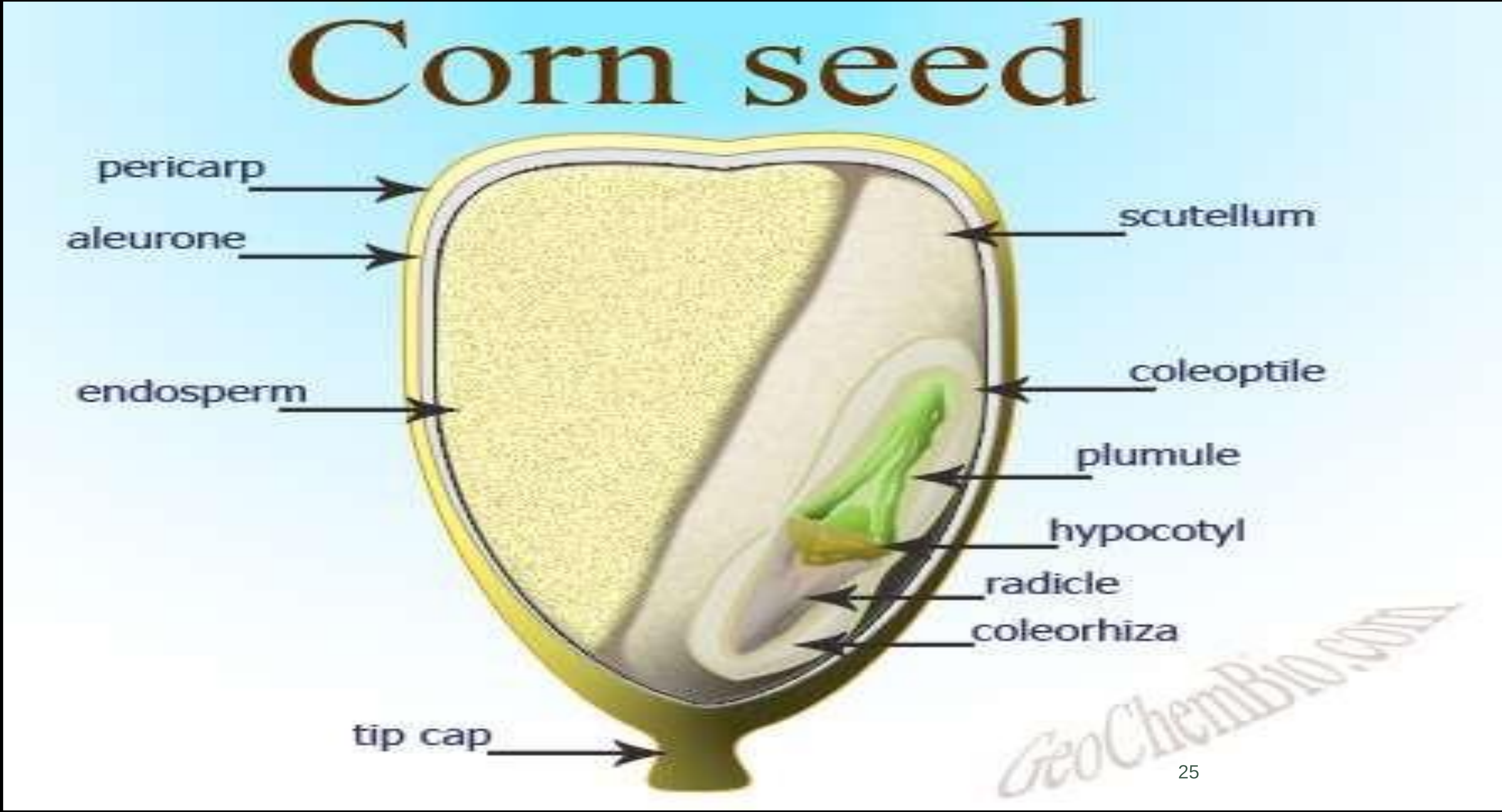
