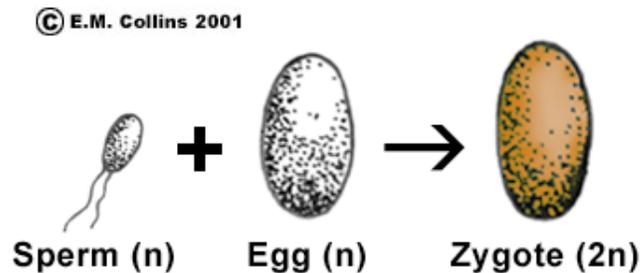


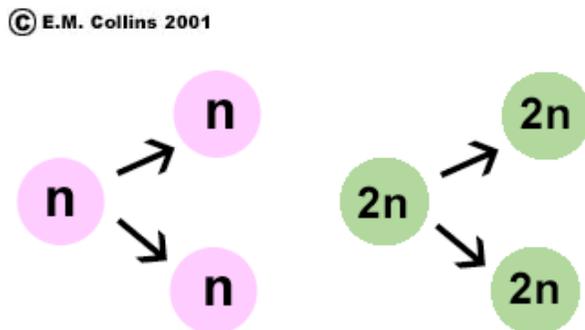
Life Cycle Patterns

We'll take a look at the basics of life cycles. We will NOT focus on gametic life cycles as these are primarily for animals (Bio 1B with John!). We'll look at Fungus (**zygotic** life cycle), Algae, Moss, Fern, Flowering Plant (including asexual) (**sporic** life cycles)

1. First some basics: Fertilization, Mitosis and Meiosis

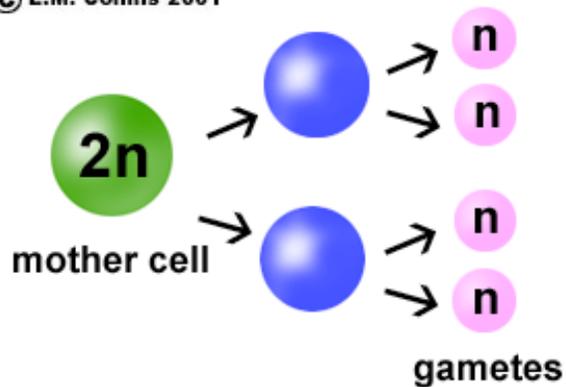


Fertilization (syngamy) is the fusion of two haploid gametes (the sperm and the egg) to form a diploid ($2n$) zygote. This is how the chromosome number in a life cycle changes from haploid (n) to diploid ($2n$). The biflagellate sperm in the above illustration is characteristic of a moss. Human sperm have a single flagellum.



Mitosis is the division of a haploid (n) or diploid ($2n$) cell into two duplicate daughter cells. In a strict definition, mitosis (karyokinesis) refers to the division of a nucleus into two duplicate nuclei, each with identical sets of chromosomes. Cytoplasmic division or cytokinesis involves a cleavage furrow in animal cells and a cell plate in plant cells. An example of cell division in haploid cells is the male honey bee (drone bee) which develops from a haploid unfertilized egg.

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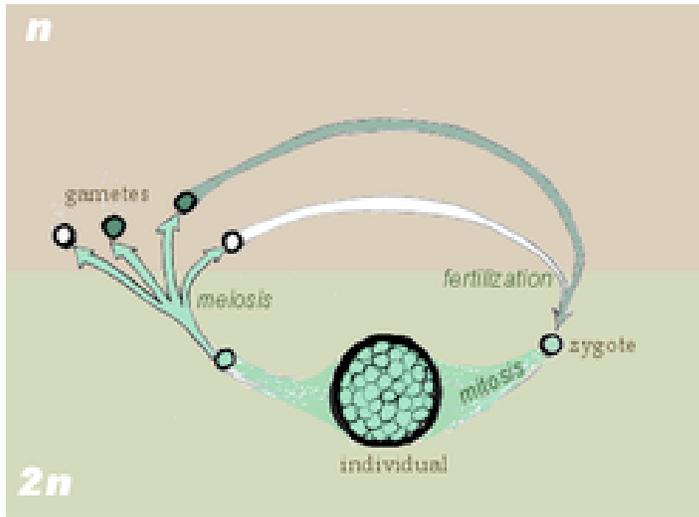


