Botany

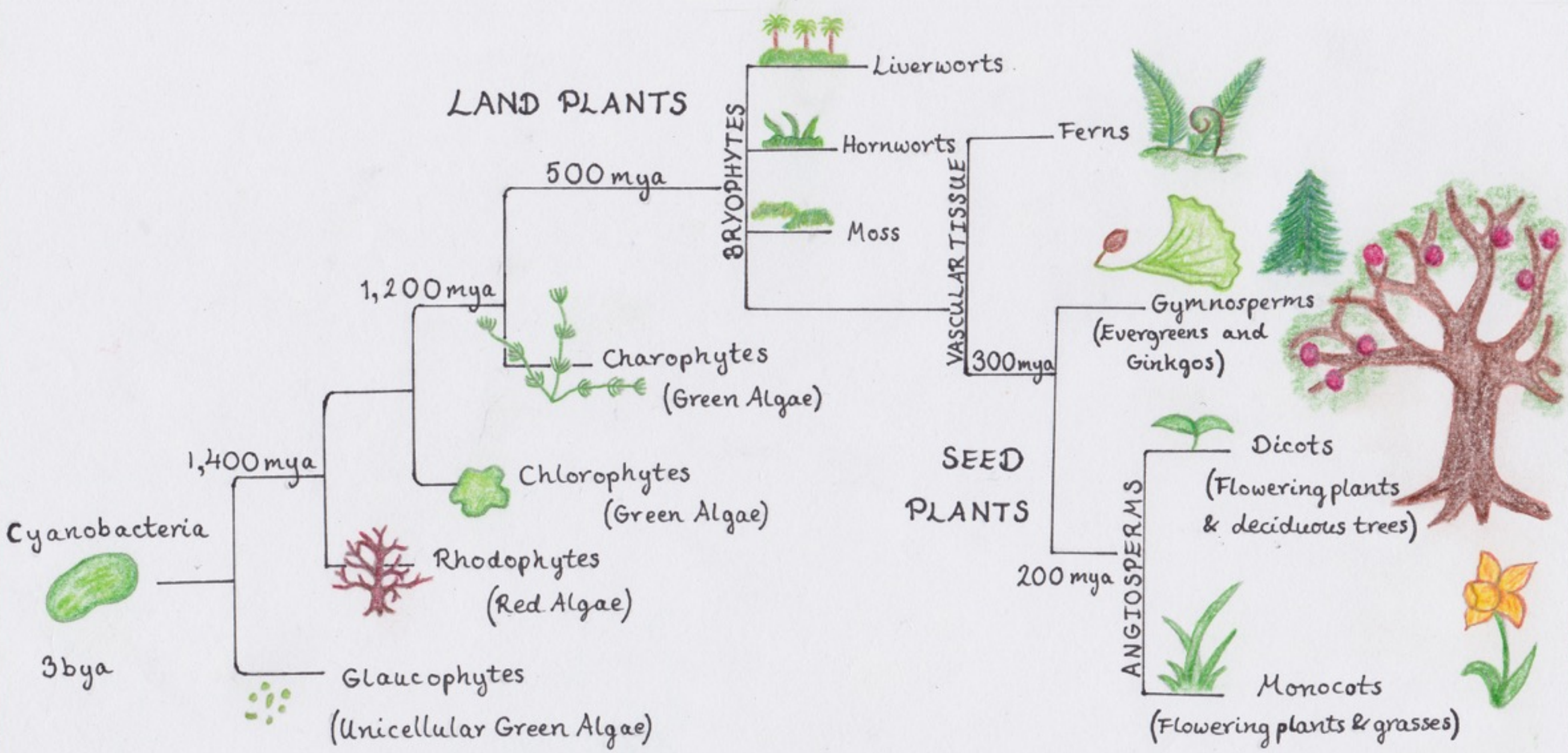
With Ms. Ohana


Alisa Levin

11th Grade - April 2016

Table of Contents

The Evolution of Plants



The Beginning of Photosynthesizing Organisms

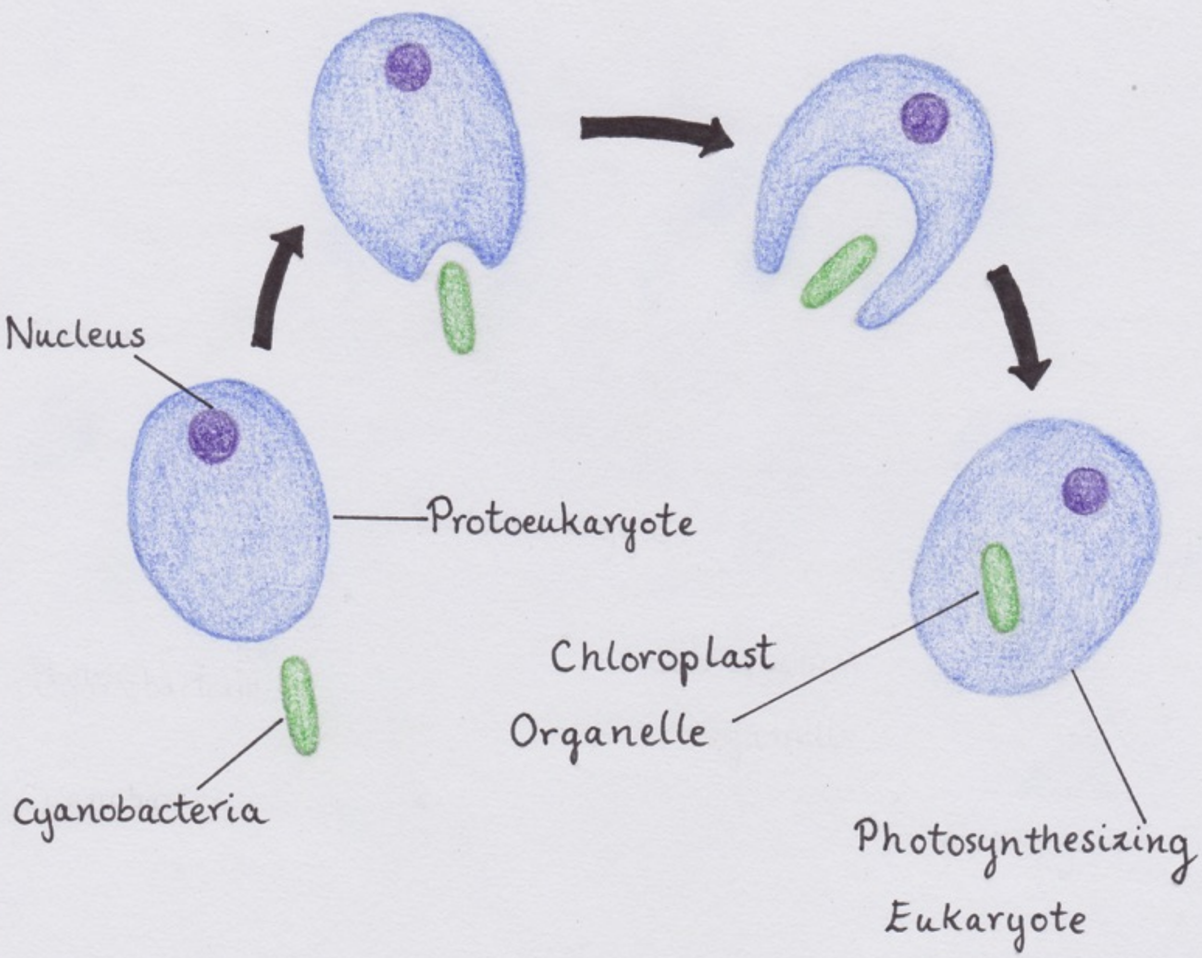
There are three domains of life: bacteria, archaea, and eukaryotes. Bacteria are prokaryotes — single-cellular organisms lacking true nuclei. Archaea are also prokaryotes, but they are extremophiles; they can live in extreme conditions. Eukaryotes, on the other hand, are organisms whose cells contain nuclei and other organelles. They are almost always multi-cellular.

The Earth is 4.6 billion years old, but photosynthesizing organisms have only been around for approximately 3 billion years. The first photosynthesizing organisms were cyanobacteria, which were responsible for the accumulation of oxygen in Earth's atmosphere. This process of oxygenation was extremely slow; it took 800 million years for there to be sufficient oxygen to support complex life.

The Endosymbiotic Theory explains how photosynthesizing eukaryotes developed. Three billion years ago, the Earth's oceans were filled with only bacteria. Over time, primitive eukaryotes began to develop. These organisms, called protoeukaryotes, were like large bacteria with primitive nuclei. According to the Endosymbiotic Theory, one of these protoeukaryotes engulfed a cyanobacterium. The cyanobacterium then got incorporated into the cell. This occurence turned out to be a symbiosis; the bacterium gave the protoeukaryote the power to recieve energy from the sun, while the protoeukaryote sheltered the bacterium from the outer environment. The new cells that were created by this process were the first photosynthesizing eukaryotes, which soon multiplied to create many of their kind.

Ocean plants, namely algae, were some of the first eukaryotes. The first plants on Earth were glaucophytes, unicellular green algae. We consider green algae to be plants because they are eukaryotic, have nuclei, and contain cellulose. These algae developed into rhodophytes — red algae — and chlorophytes — more complex green algae. Both rhodophytes and chlorophytes never evolved out of the ocean. It was charophytes — a more complex form of green algae — from which all land plants evolved.

The Development of Photosynthesizing Eukaryotes



The Beginning of Land Plants

It is theorized that land plants first evolved from green algae that grew in the shallow waters of areas that experienced periodic droughts. Because they were accustomed to exposure to air, these plants were able to evolve into the first land plants.

