Essential Ferns

Ferns are some of the oldest living things on land. They were thriving on Earth for two hundred million years before the flowering plants evolved, are older than most land animals, and far older than the dinosaurs. Ferns are the earliest group of plants to have vascular tissues. This advance allowed them to colonize new terrestrial habitats, a trait they still employ today. Unlike the other vascular plants (flowering plants and conifers), ferns reproduce from spores and an intermediate plant stage called a gametophyte, rather than directly from a seed. Today, ferns are the second-most diverse group of vascular plants on Earth, outnumbered only by flowering plants. There are around 10,500 living species of ferns (roughly 4% of all plants)!

What makes a Fern a Fern?

- Ferns don't have seeds or flowers, but instead reproduce by means of spores. Spores and the resulting gametophyte require significant moisture to reproduce.
- Fern fronds have both a photosynthetic function and a reproductive function.
- Ferns and fern allies are the only groups of plants in which both the sporophyte (big leafy fern) and gametophyte (reproductive phase that allows for mixing of genetic material) are completely independent of each other.

Fern Allies

- Horsetails (Lycophyta), club mosses (Sphenophyta), and whisk ferns (Psilophyta) are often lumped together as "fern allies." Recent molecular work, however, has demonstrated that they are actually within the fern family.
- The primary visual difference between ferns and fern allies is the presence of large, complex leaves called "megaphylls" (meaning "large leaves") found in the ferns.

Natural History

Ferns are one of the earliest land plants, and the earliest group of plants to have vascular tissue (xylem and phloem) which transport water, minerals, and sugars throughout the plant body.

- Ferns and fern allies evolved about 400 million years ago (mya), developing vascular tissues that allowed them to grow large and survive on land.
- As the planet cooled, ferns developed large leaves. This allowed ferns to became one of the most dominant groups of plants on the planet during the Carboniferous (299-369 mya). Growing in vast swamps, ferns thrived and diversified for several million years, creating forests with trees 20-100 feet tall!
- About 135 mya, flowering plants (angiosperms) spread around the globe. Of the ancient plants, only ferns could compete with seed plants and remain a significant group today
- The advent of tropical rainforests created new environments for ferns to exploit and, as a result, most modern ferns grow in the tropics. Costa Rica, for example, is smaller than

the state of West Virginia and has nearly three times as many fern species as the entire continental United States and Canada combined.

Fern Architecture

Ferns have 3 major parts: rhizome, fronds, and reproductive structures called sporangia.

- The rhizome is the stem of the fern plant. It comes in 3 basic forms:
    - An erect rhizome: a solid mass that gives rise to a tuft of fronds.
    - A lateral rhizome: grows along or under the ground and/or can climb a tree.
    - A vertical rhizome: can grow into a short or a tall trunk.
    - While the leaves may drop off due to age or cold weather, some rhizomes, particularly those underground, can persist indefinitely, sending up new leaves year after year.
- The fronds are the leaves of the fern.
    - Unlike flowering plants, fronds have a dual function: they are there for photosynthesis but they are also there for reproduction.
    - Some species produce separate fertile and vegetative (non-reproductive) fronds. In other species, reproductive parts may be found on any of the fronds.
    - Each frond usually consists of a stalk or petiole (the stipe) with a flat blade (the lamina). The frond may be simple and undivided, or it may be divided into a number of divisions (called pinnae). The main stem of the lamina is called a **rachis.**
    - New fronds are produced from the rhizome. Usually, they are tightly coiled into a spiral (called a fiddlehead or koru), and these slowly uncoil as they mature.
- Ferns reproduce by spores produced by **sporangia** (singular: sporangium) and surrounded by a think wall of cells called an **annulus**.
    - Generally, sporangia are on the underside of the frond, but they can also be along the sides.
    - Sporangia often cluster into **sori**. The location of the sori varies from species to species and can be circular, in distinct rows, or may even cover the entire underside of a leaf.

Lifecycle of Ferns

Ferns are unique in that they have two distinctly different and independent life stages in their sexual reproductive cycle. Ferns can reproduce both sexually and asexually.

