AP BIOLOGY NAME_____
PLANTS FORM & FUNCTION
ACTIVITY #2 DATE_____HOUR_____

PLANT ANATOMY

PART I: PRIMARY TISSUES IN STEMS, ROOTS AND LEAVES

All **herbaceous** (nonwoody) flowering plants produce a complete plant body composed of primary tissues, derived from apical meristem. This plant body consists of organs (roots, stems, leaves, flowers, fruits, and seeds) and tissue systems (dermal, ground, and vascular). In this section of the activity you will investigate the cellular structure and organization of roots, stems, and leaves.

A. STEMS

1. Study the prepared slide of a herbaceous dicot stem cross section and the stem pictured in Diagram #1. Identify the **dermal tissue system**, characterized by the protective cell layer covering the plant. It is composed of the **epidermis** and **cuticle**.

2. Locate the **ground tissue system**, background tissue that fills the spaces between epidermis and vascular tissue. Identify the **cortex** located between the vascular bundles and the epidermis. It is composed mostly of **parenchyma**, but the outer part may contain **collenchyma** as well.

3. Then find the **pith**, which occupies the center of the stem, inside the vascular system, and is composed of parenchyma. In herbaceous stems, these cells provide support through turgor pressure. The region is also important in storage.

4. Now identify the **vascular system**, a continuous system of xylem and phloem providing transport and support. In your stems and in many stems, the **vascular bundles** (clusters of xylem and phloem) occur in rings that surround the pith; however, in some groups of flowering plants the vascular tissue is arranged in a complex network.

5. Observe that each bundle consists of phloem tissue toward the outside and xylem tissue toward the inside. A narrow layer of vascular cambium, which may become active in herbaceous stems, is situated between xylem and phloem.

6. Phloem tissue is composed of three cell types:

   a. Dead, fibrous, thick-walled sclerenchyma cells that provide support for the phloem tissue and appear in a cluster as a **bundle (phloem) cap**.

   b. **Sieve-tube members,** which are large, living, elongated cells that lack a nucleus at maturity. They become vertically aligned to form sieve tubes, and their cytoplasm is interconnected through sieve plates located at the ends of the cells. Sieve plates are not usually seen in cross sections.

   c. **Companion cells**, which are small, nucleated parenchyma cells connected to sieve-tube cells by means of cytoplasmic strands.

7. Xylem tissue is made up of two cell types:

   a. **Tracheids**, which are elongated, thick-walled cells with closed, tapered ends. They are dead at functional maturity, and their lumens are interconnected through pits in the cell walls.

   b. **Vessel elements**, which are cylindrical cells, large in diameter and dead at functional maturity. They become joined end to end, lose their end walls, and form long, vertical vessels.

8. **Vascular cambium** is a tissue that is located between the xylem and phloem and which actively divides to give rise to secondary tissues.

9. Identify the lettered parts in Diagram #2.

Letter	Name of Part	Letter	Name of Part
A		**C**	
B			

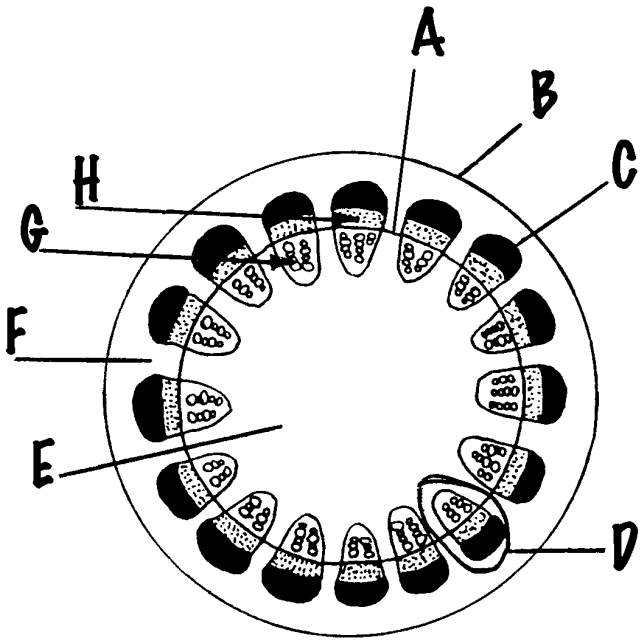
10. Identify the lettered parts in Diagram #3.

