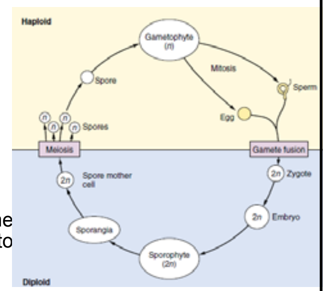
The following list summarizes the major plant adaptations for survival on land.

1. Except for the primitive division Bryophyta (mosses), the dominant generation of all plants is the diploid sporophyte generation.

A diploid structure is more adapt to survive genetic damage because two copies of each chromosome allow recessive mutations to be masked.



A generalized plant life cycle. Anything yellow is haploid and anything blue is diploid. Note that both haploid and diploid individuals can be multicellular. Also, spores are produced by meiosis while gametes are produced by mitosis.

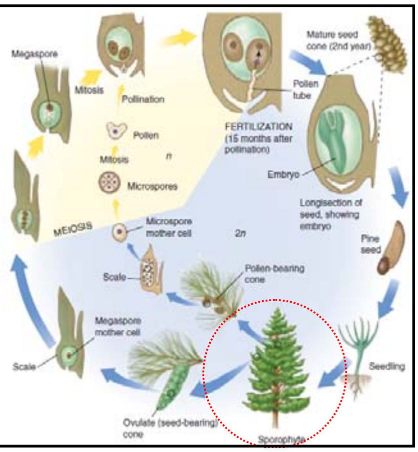
Kingdom Plantae

In order to survive the transition from water to land, it was necessary for plants to make adaptations for obtaining water and to prevent its loss by desiccation (drying out).

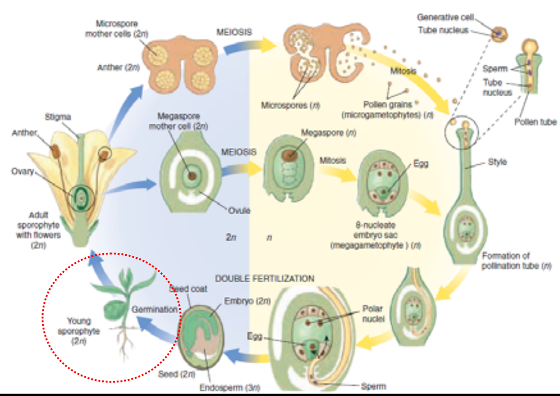
Water was also required to provide a medium for the fertilization of eggs by flagellated sperm.

In addition, once plants emerged from the protective cover of water, genetic material was more susceptible to damage by ultraviolet radiation.

Life cycle of a typical pine. The male and female gametophytes have been dramatically reduced in size. Wind generally disperses sperm that is within the male gametophyte (pollen). Pollen tube growth delivers the sperm to the egg on the female cone. Additional protection for the embryo is provided by the ovule which develops into the seed coat.



Life cycle of a typical angiosperm.



2. All plants possess a **cuticle,** a waxy covering on aerial parts that reduces desiccation.

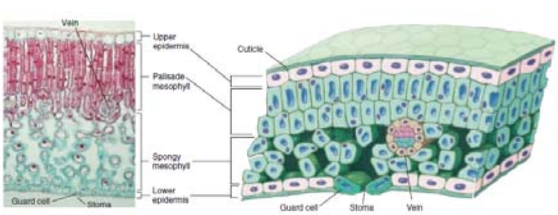
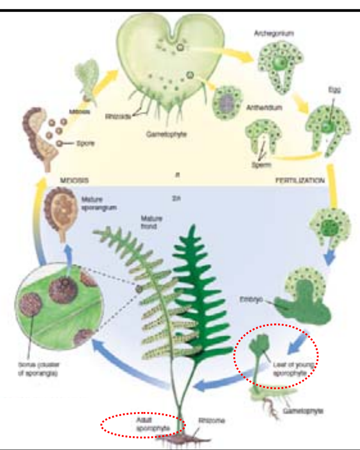


FIGURE 38.34
A leaf in cross-section. Transection of a leaf showing the arrangement of palisade and spongy mesophyll, a vascular bundle or vein, and the epidermis with paired guard cells flanking the stoma.

