Germination

Structure of Seeds

Quote:

Thomas Fuller's *Gnomologia*, 1732:
"The greatest Oaks have been little Acorns."

Seeds are found in a staggering array of shapes and sizes, but the process by which seeds germinate is similar in all species.

Abies koreana

'Korean Fir' by Roger Culos. CC BY-SA.

Acer griseum

'Paperbark Maple' by Roger Culos. CC BY-SA.

Wisteria floribunda

'Japanese Wisteria' by Roger Culos. CC BY-SA.

Alsomitra macrocarpa

'Alsomitra macrocarpa seed' by Scott Zona. CC BY.

Macrozamia communis

'BurrawangSeeds' by AYArktos. CC BY-SA.

Strelitzia reginae

'Paradiesvogelblumensamen' by Sebastian Stabinger. CC BY-SA.

Taraxicum officinale

'Achane of Taraxacum sect. Ruderalia' by Didier Descouens. CC BY-SA.

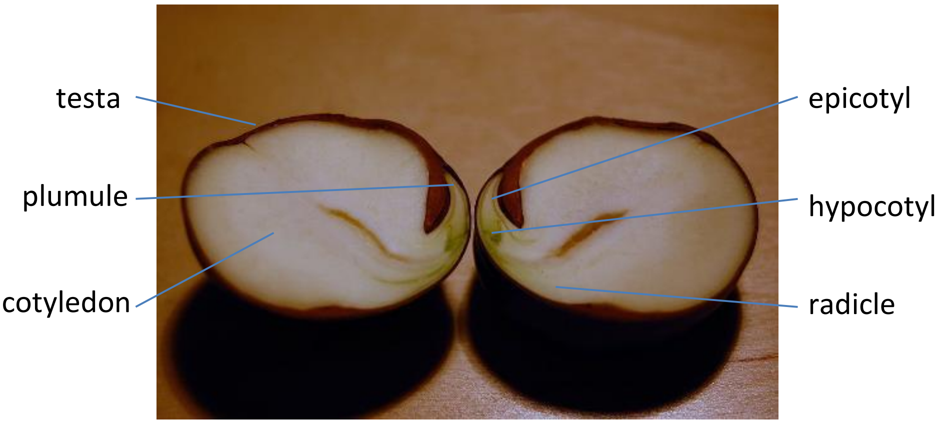
Stephanotis floribunda

'Stephanotis seed' by L. Marie"/Lenore Edman, Sunnyvale, CA. CC BY.

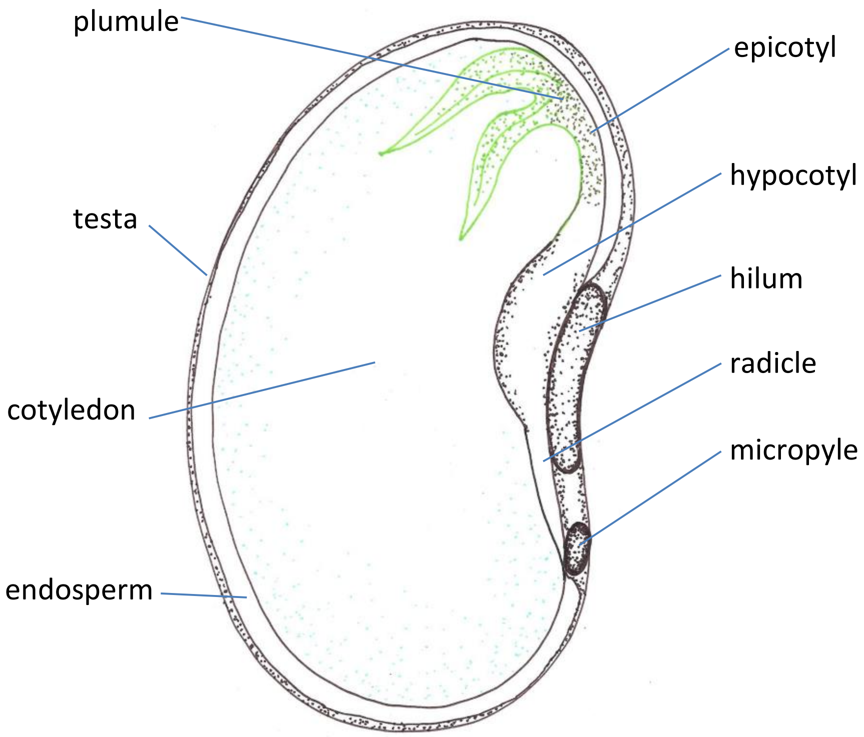
Phleum pratense

'Timoteegras vruchten Phleum pratense' by Rasbak. CC BY-SA.

