

Biology 115 Lab 8. Tissues

Animal Tissues

Tissues are groups of cells with a common structure and function. The study of tissues is called **histology**. Tissues can be classified into four basic categories: **epithelial tissue**, **connective tissue**, **muscle tissue**, and **nervous tissue**. All but the simplest animals have all four types of tissues.

Epithelial Tissues

Epithelial tissues occur in sheets of tightly packed cells that cover the outside of the body and lines organs and cavities inside the body. The main functions of epithelial tissues are protection and transport of materials into and out of cells (in other words, they secrete and absorb materials).

Epithelial tissues don't have blood vessels, and are attached to the underlying connective tissue by an extracellular **basement membrane**. Epithelial tissues are classified by the shape of the cells and by the number of cell layers. The three types of epithelial cell shapes are: **squamous** (flat or scalelike), **cuboidal** (like a cube), and **columnar** (like a column or a brick on end). The number of cell layers are described as **simple** (if there is a single layer), **stratified** (if there is more than one layer), or **pseudostratified**. Pseudostratified epithelium looks initially like it is composed of more than one layer, but in fact all cells are attached to the basement membrane, and so it is really only a single layer. Pseudostratified epithelium is only composed of columnar epithelial cells. The six common subtypes of epithelial tissues are: **simple squamous**, **simple cuboidal**, **simple columnar**, **pseudostratified columnar**, **stratified squamous**, and **stratified columnar**.

Connective Tissue

Connective tissue occurs in all parts of the body. It functions mainly to bind and support other tissues. Connective tissue consists of loosely packed cells, scattered through a non-living, **extracellular matrix**. The major types of connective tissue are **loose connective tissue**, **fibrous connective tissue**, **adipose (fat) tissue**, **cartilage**, **bone**, and **blood**.

Loose connective tissue (also called 'areolar' connective tissue) is the most widespread connective tissue. It binds epithelia to underlying tissues, and functions as 'packing' material between other tissues. When you pinch and pull your skin, it snaps back into shape primarily because of the loose connective tissue. Loose connective tissue is characterized by fibers running in all directions through an extracellular matrix.

Fibrous connective tissue is dense, because all the fibers run in the same direction. This type of connective tissue is found in **tendons**, which attach muscles to bones, and in **ligaments**, which join bones together. Fibrous connective tissue also makes up the dermis.

☞ Obtain a slide of Areolar Tissue, and examine loose connective tissue. Look for the fibers (probably at least two different kinds), and the cells that secrete the fibers and matrix. These cells are called **fibroblasts**. You will not be able to see the matrix itself.

📐 *Draw and label what you see in the space below.*

Examination of an Organ: Human Skin

🔍 Obtain a slide of human skin. Examine the fibrous connective tissue of the dermis.

Adipose (fat) tissue is a specialized form of loose connective tissue that stores fat in adipose cells distributed throughout its matrix. It may be found below the dermis in the **subcutaneous layer** or **hypodermis**. The function of adipose tissue is energy storage and insulation. Look for it on your slide.

📐 *Draw and label ALL parts of the human skin slide in the space below.* Be sure to specify which cells are connective tissue, stratified squamous epithelium, simple cuboidal epithelium, and adipose tissue; as well as, the epidermis, dermis, and hypodermis.

Cartilage is a type of connective tissue that is used for flexible support (the nose, the ears, and the rings that reinforce the trachea), and for cushioning between bones (the disks between vertebrae, joints between longbones). Cartilage is produced by cells called **chondrocytes**. These cells secrete many fibers and a rubbery matrix. The chondrocytes become surrounded by their matrix, and live in ‘holes’ in the matrix called **lacunae**.

🔍 Obtain a slide of hyaline cartilage. Focus under low power first, then switch to medium and finally high power. Adjust the aperture disk so that the image appears slightly dim. The dark ‘spots’ you see are the chondrocytes. The ‘bubble’ enclosing each chondrocyte is the lacunae in which it lives. The matrix is the apparently clear space between the lacunae. You will not be able to see the fibers. There are no blood vessels in cartilage.