Life cycle of a typical fern. Both the gametophyte and sporophyte are photosynthetic and can live independently.
Water is necessary for fertilization. The gametes are released on the underside of the gametophyte and swim in moist soil to neighboring gametophytes.
Spores are dispersed by wind.



4. In the more primitive plant divisions, flagellated sperm require water to swim to the eggs.

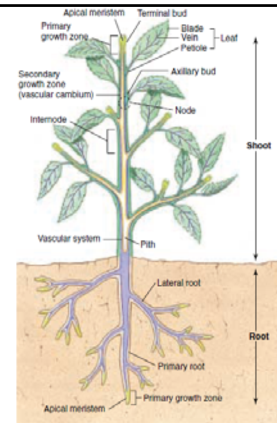
In the more advanced divisions (Coniferophyta and Anthophyta), the sperm, packaged as pollen, are adapted for delivery by wind or animals.

5. In the most advanced division, the Anthophyta (Flowering plants or angiosperms), the gametophytes are enclosed (and thus protected) inside an **ovary**.

3. The development of a vascular system in plants further reduced their dependency on water.
Without a vascular system, all cells must be reasonably close to water. A vascular system reduced this dependency by providing a system for water to be distributed throughout the plant.

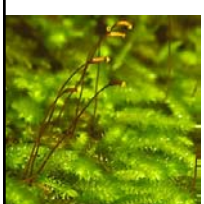
Once cells were relieved of their dependency upon water, tissues specialized for specific tasks evolved. True leaves developed as centers for photosynthesis, true stems developed to provide a framework to support leaves, and true roots developed to obtain water and anchor the plant.

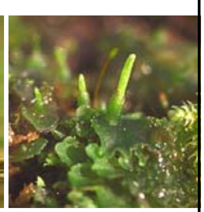
Two groups of vascular tissues evolved, **xylem** and **phloem.**
Xylem is specialized for water transport, and phloem is specialized for sugar transport.



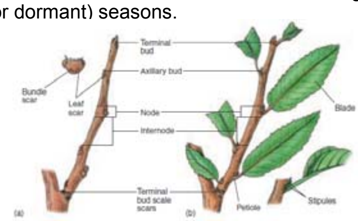
A list of the major plant divisions follows. Of particular importance is how each division shows an increasingly greater adaptation to survival on land.

1. **Bryophyta** are the
   mosses, الحزازيات
   liverworts حشيشة الكبد , and
   hornworts الحشيشة القرنية .





6. Plants of the Coniferophyta and Anthophyta have developed adaptations to seasonal variations in the availability of water and light. For example, some trees are **deciduous;** that is, they shed their leaves to minimize water loss during slow-growing (or dormant) seasons.

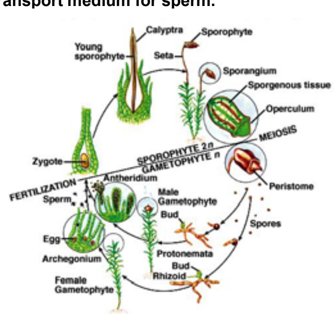


***(a)* In winter. *(b)* In summer**

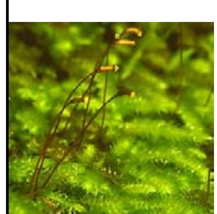
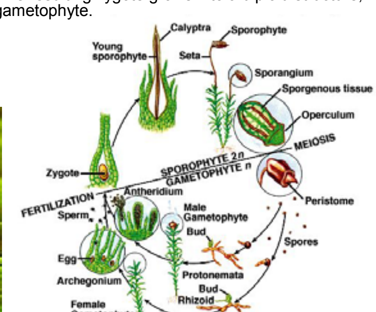
In contrast, desert annuals will germinate, grow, flower, and produce seeds within brief growing periods in response to a spring rain.