Letter	Name of Part	Letter	Name of Part
A		**D**	
B		**E**	
C		**F**	

11. Identify the lettered parts in Diagram #4.

Letter	Name of Part	Letter	Name of Part
A		**C**	
B		**D**	

12. Match the name with the correct part from the diagram.



_____ Cortex

_____ Epidermis

_____ Phloem

_____ Phloem cap

_____ Pith

_____ Vascular bundle

_____ Vascular cambium

_____ Xylem

Is this a cross section of a monocot or dicot stem?_____

How do you know?_____

13. Which are larger and more distinct, xylem or phloem cells?_____

14. What type of plant cell provides support for the stem? Where are these cells located within the stem?

_____

_____

How does the structure of these cells relate to their function?

_____

_____

15. What is the function of xylem?_____

16. What is the function of phloem?_____

17. The pith and cortex are made up of parenchyma cells. Describe the many functions of these cells.

_____

_____

_____

How does the structure of these cells relate to their function?

_____

_____

B. ROOTS

18. Study the slide of a cross section through a buttercup (*Ranunculus*) root and the root pictured in Diagram #5. Note that the root lacks a central pith. The vascular tissue is located in the center of the root and is called the **vascular cylinder (stele.)**

19. Look for a cortex. Is one present?_____

20. Identify the following tissues: **epidermis**, **cortex**, **xylem**, **phloem**, **endodermis**, and **pericycle**. The endodermis and pericycle are unique to roots. The endodermis is the innermost cell layer of the cortex. The walls of endodermal cells have a band of waxy material, called the **Casparian strip**, extending completely around each cell. This strip forms a barrier to the passage of anything moving between adjacent cells of the endodermis. All water and dissolved materials absorbed by the epidermal root hairs and transported inward through the cortex must first pass through the living cytoplasm of endodermal cells before entering the vascular tissues. The **pericycle** is a layer of dividing cells immediately inside the endodermis; it gives rise to lateral roots.

