Did you know that the double coconut palm produces the largest seed in the world? It weighs about 50 pounds. The smallest seeds are like dust. Whatever the size of the seed, the function is to grow into mature plants.

Objective:
- Discuss processes and requirements of seed germination.

Key Terms:
- amylase
- cotyledon
- embryo
- endosperm
- epicotyl
- germination
- hilum
- hypocotyl
- imbibition
- micropyle
- phytochrome
- plumule
- protease
- radicle
- scarification
- seed coat
- stratification
- suspensor
- turgid
- viability
- vigor

Seed Germination

Seeds contain everything necessary for the growth and development of a new plant. The three primary parts of a seed are the embryo, the endosperm, and the seed coat. The embryo is the young, multicellular organism before it emerges from the seed. The endosperm is a source of stored food, consisting primarily of starches. The seed coat consists of one or more protective layers that encase the seed.

Seeds begin to form an embryo following fertilization and the start of a zygote. The initial division of the zygote results in two cells. The bottom cell develops into a multicellular structure, called the suspensor, which anchors the embryo and helps to obtain nutrients from the endosperm. The top cell develops into the embryo. The first cell divisions from this top cell create a chain of cells called the proembryo. As the cell divisions continue, a globular embryo takes shape. At this point of development, cells begin to differentiate.
Next, cotyledons begin to form. The cotyledon is described as a seed leaf that stores food in the form of starch and protein for use by the embryo. Embryos of monocotyledon (monocot) plants have one cotyledon, whereas those of dicotyledon (dicot) plants have two cotyledons. Monocot plants store the bulk of their energy in the endosperm. Dicots store their food in the two cotyledons. The cotyledons grow and elongate. As the embryo matures, the pressure of the expanding embryo crushes the suspensor.

The mature embryo consists of an embryonic root, known as the radicle, an embryonic shoot, and one or two cotyledons. The embryonic shoot, known as the plumule, has two main parts, the epicotyl and the hypocotyl. The epicotyl is the portion of the embryonic stem above the point at which the stem is attached to the cotyledon(s). The hypocotyl is the portion below the point of attachment. The hypocotyl is connected to the radicle.

The seed is encased in a protective seed coat. It protects the embryo and the endosperm from drying and from physical injury. A scar, called the hilum, can be seen at the end or along the side of the seed coat. The hilum marks the point of attachment of the seed to the ovary wall. The seed coat has a tiny opening, sometimes visible near the hilum, called the micropyle.

Germination is the process by which the seed embryo begins growth. A seed is considered to have germinated when the embryonic root emerges from the seed coat. Many important crops are grown from seed. Corn, soybeans, cotton, and vegetables are started from seeds. Seed germination is a complex process that begins when conditions are favorable for growth.

DORMANCY MECHANISMS

Some plants produce seeds that germinate immediately once they are released. Others produce seeds that have internal dormancy mechanisms and do not germinate until the dormancy mechanisms have been satisfied.
**Stratification**

*Stratification* is a dormancy mechanism that involves temperature. Seeds with this mechanism must experience a period of cold temperature before the seed can germinate. Without this mechanism, a seed could germinate during a warm spell late in the year and die with the arrival of freezing temperatures.

**Scarification**

*Scarification* is a dormancy mechanism that involves the breakdown of the seed coat. Some plants have very thick and tough protective seed coats. These seed coats prevent water and oxygen from entering the seed. The seed coat must be broken before germination can begin. The seed coat can be broken down as it passes through an animal’s digestive system, by microorganisms in the soil, by repeated freezing and thawing, or from mechanical wear.

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**UNDER INVESTIGATION...**

**LAB CONNECTION: Turgor Pressure**

The processes of seed germination begin with the imbibition of water. Water moves into individual cells by osmosis. The cell vacuoles fill with water. The contents of the cells push against the plant cell walls to create turgidity. Turgor pressure, or turgidity, is the major pressure of the cell. As the cells swell from turgor pressure, numerous activities begin to take place.

The incredible force of turgor can be demonstrated by filling a mayonnaise or pickle jar half full with beans. Add sand to the jar, and shake it to get even distribution. Add more sand to fill the jar completely. Shake the materials again. Place the jar on a tray or in a shallow box and set aside. Slowly add water to the jar until it can accept no more water. Within 30 to 60 minutes, results will be witnessed.

What do you think will happen? What purpose does turgor pressure play in seed germination?
CONDITIONS FOR SEED GERMINATION

Environmental factors play key roles in seed germination. Favorable environmental conditions must exist for successful germination. Critical factors for germination include moisture, air, optimal temperatures, and possibly light or darkness.

Water triggers chemical processes associated with germination. Germination will not occur without water.

All seeds need oxygen to germinate. Oxygen is required for cellular respiration, a process necessary for converting stored food into energy.

Plant species have evolved whereby their seeds germinate within a certain range of temperatures. Temperature influences the speed of metabolic activities within the seed. In general, metabolism is faster when temperatures are warm than when temperatures are cool. The optimum temperature for seed germination of most plant species lies between 65 and 80°F. Some species’ seeds germinate at temperatures as low as 32°F and others as high as 105°F.

