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Histology Atlas: Basic Mammalian Tissue Types (BIOL 105)

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Histology Atlas: Basic Mammalian Tissue Types

General Biology I: Physiology and Cell Biology
Biology 105

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Table of Contents

1. Introduction: The Key to Understanding Histology

This histology atlas is designed to assist you in learning and understanding how to identify different tissues on prepared slides. **YOU ARE STILL REQUIRED TO TAKE NOTES AND COMPLETE ALL ACTIVITIES IN THE ATLAS – THE ATLAS IS FOR REFERENCE.** Below are some suggestions you should consider when beginning to learn histology:

A. Read the laboratory manual thoroughly (Unit 25: Histology and Mammalian Tissue Types) and textbook (Chapter 39: Physiology, Hemostasis, and Temperature Regulation; section 39.1) prior to class. Additionally, make sure to utilize the atlas to orient yourself during the laboratory session.

B. During the laboratory recitation, pay close attention to what the instructor is emphasizing. If what the instructor mentions is in the atlas, highlight/ underline the concept. If it is not, write it in the notes section in your laboratory notebook.

C. One of the essential tools to understanding histology is to identify specific underlining structures in the tissue sample. Upon identifying these structures, you should be familiar with certain terminology. All relevant terminology to your lab will be **bolded** in the atlas.

D. Finally, understanding the essential motif in biology: ***Structure = Function***. This may seem cliché, but all of biology (especially in this course – both in lecture and lab) will focus on this motif.

- *Hint:* It is always best to consider the tissue sections you are looking at in the context of the 3D structure they are derived from. Additionally, recognize that many organs have multiple tissue types and you will only be looking at certain types.

Before we continue onto the identification of tissues, we would like to introduce some relevant information to your histology lab.

The human body contains roughly 200 different types of cells. Histology (microscopic anatomy) refers to the study of animal tissues and how they form organs. The central motif of histology is this successive hierarchy:

Cells —> Tissues —> Organs —> Organ Systems —> Organism

In this laboratory, we will mainly be discussing four different tissue types: **Connective, Muscle, Epithelial, and Nervous (CMEN).** We will also be discussing **reproductive tissue types** such as the testis and ovaries, **special sense organ tissue** such a monkey eye, and **circulatory system tissue types** such as arteries and veins.

1.1 Student Learning Objectives

As you go through this lab, there are a few objectives that you should be able to achieve:

- ☐ Be able to name and identify the four main primary tissue types in the human body, and state a general function of each (This includes other tissue types that were selected for the histology lab as well)
- ☐ Be able to state the locations and/or organs of the various tissues that you identify in the lab
- ☐ List the general function and structural characteristics of each of the tissues observed
- ☐ Know the functional units of different tissue types, along with their arrangement
- ☐ Discuss how cell differentiation of structure led to the cells to perform distinct functions
- ☐ Understand the hierarchy of organization of living multicellular organisms

ACTIVITY 1: Try to define these words yourself (or with the help of your laboratory instructor):

Cell:

_____

Tissue:

_____

Organ:

_____

Organ System:

_____

Organism:

_____

ACTIVITY 2: What is the purpose of this lab?

_____

_____

_____

_____

2. General Microscopy

Instructions: If you are still confused about how to use a microscope, please review this section carefully as you do not want to damage the microscope and the histology slides.

If you have a hard time reading, please do not hesitate to refer yourself to Dr. Holtzman's video on how to use and handle a microscope. Here is the link: https://www.youtube.com/watch?v=3dkwYC-QsSA

2.1 Parts of the Binocular Compound Light Microscope

Eyepiece/ Ocular Lenses: The eyepiece is part of the microscope you look through to observe your specimen. It contains ocular lenses which have a 10x magnification. In some microscopes, you might observe a pointer and/or an ocular micrometer, which can be positioned by rotating the ocular lens.

Revolving Nosepiece/ Turret: Found attached to the head, the top, of the microscope which holds the objective lenses. The revolving nosepiece can be rotated in order to change the objective lenses that are being used to observe the specimen.

Objective Lenses: The lenses attached to the revolving nosepiece. Each objective lens has a different magnification level (4x, 10x, 40x, and 100x). *Hint: DO NOT USE THE 100X OBJECTIVE ON THE PREPARED SLIDES!!! WHEN MICROSCOPE NOT IN USE, LEAVE THE OBJECTIVE ON 4X!!!!*

Stage: Where your slide is placed on the microscope; provides support for the slide to be observed. The stage has a hole on the bottom, which allows light to pass through the specimen.

Condenser: A lens that is located beneath the stage which allows concentration of the light on the specimen. There is a knob to move the condenser up and down, however, each microscope is generally set up, so please do not move the condenser.

Iris/ Diaphragm Lever: This is a shutter that is found within the condenser which allows you to adjust the amount of light passing through the condenser, and therefore the specimen. It can be opened or closed to improve the contrast between the background and the specimen.

Coarse Adjustment/ Focus Knob: Allows you to quickly raise or lower the stage to bring the slide into view and focus on the specimen. *Hint: THIS ADJUSTMENT KNOB SHOULD ONLY BE USED UNDER THE 4X OBJECTIVE!!!*

Fine Adjustment/ Focus Knob: It allows you to bring your slide into clearer focus by moving the stage up and down in smaller increments. **Hint: If you twist the knobs towards you, the stage is being brought up towards the objective lenses and vice versa.**

Mechanical Stage Clip/ Specimen Holder: These are metal clips located on the stage of the microscope which holds and secures the specimen slide in place.

Stage Control Knobs: Allows you to move the specimen that is held within the mechanical stage clip. One knob moves the specimen along the y-axis (upper knob moves the slide forward and back) and the other moves the specimen along the x-axis (lower knob moves the slide to the left and right).

Illuminator/ Substage Light Source: A light source located in the base of the microscope allowing your slide to be viewed in the eyepiece. The light is bent or refracted by the lenses to magnify the object you are viewing.

Illumination Control/ Light Intensity Adjustment Knob: The level of light intensity can be adjusted using the illumination intensity wheel on the base of the microscope. This allows you to control the amount of light that is able to pass through the specimen. **(Some microscopes share a knob which controls both the power of the microscope and light intensity)**

Head: The top of the microscope which attaches the nosepiece and the eyepieces, which has the objective lenses.

Frame/ Arm: The 'backbone' of the microscope. It connects the base and the head of the microscope.

Base: This is the sturdiest portion of the microscope. For this reason, **a microscope should always be carried with one hand at the bottom of the base and another hand around the frame/ arm (or in the microscope holder) of the microscope**.

Power Switch: Once the microscope is plugged in, the power switch can be turned on which allows you to use the microscope and see the specimen by turning on the light source. **(Some microscopes share a knob which controls both the power of the microscope and light intensity)**

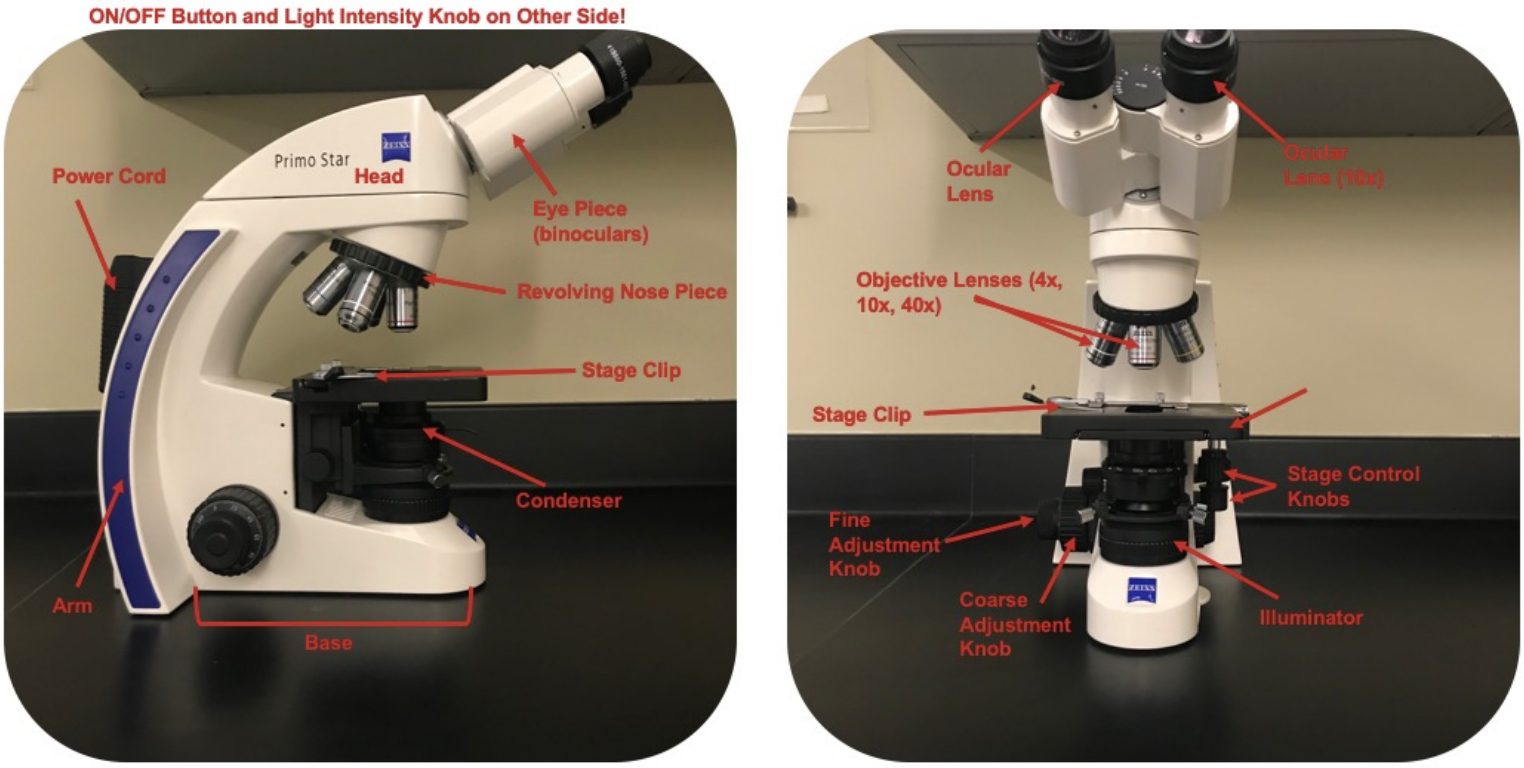


Figure 2.1

2.2 Microscopy Terminology

Instructions: Review the microscopy terms below.

Total Magnification: The total magnification of a specimen refers to the power of the ocular lens multiplied by the power of the objective lens used.

Resolution/ Resolving Power: The resolving power grants the ability to discriminate two close objects as separate. It is determined by the amount of visible light that enters the microscope. **As magnification increases, i.e. numerical aperture, the resolving power decreases.** Therefore, the intensity of light and the numerical aperture is increased when moving to a higher magnification.

Contrast: Contrast refers to the darkness of the surroundings relative to the specimen. For example, lighter specimens are easier to see on darker backgrounds and vice versa.

Numerical Aperture: The numerical aperture of an objective is the measure of its ability to gather light and to resolve for fine specimen detail while working on a fixed specimen at a distance. **As the magnification increases, the numerical aperture increases.**

Field of View: The field of view is the visible region that the specimen can be viewed in. **As magnification increases, the field of view decreases.**

Depth of Field/ Depth of Focus: The depth of field/ depth of focus is measured as the distance from the nearest object plane in focus to the farthest object plane that is simultaneously in focus. In other words, it is a measure of how much of the sample is in focus at one time. **As the magnification increases, the depth of field/ depth of focus decreases.**

Working Distance: The working distance is the physical distance between the specimen slide and the objective lens. **As magnification increases, the working distance decreases.**

Parfocal: Parfocal refers to the microscope being able to remain relativity focused when switching to a different objective lens. Therefore, the fine adjustment knob should be used to sharpen the image.

Image Orientation: When looking through a standard compound microscope and observing the specimen the image is observed as being flipped and inverted.

Calibration: By calibrating the microscope, you will be able to use the ocular micrometer to measure the features of the specimen. This is done by aligning the stage micrometer (found on a separate slide) along the ocular micrometer (found in your ocular lens), as you have done during the first week of the lab (if you remember).

2.3 Magnifications

Instructions: Review the magnifications below.

Your microscope will generally have three or four magnification levels (objectives). In addition to the objective magnification, the ocular lens in the eyepiece has a magnification level of 10x. To get the total magnification level you must multiply the magnification of the ocular lens by the magnification of the objective lens. For example, if you are viewing your slide under the 40x objective lens you would multiply that by the 10x of the ocular lens for a total magnification of 400x.

***** YOUR MICROSCOPE WILL HAVE AN OIL IMMERSION SETTING. UNDER NO CIRCUMSTANCE ARE YOU TO USE IT DURING THE COURSE OF THE SEMESTER!!! *****

Objective Lens Magnification	Ocular Lens Magnification	Total Magnification
Scanning Lens (4x)	10x	40x
Low Power Lens (10x)	10x	100x
High Power Lens (40x)	10x	400x
Oil Immersion Lens (100x)	10x	1000x

2.4 General Microscope Procedure/ Care

1. The binocular compound light microscope that you will be using for the histology lab is located in the cabinet underneath your lab bench. (Refer to Figure 2.1 below). When carrying your microscope from storage to the table top place **one hand should be placed at the bottom of the base and another hand around the frame/ arm (or in the microscope holder) of the microscope.** *Hint: Keep the microscope faced upright because the ocular lens may fall out and break.*

2. Once the microscope is positioned safely on the table, not near the edge, unwind the power cord and plug in your microscope to turn on the light. *Hint: It would be easier to observe the specimen on the slides if the ocular eyepieces are facing you*.

3. Before observing any slides, verify that the 4x objective is in place. Adjust the light so the intensity is not too low or high. Also, when looking through the objective lenses with both eyes, adjust the ocular lenses until you see one cohesive circle. *Hint: The diaphragm should be opened enough to focus on the specimen. This could be a reason your image appears dark or is not visible.*

4. When placing the slide to observe, make sure it is held securely by the metal stage clips and use the stage controls to position the specimen in the center of the field of view. *Hint: It is easier to position the slide without looking through the ocular lens at first and then verifying that it is in the field of view by looking through the ocular lenses.* ***Make sure to only touch the edges of the slide and not where the specimen is fixed.***

5. Then slowly turn the coarse adjustment knob, towards you, until you start to see the specimen on the slide come into focus (at this step, what you see may still be blurry, the goal is just to bring your specimen into better view before really focusing in on it). You may need to move the slide around to begin to see your specimen.

6. Now use the fine adjustment knob to bring your specimen into a clearer resolution. If you are sharing your microscope with other students, each student will use the fine focus knob to focus the specimen best for their eyes. *Remember, if you have glasses, take them off. The microscope corrects for near and farsightedness, not astigmatism.*

7. Once you have your slide in focus on the lowest magnification level, you can switch to the next higher objective lens. You may need to re-focus slightly with the **fine adjustment knob**.

8. Repeat this focusing process until you have reached the objective lens you want to use to inspect your specimen.

9. If the image of your slide seems too dark or bright to see anything, try adjusting the light intensity. *Hint*: *Sometimes it is not the intensity of the light or the focusing that causes the tissue to not be visible. Some of the slides have poor staining and observing tissue is difficult, so in this case, get another slide.*

10. When you are done with your microscope, be sure to lower the stage as far as it will go and switch back to the lowest objective (4X). Make sure to wipe down the stage and ocular lenses with a Kim-Wipe. Turn the power off on your microscope, unplug and wrap the cord. Carry the microscope properly back to storage and return the slide to the appropriate box facing the correct way. *Hint*: *Microscopes should be facing with the handle out, ocular lenses in, so the next student can easily access the microscope.*

Figure 2.2

3. Preparation of Histological Specimens

Before we dive into studying the different tissues, we must first understand how we prepare and section the samples. The preparation of histological specimens occurs in three steps:

A. Fixation

B. Sectioning

C. Mounting on Slides and Staining

Fixation is a critical step in the preparation of histological specimens. When “we” fixate a specimen, we preserve this biological tissue from decay due to autolysis or putrefaction.

Sectioning (or slicing) an organ or tissue reduces its three (3)-dimensional structure to a two (2)-dimensional slice, which will make the specimen easy to mount onto a slide and easy to view under the microscope. Additionally, samples need to be thin enough for light to pass through them.

Finally, mounting onto a slide just allows scientists and junior-scientists (such as you) to view the specimen under the microscope.

3.1 Tissue Sectioning

Instructions: In this histology lab, there will be various types of sectioning and it is your responsibility to be able to recognize each tissue type no matter the type of section presented.

