Unit 4 Histology

Unit Overview: Although the cell is the structural and functional unit of the human body, studying them individually does not give us a complete understanding of their organization in the human body. Like all other multicellular organisms, the human body contains cells that are specialized to perform their own tasks in an attempt to maintain homeostasis. These cells work together in groups to create crucial tissues in the body, and if they are damaged due to injury or disease, disability or death of the organism can occur.

This unit provides students with introductory information on the four main types of tissue found within the body: Epithelial, connective, nervous, and muscle. The structure, function, and location of each tissue type are discussed and a general description of each is given.

Students then spend a great deal of time in lab examining a set of known slides in order to practice tissue identification. They are then assigned a set of unknown slides to examine and identify. Upon completion of tissue identification, students examine and analyze a set of tissues that have been affected by the use of tobacco and other drugs. All of this information is compiled into a "Histology Notebook" that they can keep for future reference in college.

Objective(s)/Skills Attained: The objectives for this unit are written prior to the daily lessons, as all lessons prepare the students for activity 4:1 and have the same goals in mind.

- Students will be able to identify tissues within the body and be able to discuss physiological roles and locations of each.
- Students will identify structural and functional characteristics of tissues found within the body.
- Students will classify various types of tissue within the body.
- Students will differentiate between tissue types.
- Students will compare and contrast the structures present within various tissues.
- Students will evaluate the effects of tobacco and other drugs on the human body.
- Students will prepare a histology notebook to act as a future reference.

Homilies: This particular unit does not tend to be students' favorite, so I therefore try to keep it as practical and hands on as I can. I generally introduce each main tissue type by itself, give specific examples, functions, locations, etc. in lecture and then allow students to examine the textfolders that contain the tissues discussed. I try to introduce the entire tissue type in one class period, but occasionally students have questions that cause the lecture of some tissue types to go over into the following day. As soon as students have been introduced to each tissue type, they should examine the tissues under the microslide viewers. When all "known" tissues have been examined, they will begin to try to identify and classify the unknown slides.

Lesson 4:1 Introduction to Tissues and Epithelium

Materials: Power Point Slide Presentation: Histology: The Study of Tissues – Slides 1 – 32.

Lecture Support:
Slide 2: Remind students of the levels of structural organization that were studied in unit one – a tissue is simply one level higher than the cellular level and is therefore a grouping of cells working together. Ask students to recall the 4 main tissue types found within the human body: Epithelial, muscle, connective, and nervous.

If you like more of a discussion format rather than lecture, try to get students to recall the general function(s) played by each main tissue type as well.

Slide 3: Tissues carry out functions in the body such as storage, transportation, communication, protection, elimination of waste, etc.

Slide 4: Epithelial tissue is generally though of as being sheet like and having a large surface area. Like sheets, blankets, etc. they primarily line and cover. Connective tissue, like their name implies, is thought to bind or connect body parts. For example, tendons are made up of connective tissue and connect or bind muscle to bone. However, not all connective tissue plays a binding role. Some connective tissues support, protect, transport, insulate, etc. Muscle tissue allows movement of our physical body, as well as the internal propulsion of food, blood, urine, etc. Nervous tissue's primary role is a communicative function. It sends electrochemical impulses throughout the body.

Slide 5: Epithelial tissue is a covering, lining, or glandular tissue. Covering/Lining epithelium forms our skin, mucous membranes, and the serous membranes we discussed in unit one. Glandular epithelium forms glands within the body. The functions provided by epithelial tissues include protection, absorption, filtration, and secretion.

Slide 6: All tissues have characteristics that distinguish them apart from other tissues. Epithelial tissue has six identifying characteristics:

1) Cellularity: When viewed under a microscope, epithelial tissue is primarily made up of cells. Very little extracellular space is seen. Unlike connective tissue that we will study later, which has a very low degree of cellularity.

Slide 7: 2) Specialized Contacts: The cells of epithelial tissue are held together by structures called desmosomes and tight junctions that form sheets of close fitting cells. The tissue therefore has a large surface area.

