The life cycle of plants and trees starts with the germination of seeds. Plants and trees produce seeds and seeds develop into new plants. The cycle thus continues keeping the species alive and continuing. Seed development is the process which leads from a fertilized ovule to a mature seed.

**Parts of a Flower**

Typically, a flower has four major parts:

1. Sepals – outer most whorl of leaves (generally green) (the calyx).
2. Petals – the showy, colorful portion of the flower (the corolla).
3. Stamens – the male reproductive structure composed of anther and filament. The anther contains four pollen sacs which burst to release tiny grains of pollen, the male sex cells.
4. Pistil – the female reproductive structure made up of stigma, style and ovary. The carpels are the female reproductive parts. Each carpel has a stigma which catches the pollen grain. The style connects the stigma to the ovary. The ovary contains one or more ovules, which in turn contain the female gametes.

**Pollination & Fertilization**

The ovule arises as a dome-shaped mass of cells on the surface of the placenta. The outer cell layers of the dome form one or two protective layers called the integuments. The integuments do not fuse at the apex of the ovule, thus leaving a small opening called the micropyle. Within the ovule, the megaspore mother cell enlarges in preparation
for meiosis (cell division). The tissue from which the megaspore mother cell is derived is called the nucellus. The megaspore mother cell undergoes meiosis to produce four 1N cells of which 3 disintegrate leaving only one 1N cell. The nucleus in this 1N cell has three mitotic divisions that produce an eight nucleate embryo sac. Three of these nuclei move away from the micropyle and are called antipodals. Three other nuclei move toward the micropylar end, 2 are called synergids and one is called the egg cell. The remaining 2 nuclei remain centrally located in the embryo sac and are called the polar nuclei.

During pollination, the growing pollen tube penetrates the micropyle and the two sperm nuclei enter the ovule. One fuses with the egg cell and the other with the two polar nuclei of the central cell.

The embryo arises from fertilization of egg cell by one sperm nucleus. The endosperm is a tissue produced as a result of triple nuclear fusion between one sperm nucleus and two maternal polar nuclei. Perisperm is derived from the nucellus. The testa (seed coat) is derived from the integuments of the nucellus. In grasses, the scutellum is a modified cotyledon which acts as a transfer organ between the endosperm and embryo during germination.

The ovule matures into a seed, which will comprise the dormant embryo, a food store, and a tough protective seed coat, or testa. The embryo now consists of an embryonic shoot (plumule) and root (radicle), and either one or two seed leaves (cotyledons). The food store is contained either in the endosperm tissue, or in the cotyledons of the embryo. The number of cotyledons present in a seed is an important character in the classification of angiosperms: monocotyledons (such as grasses and corn) have a single cotyledon, whereas dicotyledons (the majority of plant species) have two.
The seed is the culmination of a phase of plant development which starts with fertilization and finishes with desiccation. In the desiccated state, the seed is able to withstand a variety of environmental stresses without undue damage and this makes the seed an ideal unit of dispersal.

**MONOCOTS**

There are approximately 59,300 species within the monocot group. In agriculture the majority of product comes from monocots. The true grasses are the most economically import family. These include all true grains (rice, wheat, maize, etc.), the pasture grasses, sugar cane and the bamboos. Another important monocot family is the onion family (*Amaryllidaceae*).

One of the most noticeable traits is that a monocot's flower is trimerous, with the flower parts in threes or in multiples of three. A monocotyledon's flower typically has three, six, or nine petals. Most monocots also have leaves with parallel veins.

**DICOTS**

There are approximately 199,350 species within the dicotyledon group. Around 300 families of flowering plants are currently identified as Dicots. Most of the fruits, vegetables, spices, roots and tubers which constitutes a very important part of our daily diet, are classified as dicots.
In addition, all legumes, beverages such as coffee and cocoa, and a great variety of flowers, oil seeds, fibers, and woody plants belong to the dicot group.

The most prominent herb and shrub family is the Asteraceae. All have compound flower heads. While it appears to be a single flower, closer examination reveals that the head is composed of many separate flowers; tiny five-petal disk flowers’ in the center and/or single petalled ray flowers’ around the outside. Dandelions have only ray flowers, thistles and coyote brush have only disk flowers, sunflowers and daisies have both. Also included in the dicots are the pea family.
Fruits versus Seeds

Sometimes what we think of as a seed during seed analysis is actually the fruit. A good example is sunflower. Fruits are categorized as to whether they are dry or fleshy and whether or not dehisce (split open) at maturity.