The best way to describe tissue sectioning is to just show you. So, here it goes:

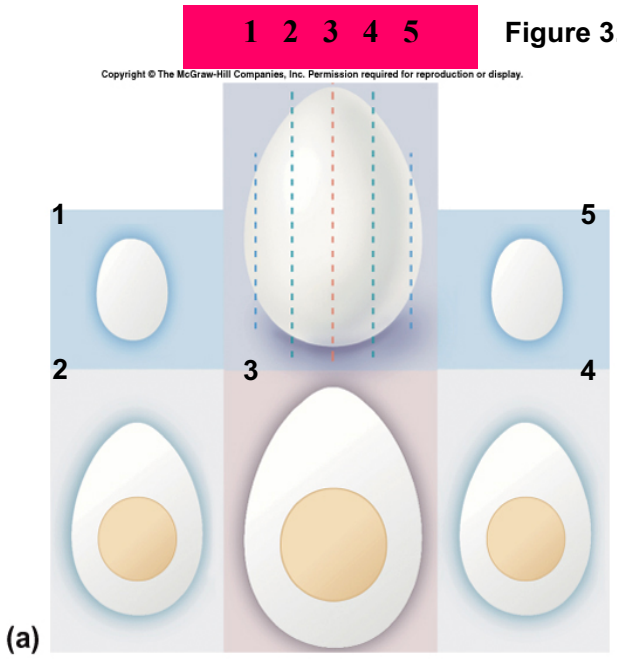


Figure 3.1

Sections 1 & 5: Missing the yolk

Sections 2 & 4: Yolk smaller than in section 3

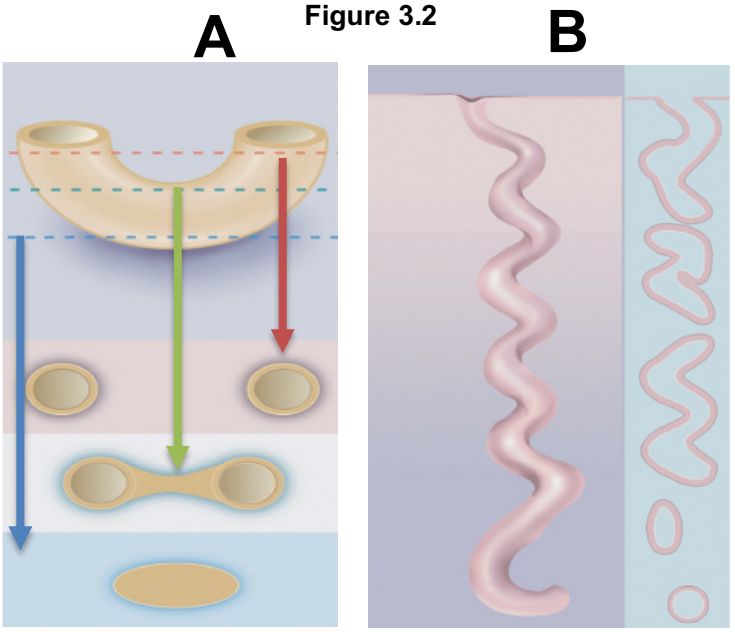


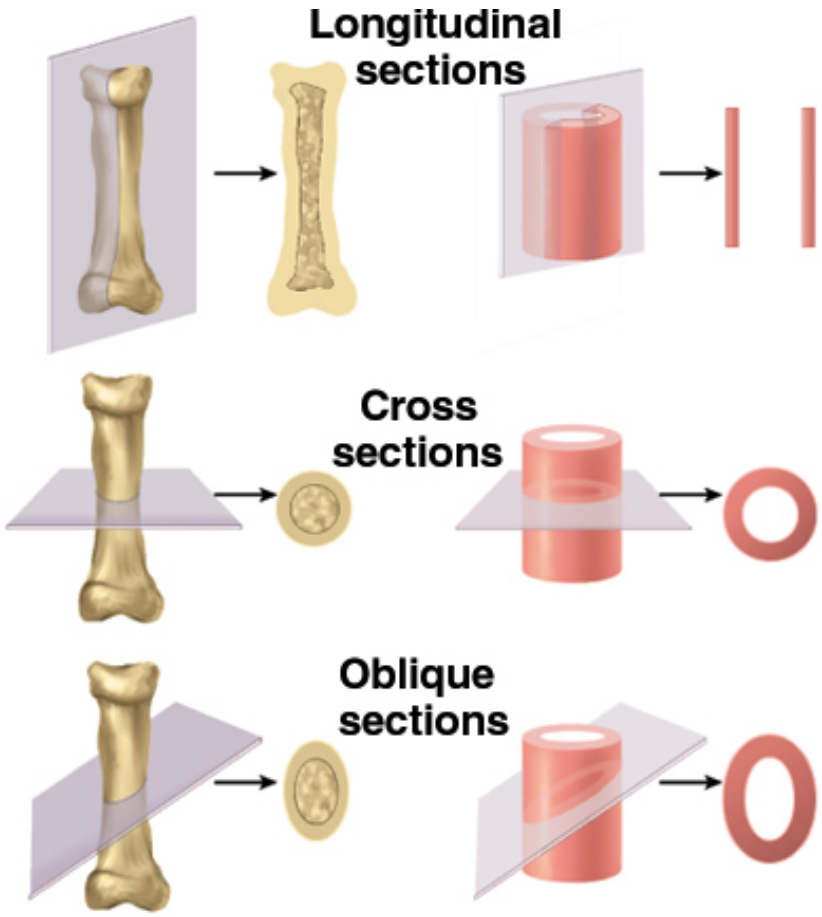
Figure 3.2

Image A is a cross section of elbow macaroni, resembling a blood vessel, piece of intestines, or other tubular organs.

Image B is a longitudinal section of a sweat gland. Notice what a single slice could look like

3.2 Types of Tissue Sections

Figure 3.3



Longitudinal Section: Tissue cut along the longest direction of an organ

Cross (Transverse) Section: Tissue cut perpendicular to the length of an organ

Oblique (Tangential) Section: Tissue cut at an angle between a cross and longitudinal section

Smear: The tissue is not cut. However, it is spread on a slide and covered with a coverslip

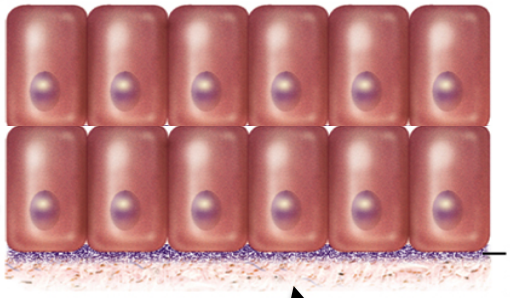
IMPORTANT NOTE: Although this atlas was made to guide you through the different tissue types and the locations in which they are found it is important to remember that what you see in this atlas might not necessarily be what you see when observing a slide in the lab. You can use the pictures in the manual to help you recognize the structures you should recognize during the histology lab, but remember that the actual tissue, sectioning, and staining may be different.

4. Epithelial Tissue

4.1 Basics of Epithelial Tissue

Epithelial tissues usually have 1+ layers of closely packed cells with either tight junctions and/ or desmosomes (***Hint:*** You do not need to know these for the lab, but they may be helpful for lecture).

Figure 4.1



(Top layer) Forms a flat sheet with the upper surface that is exposed to the environment or internal segment of body cavity

(Bottom layer) Sits on **basement membrane**

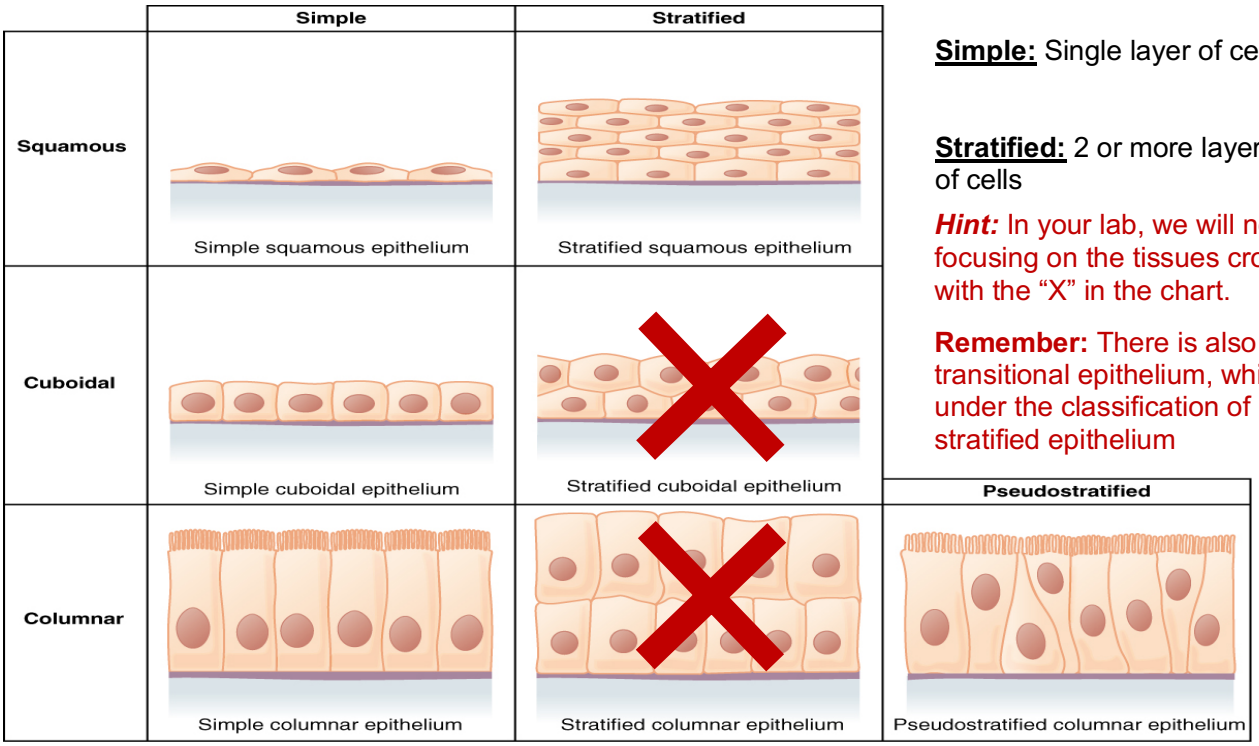
Hint: When identifying the type of epithelial tissue, look at the most apical (top) layer away from the basement membrane.

What type of tissue is "connected" to the basement membrane of epithelial tissue? _____

The **basement membrane** is a dense layer of extracellular material secreted by epithelial cells. This membrane provides an anchor for cells and serves as a protective barrier against foreign objects and other malignant cells.

In histology, we classify epithelial tissues by characterizing the arrangement of cells **(SIMPLE; STRATIFIED; PSUEDOSTRATIFIED)** and cell shape **(SQUAMOUS; CUBOIDAL; COLUMNAR; TRANSITIONAL)**.

Figure 4.2



Simple: Single layer of cells

Stratified: 2 or more layer of cells

Hint: In your lab, we will not be focusing on the tissues crossed out with the "X" in the chart.

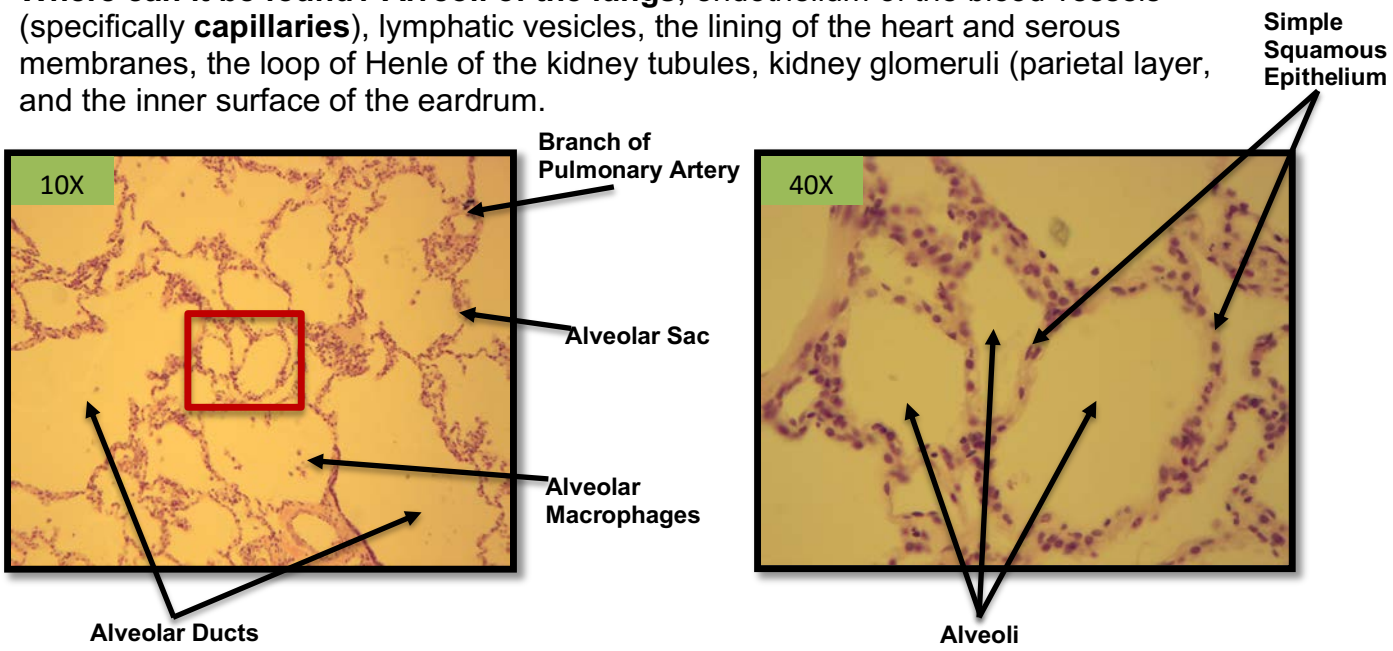
Remember: There is also transitional epithelium, which falls under the classification of stratified epithelium

4.2 Simple Squamous Epithelial Tissue

Structure: Single row of **flat cells** (scaly type; some say they look like pancakes or sunny-side-up eggs).

Function: Allows for rapid diffusion and filtration of substances (gas and liquid); Allow for secretions of serous fluids to reduce friction.

Where can it be found? Alveoli of the lungs; endothelium of the blood vessels (specifically **capillaries**), lymphatic vesicles, the lining of the heart and serous membranes, the loop of Henle of the kidney tubules, kidney glomeruli (parietal layer, and the inner surface of the eardrum.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Lung: Alveoli

Hint: You may find yourself struggling to differentiate between the alveoli and adipose tissue. The key is to remember that **alveoli have multiple cells (and nuclei) around one alveolar sac.**

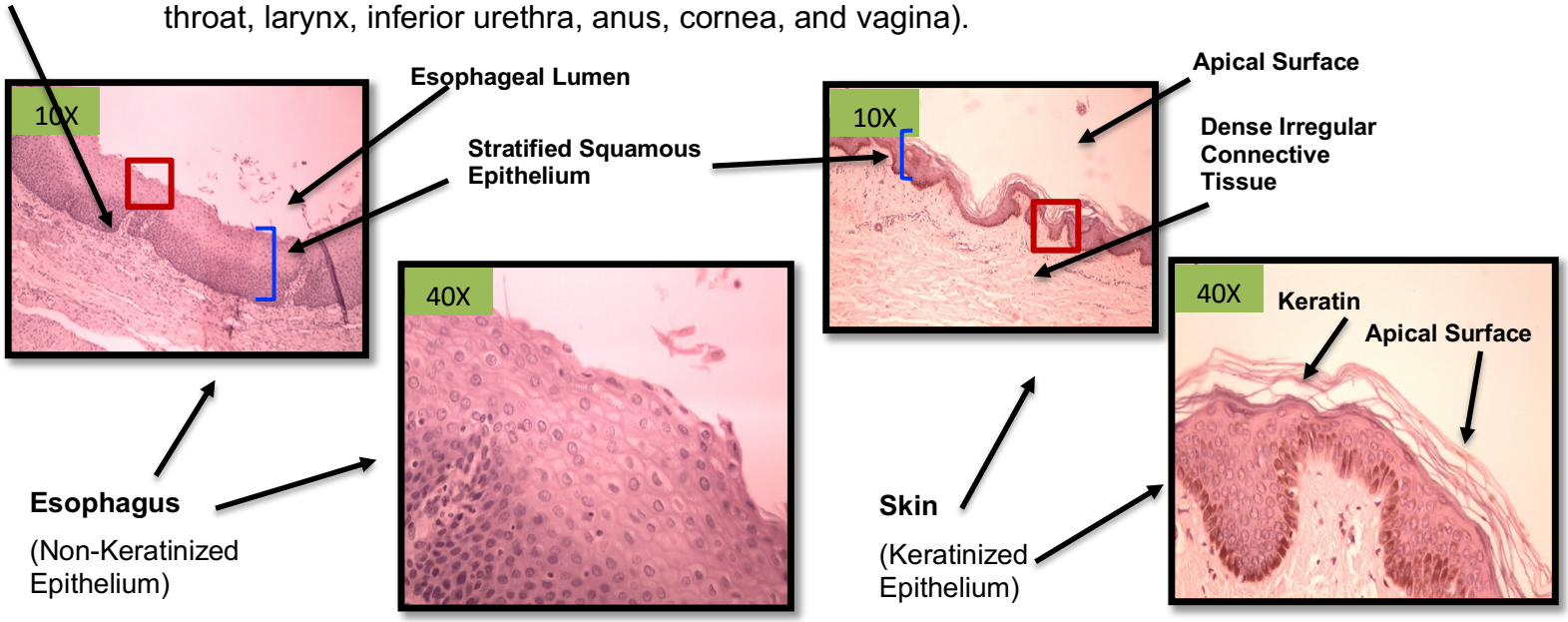
ACTIVITY 2: Why is it important for the alveoli of the lungs to have simple squamous epithelia? Why is it important for capillaries to have simple squamous epithelia?

4.3 Stratified Squamous Epithelial Tissue

Structure: Multiple rows of **flat-like cells** (stacks of pancakes) with flattened nuclei.

Function: Protects underlying structures against abrasions, scrapes, and cuts.

Where can it be found? Found in surfaces subject to abrasions. **Keratinized: epidermis of the skin**. **Non-Keratinized: esophagus**, the inner lining of the mouth, throat, larynx, inferior urethra, anus, cornea, and vagina).



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Mouth (Non-Keratinized) **Esophagus (Non-Keratinized)** **Skin (Keratinized)**

ACTIVITY 2: When trying to identify stratified squamous epithelia, one should look at the _____ layer of cells, furthest away from the basal membrane.

ACTIVITY 3: Why is it important for the skin to have stratified squamous epithelia? What about the esophagus and mouth?