21. Identify the lettered parts in Diagram #6.

Letter	Name of Part	Letter	Name of Part
A		**C**	
B			

22. Identify the lettered parts in Diagram #7.

Letter	Name of Part	Letter	Name of Part
A		**D**	
B		**E**	
C			

23. Relate the structure of the endodermis to its function.

_____

_____

24. The epidermis of the root lacks a cuticle. Why is this advantageous?

_____

_____

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

_____ Cortex

_____ Endodermis

_____ Epidermis

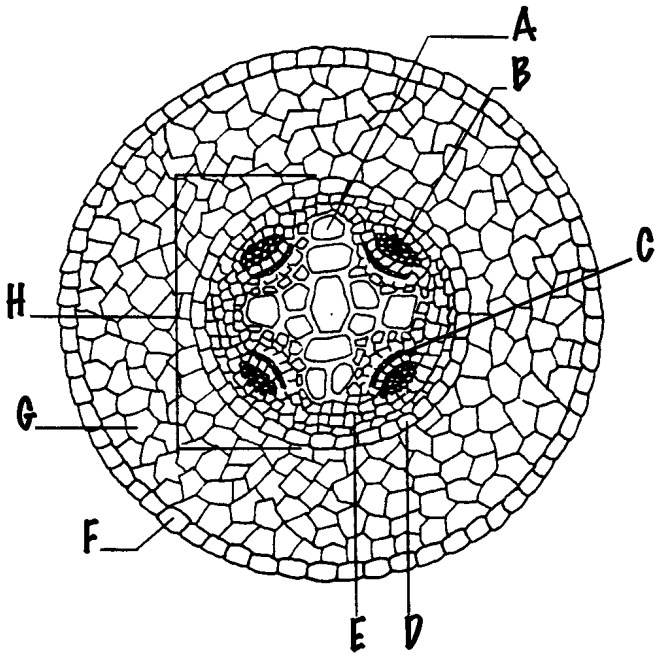
_____ Pericycle

_____ Phloem

_____ Vascular cambium

_____ Vascular cylinder

_____ Xylem



C. LEAVES

The leaf is a layer of parenchyma cells (the **mesophyll**) between two layers of epidermis. The loose arrangement of parenchyma cells within the leaf allows for a great surface area for the rapid exchange of gases. In this part of the activity you will study the internal anatomy of a leaf.

26. Examine a cross section of a lilac leaf and the leaf pictured in Diagram #8 to identify the following cells or structures: **cuticle, epidermis** (upper and lower), **palisade mesophyll**, **spongy mesophyll**, **vascular bundle** with **xylem** and **phloem**, and **stomata** with **guard cells** and **substomatal chamber**.

27. The vascular bundles in the leaf are often called **veins** and may be seen in cross section and long section in the leaf. Observe the structure of the cells in the vein. Is xylem or phloem on top in the leaf?

_____

28. Observe the distribution of stomata in the upper (Diagram #9) and lower epidermis (Diagram #10). Where are they more abundant?

_____

29. Identify the lettered parts on Diagram #11.

Letter	Name of Part	Letter	Name of Part
A		**D**	
B		**E**	
C		**F**	

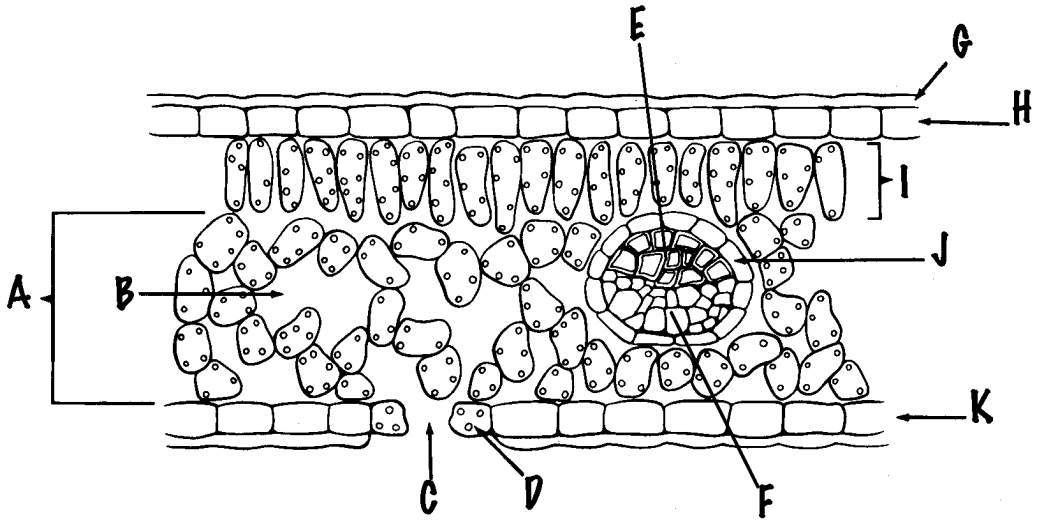
30. Identify the lettered parts on Diagram #12.

