Name _____ **Instructor** _____ **Lab Section**_____

Objectives: To gain an understanding of:

- The anatomy and physiology of plants
- Transport of water and nutrients
- Plant reproductive processes

Background material may be found in

- Chapter: 17.1-17.2; 17.6-17.11

Biology: Concepts & Connections, 8th ed.

The purpose of this lab is to examine the general structure and function of land adapted plants.

GENERAL STRUCTURE: AN OVERVIEW

The diagram located at this station summarizes the general organization of a typical land plant. Examine the potted plant at this station and try to find (if possible) each of the labeled parts in the diagram.

✍ Draw a brief sketch in the box below, including the following labeled parts: **roots, stems, buds, leaves**, and **flowers**. When you complete the entire exercise, refer back to your drawing and attempt to summarize, for yourself, the overall structure and function of the plant body.

TABLE 1: ROOTS AND STEMS

ROOTS

OBTAINING WATER AND DISSOLVED MINERALS

One primary function of the root system of land plants is to procure water, minerals, and various other nutrients from the soil. As one might expect, roots exhibit various adaptations to maximize their efficiency in carrying out this important function. One way this is accomplished is through the use of hair-like tubular extensions of the outer (epidermal) cells of the root, which are called **root hairs**. Root hairs serve to increase the total surface area of the root system, thereby increasing the surface through which water can be taken from the soil into the plant.

✍ In the boxes below, draw sketches of root hairs and a growing root tip, using the live material for root hairs and the prepared slide of the root tip as models. In the growing root tip, cells frequently undergo mitosis to make new cells. The chromosomes of these cells are stained pink, so you can look for cells in the various stages of mitosis (prophase, prometaphase, metaphase, anaphase, or telophase).

Root hairs (from germinating radish seeds):	**Growing root tip** (from prepared slide):

FOOD STORAGE

Another function roots serve is that of food storage. Typically plants produce more glucose through the process of photosynthesis than they require to satisfy their energy needs. This excess energy can be kept as sugar or assembled into long chains and stored in the form of starch.. In some plants it is the root that is the site for starch storage and in these cases the roots are called **storage roots**.

Look at the various examples of storage roots at this station and answer the question below.

✍ **QUESTION***:* Why do plants such as carrots and beets store large amounts of energy?

STEMS: TRANSPORT WITHIN THE PLANT

Water, minerals, food substances, and various other chemicals (e.g. hormones) are transported throughout the entire plant by the vascular system. As such, the vascular system of the plant, like our circulatory system, chemically connects all parts of the plant.

Tissues making up the vascular system can be divided into two basic types: **xylem** tissue and **phloem** tissue.

The xylem cells are responsible for the transport of water and minerals in a single direction, up the plant body from the roots to the stems to the leaves (like a "one-way street"). Xylem cells are dead cells, whose remaining cell walls (made up of cellulose) form hollow tubes through which materials can pass. In the so-called "woody" plants, the cell

walls of the xylem are greatly thickened and it is the dead xylem cells which make up the material which we call "wood" (see the cross section of a woody stem).

Whereas xylem cells are dead cells, phloem consists of living cells. These cells function to transport food and hormones both up as well as down the plant body (like a "two-way street").

Look at the demonstrations at this station involving the movement of dye through the xylem tissue of a carnation.

QUESTION

1. In order to move from the roots of a plant to the tips of its leaves, water must move against the force of gravity. Propose a hypothesis to explain how water moves through the xylem from the roots through the stem and up to the leaves of a plant. What would be the energy source for this movement?

ROOTS VS. STEMS

Typically one thinks of any underground portion of a plant as being a root. However, this is not always the case. At this station, examine a carrot, a sweet potato, and a potato.

A carrot is a thick tapering root, more specifically referred to as a **taproot**. Note the presence of thinner lateral roots and root hairs that may extend from this primary root.

A sweet potato, on the other hand, is a **storage root** which, as discussed above, is the site where excess glucose is stored as starch.

Unlike the other two structures, the potato, despite the fact that it is found underground, is not a root. Instead it is a thickened underground *stem* called a **tuber**.

QUESTION

How could you distinguish between a thickened root such as a carrot or sweet potato and a tuber such as a potato? (Hint - As with questions concerning matters of the heart, the answer is in the "eyes".) Come back to this question later, after dealing with the section on leaves and buds.

TABLE 2: LEAVES AND BUDS

LEAVES

GENERAL STRUCTURE

Using the models and drawings provided, make a sketch of a leaf cross-section. Label the following structures: **epidermis** (upper and lower), **mesophyll**, **chloroplasts**, **vein** (with xylem and phloem)**, stoma**, **guard cells**.

