


## PLANTS III: SEED PLANT REPRODUCTION

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In the first plant lab, you were introduced to the main groups of plants: nonvascular plants, vascular non-seed plants, and vascular seed plants (the gymnosperms and angiosperms). In the second plant lab, you were introduced to some basic anatomical elements of the leaves, stems, and roots of flowering plants. Also included in the second plant lab were some characteristics of monocots and dicots, two main groups of flowering plants. Today's lab will cover reproductive and developmental characteristics of seed plants, with an emphasis on flowering plants.

 **Reading:** Campbell, Ch. 30, Plant Diversity II: The Evolution of Seed Plants.

 **Reading:** Campbell, Ch. 38, Angiosperm Reproduction and Biotechnology (we'll only cover the reproduction part).

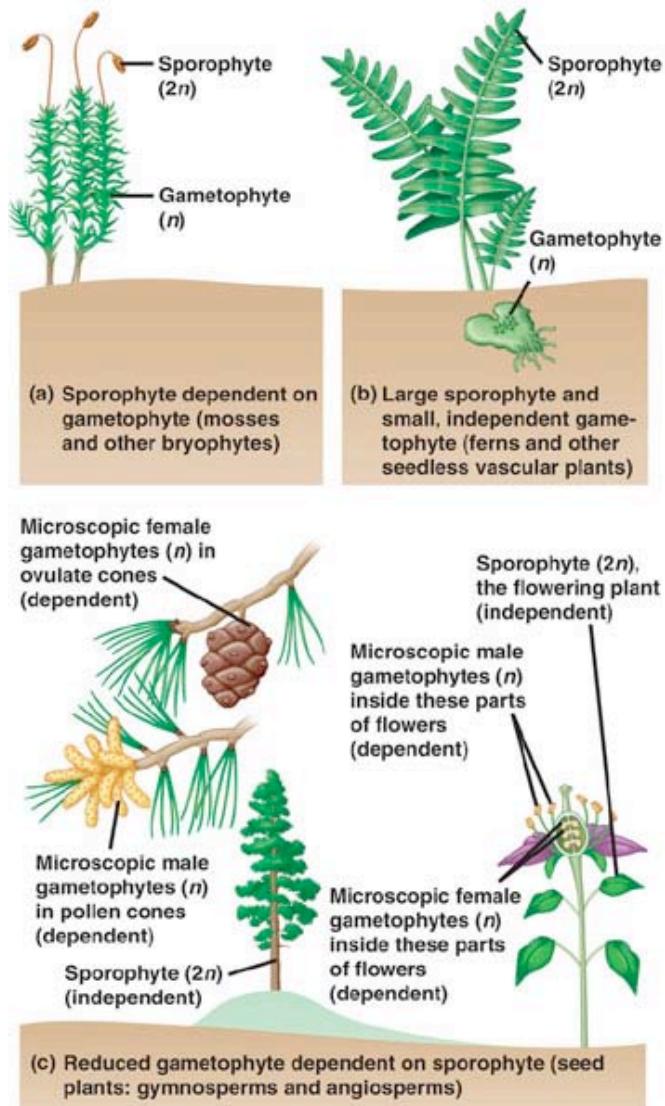
### PLANT LIFE CYCLE REFRESHER

The first plant lab compared and contrasted the life cycles of the main groups of plants. You may want to review that material in the handout and in Campbell. Remember that all plants, like the rest of the eukaryotes, have a haploid and a diploid phase in their life cycle. In addition, all plants also show **alternation of generations**: both the haploid phase and the diploid phase are multicellular. This, of course, is quite different from the animal life cycle; in animals, the haploid phase is unicellular and consists only of an egg or a sperm.

It's essential to remember the terminology that describes the life cycles of plants. The **sporophyte** is **diploid** ( $2n$ ). At some point, cells in the sporophyte undergo **meiosis**, cutting chromosome number in half to make haploid spores. A **spore** is a haploid cell that can grow into a new multicellular **haploid** ( $1n$ ) phase called the **gametophyte**. The gametophyte makes haploid **gametes** via mitotic cell division.

While all the plants show alternation of generations, they vary in terms of the size and degree of independence of each phase.

- **Nonvascular plants (e.g. mosses):** The gametophyte is



large, leafy, and green (photosynthetic). The sporophyte is smaller and shorter-lived, and it grows as a brown stalk out of the female gametophyte. Moss gametophytes produce naked sperm that need water to swim to the egg in the female gametophyte. Mosses live on land, but they can only complete their life cycle in very wet conditions (drenched in rain, for example).