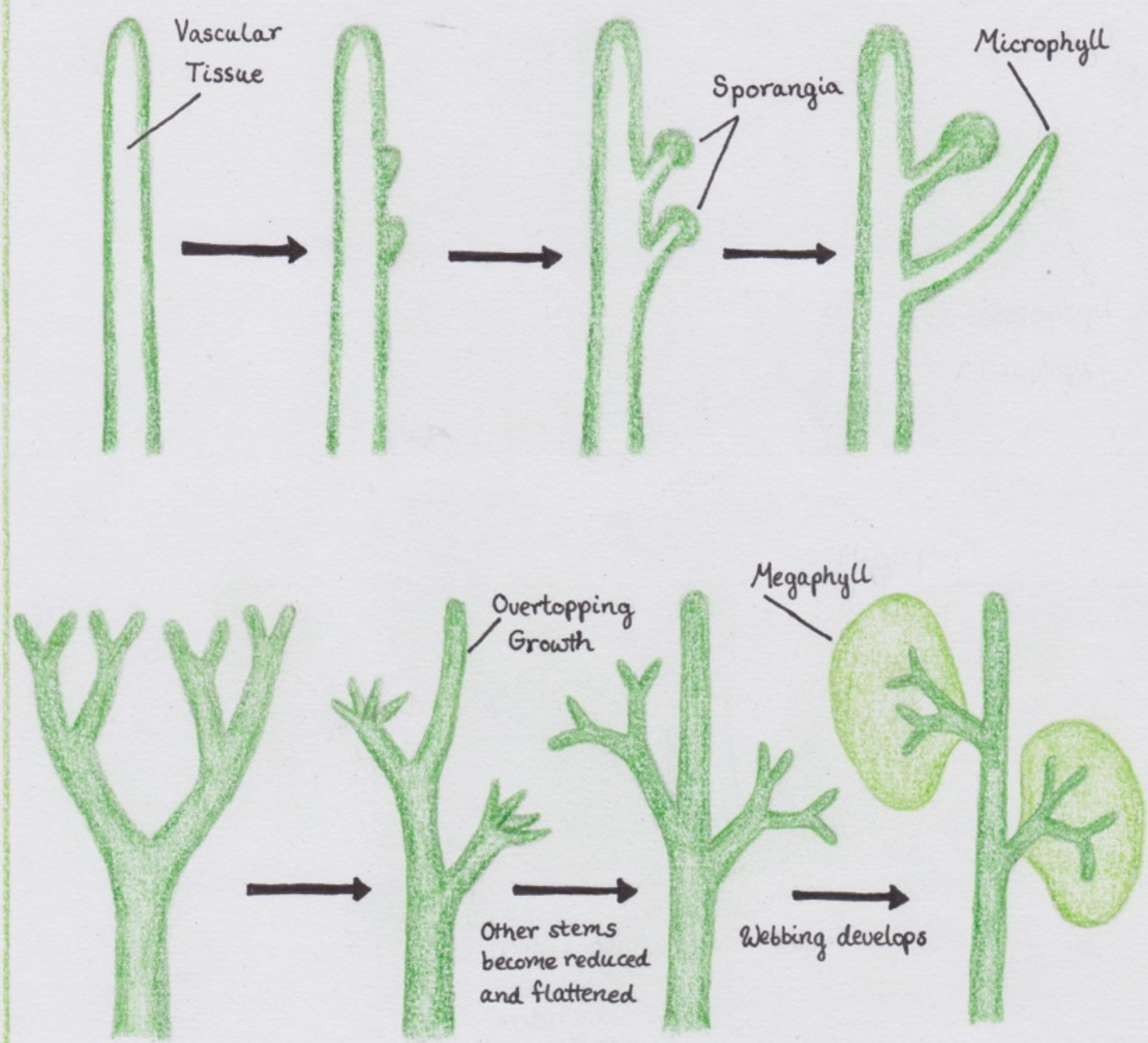
Land plants all share a set of defining characteristics. For example, all plants have ways of protecting their embryos from drying out. All land plants are also covered by a waxy cuticle to prevent water loss. Aside from bryophytes, all land plants have leaves. These leaves contain stomata, small pores that allow for water and gas to be exchanged between the plants and the air.

The oldest and simplest forms of land plants are bryophytes, which date back to approximately 500 million years ago. Bryophytes come in three forms: liverwort, hornwort, and moss. All three of these forms are colonizers; they can live in conditions that are considered inhospitable to other plants. For example, bryophytes can live on rocks. In fact, they can even slowly break rocks down into soil. Although bryophytes require damp conditions in order to grow, they can remain without water for years and then come back to life upon rehydration. Like other land plants, bryophytes follow the life cycle of alternation of generations, which consists of gametophyte and sporophyte stages. The gametophyte is the sexual stage of the plant. This stage is concerned with haploid cells, which only have one set of chromosomes. The sporophyte stage develops from a zygote, which is produced by a haploid egg being fertilized by a haploid sperm. This stage is concerned with diploid cells, which have two sets of identical chromosomes. Bryophytes continuously alternate between the two stages of this cycle; hence the term "alternation of generations."