_____

_____

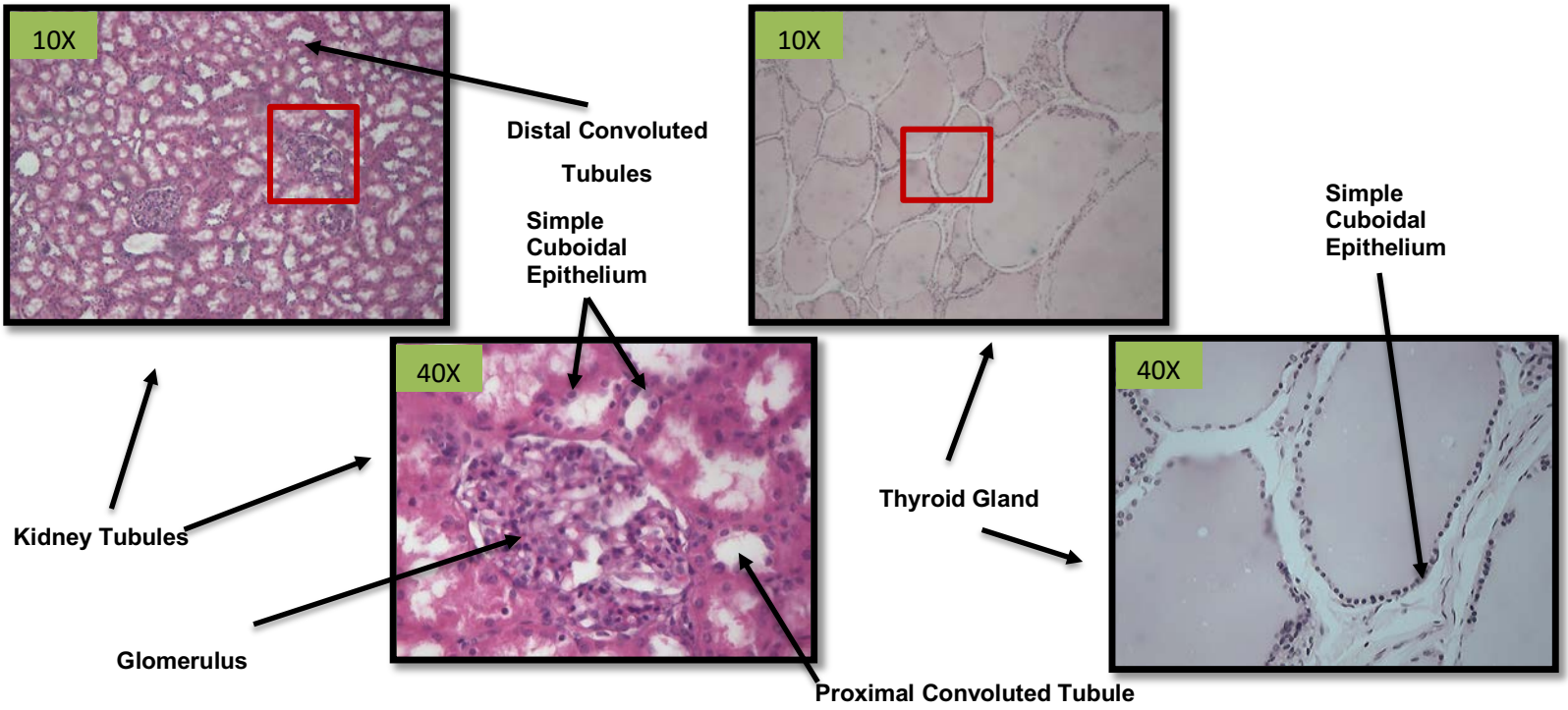
_____

4.4 Simple Cuboidal Epithelial Tissue

Structure: Single row of **cube-shaped cells with very round large nuclei**.

Function: Secretion and absorption.

Where can it be found? Ducts and secretory portions of small glands, **thyroid gland**, lining terminal bronchioles (of the lungs), **kidney tubules**, choroid plexus of the brain, and the surface of the ovaries.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Kidney Tubule(s)

Thyroid Gland

ACTIVITY 2: What types of cells do you think make up the Glomerulus and enclose Bowman's Capsule? What is their function? *Hint:* We already learned about the cells.

4.5 Stratified Cuboidal Epithelial Tissue

Structure: Typically made of two-three rows of **cube-shaped cells with large, spherical central nuclei**.

Function: Secretion and absorption.

Where can it be found? Largest ducts of **sweat glands**, ovarian follicular cells, mammary glands, and **salivary glands**.

Salivary Gland

ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Salivary Gland

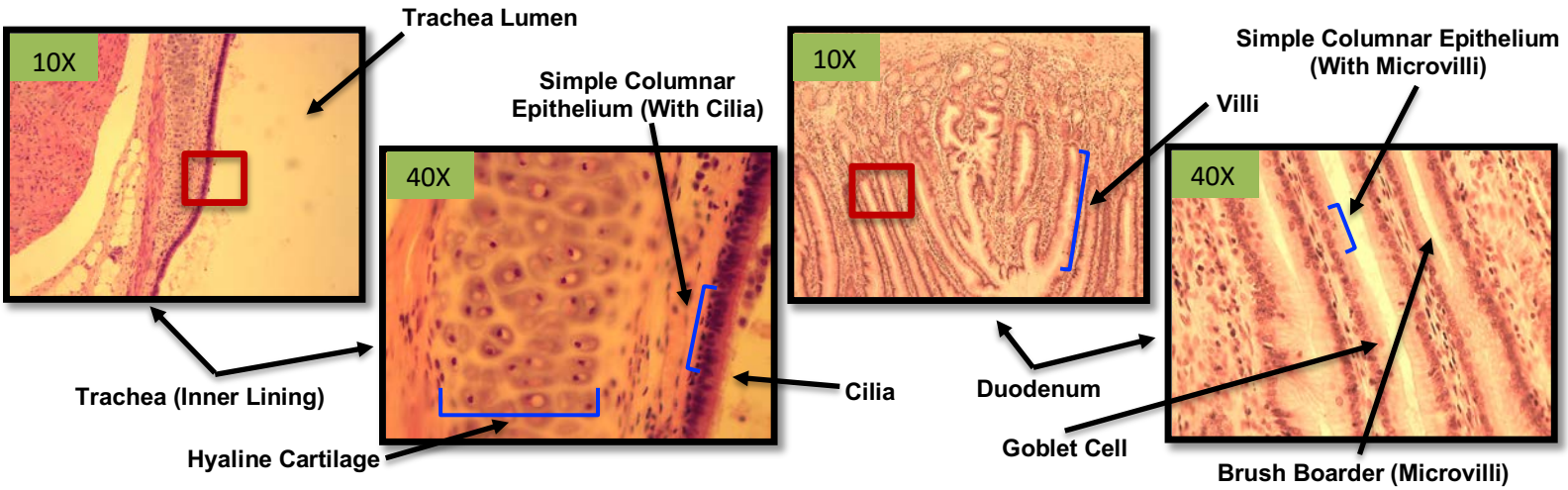
ACTIVITY 2: Why do you think stratified cuboidal epithelium are found in larger glands such as sweat and salivary glands. Hint: Think about its secreting function.

4.6 Simple Columnar Epithelial Tissue

Structure: Single row of **tall, narrow cells** (usually are vertically oriented with oval nuclei basal half of the cell). **Microvilli** in the digestive tract, **cilia** in the respiratory and reproductive system, and **stereocilia** in the auditory system.

Function: Absorption; secretion enzymes and mucus by goblet cells.

Where can it be found? Most of the inner lining of the gastrointestinal tract such as the **stomach** and **intestines** (**Duodenum**)**, the airway of the trachea (bronchioles of the lungs)**, auditory tubes, gallbladder, uterus, uterine tubes, and ventricles of the brain.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Trachea **Duodenum**

ACTIVITY 2: What is the function of the **villi and microvilli** found in the duodenum? How do the villi and microvilli relate to surface area for absorption of nutrients?

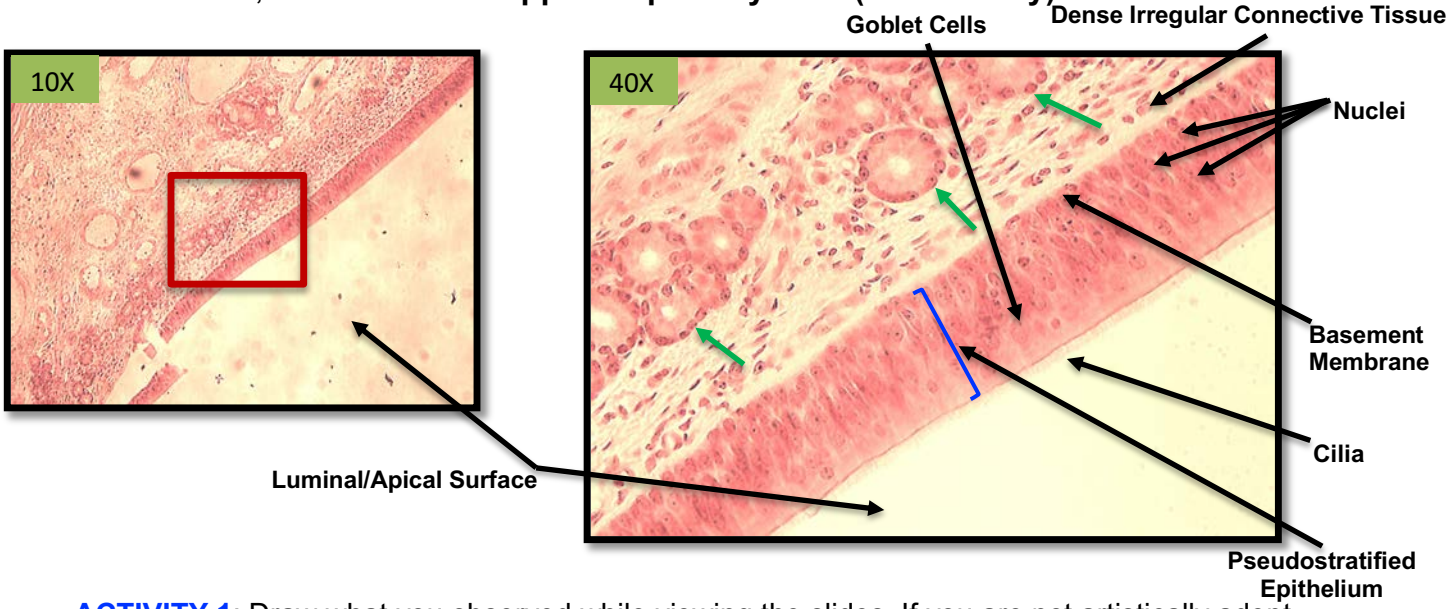
ACTIVITY 3: What is the function of the **cilia** found in the airway of the trachea?

4.7 Pseudostratified Epithelial Tissue

Structure: Single row of cells that have differing heights, some not all of which reach the free (apical) surface, thus nuclei can be seen at differing levels. **All cells have contact with the basement membrane**.

Function: Secretion of mucus by goblet cells, **ciliary action** (propels foreign material)

Where can it be found? Found within the **epididymis**, **trachea**, ducts of large glands, the inner ear, and most of the **upper respiratory tract (nasal cavity)**.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Epididymis

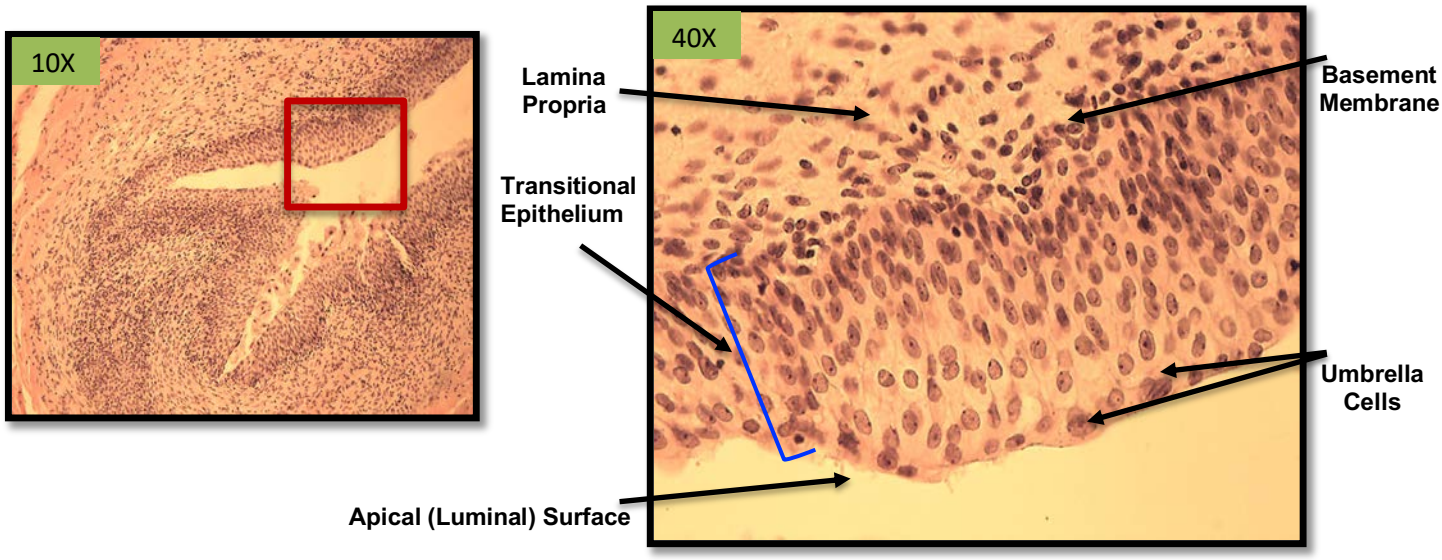
ACTIVITY 2: What is the function of the **epididymis**? Describe the appearance of your histological sample of the epididymis (what do you see)? What type of epithelium is indicated by the green arrows?

4.8 Transitional Epithelial Tissue

Structure: Resembles both stratified squamous (when stretched) and stratified cuboidal epithelium (when relaxed). The surface cells, **umbrella cells**, create a dome shape that covers two or more underlying cells.

Function: Stretches, **accommodates**, and readily permits distension of urinary bladder by contained urine. **Protects against the caustic effects of urine**.

Where can it be found? Lines the ureters, **urinary bladder**, and **superior urethra**.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Urinary Bladder

ACTIVITY 2: When do you think the transitional epithelium will be stretched to its fullest elasticity? When do you think the transitional epithelium be relaxed?

5. Connective Tissue

5.1 Basics of Connective Tissue

Connective tissue is the most abundant of the four main tissue types that acts as the "glue" which connects varies tissues and provides support. Connective tissue is comprised of three main components: **ground substance**, cells, and fibers. The ground substance is a viscous gel-like liquid that separates cells (providing structural support) composed of proteoglycans and cell adhesion proteins; when combined with fibers is referred to as the **extracellular matrix**. The cells are **fibroblast** which aid in the synthesis of the extracellular matrix and collagen. The fibers of connective tissue provide support and are **collagen fibers**, **elastic fibers**, and **reticular fibers**.

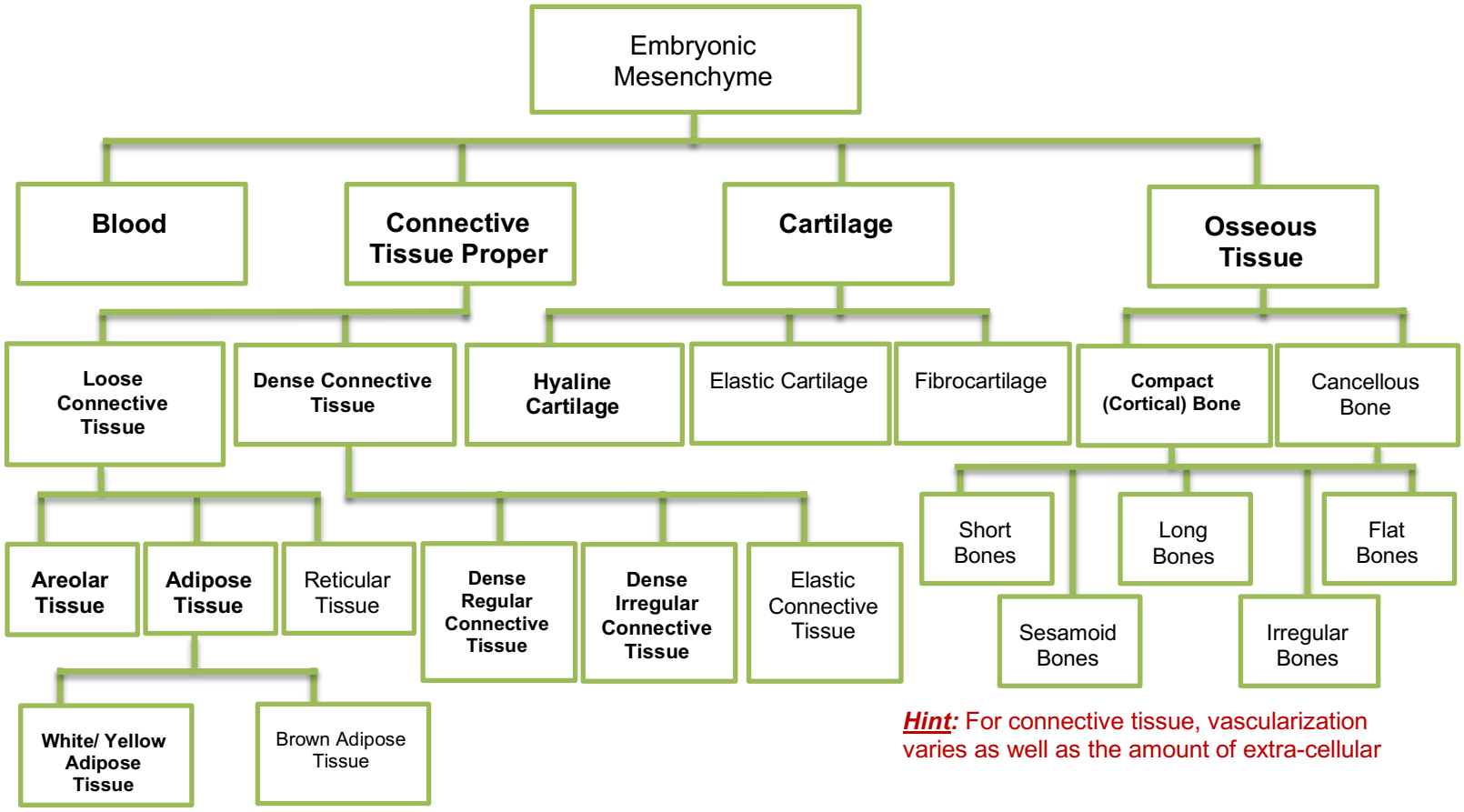
Collagen fibers are fibrous proteins that **provide high tensile strength to the matrix**.