Slide 8: 3) Polarity: Polarity simply means that two ends of an object are "opposite" or different from one another. Like the N and S poles of a magnet, the + and – ends of a battery, the 5′ and 3′ end of DNA. In epithelial tissue, there are two different sides or surfaces of the tissue.

One surface, the apical surface, does not touch any other structure and either opens up to the exterior of the body or some type of internal cavity, organ, gland, etc. The opposite surface, the basal surface, is attached to a structure called the basement membrane and connective tissue below it. In other words, it is anchored.

Slide 9: 4) Supported by Connective Tissue: As stated in the previous slide, there is a structure on the basal surface of epithelium to which it is anchored. This basement membrane consists of the basal lamina and the reticular lamina. The basal lamina is a non-cellular layer that is secreted by the epithelial cells. It acts as an adhesive and filter for diffusing materials. It consists primarily of glycoproteins. The reticular lamina is secreted by the connective tissue that lies beneath the epithelium and consists of collagen fibers. Together the basal and reticular lamina help to protect the epithelium from stretching and tearing.

Slide 10: 5) Innervated but Avascular: Epithelial tissue has a good supply of nerves to it; however, it has no blood supply. Nutrients and other necessary materials, such as oxygen, must diffuse from blood vessels found in the underlying connective tissue.

Slide 11: 6) Regeneration: Because epithelial tissue is often found in areas of high abrasion, or is exposed to substances in the environment that cause damage, it is highly mitotic and replaces itself rapidly.

Slides 12 – 18 discuss how epithelial tissue receives its name according to shape and number of cell layers. They are self explanatory. You may want to stress that Cuboidal and columnar cell shapes are apparent in the name. Believe it or not, some students do not associate Cuboidal with "cube" and columnar with "column".

Slides 19 - 20 discuss the location and function of SSET, my abbreviation for Simple Squamous Epithelial Tissue. You may want to help students associate the mesothelium with the serous membranes that were discussed in chapter one. Have them recall them if you desire: Parietal and visceral pleura/pericardium/peritoneum etc. Also help students realize that the function is often associated with the location and thickness of the tissue.

Slide 21: Link to the internet to see some images of simple squamous epithelium tissue.

Slides 22 – 28 follow this same format and discuss the location and function of Cuboidal and columnar epithelial tissues. They are self explanatory.

Slide 29 just adds some images to reinforce the concepts of protection, sweat glands, and the pharynx.

Slides 30 – 32 are self-explanatory and discuss the location and function of Pseudostratified epithelial tissue.

At this point, you will want students to begin looking at these tissues underneath the microscope. Students should follow the student activity 4:1 and examine the following known slides: Textfolder # 10 slide 1 and textfolder #50 slides 3, 4, 6, and 7. I generally expect my students to read the accompanying textfolder information and sketch in detail three to four slides per class period. This will definitely carry over into the next period.

When all students have completed looking at epithelial tissue, move on to lesson #2: Muscle Tissue.

Lesson 4:2 Muscle Tissue

Materials: Power Point Slide Presentation: Histology: The Study of Tissues – Slides 33 – 47. (Muscle Tissue)

Lecture Support and Procedure:

Slides 33 – 47 introduce muscle tissue. These slides are pretty detailed and should not need a lot of additional information, but some key points are mentioned below.

Slide 34: Skeletal muscle tissue can also be referred to as voluntary muscle tissue or striated muscle tissue. Smooth muscle tissue can also be called visceral or involuntary muscle tissue. Cardiac muscle tissue is generally only referred to as cardiac tissue. We will discuss why this is true later.

Slide 35: This slide explains why skeletal muscle tissue receives its name – it's attached to the skeletal system of the body and produces movement of it by pulling on our bones. It is controlled voluntarily, or when we want it to.

Slide 36: Skeletal muscle tissue is also referred to as striated muscle because of the striations or stripes that are seen within the individual cells.

I tell students to think of a bundle of drinking straws when they think about the shape and arrangement of skeletal muscle cells. They are cylindrical, like straws and they do not branch. The cells all run parallel to one another.