Dicotyledon seeds

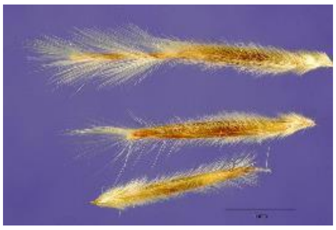


'Aesculus hippocastanum seed section' by Boronian. CC BY.



Monocotyledon seeds





Parts of a seed

Testa

The seed coat. A protective layer which is tough and hard and it protects the seed from attack by insects, fungi and bacteria.

Cotyledon

Dicotyledons have 2 cotyledons	Monocotyledons have 1 cotyledon

A cotyledon is an embryonic leaf. It is the first leaf to appear when a seedling grows. They often contain reserves of food which the developing seedling can use to grow.

Epicotyl

The section of stem between the cotyledon(s) and the plumule. In a seedling it is the section of stem between the cotyledons and the first true leaves.

Hypocotyl

The section of stem below the cotyledon(s) and above the radicle, or root in a seedling.

Radicle
The first part of the embryo to emerge when a seed germinates, it becomes the root.

Plumule
The embryonic growing shoot and first leaves of a plant. This is the part of the plant that grows above the cotyledon(s) when the seedling develops.

Hilum
The scar where the seed was attached to the parent plant.

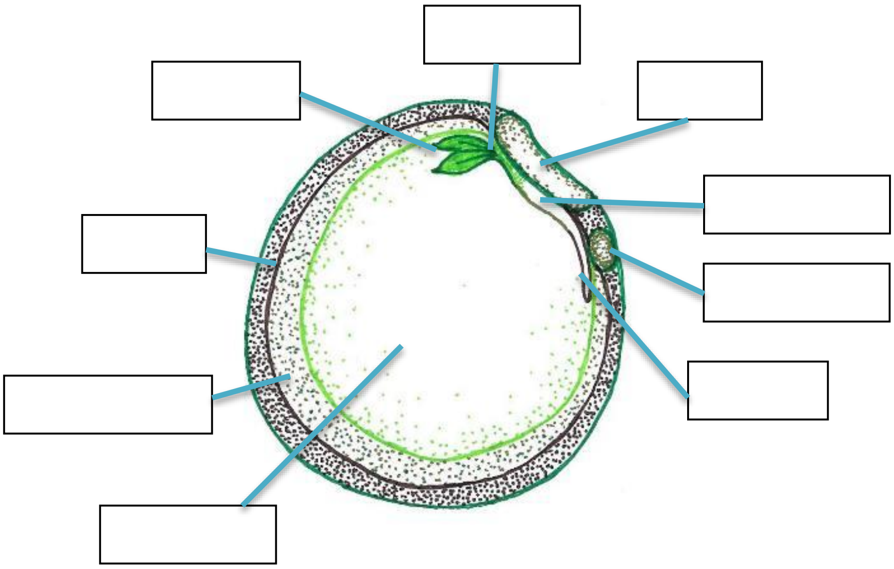
Endosperm
The food store made up of protein and starch which feeds the developing seedling before it is able to uptake water and nutrients through its own roots.

Micropyle
This is a tiny pore in the testa located just opposite the radicle which lets water into the seed.

Seed Structure Activity

Fill in the names of the seed parts on the diagram below

hilum epicotyl radicle endosperm testa plumule cotyledon hypocotyl micropyle



Seed Dormancy

Normally when environmental conditions are favourable a seed will begin to germinate, but in some cases a seed can remain dormant even though the conditions are perfect for germination.

Why?

↓

To delay germination

↓

Why?

↓

To cause germination to be staggered which allows seeds to travel different distances before they germinate. This ensures a wide geographical spread so that seeds germinate at different times, protecting some of the seedlings against short periods of inclement weather or passing herbivores.

Video link:

https://www.youtube.com/watch?v=JRc7FAHiNOo

Some seeds can germinate after 2000 years of dormancy!

Seed dormancy can be primary or secondary

Primary dormancy

Seeds are released from the plant in a dormant state

Secondary dormancy

Seeds are not dormant when they are released from the plant but become dormant if environmental conditions are unfavourable

Two types of seed dormancy

Coat Imposed Dormancy

- Prevention of water uptake
- Mechanical constraint
- Interference with gas exchange
- Retention of inhibitors
- Inhibitor production

Embryo Dormancy

- Embryo inhibits germination through the presence of growth inhibitors and the lack of growth promoters.

Seed Dormancy Quiz

Video link:

https://www.youtube.com/watch?v=scU9NsEtHn8

Watch the video and then see if you can answer these questions.

