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The Bryophytes

Professor Ralph E. Taggart

Departments of Plant Biology and Geological Sciences

Michigan State University

Division Bryophyta

The bryophytes, which include **mosses, liverworts,** and **hornworts,** may have been the first group of multi-cellular plants to make the transition to life on land, although their fossil record is too sparse to test this hypothesis. All these plants **lack a vascular system** and are confined to relatively wet sites since ample water is required for the growth of the gametophytes (the dominant phase of the life cycle). Liquid water (raindrops or dew) is required if sperm cells are to swim to the eggs and complete sexual reproduction.

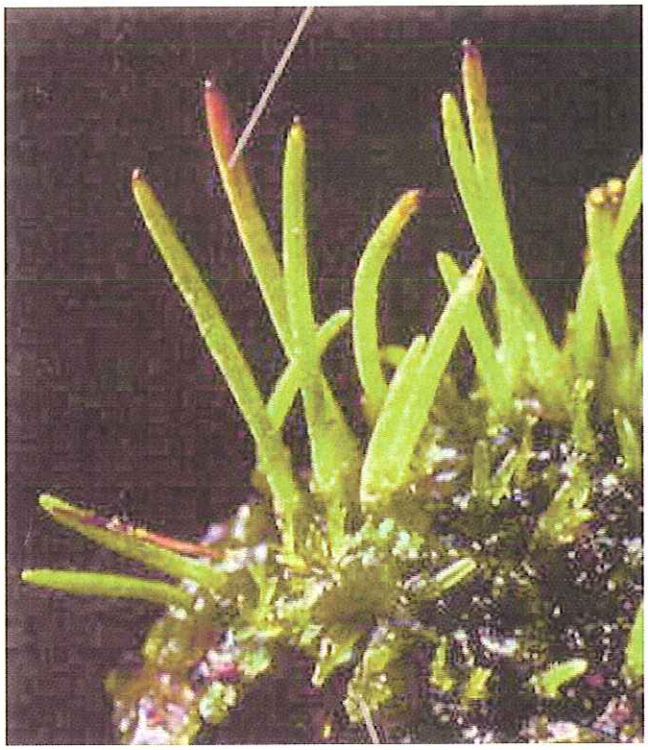
Botanists traditionally believed that the Bryophytes were transitional between the green algae (from which they are clearly derived) and more complex vascular land plants. However, that view went out of fashion by the mid-1900s and it was generally assumed that they represented one or more distinct lineages that may have no ancestral role with respect to more complex terrestrial plants. Now, with the availability of DNA evidence, the traditional view once again prevails.

Liverworts

A liverwort. The flattened green portions of the plant represent the non-vascular gametophyte stage, while the stalked structures are the sporophytes. While liverworts differ in detail from mosses with respect to their sexual cycle, the overall pattern is similar.

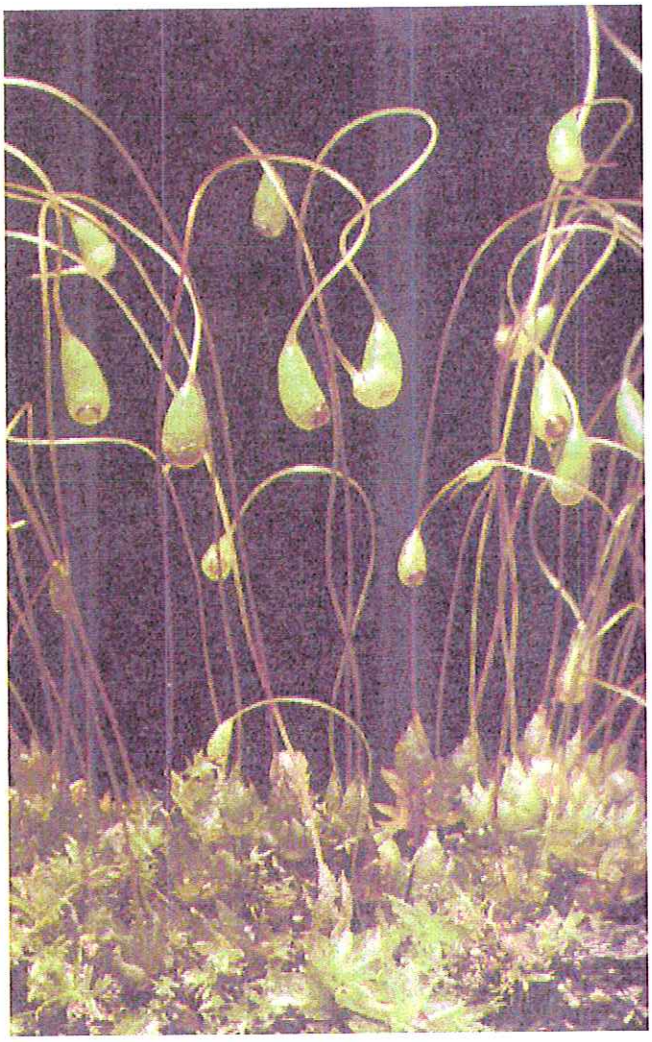
Genetic evidence suggests that the Liverworts are the most ancient Bryophyte group and thus probably represent the first plants to make the transition to life on land.