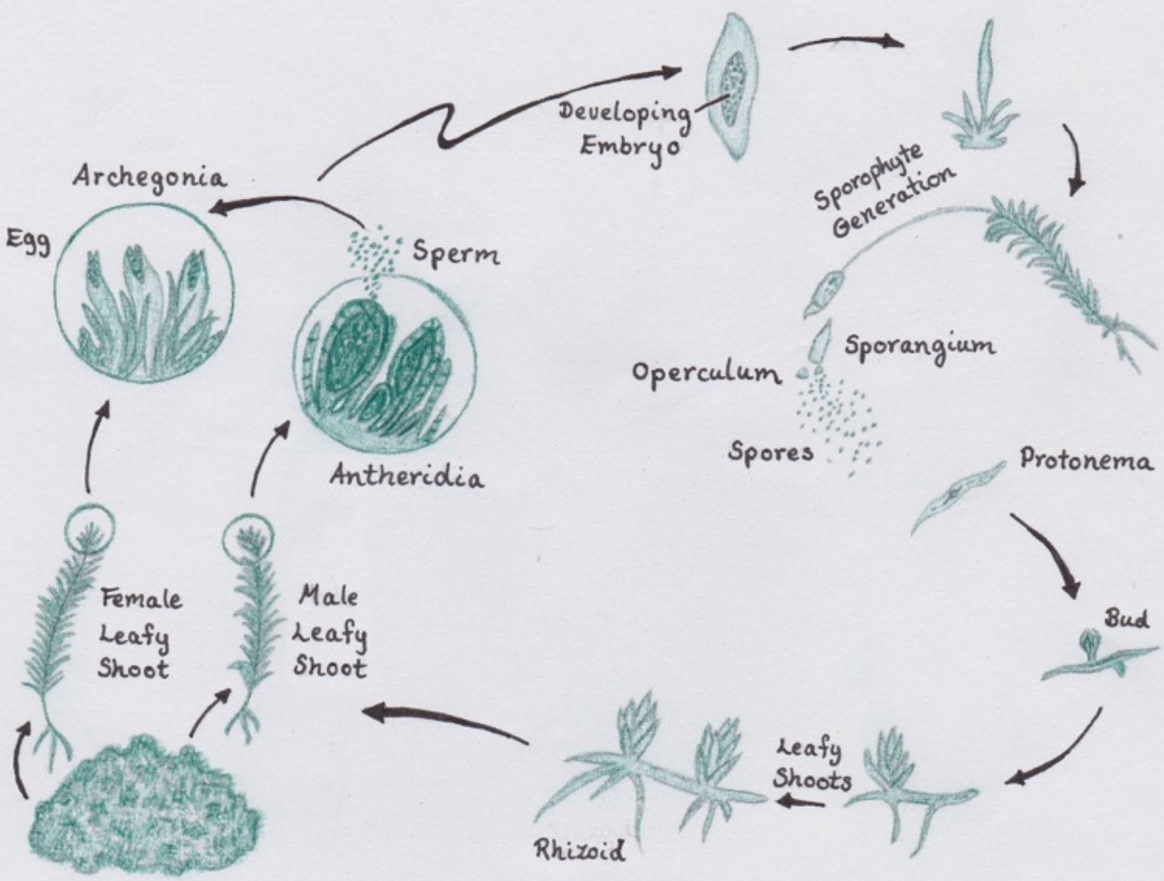
All bryophytes are small because they don't have vascular tissue — tissue that is specialized for the transport of water and nutrients throughout the body of the plant. Since their entire bodies can photosynthesize, bryophytes don't need vascular tissue to help them transport water or nutrients. Vascular tissue has two veins: the xylem vein transports water and the phloem vein transports nutrients.

The first plants to contain vascular tissue were seedless, still relying on spores to reproduce. Cooksonia—which evolved approximately 420 million years ago, but has since gone extinct — is believed to be the ancestor to all vascular plants. Cooksonia consisted of stems that forked evenly to produce branches ending in sporangia, spore-retaining capsules. Because cooksonia had many sporangia, they were able to increase their genetic output, an attribute that was favored by evolution as vascular plants continued to develop. Another form of seedless vascular plants are lycophytes, which are commonly called club moss. Lycophytes have no true roots or leaves and contain microphylls; single strands of vascular tissue running throughout their bodies. There are about 1,500 different species of lycophytes, and they all look like miniature pine trees. A third form of seedless vascular plants are pteridophytes, plants such as ferns and horsetails. Pteridophytes were the first plants to develop megaphylls. Megaphylls are the first leaf-like structures and contain several strands of vascular tissue. This allows pteridophytes to efficiently collect solar energy.