Elastic fibers are long, thin fibers that give connective tissue the ability to **stretch and recoil**.

Reticular fibers are short, fine collagenous fibers from a **delicate structural network within the tissue**.

The major function of connective tissues is binding and supporting other tissues, protection, insulation, energy storage, and transportation of substances within the body.

Connective tissue is divided into four main categories: **connective tissue proper**, **cartilage**, **bone**, and **blood**. Connective tissue proper is further divided into two subcategories: **loose connective tissue** and **dense connective tissue**. Although these are the main classification there are a few other connective tissues such as embryonic mesenchyme. Please use the flow chart below to get a better understanding of the connective tissue classifications.



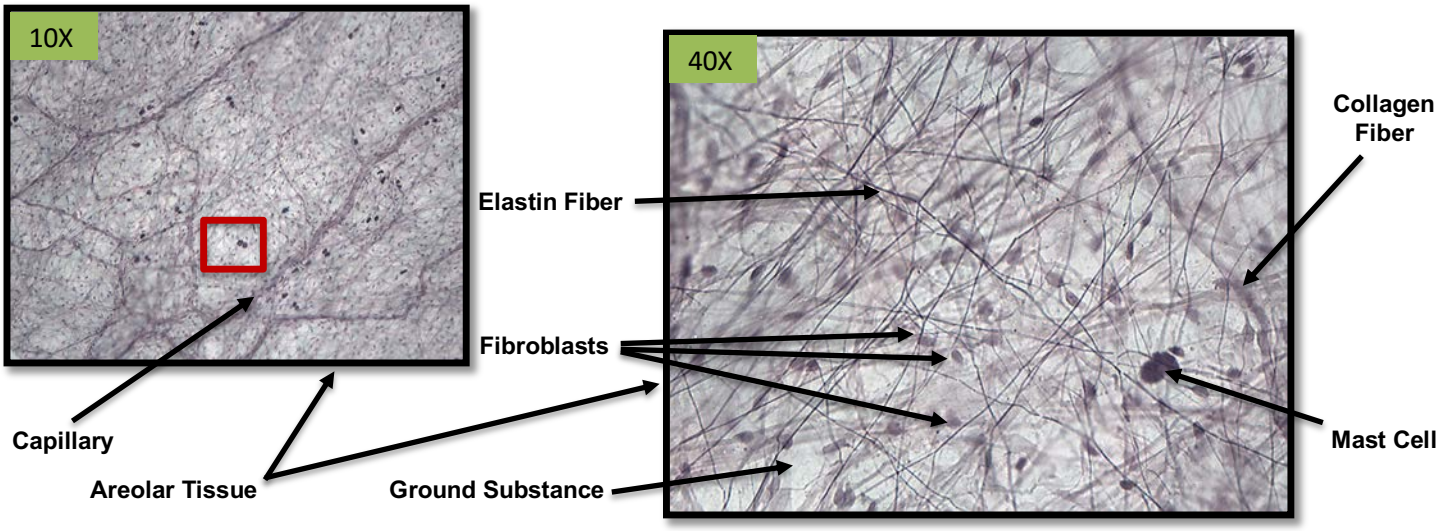
Hint: For connective tissue, vascularization varies as well as the amount of extra-cellular

5.2 Areolar Tissue/ Loose Irregular Connective Tissue

Structure: A network of fibers, including **collagen and elastin fibers**, and cells (fibroblast, macrophages, mast cells, and lymphocytes) **that forms a gel-like matrix.**

Function: Wraps and cushion organs, provides a role in inflammation, phagocytizes bacteria, and **provides support and nourishment to associated structures**. It also aids in skin attachment to the underlying tissue.

Where can it be found? Distributed widely throughout the body and **under epithelia**. Packed between glands, muscles, and nerves**.**



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Areolar Tissue

Fun Fact: Areolar tissue is the most abundant type of connective tissue; it is usually found wrapping organs and under the skin.

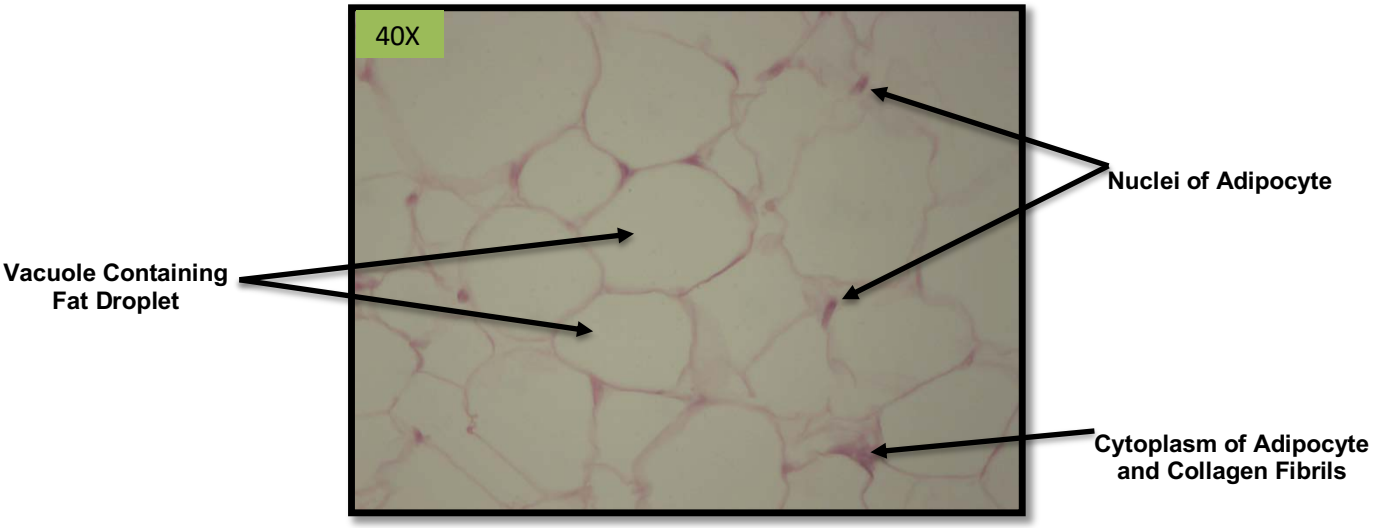
ACTIVITY 2: Why do you think it is important for certain organs and structures to be wrapped by areolar tissue? Hint: Think about vacuolization and immunity.

5.3 Unilocular White/ Yellow Adipose Tissue

Structure: Adipose fat cells, or **adipocytes**, are closely packed together causing the nuclei to be pushed to the side of the fat droplet. Also, there is very little extracellular matrix. Women have a higher percentage of white adipose tissue than men.

Function: Reservoir of energy, **thermal insulator**, and **organ protection**.

Where can it be found? Usually found in the **subcutaneous region of the skin (hypodermis)**, within the **abdomen**, **breast**, omentum, mesenteries, eyeballs, and around areas of the body that need more cushioning or protection.



White Adipose Tissue

ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

White/ Yellow Adipose Tissue

Hint: You may find yourself struggling to differentiate between the alveoli and adipose tissue. The key is to remember that **alveoli have multiple cells (and nuclei) around one alveolar sac.**

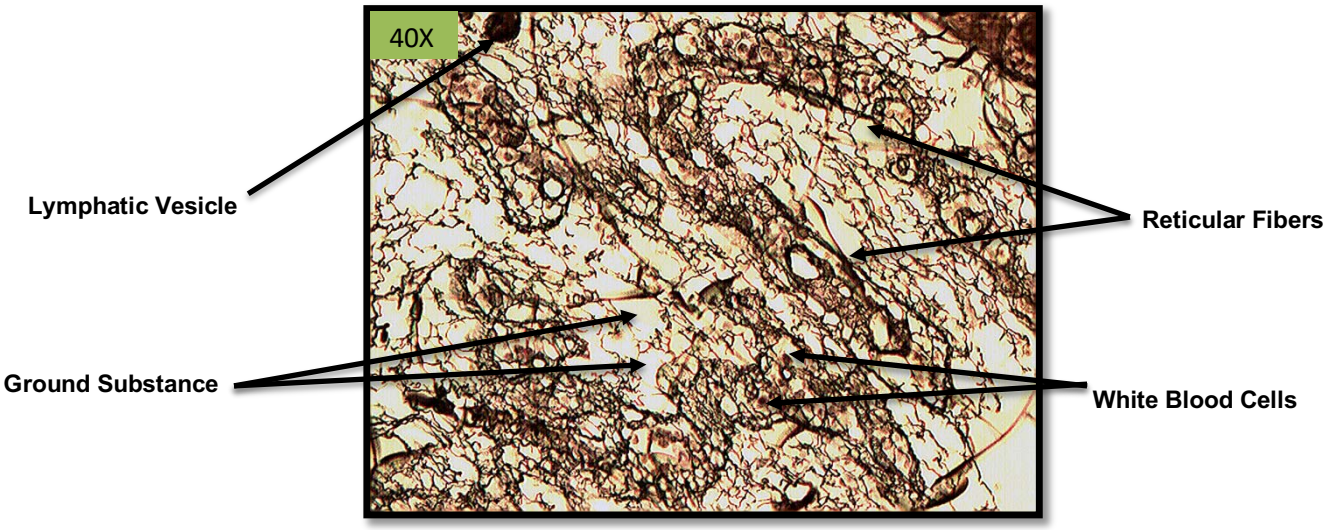
ACTIVITY 2: Many people in America make it their New Year's Resolution to lose weight. Why do you think losing too much body fat is not necessarily a good think?

5.4 Reticular Connective Tissue

Structure: Easily identifiable by the dense dark **reticular fibers** that are distributed irregularly throughout the ground substance.

Function: Acts as **structural support** to lymphatic and hemopoietic tissues (a soft skeleton), aids in immune response with lymphocytes, mast cells, and macrophages.

Where can it be found? Found in lymphoid organs **(lymph nodes, bone marrow, and spleen)**.



Spleen

ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Reticular Tissue

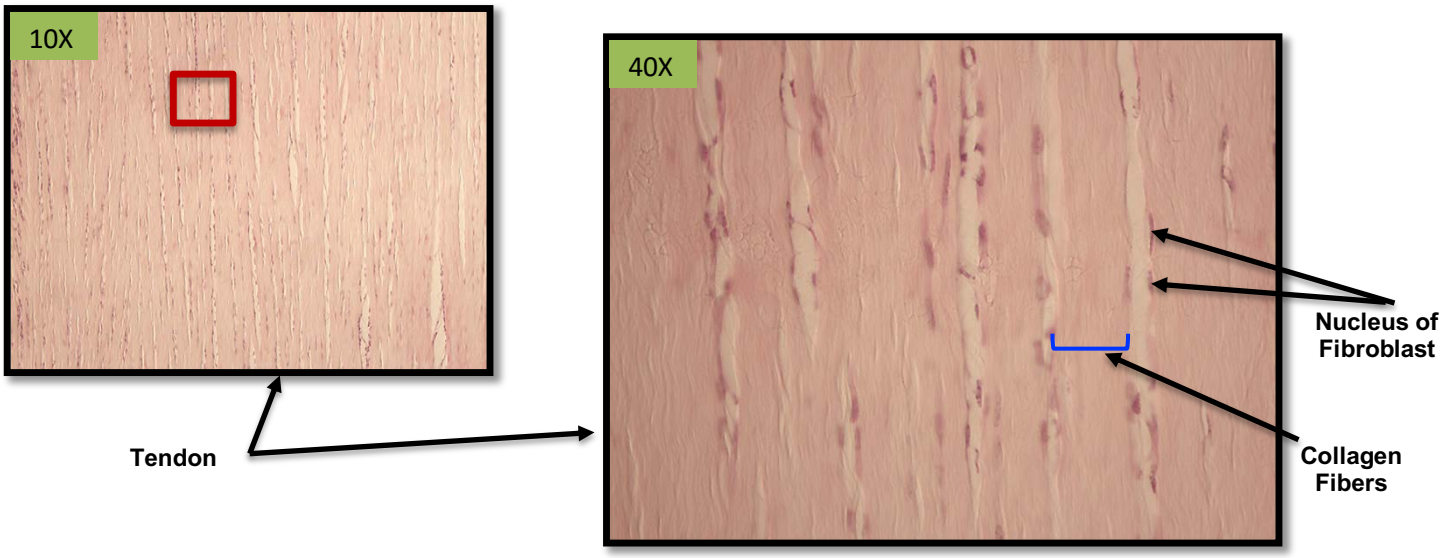
ACTIVITY 2: Why do you think reticular tissue is found in lymphatic organs? Hint: Think of the "soft skeleton" or stroma it forms; lymphatic organs tend to be soft and vulnerable.

5.5 Dense Regular Connective Tissue

Structure: Composed of mainly **collagen fibers**, with very few elastic fibers, and **fibroblasts** all running in somewhat of the **same direction**.

Function: Attaches muscles to bones or bone to bone. Able to **withstand great tensile stress** when pulling force is applied in the direction of the fiber orientation. Has **stretching ability as well as resistance**.

Where can it be found? Tendons (muscle to bone), **ligaments** (bone to bone), and aponeurosis.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Tendon

Hint: You may find yourself struggling to differentiate between the dense regular connective tissue and smooth muscle. The key **is dense regular connective tissue looks like it is made up of "strings" or fibers.**

ACTIVITY 2: How do you think the arrangement of the collagen fibers is important in providing the connective tissue its ability to withstand tensile stress?

_____

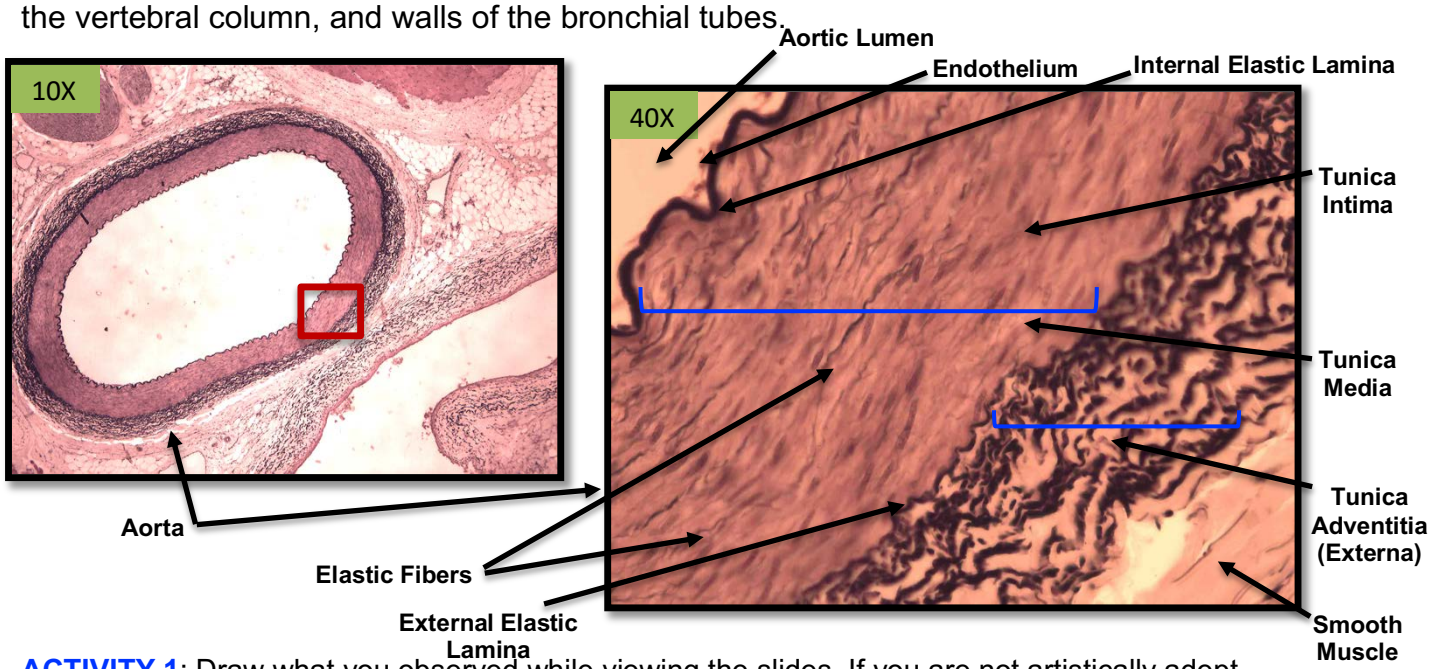
_____

5.6 Elastic Connective Tissue

Structure: It is a dense regular connective tissue that has a high proportion of **elastic fibers**, all running in somewhat of the **same direction**.

Function: Allows tissue recoil following being stretched. Help maintain the pulsatile blood flow through arteries and passive recoil in the lungs following inspiration.

