Plant Structure and Function Lab

Prior to coming to lab this week, please print a copy of this worksheet and read through the entire lab. Much of the material comes from Chapter 31 of your textbook, which we have not covered in detail during lecture. Therefore, bring your textbook with you to lab.

At the end of the lab you will be able to:
1. Identify the basic structures and tissues of vascular plants.
2. Describe the role of each basic structure in helping a plant maintain homeostasis.

I. Laboratory Purpose

Plant survival is dependent upon their ability to maintain homeostasis. Although the general components for achieving homeostasis are common among plants: sensor, communicator, integrator, and responder, the specific detailed mechanisms by which plants regulate their internal environment relative to the external environment are varied. Remember that plants must monitor multiple factors in their environment in order to survive and given that plants are immobile, the primary response mechanism in plants is growth. Using your new knowledge of plant anatomy and function, you should be able to describe the role of each feature in helping the plant maintain homeostasis.

II. Background

Anyone who has grown plants realizes the importance of providing proper amounts of water, nutrients, and light. Unless you’re the proverbial "green thumb", it may appear that plants are decidedly temperamental about getting these necessities in the proper amounts. How do you suppose that plants that grow unattended meet these needs in an unpredictable natural environment? Only cursory observation is required to reveal the specialized features of plants that enable them to satisfy these needs and survive the inclement environmental periods. Don’t forget that such features are adaptations acquired through evolution.

An investigation of plant anatomy highlights the adaptations necessary for obtaining appropriate levels of water, nutrients and light. Examples of these adaptations can be found at multiple levels (cell, tissue, and organ). Most importantly, an understanding of how plants maintain homeostasis requires knowledge of how these levels are integrated in the plant. For example, in order for a root tip to grow in the appropriate direction, it requires specialized structures in cells to sense gravity and to communicate direction to the growing tissue at the tip of the root. In any given plant, these adaptations have developed according to the environmental pressures that have molded individual species in preceding generations. The combination of adaptations causes each species to be unique and distinctive.

This lab will focus on angiosperm anatomy, for which there are ~250,000 known species. Within angiosperms there are two main systems: root and shoot. The shoot system is further subdivided into two basic organs, stems and leaves. By definition, an organ consists of groups of tissues that carry out the processes essential to life. A tissue is a group of cells with some similarity in structure and/or position that work together to perform common functions. Cells that carry out a particular function usually have very similar characteristics.

Keep in mind that growth in plants is a nearly constant process terminated only by death (indeterminate growth compared to determinate growth seen in animals) and this is the primary way that plants respond to their environment. Plants possess tissues that "specialize" in growth. That is, tissues whose cells remain undifferentiated (not mature) and retain the ability to divide. These tissues, called meristems, occur at strategic positions where growth is required to support the plant’s continuing quest for light, water, and other essentials from the environment (see Figure 1). As these cells divide they give rise to cells that “specialize” through differentiation (maturity) to form the other tissues in the plant. Tissues produced from apical meristems are called primary tissues, and this growth is called primary growth. Primary growth occurs along the plant axis at the shoot and root tips. In woody plants, cell division of lateral meristem tissue within the stem leads to secondary growth, which increases the diameter of the stem.
The shoot system and root system contain the following structures, which you should be able to identify.

**Shoot system:**
- **Nodes** are regions of the stem from which leaves, buds and branches arise and which contain areas of meristematic tissues (areas of cell division).
- **Internodes** are regions of the stem between the nodes.
- **Terminal or apical buds** are located at the tips of stems and branches. They enclose the short apical meristem, which gives rise to leaves, buds, and all primary tissue of the stem. Only stems produce buds.
- **Axillary or lateral buds** are located in the leaf axils at the nodes; they may give rise to lateral branches.
- **Leaves** consist of flattened shapes attached at the node of a stem by a stalk, or petiole. Specially adapted for photosynthesis, the thin leaves provide a very large surface area for the absorption of light, uptake of carbon dioxide, and release of oxygen through openings called stomata.

**Root system:**
- **Primary root** is the first root produced by the plant embryo and may become a long taproot.
- **Secondary roots** arise from meristematic tissue deep within the primary root.
- **Root tips** consist of a root apical meristem that gives rise to a root cap and to all the primary tissues of the root proper.
- **Root hairs** are the principal site of water and mineral absorption.

Plants exhibit three basic tissue types that are arranged differently in leaves, stems and roots (see Figure 1). Within plants there is almost unlimited variation for each tissue.