- **Vascular non-seed plants (e.g. ferns):** The sporophyte is large and green. The gametophyte (also green) lives separately but is small and short-lived. Like mosses, fern gametophytes make naked sperm that needs water to swim to the egg. Fern gametophytes commonly make both eggs and sperm, but since they make these at different times, fertilization usually occurs between two different gametophytes. Ferns also need very wet conditions to complete their life cycle.
- **Vascular seed plants (including both conifers and flowering plants):** The sporophyte is large, long-lived, and green. The gametophyte is tiny (only a few cells) and develops completely inside the sporophyte. The male gametophyte is a pollen grain, which can withstand dry conditions. Seed plants can reproduce in dry conditions.

### WHAT MAKES SEED PLANTS DIFFERENT?

Seed plants are highly adapted to life on land. Non-seed, non-vascular plants such as mosses require water to carry their gametes for fertilization. Seed plants have two key tricks that allow them to reproduce in dry environments: seeds and pollen.

- **Seeds.** Seeds provide protection and nourishment for the developing **embryo** (the young sporophyte). Thanks to seeds, plants can be dispersed widely by animals or by wind. Seeds also allow many plants to survive harsh conditions. In a vascular non-seed plant such as a fern, the young sporophyte is dependent on the gametophyte, so it can't be dispersed and can't survive a period of harsh weather that would kill the gametophyte.
- **Pollen.** Pollen grains contain male gametophytes, the tiny haploid stage that makes the sperm. Thanks to pollen, gametophytes (and gametes) can be widely dispersed by animals or wind. In a fern, the sperm must be dispersed by water. The female gametophytes remain within the sporophyte, inactive until the pollen arrives.

You'll look at both seeds and pollen later in this lab, and you'll see how they fit into the two big groups of seed plants:

- **Gymnosperms.** Non-flowering seed plants, including pine trees and other conifers.
- **Angiosperms.** Flowering seed plants, including most of the plants you are familiar with.