Dry, indehiscent fruits

Achene--one seed which is free of the pericarp (fruit wall); e.g. sunflower (*Asteraceae*)

Samara--an achene with a wing for wind dispersal; e.g. maple (*Sapindaceae*)

Carvopsis or Grain--one seed which has the seed coat fused to the pericarp; e.g. grasses (*Poaceae*)

Nut--one seeded by abortion (only one ovule matures), usually hard-shelled; e.g. oak acorn (*Fagaceae*). A small nut is a nutlet; e.g. stickseed (*Boraginaceae*)

Dry, dehiscent fruits

Follicle--from one simple pistil, dehisces along one suture; e.g. milkweed (*Apocynaceae*)

Legume--from a simple pistil, dehisces along two sutures; e.g. pea (*Fabaceae*)

Capsule--usually from a compound pistil, usually many-seeded. Capsules show various means of dehiscence; e.g. lily (*Lilaceae*)

Silique or silicle--special capsule with two halves which fall away from a central false septum (replum) to which the seeds are attached. Found in *Brassicaceae*. Siliques are long and thin; silicles are short and fat.

Schizocarp--from a compound pistil, splits into mericarps (pieces) which enclose one or more seeds and resemble fruits themselves; e.g. mallow (*Malvaceae*) or carrot (*Apiaceae*)

Fleshy fruits

Drupe--from a simple pistil, one seed within a stony endocarp; e.g. plum or cherry (*Rosaceae*)

Berry--from a compound pistil, few too many seeds; e.g. nightshade (*Solanaceae*)

Pepo--a berry with a hard, leathery rind, usually applied to fruits in the squash family (*Cucurbitaceae*)

Hesperidium--a berry with an aromatic leathery rind; inside divided into segments; e.g. a citrus fruit (*Rutaceae*)
Hip--mature hypanthium containing achenes derived from multiple simple pistils; e.g. a rose fruit (*Rosaceae*)

Pome--from an inferior ovary with the hypanthium/receptacle tissue swollen and juicy; e.g. an apple (*Rosaceae*)

**Other types of fruits.**

**Aggregate**--fruit composed of mature ovaries from separate pistils of ONE flower; e.g. raspberry (*Rosaceae*)

**Multiple**--fruit composed of mature ovaries from separate pistils from SEVERAL flowers; e.g. mulberry or fig (*Moraceae*)

**Accessory**--fruit where the "fruit" part is derived from something other than ovary tissue; e.g. strawberry (*Rosaceae*) where the small achenes are borne on the surface of a swollen, edible receptacle.

**Conditions Necessary for Germination**

A seed can germinate only if the following conditions are present:

1. Presence of water, Water is an essential factor to trigger the process of seed germination.
2. Presence of oxygen
3. Presence of adequate temperature. Not all seeds prefer the same temperature.
4. Presence of light – Depending upon the seed type, light may be a requirement for germination.

Other factors:

**Soil:** During growth, seeds require mineral elements for further growth which is obtained from the soil.

**Viability of the seeds:** After the seeds are formed, they remain viable up to certain period which may vary from plant to plant or seed to seed. Many seeds die or incapable of supporting growth after a certain period of time.

**Dormancy period:** Many seeds do not germinate abruptly after they are produced. Certain seeds undergo a resting time through which they stay dormant and germinate when conditions are favorable. Presence of growth inhibitors like abscisic acid induce dormancy in seeds.

**Thinness or thickness of seed coat:** Different seeds have varying degrees of thickness to enable the seeds to remain feasible. Seeds with a thin seed coat tend to germinate faster than those with thicker seed coats.
**Steps of Germination**

1. **Imbibition (water uptake)**  
The initial step in the development of seed germination is to absorb water or imbibition. The seed absorbs water and as a result it swells. The swelling of seed causes the seed coat to rupture and allows the radicles to move downward forming the root.

2. **Metabolic processes resume (enzyme processes and respiration).** When the seed absorbs water, it also respires. While in the beginning the respiration is anaerobic and later it becomes aerobic.

3. **Increase in Size**

4. **Growth of embryo with radicle first.** The first thing to come out is the main root. The skin or seed coat starts to split and the tiny shoot straightens, carrying the cotyledons with it. This is called radicle or the main root which grows bigger. Root hairs appear as the growth takes place. Gradually, first leaves called plumule starts growing which forms the shoot in initial stages.