- **Dermal tissue** is adapted almost exclusively for protection against desiccation or external agents such as pathogens. You should be able to find a single layer of tightly-packed cells called the epidermis and, on the surface of most stems and leaves, a waxy-coating called the cuticle.
- **Vascular tissue** is adapted primarily for physical support and translocation or movement of materials within the plant. Within this main tissue are discrete vascular bundles of xylem and phloem.
- **Ground tissue** is the most varied in function and form, but is generally associated with functions of synthesis and accumulation of organic compounds as well as support.

We round out our basic plant anatomy and function discussion by considering the importance of flowers. From an evolutionary perspective, any structure in a plant is adapted to make sure that a plant can survive and produce viable, fertile offspring. In angiosperms, flowers contain the reproductive organs of the plant and there is enormous variation, as you will see when you visit the UVM greenhouse. Even with the variation, there are four modified leaf structures that can be identified in the majority of flowers (see Figure 2).

- **Sepals** function to protect and enclose the flower before it opens; these structures look the most leaflike.
- **Petals** function to attract pollinators.
- **Stamens**, which include anthers and filaments, are the male reproductive organs.
- **Carpels**, which include the stigma, style and ovary, are the female reproductive organs.
Figure 1

Figure 2
III. Methods

**BEFORE YOU START the lab, take a sample of the plant provided by your TA, and put the stem in toluidine blue stain.**

As you work through the lab, record your answers to the questions and illustrations on the back pages of this handout. Also, keep these goals in mind.

1) locate the basic tissue types
2) examine the variations of cell types within these tissues and their relative positions to one another
3) remind yourself of the function(s) for a tissue or organ, or if the function is not clear, speculate about the function as you examine the structure
4) create drawings and include everything you see

Important Terms:
Longitudinal section – a section cut through the long axis of a structure
Cross-section – a section cut across (transverse) the axis of a structure

Exercise #1 – Gross Plant Anatomy

Select a Coleus plant and sketch a picture. Be sure to label all of the structures in the shoot system.

Exercise #2 – Apical Bud

Examine a prepared slide of a longitudinal section through an apical bud of Elodea (or Anachris). Use low power for an overview and then increase magnification. Draw what you see at high magnification and label the epidermis and meristem.

Exercise #3 – Root Anatomy

Examine a prepared slide of a root in cross section and longitudinal section. Illustrate what you see for ONLY one of the two sections and label the epidermis, vascular tissue, ground tissue and root hairs, if visible.

Exercise #4 – Stem Anatomy

1) Take the stem you placed in toluidine blue at the beginning of the laboratory. Make a thin cross-section of the stem through an internode and place the section in a drop of water on a clean glass slide.

2) Next, make a thin longitudinal section of the stem through a node and internode and place the section in a drop of water on a clean glass slide.

Illustrate what you see for each section and label the epidermis, cortex, vascular tissue, and ground tissue in each image.

Exercise #5 – Leaf Anatomy

1) Make an epidermal peel from the lower surface of the leaf material provided. Place it carefully in a drop of water on a clean microscope slide. You should be able to see two main types of cells: epidermal and guard cells. Guard cells are paired and regulate the opening/closing of stomata, which in some plants may number between 30,000 and 50,000 guard cells/square inch. AMAZING!! Draw a picture of what you see and label the guard cells, epidermal cells and stomata.
2) Repeat the process with an epidermal peel from the upper surface of the leaf. Compare the distribution of stomata in the upper surface with the slide from the lower surface.

3) Look at a cross section of a lilac (Syringa) leaf under medium power. Illustrate what you see and label the epidermis, cortex, vascular tissue, and ground tissue.

Exercise #6 – Flower Anatomy

1) Select a flower of Alstroemeria to dissect. Alstroemeria is a scraggly climbing plant that grows near treeline in the southern Andes, in Bolivia and Peru. Draw an image of the flower and label the petals, sepals, stamen (anther and filament), and carpel (stigma, style and ovary). See descriptions of each feature in the introduction and below.

2) Now prepare to dissect your flower using a dissecting microscope. Have two probes at hand.

3) In theory the flower is a kind of shoot -- that is a stem with leaves attached. However the leaves are highly specialized and the internodes are so short that the flower parts appear to be attached to a single point on the stem, called the receptacle.

4) Begin by looking at the two whorls (groups) of colorful structures – together called the perianth.
   a. The outer whorl, the sepals, is slightly different from the inner whorl, and it encloses the whole flower when it is a bud (unopened).
   b. The inner whorl, the petals, has a complex pattern of color and marking on the inner surface for guiding the pollinator (ordinarily bumblebees in the Andes).