Meiosis is a special kind of cell division in which the chromosome number is reduced in half. This is how the chromosome number in a life cycle changes from diploid ($2n$) to haploid (n). In humans, the only cells that undergo meiosis are egg mother cells (oöcytes) in the ovaries and sperm mother cells (spermatocytes) in the testes. Egg formation and sperm formation are referred to as oögenesis and spermatogenesis. In flowering plants, meiosis occurs in megaspore mother cells (megasporocytes) within the ovules of ovaries, and in microspore mother cells (microsporocytes) within the anthers of stamens. In the first division (blue cells in above illustration), the homologous chromosome doublets separate from each other so they are no longer in pairs. In the second and final division the chromatids of each doubled chromosome separate from each other forming the haploid gametes. During the first and second divisions of meiosis nondisjunction can occur, as shown in the following illustration.

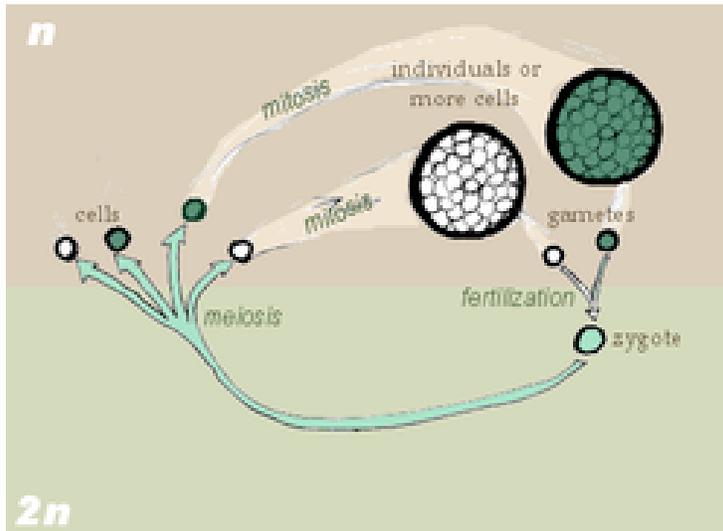
In normal spermatogenesis, X-bearing and Y-bearing sperm are produced. If an X-bearing sperm unites with an X-bearing egg, the resulting zygote is female (XX). If a Y-bearing sperm unites with an X-bearing egg, the resulting zygote is male (XY). Sometimes the X and Y chromosomes do not separate properly during the first division (Anaphase I) or the second division (Anaphase II) during spermatogenesis, a phenomenon known as nondisjunction. Nondisjunction may result in sperm that carry an extra X or an extra Y chromosome, such as XX-bearing sperm, XY-bearing sperm and YY-bearing sperm. If these sperm unite with an X-bearing egg, the result could be XXX (triple-X syndrome), XXY (Klinefelter's syndrome) or XYY (XYY-syndrome). This is also one way that **polyploidy** is achieved in plants – not an uncommon phenomenon.