In mosses, this structure is a stalk bearing a capsule which contains haploid spores produced by meiosis.

The spores are dispersed by wind, germinate, and grow into haploid gametophytes. Since bryophytes lack the specialized vascular tissues xylem and phloem, they do not have true roots, true stems, or true leaves. Thus, bryophytes must remain small, and water must be readily available for absorption through surface tissues and as a transport medium for sperm.

Gametes are produced in protective structures called **gametangia** on the surface of the gametophytes, the dominant haploid stage of the life cycle of bryophytes. The male gametangium, or **antheridium** (plural, **antheridia**), produces flagellated sperm that swim through water to fertilize the eggs produced by the female gametangium, or **archegonium** (plural, **archegonia**). The resulting zygote grows into a diploid structure, still connected to the gametophyte.

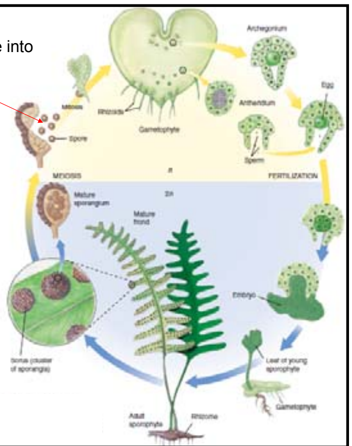



all produce spores that germinate into small gametophytes.

Like the bryophytes, the gametophytes produce antheridia and archegonia, which produce sperm and eggs, respectively.

The flagellated sperm swim to the archegonia to fertilize the eggs. Successful fertilization produces a diploid zygote which grows into the sporophyte.

Unlike the bryophytes, however, the sporophyte is the dominant generation.

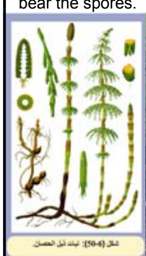


The following divisions of plants are informally categorized as **tracheophytes,** or **vascular plants,** because they possess xylem and phloem. As a result, they have true roots, true stems, and true leaves.

The **Lycophyta**,
Sphenophyta, and
Pterophyta

3. Sphenophyta النباتات المفصلية include extinct woody trees common during the Carboniferous period and extant herbaceous plants called **horsetails.** Horsetails have hollow, ribbed مضلع stems that are jointed at **nodes.** The nodes occur at intervals along the stem and produce small, scalelike leaves and, in some species, branches. The bushy كث branches give the appearance of a horsetail.

The stems, branches, and leaves are green and photosynthetic and have a rough texture due to the presence of silica (silicon dioxide, SiO_2). Strobili مخروط bear the spores.



Horsetails (Equisetum telmateia ssp. braunii)

2. Lycophyta الحزازيات الصولجانية أو السنبلية include two groups of plants. One group, now extinct, consisted of woody trees that were dominant in the forests of the Carboniferous period, about 300 million years ago.

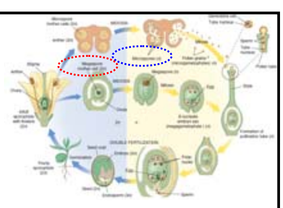
The second, extant, group consists of tropical **epiphytes,** plants that live on other plants, and small herbaceous plants. Many of the herbaceous plants are called club mosses because of their club-shaped هراوة , spore-bearing cones, or **strobili مخاريط.**

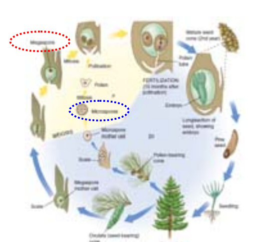
An ornamental *Lycopodium*

The next two plant divisions (Anthophyta and Coniferophyta النباتات المخروطية) produce seeds.

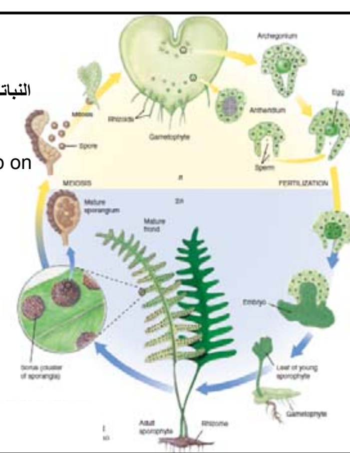
In addition, two kinds of spores are produced, male spores and female spores.