5) Decide on the symmetry of the flower. Looking straight at the top of the flower, decide whether the symmetry is radial, like a snowflake, or bilateral, like a face and record your answer.

6) Check out the bottoms of the sepals and petals. Are they separate from each other, or are they partially combined together to form a tube, what we call fused?

7) Now look at the stamens, which are the pollen producing organs. They consist of two parts, an anther (male-sperm), where meiosis occurs and a filament, which is the support and display axis for the anther.
   a. Count the stamens and record your count.
   b. Look closely at the anther under your dissecting ‘scope. You should be able to break open the anther with a probe and see the pale yellow pollen grains inside. Remove some of the pollen grains and place them on a microscope slide. Using the light microscope, look for shape and markings on the pollen. Draw an image of a pollen grain.

8) Locate the carpel, in the center of the flower. The carpel has three parts.
   1. At the top is the stigma with three sticky lobes. Look for pollen: some may have already been dumped from the stamens onto the stigma -- this is the actual event of pollination (the arrival of pollen at the stigma.)
   2. Beneath each stigma is a stem-like display axis called the style.
   3. At the base of the style, is a swollen part of the carpel called the ovary (female – egg). Inside this portion of the carpel is the other place where meiosis takes places in flowers and where seed (zygote) development takes place.
   4. Tear open the ovary with your probe to expose a group of small, spherical whitish green things inside. These are the ovules – inside each one is a single egg. If fertilized, the ovules develop into the seeds that have the potential to establish a new plant.
This assignment has two components and the total point value is 15. The first part includes credit for the drawings you create during the lab and the answers to the questions. The second part requires a visit to the University of Vermont greenhouse in order for you to answer the questions. Please follow the instructions for each part.

Part A: Please create your illustrations here and answer the questions. Using pencil is highly recommended for the drawings. If you need extra space, please feel free to use blank (unlined paper). (10 points)

Exercise #1 drawing:

Exercise #2 drawing:

Answer the following: Describe ONE way that the apical bud helps a plant maintain homeostasis.
Exercise #3 drawing:

Answer the following: Choose ONE of the root structures and describe how this structure helps a plant maintain homeostasis.

Exercise #4 drawings: (cross-section AND longitudinal section of stem)

Answer the following: Compare the vascular tissue organization in the root and the stem. Describe, in general, how the organization of vascular tissue is different between a root and a stem.
Exercise #5 drawings: (epidermal peel of lower leaf surface AND leaf cross-section)

Answer the following:

a. Describe the difference in distribution of stomata between the upper surface and the lower surface of the leaf.

b. Describe ONE way that the stomata help a plant maintain homeostasis.
Answer the following:
1. What is the symmetry?

2. Are sepals and petals separate or fused?

3. Number of stamens

4. Both sperm and eggs in angiosperms are covered by one or more layers of cells. Give ONE reason for the evolution of this characteristic.
Part B: As a follow-up to the lab, you are required to visit the UVM greenhouse. This facility is open every Monday through Friday from 8 AM – 4 PM. You should TYPE your responses to the following questions/statements and submit it to your TA, along with your plant anatomy drawings and answers, at the beginning of lab next week. Please limit your Part B responses to NO MORE than 1/2 page, single spaced, or 1 page, double-spaced. (5 points)

1. When you enter the greenhouse you should look for six plants that have labels: BIOL002 numbered 1 – 6.
2. Take time to look at each of these plants and any of the other plants that are present. Once you have looked briefly at all six plants, you should select two of these plants and write down the scientific name (and common name, if applicable) of BOTH plants (whatever is written on the little plaque).
3. For your two plants, describe the environmental conditions in which each plant is growing in the greenhouse. Several key pieces of information to help you are posted on the door to each section’s entrance.
4. Observe the stem, leaf and flower structures of each plant. NOTE: Quantitatively measuring any aspect of these structures is a valid way to describe a difference.
   a. Describe the stem structure in both plants and highlight ONE difference between the two.
   b. Describe the leaf structure in both plants and highlight ONE difference between the two.
   c. Describe the flower structure in both plants and highlight ONE difference between the two.
5. Choose one of your two plants ___________________. Then, select one morphological feature of the stem, leaf or flower you described in activity 4 above. Explain how this feature would help the plant to thrive in the environmental conditions in which it lives.