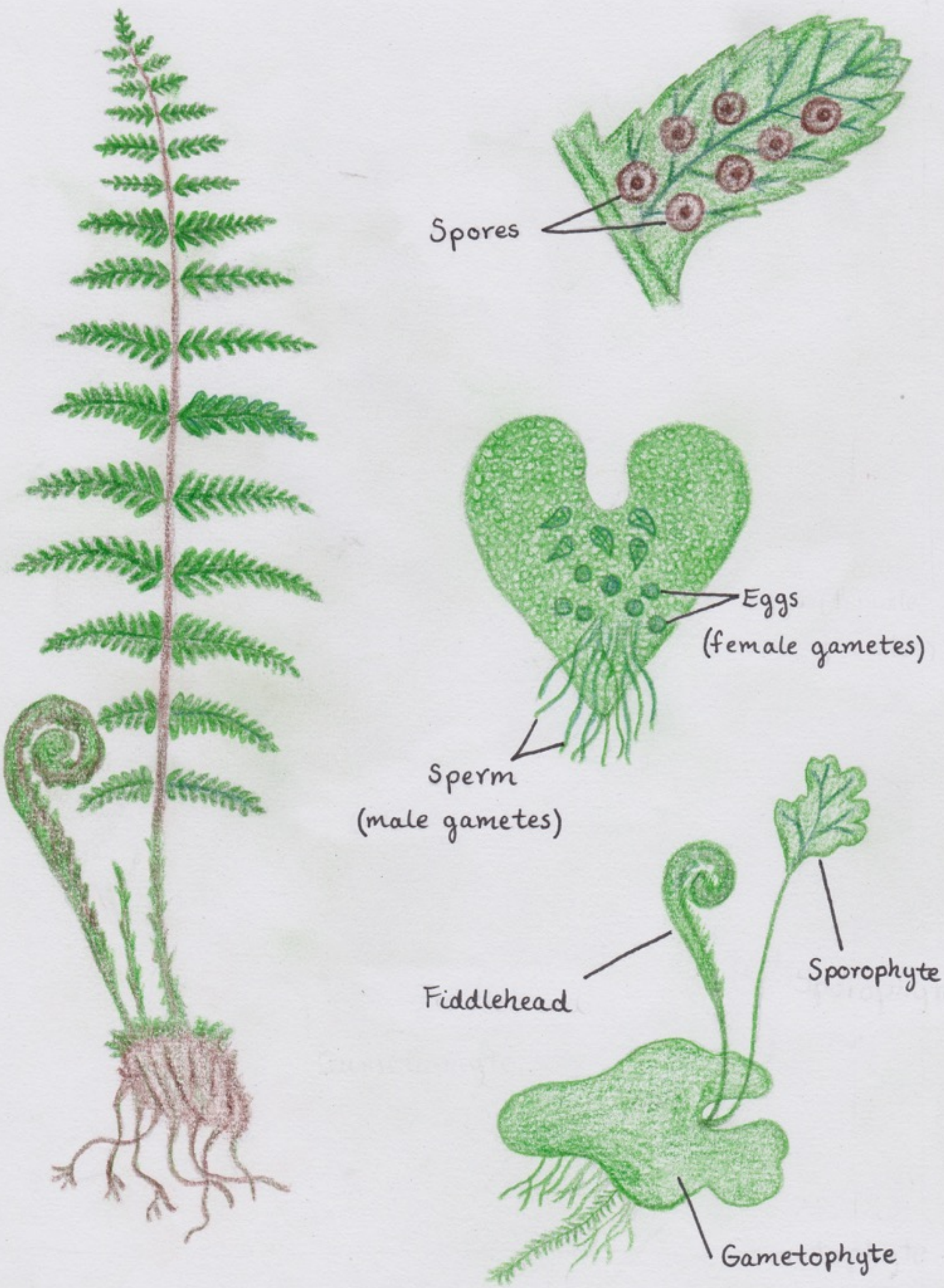
The Development of Megaphylls



The Moss Life Cycle



Ferns

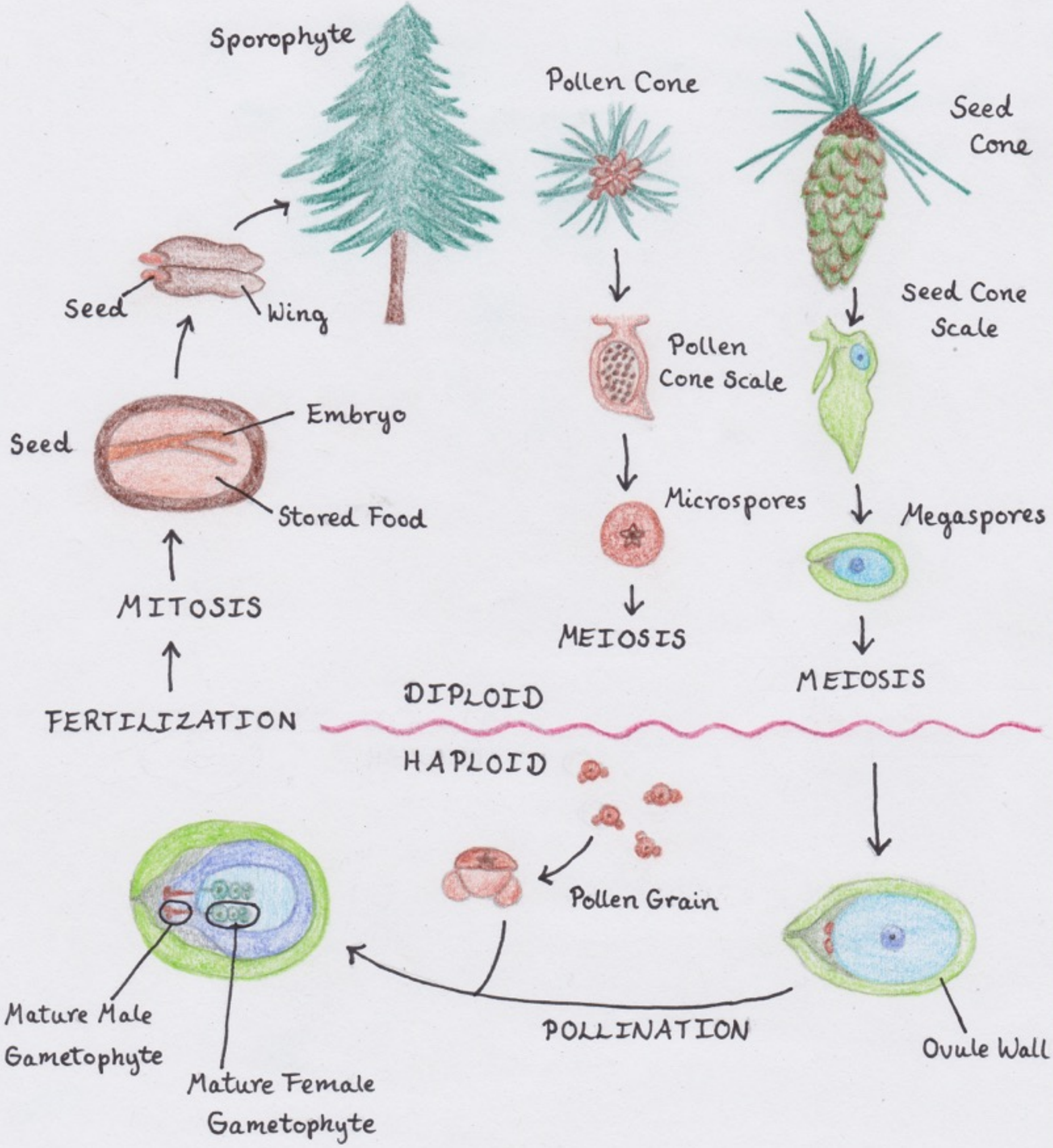

Spores
Eggs
(female gametes)
Sperm
(male gametes)
Fiddlehead
Sporophyte
Gametophyte