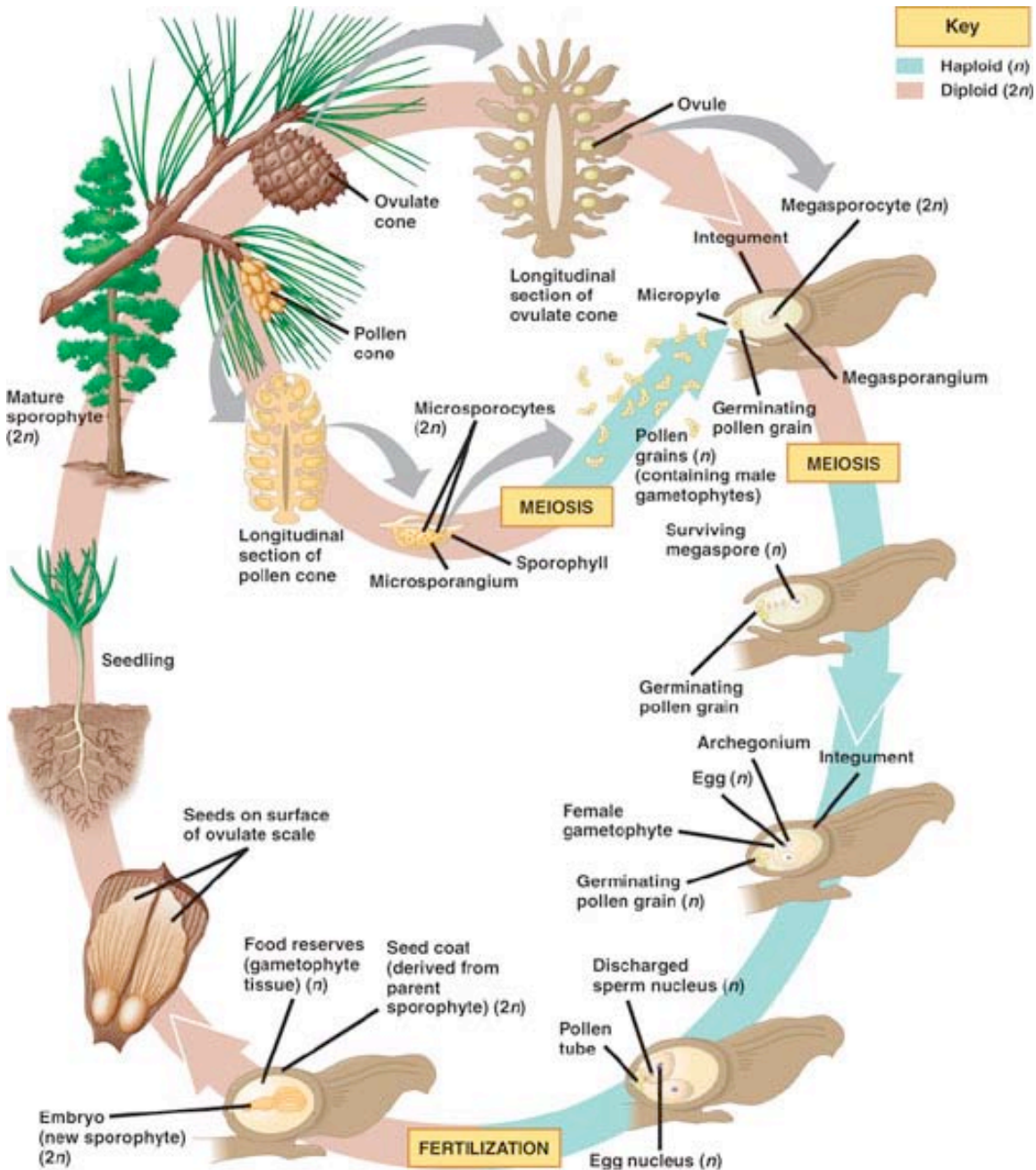
### GYMNOSPERM REPRODUCTION

You looked at some parts of pine trees (which are gymnosperms) in a previous lab. You should review them now, and study the pine tree life cycle diagram (fig. 30.6) in detail.

- 📖 **Observe the male and female pine cones (whole specimens).** What parts of the life cycle can you find in the cones?
- 📖 **Observe the prepared slide of the male cone ("staminate cone").** Are you looking at gametophyte or sporophyte? Would there be spores in this slide? Sperm?
- 📖 **Observe the prepared slide of the pollen grain.** Pine trees are pollinated by the wind. They make huge amounts of pollen, which falls like yellow dust from the trees. If they're

lucky, the wind may blow some pollen from a male cone on one tree to a female cone on another tree. Note the little wings on the pollen grains; this helps them get dispersed by the wind. When you look at a pollen grain, are you looking at haploid cells or diploid cells?

Pollen is one of the key evolutionary innovations helping plants survive on dry land. Pollen is the male gametophyte of seed plants (both gymnosperms and angiosperms). It is different in two key respects from the gametophytes of non-seed plants: it's tiny enough to be carried by wind or insects, and it has a tough outer wall that protects it from drying or other stresses. A pollen grain consists of just two cells: one that produces sperm, and another that produces a sperm tube that helps the sperm get to the egg. When a pollen grain lands on the ovary of another flower, it begins to grow and develop, eventually producing sperm. Since the male gametophyte is brought into contact with the female gametophyte, seed plants don't need to be wet to enable sperm to get to the egg.



📖 **Observe the prepared slide of the “young ovulate cone”** (female). *Hint: this isn't a mature cone.* Are you looking at haploid cells or diploid cells? Where is the female gametophyte? Where would meiosis occur? Where would fertilization occur? Would there be spores in this slide? Sperm? Eggs?

On the life cycle diagram, note how tiny the gametophytes are; a pine tree is basically a big sporophyte.

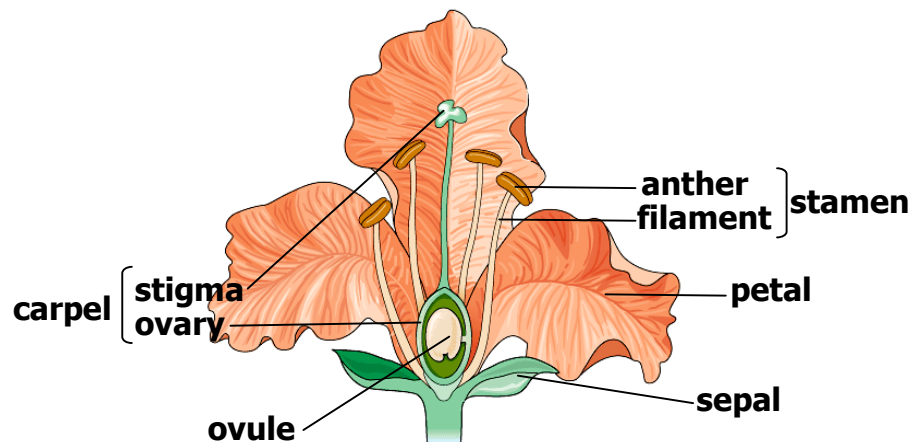
## ANGIOSPERM REPRODUCTION

Angiosperms are flowering plants. They have seeds and pollen like gymnosperms, but they also have flowers and fruits.