1. What is seed dormancy?
    a. Seeds from unfertilised flowers that cannot germinate
    b. Seeds that do not germinate even when environmental conditions are correct
    c. Seeds that have not formed properly and so cannot germinate

2. What advantage does seed dormancy give to plants?
    a. It protects them from attack by fungi and bacteria
    b. It makes them better for human consumption
    c. It staggers timing of germination to allow for dispersal

3. What is primary dormancy?
    a. Seeds are in a dormant state when they are released from the plant
    b. Seeds become dormant when the environmental conditions are unfavourable
    c. Seeds are in the first of a series of dormant phases

4. What is secondary dormancy?
    a. Seeds are in a dormant state when they are released from the plant
    b. Seeds become dormant when the environmental conditions are unfavourable
    c. Seeds are in the first of a series of dormant phases

5. What are the two types of seed dormancy?
    a. Coat imposed dormancy and embryo dormancy
    b. Coat imposed dormancy and root dormancy
    c. Root dormancy and embryo dormancy

Stimuli that break dormancy

The seeds from different species of plant are brought out of dormancy by a variety of stimuli. Most seeds respond to more than one stimuli, so mimicking one condition when breaking seed dormancy may not be enough.

After ripening

Some seeds germinate once they have dried out to a certain extent. For the majority of seeds if they dry out so that they contain less than 5% water they can be damaged.

Fire

Some seeds require extreme high temperatures for the seed coat to be broken to allow germination to take place.

Digestion

Some seeds will not germinate unless they have been eaten and excreted.

Chilling

Some seeds need a cold treatment to germinate which mimics the seeds going through winter. Once the cold spell is over they germinate in the spring. The process of chilling seeds is often referred to as stratification.

Oxygen

Seeds need to absorb oxygen to begin the process of germinating. Without oxygen the seed cannot carry out respiration which provides the energy for growth.

Light

Many seeds germinate when they are exposed to light. This may be a brief exposure, intermittent exposure, or exposure in a specific pattern such as short or long day length.

Water

Seeds need to absorb water (imbibition) to begin the process of germinating.

Warmth

Seeds from different species require different minimum temperatures to germinate.

Imbibition

'The breaking of the seed coat' by Mr Revolution. CC BY.

When a seed comes into contact with water it absorbs it and swells up. The seed imbibes water. Imbibe means 'to drink'. Do not get this process mixed up with osmosis, it is not the same thing!

This is possible because of the presence of colloidal particles in the testa which attract water and cause the seed to swell.

Watch this video, paying particular attention to the seeds imbibing before they start to germinate.

Video link:

https://www.youtube.com/watch?v=pB4ASdELBbQ

Osmosis is the movement of water across a semi-permeable membrane from an area of low solute concentration to an area of high solute concentration

Do not get the process of imbibition mixed up with the process of osmosis, it is not the same thing!

Factors limiting imbibition

Temperature: The rate of imbibition increases with temperature increase.

Solute concentration: The purer the water is, the higher the rate of imbibition. If the water is high in solutes (dissolved compounds) then the rate of imbibition will be low.

Why is imbibition so important?

It plays a key role in the initial stage of water absorption by roots when seedlings are young.

It initiates seed germination.

It plays a role in adhering water to xylem tissues.

It helps fruits to retain water.

Storage Tissues

The endosperm in the seed is a store for energy that allows the seed to grow and the seedling to develop to the point that it can feed itself from its roots.

What is in the endosperm?
Starch
Protein
Sometimes Oils and Fats

Endo = 'within'

Sperm = 'seed'

Endosperm = 'within seed'

During germination the embryo submits signals to the endosperm which causes it to start breaking down and releasing nutrients. The endosperm also breaks down structurally which allows the cotyledons to emerge from the seed.

The endosperm is able to recognise environmental signals and it can give signals to the embryo to regulate its growth according to the environment around the seed.

Some tiny, dust-like, seeds have no endosperm

Substrate breakdown in the endosperm:

Enzymes in the seed which become active when the seed imbibes water break down the large storage molecules of starch in the endosperm and cotyledons. The large molecules are broken into smaller molecules of glucose which can be used for respiration to produce energy for growth. Specific enzymes which loosen the cell wall are also produced during this phase of germination to prepare for the radicle to emerge from the seed.

Advanced reading activity:

http://aggie-horticulture.tamu.edu/faculty/davies/pdf%20stuff/ph%20final%20galley/Chap%207-%20M07_DAVI4493_00_SE_C07.pdf

Seed to Seedling

Video link: https://www.youtube.com/watch?v=Sxjv18W9cDQ

Radicle Emergence

'Sprouted chickpea stages' by Edukeralam. CC BY-SA.