📐 *Draw what you see in the space below.* Label the chondrocytes, lacunae, and matrix.

Bone is mineralized connective tissue that supports and protects the bodies of most vertebrates. Bone is a living tissue formed by **osteocytes**. Like chondrocytes (remember, the cells that form cartilage) the osteocytes live in ‘holes’ in the matrix called

lacunae. The matrix of bone (a mineral called **hydroxyapatite**) is what makes it hard, yet somewhat flexible. Living bone consists of repeating circular units called **Haversian systems** or **osteons**. Each system has concentric layers (**lamellae**) of the matrix deposited around a central Haversian **canal**. The blood vessels and nerves that supply the osteocytes run through this central canal. There are several osteocytes between the lamellae of each osteon. Because bone matrix is hard, substances needed by the osteocytes cannot diffuse from the central canal to the cells. Therefore, the osteocytes (living in their lacunae) are connected to each other, and to the central canal, by smaller canals called **canaliculi**. The osteocytes get their nutrients from the blood, and pass their wastes to the blood, through these canaliculi. The canaliculi look like small dark threads running between the layers of the osteon.

☞ Get a slide of ground bone, and identify an osteon, the central canal, the lacunae where the osteocytes live (you won't be able to see an actual osteocyte), and the canaliculi.

📎 *Draw and label these structures in the space below.*

Blood is considered a connective tissue because it has an extensive extracellular matrix. The matrix is called **plasma**, and consists of water, salts, and dissolved proteins. There are two basic types of blood cells. Red blood cells (**erythrocytes**) carry oxygen to the cells of the body and remove carbon dioxide. White blood cells (**leukocytes**) function in defense against viruses, bacteria, and other foreign invaders. Also suspended in the matrix are **platelets**. Platelets are very small blood cells that serve to help blood clot.

Red blood cells are the most numerous, and look like small, red 'doughnuts' without a complete hole through the middle. In mammals, they do not have nuclei (although they do in other vertebrates). White blood cells are generally larger than red blood cells, and have darkly-staining nuclei.

☞ Obtain a slide of human blood, and look for the red blood cells, white blood cells, and platelets.

📎 *Draw and label what you see in the space below.*

Muscle Tissue

Muscle tissue is composed of long, excitable cells that are capable of contraction. Inside

each cell, there are many **microfilaments** arranged in parallel. These microfilaments are of two types: **actin** and **myosin**. When a muscle cell contracts, these microfilaments slide past each other, and the muscle cell shortens. In vertebrates, there are three types of muscle tissue: **skeletal muscle**, **cardiac muscle**, and **smooth muscle**. Each of these three types has a different structure and function.

Skeletal muscle is what you think of when you normally think of a muscle. It is attached to bones by **tendons**, and is generally responsible for the **voluntary** movements of the body. You can control (to some extent) your skeletal muscle. Adults have a fixed number of skeletal muscle cells. Lifting weights or other training does not increase the number of skeletal muscle cells, it simply increases the size of those cells already present.

Skeletal muscle is considered a **striated** muscle tissue because under the microscope it has light and dark bands (**striations**) running across the cells. These striations are due to the arrangement of the actin and myosin microfilaments inside the cell. In striated muscle (you will see below that cardiac muscle is also striated), the actin and myosin filaments are arranged “**in register**”, or in columns within the cell. Where a column of actin overlaps with a column of myosin, it appears as a dark line crossing the cell. Where the two columns do not overlap, it appears as a lighter area crossing the cell.

Each skeletal muscle cell has **many nuclei**. These nuclei are pressed to the edge of the cell by the microfilaments. Skeletal muscle cells are very long, and run the length of the muscle.

☞ Obtain a slide of skeletal muscle. Focus first with low power, then switch to medium and finally high power. Identify the muscle cells, striations, and nuclei.