Flowers help the sperm and eggs of plants get together. The sperm comes from the pollen, and the flowers of many plants function to induce animals (bees, for example) to carry pollen from one flower to another. Flowers are mostly sporophyte ( $2n$ ) tissue of the parent plant, but they contain the tiny haploid gametophytes of the next generation. Many flowers make both male gametophytes (**pollen**) and female gametophytes (**embryo sacs**).

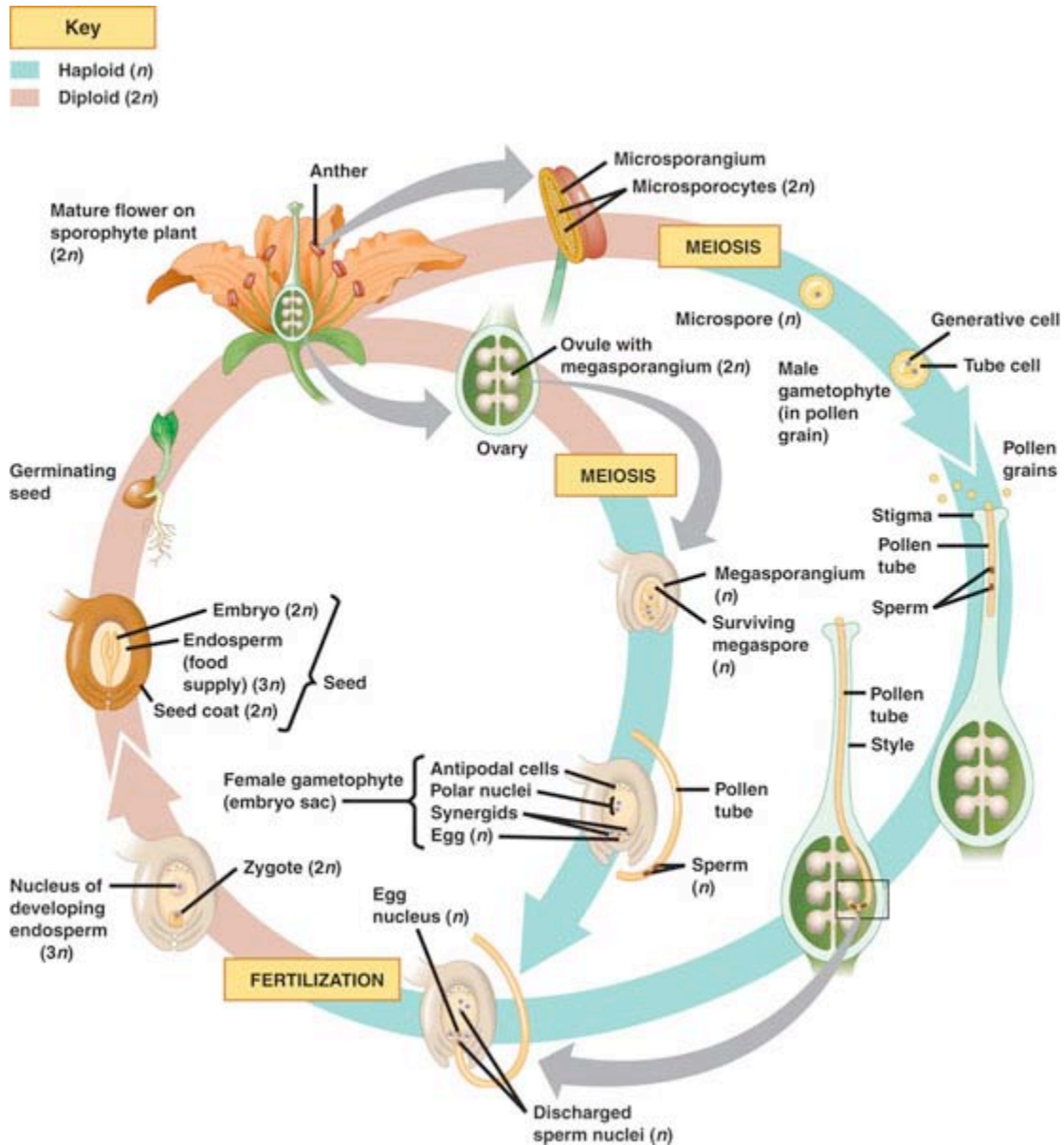
**Anatomy.** Flowers have four basic types kinds of organs:

- **Sepals.** These are usually like green leafy petals forming an outer whorl around the flower.
- **Petals.** Often brightly colored and elaborately shaped, in many species the petals help attract animals that pollinate the flowers.
- **Stamens.** Male gametophytes (pollen grains) develop in the stamens. Each stamen has an **anther** where pollen forms and a filament that holds the anther up.
- **Carpels.** Female gametophytes (embryo sacs) develop in the carpels. A carpel consists of an ovary (holds the **ovules**, in which the **embryo sacs** develop), a stigma (receives pollen), and a style (holds up the stigma).



