Week 1

TREE PHYSIOLOGY DEFINITION:

Tree Physiology is the study of **how** trees **grow** and **develop** in terms of genetics, biochemistry, cells, tissues, and organ functions. It also relates to a tree's **interaction** with environmental factors. While many physiological processes are similar in trees as in other plants, trees possess **unique** physiologies that help determine their outward appearance.

Have you ever wondered **how trees begin**? You know it is from **seeds**, but what tells the seed to begin to grow? Then you have to wonder, how does the seed know the conditions are just right so the **embryo** will be able to grow into a seedling and then into a tree? **What parts** of a tree begin to grow first?

REPRODUCTION AND GERMINATION

Germination

Let's start with germination which is defined as the **growth of an embryonic** tree contained within a seed. It results in the formation of a tree **seedling**. Seed germination depends on both **internal** and **external** conditions being just right to support seedling growth. Often this depends on the individual **seed variety** and is closely linked to the **ecological conditions** of a tree's natural habitat.

Role of internal enzymes in germinating seeds

Ecological Factors Inducing Germination

The most important **external factors** to induce germination include **temperature**, **water**, **oxygen**, and sometimes **light** or darkness. Various trees require different environmental trigger levels for successful seed germination.

- **Temperature: it** affects germination in three primary ways:

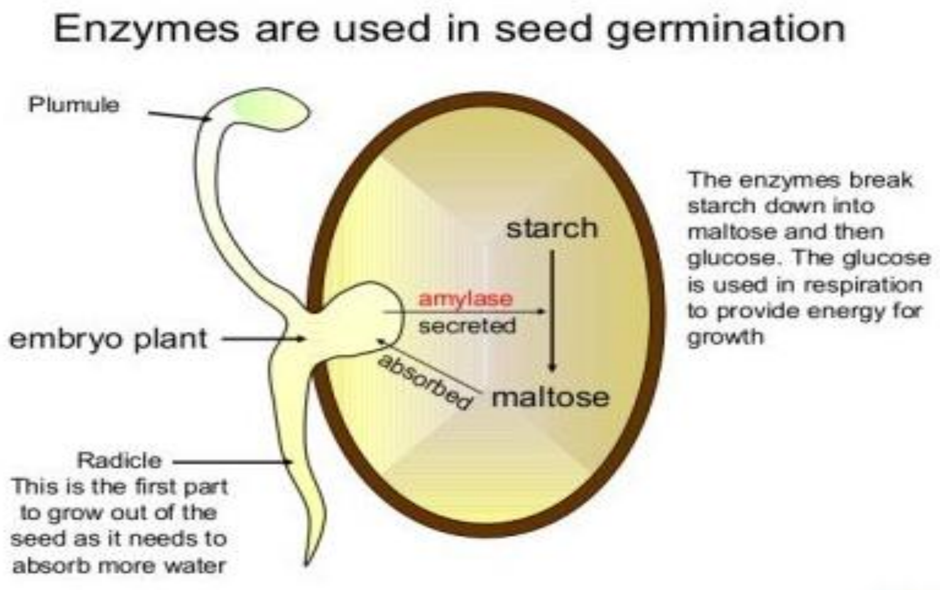
1. **Moisture**, for seeds to germinate, they need to imbibe water. For this to occur, sufficient moisture must be present. A warmer climate may increase evaporation and decrease moisture, which would negatively affect germination.

2. **Hormones**: Two different **hormones** regulate germination: **abscisic acid** and **gibberellins**. Abscisic acid promotes dormancy and inhibits germination while gibberellins advance germination. Temperature affects the transcription of genes that control the production of gibberellins, dormancy is released, and germination occurs.

3. **Enzymes**: Chemical signaling regulates production of enzymes, which is in turn regulated by temperature. For example:

a. Enzymes are required to facilitate germination. For example, **enzymes degrade endosperm tissue and rupture** the seed coat.

b. Seeds contain **stored food** in the cotyledons to provide energy for growth. This is usually in the form of **insoluble starch** (long chain of glucose). The starch needs to be changed into a *soluble* molecule (**sugar**) with help of **enzymes** for the seeds to make use of. In the presence of **H_2O**, **Gibberellin** or **gibberellic acid** (GA) stimulates the production of **amylase**. **Amylase** breaks down **starch** to **maltose**, allowing for the formation of **ATP** (via glucose). The **energy** produced in the embryo is used to facilitate germination.