When you have sown seeds the first noticeable indication of germination is the appearance of the radicle which protrudes from the seed and starts to grow down. To start with the radicle growth is caused by cell elongation, but as the radicle continues to grow the cells start to divide at the growing tip.

Shoot Emergence

'Seed germination' by U.S. Department of Agriculture. CC BY.

Once the radicle has emerged and started to grow down into the soil the shoot begins to emerge. The emerging seedling uses food reserves from the endosperm and cotyledons to grow the hypocotyl region which lengthens the seedling stem and pushes it out of the seed and towards the light. The cotyledons (single cotyledon if it is a monocotyledonous plant) then unfold and you can see your seedling. The epicotyl then starts to develop and you see the first true leaves begin to emerge and the seedling can then start feeding itself through uptake of nutrients and water from the soil through its roots and photosynthesis in its leaves.

Heterotrophic growth	**Autotrophic growth**
This is when the germinating seed and developing seed is feeding from organic material i.e. using the stored food in the endosperm and cotyledons	This is when the seedling is old enough and can feed itself from water and nutrients taken up through its roots and photosynthesis.

Environmental Factors

Temperature

Three temperature points:
Minimum · Optimum · Maximum
Germination occurs most rapidly at the optimum (perfect) temperature. Below the minimum, and above the maximum temperature germination will not occur. Each species of plant has a different minimum, optimum and maximum temperature.

Water

Seeds need moist conditions to germinate, but not too wet, and seedlings are very sensitive to drying out. But both seeds and seedlings can be killed by waterlogging as if the germinating seed, or the root of the young seedling, becomes completely surrounded by water then they cannot uptake gases for respiration.

Gases

Oxygen uptake is essential for germination but becomes impossible for the seeds if the soil is too compacted or becomes waterlogged. If a hard crust forms on the soil surface then oxygen diffusion into the soil is limited, and this reduces germination rates. Some water plant seeds can only germinate in water and are inhibited by exposure to air.

Light

Many plant species which produce small seeds need light to trigger germination. For some it is the correct wavelength of the light, and for some it is the correct photoperiod (day length) that triggers germination. Small seeds do not have big food reserves and so the epicotyl needs to reach the soil surface quickly so that the first leaves can start to photosynthesis to feed the seedling.

Images for temperature:

 or  and 

Image for water:

 and 

Image for gases:

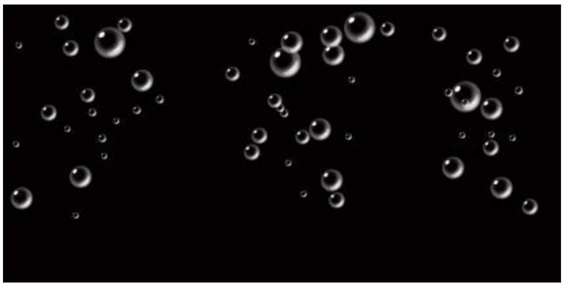
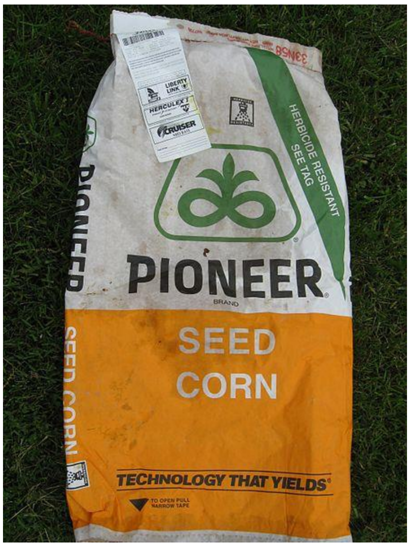


Image for light:

Seed Technology

A seed technology laboratory



Genetically modified seed which is resistant to herbicides

Seed technology is the improvement of physical or genetic properties of seeds and the plants they grow into. It is particularly important in agriculture as disease resistance, drought resistance, herbicide resistance, physical strength and many other attributes are important properties to ensure reliable, high yielding crops.

Genetic modification of plants is a controversial, although very widely used, technique. One side of the debate states that it is an unnatural process and a threat to native ecosystems, the other side states that it is a necessary process to be able to feed the world's rapidly increasing population.

Reading activity:

http://www.senseaboutscience.org/data/files/resources/9/MSofGM2011.pdf

Reference:

- Fuller, T., 1732. Gnomologia: Adagies and Proverbs; Wise Sentences and Witty Sayings, Ancient and Modern, Foreign and British. B. Barker; and A. Bettesworth and C. Hitch.