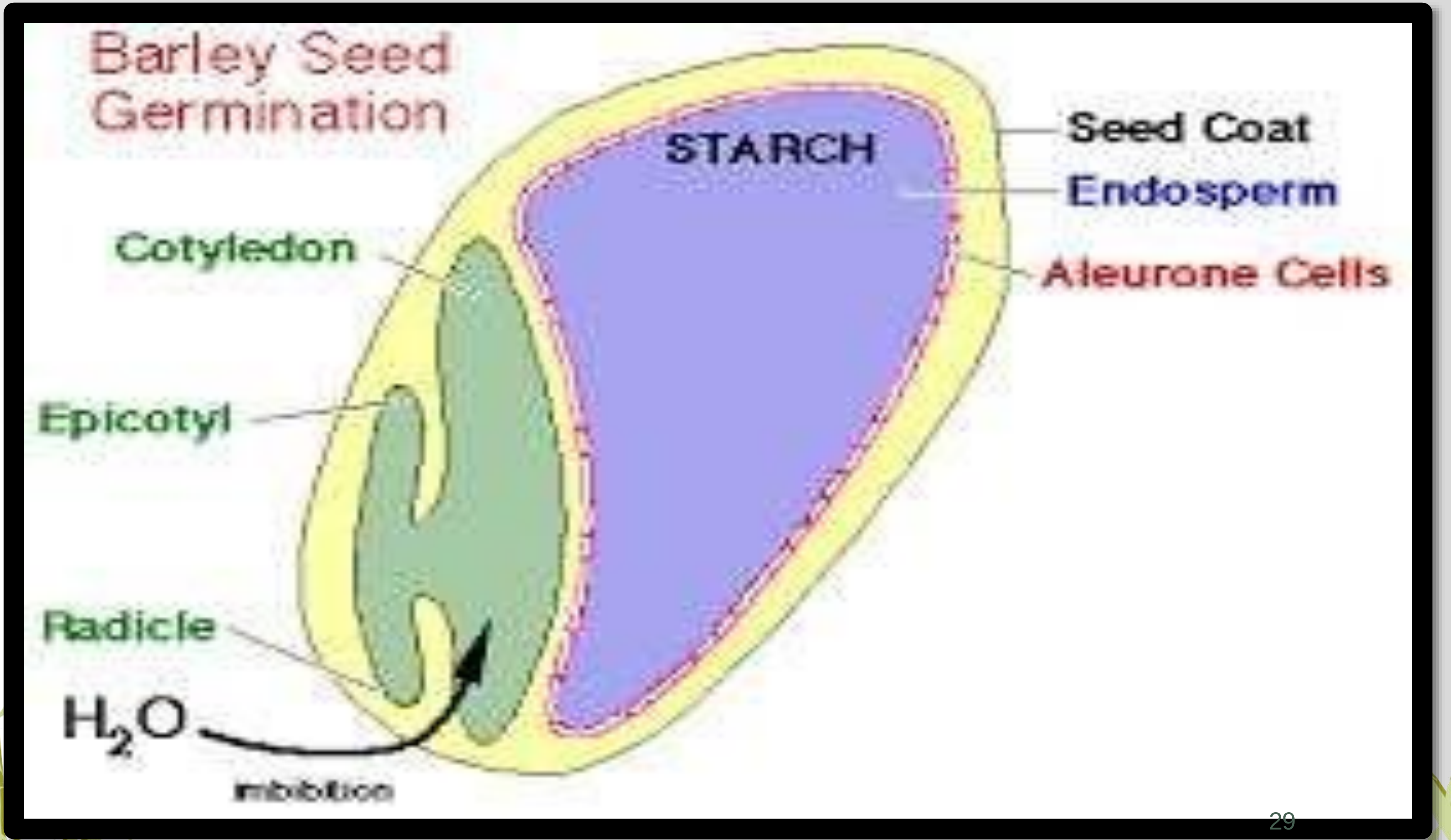