Seeds of some plants need exposure to light before they will germinate. Seeds of other plants require darkness in order to germinate, and there are those that are not influenced by light or darkness. Seeds that are light sensitive have a photoreceptor pigment, called phytochrome, found in the seed coat. This pigment sends messages to the seed instructing it to initiate or to stop germination.

![Figure 3. Several conditions must be met for the germination process to occur.](image-url)
Lot No.
65321

Net Wt.
1/32 oz

140 SUPER BOY VFNT
F1 Hybrid Tomato

Super Seeds Company, Inc.

Lot number. For identification by seller.

Trade or brand name.

Seed catalog number. Name of hybrid, resistance to verticillium and fusarium wilts, nematodes, and tobacco mosaic virus.

Description of seed treatment. Fungicide, insecticide, or hot-water treatments for protection from certain insects and diseases.

Season that seeds were packaged for sale.

Date of germination test.

Percent of seeds germinated under specific laboratory conditions.

Name and address of seller.

Packet produces about 40 plants

Germination procedure

When to plant

How to plant

Where to plant

Conditions of sale

General planting and growing instructions.

Warranty. Limits the liability of the seller to the purchase price of the seeds. The seller guarantees the seeds in this packet to be exactly as described, true to name, and free from insects and diseases.

FIGURE 4. A germination rate is typically printed on seed packets.
SEED QUALITY

Seed quality is crucial to seed germination. Seed quality refers to viability and vigor. **Viability** is the ability of seeds to germinate under optimal conditions. **Vigor** is defined as the ability of seeds to germinate under different conditions and still produce healthy plants. Producers value seeds that are viable and have vigor because of their high rate of germination. As seeds age, they lose viability and vigor.

Seed producers test seeds to determine the percentage of seeds that will germinate. Germination rates from the tests are printed on the seed container label.

The proper storage of seeds until they are sold and planted helps to ensure the highest possible germination rates. The goal is to maintain seed viability and vigor during the storage period. Recommended seed storage conditions consist of cool temperatures (about 40°F) and low humidity (approximately 15%).

THE GERMINATION PROCESS

There are three major stages in the germination process. These are the imbibition of water, increased metabolic activity, and swelling of cells.

Germination begins with the seed’s **imbibition** (absorption) of water. Most dormant seeds have 5 to 10 percent moisture content. When conditions are right, water is imbibed very rapidly. Most water is imbibed through the micropyle. As the cells hydrate, they swell and become **turgid**, or rigid. The moisture triggers an increase in cellular respiration, which converts starches to energy. It should be noted that oxygen must be present for cellular respiration to take place.

In the second phase of seed germination, metabolic activity surges. Proteins are synthesized. A group of plant hormones, called gibberellins, stimulate the production of enzymes. The enzyme **amylose** converts stored starches to sugars, while the enzyme **protease** breaks down stored proteins into amino acids. The sugars and amino acids are directed toward cell division, growth, and differentiation sites at the root and shoot meristems, or tips.

Metabolic processes increase in the third phase of germination. Pressure produced by the swelling of cells causes the seed coat to rupture. The radicle emerges downward, and the stem grows upward. The shoot with its leaves begins manufacturing food through photosynthesis. The roots absorb water and nutrients.

Summary:

The three primary parts of a seed are the embryo, the endosperm, and the seed coat. The mature embryo consists of the radicle, an embryonic shoot, and one or two cotyledons.
Germination is the process by which the seed embryo begins growth. A seed is considered to have germinated when the embryonic root emerges from the seed coat.

Stratification is a dormancy mechanism whereby seeds must experience a period of cold temperature before the seed can germinate. Scarification is a dormancy mechanism that involves the breakdown of the seed coat.

Environmental factors for germination include moisture, air, optimal temperatures, and possibly light or darkness.

Viability is the ability of seeds to germinate under optimal conditions. Vigor is defined as the ability of seeds to germinate under different conditions and still produce healthy plants.

Three major stages in the germination process are the imbibition of water, increased metabolic activity, and swelling of cells.

**Checking Your Knowledge:**

1. What are the primary parts of a seed?
2. What are two seed dormancy mechanisms?
3. How do environmental factors affect seed germination?
4. How do viability and vigor compare?
5. What are the three major phases of seed germination?

**Expanding Your Knowledge:**

Obtain 25 bean seeds and space them out along a wet paper towel. Roll the towel up and place it in a plastic bag. Keep the bag at room temperature and open it after three days to observe the seeds. What changes have occurred with the seeds? Have all of them germinated?

**Web Links:**

- **Plant Propagation: Sexual Reproduction**
  [http://ag.arizona.edu/pubs/garden/mg/propagation/sexual.html](http://ag.arizona.edu/pubs/garden/mg/propagation/sexual.html)

- **Germination**

- **Sowing Seeds**
  [http://theseseedsite.co.uk/seedsowing.html](http://theseseedsite.co.uk/seedsowing.html)

- **Agricultural Career Profiles**
  [http://www.mycaert.com/career-profiles](http://www.mycaert.com/career-profiles)