Water is required for germination. The uptake of water by seeds is called **imbibition**, which leads to the swelling of the food reserves within the seed, which causes the **breaking of the seed coat**. When the seed **imbibes water**, **hydrologic enzymes** are activated which **break down** these stored food resources into metabolically **useful chemicals** that will begin the growth process.

- **Oxygen** is used in **aerobic** respiration, the main source of the seedling's **energy** until it grows leaves. Oxygen is found in pore spaces **between the particles of soil**. If a seed is buried **too deeply** within the soil or the soil is **waterlogged**, the seed can be **oxygen starved** and germination will be **delayed**. The seed will also die from **rot** caused by oxygen deprivation if **too much water** occurs **after the germination** process has started.

- **Light** or darkness can be an environmental trigger for germination and is a type of **physiological dormancy**. Most seeds are not affected by light or darkness, but many seeds, including species found in **forest** settings, will not germinate until an **opening in the canopy** allows sufficient light for growth of the seedling. the photochrome inside the seeds reacts, causing the seed to break dormancy and sprout. light in the red wave length usually promotes germination whereas blue light inhibits it.

Seed dispersal strategies

1. **Wind-driven seeds** such as on a **maple tree.**
2. **Seeds falling on the ground** beneath the trees such as a **nut tree.**

3. **carried away** by certain species of animals or birds such as a **crabapple** being eaten by a bird and the seeds are dropped some distance from the tree.

All seeds can germinate?
Some viable seeds might not germinate. Many seeds have developed a **dormancy** (or sleep) period. **Seed dormancy** is a condition that **prevents** germination even under optimal environmental conditions.

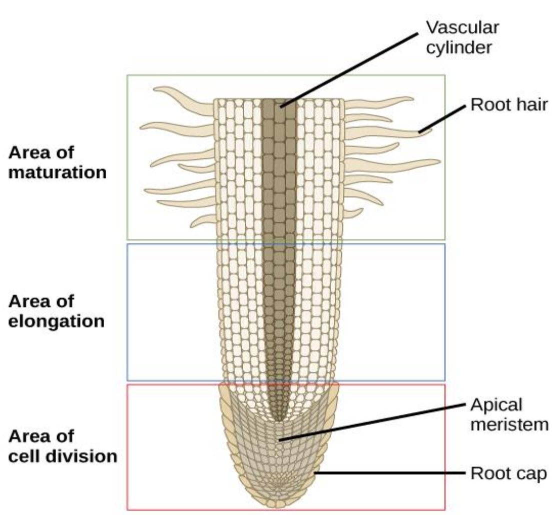
Why would it benefit seeds to not all germinate when conditions are right?
In nature, staggering germination keeps some seedlings safe from possible bursts of bad weather or herbivores that might eat them. For seeds to come out of dormancy, we have to **break their physical or chemical** dormancy factors;

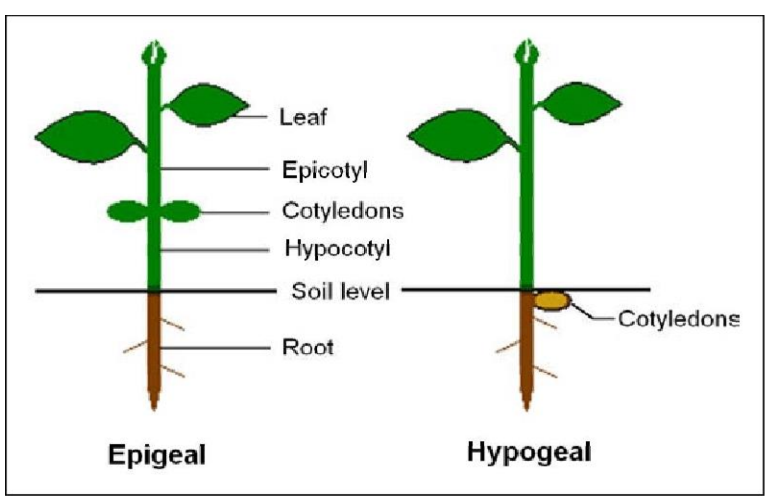
Physical dormancy:
Seeds might have a hard or thick seed coat (physical dormancy). This can be **broken** by soaking or **scarifying** (scratching the surface) the seed.