Letter	Name of Part	Letter	Name of Part
A		**B**	

31. Identify the lettered parts on Diagram #13.

Letter	Name of Part	Letter	Name of Part
A		**E**	
B		**F**	
C		**G**	
D			

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



_____ Air space

_____ Bundle sheath cell

_____ Cuticle

_____ Guard cell

_____ Lower epidermis

_____ Palisade mesophyll

_____ Phloem

_____ Spongy mesophyll

_____ Stomata

_____ Upper epidermis

_____ Xylem

33. Match the structure with the correct function.

_____ Transports water	A.	Cuticle
_____ Transports food	B.	Guard cells
_____ Waxy layer that decreases water loss	C.	Epidermis
_____ Protects	D.	Palisade mesophyll
_____ Site of photosynthesis; cells arranged in neat rows	E.	Phloem
_____ Cells arranged randomly; arrangement allows for air circulation; cells carry on photosynthesis	F.	Spongy mesophyll
_____ Allows carbon dioxide to enter leaf and oxygen and water vapor to exit	G.	Stomata
_____ Open and close the stomata	H.	Xylem

PART II: PRIMARY GROWTH IN STEMS

Plants produce new cells throughout their lifetime as a result of cell divisions in meristems. Tissues produced from apical meristems at the tips of stems and roots, are called primary tissues, and this growth is called primary growth. Primary growth occurs along the plant axis at the shoot and root tip. Certain meristem cells divide in such a way that one cell product becomes a new body cell and the other remains in the meristem. Below the zone of active cell division, new cells become enlarged and specialized for specific functions (resulting, for example, in vessels, parenchyma, and epidermis. The investigation of the genetic and biochemical basis of this cell differentiation continues to be an area of exciting biological research.

In this activity, you will examine a long section through the tip of the stem and root, observing the youngest tissues and meristems at the apex, then moving down the stem or up the root, where you will observe more mature cells and tissues.

34. Examine the prepared slide of a longitudinal section through an apical bud of *Coleus* and Diagram #14. Use low power to get an overview of the slide, then increase magnification. Locate the apical meristem, a dome of tissue nestled between the **leaf primordia**, young developing leaves. Locate the **bud primordia** between the leaf and stem.

35. Move the specimen under the microscope so that cells may be viewed at varying distances from the apex of the bud, and cells of increasing maturity and differentiation can be seen as you move away from the apex. Follow the early development of vascular tissue, which differentiates in relation to the development of primordial leaves.

a. Locate the narrow, dark tracks of undifferentiated vascular tissue in the leaf primordia.

b. Observe changes in cell size and structure of the vascular system as you move away from the apex and end with a distinguishable vessel element of the xylem, with its spiral cell wall thickening the stem. You may need to switch to high power to locate these spiral cell walls.

36. Label the lettered parts on Diagram #15.

Letter	Name of Part	Letter	Name of Part
A		**D**	
B		**E**	
C		**F**	

37. Match the structure with the correct letter from the diagram at the right.

_____ Apical meristem

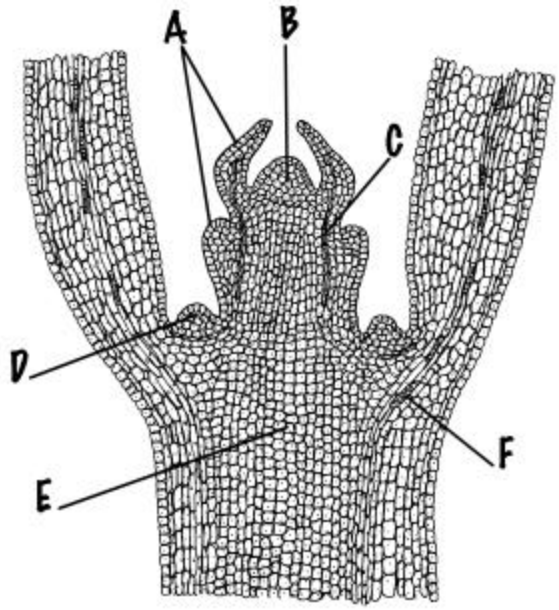
_____ Bud primordial

_____ Developing vascular tissue

_____ Ground meristem

_____ Leaf primordia

_____ Procambium



38. Describe the changes in cell size and structure in the stem tip. Begin at the youngest cells at the apex and continue to the xylem cells.