Gymnosperms

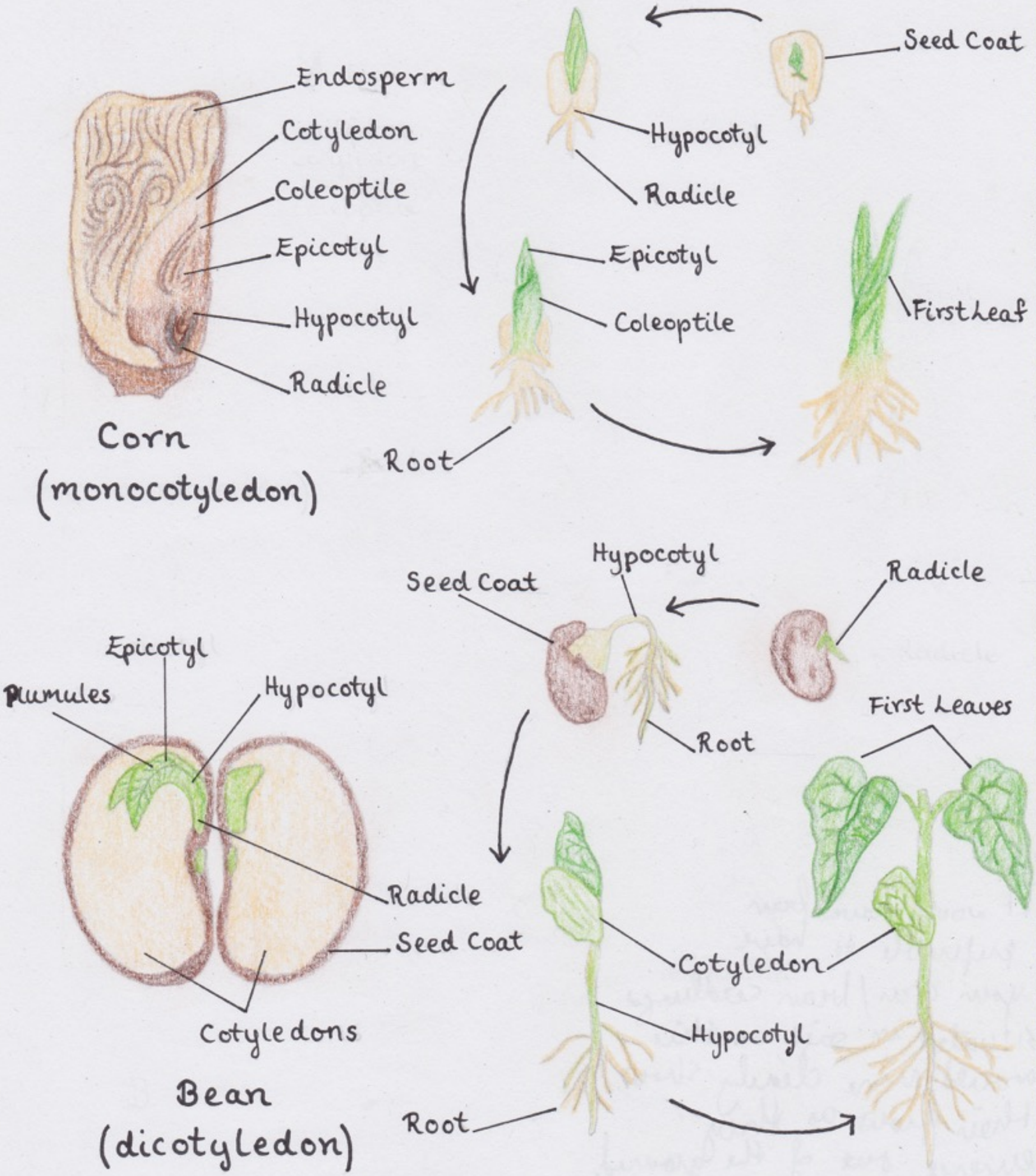
Gymnosperms were the first plants to have seeds. What's particularly interesting about gymnosperm seeds is that they are naked. In fact, the word gymnosperm itself means "naked seed" in Greek. These seeds, unlike those of other plants, are not protected by fleshy layers of fruit or shelling. Gymnosperm's small, naked seeds, allow for aerial dispersal. This is an evolutionary advantage because gymnosperms do not have to waste energy on forming beautiful blossoms so that insects and animals will assist them with the reproductive process. Instead, gymnosperms can rely on the wind to carry their seeds to neighboring trees for fertilization. The seeds of gymnosperms are protected by thick coats that allow them to remain dormant for many years. The inside of each seed is the sporophyte embryo and the endosperm — the food storage.

There are four types of plants in the gymnosperm family. The first of these are conifers. Conifers are evergreen trees that have needles. Due to their thick tissue, the needles of conifers can survive throughout the winter. This allows the trees to expend less energy because they do not have to grow new needles each spring. Another plant in the gymnosperm family are cycads, tropical plants that resemble palm trees with cones. Cycads are dioecious, having male pollen cones and female seed cones on different plants. Ginkgoes are also members of the gymnosperm family. They have fleshy, naked seeds, loose their leaves in the winter, and — like cycads — are dioecious. The fourth types of plant in the gymnosperm family are gnetophytes. Gnetophytes are very controversial plants; they look nothing like gymnosperm trees, but scientists are unsure where else to place them.