Sexual Reproduction

- In ferns, a mature sporophyte (what we think of as a fern) develops spores which are dispersed into the surrounding environment.
- When the spores are ripe and/or the frond dries out, the annulus breaks, tearing the sporangium apart, and catapulting the spores away from the frond and onto the wind.
- Most fern spores are dispersed by wind, but they can also travel on animal fur or bird feathers, in flowing waterways, or through animal's droppings.

Essential Ferns

- If the spore finds suitable conditions, it will grow into a tiny heart-shaped plantlet called a **prothallus**. The prothallus is not the full fern, but a plant with only half the genetic material of the adult fern (a gametophyte), rather like a sperm cell or an egg cell. It is the intermediate stage from spore to adult fern.
- The prothallus has two sets of reproductive organs on its underside - the male parts called the *antheridia*, and the female parts called the *archegonia*. Archegonia (female) are produced near the “notch” of the heart and contain egg cells; antheridia (containing sperm cells) can be found near the tip among several rhizoids that arise from the main gametophyte body and serve to anchor it to the substrate.
- Sperm in all ferns are motile, possessing several flagella that allow them to travel short distances. If there is a film of moisture, the sperm cells swim towards the egg cells on the same prothallus or an adjacent one to fertilize it.
- When the sperm cells find the egg cells, they fuse their genetic material to make a cell with the full adult set of genes. The new diploid sporophyte (the big green part we think of as the fern) grows directly from the prothallus, after which is subsumed within the new growth.
- As it becomes the sporophyte (the adult fern), it can produce spores of its own, to repeat the life cycle.
- Many ferns are not able to self-fertilize, so enough spores must develop in to a prothallus that the sperm can swim between them to cross-fertilize.

Asexual Reproduction

- A sporophyte can grow from a gametophyte without fertilization (a process known as *apogamy*) in drier areas where there is insufficient water to allow normal fertilization.
- Ferns can also grow from spreading rhizomes (roots) of existing plants.
- Or they can sprout baby ferns at the "proliferous" tips of their fronds. When the parent frond droops and touches the soil, the baby plant takes root on its own.

Other Interesting Natural History of Ferns

- The ability to grow continuously, and often asexually, in some ferns means that they can live indefinitely.
- Because the gametophyte and sporophyte stages of ferns require different environmental conditions to thrive, some ferns have developed a spatial separation of the two generations.
    - Some gametophytes can live in protected microhabitats and/or tolerate a wider range of environmental conditions than their sporophyte counterparts. Around thirty known species of ferns have distributions in which the gametophyte occupies a wider geographic range than its sporophyte, and at least three fern species have no known sporophyte anywhere on Earth.
    - Mature ferns may thrive in a relatively hostile environment, but they may not reproduce there. You will only find ferns growing naturally in areas where, at

least for some of the time, the conditions suit both survival of the adult plant and survival of the gametophyte.

- Ferns are often the first plant to colonize recently disturbed areas.
    - When spores buried in the soil are exposed, they germinate and the prothallus grows quickly to establish new sporophytes before the next disturbance or they face competition from other plants.
- Spores from some ferns show the possible evolution of seeds.
    - Most ferns are homosporous, meaning they produce spores of a single size.
    - A few aquatic ferns make heterosporous spores: a single plant produces both small microspores, which develop male gametophytes, and a few much larger megaspores, which develop into female gametophytes.
    - In most ferns, the spore casing breaks open when fertilized, becoming independent and photosynthetic. However, the female gametophytes of heterosporous species remain within the megaspore and are dependent on stored lipids (fats) and carbohydrates for nutrition during development.
    - This retention of the egg within a larger, protective structure likely led to the evolution of the first seeds.

Human History

- Many different species been used as a minor food source and for medicine in various parts of the world, but many ferns, even those eaten, can be toxic.
- The greatest economic value of living ferns has been in horticulture with large nurseries supplying millions of plants annually for both indoor decoration and outdoor gardens and landscaping.
- Humans rely on the ancient fern forests and swamps from 200 million years ago.
    - When ferns and fern allies died, they sank into ancient anoxic swamps, where the lack of oxygen prevented bacteria from degrading dead tissue. The burial of these swamps created coal and natural gas deposits we have today. Every time you drive your car, you're using fossilized ferns to reach your destination.

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