Structures relating to the production of these spores are prefixed with "micro" and "macro," respectively. Thus, the **microsporangia** produce the **microspores** (male spores), and the **macrosporangia** produce the **macrospores** (female spores).

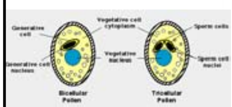


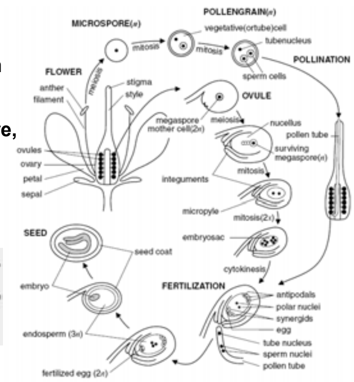


4. Pterophyta النباتات السرخسية are the ferns. Clusters of sporangia called **sori** (singular, **sorus**) develop on the undersurface of fern fronds. The sporangia undergo meiosis and produce the spores.



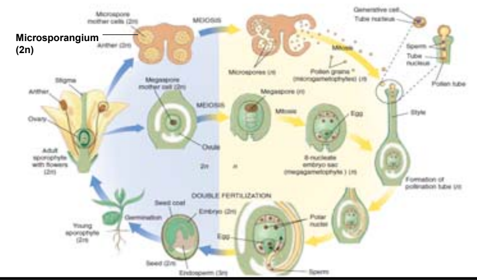
The pollen grain further divides into three cells (in flowering plants) or four cells (in conifers). One of these cells is a **vegetative,** or **tube,** cell that controls the growth of the pollen tube. Other cells become the sperm cells.



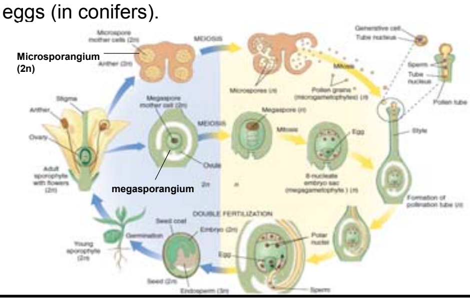


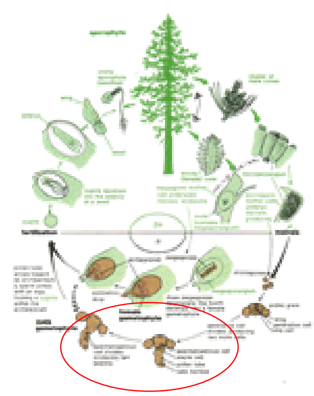
A summary of reproduction in seed plants follows:

- The microsporangium produces numerous **microspore mother cells,** which divide by meiosis to produce four haploid cells, the **microspores**. The microspores mature into **pollen grains.**



- The megasporangium, called the **nucellus** النيوسـيلة **,** produces a **megaspore mother cell,** which divides by meiosis to produce four haploid cells. One of these cells survives to become the megaspore and represents the female gametophyte generation. The megaspore divides by mitosis to produce one egg (in flowering plants) or two eggs (in conifers).

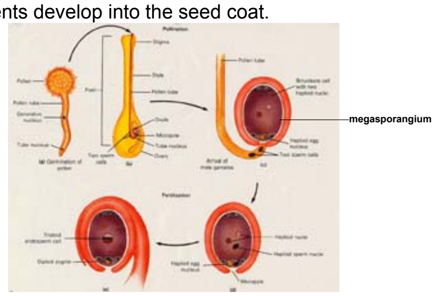




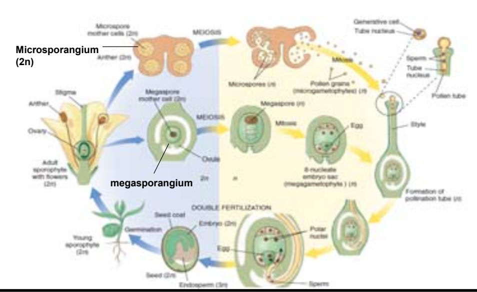
The pollen grain divides into four cells (in conifers).