📄 *Draw and label what you see in the space below.*

Cardiac muscle forms the contractile wall of the **heart**. Like skeletal muscle, it is striated because the actin and myosin filaments are arranged in register. However, unlike skeletal muscle, cardiac muscle cells only have one nucleus per cell. Also, cardiac muscle cells are **involuntary**, you can't exercise voluntary control over your heartbeat (usually). Cardiac muscle also differs from skeletal muscle in two other ways: cardiac muscle cells are **branched**, and cardiac muscle cells are joined together by special structures called **intercalated disks**. The branching of cardiac muscle cells, and their connections via intercalated disks serve to transmit and regulate signals that control heartbeat. On a slide of cardiac muscle, the intercalated disks look like especially dark striations.

☞ Obtain a slide of cardiac muscle. Identify the branched muscle cells, striations, nuclei, and the intercalated disks.

📄 *Draw and label what you see in the space below.*

You saw **smooth muscle** in the slide of the mammalian intestine early in the course. It is called smooth muscle because it lacks the striations seen in skeletal and cardiac muscle. Smooth muscle is still composed of actin and myosin microfilaments, but these are not arranged in discrete columns within the cell, and so do not result in a

striated appearance. Smooth muscle lines the walls of the digestive tract, bladder, arteries, and other internal organs. Like cardiac muscle, smooth muscle is considered to be **involuntary**. Contractions of smooth muscle are generally controlled by the involuntary nervous system and are generally not under conscious control. Smooth muscle cells have **one nuclei** per cell (centrally located), and are generally **spindle shaped** (fat in the middle, and pointy at both ends).

🌀 Obtain a slide of smooth muscle. Locate the muscle cells and their nuclei.

📐 *Draw and label what you see below.*

Nervous Tissue

Nervous tissue senses stimuli and transmits signals from one part of an organism to another. This tissue is found in the brain and spinal cord (together called the **central nervous system**) as well as in the nerves leading to and from all of the body's organs (the **peripheral nervous system**). The functional unit of the nervous system is the nerve cell or **neuron**. Neurons consist of three parts: the **cell body**, **dendrites**, and **axons**. The cell body is where the nucleus is, and where most of the organelles are located. Dendrites and axons are long, thin processes extending away from the cell body. Dendrites carry nerve impulses (**action potentials**) toward the cell body, while axons carry nerve impulses away from the cell body.

🌀 Obtain a slide of nervous tissue. Focus under low power, and then switch to medium.

Scan around until you can find a neuron cell body. Switch to high power. The cell body of the neuron should stain relatively more darkly than the surrounding material, and in the center should be a very dark, circular nucleus. The long thin strands leading away from the cell body are the axons and dendrites. You cannot tell which is which in on this slide. In the surrounding matrix, you will notice many small dark spots. These are **glial cells**. Glial cells support and nourish the neuron.

📐 *Draw a neuron and some glial cells as they appear under your microscope.* Be sure to label all parts.

Skeletal Anatomy

There are three main functions of skeletal systems: support, protection, and movement. Most land animals would sag from their own weight if they had no skeletal support. Even an aquatic animal would be a formless mass if there were no structure or framework to maintain its shape. Many animals have hard skeletons to protect soft

tissues. Your skull, for example, protects your brain. Your ribs protect your heart and lungs, etc. Additionally, skeletons give muscles something to work against to produce movement. There are three basic types of skeletal systems in animals: **hydrostatic skeletons**, **exoskeletons**, and **endoskeletons**.

Types of skeletal systems in animals

Hydrostatic skeleton

A hydrostatic skeleton consists of fluid held under pressure in a closed body compartment. This is the main type of skeleton in worms, slugs, and aquatic invertebrates like sea anemones. Because fluid (usually water or blood) is incompressible, these organisms can tighten muscles around their body and extrude a part, or pull another part back. Its kind of like when you squeeze a water balloon in the middle, the ends stick out farther.

☞ Look at the examples of organisms with hydrostatic skeletons on display in the lab.