2. Three major kinds of life cycles: Gametic, zygotic, and sporic

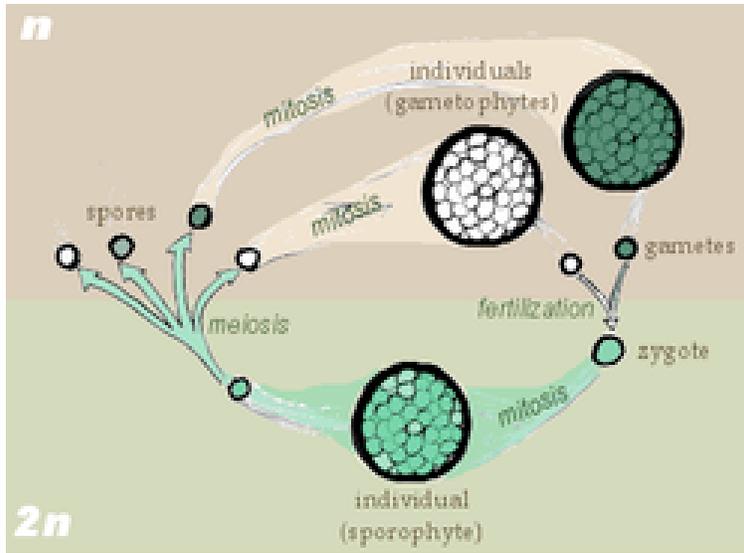
A. Gametic: Animals. Only one multicellular stage: diploid (2n)



B. Zygotic: most Fungi. Often a dominant, multicellular haploid stage (n), transitory diploid stage ($2n$)

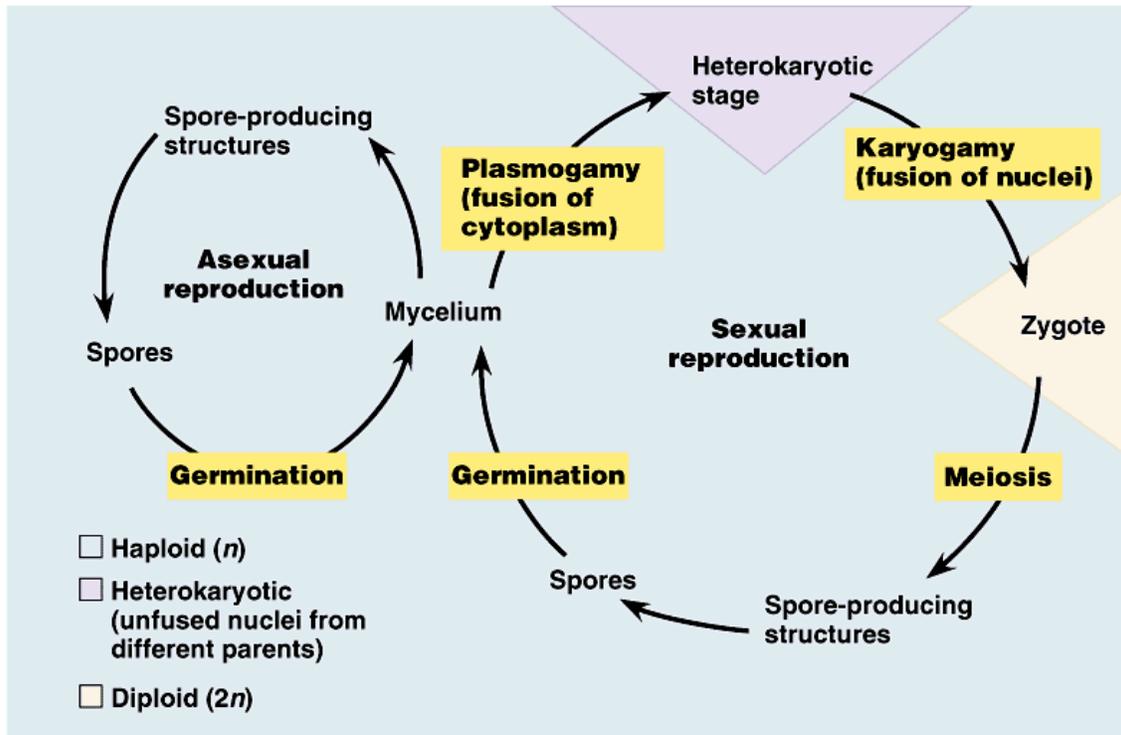


C. Sporic: Alternation of generations: both haploid (n) and diploid ($2n$) are multicellular. Which one is dominant depends on the organism.