Leaf cross-section:

The primary function of the leaves is to carry out photosynthesis, producing food for the plant. In order to do this, leaves need water, sunlight, and carbon dioxide. Water is supplied from the roots via xylem. Energy from sunlight is absorbed by chlorophyll in the leaves' mesophyll tissue. Carbon dioxide must also be absorbed across the leaf surface, and this gas enters the leaf through pores called stomata (stomata is the plural form of stoma, which means *mouth*). When the guard cells change shape to allow the stomata to open, CO_2 enters the leaf and excess O_2 exits. Leaves can also lose water through the stomata, a process called **transpiration**. Transpiration occurs when the leaf is hot, causing the water to evaporate.

STOMATA AND GUARD CELL OBSERVATION

View the slide of a leaf epidermis, and locate several stomata with guard cells.
Make a sketch of 2-3 of these stomata:

QUESTIONS

1. What is the function of the stomata?

2. Why are the guard cells necessary (that is, why aren't the stomata always open)?

3. On what surface of the leaf (top or bottom) would you expect to find stomata? ***Why?***

LEAF SIZE AND WATER LOSS

One major problem facing land plants is how to obtain carbon dioxide for photosynthesis while minimizing water loss by evaporation. Since the leaf is the primary structure used for gas exchange, one might expect to see adaptations to cope with this problem. One such adaptation is leaf size in relationship to the water availability in the natural habitat of the plant. In the Botanic Garden we will examine other adaptations to cope with water loss.

Look at the leaf size in the 3 different plants at this station. One plant is adapted to a moist habitat, the other to an intermediate moisture situation, and the third to a habitat with an extreme lack of moisture (note: in this case the spines of the cactus are modified leaves).
Also look at the demonstration involving water loss in plants with different sized leaves. The amount of moisture collecting on the inside of the inverted beaker over each is an indication of the extent of their water loss.

QUESTIONS

1. Why is it so important for plants to minimize their water loss? (Why is water so important in living systems?)

2. How is a plant's leaf size related to the availability of water in the habitat where the plant has evolved and how is this related to water loss in terms of leaf surface area and evaporation?

3. How is the relationship between leaf size and water loss similar to the relationship between root hairs and the water uptake capabilities of roots?

DECIDUOUS VS. EVERGREEN

The leaves of plants are particularly susceptible to injury and damage when exposed to unfavorable environmental conditions (e.g. extremes in temperature, lack of water, too much/little sunlight, strong winds, etc.). Given that leaves are relatively fragile structures, plants have evolved various adaptations in their leaves to cope with those times of the year during which they may encounter harsh environmental conditions.

Cold temperatures that typically accompany the winter months are particularly stressful. There are two basic adaptations of plants that help them cope with these unfavorable winter conditions: (a) they either drop all of their leaves during these times and we say that they are **deciduous** or (b) they keep their leaves throughout the year (continuously dropping and replacing their leaves year round) and endure the extremes of the winter months with their leaves present and intact. We refer to these plants as **evergreens**.

Look at the leaves of a deciduous and an evergreen plant at this station. Also, (if available) look at the over wintering buds of a deciduous or evergreen tree.

QUESTIONS

1. If a deciduous plant drops its leaves during the winter months, what does that indicate about its overall metabolism during the winter?

2. How are the leaves of coniferous evergreens adapted for survival during the harsh conditions of winter?

3. Pine trees grow in habitats that have hot dry summers. How are the leaves of pine trees adapted for survival during the harsh conditions of summer?

BUDS

New leaves and stems are produced by actively dividing (mitotic) cells in specific regions on the stems of plants. At the tip of each stem is located what is called an **apical bud**; the site where new leaves are produced and the stem increases in length. In addition to apical buds, at the junction where the petiole of each leaf joins the stem, there is located an **axillary bud**, which under the proper conditions, will produce new leaves and lateral stems.
Look at the head of cabbage which has been cut in half. Note the small leaves closest to the growing point (i.e. apical bud) and the progressively larger leaves further away and down the stem of the plant.

QUESTIONS

1. What plant structures are the "eyes" of a potato? What happens if the eyes are allowed to grow?

2. What typically happens to the axillary buds when you pinch off the apical bud of a stem?

FLOWERS AND CONES

Buds don't always develop into new leaves and stems. Some type of buds develop into **flowers** or **cones**, whose parts are in fact nothing more than leaves highly modified for the purpose of reproduction.