5. **Mobilization of reserves (function of reserves is to sustain the seedling until it is firmly established.)** The cotyledons store food inside the seed and provides nutrients till the seed coat ruptures and the seedling is capable enough of drawing nutrients from the soil and the surroundings.
Corn

Pumpkin

Cilantro

Seed Germination
The part of the plant that first emerges from the seed is the embryonic root, termed the radicle or primary root. It allows the seedling to become anchored in the ground and start absorbing water. After the root absorbs water, an embryonic shoot emerges from the seed. This shoot comprises three main parts: the cotyledons (seed leaves), the section of shoot below the cotyledons (hypocotyl), and the section of shoot above the cotyledons (epicotyl). The way the shoot emerges differs among plant groups.

**Epigeal**

In epigeal germination, the hypocotyl elongates and forms a hook, pulling rather than pushing the cotyledons and apical meristem through the soil. Once it reaches the surface, it straightens and pulls the cotyledons and shoot tip of the growing seedlings into the air. Beans, tamarind, and papaya are examples of plants that germinate this way.

**Hypogeal**
Germination can also be done by hypogeal germination, where the epicotyl elongates and forms the hook. In this type of germination, the cotyledons stay underground where they eventually decompose. Peas and mango, for example, germinate this way.

**Monocot Germination**

In monocot seeds, the embryo's radicle and cotyledon are covered by a coleorhiza and coleoptile, respectively. The coleorhiza is the first part to grow out of the seed, followed by the radicle. The coleoptile is then pushed up through the ground until it reaches the surface. There, it stops elongating and the first leaves emerge.
Germination of a Monocot

Allium cepa
(onion)

(c) Pea
Inflorescence Structures

Inflorescence – a flower cluster

Spike – sessile flowers attached directly to the rathis. Example barley or wheat

Raceme – flowers on sort pedicels on a single floral axis. Example alfalfa or soybean

Panicle – loosely arranged flowers on a branched inflorescence. Example oats

Head – has sessile flowers on a common receptacle. Example sunflower

Umbel – has flowers on pedicels originating from one point. Example onion
Vernation
The arrangement of a leaf or leaves in the bud shoot. In general they may be classified as rolled or folded. (Example: New shoots of Kentucky bluegrass are folded. New shoots of Quack grass are rolled.)

Ligule
The structure which clasps the stem at the junction of blade and sheath. The type (membranous or hairy) and shape (tall, short, jagged, etc.) remaining fairly uniform and constant within each given species.

Collar
The area on the outer side of the leaf where the blade and the sheath join. It is generally much lighter in color and varies in size and shape from species to species.

Auricles
Appendages that project from either side of the collar. They may be slender, claw-like, long or short. In Quack grass slender auricles clasp the stem.

Sheath
The tubular portion of the leaf which wraps around or encloses the stem. Edges of the sheath may join, overlap or be closed. They are also rough or smooth, cylindrical, flattened or compressed.

Blade
The upper portion of the leaf, which is divided from the sheath by the collar and the ligule. The length, width, type of tip, roughness or smoothness are a few characteristics of various species.

Rhizomes
An underground stem that produces a new plant. Rhizomes are present or absent, strong or weak.

Stolons
A horizontal, above ground stem that takes root at various intervals and gives rise to new plants.

Seed head
The collection of flowering or seeding parts which are arranged in various ways, (spike, panicle, etc.). A very important identifying feature.

Spikelet
The unit of the seed head which composes the seeding parts. Properly dissected and analyzed, it provides the most accurate method for the identification of various species.
The Types of Grass Inflorescence

The inflorescence of grasses can be divided into 2 groups:

1. Spike – the floral parts are attached directly (sessile) to the central axis (rachis). Example Wheat Head

2. Panicle – the floral parts are suspended from the central axis (rachis) by branches (rachis, branches or pedicel). Example Oat head.

The grass flower is composed of the stamen and the pistil.

The stamen (male) is composed of the anther which contains the pollen and the filament which is a slender stalk supporting the anther.

The pistil (female) is composed of the stigma which is a feathery extension of the ovary wall and traps the pollen grains, the style which connects the stigma to the ovary and the ovary which contains the ovule.

Each grass flower has three stamens and one simple pistil.

The accessory parts of the grass inflorescence include the following structures:

Awn, flag leaf, floret (including both sterile ad fertile flowers), glumes, lemma, lodicules, palea, pedicel, peduncle, rachilla, rachis, rachis branch and spikelet.
Floret bases showing sinus and rachilla segments (left) and bulge (right)
Flower: Small, consisting of an ovary with 2 plumose stigmas, 3 stamens, and no petals.

Floret: Flower plus 2 modified leaves (bracts), lemma and palea, that enclose the flower.