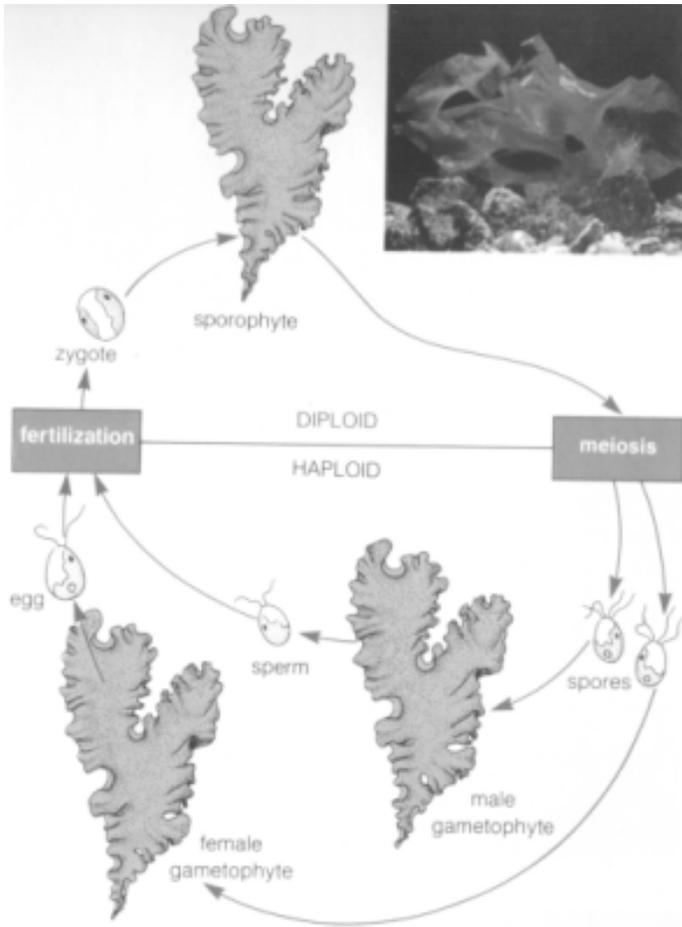
3. Examples of zygotic and sporic life cycles:

A. Zygotic: An example of a generic fungal life cycle (**zygotic**): note the short single celled diploid stage and the more complex multicellular haploid stage. In some shrooms the diploid stage has never been seen!

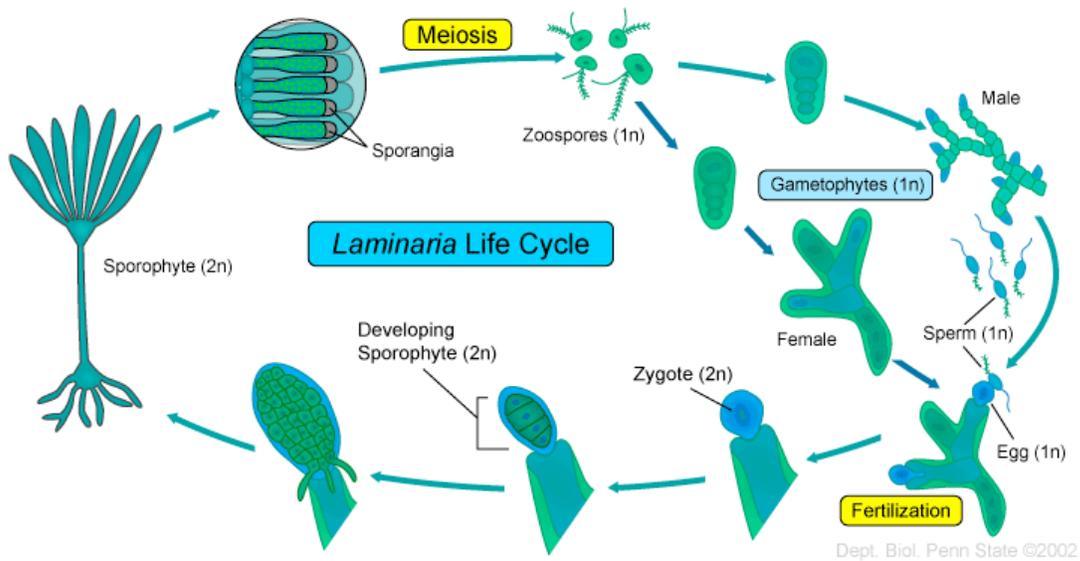


B. Some variations on the **sporic** life cycle, and some we will be studying:

Algae Life cycle (isomorphic alternation of generations):