Exoskeleton

An exoskeleton is a hard encasement deposited on the surface of an animal. For example, clams and other mollusks are enclosed by an exoskeleton, their shell. Arthropods (insects, crustaceans, spiders, etc.) are also enclosed in an exoskeleton. It is called a cuticle, and is composed primarily of chitin secreted by the epidermis. Exoskeletons must be shed (molted) periodically as the organism grows.

☞ Look at the examples of organisms with exoskeletons on display in the lab.

Endoskeleton

An endoskeleton consists of hard supporting elements, such as bones, buried within the soft tissues of an animal. Sponges have a type of endoskeleton, hard **spicules** made up of inorganic material. Starfish and sea urchins (echinoderms) have hard plates of calcium carbonate crystals beneath the skin. Vertebrates have endoskeletons composed of cartilage, bone, or some combination of the two. The mammalian skeleton is composed of over 200 bones, some fused, some joined together by ligaments allowing movement at joints.

Anatomists divide the vertebrate skeleton into two classes: the **axial skeleton** consisting of the skull, vertebral column and rib cage; and the **appendicular skeleton** consisting of the limb bones and the pectoral and pelvic girdles that anchor the appendages to the axial skeleton.

☞ Look at the examples of organisms with endoskeletons on display in the lab. We will go into greater detail on the vertebrate skeleton below.

Vertebrate Skeletal Anatomy

The skeletons of most terrestrial vertebrates are basically alike. They differ primarily with respect to meeting different stresses resulting from different methods of support and locomotion.

Use the diagrams provided, the human skeletons, and the other vertebrate skeletons on display to find the bones and structures described below.

Axial Skeleton

Skull - The skull consists of a **cranial region** housing the brain and the inner and middle ear, and a **facial region** containing the eyes, nose and forming the upper and lower jaws. The **orbits** are depressions that house the eyes. The lower jaw is a single bone, the **mandible**. The spinal cord enters the back of the skull through an opening, the **foramen magnum**.

Vertebral Column - The vertebral column consists of the **vertebrae**, and can be divided into five regions. The **cervical region** consists of the vertebrae of the neck. The **thoracic region** is the portion of the vertebral column to which the ribs attach. The **lumbar region** is posterior to the thoracic region and does not bear ribs. The **sacral region** consists of fused vertebrae that attach to the pelvic girdle. The **caudal region** consists of the tail vertebrae. In humans, vertebrae of the caudal region are used into the 'tailbone' or coccyx.

Ribs and Sternum - Humans have 12 pairs of **ribs**, but different vertebrate species have different numbers of ribs (snakes may have as many as 150 or more!). The ribs are connected to the thoracic vertebrae dorsally, and all but the last few connect ventrally to the **sternum** (breastbone).

Appendicular Skeleton

The girdle of the forelimbs (or arms) is the **pectoral girdle**. It consists of two bones: the **scapula** (shoulderblade) and the **clavicle** (collarbone). The bones of the forelimbs consist of a single **humerus** in the upper arm, and two bones in the lower arm: the **radius** and the **ulna**. The ulna goes from the elbow to the outside of the wrist (the side with the little finger), and the radius goes from the outer-top of the forearm across the ulna to the side of the thumb at the wrist. If you turn your right hand over and hold it so you are looking at the palm, the radius will be on the right and the ulna will be on the left, going from your elbow to your wrist. The bones of the wrist are called the **carpals**. The bones of the hand are called the **metacarpals**, and the bones of the digits are called **phalanges**.

The girdle of the hindlimbs is the **pelvic girdle**. The bone of the upper leg is called the **femur**. Again, there are two bones in the lower leg: the **tibia** and the **fibula**. The tibia is the larger of the two, and forms the shin. The fibula is thinner, and runs along the outside of the lower leg. The two bones that you can feel as 'bumps' on the inside and outside of your ankle are the lower ends of the tibia (on the inside) and fibula (on the outside). At the joint between the femur and the tibia and fibula (knee-joint) is a bone, the **patella** (kneecap). The bones of the ankle are the **tarsals**, and the bones of the foot are the **metatarsals**. Again, the bones of the digits are **phalanges**.