_____

_____

_____

39. The meristems of plants continue to grow throughout their lifetime, an example of **indeterminate growth**. Imagine a 200-year-old oak tree, with active meristem producing new buds, leaves, and stems, each year. How is this type of growth different from the growth pattern in humans?

_____

_____

_____

PART III: PRIMARY GROWTH IN ROOTS

40. Examine the longitudinal section of a root tip under low power (Diagram 16.) Identify the **root cap**, **zone of cell division**, **zone of cell elongation, zone of maturation**, and **root hairs.**

41. Identify the **root hairs** in the zone of maturation. Root hairs increase the surface area of the root for water absorption.

42. Why are the delicate root hairs found only in the mature part of the root tip?

_____

_____

43. Switch to high power and examine the zone of cell division. Note the many mitotic figures in the columns of **meristem** cells along the sides of the root. The new cells formed by mitosis elongate, and push to the root tip away from the older section of the root. The mature cells remain fixed in position relative to the soil while the tip of the root moves down continuously.

44. The innermost layer of root cap cells constantly divides to produce more cells. These replace the cells sloughed off from the outer layers of the root cap as the growing root forces its way through the soil. What is the purpose having a root cap?

_____

45. Identify the lettered parts on Diagram #17.

Letter	Name of Part	Letter	Name of Part
A		**C**	
B		**D**	

46. Identify the lettered parts on Diagram #18.

Letter	Name of Part	Letter	Name of Part
A		**C**	
B		**D**	

47. How does the growth of plants compare to that in animals?

_____

_____

48. What are meristems?_____

_____

_____

49. Where does primary growth of the plant occur?_____

_____

Is primary growth growth in length or width?_____

PART IV: TISSUES PRODUCED BY SECONDARY GROWTH

The lateral meristems, the cork cambium and the vascular cambium, produce the secondary growth in stems. The vascular cambium is a single layer of meristematic cells located between the secondary phloem and secondary xylem. Dividing cambium cells produce a new cell at one time toward the xylem, at another time toward the phloem. Thus, each cambial cell produces files of cells, one toward the inside, another toward the outside of the stem, resulting in an increase in stem girth (diameter). The secondary phloem cells become differentiated into sclerenchyma fiber cells, sieve-tube cells, and companion cells. Secondary xylem cells become differentiated into tracheids and vessel elements. Certain cambial

cells produce parenchyma ray cells that can extend radially through the xylem and phloem of the stem.

50. Examine the prepared slide of basswood (*Tilia*) stem (Diagram 19.)

51. Locate the **cork cambium**. The cork cambium is a meristematic tissue that divides, producing cork tissue to the outside of the stem and other cells to the inside. The cork cambium and the secondary tissues derived from it are called the **periderm**. The cork cells have thick walls impregnated with a waxy material called **suberin** and are dead at maturity. The periderm layer replaces the epidermis and cortex in stems and roots with continual secondary growth. These layers are continually broken and sloughed off as the tree grows and expands in diameter. The term **bark** is used to describe the phloem and periderm on the outside of the woody plants.

52. Observe the cellular nature of the following tissues or structures beginning at the outermost edge of the stem and moving inward to the central pith region: **cork, cork cambium, secondary phloem, vascular cambium, secondary xylem, pith,** and **lateral rays**.

53. Note the **annual rings** of xylem, which make up the wood of the stem surrounding the pith. Each annual ring of xylem has several rows of **spring wood**, thin-walled, large-diameter cells that grew in the spring, and outside of these, a few rows of **summer wood**, thick-walled, smaller-diameter cells that grew in the summer.