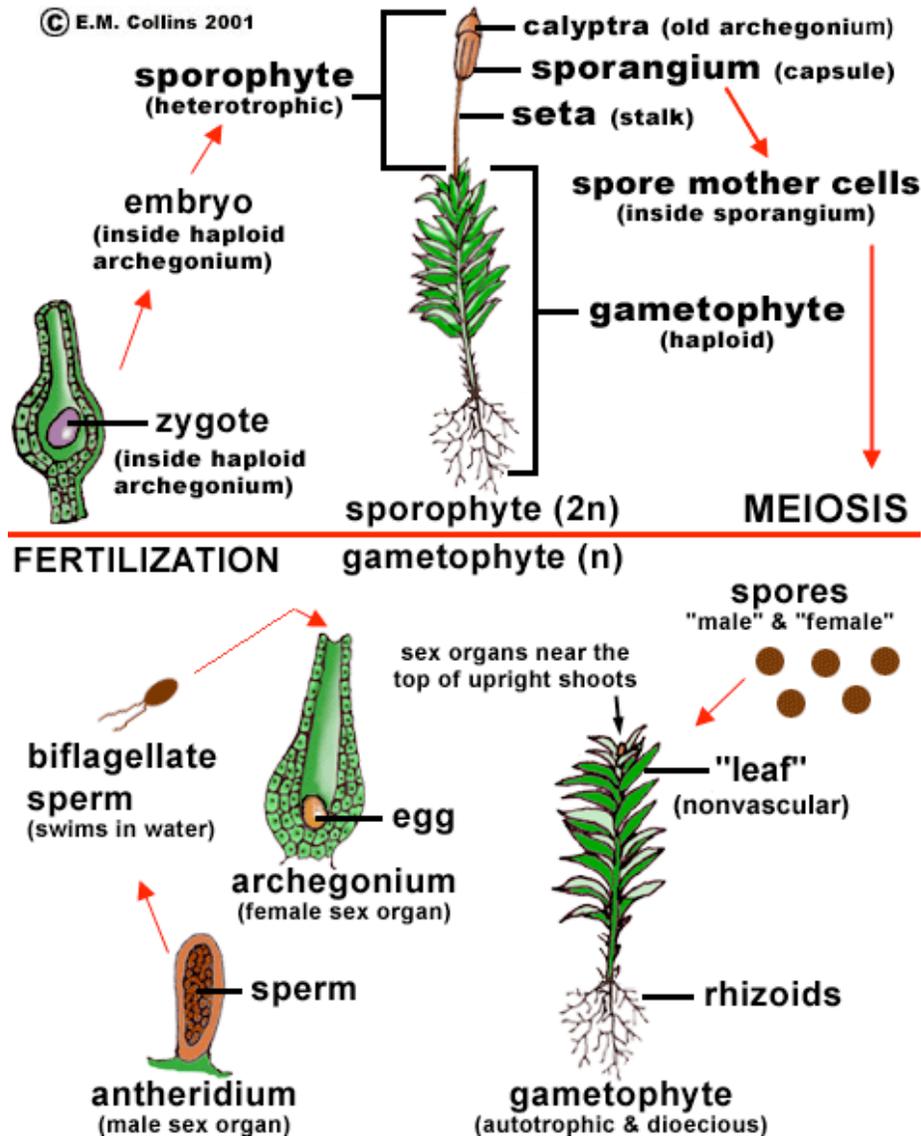


Algal Life cycle: heteromorphic alternation of generations



Note: In The Following Life Cycles, Everything Above The Red Line Is Diploid (2n) And Everything Below The Red Line Is Haploid (n)