GENERAL FLOWER STRUCTURE AND VARIATIONS

Using the general flower model and the diagram on the next page try to identify each of the parts indicated below in the specimens available at this station. For those of you particularly interested in taking a closer look at various flowers, ask your instructor for some specimens to dissect and view under the scope.

Note that the structures found in grasses (e.g. foxtails, etc.) are flowers also (see the grass flower model). In examining the grasses carefully look for the various flower parts using the scope and tools available on the tray.

In the box below, sketch a cross-section of a dissected flower as seen through the microscope provided. Using the diagram provided beside the microscope, label the following structures:

sepals, petals
male structures (parts of the **stamen**): **anther, filament**
female structures (parts of the **carpel**): **stigma, style, ovary** with **ovules**

Flower Cross-section:

In examining the daisy or sunflower (if available) note that what is typically regarded as a flower, is really a large number of smaller individual flowers organized into what appears to be a single flower. This "flower" is actually a collection of flowers or **inflorescence**. The inflorescence in a daisy or sunflower is a **composite inflorescence**. If desired, you can look at a composite under the dissecting scope and try to find the various parts in one of the individual flowers. In order to get a good view, use whatever tools are needed to tease apart the tiny flowers.

ADAPTATIONS FOR POLLINATION

Being highly immobile, plants rely on external agents to transport **pollen** (containing sperm) to the egg (contained within the ovary of the carpel). These agents include such **abiotic** (non-living) factors as wind and water and such **biotic** (living) agents as birds, insects, and mammals, which are known as **vectors**. One can see various adaptations in the various parts of the flower to facilitate the exploitation of particular vectors for reproduction.

Try to figure out how a biotic pollinating agent (a vector) attracted to the flower model of a pea or the Bird of Paradise flower might mechanically "trigger" the flower to deposit pollen on it to be transported to another flower.

Also look at the orchids and cones at this station and then answer the following questions.

QUESTIONS

1. What function do the colors, patterns, shapes and odors of petals serve?

2. What is the function of the nectar of the flower?

3. In looking at the orchids from an "insect's perspective," what other possible "rewards" might the flower have evolved to entice you to make a visit?

4. Why aren't the cones of pines and redwoods, and flowers of many grasses (e.g. wild oats) brightly colored or odorous? That is, what agent serves in their pollination and how does this relate to the relatively dull colored reproductive structures?

5. What common features do grasses and pines share in terms of their distribution in the environment? Are they typically grouped together in large stands or spaced widely apart? How does this pattern of distribution aid their method of pollination?

FRUITS AND SEEDS

Following pollination, **fertilization** (the union of sperm and egg) occurs within the ovary. Once fertilization has occurred, the ovary then begins to mature into a fruit that surrounds the fertilized ovules, which become seeds. To many people the term "**fruit**" implies a fleshy, sweet tasting structure, but as you'll see, this is not necessarily so, sometimes with the mature ovary forming a dry/paper-thin structure.

Within the fruit are located the seeds, which contain the young plant (the **embryo**) along with a food supply (the **endosperm**) to begin its development. Many actual fruits are known as "**seeds**" to the gardener and farmer. For example, the kernel of corn, wheat or oats, and the so called "seed" of the sunflower, are in reality fruits (i.e. a ripened, mature ovary and other closely associated flower parts).

Look at the various types of fruits at this station. If possible, try to locate the remnants of other flower parts (e.g. stigma, style, anther, stamen, sepal, etc.) in each. Try to picture how each of the fruits developed from the ovary of a flower. Look at the assortment of fruits and vegetables on display.

QUESTIONS

1. With regard to plant structures, what is a fruit?

2. Look at the sample of foods that we call “vegetables”. What plant parts are on display here?

3. What foods that we commonly call vegetables are, botanically speaking, fruits?

DISPERSAL OF SEEDS

As with pollination, plants must also use external agents or vectors for the dispersal or distribution of their seeds some distance away from the parent plant. The mature ovary or fruit around the seeds is adapted to exploit various vectors for this end. Look at the fruits and the "Seed Dispersal" display case. While doing so consider the following questions:

QUESTIONS

1. How do sweet, odorous, colorful, fleshy fruits aid in seed dispersal?

2. What adaptations must the seeds have to survive this means of dispersal?

3. What would the dispersal agent be if a dried, mature ovary (i.e. fruit) surrounding a seed had wings?

4. What would the dispersal agent be if a dried, mature ovary (i.e. fruit) surrounding a seed had barbs?

5. Before humans began transporting coconuts, what do you think the natural dispersal agent was? What features does the fruit of the coconut (i.e. its husk) have to use this abiotic (non-living) vector?

LABORATORY NOTES