54. Match the structure with the correct letter from Diagram #20.

_____ 1st year xylem _____ 2nd year xylem

_____ 3rd year xylem _____ Bark

_____ Cortex _____ Phloem

_____ Pith _____ Wood

55. Match the structure with the correct letter from Diagram #21.

_____ Cortex _____ Lateral ray

_____ Periderm _____ Phloem

_____ Spring wood _____ Summer wood

_____ Vascular cambium

56. How old is the stem pictured in Diagram #22?_____

57. Phloem is also produced during the spring and summer. Why can't you determine the age of you stem by counting the phloem rings?

_____

_____

58. Based on your observations of the woody stem, does xylem or phloem provide the structural support in trees?

_____

59. What is the function of the ray cells?_____

60. How might the structure of early wood and late wood be related to seasonal conditions and the function of cells? Think about the environmental conditions during the growing season.

_____

_____

61. What is the function of the:

a. Vascular cambium?_____

_____

b. Cork cambium?_____

_____

62. Which group of angiosperms (monocots or dicots) has lateral meristems?

_____

63. Complete the following chart comparing apical and lateral meristems.

Meristem	Location	Produces Primary or Secondary Growth	Causes Growth in Length or Width
Apical			
Lateral			

PART VI: QUESTIONS

64. Cells of the epidermis frequently retain a capability for cell division. Why is this important?

_____

_____

65. Why is the endodermis essential in the root but not in the stem?

_____

_____

_____

_____

66. The belt buckle of a 20-year-old man may be a foot higher than it was when he was 10, but a nail driven into a 10-year-old tree will be at the same height 10 years later. Explain.

_____

_____

_____

67. The oldest living organisms on earth are plants. Some bristlecone pines are over 4,000 years old, and a desert creosote bush is known to be 10,000 years old. What special feature of plants provides for this incredible longevity?

_____

_____

_____

68. Many of the structural features studied in Activity #1 and #2 evolved in response to environmental challenges of the terrestrial habitat. Complete the following table, naming the cells, tissues, and organs that have allowed vascular plants to adapt to each environmental factor.

Environmental Factor	**Adaptations to Land Environment**
Desiccation (water loss)	
Transport of materials between plant and environment	
Gas exchange	
Anchorage in substrate	
Transport of materials within plant body	
Structural support in response to gravity	

69. Listed below are characteristics of the types of plant cells. Use the key below to indicate which type of plant cell is being described.

C. Collenchyma
P. Parenchyma
S. Sclerenchyma
STM. Sieve-tube members
TVE. Tracheids & Vessels Elements

_____ Relatively unspecialized cells

_____ Cells have thin, flexible primary walls; lack secondary walls

_____ These cells carry on most of the metabolism in the plant. They function in photosynthesis and food storage.

_____ Cells have an unevenly thickened primary wall and lack secondary walls.

_____ Consists of strands or cylinders of cells that provide support and elongate with young plant parts.

_____ Cells have thick secondary cell walls thickened with lignin; cells may be dead

_____ Can exist in two forms – fibers and sclereids

_____ Specialized for support

_____ These cells conduct water and minerals.

_____ These cells are dead at functional maturity.

_____ The secondary walls are deposited in spiral or ring patterns to provide additional strength.

_____ The secondary walls may have scattered pits.

_____ These cells make up xylem.

_____ These cells make up phloem.

_____ These cells conduct sucrose, other organic compounds, and some minerals.

_____ These cells are alive at maturity but the protoplast lacks organelles.

_____ These cells have specialized end walls called sieve plates that facilitate fluid flow from cell to cell.

_____ Associated with companion cells.

70. Identify the plant tissue system described in each of the following. Use the key below to indicate your answers.

D = Dermal Tissue System
G = Ground Tissue System
V = Vascular Tissue System

_____ Epidermis

_____ Covers the surface of the plant and provides protection

_____ Xylem and phloem

_____ Transport water, minerals, and food

_____ Makes up the bulk of a young plant

_____ Occupies the space between the epidermis and the vascular tissue system

_____ Predominately parenchyma, but may include collenchyma and sclerenchyma cells

_____ Functions include photosynthesis, storage, and support