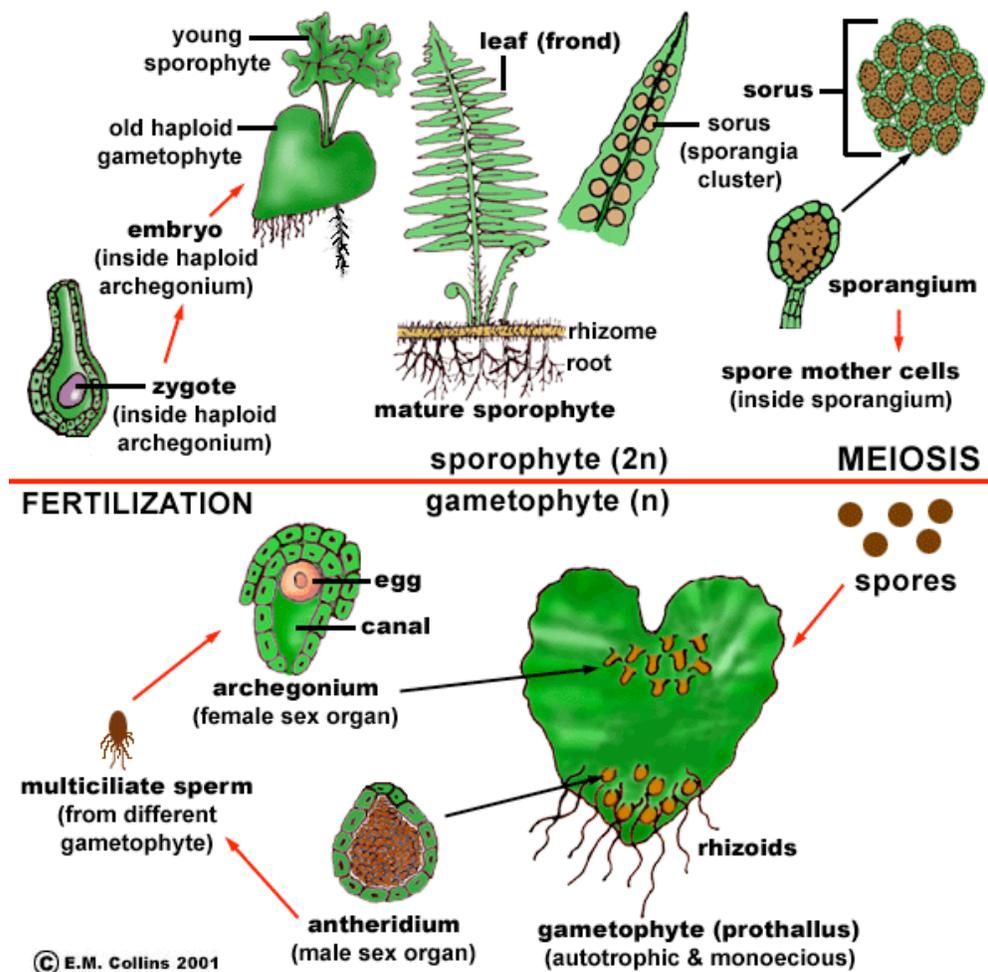
Moss Life Cycle: Dominant gametophyte, dependent sporophyte