It is also important to point out that skeletal muscle is multi-nucleate. It has several nuclei found within each cell. You can have students discuss hypotheses to this occurrence or you can allow them to critically think about it for the analysis questions that accompany the lab activity.

The cytoplasmic volume in muscle cells is so extensive that one nucleus would never contain enough DNA to synthesis enough proteins for the cell, nor would it be able to regulate other cellular activities for the cell. Therefore, several nuclei share the role.

Slides 37 and 38 take you to images of skeletal muscle (striated muscle) on the internet. Point out the characteristics that are helpful in identifying the tissue: Striations, several nuclei per cell – generally pushed off toward the cell membrane, and cylindrical non-branching cells.

Slide 39 introduces cardiac muscle tissue. This tissue receives its name due to its location. It is found only in the heart. It is responsible for producing contractions that cause the heart to pump blood throughout our circulatory system. It is involuntarily controlled – because we can not stop it or start it at will.

Slide 40: Microscopically, cardiac muscle resembles skeletal muscle. It is important to note the similarities and differences so the two tissues can be differentiated. Both tissues are striated. Both tissues have cylindrical cells. However, cardiac muscle cells branch and often form "Y" shaped cells. Cardiac muscle is also NOT multi-nucleate. Each cell has only one centrally located nucleus – occasionally two. The most notable structure that distinguishes cardiac tissue from skeletal muscle is the presence of intercalated discs. They appear to be dark lines at the end of each cell. They function to synchronize all the cells within the tissue so they contract at the same time – causing the pumping action of the heart. Skeletal muscle tissue does not have this structure present!

Slides 41 – 43 illustrate the above information quite readily. Allow students to examine these carefully before going on.

Slide 44 - 47: Smooth muscle is notably different from skeletal and cardiac muscle tissue. It is not easily confused with either of them. However, it does resemble dense regular connective tissue, so be careful when examining the two under the microscope. Smooth muscle receives its name "smooth" because it is not striped, or striated. It is found within the hollow organs of the body and therefore is often
referred to as visceral muscle. It is not controlled at will, so therefore is also called involuntary muscle. The cells themselves are spindle shaped, meaning they are "fat" in the middle and tapered toward both ends – like a cigar. They are uni-nucleate.

At this point, you will want students to begin looking at these tissues underneath the microscope. Students should follow the student activity 4:1 and examine the following known slides: Textfolder #51: Slides, 1, 2, and 3. Again, I generally expect my students to read the accompanying textfolder information and sketch in detail three to four slides per class period. This will definitely carry over into the next period.

When all students have completed looking at muscle tissue, move on to lesson #3 Connective Tissue.

Lesson 4:3 Connective Tissue

Materials: Power Point Slide Presentation: Histology: The Study of Tissues – Slides 48 - 73. (Connective Tissue)

Lecture Support:

Connective tissue is the most abundant and varied tissue in the body. Due to its abundance and variety, it serves several functions within the body. It binds and supports, protects, insulates, and transports substances. Connective tissue can fall into one of four main classes: 1) Connective tissue proper, which includes fat and the fibrous tissue of ligaments, 2) cartilage, 3) bone, and 4) blood.

As in other tissues already studied, connective tissue also has characteristics that distinguish it apart from other tissues. These characteristics are covered in the following slides.

Slide 48 introduces the roles connective tissues play in the body.

Slide 49: Connective tissues arise from the mesoderm. While an embryo is developing, three primary germ layers develop. The ectoderm, mesoderm, and endoderm lie on top of one another like a stack of pancakes. The ectoderm is near the outside, while the endoderm is closest to the inside. These germ layers specialize and then give rise to the four main tissue types, which eventually form all body organs.

Epithelial tissue is derived from all three germ layers, muscle and connective tissue arise from the mesoderm, and nervous tissue develops from the ectoderm. The specific embryonic tissue that gives rise to connective tissue is called mesenchyme. Images of this tissue are visible on the next slide.

Slide 51: Connective tissue has varying degrees of vascularity, meaning some connective tissues, such as cartilage, are completely avascular, while others have a very good blood supply. Blood itself is connective tissue!