Where can it be found? Found in walls of **large arteries (aorta)**, certain ligaments in the vertebral column, and walls of the bronchial tubes.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Elastic Connective Tissue

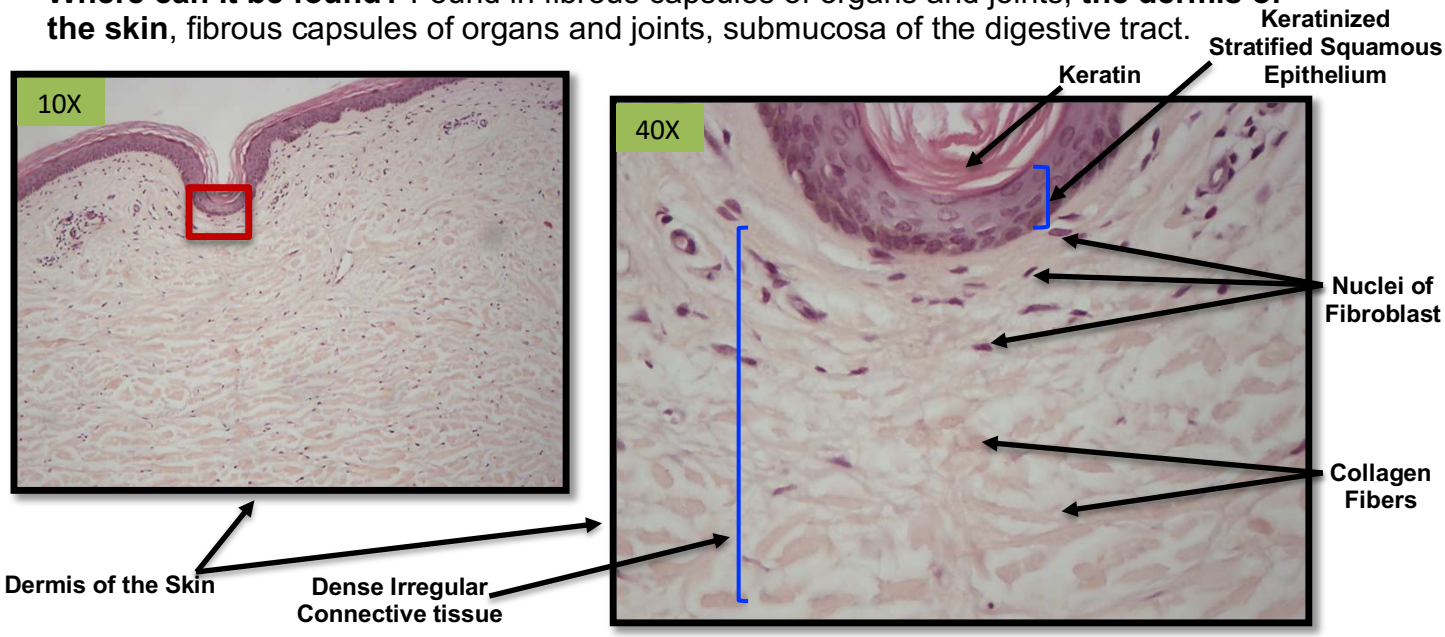
ACTIVITY 2: Why do you think the walls of the aorta has an abundance of elastic fibers embedded within the musculature?

5.7 Dense Irregular Connective Tissue

Structure: A high proportion of **collagen fibers**, with some elastic fibers, and **fibroblasts** all running in different **directions**.

Function: Able to **withstand great tensile stress** when pulling force is applied in various directions. It also provides **structural strength**.

Where can it be found? Found in fibrous capsules of organs and joints, **the dermis of the skin**, fibrous capsules of organs and joints, submucosa of the digestive tract.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Dermis of the Skin

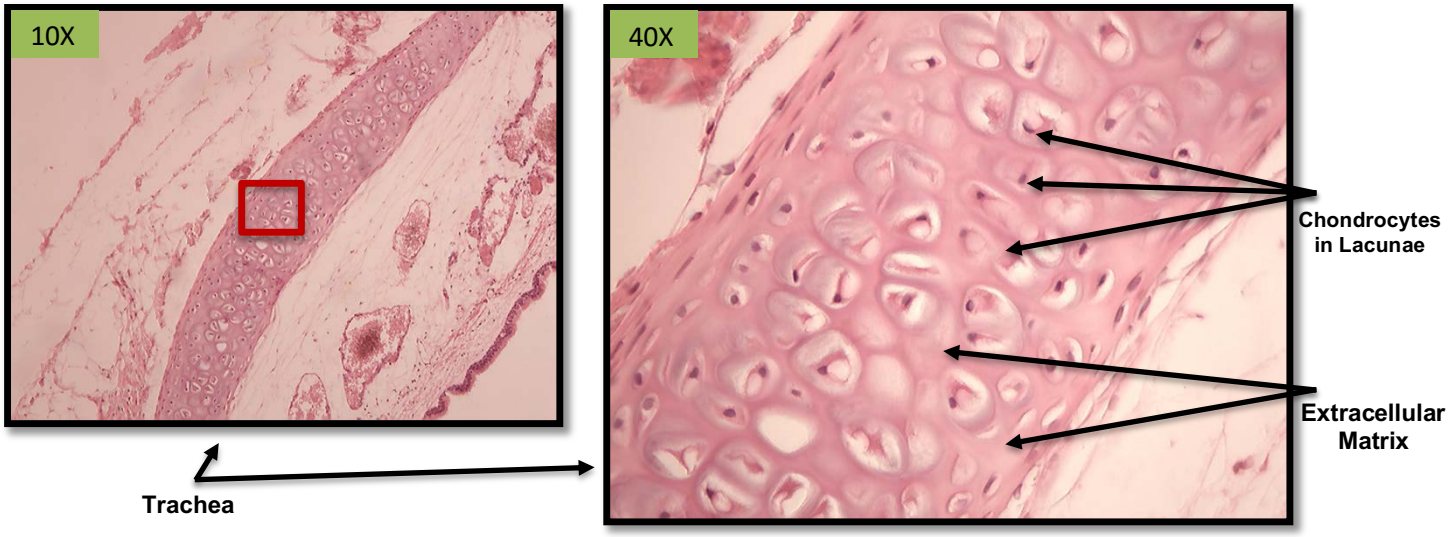
ACTIVITY 2: Why do you think the arrangement of the collagen fibers is important in providing the connective tissue its ability to withstand tensile stress from many directions?

5.8 Hyaline Cartilage

Structure: An amorphous, but firm matrix. The collagen fibers form a tough complex where the **chondroblast** produces the matrix and mature into **chondrocytes** which are housed in **lacunae**. Hyaline cartilage is also **avascular**.

Function: Offers **support and reinforcement**, serves as a **resilient cushion**, and **resists compressive stress**.

Where can it be found? Forms most of the embryonic skeleton, **covers the ends of growing long bones**, forms **costal cartilages of ribs**, cartilage of the nose, **trachea**, and the **larynx**.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Trachea

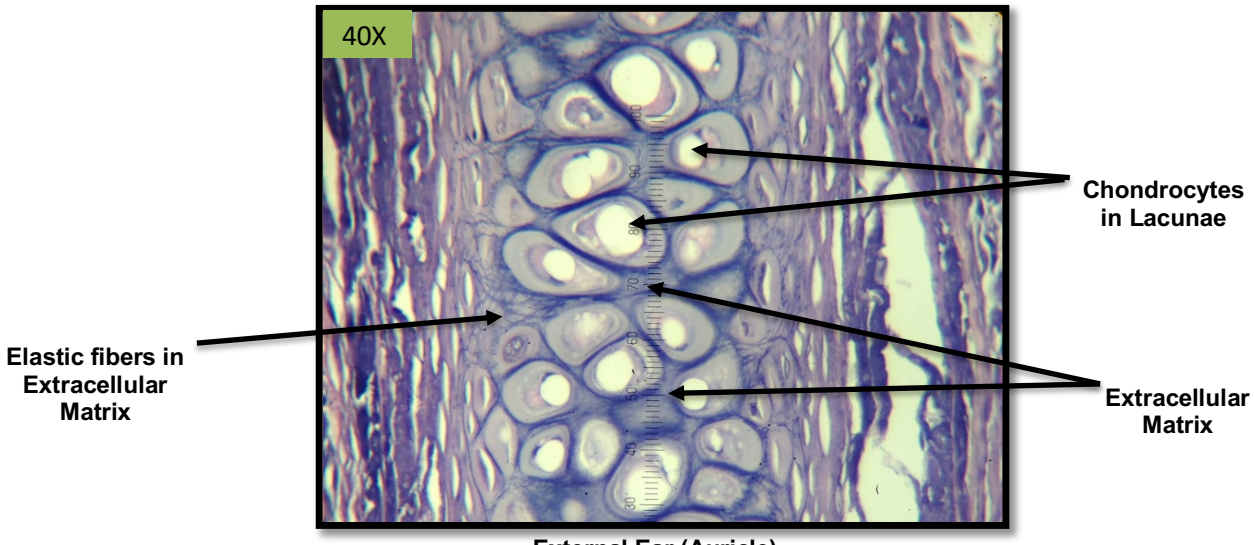
ACTIVITY 2: The embryotic skeleton is mainly composed of hyaline cartilage. Why do you think having hyaline cartridge for an embryotic skeleton is beneficial during birth rather than bone?

5.9 Elastic Cartilage

Structure: Firm matrix just as hyaline cartilage, however, has an abundance of **elastic fibers** distributed throughout the extracellular matrix. The collagen fibers form a tough complex where the **chondroblast** produces the matrix and mature into **chondrocytes** which are housed in **lacunae**. Elastic cartilage is also **avascular**.

Function: Maintains the shape of a structure while allowing great flexibility.

Where can it be found? Supports the external ear (**auricle; pinna**), **epiglottis**, and auditory tubes.



External Ear (Auricle)

ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

External Ear (Auricle)

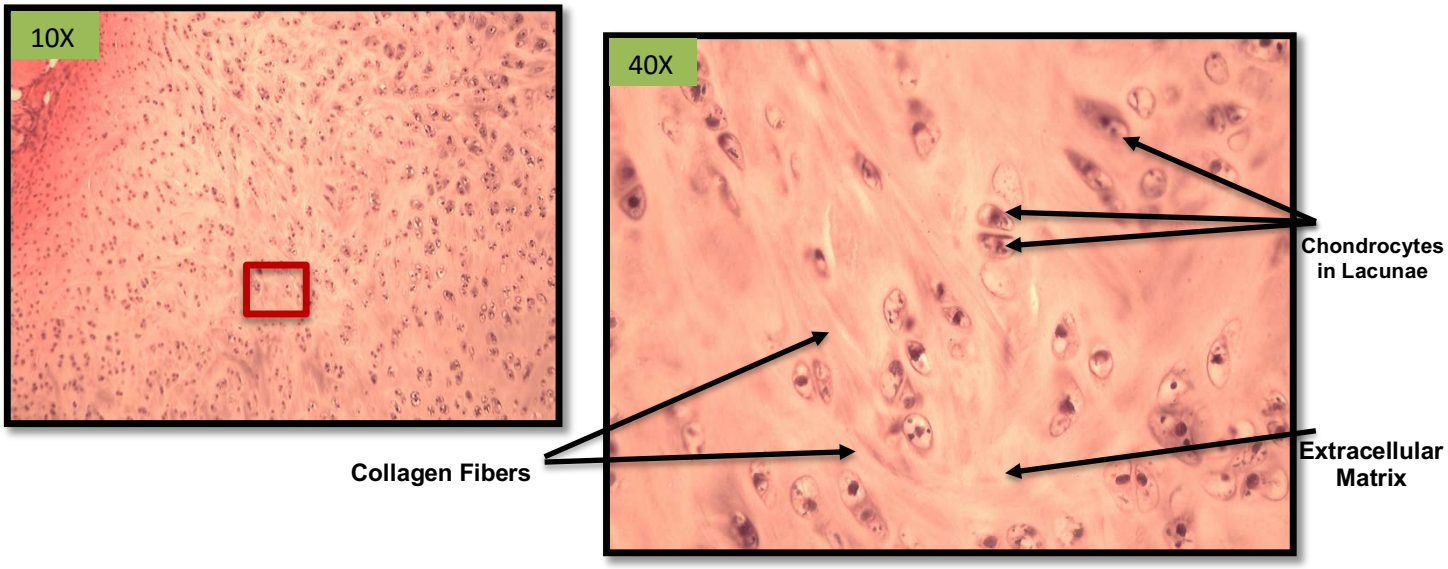
ACTIVITY 2: Why do you think elastic cartilage has a higher amount of elastic fibers than hyaline cartilage? Hint: Think of the location of the elastic cartilage.

5.10 Fibrocartilage

Structure: The matrix is similar to hyaline cartilage; however, it is **less firm**. The collagen fibers, which are **more predominant in thick bundles**, are distributed throughout the complex where the **chondroblast** produces the matrix and mature into **chondrocytes** which are housed in **lacunae**. Fibrocartilage is also **avascular**.

Function: Tensile strength with the ability to absorb compressive shock and pressure.

Where can it be found? Intervertebral discs, pubic synthesis, and articular discs (knee and temporomandibular joints).



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Fibrocartilage

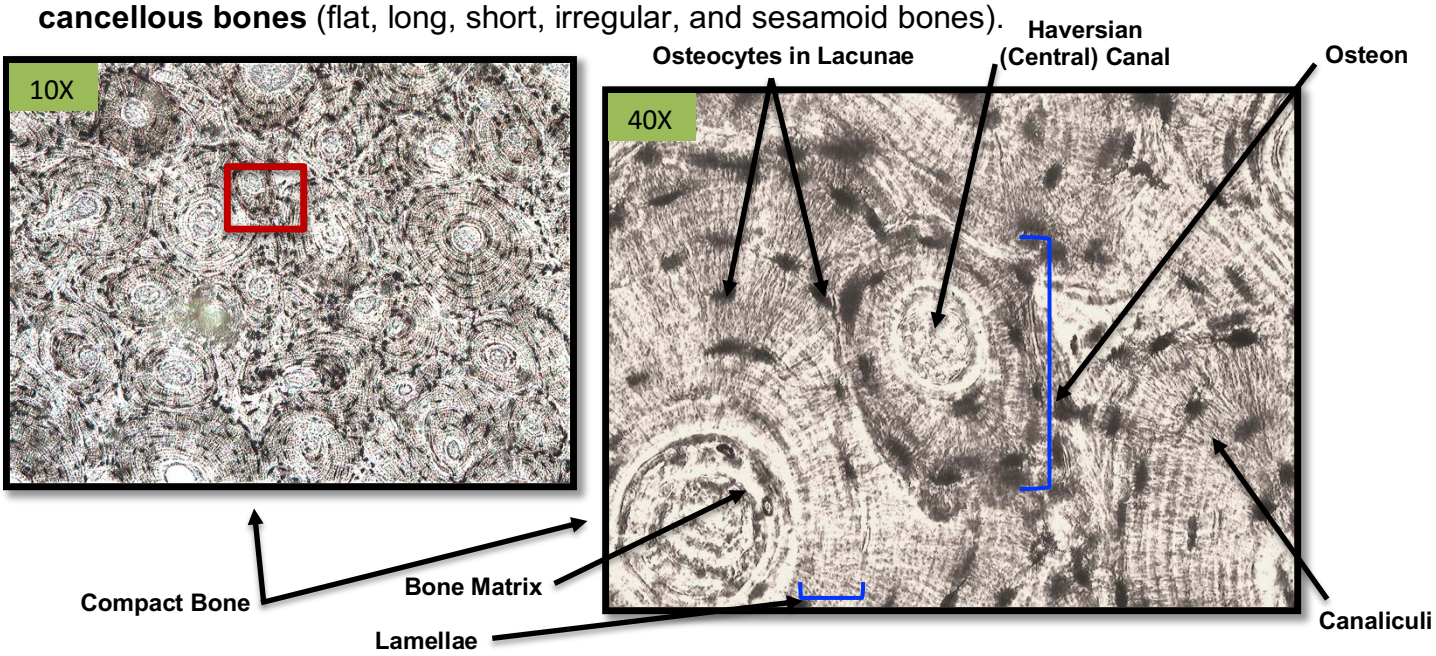
ACTIVITY 2: Why do you think fibrocartilage is found in intervertebral discs? What would happen bone was located where the interverbal discs are? Hint: Think about movement.

5.11 Osseous Tissue: Compact Bone

Structure: A hard calcified matrix containing many collagen fibers and calcium phosphate; **osteocytes** lie within the **lacunae**, with vascularization in the **Haversian (central) canal.** Distinguishable by **osteons**, **lamellae**, and **canaliculi**.

Function: Supports and protects, provides levels for muscle attachment, **stores calcium, minerals, and fat.** The marrow inside bones is the site for **hematopoiesis**.

Where can it be found? Osseous tissue can be found in **compact bones and cancellous bones** (flat, long, short, irregular, and sesamoid bones).



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Fun Fact: Compact bone is mainly avascular but has vascularization and nerve innervation through the Haversian Canal. Cells in the bone receive nutrients through diffusion.

Compact Bone

Fun Fact: Osseous tissue has many names. Compact bone is also referred to as cortical bone. Spongy bone is also referred to as either trabecular bone or cancellous bone.

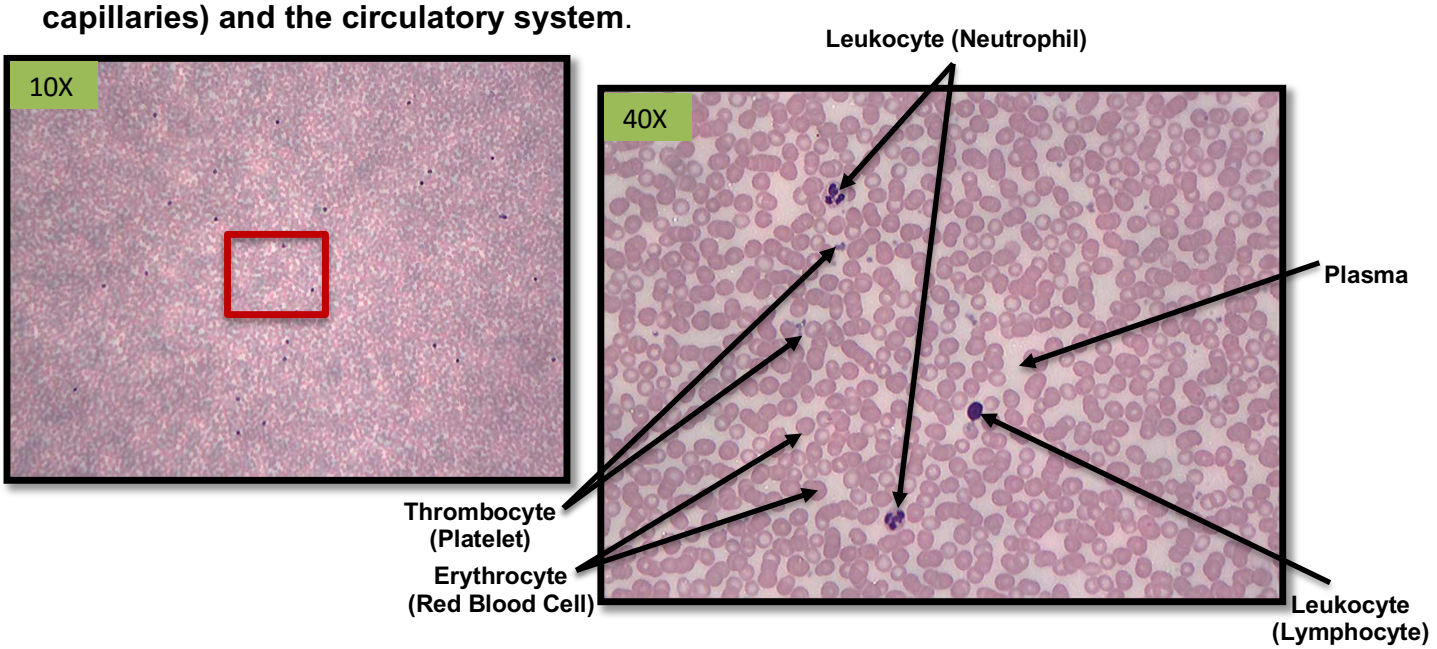
ACTIVITY 2: If compact bone is tightly compacted, with a solid bone matrix, how do the osteocytes get nutrients and expel waste?

