Experimental Anatomy of Plant Development

Laboratory 2

Cell Types, Tissue Composition and Tissue Systems

Introduction

In this laboratory we will examine several of the most important types of mature cells found in vascular plants. Additional types of cells occur in all plants, and many of these will be examined in other laboratories. Relatively complete listings of plant cell types may be found in your text, or in Esau's Plant Anatomy, 2nd edit., 1965.

Activity 1. Cell Types

A. Parenchyma. This cell type is widely distributed throughout the plant body. It usually constitutes the major portion of the cortex, pith, and mesophyll. In addition, parenchyma is present in the more complex tissues, xylem and phloem. Parenchyma cells vary greatly in shape ranging from isodiametric (theoretically forming a tetrakaidecahedron) to stellately branched and cylindrical. The cell wall contains simple pit fields, and the protoplast generally persists for a long while with the cells retaining the capacity for growth and division. Parenchyma is a general purpose type of cell often capable of photosynthesis and some conduction. It is frequently a storage type cell for water and reserve foods.

Cut a free-hand section of a Begonia (*Pelargonium*) petiole and make a wet mount of the tissue. In the central part of the petiole you will find typical parenchyma cells. Look for the nucleus, cytoplasm, chloroplasts, crystals, and pits in the cell wall. Additional parenchyma containing abundant chloroplasts is present near the outer surface of the petiole (outer part of the cortical region). Draw a typical parenchyma cell. Be sure to include the important features of the wall and cytoplasm that allow you to identify the cell type.

Now examine a prepared slide of the stem of *Coleus*. Note the features of the parenchyma cells of the pith region. Draw one cell.

B. Collenchyma. This cell type is characterized by irregularly thickened primary cell walls. In addition, the cells are elongate and are usually found aggregated into stands or cylinders just within the epidermis. These cells are supportive in function and are alive for a long while. They may contain chloroplasts.

Using the same preparation of *Begonia* petiole study the area just within the epidermis. Locate strands of collenchyma cells and note the irregular thickening of the walls. Draw a few cells as they appear in cross section.

A transverse section (prepared slide) of the stem of *Helianthus*, the sunflower, may be examined to see similar collenchyma as it appears in a permanent stained section. Draw one of these cells.

Cut a cross section of the petiole of celery. Locate the strands of collenchyma and note the features of the cell walls. Now cut a longitudinal section through a collenchyma strand and examine the cells in this view. What is their shape? Draw a collenchyma cell as it appears in both cross and longitudinal section.

C. Sclerenchyma. This type of cell is characterized by having relatively thick secondary cell walls which become lignified. They are further characterized by a protoplast that dies relatively soon after the cell reaches maturity so that the cell persists solely as cell wall. Sclerenchyma cells most often make up hard and incompressible parts of the plant. They occur in the cortex, phloem, pith, and mesophyll either singly or in clusters. In addition, special types of sclerenchyma cells known as fibers, tracheids and vessel elements from important cellular components of the xylem or wood. Sclerenchyma in the form of fibers occurs in the phloem, which like the xylem is a conducting or vascular tissue. The walls of sclerenchyma cells are highly variable and you will see some of the most important types in this laboratory.

Several categories of sclerenchyma cells are generally distinguished and include the following.

1. **Sclereid**—highly variable in form, may be columnar, polyhedral, or much branched. These cells have a massive wall with simple pits (no special ornamentations associated with the pits).

Examine the demonstration slide of a developing fruit of pear (*Pyrus*). Locate clusters of isodiametric sclereids. These are polyhedral in shape with thick walls, elongated and branched simple pits, and relatively small cell lumens. Draw two or three sclereids.

2. **Fiber**—a much elongate, thick-walled sclerenchyma cell with a long, narrow cell lumen and a lignified wall having simple or unornamented pits. Fibers from supportive structures and are widely distributed in plant bodies. They often make up a considerable part of secondary xylem and phloem, especially in woody plants. They also occur in the protective layers of seeds and fruits.

Examine a prepared slide of macerated oak wood (*Quercus*). Locate very much elongated cells with pointed ends. These are called **libriform fibers**. Simple pits should be sparsely present on these fiber cells. Draw a single fiber of this type.

To see how fibers appear when cut in cross section in an intact plant part, examine a prepared slide of a *Medicago* stem, in which very prominent stands of fibers occur in association with each of the vascular bundles (immediately to the outside of the xylem and phloem). Draw a few fibers as they appear in this view.

3. **Tracheid**—a cell that is characteristic of xylem, both primary and secondary. The cells are elongate with a secondary wall that is lignified. This wall is deposited in varying patterns, as rings, spiral bands, transverse bars, a reticulum, or is continuous except for pits. These pits often have ornamented margins. The tracheid is the basic xylem cell from which the various types of cell found in the xylem of a highly evolved vascular plant have developed.