Cotyledons
Hilum
Seed coat
Embryo
Bean seed split in half and the seed coat removed
Whole dried bean seed
Seed coat
Hilum


Corn seed
pericarp
aleurone
endosperm
scutellum
coleoptile
plumule
hypocotyl
radicle
coleorhiza
tip cap
GeoChemBio.com

IMBIBATION



Barley Seed Germination
STARCH
Seed Coat
Endosperm
Aleurone Cells
Cotyledon
Epicotyl
Radicle
H_2O
imbibition

IMBIBATION

- The initial rapid uptake of water by the dry seed during Phase I is referred to as imbibition, to distinguish it from water uptake during Phase III.
- Although the water potential gradient drives water uptake in both cases, the causes of the gradients are different.
- In the dry seed, the **matric potential** (lflm) component of the water potential equation lowers the 1f1and creates the gradient. The matric potential arises from the binding of water to solid surfaces,
- such as the micro capillaries of cell walls and the surfaces
- of proteins and other macromolecules
- There hydration of cellular macromolecules activates basal metabolic processes, including respiration, transcription, and translation.
- Imbibition ceases when all the potential binding sites
- for water become saturated, and *lflm* becomes less negative.

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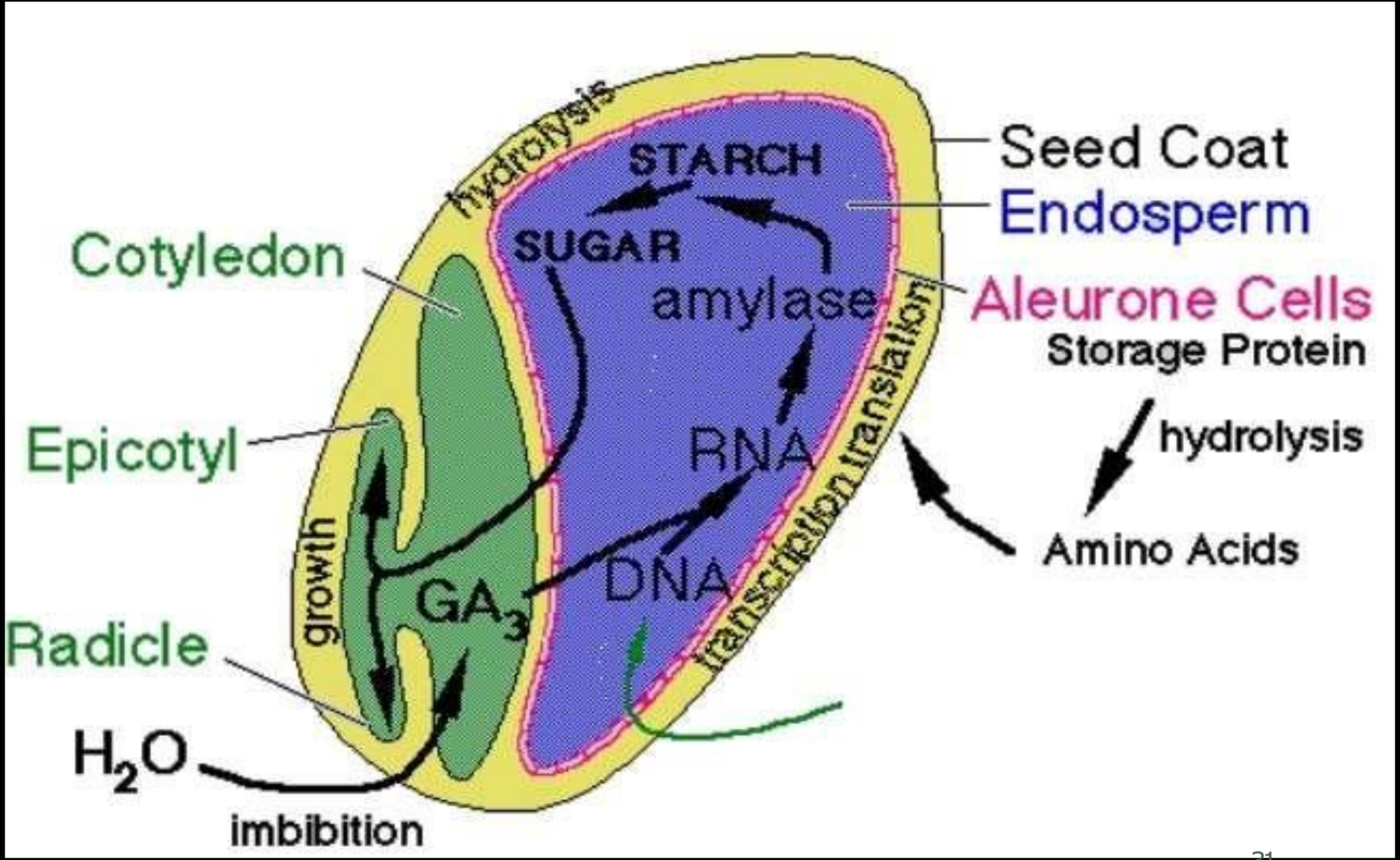
LAG PHASE:



hydrolysis
STARCH
SUGAR
amylase
RNA
DNA
GA3
transcription translation
growth
Seed Coat
Endosperm
Aleurone Cells
Storage Protein
hydrolysis
Amino Acids
Cotyledon
Epicotyl
Radicle
H2O
imbibition

PHASE II:LAG PHASE

- The rate of water uptake slows down until the water potential gradient is reestablished.
- Phase II can thus be thought of as the lag phase preceding growth, during which the solute potential *(If!.)* of the embryo gradually becomes more negative due to the breakdown of stored food reserves and the liberation of osmotically active solutes.

- The seed volume may increase as a result, rupturing the seed coat.
- At the same time, additional metabolic functions come online, such as the re-formation of the cytoskeleton and the activation of DNA repair mechanisms.

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LAG PHASE

- The emergence of the radicle through the seed coat in Phase II marks the end of the process of germination.
- **Radicle emergence** can be either a one-step process in which the radicle emerges immediately after the seed coat (testa) is ruptured, or it may involve two steps in which the endosperm must first undergo weakening before the radicle can emerge.

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PHASE III

- During Phase III the rate of water uptake increases rapidly due to the onset of cell wall loosening and cell expansion. Thus, the water potential gradient in Phase III embryos is maintained by both cell wall relaxation and

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Important stored resorces

- Carbohydrates (starches),
- proteins
- lipids

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Mobilization of Stored Reserves

- The major food reserves of angiosperm seeds are typically stored in the cotyledons or in the endosperm.
- The massive mobilization of reserves that occurs after germination provides nutrients to the growing seedling until it becomes autotrophic.

ENZYMES AND STARCH DEGRADATION:

- At the subcellular level, starch is stored in **amyloplasts** in the endosperm of cereals.
- Two enzymes responsible for initiating starch degradation are a- and ~-amylase.
- **a-Amylase** (of which there are several isoforms) hydrolyzes starch chains internally to produce oligosaccharides consisting of a(1,4)-linked glucose residues.
- **~-Amylase** degrades these oligosaccharides from the ends to produce maltose, a disaccharide. Maltase then converts maltose to glucose.
- The hormonal regulation of these enzymes is described in more detail in the next section.

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ENZYME AND PROTEIN

- Protein storage vacuoles are the primary source of amino acids for new **protein synthesis** in the seedling.
- In addition, protein storage vacuoles contain **phytin,** the K+, Mg2+, and Ca2+ salt of phytic acid a (myo-inositol hexaphosphate), a major storage form of phosphate in seeds.
- During food mobilization, the enzyme **phytase** hydrolyzes phytin to release phosphate and the other ions for use by the growing seedling.

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Physiology of Seed germination

Structure of a cereal grain

- Cereal grains consist of three parts:
- The embryo
- The endosperm
- The fused testa-pericarp

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THE EMBRYO

- The embryo, which will grow into the new seedling, has a specialized absorptive organ, the **scutellum.**

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ENDOSPERM

- The triploid endosperm is composed of **two tissues**:
- **starchy endosperm**
- **aleurone layer.**