5.12 Blood

Structure: This **fluid connective tissue** is composed of fluid (**plasma**) with suspended cells and cell fragments. These include **erythrocytes**, **leukocytes**, and **thrombocytes**.

Function: Transport of dissolved proteins**, gasses (O_2 and CO_2), nutrients, metabolic wastes,** hormones, **and electrolytes; immune response; blood clotting**.

Where can it be found? Contained within blood vessels (arteries, veins, and capillaries) and the circulatory system.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Blood Smear

ACTIVITY 2: How does each component in blood contribute to its overall function? Hint: Pertaining mainly to erythrocytes, leukocytes, and thrombocytes.

6. Muscle Tissue

6.1 Basics of Muscle Tissue

There are three main types of muscle tissue**: skeletal muscle (striated muscle)**, **smooth muscle**, and **cardiac muscle**. This type of tissue is not only excitable, but it is also contractile. Muscle tissue can further be categorized functionally and morphologically. Functionally, muscle tissue can be under **voluntary or involuntary control**. Voluntary control means that the muscle is under conscious control. Involuntary control means that muscle movement is not under conscious control.

Muscle cells (which are also called **myocytes**) contain myofibrils which are composed of **actin** and **myosin myofilaments**. When numerous myocytes come together, they make up muscle tissue. Within the myocyte, actin and myosin come in contact and form the functional contractile unit, the sarcomere. These **sarcomeres** are observed as striations in muscle tissue (except in smooth muscle).

Skeletal muscle is under **voluntary control**, **striated**, and are **multinucleated**. They are the most abundant muscle type and aid in the movement of the limbs, among other roles.

Smooth muscle is under **involuntary control**, **non-striated**, **mononucleated**, and are found in internal organs of the body. Smooth muscle has a generally slower response rate than skeletal muscle, but it can sustain contraction for a longer period of time.

Cardiac muscles are **mononucleated, striated**, fundamentally **involuntary** and exclusively found within the heart. The function of cardiac muscles is to pump the heart through automatic contractions (**myogenic rhythm**) in a pumping and twisting motion. Cardiac muscles organize into branching fibers which aid in the overall endurance of the continuous pumping of the heart and resist the pressure exerted from the pumped blood. In addition, the cardiac muscle contains intercalated disks that connect the muscle fibers through gap junctions. These gap junctions allow communication between the fibers, more specifically the depolarizing electrical current needed for simultaneous contraction.

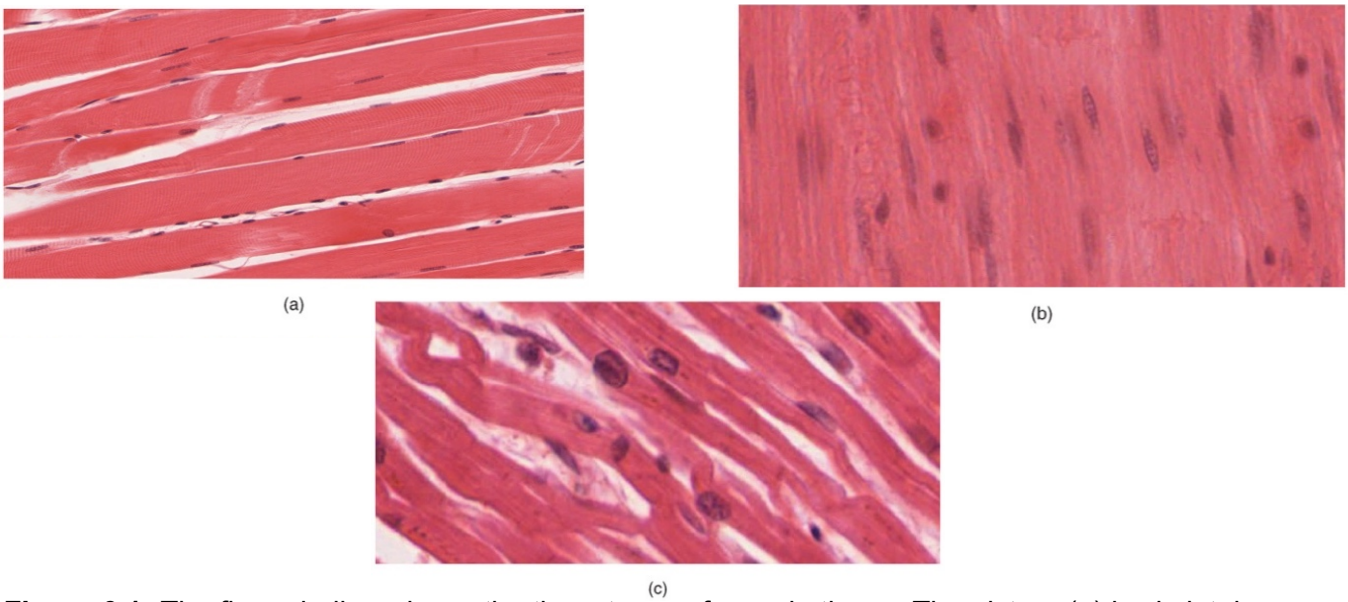


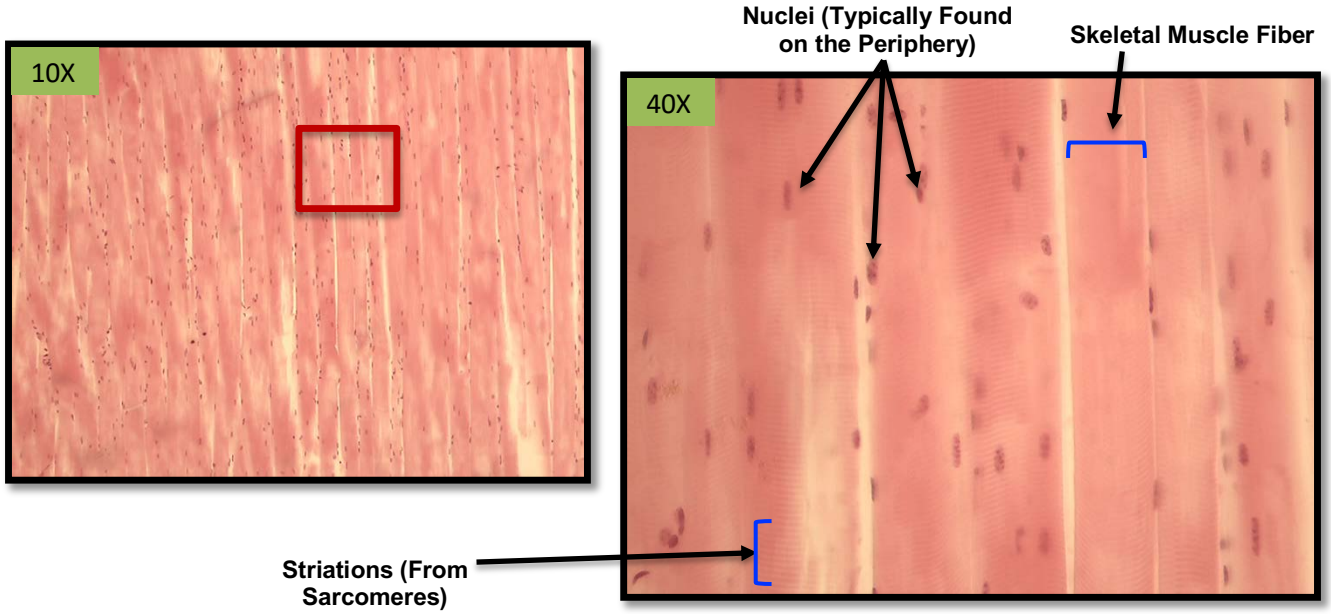
Figure 6.1: The figure bellow shows the three types of muscle tissue. The picture (a) is skeletal muscle, (b) is smooth muscle, and (c) is cardiac muscle.

6.2 Skeletal Muscle (Striated Muscle)

Structure: Skeletal muscle cells are **multinucleated**, long, and **cylindrical** fibers that appear **striated**. Striations are due to **sarcomeres** of the **myocytes**.

Function: Voluntary movement of the body (locomotion, manipulation of the environment, facial expression, etc.).

Where can it be found? Attaches to bones, skin, or other connective tissue.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Skeletal Muscle

Muscle Composite Slide: Skeletal Muscle

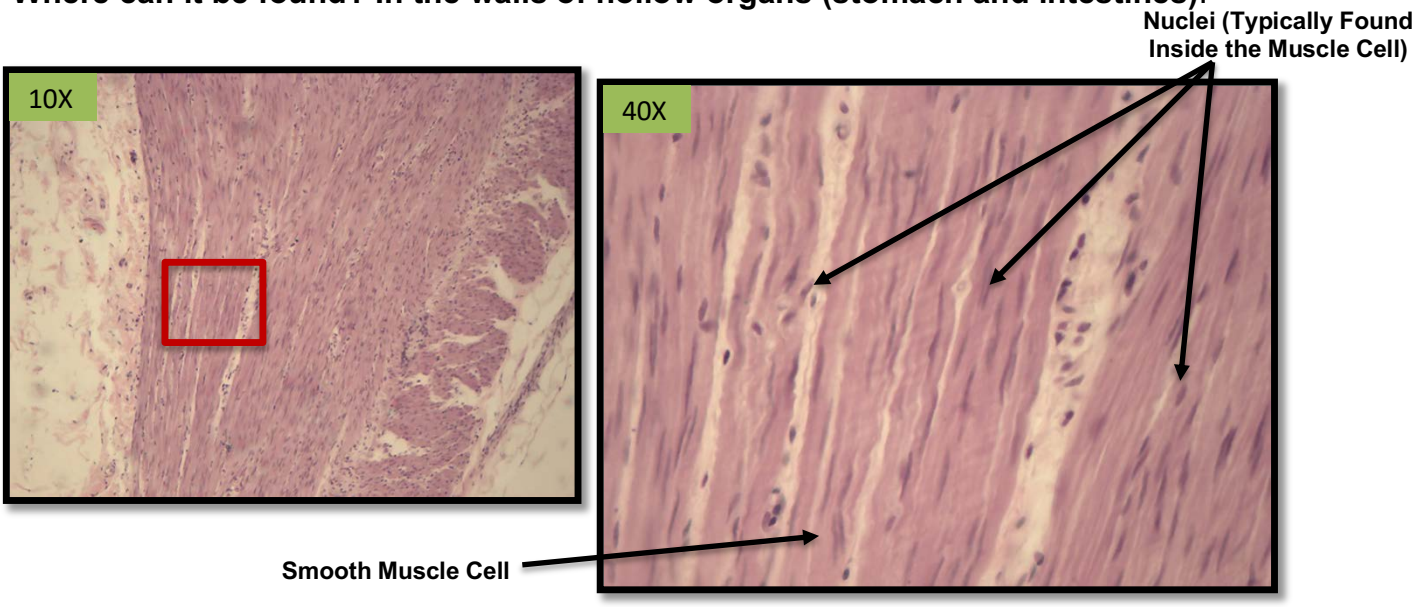
ACTIVITY 2: Why do you think skeletal muscle is multinucleated? Hint: Think about the function of the nuclei.

6.3 Smooth Muscle

Structure: Smooth muscle cells are **mononucleated**, **spindle-shaped**, have a central single nucleus that is elongated, and have no **striations**. The cells are arranged closely to form sheets.

Function: Involuntary movement of the body (**peristalsis**, pupillary light reflex, "goosebumps", contractions, regulation of organ size, etc.).

Where can it be found? In the walls of hollow organs (stomach and intestines).



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Muscle Composite Slide: Smooth Muscle

Hint: You may find yourself struggling to differentiate between the dense regular connective tissue and smooth muscle. The key **is dense regular connective tissue looks like it is made up of "strings" or fibers.**

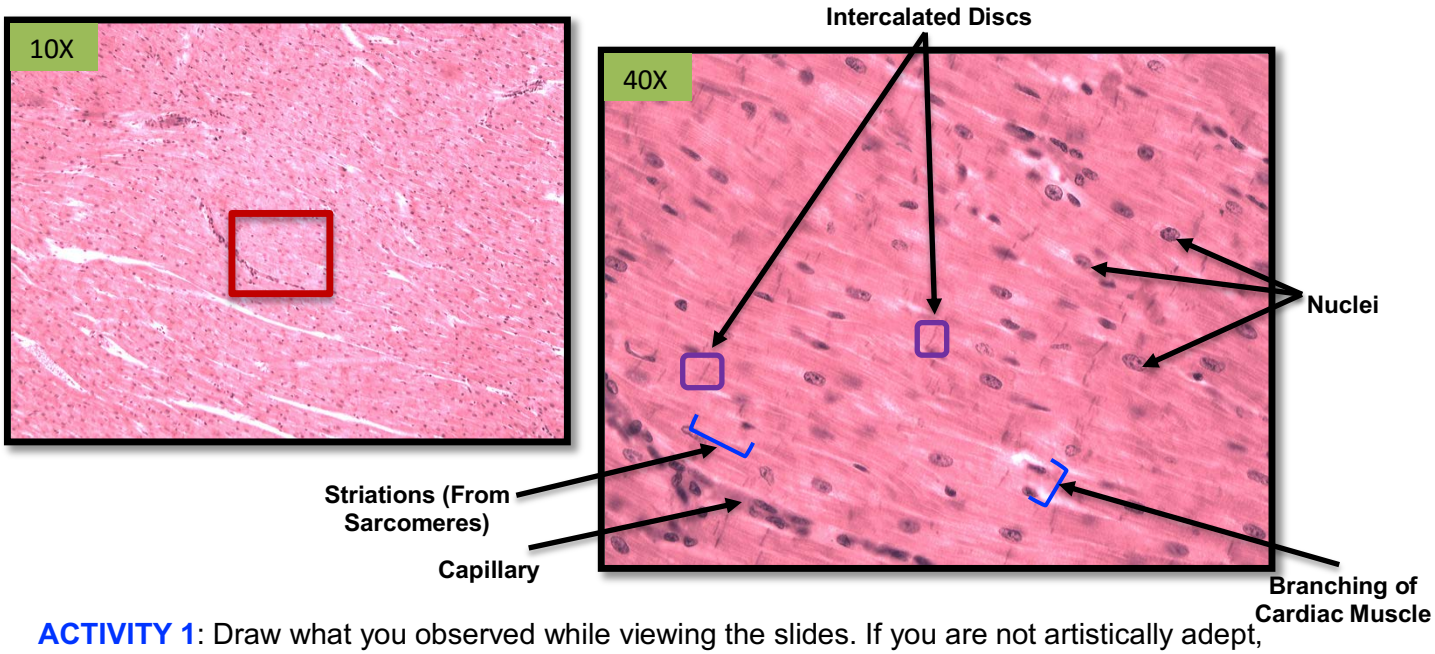
ACTIVITY 2: Why would it be beneficial to have smooth muscle in the walls of internal organs? Hint: Think about its involuntary function.

6.4 Cardiac Muscle

Structure: Cardiac muscle cells are **mononucleated**, have **branching**, have a central single nucleus, and have **striations**. The cells integrate with each other through **intercalated discs** that have gap junctions; have self-excitatory **cardiac myocytes**.

Function: Involuntary pumping of blood in and out of the heart (during contraction).

Where can it be found? The walls of the heart.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Muscle Composite Slide: Cardiac Muscle

ACTIVITY 2: Why do you think it is important for the muscle of the heart to all be communicating through gap junctions? Hint: Think of synchronization of the beating heart.

7. Nervous Tissue

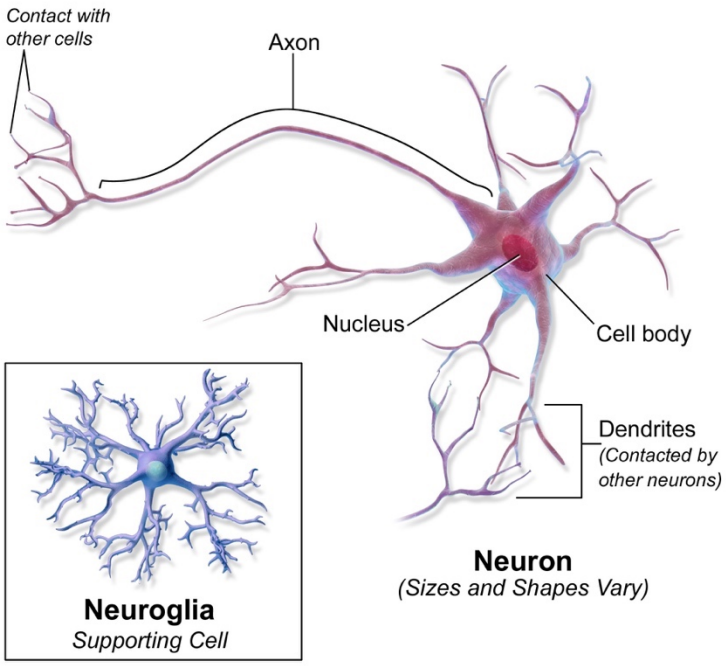
7.1 Basics of Nervous Tissue

Nervous tissue can be found in both the **central nervous system (CNS)** and **peripheral nervous system (PNS)**. Nervous tissue can be divided into two main cell populations: **neurons and neuroglia**. The neuroglia, like Schwann cells and oligodendrocytes, are supporting cells that protect, support, and insulate the neuron. Neurons are highly specialized cells that are excitable, generating an electrical signal to be sent to various parts of the body.

