

# Plants I

## Objectives:

1. List the characteristics of plants that link them to their ancestral green algae.
2. Describe the problems faced by plants that moved onto the land.
3. Describe the adaptations of land plants to each problem listed in objective 2 above.
4. Describe the life histories that apply to mosses and ferns and indicate which is the dominant generation in each phylum.
5. Given a plant specimen or description, place it correctly in one of these groups: *Bryophyta*, *Hepatophyta*, *Anthoceroophyta*, *Lycophyta*, or *Monilophyta*.

## Introduction

Although some algae and fungi can eke out a living on land, their relatively undifferentiated bodies have never allowed them to develop adaptations for a truly terrestrial life. Most members of the plant groups that you will be studying in this exercise live exclusively on land, taking advantage of its plentiful sunlight, CO<sub>2</sub> and oxygen, and absence of predators and competition. They have evolved adaptations that enable them to cope in some fashion with the resulting problems of obtaining water, supporting their bodies in air, and providing a mechanism for fertilization. Land plants are thought to have arisen from green algae as both groups contain chlorophylls *a* and *b* (and carotenoid accessory pigments), their cell walls contain cellulose, and they usually store their food reserves in the form of starch. An alga that developed some kind of waterproofing and root-like structures to draw water up from the soil would have been able to live out of water on the shore. This ancestral plant would also have had to nourish and protect the zygote and developing embryo from drying out; it might have done this by retaining the embryo within its body. Such a plant may have given rise to the more highly adapted land plants.

All of these plants show alternation of generations between the sporophyte and gametophyte generations. Sometimes there is a large photosynthetic gametophyte (n) and a tiny sporophyte (2n) that can produce only relatively few spores for dispersal of the species. In other cases, the sporophyte is a large photosynthetic plant that propagates the species through dispersal of many spores or seeds. The trend from simpler plants to more highly evolved plants is for the dominant gametophyte to become smaller and less conspicuous and for the sporophyte to become large and dominant.

The reproduction of many land plants (Phyla *Bryophyta*, *Hepatophyta*, *Anthoceroophyta*, *Lycophyta*, and *Monilophyta*) still involves a flagellated sperm that must swim to the egg through a film of water. These plants are restricted to a moist environment for fertilization to occur. All plants, however, do have the same important adaptation for reproduction on land: the zygote is held within the female reproductive organ where it is surrounded by a layer of sterile jacket cells. These cells protect the embryo while it starts to develop into a new sporophyte within the female reproductive organ.

Ferns, horsetails, and club mosses, as well as the seed plants, have true vascular tissue. The system of xylem and phloem conducts water, minerals, and the products of photosynthesis from one part of the plant to another. The organs of these plants are considered to be true roots, stems, and leaves because they contain vascular tissue. The evolution of vascular tissue had tremendous implications for the plants in these groups. They could grow tall, and their root systems could be extensive. The bryophytes, lacking vascular tissue, are small because there is no way for water to

move from deep in the soil to the leaves or for the leaves to nourish distant roots other than by simple diffusion. Diffusion is only effective over very short distances (2-3 cell diameters) so the photosynthetic and non-photosynthetic parts of a nonvascular plant must be quite close together.

In this exercise you will be examining representatives of the plant divisions whose members do not produce seeds. Using prepared slides and, in some cases, fresh tissue, you will learn to identify the major nonvascular and seedless vascular plant divisions based on their anatomy and morphology. As you examine the slides and plant material, attempt to identify the adaptations in the morphology and lifecycle of these divisions that allowed them to colonize the land and have made them so successful in a terrestrial environment.

## **Kingdom: Plantae**

- Eukaryotes, multicellular.
- Photosynthetic organisms; possess cell walls of cellulose.
- Possess alternation of generations (diploid (2n) sporophyte and haploid (1n) gametophyte).
- Important primary producers; important source of oxygen; control soil erosion; primary succession.
- Distinguished by life cycle and adaptations to land.

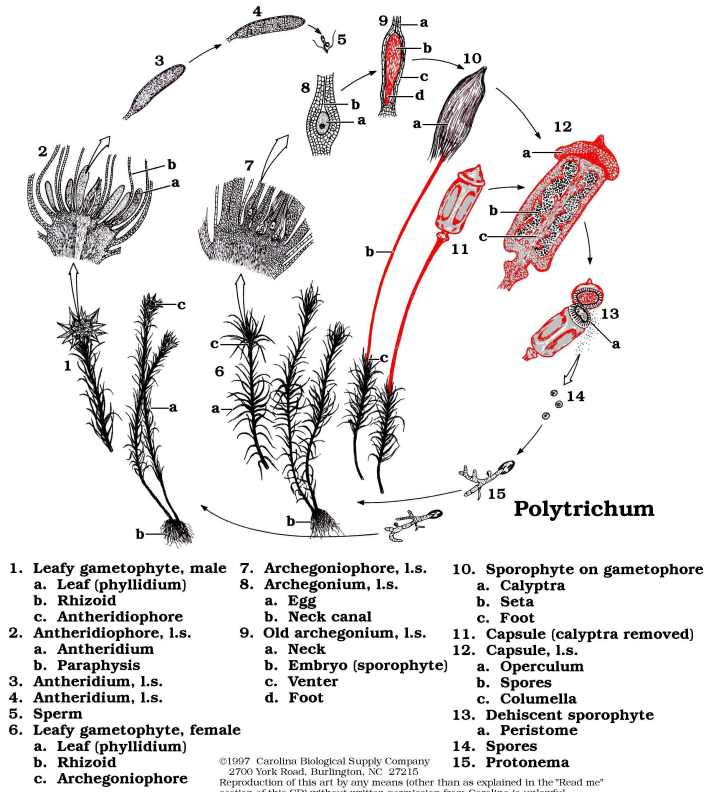
## **Group: Nonvascular plants or Bryophytes**

- Over 15,000 species.
- Haploid (1n) gametophyte is the dominant generation.
- Lack specialized vascular system to transport nutrients, water and minerals. They rely on osmosis and diffusion.
- Lack true roots, stems, or leaves.
- Rather small, the bryophytes require a moist environment for active growth and reproduction.

## **Phylum: Bryophyta** (Greek *Bryon*, moss; *phyta*, plant)

- Mosses.
- About 12,000 species.
- They usually live in dense colonies or beds and play a great role in forming soil in "sterile" environments such as volcanic flows.
- Mosses are also important in helping preventing erosion and holding water.
- Mosses have a leafy gametophyte; bears diploid (2n) leafless sporophyte at the top of the plant or on a short side branch.
- They reproduce both sexually (antheridia and archegonia) and asexually (gemmae and gemmae cups).
- They live in moist tropical and temperate habitats, including freshwater.
- Example: *Sphagnum* (peat moss) and *Polytrichum* (true moss). See diagram of life cycle below.

## MOSS LIFE CYCLE



Answer the following questions:

1. Are spores produced by the moss sporophyte formed by meiosis or mitosis? Are they haploid or diploid?
2. Do the spores belong to the gametophyte or sporophyte generation?
3. Are the gametes haploid or diploid? Are they produced by meiosis or mitosis?
4. Is the dominant generation for the bryophytes the gametophyte or the sporophyte?

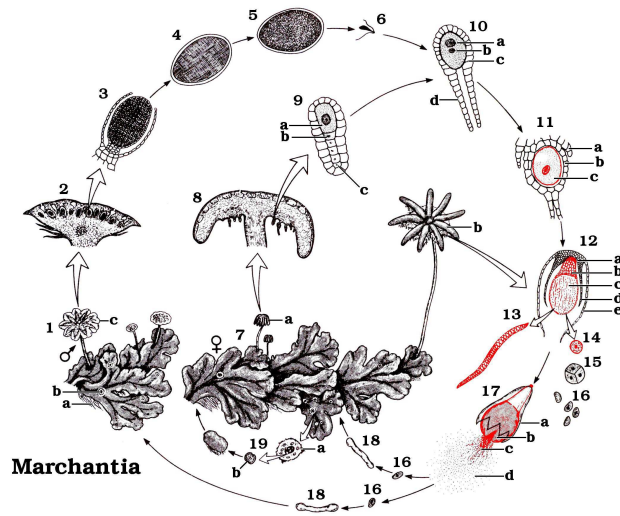
5. Can you suggest an ecological role for bryophytes?

6. What features of the life cycle differs for bryophytes compared with all other land plants?

**Phylum: Hepatophyta** (Greek *Hepar*, liver; *phyta*, plant)

- Liverworts (called liverworts due to the liver-shaped outline of some thalloid gametophytes).
- About 6,500 species
- Liverworts have either a leafy gametophyte (85%) or a thalloid gametophyte (15%).
- They reproduce both sexually (antheridia and archegonia) and asexually (gemmae and gemmae cups).
- They live in moist habitats in tropical regions, on rock, shaded trees, soil, fallen logs, or as epiphyte in waterfalls. Also found in Antarctica.
- They are important pioneer plants in burned areas or other inhospitable areas.
- Examples: *Marchantia* or *Lunularia* (thalloid form) and *Frullania* (leafy form). See diagram of life cycle below.

## LIVERWORT LIFE CYCLE



- |                           |                        |                          |
|---------------------------|------------------------|--------------------------|
| 1. Thallus (gametophyte)  | 10. Archegonium (l.s.) | 13. Elater               |
| a. Rhizoids               | a. Egg nucleus         | 14. Spore mother cell    |
| b. Gemmae cup             | b. Sperm nucleus       | 15. Tetrad               |
| c. Antheridiophore        | c. Venter              | 16. Spores               |
| 2. Antheridiophore (l.s.) | d. Neck                | 17. Dehiscent sporophyte |
| 3-5. Sperm                | 11. Archegonium (l.s.) | a. Sheath                |
| 6. Sperm                  | a. Sheath (involucre)  | b. Capsule               |
| 7. Thallus (gametophyte)  | b. Venter              | c. Elaters               |
| a. Young archegoniophore  | c. Zygote              | d. Spores                |
| b. Mature archegoniophore | 12. Sporophyte         | 18. Germinating spores   |
| 8. Archegoniophore (l.s.) | a. Foot                | 19. Asexual cycle        |
| 9. Archegonium (l.s.)     | b. Seta                | a. Gemmae cup            |
| a. Egg                    | c. Capsule             | b. Gemmae cup            |
| b. Ventral canal cell     | d. Venter              |                          |
| c. Neck canal cells       | e. Sheath              |                          |

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Answer the following questions:

1. Is the plant you observed the gametophyte or the sporophyte?
2. Are the gemmae responsible for asexual or sexual reproduction? Explain your answer.
3. Why are these plants, like most bryophytes, restricted to moist habitats, and why are they always small?

**Division: Anthocerophyta** (Greek *Anthos*, flower; *keros*, wax; *phyta*, plant)

- Hornworts.
- About 100 species.
- They are found in temperate and tropical regions, on tree trunks, cliffs, and in disturbed habitats such as fallow fields and roadsides.
- Hornworts have a thalloid gametophyte and a green and photosynthetic sporophyte.
- They have also a mucus-filled cavity within their thallus, containing cyanobacteria.
- They are pioneers of sterile substrates.
- Example: *Anthoceros*.

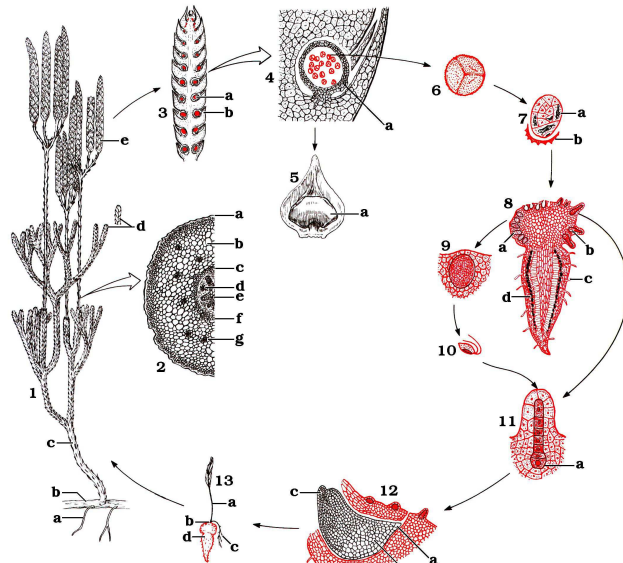
### **Group: Seedless Vascular Plants**

- Over 11,000 species
- Sporophyte is the dominant generation.
- Phloem and xylem are present for support and conduction. . Reproduce and disperse by spores
- Increase in size
- Common in temperate woodlands and tropical rain forests.

**Phylum: Lycophyta** (Greek *Lycos*, wolf; *phyta*, plant)

- Club mosses, spike mosses, quillworts.
- About 1,000 species, all herbaceous (treelike now extinct, many fossils).
- They have unique leaves called microphylls (sterile). If fertile, they bear sporangia and are called sporophylls.
- Some species are heterosporous (e.g. *Selaginella*).
- They live in temperate and tropical habitats.
- Examples: *Lycopodium* (ground pine or ground cedar – see lifecycle diagram below) and *Selaginella* (spike moss).
- Slide of micro and macrosporangia in *Selaginella* strobili.

## LYCOPODIUM LIFE CYCLE



- |  |   |   |
|--|---|---|
| <p><b>1. Sporophyte</b><br/>                     a. Root<br/>                     b. Rhizome<br/>                     c. Stem<br/>                     d. Leaf<br/>                     e. Strobilus</p> <p><b>2. Sporophyte stem (c.s.)</b><br/>                     a. Epidermis<br/>                     b. Cortex<br/>                     c. Pericycle<br/>                     d. Phloem<br/>                     e. Xylem<br/>                     f. Endodermis<br/>                     g. Leaf trace</p> | <p><b>3. Strobilus (l.s.)</b><br/>                     a. Sporangium<br/>                     b. Sporophyll<br/>                     c. Sporophyll (l.s.)</p> <p><b>4. Sporophyll (l.s.)</b><br/>                     a. Sporangium</p> <p><b>5. Sporophyll, adaxial view</b><br/>                     a. Sporangium</p> <p><b>6. Spore tetrad</b></p> <p><b>7. Germinated spore</b><br/>                     a. Endophytic fungus<br/>                     b. Spore case</p> <p><b>8. Gametophyte (l.s.)</b><br/>                     a. Antheridium<br/>                     b. Archegonium<br/>                     c. Rhizoid<br/>                     d. Endophytic fungus</p> | <p><b>9. Antheridium (l.s.)</b></p> <p><b>10. Sperm</b></p> <p><b>11. Archegonium (l.s.)</b><br/>                     a. Egg</p> <p><b>12. Embryo (l.s.)</b><br/>                     a. Suspensor<br/>                     b. Foot<br/>                     c. First leaf</p> <p><b>13. Young sporophyte</b><br/>                     a. Shoot<br/>                     b. Foot<br/>                     c. Root<br/>                     d. Gametophyte</p> |
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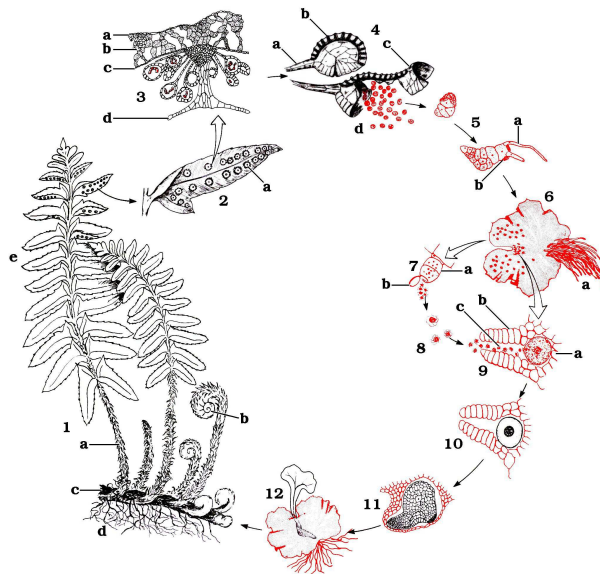
Answer the following questions:

1. Are these leafy plants part of the sporophyte or the gametophyte generation? Do you have any evidence to support your answer?
  
2. What features would you look for to determine if this were a seedless vascular plant?
  
3. Are microspores and megaspores produced by mitosis or meiosis? Will megaspores divide to form the female gametophyte or the sporophyte?

## Phylum: Monilophyta

- Ferns, Horsetail, Whisk ferns and relatives.
- About 12,000 species, ranging from the tropics to the Arctic Circle.
- Mostly terrestrial inhabiting; a few live in aquatic habitats. They can be found in swamps, marshes, moist woodlands, stream banks, rocky crevices of cliffs or mountains, and deserts
- Sporophyte has true roots, rhizome (underground stem), and leaves called megaphylles or fronds that can be fertile or sterile.
- Spore production occurs in clustered sporangia called sori under the fronds.
- Examples: *Salvinia*, *Marsilea* (cloverleaf fern), *Azolla* (water fern), Royal fern, Cinnamon fern, Bracken fern, Goldfoot fern, Shoestring fern, and Resurrection fern (*Pleopeltis polypodioides*). Also slides of sporophyte; sori; gametophyte with archegonia and antheridia. See diagram of life cycle below. (homosporous ).

### FERN LIFE CYCLE



- |                                 |                       |                               |
|---------------------------------|-----------------------|-------------------------------|
| 1. Mature sporophyte            | 4. Sporangium         | 7. Antheridium                |
| a. Petiole (leaf stalk)         | a. Stalk              | a. Ring cell                  |
| b. Circinate leaf (fiddle head) | b. Annulus            | b. Cap cell                   |
| c. Rhizome (stem)               | c. Lip cell           | c. Neck cell                  |
| d. Adventitious roots           | d. Spores             | 8. Sperm                      |
| e. Frond                        | 5. Young prothallium  | 9. Archegonium with egg       |
| 2. Leaflet, undersurface        | a. Rhizoid            | a. Venter                     |
| a. Sorus                        | b. Spore wall         | b. Neck                       |
| 3. Section of Sorus             | 6. Mature prothallium | c. Neck canal                 |
| a. Upper epidermis              | a. Rhizoids           | 10. Archegonium with zygote   |
| b. Spongy tissue                |                       | 11. Sporophyte embryo         |
| c. Lower epidermis              |                       | 12. Sporophyte on gametophyte |
| d. Indusium                     |                       |                               |

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Answer the following questions about ferns:

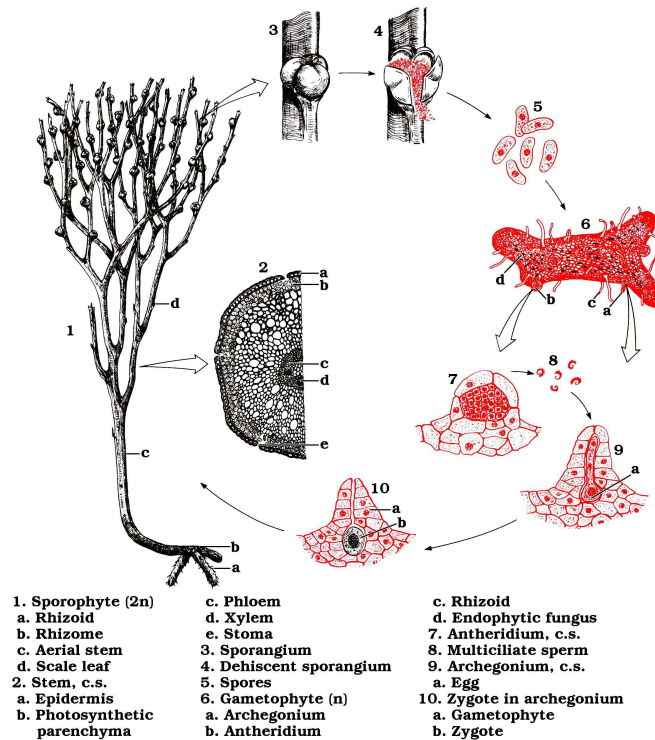
1. Are the spores produced by the fern sporophyte formed by mitosis or meiosis?
2. Do the spores belong to the gametophyte or the sporophyte generation?
3. Are the gametes produced by mitosis or meiosis?
4. Are the archegonia and antheridia haploid or diploid? (HINT: Think about which generation produces them)
5. Is the dominant generation for the fern the gametophyte or the sporophyte?
6. Can you suggest an ecological role for ferns?

### **Psilotophyta** (Greek *Psilo*, bare, smooth; *phyta*, plant)

- Whisk ferns.
- About 12 species
- They are the simplest vascular plants. They have dichotomous branching with vascular tissue, many chromosomes, and lack true roots and leaves (like nonvascular plants).
- Most species are extinct, the remaining species are found in the subtropical and temperate areas.

- Considered fern allies, they are closely related to the ferns because of similarities at the molecular level (now commonly included in fern division).
- Example: *Psilotum nudum*. See the lifecycle diagram below.

### PSILOTUM LIFE CYCLE

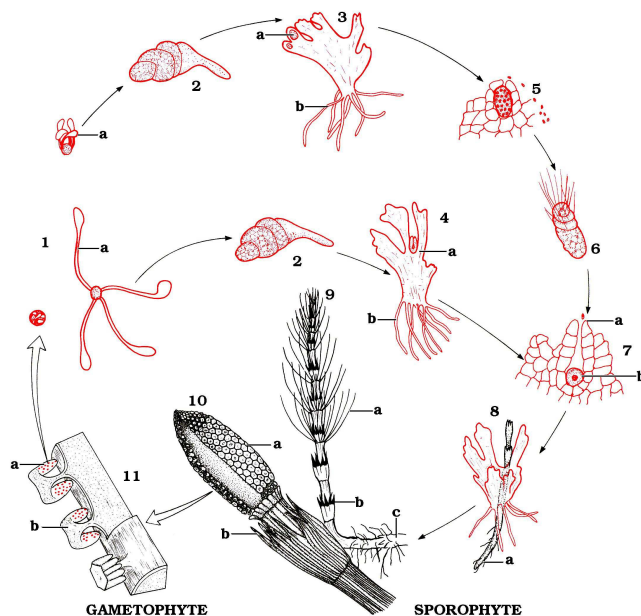


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### Sphenophyta (Greek *Sphen*, wedge; *phyta*, plant)

- Horsetails (scouring rushes).
- About 15 species, all herbeaceous.
- They have true roots, rings of wedge-shaped leaves and jointed hollow stems impregnated with silica, giving them a gritty texture.
- They can produce two kinds of shoots: vegetative (non-reproductive) shoots and fertile shoots.
- The spores are produced in sporangia on cone scales on a cone called strobilus, located at the end of the fertile shoots.
- They live in salt flats, along roadsides and stream banks, and in moist woods.
- In pioneer days the stems were used for scouring pots and pans, thus the common name of scouring rushes.
- Example: *Equisetum*. See the lifecycle diagram below.

## EQUISETUM LIFE CYCLE



### GAMETOPHYTE

1. Spore
  - a. "Elaters"
2. Germinating spore
3. Prothallium
  - a. Antheridium
  - b. Rhizoid
4. Prothallium
  - a. Archegonium
  - b. Rhizoid
5. Antheridium
6. Sperm
7. Archegonium
  - a. Sperm
  - b. Egg

### SPOROPHYTE

8. Young sporophyte on gametophyte
  - a. Primary root
9. Vegetative shoot
  - a. Branches
  - b. Scale leaf
  - c. Rhizome
10. Fertile shoot
  - a. Strobilus
  - b. Scale leaf
11. Portion of strobilus with three sporophylls
  - a. Sporangium
  - b. Sporangiphore

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Answer the following questions about Whisk ferns and Horsetails:

1. Are the spores in the sporangia produced by mitosis or meiosis?
  
2. Are the sporangia haploid or diploid? (HINT: Think about which generation produces them)
  
3. Once dispersed, will these spores produce the gametophyte or the sporophyte generation?

## Laboratory Questions

1. Draw a diagram of at least one member of each of the plant divisions listed above, identifying the major morphological features. Where slides are available of the reproductive structures for these plants, include these in your drawings.

2. Fill out the table below, indicating the primitive and advanced features of seedless vascular plants with respect to their success in a terrestrial environment. (Primitive refers to ancestral traits, that is, inherited from ancestral algae species, while advanced refers to derived traits, that is, an adaptation to life on land)

<b>Primitive features</b>	<b>Advanced features</b>

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3. For each of the features listed below describe its contribution, if any, to the success of land plants.

Gametangium

Cuticle

Rhizoid

Motile sperm

Vascular tissue

Gemma

4. Identify the function of each structure listed below. Indicate whether they are part of the gametophyte or sporophyte generation, and provide an example of a plant that has each structure.

<b>Structure</b>	<b>Function</b>	<b>Sporophyte/Gametophyte</b>	<b>Example</b>
Antheridium			
Archegonium			
Spore			
Gamete			
Rhizome			
Gemma			
Sporangium			
Strobilus			
Sorus			

5. What is the major difference between the alternation of generations in the life cycles of bryophytes and seedless vascular plants?