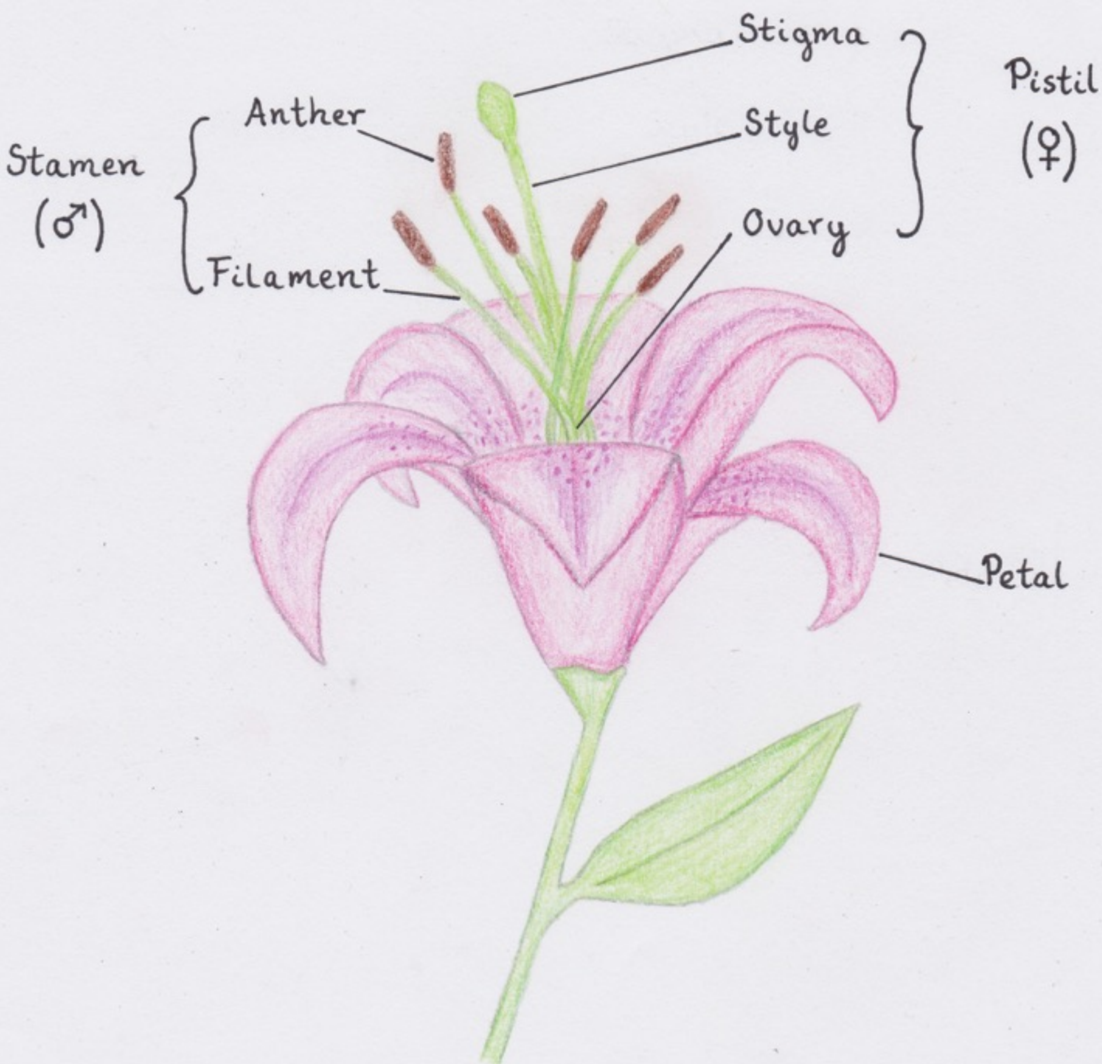
Gymnosperm Life Cycle



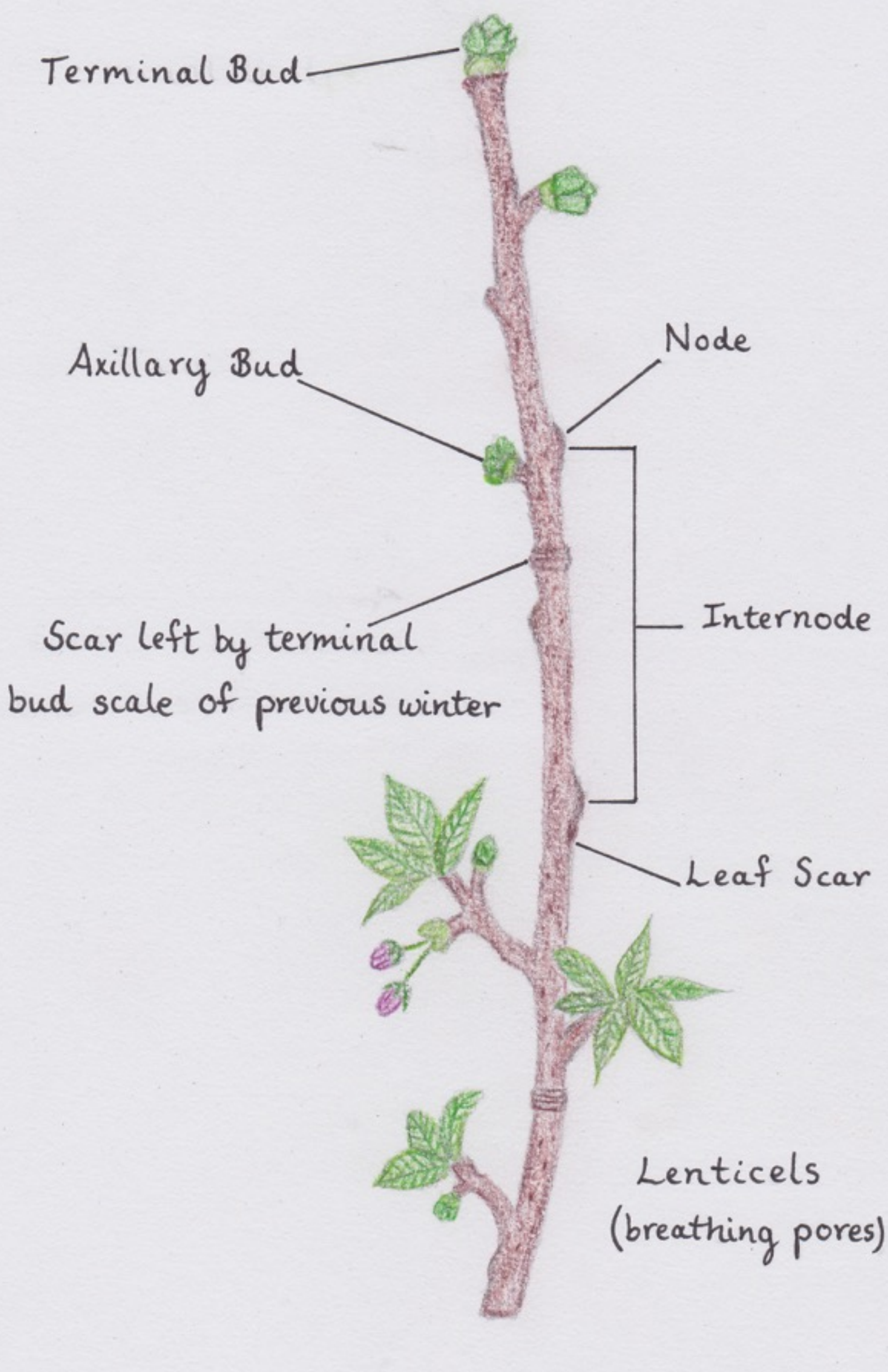
Corn and Bean Growth



Reproductive Parts of a Flower



Anatomy of a Woody Branch



The Adventures of the First Angiosperm

My new life begins with rain. So much rain that the whole world turns cold, dark, and wet. It floods the forest and washes me away from my parent, away from my safe home under the great sequoia tree. For hours, I am drowned in this river of rain and swept down over the hills. Finally, the storm subsides and the water seeps into the earth, taking me with it. Engulfed by soil, I rest in complete darkness.

It is not long before I can feel myself changing. This is the process that my parent has taught me about — the process of germination that I always looked forward to as a young seed. My seed coat cracks open and I can feel my radicle growing. It stretches down into the depths of the earth and branches out to collect the maximum amount of water and nutrients. Soon my hypocotyl arches up and out of the soil, followed by my epicotyl. My two cotyledons spread out in the sunlight, followed by two plumules that begin to grow into primary leaves. As my leaves develop, I observe their branched network of vascular tissue. This is so exciting!

After my leaves have developed, I focus on taking in as much sunlight as possible. This process is so exhausting and I need all the energy that I can get to grow my blossom. As I take in the noonday sun, I turn my attention for the first time to the world around me. Everything is so bright and beautiful — so different from the world inside my warm seed coat and the cold, damp earth. I contemplate the trees towering above me. These trees look different from the sequoia trees that I knew as a small seed. Perhaps these are