Moss Life Cycle. Mosses belong to the Division Bryophyta characterized by nonvascular plants with embryos that develop within multicellular female sex organs called archegonia. The dominant (conspicuous) part of the life cycle is the haploid, leafy gametophyte. The diploid sporophyte consists of a sporangium-bearing stalk that grows directly out of the gametophyte. Spore mother cells within the sporangium undergo meiosis, producing numerous haploid spores that fall to the ground like tiny particles of dust. Since the sporophyte is without chlorophyll, it is completely dependent on the autotrophic (photosynthetic) gametophyte for its water, minerals and carbohydrate nutrition. Consequently, the sporophyte of the moss is heterotrophic and parasitic on the gametophyte. Most moss gametophytes are dioecious, with separate male and female

individuals in the population. The gametophytes are produced by "male" and "female" spores. Mosses have a primitive method of fertilization that involves a motile, biflagellate sperm that swims through water to reach the egg on female plants. Some lichens superficially resemble mosses from a distance, particularly fruticose (branched) lichens growing on the branches and trunks of trees. Lichens are essentially fungi containing symbiotic algal cells. The photosynthetic algae provide carbohydrate nutrition for the fungus, while the fungus provides a protective place for the algal cells to thrive in an otherwise hostile environment. Because the relationship or "marriage" is beneficial to both partners, this particular example of symbiosis is classified as mutualism.

Fern Life Cycle: dominant sporophyte:

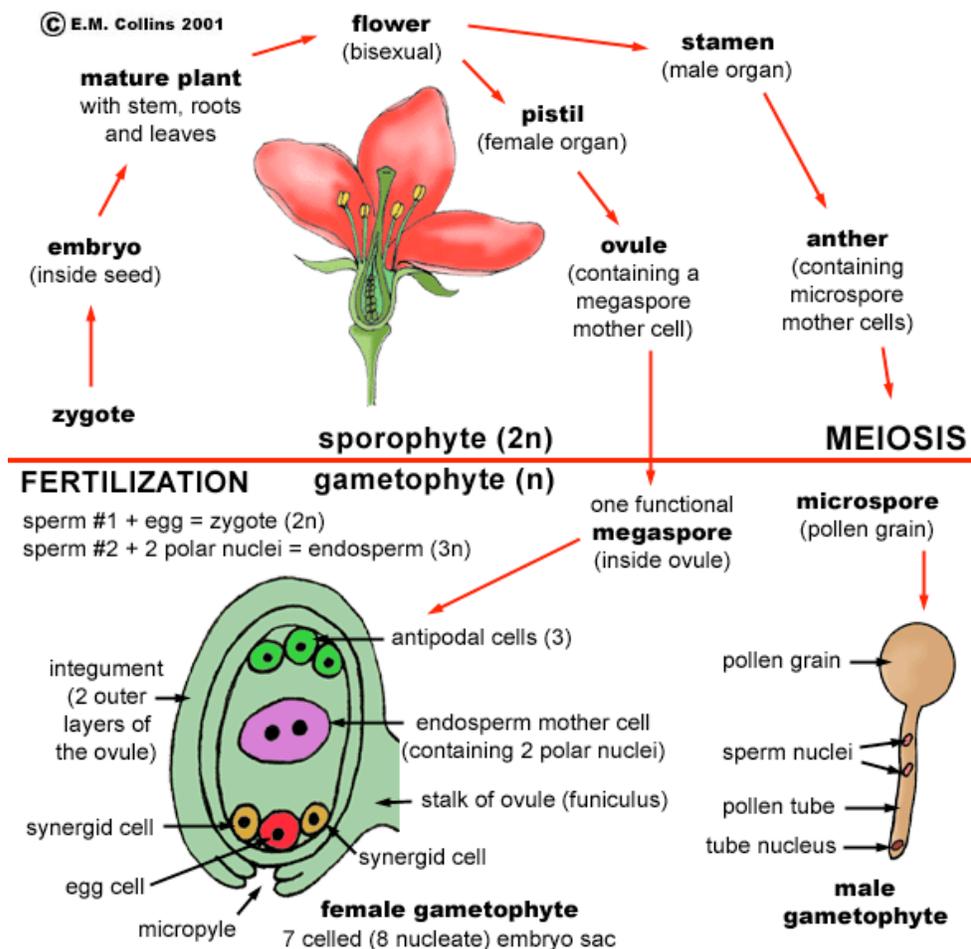


Fern Life Cycle. Ferns belong to the Division Pterophyta characterized by vascular plants with leaves (fronds) arising from subterranean, creeping rhizomes. In tree ferns, the leaves are produced on a definite woody trunk. The dominant (conspicuous) part of the life cycle is the diploid, leaf-bearing sporophyte. On the underside of the leaves are rows of brown sori. Each sorus is composed of a cluster of sporangia, and is often covered by a