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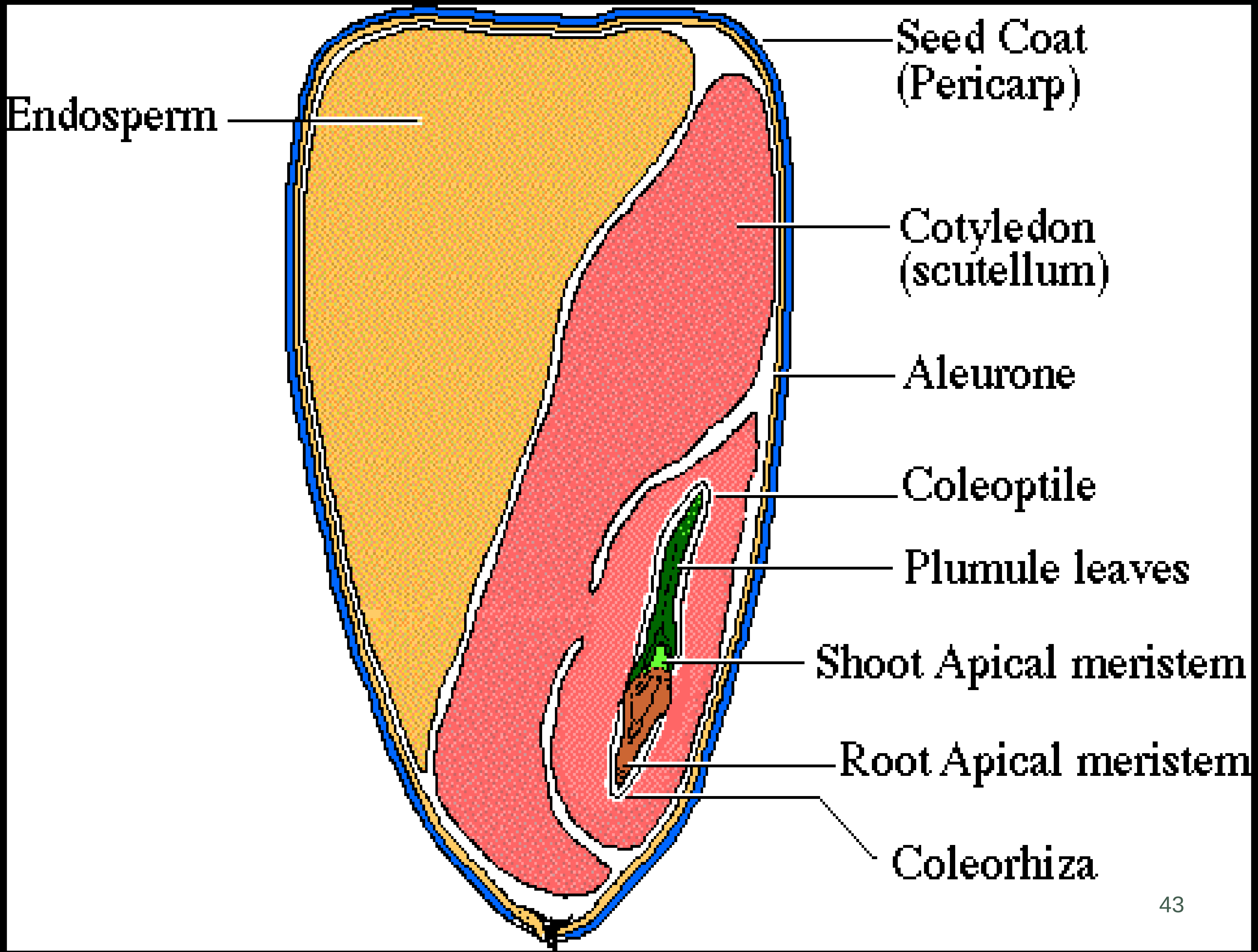
Endosperm
Seed Coat
(Pericarp)
Cotyledon
(scutellum)
Aleurone
Coleoptile
Plumule leaves
Shoot Apical meristem
Root Apical meristem
Coleorhiza

starchy endosperm

- The nonliving starchy endosperm consists of thin-walled cells filled with starch grains and it is centrally located.

Aleuron layer

- Living cells of the aleurone layer, which surrounds the endosperm, synthesize and release hydrolytic enzymes into the endosperm during germination.
- As a consequence, the stored food reserves of the endosperm are broken down, and the solubilized sugars, amino acids, and other products are transported to the

growing embryo via the scutellum.

- The isolated aleurone layer, consisting of a homogeneous population of cells responsive to gibberellin, has been widely used to study the gibberellin signal transduction pathway in the absence of non responding cell types.

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THANKS