Chemical dormancy:
Seeds have internal chemical or metabolic conditions that prevent germination (chemical dormancy). It includes the presence of certain **plant hormones**--notably, **abscisic acid,** which **inhibits germination**, and **gibberellin**, which ends seed dormancy.

To **break** chemical dormancy, you might have to leach the seed or use cold/moist stratification or fire scarification (put the seeds in a plastic bag, then placed them inside a refrigerator for about a month).

Radicle growth:
First to emerge from the seed coat is the **primary root**, or **radicle** as it is called in the embryo. This radicle is composed of **one major root** that is thicker at its base and tapers toward the growing tip. **Early root growth** is one of the functions of the **apical meristem** located near the **tip** of the root. The meristem cells more or less **continuously divide**, producing **more meristem**, **root cap** cells (these are sacrificed to protect the meristem), and undifferentiated root cells. The latter become the primary tissues of the root, first undergoing **elongation**. Gradually these cells differentiate and mature into specialized cells of **root tissues**.





Plumule growth:

The plumule is the part of a seed embryo that develops into the shoot bearing the first true leaves of a plant. ... Growth of the plumule does not occur until the cotyledons (the **first leaf or one of the first pair** developed by the embryo of a seed plant) have grown above ground. This is epigeal germination.

Epigeal germination is a type of germination whereby the seed leaves or the cotyledons are brought on to the surface or **above the soil** along with the shoot during germination.

Hypogeal germination is a type of germination whereby the seed leaves or the cotyledons **remain below the soil** surface during germination.

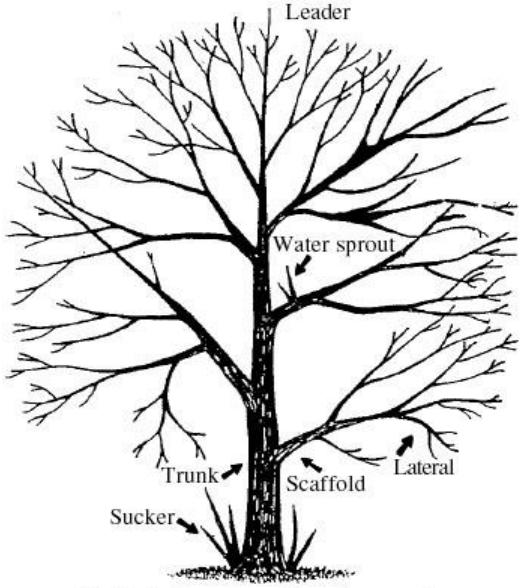
Seedling growth:

After the **embryonic seedling emerges** from the seed coat and starts growing roots and leaves, the embryonic seedling's **food reserves** are quickly **exhausted**. At this point **photosynthesis** provides the energy needed for continuing growth and the seedling now requires a continuous **supply of water**, **nutrients**, and **light**. Most tree species grow a **taproot** from the seed until moisture is reached and the seedling can then focus on **spreading structural** roots, absorbing water and nutrients, and letting the leaves manufacture food.

Vegetative Reproduction

Besides seeds, trees can be propagated with the assistance of mankind.

1. Cultivars are created by **grafting a bud** or **stem** of the parent tree onto a **seedling rootstock** of the species.
2. **Clones** are created by **encouraging roots to develop** on **cuttings** of the parent tree.
3. **Sprouts** and **suckers** start with dormant buds that "come alive" to form **new shoots** off the parent trees. Sprouts are shoots from stumps of a tree. Suckers are shoots that originate from buds on the root systems. Both sprouts and suckers have the **potential to grow into new full size trees genetically identical to the parent**. **Often times**, sprouts and suckers will not grow until the **parent tree dies or becomes very sick**.



Typical above-ground tree framework

4. **Vegetative layering: branches** or **stems** come in **contact with the soil**, the cambium tissue sometimes will form roots.
5. **Tissue culture** is an **invention** of modern science to extract **cells** of desirable trees and grow these cells into **trees** within laboratory conditions. Trees from this process are genetically identical to the parent.