thin outer layer called the indusium. Some ferns such as Polypodium and Cyrtomium do not have the indusium. Ferns are classified by the arrangement of the sori and shape of the indusium. The sori and indusium superficially resemble an infestation of scale insects, and some people actually spray their ferns! Spore mother cells within the sporangium undergo meiosis, producing numerous haploid spores. The sporangia split open at maturity, releasing millions of spores that fall to the ground like tiny particles of dust. The splitting open of a sporangium is caused by a thick-walled, outer belt of cells called the annulus. As the cells of the annulus dry out, the annulus contracts and rips open the sporangial wall, thus dispersing the spores.

Each spore germinates and grows into a heart-shaped gametophyte (prothallus) which is smaller than your little finger nail. This haploid gametophyte bears male and female sex organs (antheridia and archegonia). With respect to populations of gametophytes, ferns are typically monoecious with both male and female sex organs on the same gametophytes. Unlike the unisexual gametophytes of a moss, a fern gametophyte is bisexual. Like mosses, ferns have a primitive method of fertilization that involves a multiciliate sperm that swims through water to reach the egg. The gametophytes and sporophytes of ferns are photosynthetic and autotrophic.

Flowering Plant Life Cycle



Flowering Plant Cycle. Flowering plants (angiosperms) belong to the vascular plant division Anthophyta. Like ferns, the diploid sporophyte consists of a herbaceous or woody plant with roots, stems and leaves. Unlike ferns, flowering plants produce reproductive organs called flowers and seed-bearing fruits. The term angiosperm is derived from angio (vessel) and sperm (seed), referring to the seed-bearing vessels (containers) called fruits. Flowers may be unisexual or bisexual, depending on whether they contain only one type of sex organ (the male stamen or female pistil), or whether they contain both stamens and pistil in the same flower. Species with separate male and female flowers on the same plant are termed monoecious, including oaks (*Quercus*), alder (*Alnus*) and walnut (*Juglans*). Species with separate male and female flowers on separate individuals are termed dioecious, including willows (*Salix*), cottonwoods (*Populus*), date palms (*Phoenix*), some figs (*Ficus*) and marijuana (*Cannabis*). The following illustration shows a typical bisexual flower:

The general evolutionary trend is a gradual increase in the diploid sporophyte phase and a decrease in the gametophyte phase. In the moss, the diploid phase consists of a sporangium and stalk that grows out of the haploid female gametophyte. In the fern and flowering plant, the entire leaf-bearing plant is diploid. The haploid gametophyte of a fern is reduced to a small, heart-shaped prothallus. In flowering plants, the haploid gametophyte is greatly reduced and consists of two microscopic structures: A seven-celled, eight-nucleate embryo sac containing the egg and endosperm mother cell, and a pollen grain plus pollen tube containing 3 nuclei, two of which are the sperm which penetrate the embryo sac during fertilization.

Asexual reproduction:

Many species of plants reproduce asexually without gametes. They simply clone themselves by the formation of bulbs, corms, tubers, rhizomes, runners, turions, plantlets and "pups." In the duckweed family (*Lemnaceae*) daughter plants are produced vegetatively in budding pouches. Each "mother plant" produces up to a dozen daughter plants during its lifetime of 1-2 (or more) months. The daughter plants repeat the budding history of their clonal parents, resulting in exponential growth. It has been estimated that the Indian *Wolffia microscopica* may reproduce asexually by budding every 30 hours under optimal growing conditions. At the end of 4 months this would result in about 1 nonillion plants (1 followed by 30 zeros) occupying a total volume roughly equivalent to the planet earth. Some of these methods are discussed under vegetative terminology at the following links: