AP BIOLOGY
DIVERSITY OF LIFE
ACTIVITY #4

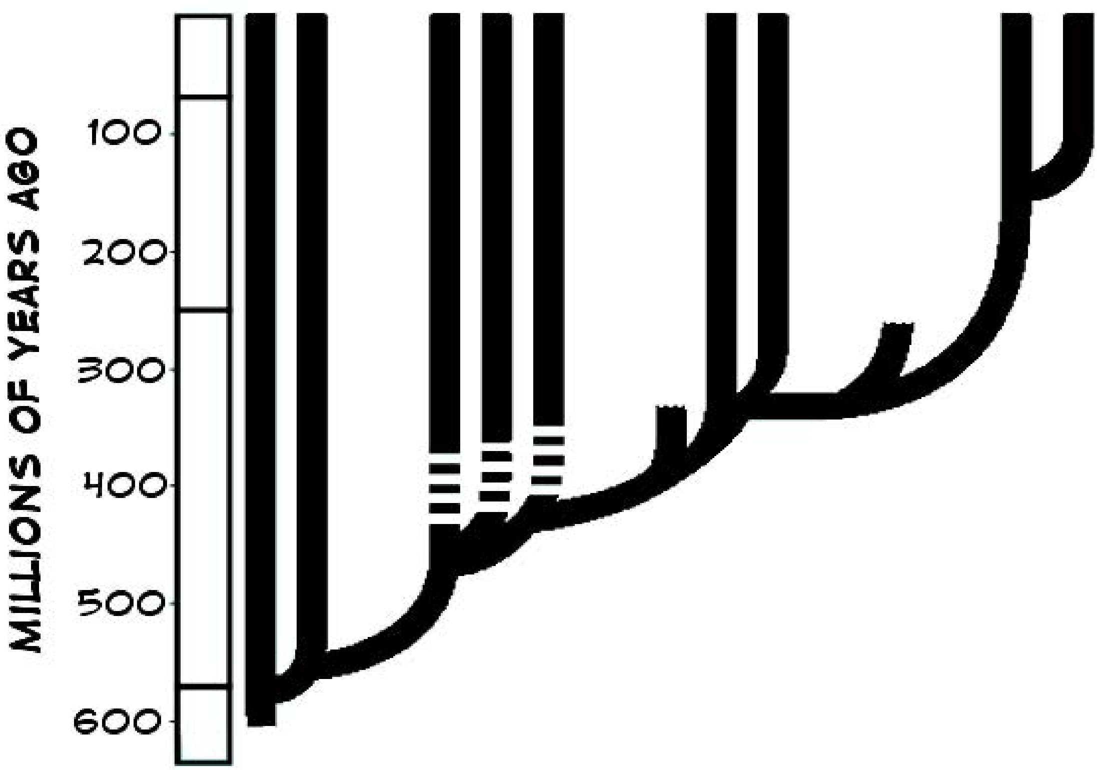
NAME______________________

DATE___________HOUR_____

KINGDOM PLANTAE

GENERAL CHARACTERISTICS

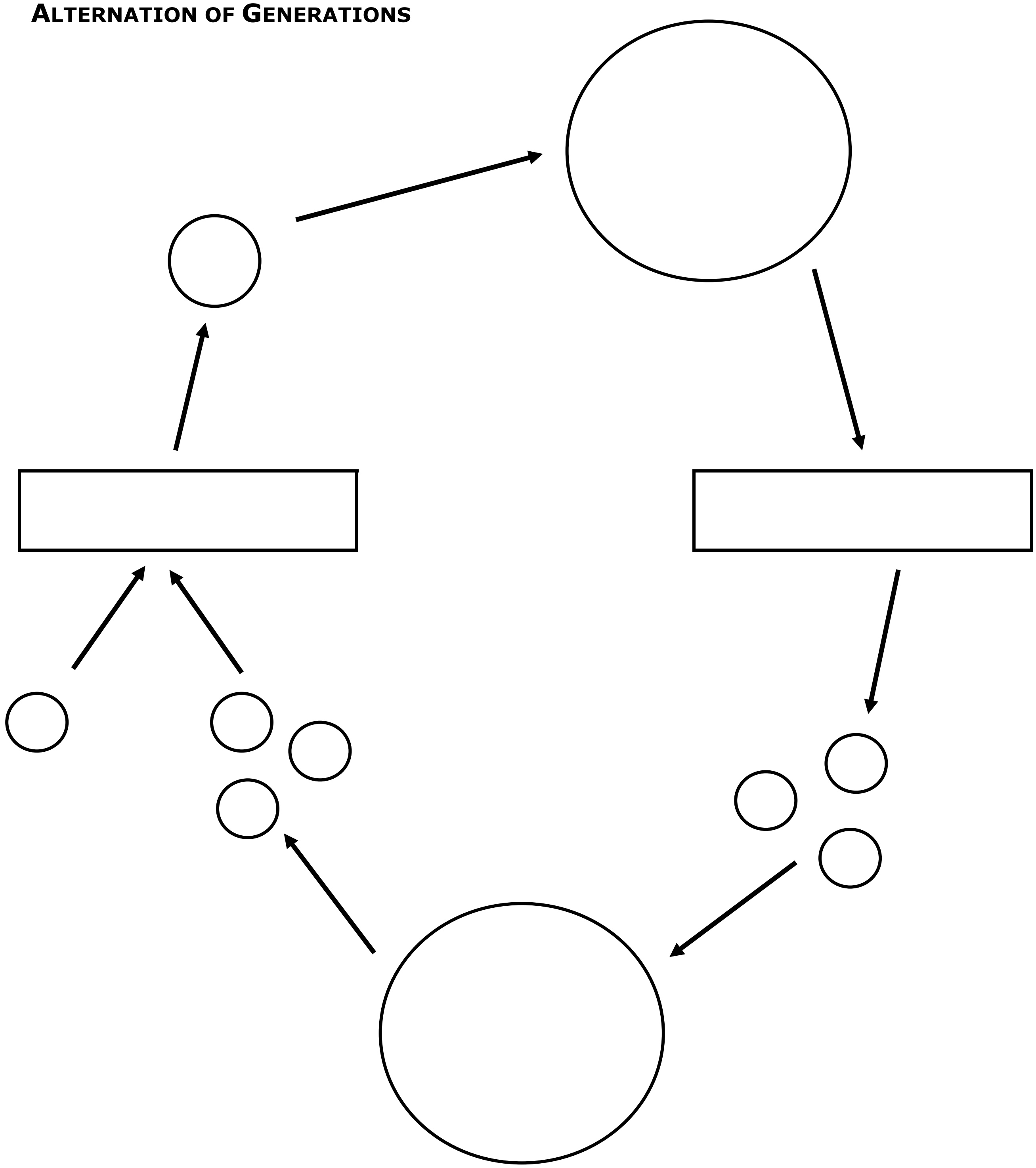
PLANT EVOLUTION HIGHLIGHTS



Challenges to Life on Land

Problem: Resources of water and light segregated **Solution:**
Problem: Support **Solution:**
Problem: All parts of the plant are not exposed to water. All parts of the plant are not photosynthetic. **Solution:**
Problem: Lack of water for sperm transport **Solution:**
Problem: Exposure to damaging UV Radiation **Solution:**

ALTERNATION OF GENERATIONS



PLANT LAB PART I: BRYOPHYTES

INTRODUCTION

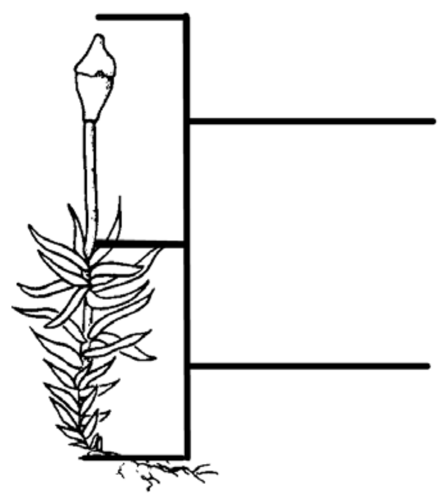
The bryophytes are composed of three divisions of related plants that share some key characteristics and include mosses (Bryophyta), liverworts (Hepatophyta), and hornworts (Anthocerophyta). The term *bryophyte* does not refer to a taxonomic category; rather, bryophytes are an ancient group of plants that appear to have evolved into several different groups independently and that did not give rise to any other living group of plants. They are small plants that generally lack any **vascular tissue** (specialized cells for the transport of material), although water-conducting tubes appear to be present in some mosses. However, these tubes may be unrelated to the vascular tissue in vascular plants. The life cycle for bryophytes differs from all other land plants because the gametophyte is the dominant and conspicuous plant. Because bryophytes are nonvascular, they are restricted to moist habitats and have never attained the size and importance of other groups of plants. The gametophyte plants remain close to the ground, enabling the motile sperm to swim from the antheridium to the archegonium and fertilize the egg. They lack stomata on the surface of the **thallus** (plant body), which is not organized into roots, stems, and leaves.

Bryophytes are not important economically, with the exception of sphagnum moss, which in its harvested and dried form is known as peat moss. Peat moss is absorbent, has an antibacterial agent, and was reportedly used as bandages and diapers. Today peat moss is used primarily in the horticultural industry.

STATION #1 – MOSS PLANT

1. Examine the living colonies of mosses. Usually you will find both generations, gametophyte and sporophyte, growing together. Identify the leafy **gametophyte** and the dependent **sporophyte**, which appear as elongated structures growing above the gametophyte. The sporophyte develops and matures while attached to the gametophyte and receives its moisture and nutrients from the gametophyte

2. Label the **gametophyte** and **sporophyte** on the diagram at the right.

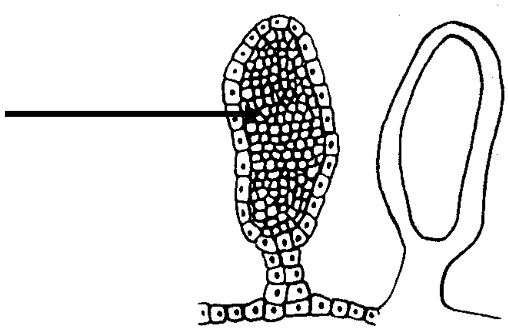


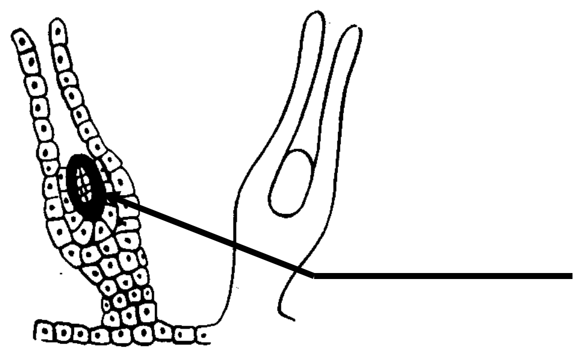
Station #2 – Moss Antheridia and Archegonia

3. The gametes are produced by the gametophyte in gametangia, which protect the gametes but are not readily visible without a microscope. Observe the prepared slide of the **antheridia**. The antheridia are found at the tip of the male gametophyte and produce the **sperm**. Find the sperm-forming tissue inside the antheridia.

4. Observe the prepared slide of the **archegonia**. The archegonia are found at the tip of the female gametophyte. The moss archegonium has a very long neck and a rounded base. A single **egg** should be visible at the base of the archegonium.

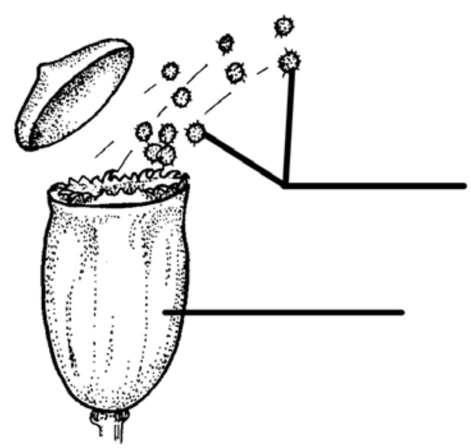
5. Indicate which diagram represents the **antheridia** and which represents the **archegonium** by writing the name of the structure in the box above the diagrams. Then label the **sperm** and **egg**.





Station #3 – Moss Capsule

6. The sperm swim through a film of water to the archegonium and swim down the neck to the egg, where fertilization takes place. The diploid zygote divides by mitosis and develops into an embryonic sporophyte within the archegonium. As the sporophyte matures, it grows out of the gametophyte body. **Spores** develop in the **sporangium (capsule)** at the end of the sporophyte. The spores are discharged from the capsule and will germinate to form the **protonema**. Examine the prepared slide of a capsule and label the following structures on the diagram at the right: **capsule**, **spores**.



MOSS LIFE CYCLE

7. Match the structure with the correct letter from the diagram below.

______ Antheridia

______ Archegonia

______ Egg cell

______ Female gametophyte

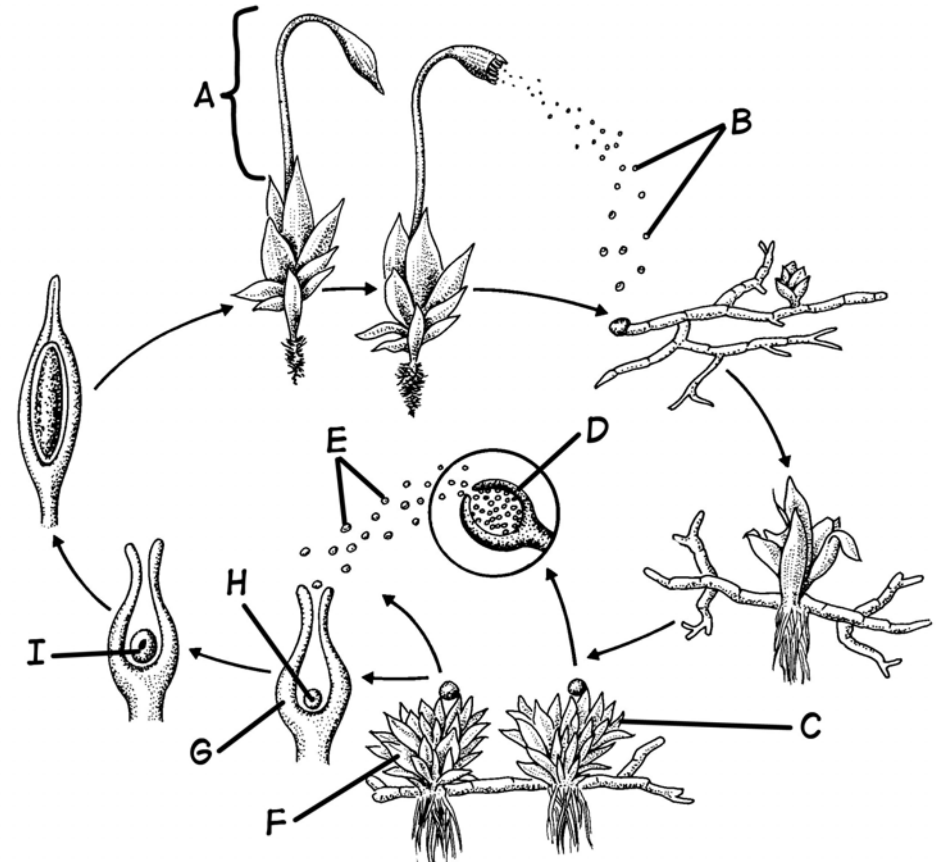
______ Male gametophyte

______ Sperm cells

______ Spore

______ Sporophyte

______ Zygote



8. Are the spores produced by meiosis or mitosis? ________________________

9. Are the spores haploid or diploid? ___________________________________

10. Are the gametes produced by meiosis or mitosis? ______________________

11. What is the dominant generation (sporophyte or gametophyte)? __________

PLANT LAB PART II: FERNS – SEEDLESS VASCULAR PLANTS

Seedless, terrestrial plants are analogous to the first terrestrial vertebrae animals, the amphibians, in their dependence on water for external fertilization and development of the unprotected, free-living embryo. Both groups were important in the Paleozoic era, but have undergone a steady decline in importance since that time. Seedless plants were well suited for life in the vast, swampy areas that covered large areas of the Earth in the Carboniferous, but were not suited for the drier areas of the Earth at that time or for later climatic changes that caused the vast swamps to decline and disappear. The fossilized remains of the swamp forests are the coal deposits of today.

Although living representatives of the seedless vascular plants have survived for millions of years, their limited adaptations to the land environment have restricted their range. All seedless vascular plants have vascular tissue, which is specialized for conducting water, nutrients, and photosynthetic products. Their life cycle is a variation of alternation of generations, in which the sporophyte is the dominant plant; the gametophyte is usually independent of the sporophyte. These plants have stomata and structural support tissue. However, they still retain the primitive feature of motile sperm that require water for fertilization; therefore, the gametophyte is small and restricted to moist habitats.

Economically, the only important members of this group are the ferns -- a significant horticultural resource.

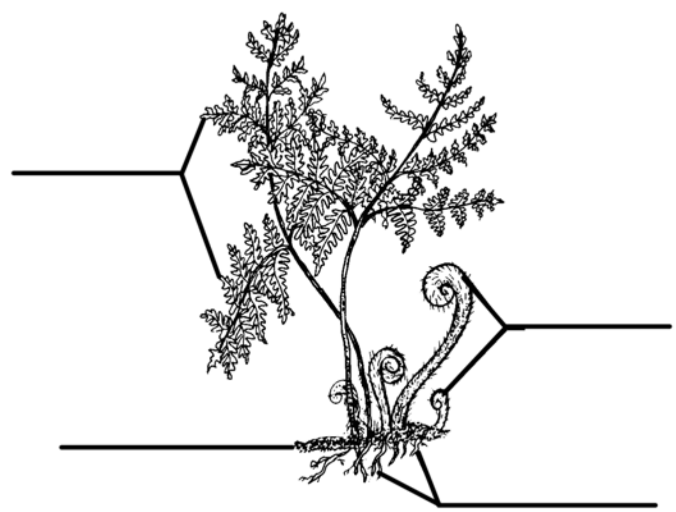
The divisions included in the seedless vascular plants are Lycophyta (club mosses), Sphenophyta (horsetails), and Pterophyta (ferns). Only the ferns will be studied in this lab.

Most ferns are small plants that lack woody tissue. However, an exception would be the tree ferns found in tropical regions. Ferns are the most successful of the seedless vascular plants, occupying diverse habitats from the desert to the tropical rain forests. Many cultivated ferns are available for home gardeners.

STATION #4 – FERN SPOROPHYTE

12. Examine the living fern sporophyte on display. Note the deeply dissected leaves **(fronds),** which arise from an underground stem called the **rhizome.** The rhizome functions like a root to anchor the plant. See if you can find any "fiddleheads", uncoiled leaves at the base of the rhizome.

13. Label the following parts on the diagram at right: **Frond, rhizome, roots, fiddlehead.**



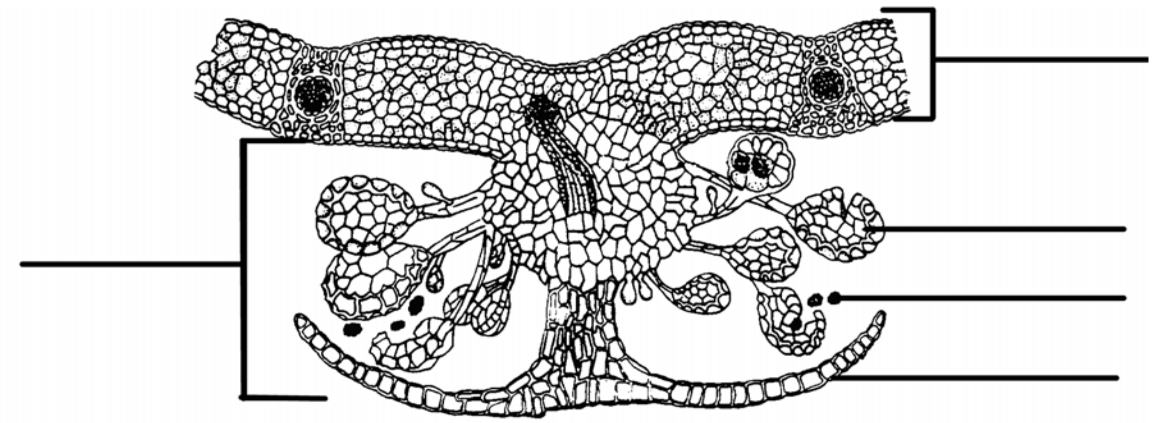
STATION #5 – SORI

14. Observe the dark spots, or **sori** (sorus, s.), which are clusters of sporangia, on the underside of some leaves, called **fertile fronds**.

15. Observe the prepared slide of a whole mount of sori. Identify the stalked **sporangia**. The sporangia contain cells in different stage of meiosis, leading to spores that are seen in different stages of maturation. These stages will not be distinguishable to you under the microscope.

16. Examine the prepared slide of a cross section through a sorus. Identify the **frond, sporangia, spores** inside the **sporangia**, and the **indusium**, a protective covering over the sporangia.

17. Label the following structures on the diagram below:
Frond, indusium, sorus, sporangium, spores



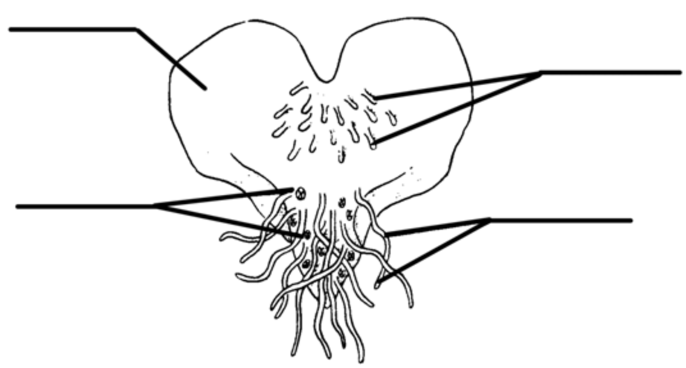
STATION #6 – FERN GAMETOPHYTE

18. The haploid spores of ferns fall to the ground and grow into heart-shaped, **gametophyte** plants. Examine the fern gametophyte on display. Note the shape, color, and the presence of **rhizoids**, root-like multicellular structures.

19. All seedless terrestrial plants depend on an external source of water for sperm to swim to the egg for fertilization. The sexual organs, which bear male and female gametes, are borne on the underside of the gametophyte. Egg cells are borne in urnlike structures called **archegonia**. Archegonia are usually found in the notch of the heart-shaped gametophyte. Examine the prepared slide of the archegonia.

20. The sperm are produced in globular structures called **antheridia**. Antheridia are usually found over most of the underside of the gametophyte. Examine the prepared slide of the antheridia.

21. Label the following structures on the diagram at the right:
Archegonia, antheridia, gametophyte, rhizoids



FERN LIFE CYCLE

22. Match the structure with the correct letter from the diagram

_______ Antheridium

_______ Archegonium

_______ Egg cell

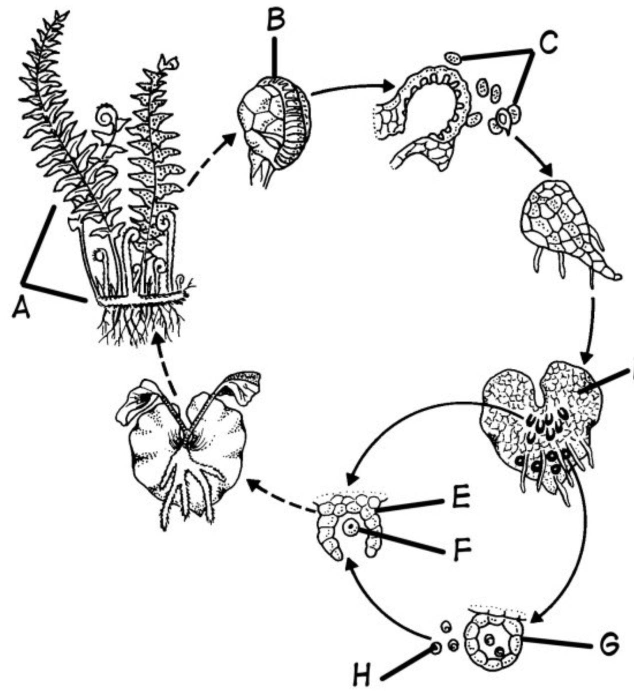
_______ Gametophyte

_______ Sporangia

_______ Sporophyte

_______ Spores

_______ Sperm



23. Are the spores produced by meiosis or mitosis? ___________________________

24. Are the gametes produced by meiosis or mitosis? ________________________

25. Are the archegonia and antheridia haploid or diploid? _____________________

26. What is the dominant generation (sporophyte or gametophyte)? ___________

27. How is the life cycle of a fern different from that in the moss?

____

____

PLANT LAB PART III: PINE LIFE CYCLE

INTRODUCTION

For 425 million years, plants have been adapting to the rigors of the land environment. The nonvascular bryophytes with their small and simple bodies survived in moist habitats, at least moist for part of their life cycle. During the cool Carboniferous period, vascular seedless plants dominated the landscape of the swamp forests that covered much of the Earth. Although these plants were more complex and better adapted to the challenges of the land environment, they still were dependent on water for sperm to swim to the egg. During the Mesozoic era, 150 million years ago, the Earth became warmer and drier and the swamp forests declined, presenting another challenge to terrestrial plants and animals. The Earth at that time was a world dominated by reptilian vertebrates, including the flying, running, and climbing dinosaurs. The landscape was dominated by a great variety of seed-bearing plants called **gymnosperms** (literally, "naked seeds"), which in the Carboniferous period had been restricted to dry sites. During the Mesozoic, a number of distinct gymnosperm groups diversified, and a few of the spore-bearing plants survived.

Vertebrate animals became fully terrestrial during the Mesozoic with the emergence of reptiles, which were free from a dependence on water for sexual reproduction and development. This was possible because of an internal method of fertilization and the development of the amniotic egg. The amniotic egg carries its own water supply and nutrients, permitting early embryonic development to occur on dry land, a great distance from external water. In an analogous manner, the gymnosperms became free from dependence on water by a process of internal fertilization via the pollen grain and development of a seed, which contains a dormant embryo with a protective cover and special nutrient tissue.

Several features of the gymnosperms have been responsible for their success. They have reduced gametophytes; the male gametophyte is a multinucleated pollen grain, and the female gametophyte is small and retained within the sporangium in the ovule of the sporophyte generation. The pollen grain is desiccation-resistant and adapted for wind pollination, removing the necessity for fertilization in a watery medium. The pollen tube conveys the sperm nucleus to an egg cell, and the embryonic sporophyte develops within the gametophyte tissues, which are protected by the previous sporophyte generation. The resulting seed is not only protected from environmental extremes, but is packed with nutritive materials and can be dispersed away from the parent plant. Gymnosperms also have advanced vascular tissues: xylem for transporting water and nutrients, and phloem for transporting photosynthetic products. The xylem cells are called tracheids and are more efficient for transport than those of the seedless vascular plants.

All gymnosperms are **wind-pollinated** trees or shrubs, most bearing unisexual, male, and female reproductive structures on different parts of the same plant. Gymnosperms produce two kinds of spores: male **microspores,** which develop into **pollen,** and female **megaspores.** The megaspore develops into the female gametophyte, which is not free-living as with ferns, but retained within the **megasporangium** and nourished by the sporophyte parent plant. Numerous pollen grains (the male gametophytes) are produced in each **microsporangium** and when mature are released into the air and conveyed by wind currents to the female cone. **Pollen tubes** grow through the tissue of the megasporangium, and the **sperm nucleus** is released to fertilize the egg. After fertilization, development results in the formation of an **embryo.** A **seed** is a dormant embryo embedded in nutrient tissue of the female gametophyte and surrounded by the hardened sporangium wall, or **seed coat.**

STATION #7 – PINE SPOROPHYTE

28. Examine the pine branch and notice the arrangement of leaves in a bundle. A new twig at the end of the branch is in the process of producing new clusters of leaves.

    Is this plant haploid or diploid? ____________________________________

29. Examine the small **cones** produced at the end of the pine branch on the specimen. Remember that cones contain clusters of sporangia.

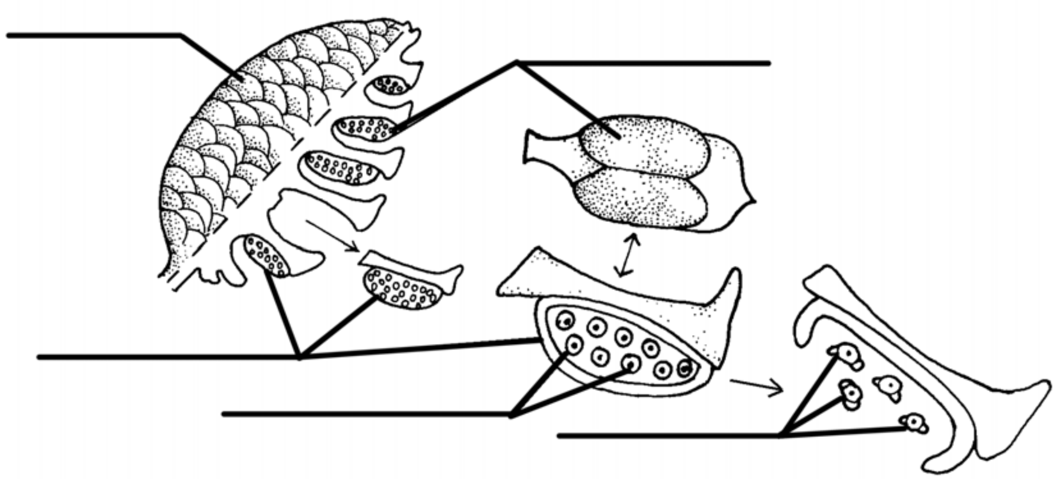
    What important process occurs in the sporangia? ______________________

30. Locate the ovulate cone and a pollen cone. Elongated male **pollen cones** are present only in the spring, producing pollen within overlapping bracts or scales. The small, more rounded female cones that look like miniature pine cones are produced on stem tips in the spring and are called **ovulate cones**. Female cones persist for several years. Observe the overlapping scales, which contain the sporangia.

STATION #8 – PINE MALE GAMETOPHYTE

31. Examine a longitudinal section of the pollen cone on a prepared slide and identify its parts. Observe that pollen cones are composed of radiating scales, each of which carriers two elongated sacs on its lower surface. The sacs are the **microsporangia**. **Microspore mother cells** within microsporangia divide by meiosis. Each produces four haploid **microspores**, which develop into **pollen grains**.

32. Label the following parts on the diagrams below:
    Pollen cone, microsporangia, microspore mother cells, pollen grains



33. Observe a slide of pine pollen. Note the wings on either side of the grain. The pollen grain is the greatly reduced male gametophyte. The outer covering of the pollen is desiccation-resistant. Once mature, pollen will be wind dispersed, sifting down into the scales of the female cones. Draw several pollen grains in the box at the right.

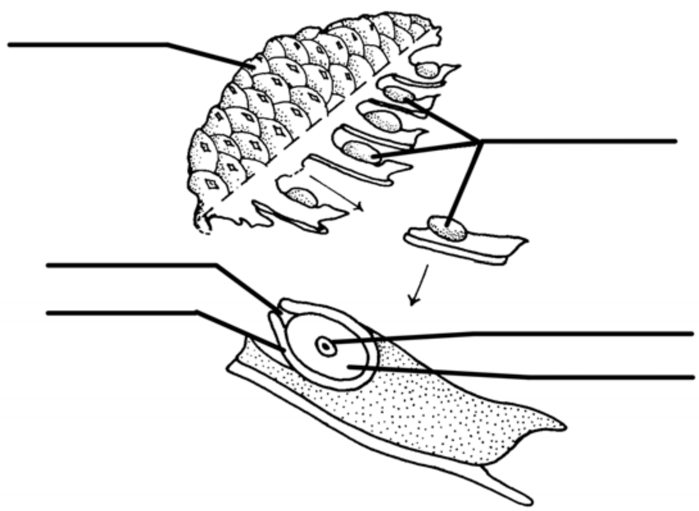
Pollen Grains

STATION #9 – PINE FEMALE GAMETOPHYTE

34. Examine a longitudinal section of a young ovulate cone on a prepared slide. Note the **ovule**, (contains the megasporangium) on the upper surface of the scales. Protective **integuments** (wall of the ovule) surround the **nucellus** (megasporangium). In the center of the nucellus is the **megaspore mother cell**. The diploid **megaspore mother cell** will produce haploid **megaspores**, the first cells of the gametophyte generation. In the first year of ovulate cone development, pollen sifts into the soft bracts (pollination) to the **micropyle** (the opening in the ovule). The pollen tube begins to grow, digesting the tissues of the ovule.

35. Label the following parts on the diagram below:

Ovulate cone
Ovule
Integuments
Nucellus
Megaspore mother cell
Micropyle



PINE LIFE CYCLE

36. What is the function of the wings on the pollen grain?

____

37. Why is wind-dispersed pollen an important phenomenon in the evolution of plants?

____

____

38. Are microspores and megaspores produced by mitosis or meiosis? _________

39. One of the major trends in plant evolution is the reduction of the gametophytes. Describe the male and female gametophytes in terms of size and location.

____

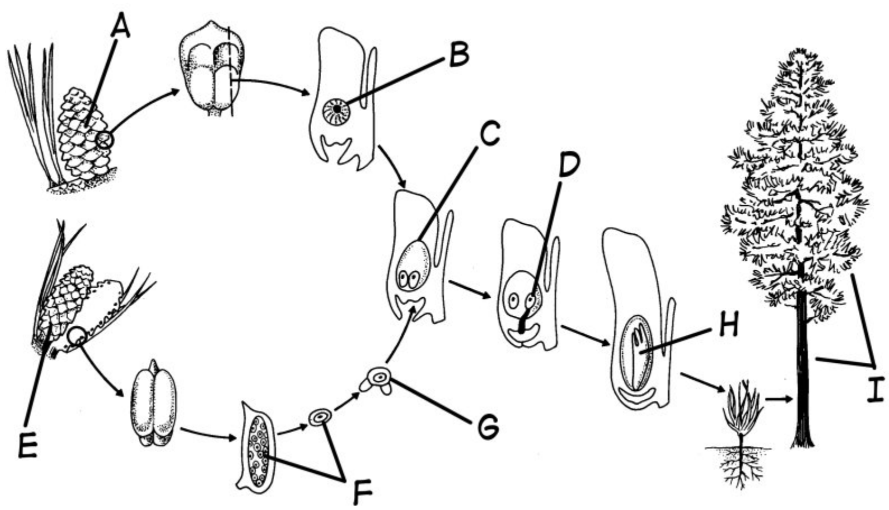
____

40. How is the life cycle of a pine different from that of a fern?

____

____

41. Match the structure with the correct letter from the diagram.



_______ Egg cell	_______ Microspores
_______ Embryo	_______ Ovulate cone
_______ Female gametophyte	_______ Pollen cones
_______ Male gametophyte	_______ Pollen grain
_______ Megaspore mother cell	_______ Sporophyte

PLANT LAB PART IV: ANGIOSPERM LIFE CYCLE

INTRODUCTION

Flowering plants (also known as **angiosperms)** are economically important to humans for many reasons. The number of products we use each day that come from flowering plants is staggering. They produce much of our food and large amounts of fiber for our housing and clothing. These products include your morning paper, the wooden chair you may be sitting on, or the watermelon you had for lunch.

The life cycle of flowering plants may be confusing because sexual qualities are often mistakenly attributed to the sporophyte generation and because the gametophyte is usually not known at all. The life cycle of the flowering plants is similar to the life cycle of the mosses and the ferns, but with some major modifications.

There are many different types of flowers that can appear on sporophyte plants. Some flowers contain both **stamens** and a **carpel,** while others have just one or the other. Both the stamen and carpel contain tissue where spores are produced by meiosis. Angiosperms can produce two types of spores within the flower. The smaller of the two kinds of spores (microspores) develop into the male gametophyte and the larger spores (megaspores) develop into the female gametophyte.

Special cells within the **anther** portion of the stamen produce four cells called **microspores** from one microspore mother cell, or **microsporocyte.** The single nucleus of each microspore divides mitotically and produces a cell with a generative nucleus and a tube nucleus. This microscopic cell (pollen grain) contains two nuclei and is the male gametophyte plant. The generative nucleus will divide and produce two sperm nuclei.

How do these sperm reach the egg? The entire male gametophyte plant (pollen grain) is carried by the wind, insects, birds, or bats to the carpel containing the egg. This process is called **pollination.**

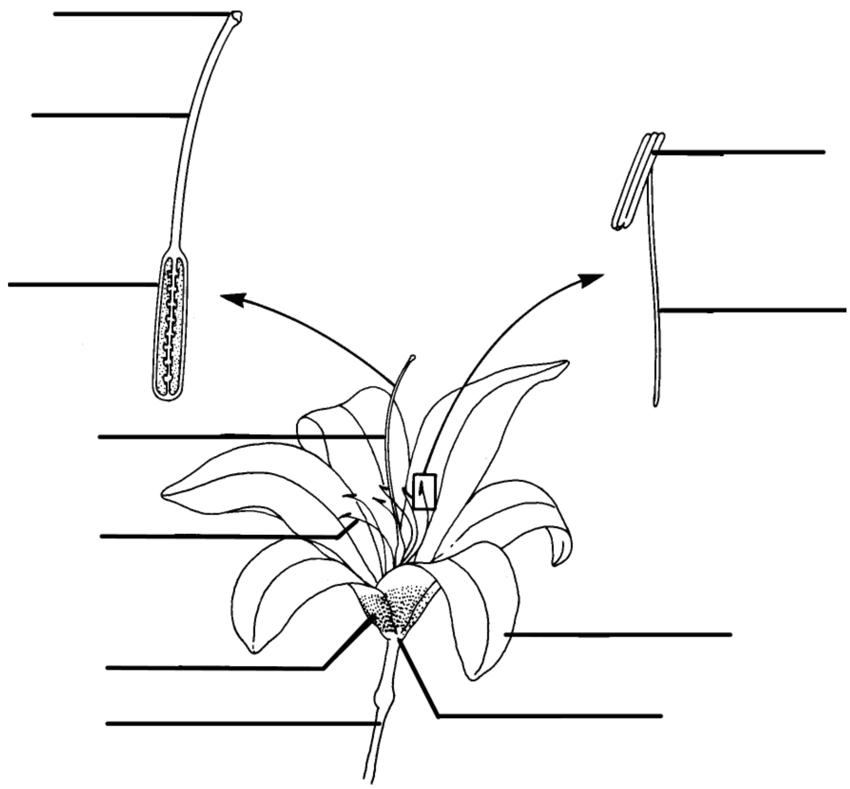
The base of the carpel of the flower contains the ovary. Within the ovary one or more ovules are found, containing a specialized cell called a megaspore mother cell, or **megasporocyte.** This diploid cell produces four haploid cells by meiosis. Three of these atrophy and the remaining one develops into a megaspore. As you have learned previously, spores germinate and grow, but in this instance the megaspore develops within the ovule, which is within the ovary. The development proceeds as follows: The single nucleus produces two, then four, then eight nuclei by mitosis. One nucleus from each set of four migrates to the center of the **embryo sac** (female gametophyte) and becomes the two polar nuclei. Cytokinesis then occurs, walling off three cells at one end of the developing female gametophyte and three at the opposite end. Thus the microscopic female gametophyte contains eight nuclei in seven cells.

Huge quantities of pollen must be produced to ensure that pollen arrives at a carpel of another flower of the same species. Once the pollen reaches the carpel, the tube nucleus of the pollen grain causes a pollen tube to grow through the tissue of the carpel and enter through the **micropyle** (an opening in the ovule) to reach the egg within the female gametophyte. One sperm fertilizes the egg and produces a diploid (2n) zygote, which grows into an embryo sporophyte. The second sperm fertilizes the two already fused polar nuclei, producing a triploid (3n) endosperm nucleus. This endosperm cell will produce a large number of cells by mitosis to serve as food for the sporophyte embryo. Portions of the ovule, the embryo, and the endosperm tissue make up the resulting seed. When the seed is planted it germinates, and the embryo sporophyte grows rapidly into a new mature sporophyte.

STATION #10 – FLOWER

42. Study the flowers on display. Identify the parts in the chart below and label the drawing.

FLOWER PART	**DESCRIPTION**
Pedicel	Stalk of the flower
Receptacle	The tip of the pedicel where the flower parts attach
Sepal	The outer whorl of modified leaves; may be green, brown, or colored like the petals; may appear as small scales or be petal-like
Petal	Colored, white, or even greenish whorl of modified leaves found just inside the sepals
Stamen	The male reproductive structure; produces pollen; composed of the **filament** (the thin stalk that supports the anther) and **anther** (the pollen-producing structure)
Carpel	The female reproductive structure; composed of the **stigma** (receptive tip of the carpel that is often sticky or hairy and is where pollen is placed), the **style** (tissue connecting the stigma and ovary), and the **ovary** (base of the carpel that protects the ovules found within)

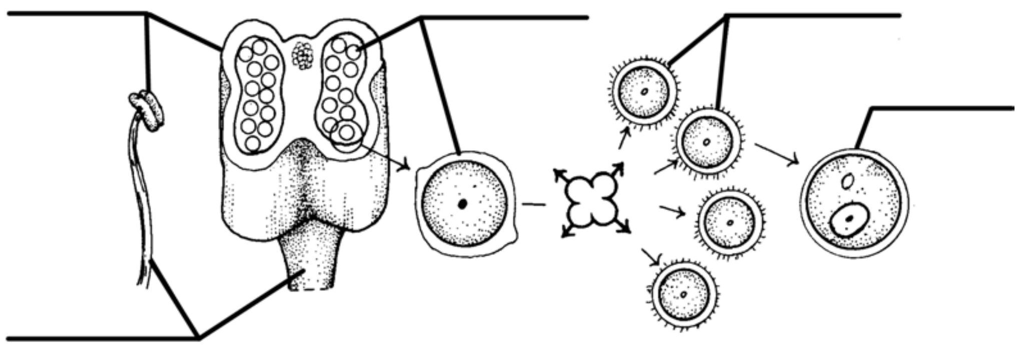


STATION #11 – ANGIOSPERM MALE GAMETOPHYTE

43. Examine the prepared slide of a cross section through the **stamens** of *Lilium*. The slide shows six anthers and may include a centrally located ovary that contains ovules.

44. Observe a single **anther**, which is composed of four **anther sacs** (microsporangia). Note the formation of **microspores** (with a single nucleus) from a diploid **microspore mother cells**. You may also see mature **pollen grains** with two nuclei.

45. Label the following parts on the diagram below:
Anther, filament, microspore mother cell, microspore, mature pollen grain



STATION #12 – ANGIOSPERM FEMALE GAMETOPHYTE, POLLINATION, & FERTILIZATION

46. Examine the prepared slide of the *Lilium* ovary and locate the developing ovules. Each **ovule**, composed of the megasporangium and other tissues, contains a **megaspore mother cell** (diploid), which produces **megaspores** (haploid), only one of which survives. The megaspore will divide three times by mitosis to produce the eight nuclei in the **embryo sac**, which is the greatly reduced female gametophyte. Note that angiosperms do not even produce an archegonium.