Macerated wood of *Pinus* (prepared slide) should be examined to see a tracheid with bordered pits. Each pit has a circular border which is very prominent. Draw a tracheid of pine in this view.

Now examine a prepared slide of *Pinus* as it appears in cross section. Note the features of the tracheids in the wood. Can you identify the bordered pits in the view? Draw two adjacent tracheids as they appear in this view.

Not all tracheids (or vessel elements) have bordered pits. Some cells (usually but not always in the primary xylem) have other patterns of secondary wall thickenings. The four commonly recognized types of wall thickenings are:

a. rings-**annular** element
b. helix or spiral-**helical** or **spiral** element
c. ladder-like with transverse bars connected in corners-**scalariform** element
d. uniform wall with ornamentation of pits-pitted element

All of these types of tracheids can be located on a prepared slide of a longitudinal section of the pollen cone of Ginkgo. Draw one cell of each type.

4. **Vessel Element**—an elongated cell similar to a tracheid, but with perforated end walls. These modified end walls are so- called perforation plates and may bear one or more variously arranged openings. Vessel elements occur in primary and secondary xylem of some vascular plants, and in vertical series of interconnected cells. Such a series is the vessel. Whereas the tracheid is a more generalized cell serving a supportive as well as a conducting function, the vessel element is more highly specialized for conduction. The lateral walls of vessel elements exhibit the same range of variation in the deposition of secondary wall as does the tracheid.

Examine prepared slides of macerated oak wood (Quercus). Located elongate, cylindrical cells with openings in the end walls-the vessel elements. The most obvious vessel elements come from the wood produced in the spring. These are very broad and short, and have a single massive perforation in the perforation plate. This wood also contains tracheids, fibers, and parenchyma cells. Draw two or three vessel elements that show a wide range of variation in size and shape.

Activity 2. Tissues and Tissue Systems

A tissue may be defined in a general way as being a more or less continuous group of cells having similar origin, major function, and a characteristic complement of one or more types of cells. Tissues also may be classified as meristematic (immature) or permanent. Tissues that extend through out the plant body are referred to as tissue systems. We will emphasize permanent tissues and tissue systems in this laboratory, and stress meristematic tissues later in the quarter.

A. **Permanent tissue**

Tissue in which growth has ceased is referred to as permanent tissue. In some cases the tissue may return to a meristematic condition.

1. Simple Permanent Tissue

A permanent tissue composed of one kind of cell. The major types of simple permanent tissues include:

a. **Parenchyma**—composed of parenchyma type cells. Several types of parenchyma tissues are generally recognized: **chlorenchyma**—very green, highly photosynthetic parenchyma; **aerenchyma**—parenchyma having very prominent intercellular air spaces or lacunae. Due to its widespread occurrence in the plant body parenchyma tissue is usually referred to by location so widespread occurrence in the plant body parenchyma tissue is usually referred to by location so that one speaks of cortical parenchyma, pith parenchyma, etc. Examine a cross section of the stem of *Selaginella*. Identify the chlorenchyma and aerenchyma tissue in the stem and leaf base.

b. **Collenchyma**—composed of collenchyma type cells.

c. **Schlerenchyma**—composed of one of the types of sclerenchyma cells. Refer to your drawings of collenchyma and sclerenchyma cells to refresh your memory about the appearance of these types of tissue.

d. **Endodermal**—consisting of living cells with thin walls and having a thickened band of suberized wall on the lateral and upper and lower cell sides. This tissue is usually associated with the vascular system.
Examine a transverse section of the leaf of pine (*Pinus*), and locate the single cell layer of endodermis. Note that this tissue forms a cylinder surrounding the vascular tissue in the central part of the leaf. The lateral (radial) walls will show the suberized band, the casparian strip. Casparian strips are a common feature of the endodermis of roots. Draw and label a few endodermal cells.

2. Complex Permanent Tissue

A permanent tissue composed of two or more kinds of cells. The two most important complex tissues are vascular tissue (xylem and phloem), and epidermis.

a. **Xylem** (commonly called wood). A vascular or conducting tissue having oftentimes numerous cell types and a complex organization.

   Examine a prepared slide of a cross section of a *Lycopodium* stem. In the central area you will see several plate- like zones composed of thick-walled cells. These comprise the xylem and the cells are tracheids. This is the simplest sort of xylem found in vascular plants. It is primary xylem, the cells of which were produced at the apical meristem or growing tip of the stem. Diagram this stem, and label the xylem.

   Slightly more complex xylem may be found in *Gleichenia*. Here a prepared slide of a cross section of the stem reveals a central zone, circular in outline, containing large tracheids and smaller scattered parenchyma cells. These two cell types make up the primary xylem of this plant. Diagram and label the xylem in this stem.