•When a pollen grain contacts the megasporangium, the tube cell directs the growth of a **pollen tube** through the micropyle and toward the egg. After fertilization by the sperm cells, the zygote divides to form an embryo, the beginning of the sporophyte generation.

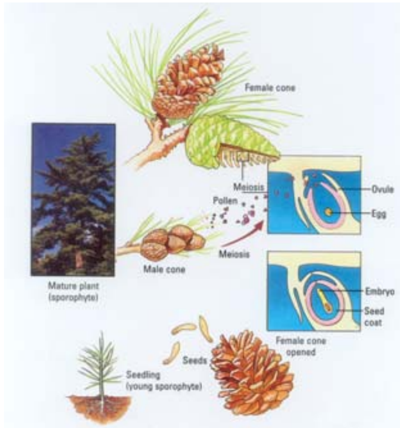
The integuments develop into the seed coat.



- Other accessory cells, in addition to the eggs, may also be produced. One to two tissue layers called **integuments** غلاف surround the megasporangium. The integuments, nucellus, and megaspore daughter cells are collectively called the **ovule** البويضـة. An opening through the integuments for pollen access to the egg is called the **micropyle** النقـير **.**



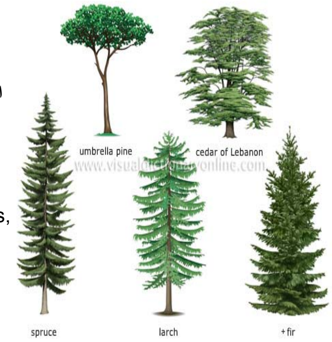
The male and female reproductive structures are borne in pollen bearing male cones and ovule bearing female cones.



There are two groups of seed plants, as follows:

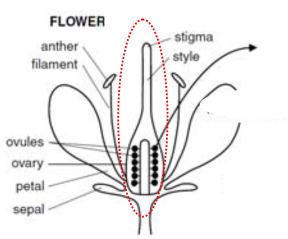
5. Coniferophyta المخروطيات are the familiar conifers (literally, "cone-bearing").

They include pines الصنوبر , firs تنوب , spruces التنوبيات , junipers سرو جبلي , redwoods, cedarsأرز, and others.

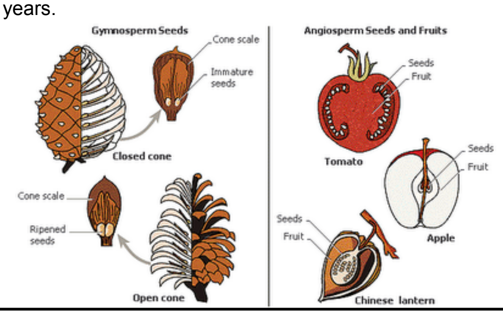


6. Anthophyta, or **angiosperms,** consist of the flowering plants. Major parts of the flower (Figure 9-1) are as follows:

- The **carpel** كربلة (or **pistil** المدقة) is the female reproductive structure and consists of three parts: an egg-bearing **ovary** مبيض **, a style** قلم **, and a stigma** ميسم **.**
- The **stamen** السداة is the male reproductive structure and consists of a pollen-bearing **anther** المتك and its stalk, the **filament** خيط **.**
- **Petals,** and sometimes **sepals,** function to attract pollinators.