Spikelet: A pair of glumes (bracts) plus 1 or more florets.
DEFINITIONS

1. Applied or Economic Botany – applied in a practical way to scientific agriculture

2. Systematic Botany (Taxonomy) – identification & classification

3. Plant Morphology – structure of plants

4. Histology – details of internal structures
   a) Plant Anatomy – phase of morphology minute structures tissues
   b) Cytology – study of living material, protoplasm, responsible for growth & formation

5. Plant Physiology – chemical and physical growth, behavior

6. Annual – grow from seed and form seed in a single year then dies

7. Winter Annual – matures and drop their seeds in early summer

8. Biennial – requires 2 years from seed planting to seed production then dies

9. Perennial – live for many years forming seeds each year after reaching maturity

10. Tropisms – the turning or other reaction of a plant or of its parts in response to some external stimulus

11. Geotropism – a root that is pulled downward by gravity

12. Phototropism – the aerial portion of a plant in response to light

13. Negative geotropism – a root that goes upward and against gravity

14. Achene – a dry hard, one chambered, one seeded indehiscent fruit, as in buckwheat and spinach

15. Caryopsis – a single-seeded fruit or grain of the grass family; the fruit wall (pericarp) is united with the seed coat (testa)

16. Capsule – a dry fruit of two or more carpels, usually dehiscent by valves. (carpel – female portion of the flower/a portion of the ovary)

17. Cypsela – an achene with an adnate perianth, as in Asteraceae (adnate – organic fusion of unlike parts.

18. Floret – an individual flower of an inflorescence or spikelet.

19. Follicle – a many seeded dry-fruit, derived from a single carpel, and splitting longitudinally down one side. Example common milkweed.

20. Schizocarp – a dry indehiscent fruit that splits apart into one-seeded carpels or parts; a fruit that splits up at maturity into two equal halves (mericarps) containing one seed each as in the carrot family.
21. Silique – a dry elongated fruit divided by a partition (septum) between the two carpels into two sections as in *Brassicaceae*. Example Canola

22. Spike – an elongated inflorescence with sessile or nearly sessile flowers.

23. Reticulations – netting found on the seed coats. Example *Brassica juncea*

24. Raphe – the ridge running between the hilum and micropyle. Example clovers

25. Sinus – the depression or notch at the base of a grass seed

26. Brush – hairs on the end of seed. Example wheat kernel

27. Scutellum – a shield shaped cotyledonary structure in the embryo of the grasses which serves to absorb nutrients from the endosperm. Example wheat kernel

28. Pappus – the umbrella or feather-like extension on the seed coat of asteraceae achenes that allows for wind dispersal. Example dandelion


30. Caruncle – an outgrowth near the micropyle and hilium of the seed.

31. Endosperm – food storage material in a caryopsis that develops as a result of double fertilization.

32. Nerve - the vein up the dorsal side of a grass seed; veined conspicuous vascular bundles.

33. Seed – a mature (ripened) ovule, consisting of an embryo, with or without endosperm, and a surrounding protective coat.

34. Angiosperm – a flowering plant, produces seeds enclosed in an ovary.

35. Basal – borne at or near the base.

36. Apex – the top or tip of an organ or plant, the growing point.

37. Awn – an extension of the mid-rib of a glume or lemma.

38. Funiculus – the small stalk connecting an ovule to the placenta in an ovary.

39. Flower – the reproductive structure of angiosperms, often consisting of sepals, petals, stamens and a pistil.

40. Integuments – tissues covering or surrounding the ovule which develop into the testa or seed coat of the mature ovule.

41. Chalaza – the point at which the nucellus (the body containing the embryo sac in the developing seed attaches to the integuments. It can be seen on some seeds. Example clovers

42. Hilium – the scar that marks the point of detachment of the seed from the seed stalk (funiculus)
43. Seed Taxonomy – the study or science of seed identification and classification.

44. Perianth – collection term for the calyx and corolla of a flower. Example papery tissues on seed coat of buckwheat.

Longitudinal section of the embryo from a mature grain, with the apex and leaves of the shoot present and a tiller bud visible.
Binomial System of Nomenclature

Binomial system was invented in 17th century and was first used by Linnaeus (1707-1778), a Swedish taxonomist. It is the international language of science. As common names may and do change from region to region from country to country, the botanical names do not. There may be synonymous names as more is learned about a plant species.

*Zea mays* L.

The genus is capitalized always; the species is not-capitalized; neither is the subspecies if there is one. The genus, species and subspecies is italicized. The authority (initial or abbreviations of person who names the species) is not italicized though it can be capitalized). The abbreviations of var. and subsp. are not italicized.