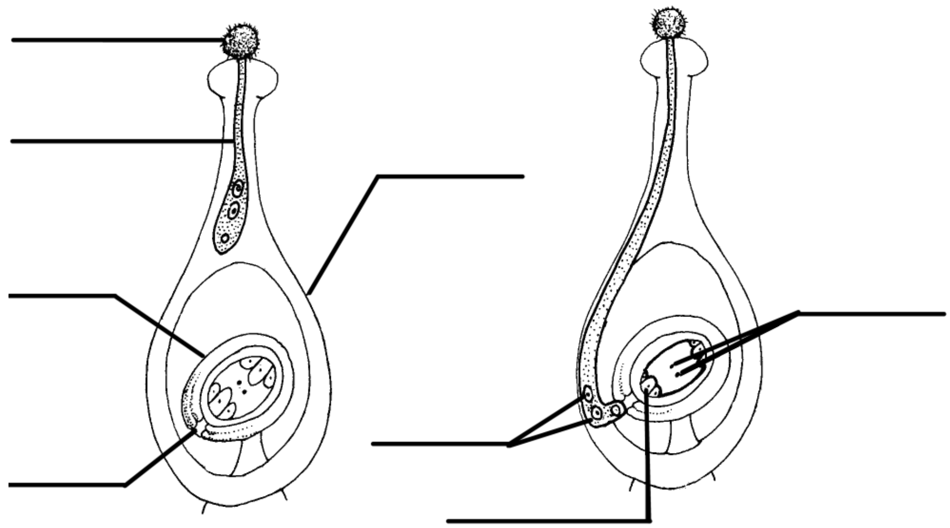
47. The slide will not contain all stages of development, and it is almost impossible to find a section that includes all eight nuclei. Locate the three nuclei near the opening to the ovule. One of these is called the **egg cell**. The two nuclei in the center are the **polar nuclei**.

48. When pollen grains are mature, the anthers split and the pollen is released. When pollen reaches the stigma, it germinates to produce a **pollen tube**, which grows down the style and eventually comes into contact with the opening to the ovule (the **micropyle**). During this growth, one pollen nucleus divides into two **sperm nuclei**. One sperm nucleus fuses with the egg to form the **zygote**, and the second fuses with the two polar nuclei to

form the triploid **endosperm**, which will develop into a rich nutritive material for the support and development of the embryo. The fusion of the two sperm nuclei with nuclei of the embryo sac is referred to as **double fertilization**. Formation of triploid endosperm and double fertilization are unique to angiosperms. Examine the prepared slide showing pollen tubes.

49. The zygote formed at fertilization undergoes rapid mitotic divisions, forming the embryo. The endosperm also divides; the mature ovule forms a seed. At the same time, the surrounding ovary and other floral tissues form the fruit.

50. Label the following parts on the diagram below:
Pollen grain, pollen tube, sperm nuclei, ovary, ovule, polar nuclei, egg cell, micropyle



ANGIOSPERM LIFE CYCLE

51. What part of the life cycle is represented by the mature pollen grain?

____

52. How does the female gametophyte in angiosperms different from the female gametophyte in gymnosperms?

____

____

53. Do you think that all pollen germinates indiscriminately on all stigmas regardless of species? How might pollen germination and growth be controlled?

____

____

54. How is the angiosperm life cycle different from the gymnosperm life cycle?

____

____

55. Match the structure with the correct letter from the diagram.

_______ Egg nucleus

_______ Embryo

_______ Endosperm

_______ Female gametophyte

_______ Megaspore mother cell

_______ Megaspore

_______ Microspores

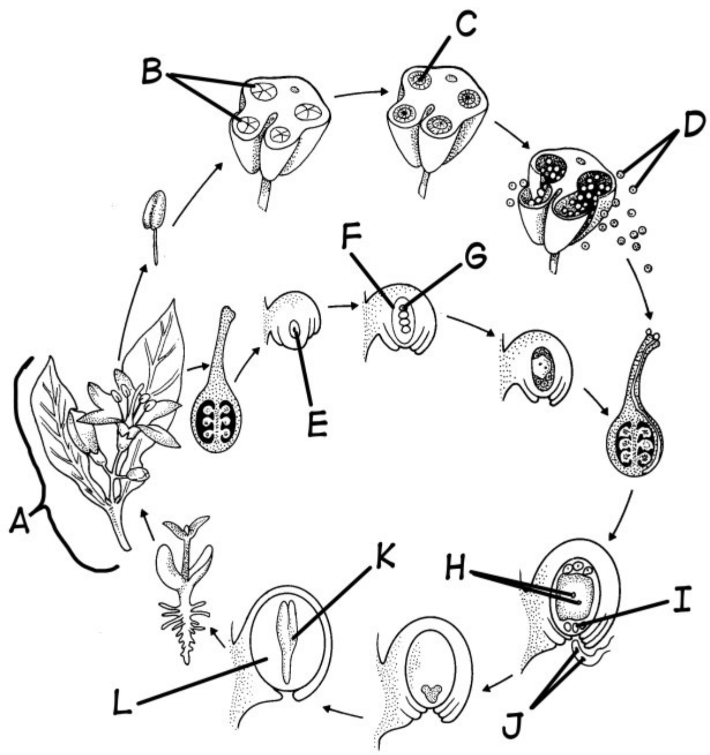
_______ Microspore mother cell

_______ Polar nuclei

_______ Male gametophyte

_______ Sperm nuclei

_______ Sporophyte



PART III: QUESTIONS

56. Complete the following chart comparing the four major plant groups. Use the choices at the bottom of the page to complete the chart.

CHARACTERISTIC	BRYOPHYTES	PTERIDOPHYTES	Gymnosperms	ANGIOSPERMS
Common Name				
Dominant Generation				
Fluid Transport				
Sperm Transport				
Dispersal Unit				

Common Name choices:............Conifers, Ferns, Flowering plants, Mosses
Dominant Generation choices:.....Gametophyte, Sporophyte
Fluid Transport choices:.............Vascular, Nonvascular
Sperm Transport choices:...........Flagellated sperm, pollen
Dispersal Unit choices:..............Spores, Naked seeds, Seeds in fruit

57. Why is internal fertilization essential for true terrestrial living?

____

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

Gametangia	
Cuticle	
Rhizoid	
Flagellated sperm	
Vascular tissue	

59. What evidence supports the hypothesis that plants evolved from green algae (Chlorophyta)?

____

____

60. What adaptations allowed bryophytes to move onto land?

____

____

61. How are bryophytes still tied to water?

____

62. What adaptations contributed to the success of seed plants?

____

____

63. What adaptations contributed to the success of flowering plants?

____

____