In addition to the cellular component of connective tissue, there is also a non-living (inorganic) portion referred to as matrix. It is this matrix that determines the consistency of the connective tissue. Bone is extremely dense, while blood is fluid. There are varying degrees of consistency as well as vascularity.

Slide 52: Matrix, in my mind, is the single most unique property that distinguishes connective tissue from other tissues. It consists of two components: Ground substance and fibers.

Ground substance surrounds the cells and fills the spaces between them. It is unstructured, consisting of interstitial fluid, cell adhesion proteins, and proteoglycans.

Interstitial fluid is simply excess fats and fluids that seep out of the cells and fill the spaces between the cells. Cell adhesion proteins act as a glue to attach the connective tissue cells to the matrix. The main ingredients found in ground substance are glycoproteins and Proteoglycans. Proteoglycans resemble a bottle brush. Their core consists of the protein to which, glycosaaminoglycans (GAGs), specifically hyaluronic acid, chondroitin sulfate, attach. These GAGs bind water and other tissue fluids that are needed for the exchange of nutrients, and wastes, and act as a lubricant and shock absorber. It functions almost like a protective gauze/mesh and prevents the invasion of microorganisms or foreign substances, while allowing the diffusion of nutrients and other necessary materials. The greater the GAG content, the more viscous the ground substance is. Diffusion of necessary materials is slowed down by the fibers that are embedded within the ground substance.

Slide 53: Collagen, elastic, and reticular fibers are the three types of fibers found embedded within the ground substance. Together, the ground substance and the fibers determine the consistency of the matrix, and ultimately the connective tissue. Some connective tissues are very fluid like blood, while others are dense like bone.

Slide 54: Collagen fibers are made up of a fibrous protein (collagen), hence its name. These fibers form cross links and bundle together to form thick, tough fibers. They provide tensile strength for tissues, giving them the ability to resist longitudinal stress. Stress tests actually indicate collagen fibers are stronger than steel fibers. Collagen fibers are also often referred to as white fibers because they are glistening white in appearance.

Elastic fibers, consisting of the protein elastin, are more resilient and rubber-like. They are able to stretch and recoil. Collagen fibers and elastic fibers work together within a tissue. Tissues can only be stretched so far because the collagen fibers prevent too much stress in the longitudinal direction. When a tissue is stretched to its limit, the elastic fibers then help to return the tissue to its original shape and size. Elastic fibers are found in areas of the body that need greater elasticity, such as the lungs, skin, and blood vessel walls. Elastic fibers are often referred to as yellow fibers because they are yellow in color.

Reticular fibers form a very fine network of collagenous fibers. They are similar to collagen fibers; however, their chemistry differs and they are continuous with the collagen fibers. They form extensive networks of tissue around small blood vessels and soft tissues of organs. They can be found in the basement membrane of epithelial tissues, and around capillaries.

Slide 55: Embedded within the fibers and ground substance of connective tissue, are cells that exist in immature and mature forms. The immature cells are actively undergoing mitosis and are responsible for secreting the fibers and ground substance of the matrix. The suffix "blast" is found within the cell type name to indicate this immature state. The main blast cell type found in connective tissue proper is the fibroblast. The chondroclast is found in cartilage, the osteoblast is found within bone, and the hematopoietic stem cell is found within blood. Note the prefixes "chondr", meaning cartilage and "osteo" pertaining to bone.

Upon secretion of the matrix, the blast cells become less active and mature. This state is indicated by the suffix "cyte". Therefore, a mature cartilage cell would be called a chondrocyte.

Slide 56: There are 4 main classes of connective tissue: Connective tissue proper, cartilage, bone, and blood. All mature connective tissue, except for bone, cartilage, and blood belong to connective tissue proper. Examples include all of the loose connective tissues such as adipose and loose areolar connective tissue. Dense connective tissue includes dense regular and dense irregular connective tissue.

This slide focuses on loose areolar connective tissue, which falls into the connective tissue proper class. Its locations and functions are discussed on **slide 57 and 58**.