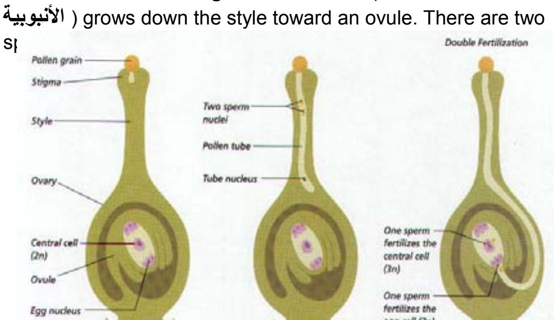


The conifers, together with several other minor divisions (not discussed here), make up a group informally called the **gymnosperms** معراة البذور **.** The term gymnosperms (literally, "nakedseeds") refers to seeds produced in unprotected megaspores near the surface of the reproductive structure. Fertilization and seed development is lengthy, requiring one to three years.



Details of fertilization typical in many angiosperms are as follows (Figure 9-1):

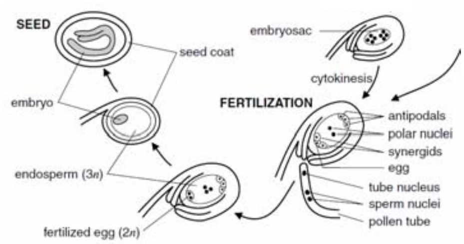
- Pollen lands on the sticky stigma. A pollen tube, an elongating cell that contains the **vegetative nucleus** (or **tube nucleus** **النواة الأنبوبية**) grows down the style toward an ovule. There are two s



The flower is a major evolutionary advancement for the following reasons:

- The flower is a special adaptation to attract **pollinators,** such as insects and birds.
- The ovules are protected inside an **ovary.**
- The ovary develops into a **fruit** which fosters the dispersal of seeds by wind, insects, birds, mammals, and other animals.

• When the pollen tube enters the embryo sac through the micropyle, one sperm cell fertilizes the egg, forming a diploid zygote. The nucleus of the second sperm cell fuses with both polar nuclei, forming a triploid nucleus. The triploid nucleus divides by mitosis to produce the **endosperm,** which provides nourishment for subsequent development of the embryo and seedling. The fertilization of the egg and the polar nuclei each by a separate sperm nucleus is called **double fertilization.**



• Ovules within the ovary consist of a megaspore mother cell surrounded by the nucellus and integuments.

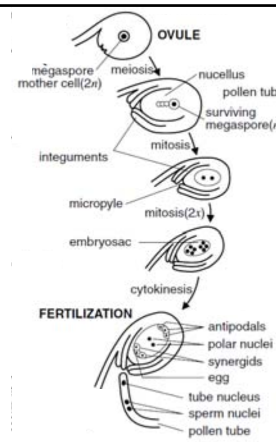
The megaspore mother cell divides by meiosis to produce four haploid cells, the megaspores.

One surviving megaspore divides (three times) by mitosis to produce eight nuclei. Six of the nuclei undergo cytokinesis and form plasma membranes. The result is an **embryo sac.**

At the micropyle end of the embryo sac are three cells, an **egg** cell and two **synergids** الخليتين المساعدتين .

At the end opposite the micropyle are three **antipodal cells** الخلايا السمتية .

In the middle are two haploid nuclei, the **polar nuclei** النواتين القطبيتين .



The characteristics of the divisions of the plant kingdom are summarized in Table 9 1

Additional detail with respect to plant structure, transport, reproduction, and development is given in the section on plants.

Table 9-1

Division	*Common Name*	*Dominant Generation*	*Fluid Transport*	*Sperm Transport*	*Dispersal Unit*
Bryophyta	mosses	gametophyte	nonvascular	flagellated sperm	spores
Lycophyta	club mosses	sporophyte	vascular	flagellated sperm	spores
Sphenophyta	horsetails	sporophyte	vascular	flagellated sperm	spores
Pterophyta	ferns	sporophyte	vascular	flagellated sperm	spores
Coniferophyta	conifers	sporophyte	vascular	wind-dispersed pollen	seeds
Anthophyta	flowering plants	sporophyte	vascular	wind- or animal-dispersed pollen	seeds

Other evolutionary advancements among the angiosperms, including more specialized vascular tissues and numerous variations in habit and growth, developed to advance survival in a variety of environmental conditions.