pine trees! Yes, they resemble the pine trees that the wind once whispered to me about. I am satisfied with my new home; the water seems abundant and the sun is radiant and warm. Then, suddenly, the ground shudders as a large, reptilian creature passes through the pines. I tremble in fear as I recall the dinosaurs that a thrip visiting my parent once described to me. She told that these large terrestrial vertebrates love to eat small, unassuming plants as casual snacks. What if I am eaten by a dinosaur and don't have the chance to grow and become pollinated?!

Luckily, the pine trees shelter me from the dinosaurs long enough for my sepals to open and reveal a charming blossom of five pink petals. I watch joyfully as the fuzzy, copper-colored anthers of my five stamen sway in the wind, dancing around my urn-shaped pistil. Within a couple of days, my flower has fully developed and is ready for pollination. I am overjoyed when a thrip is finally attracted by the bright colors of my blossom. As it drinks my sweet nectar, I tell the thrip about my experiences in the past few weeks: about my experiences of germination and what it was like to develop from a seedling into a fully-grown flower. In exchange, the thrip tells me about the other plants it has visited up in the sequoia forest where I was born. Then, once it has finished pollinating me, the thrip wishes me the best of luck with my seed embryos and flits away.

One evening, I hear the crackling of a storm in the distance. As darkness falls, a heavy downpour of rain arrives, and I can feel my little seeds being torn away from me, becoming lost in the torrent of the flood. When the storm has finally passed, in the stillness of the night, I think of my seeds and their adventures that lie ahead.

The Adventures of the First Angiosperm