Slide 59: This slide has a hyperlink to an image of loose areolar connective tissue on the web.

Slide 60: Adipose tissue is basically "fat." It is structurally and functionally similar to areolar tissue; however, it is able to store nutrients much more readily. Ninety percent of this tissues mass is comprised of adipocytes (fat cells). The matrix is scarce because the cells fit closely together. When viewed under a microscope, it takes on almost a beehive appearance. The nucleus is displaced by a large fat droplet within the cytoplasm. The location and function of adipose tissue is discussed on the slide.

Slide 61: This slide has a hyperlink to an image or adipose tissue on the web.

Slide 62: Osseous tissue is bone. Its matrix consists of abundant collagen fibers and inorganic calcium salts, which contribute to its hardness and ability to support and protect. The characteristic "target-like" structures making up this tissue are hard to miss when identifying it. The structure of osseous tissue will be covered more in depth during the skeletal system unit. Function and location are discussed on this slide.

Slide 63: This slide has a hyperlink to an image of osseous tissue on the web.

Slide 64 - 71: The images on slide 64 help illustrate the fact that cartilage has the ability withstand tension and compression. It is flexible, yet tough. It lacks a blood (avascular) and nerve supply.

Three types of cartilage exist: Hyaline, Elastic and Fibrocartilage.

Slide 66: Hyaline cartilage, the most abundant type of cartilage, is found on the articulating surfaces of bones, within the tip of the nose, the larynx, trachea, and between the sternum and ribs. Its primary role is support and cushioning. **Slide 66** has a hyperlink to an image of hyaline cartilage on the web.

Slide 68: Elastic cartilage is almost identical structurally to hyaline cartilage, except for the fact that it contains more elastin fibers, giving it improved ability to withstand repetitive motion. It is found forming the external ear and epiglottis. **Slide 69** has a hyperlink to an image of elastic cartilage on the web.

Slide 70: Fibrocartilage is found where there is a great need for support in addition to withstanding heavy pressure. Intervertebral discs consist of fibrocartilage as well as the menisci of the knees. **Slide 71** has a hyperlink to an image of fibrocartilage on the web.

Slide 72: The last of the connective tissues that we will examine is blood. Blood is not a typical connective tissue, because it does not play a role in connection, binding, or support. However, it develops from the same embryonic tissue as all other connective tissues and the blood cells are surrounded by an inorganic matrix – the plasma.

Instead of binding, connecting, and supporting, blood serves as a transporter. It transports nutrients, oxygen, carbon dioxide, and waste products throughout the body. Obviously, blood is contained within the circulatory system. Nutrients and oxygen are delivered to body tissues, while the carbon dioxide and waste is carried away. Hormones and other necessary chemicals are also transported throughout the body via the blood.

Basically, blood can be divided into 2 components: Formed elements and plasma.
Plasma makes up approximately 55% of blood volume and consists of 90% water and over 100 dissolved substances including gases, hormones, nutrients, wastes, proteins, and ions.

Formed elements include the cellular components of blood: Red blood cells (erythrocytes), which make up 45% of blood's volume, and white blood cells (leukocytes) and platelets (thrombocytes), which make up the remaining 1%.

Slide 73: This slide has a hyperlink to an image of blood on the web.

Again, t this point, you will want students to begin looking at these tissues underneath the microscope. Students should follow the student activity 4:1 and examine the following known slides: Textfolder #10: Slides 2, and 4, Textfolder #50: Slide 5, and Textfolder #51: Slides 4, 5, 6, and 7. AS stated earlier, I generally expect my students to read the accompanying textfolder information and sketch in detail three to four slides per class period. This will definitely take one additional class period and ½ of a third.

Lesson 4:4 Nervous Tissue

Materials: Power Point Slide Presentation: Histology: The Study of Tissues – Slides 74 - 76. (Nervous Tissue)

Lecture Support:

Hopefully, when students think of nervous tissue, the nervous system comes to mind. This will help them think about the location of this tissue in the body – it's found within the organs of the nervous system: the brain, spinal cord, and peripheral nerves and functions to send electrochemical impulses throughout the body.