   We will reserve the examination of structurally more complex xylem to a later time in this course.

b. **Phloem** (sometimes referred to as bast). A vascular or conducting tissue which like the xylem may contain numerous cell types in a complex organization within the tissue.

   Examine a cross section of a stem of *Cucurbita* and locate an area of xylem. Both outside and inside this xylem zone are areas of phloem. In this phloem tissue you will find large sieve tube elements and smaller cells resembling parenchyma. Examine the various areas of phloem and try to locate a sieve tube element in which a sieve plate is visible. This end wall of the sieve tube element is equivalent to the perforation plate of the vessel element. The sieve tube elements are oriented in vertical files each file comprising a sieve tube. How does this resemble the structures of xylem with vessels? Draw a sieve element that shows a sieve plate. Can you also identify, draw and label a sieve area?

Tissues are also sometimes classified on the basis of their developmental origin within the plant body. A tissue may be either **primary** or **secondary**. Primary tissues are composed of cells produced by the apical or intercalary meristems and as a whole make up the structurally and functionally complete primary body of the plant. Secondary tissues make up the so-called secondary body of the plant. They are usually produced by cambia, and are added to the existing primary body. The most important secondary tissues are secondary xylem, secondary phloem, and periderm.

c. **Epidermis.** The primary outer covering of vascular plant organs. At times, epidermis may be considered to be a complex tissue since it can contain several types of cells. The characteristic structure found in the epidermis is the stoma. This is an opening or pore, surrounded by two guard cells which regulate the opening and closing of the aperture. In some cases, specialized cells may be present surrounding the guard cells. In other instances, the guard cells are surrounded by typical, non- modified epidermal cells of the type found in the areas lying between the stomata. Various other types of specialized cells also occur in epidermis and include, siliceous cells, cork cells, hair bases, and various glands.

Obtain a fresh leaf of geranium (*Pelargonium*) and carefully strip off a piece of the lower epidermis. Make a wet mount of the tissue. Locate the stomata with the characteristic guard cells, and the typical irregularly shaped epidermal cells. Several types of trichomes, including some glandular types are also present here. Draw and label a patch of epidermis that shows as many features as you can find.

B. Meristematic Tissue (We will examine these further in a later lab.)

1. Immature tissue in which growth is taking place at tips of stems and roots, and in developing leaves—**Apical meristem** tissue.

2. Persistent meristematic tissue some distance below the apical meristem, usually extending horizontally across the organ—**Intercalary meristem** tissue.

3. **Cambium**—(pl. **cambia**) so-called lateral meristems extending parallel to the long axis of the plant organ. These produce secondary tissues and have a characteristic cell makeup that is different than typical apical meristematic tissue. The developmental origins of cambia within the plant body are variable.

C. Tissue Systems

Following the original usage of Sachs, several groupings of plant tissues are conveniently employed, the so-called tissue systems. These terms as now used are solely for convenience of referral to groups of tissues. The three tissue systems commonly used are: The Dermal or Integumentary System, the Fundamental or Ground System, and the Fascicular or Vascular System. The Dermal System consists of the epidermis, and some people also include here periderm, a second tissue aggregation which often replaces the epidermis in woody plants and becomes the outermost tissue. The Fundamental System consists of the cortex, pericycle, pith, and mesophyll. The Facicular System consists of the vascular tissues.

Obtain a slide of each of the following: *Medicago* stem cross section, *Ranunculus* root cross section, and Ligustrum leaf cross section. In the leaf, locate the **Dermal** and **Fundamental** (or **Ground**) Systems. The latter consists of the mesophyll- composed of

thin walled, chlorophyllous cells with air spaces. Note that the **Fascicular System** consists of separate strands of vascular tissue. These strands are called vascular bundles and each contains xylem and phloem. Diagram and label the positions of the tissue systems in this leaf.

Refer now to the root and locate the xylem in the very center. Phloem may be found in the embayments between the radiating arms of xylem. These two tissues make up the Fascicular System of this root. The Dermal System again, consists of the single outer cell layer of the root, the epidermis. The Fundamental System is made up of the remaining tissues of the root. Diagram and label the positions of the tissue systems in this root.

In the stem, locate a ring of discrete areas in which the vascular tissues occur. these are vascular bundles and xylem makes up the inner part of each. Phloem is also present in each bundle, and exterior to this, a prominent bundle cap of fibers (sometimes called pericycle) is present. In the central part of the stem is the pith. What kind of cell composes this area? Find the Dermal System. What types of simple tissues make up the Fundamental System in this stem? Diagram and label the positions of the tissue systems in this stem. Also draw and label the simple tissues that make up the fundamental system in the stem.