Hornworts



Hornworts generally appear similar to mosses but have distinctive conical or horn-shaped sporophytes as shown here. Both Hornworts and mosses appear to have evolved from liverworts and the complex is the probable point of origin for the evolution of **vascular** land plants.

Mosses

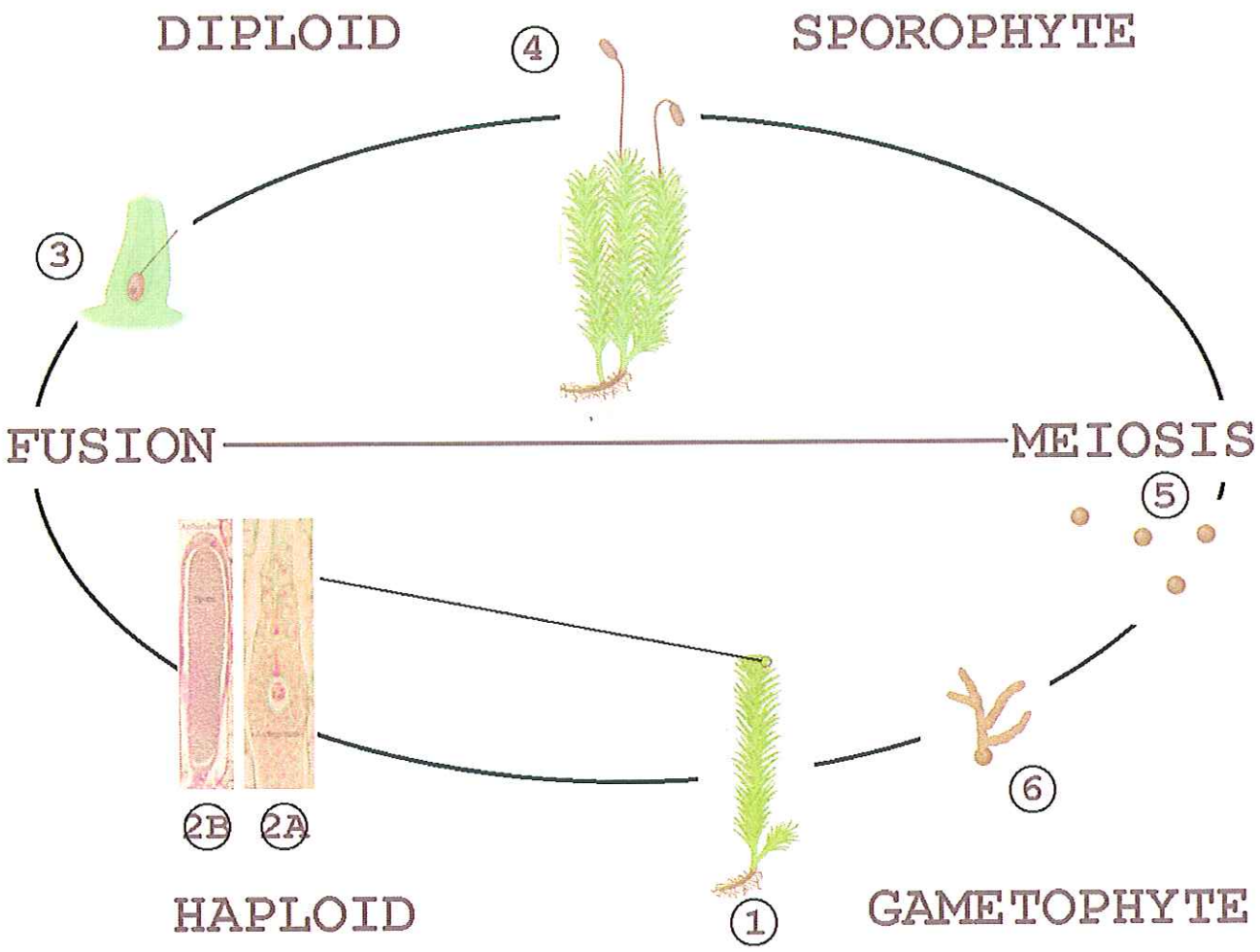


A typical moss plant. The "leafy" green plants near the bottom of the photo represent the **gametophyte** stage of the plant life cycle. The gametophyte plants are the dominant phase of the moss life cycle, but the plants are non-vascular and lack true roots and leaves. In general, mosses are limited in size to no more than a few inches, since water must be drawn up by simple capillary action.

The gametophyte plants produce eggs and sperm in small sex organs near the apex of the plant body. The swimming sperm require **free water** to make their way to the eggs. The fertilized egg or **zygote** is retained in the female organs at the apex of the plant and will develop into the diploid sporophyte stage of the life cycle.

The stalked capsules represent the **sporophyte** stage of the life cycle. The sporophytes grow in attachment to the gametophytes (and are nutritionally dependent on them). They have a diploid chromosome compliment and produce the airborne **spores** (via **meiosis**) which permit mosses to disperse over a wide area. If the spores land on a moist substrate, they will grow into a filamentous, algae-like **protonema**, from which new gametophyte plants will develop.

MOSS LIFE CYCLE



The dominant and obvious state in the moss life cycle is the "leafy", green gametophyte (1) - the "moss plant" that you will encounter on forest floors and other moist habitats. This haploid plant is multi-cellular but non-vascular, so it cannot have true roots, stems, and leaves. The plant does have cellular "rhizoids" that anchor it to the soil or other substrate, a central stem-like stalk, and leaf-like organs. The sex organs are located at the apex of the plant and consist of archegonia, containing an egg (2A), and antheridia (2B) packed with sperm cells. Since the gametophyte plant is already haploid, the gametes (egg and sperm) are produced by simple mitosis.

Fertilization requires a drop of water that will permit sperm cells to swim from the antheridium to the archegonium. The fact that the non-vascular gametophytes require a moist environment and that free water is required for fertilization, essentially limits Bryophytes to environments that are at least seasonally wet. Once the eggs is fertilized, it is now a diploid **zygote** (3) imbedded in the haploid archegonium at the top of the gametophyte plant.

The diploid zygote developes into a simple embryo that grows into the mature **sporophyte**

emerging from the top of the gametophyte plants (4). Early in its development the sporophyte is typically green, but by the time it is mature it is usually non-photosynthetic and dependent on the gametophyte for water and nutrients. The sporophyte has three parts, a bulbous "foot" anchored in the old archegonium, a "stalk", and a "capsule".

Meiosis occurs in the mature capsule, producing four **haploid spores** (5) for each cell that divides. There spores are dispersed by the air and, if the land on a moist substrate, they will produce a filamentous, algal-like structure known as a **protonema** (6). The gametophyte plants (1) develop from the delicate protonema, completing the life cycle.

Ralph E. Taggart (taggart@pilot.msu.edu)