Slide 74: Nervous tissue consists of two types of cells: Neurons and neuroglia. Neurons are the actual cell that creates and sends the nerve impulses throughout the body. They are "insulated" (like an electrical wire) by supporting cells called neuroglia cells. Neurons themselves are atypical, branching cells that resemble octopi. They have cellular extensions that branch out of the cell body and conduct impulses into and out it.

The short extensions are referred to as dendrites. There are generally several per cell and they are responsible for conducting the impulse into the cell body. One longer extension, known as an axon, sends the nerve impulse away from the cell body.

Slides 75 and 76 have hyperlinks to images of nervous tissue on the internet.

To conclude the viewing of known histology slides, students need to examine Textfolder #51: Slide 8 and Textfolder #58: Slide 6.

Students should use the remainder of the class period to sketch these slides and complete any others they have to finish.

Lesson 4:5 Viewing Unknown Tissues

During this portion of the laboratory activity 4:1, students examine 17 unknown slides. You need to have at least one prepared microscope slide of each of the tissues listed below.

Supply companies always label the slide, so you need to prepare the slides for the activity by cutting small strips of a thick paper (such as construction paper) and wrap and tape it around the label. Use a permanent marker to number each slide. Keep track of the number you assign to each tissue (do not number them in the order they were examined – mix it up) and place it in the table below. You can then use that as your key. Although students were introduced to both fibrocartilage and elastic cartilage in lecture, I only have them identify one type of cartilage – hyaline.

Tissue	Slide #	Tissue	Slide #
Simple Squamous ET		Hyaline Cartilage	
Simple Cuboidal ET		Loose Areolar CT	
Simple Columnar ET (non-ciliated)		Adipose Tissue	
Ciliated Columnar ET		Osseous Tissue	
Stratified Squamous ET		Blood	
Skeletal Muscle		Nervous Tissue	
Smooth Muscle			

Now, you have the option of setting up 17 different microscopes around the classroom and have students move from scope to scope to view and identify the 17 slides, or you can have them exchange the slides on a tray. I allow my students to work two to a microscope and they are able to use their sketches and notes from examining the known slides. (Because this course is taken after biology, it is assumed that students remember correct microscope usage. If not, you may need to briefly run through the correct care and operation of a compound light microscope.)

I do not require my students to sketch these tissues as they will resemble the known slides. I simply have them include the number of the unknown slide on the same page as their "known" tissue.

I have found that students are pretty unsure of themselves to begin with, so it generally takes one and a half to two class periods for them to look at the 17 slides.
If students have been absent, they will also be trying to catch up with sketching the known slides. If students finish early, encourage them to start thinking about their analysis and conclusion questions at the end of the activity or they can begin looking at tissues affected by smoking and other drug use.

Lesson 4:6 Examining Tissues Affected by Tobacco and Other Drugs

Materials: Smoking and Health Textfolder and the Drug Abuse Textfolder.

This portion of activity 4:1 is completely student driven. They need to examine the slides within the Smoking and Health Textfolder and the Drug Abuse Textfolder. Each slide should be sketched, the accompanying information within the textfolder should be read and analyzed and a statement discussing the negative physiological effects of smoking and drug affects on the tissue should be made.

It is important to point out to students that the tissue type being affected needs to be identified. Sometimes the textfolder identifies the tissue and sometimes it needs to be deduced from its location and function in the body.

There are a total of 16 slides to examine within the textfolders. A couple of the slides show healthy/normal tissue for comparison. I generally do not have students redraw these tissues. They already have examples of what normal tissue looks like in the section of their lab that contains the known slides. It should take 2 ½ to 3 class periods if students are making detailed sketches, labeling effects, and discussing the physiological effects of smoking and drugs on the body.

When they have finished examining the textfolders, they should work on the clinical application and critical thinking questions. You may want to give them one additional class day to prepare their answers and finalize their notebooks before turning them in.

The following pages are an example of a student lab that was turned in to me by one of my students (minus the sketches). Any anatomy text book or images on the web will help you with proper structure identification.