Neurons take in environmental physical stimuli (such as light, sound, etc.) and turn it into chemical and electrical signals in the nervous system. The basic structure of the neuron is composed of a **soma** and **neural processes**. The soma is the cell body of the neuron which has the nucleus. The soma has **Nissl bodies** (which is synonymous with the endoplasmic reticulum) which are responsible for protein synthesis.

The neural processes which receive signals are called **dendrites** which then gets passed to the soma for processing. Dendrites often spread widely from the soma to maximize the signals received. Once processed by the soma, the electrical signal is then propagated down the **axon** toward another neuron or muscle.

In the human body, there are six types of neuroglia cells; four of which are found within the CNS and the other two are found in the PNS. The neuroglia that are found in the CNS are **astrocytes**, **microglial cells**, **ependymal cells**, and **oligodendrocytes**. The neuroglia found in the PNS are **satellite cells** and **Schwann cells**.



Neural Tissue

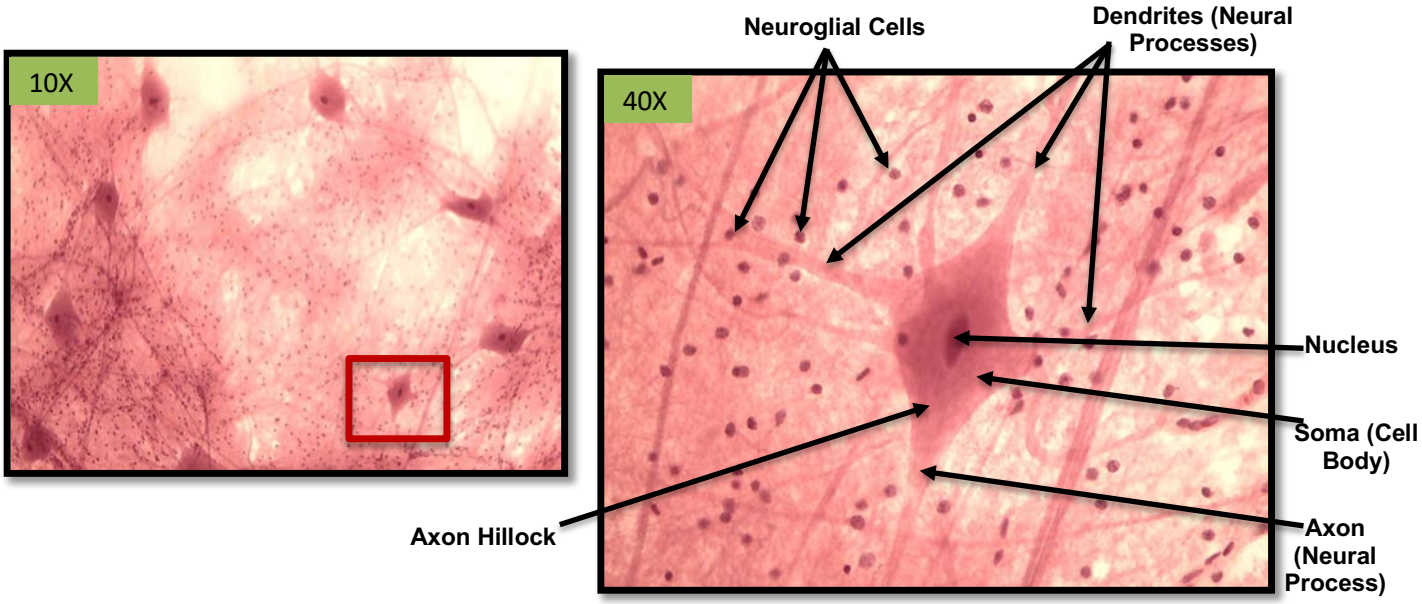
(Figure 7.1) ***Tip to Remember:*** When there is a propagation of an action potential down the axon, the electrical impulse jumps from one **Node of Ranvier** to another down to the axon terminal. At the axon terminal, the neuron could either send the electrical impulse to another neuron or to a postsynaptic cell such as a muscle.

7.2 Motor Nerve Cells

Structure: Nervous tissue is composed of **neurons** that branch and communicate with each other. The neuron is composed of **dendrites, soma (cell body), axon, and axon terminal**. There are also supporting cells around neurons called **neuroglia.**

Function: Has **sensory**, **integrative**, **and motor function**.

Where can it be found? Found within the nervous system (More likely in the peripheral nervous system (PNS) rather than the central nervous system (CNS)).



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Motor Nerve Cells

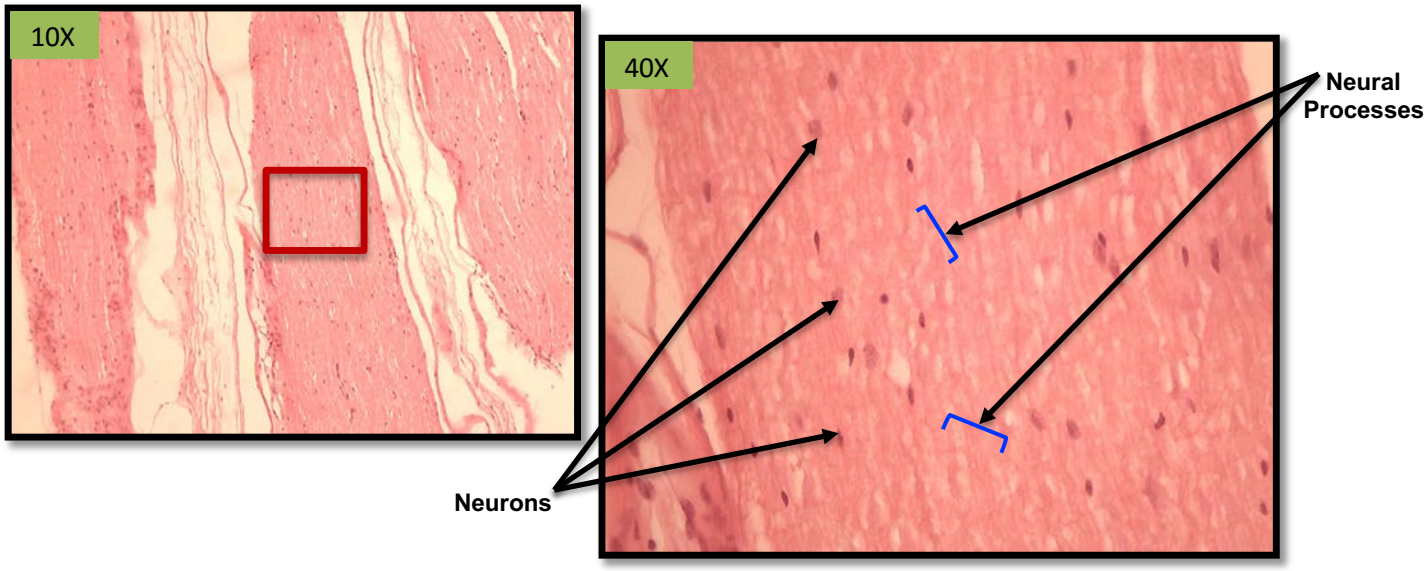
ACTIVITY 2: Why do you think some areas of the body (lips for example) have a lot of neural connections?

7.3 Peripheral Nerves

Structure: Peripheral nerves are found in the **peripheral nervous system (PNS)**. Most peripheral nerves have long neural processes. Their myelin sheath is formed by the neuroglia **Schwann cells**.

Function: Has **sensory**, **integrative**, **and motor function**.

Where can it be found? Cranial nerves, **spinal nerves**, ganglia, enteric plexuses, and sensory receptors.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Peripheral Nerves

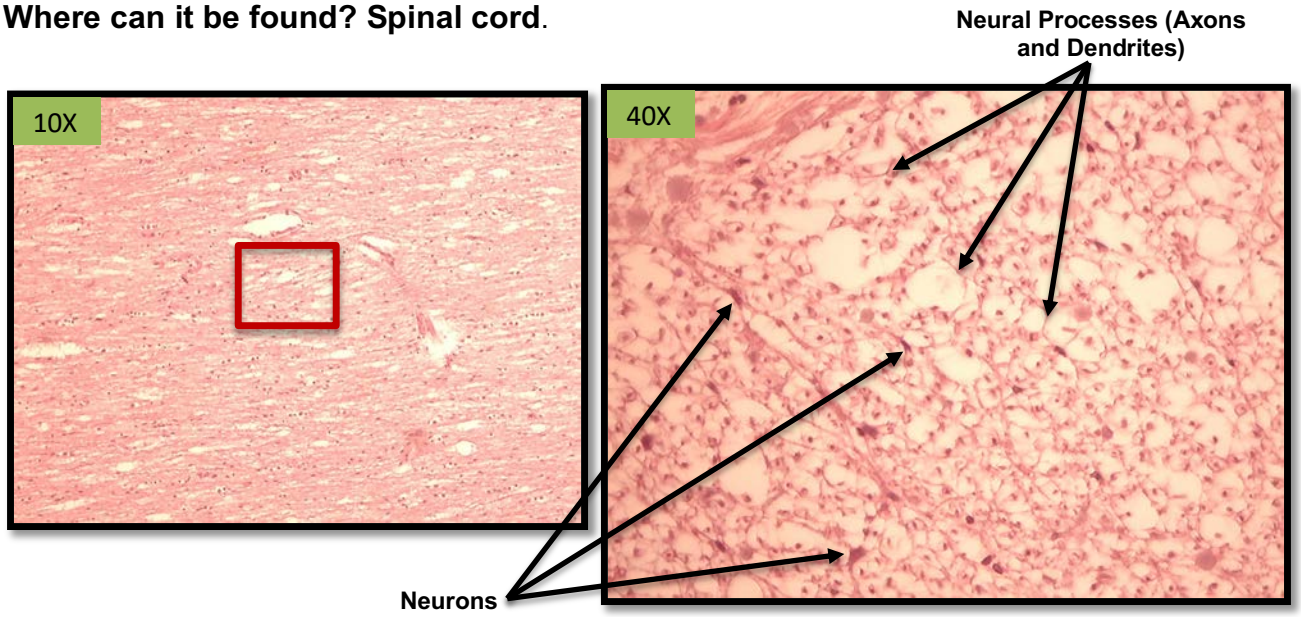
ACTIVITY 2: Why do you think peripheral nerves have long neural processes?

7.4 Spinal Cord Nerves

Structure: Spinal cord nerves are found in the **central nervous system (CNS)**. Spinal cord nerves are highly interconnected through their neural processes. Their myelin sheath is formed by the neuroglia **oligodendrocytes**.

Function: Has **sensory**, **integrative**, **and motor function**.

Where can it be found? Spinal cord.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Spinal Cord

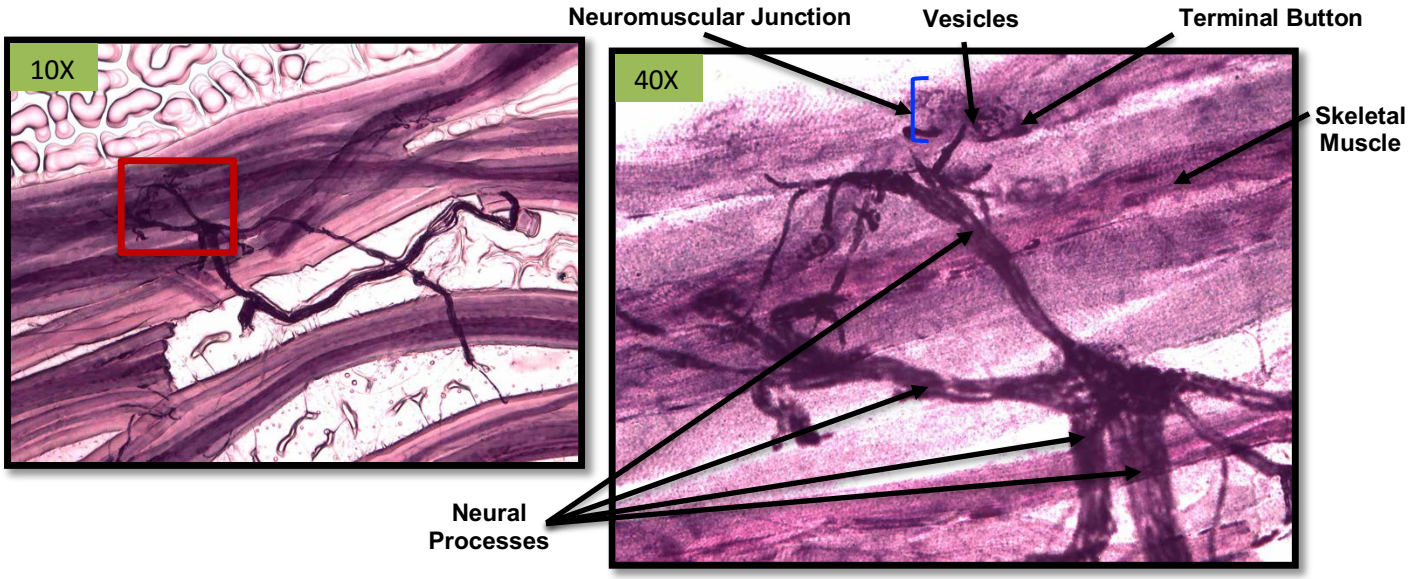
ACTIVITY 2: How do you think Schwann cells (in the peripheral nervous system) and oligodendrocytes (in the central nervous system) aid in synaptic transmission?

7.5 Neuromuscular Junction

Structure: The neuromuscular junction is the interaction of the **nervous and muscular system**. Once the electrical signal propagates down the axon, the neurotransmitters are released into the synaptic cleft which then triggers muscle contraction.

Function: Transmission of electrical conductance in order for **muscle contraction**.

Where can it be found? Interactions of skeletal muscles and neurons.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Neuromuscular Junction

ACTIVITY 2: Describe how the unique structure of a neuron relates to its function in the body.

8. Miscellaneous Tissue Types

8.1 Other Tissue Types

In histology, there are various tissue types of which are associated with numerous organ systems. These include the circulatory system, integumentary system, skeletal system, immune system, respiratory system, gastrointestinal tract, urinary system, endocrine system, male reproductive system, female reproductive system, central nervous system, and special sense organs – just to name a few.

As you can see, there are many different histological samples that can be observed. So many in fact, that a whole course can be designed around it (Biology 360: Vertebrate Histology). However, in Biology 105 we are observing the basics of the four main tissue types and selecting a few other tissue types. For this purpose, we are going to label this group as miscellaneous tissue types.

The other tissue types that we will be observing in Biology 105 are the special sense organ tissues: the monkey eye, male reproductive tissue: testes, female reproductive tissue: ovaries, and circulatory system tissue: arteries, veins, and nerve bundle.

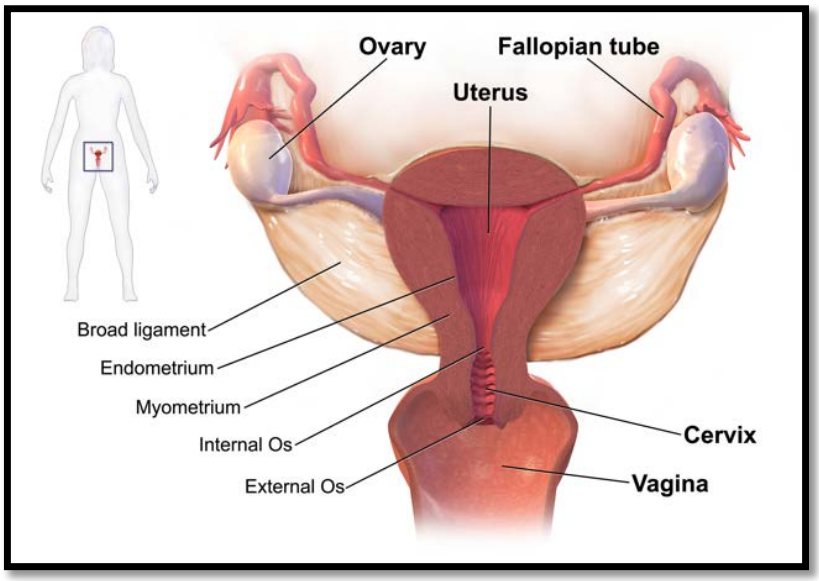


Figure 8.1:

Female Reproductive System.

(You will be examining the cross section of an **Ovary**).

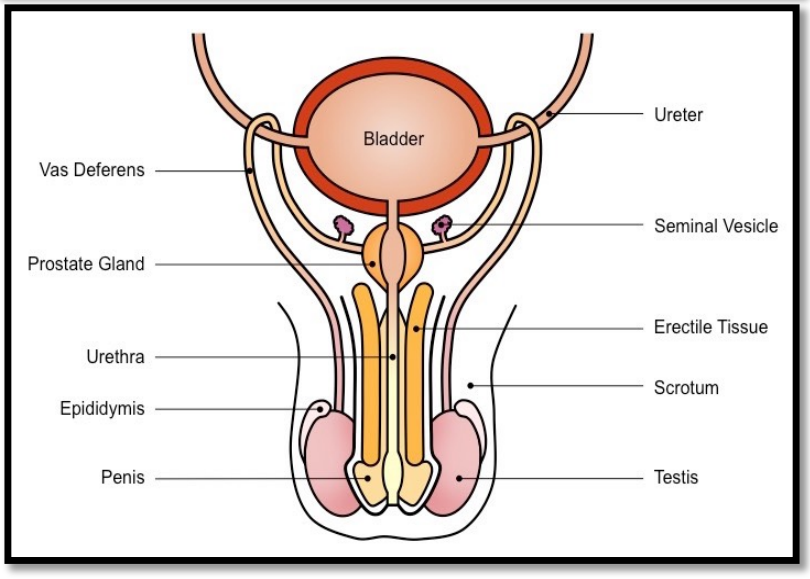


Figure 8.2:

Male Reproductive System.