Some flowers may be missing some parts – they may not have sepals, or they may have only carpels or only stamens. Some flowers may have duplicate parts – for example, many cultivated flowers have been bred to produce extra whorls of petals. As you might guess, flowers are found only in flowering plants.

There is a lot of terminology for flower parts. You should try to remember all the terms in bold type above.



- ☞ **Observe the prepared slides of lily flowers.** Compare what you see on the slide to the diagrams in Campbell (figs. 38.2, 38.4, 38.6, 38.7).
- ☞ **Observe the live flowers.** You should be able to find the same parts in the live flowers and in the microscope slides. You'll have to dissect them to see what's inside. Note that in the carpels, you may find gametophyte and sporophyte tissues together.
- ☞ **Observe the fresh pollen of the lilies.** Take some pollen and put it on a microscope slide with a little water and a cover slip. Compare this to the pine pollen.

### Fertilization in angiosperms

Fertilization is when two haploid gametes together to make a new diploid individual. Flowering plants have a complex process called **double fertilization**. This process is diagrammed in Campbell (fig. 38.7).

The essence of double fertilization is that two sperm come from a single pollen grain. One sperm fertilizes the egg, and the other joins with the two haploid polar nuclei of the female

gametophyte, creating a triploid (3N) nucleus. This triploid cell then develops into the endosperm, the part of the seed that provides nutrition for the developing embryo.

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## **Seeds**

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Seeds are one of the key evolutionary innovations helping plants survive on dry land. A seed contains an embryo (the new generation sporophyte), a seed coat that protects it from the outside world, and some triploid endosperm that provides nutrition for the growing embryo.

📖 **Observe the various whole specimens of seeds.** Identify the embryo, the endosperm, and the parental tissues.

## **Fruits**

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Plants don't get around much, but there are two key points in their life cycle where dispersal to a new environment can happen. The first is the pollen, which can be carried great distances by wind or animals. The second is dispersal of the seeds. After fertilization, a flower turns into a fruit. Many angiosperms have fruits that encourage animals to eat the fruit (which is made from tissue of the parent sporophyte); the animals may digest the fruit but not the seeds, eventually depositing the seeds in a new location.

📖 **Observe the various whole specimens of fruits.** Identify the carpels, the seeds, and the parental tissues.

## **Embryos & Early Development**

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In the first stages of sporophyte development, the difference between monocots and dicots is very clear: monocots have one tiny leaf growing out of the seed, and dicots have two.

📖 **Observe the live specimens of sprouting seeds.** Which parts are the new sporophyte? The triploid endosperm? Are there any tissues remaining from the parent sporophyte?

### QUESTIONS FOR PLANT LAB 3

1. Compare and contrast the gametophytes of mosses, ferns, and gymnosperms, and angiosperms.
2. Compare and contrast the sporophytes of mosses, ferns, and gymnosperms, and angiosperms.
3. Compare and contrast the spores of mosses, ferns, and gymnosperms, and angiosperms.
4. Compare and contrast the gametes of mosses, ferns, and gymnosperms, and angiosperms.
5. How can ferns get dispersed to new locations? How can mosses get dispersed to new locations? How can angiosperms and gymnosperms get dispersed to new locations?

### PLANT STRUCTURES, PROCESSES, & SPECIMENS TO REMEMBER

You've now done three plant labs. You should be ready to recognize and understand the following in any of the specimens you've seen:

Angiosperm	Monocots & dicots
Anther	Nonvascular plant
Apical & lateral meristems	Ovary
Carpel	Petal
Demal, ground, & vascular tissues	Phloem
Double fertilization	Pollen
Embryo	Primary & secondary growth
Endosperm	Prokaryote
Epidermis	Protist
Fertilization: <i>where it occurs, what it produces</i>	Seed
Filament	Sepal
Flower	Spore
Fruit	Sporophyte
Gametes (eggs & sperm)	Stamen
Gametophyte	Stigma
Guard cells	Stomata
Gymnosperm	Vascular non-seed plant
Haploid vs. diploid vs. triploid	Vascular seed plant
Meiosis: <i>where it occurs, what it produces</i>	Xylem
Mesophyll	Zygote