(You will be examining the cross section of the **Testes**).

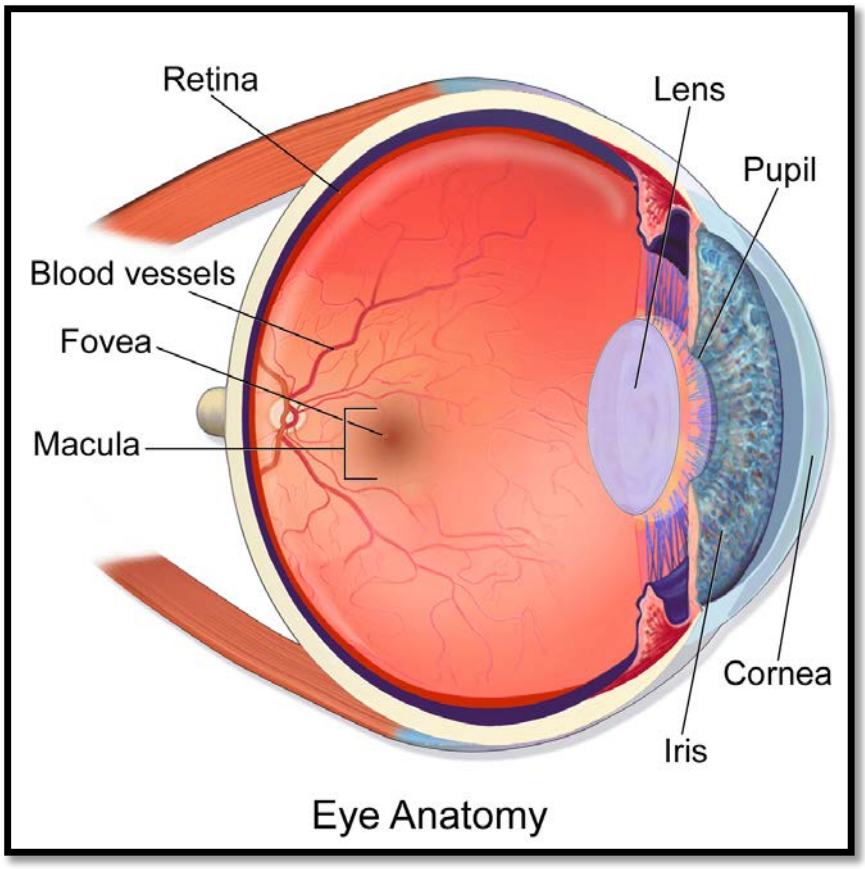


Figure 8.3:

Anatomy of the human eye.

(You will be examining a longitudinal section of the **monkey eye**).

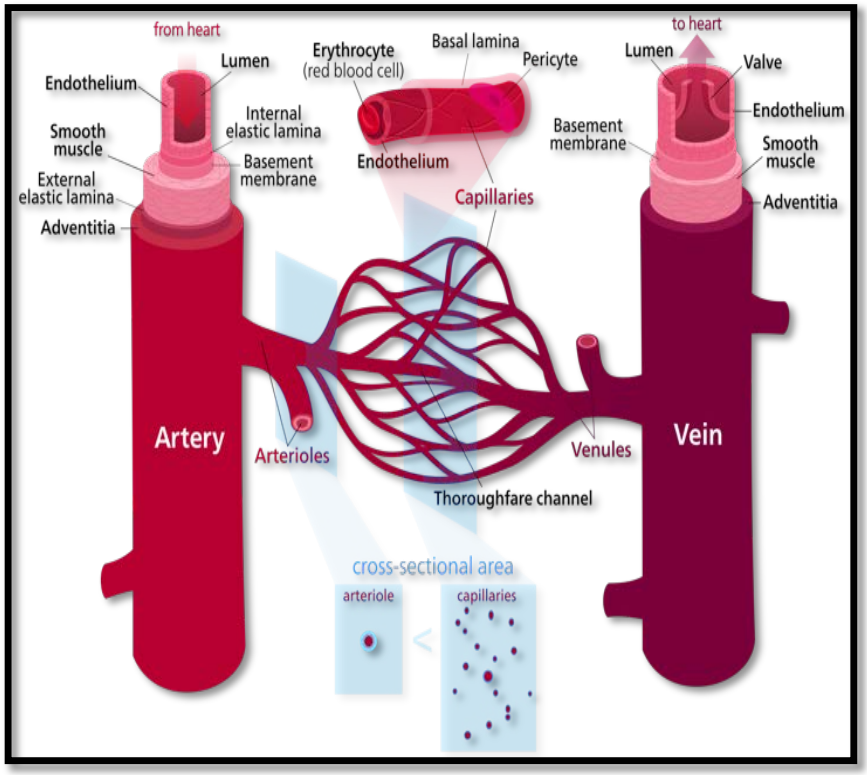


Figure 8.4:

Anatomy of the blood vessels.

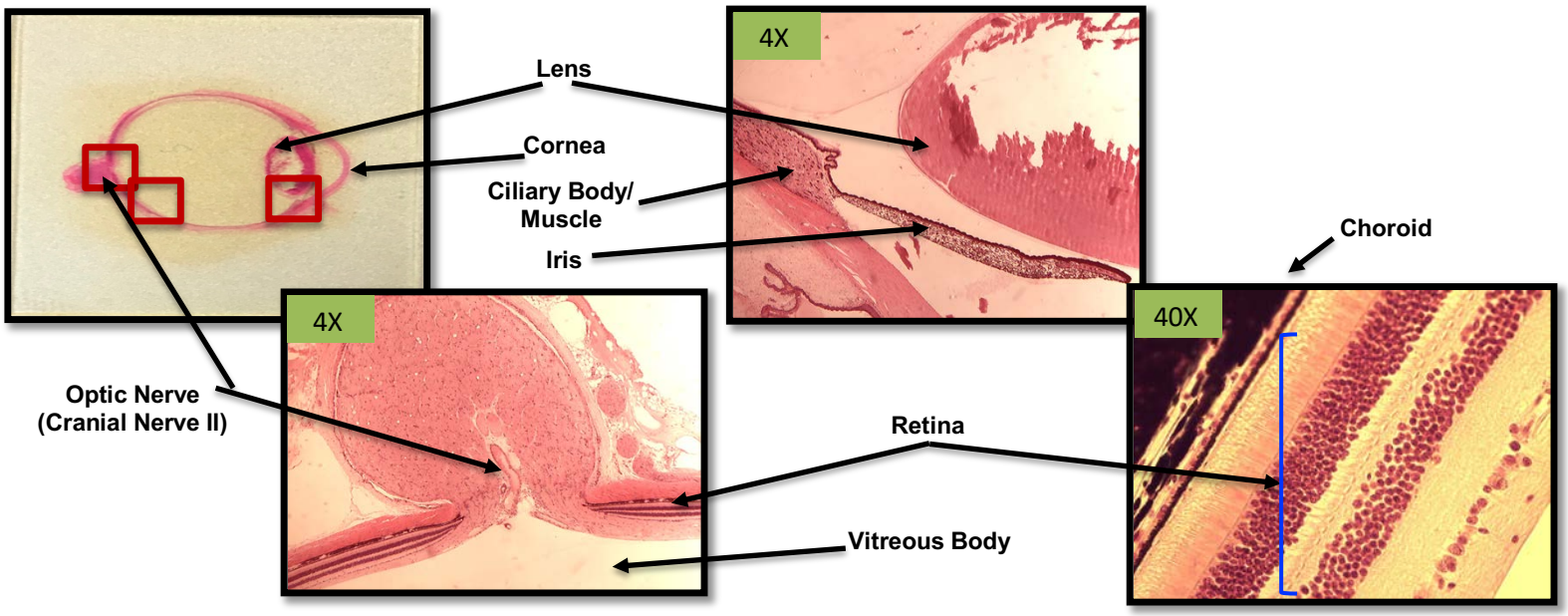
(You will be examining a cross section of the **artery, vein, and nerve**).

8.2 Special Sense Organ Tissue: Mammalian Eye

Structure: The eye is one of the most important special sense organs. Within the eye, light is concentrated by the lens and directed to **photoreceptors**, **rods and cones**, that are located in the **retina** at the back of the eye. The sensory information is then sent to the brain for further processing by the **optic nerve (Cranial Nerve II)**.

Function: Absorption and processing of environmental light stimuli that is refracted through the lens in order to visualize objects in the visual field.

Where can it be found? Within the orbital cavities of the skull



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Mammalian Eye: Retina

Mammalian Eye: Optic Nerve

Mammalian Eye: Lens and Iris

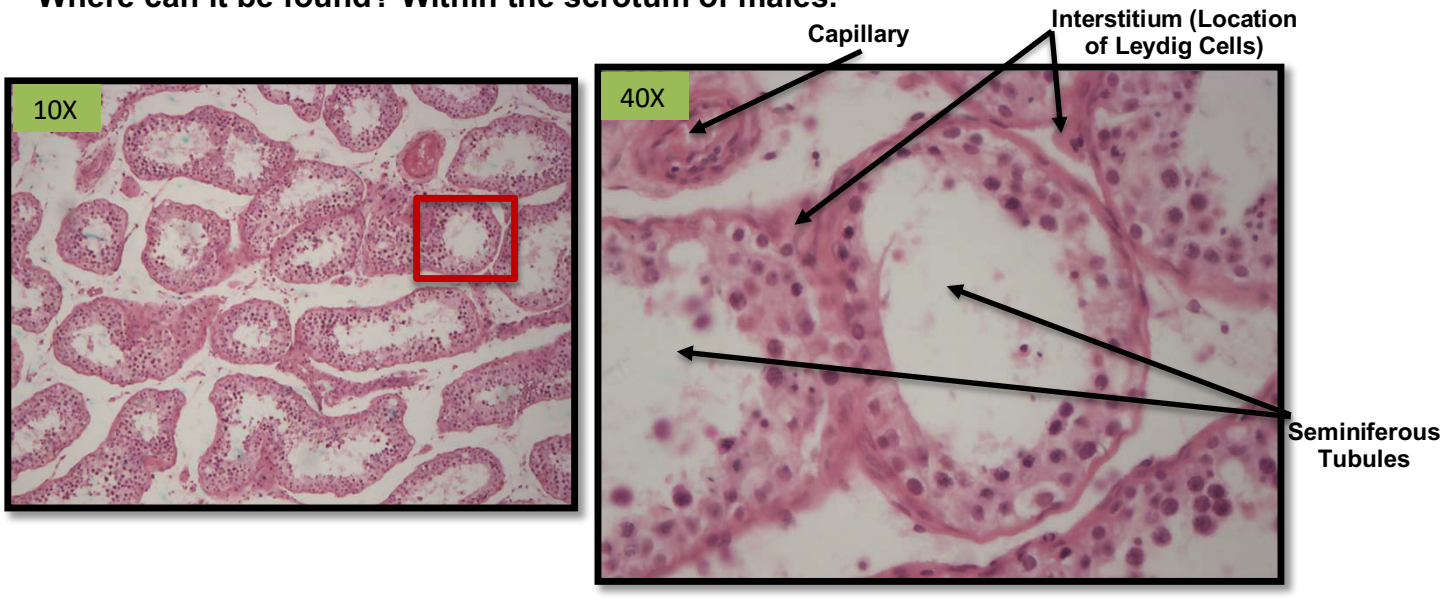
ACTIVITY 2: The retina has two main types of photoreceptors: rods and cones. How do these two photoreceptors differ?

8.3 Male Reproductive System Tissue: Testes

Structure: The testes are a male reproductive organ that are housed within the **scrotum**. Under a histological section, the tissue looks like a circle of islands, which are the **seminiferous tubules**. In one circle **as you progress more towards the center, the sperm is more developed**.

Function: Spermatogenesis and hormone production/ secretion.

Where can it be found? Within the scrotum of males.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Testes

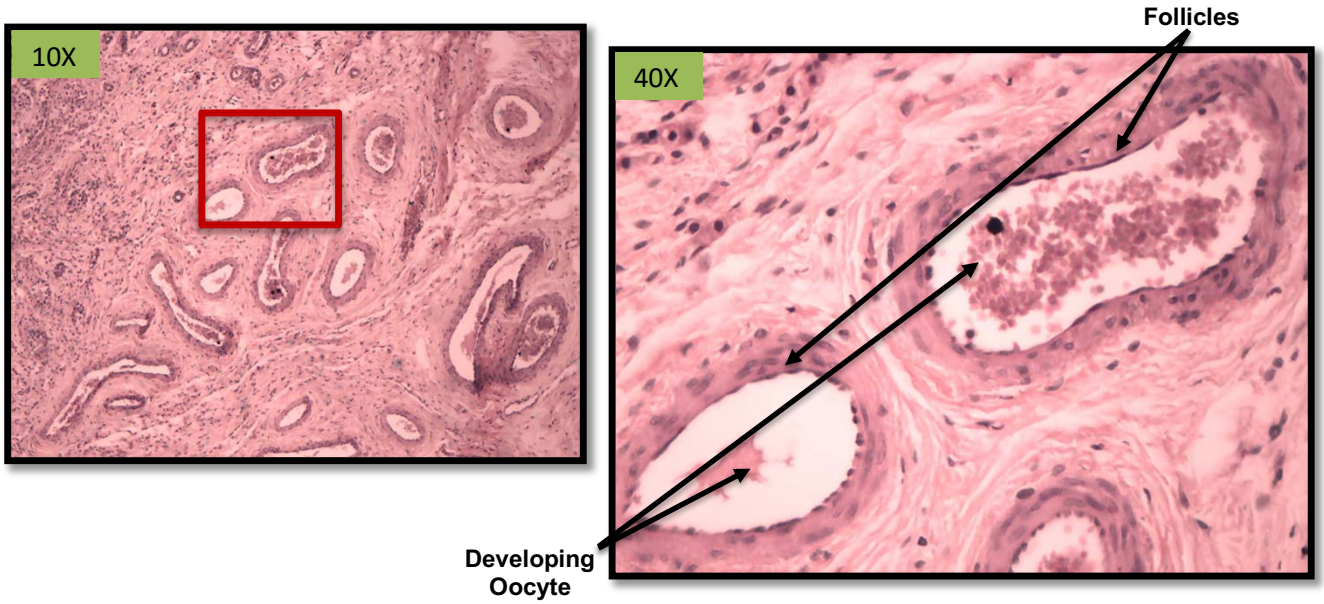
ACTIVITY 2: Trace the pathway of the developing spermatogonia to spermatozoa. What cells support and nourish the developing spermatogonia?

8.4 Female Reproductive System Tissue: Ovary

Structure: The ovaries are a female reproductive organ that are housed within the **abdominopelvic cavity**. Under a histological section, the tissue looks like pockets with some tissue in the middle, which are the **follicles with the developing oocyte.**

Function: Oogenesis, ovulation, and hormone production/ secretion.

Where can it be found? Abdominopelvic cavity attached to the uterus.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Ovaries

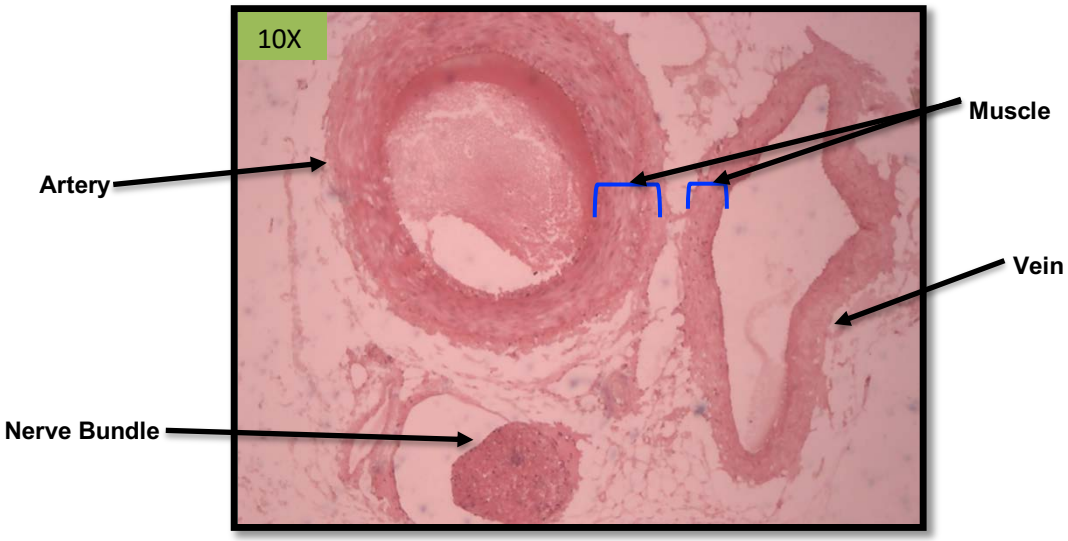
ACTIVITY 2: Oogenesis and spermatogenesis are both forms of meiosis. How do the two differ? Hint: Think about the number of gametes each process produces at the end of meiosis.

8.5 Circulatory System Tissue: Artery, Vein, and Nerve

Structure: The artery is circular and has a thick muscular wall which is important for being able to exert enough pressure to pump blood away from the heart. The vein is somewhat collapsed and has a smaller muscle wall surrounding it. The nerve bundle is a collection of axons that appears as a sphere.

Function: Arteries pump blood away from the heart, veins bring blood back towards the heart, and the nerve bundle transmits electrical signals to or from the central nervous system (CNS).

Where can it be found? Various locations throughout the body.



ACTIVITY 1: Draw what you observed while viewing the slides. If you are not artistically adept, just take a picture using your phone, print out the picture, and paste it into the box below. **Make sure to label!!!**

Artery, Vein, and Nerve

ACTIVITY 2: Why do you think blood from the legs going to the heart is able to get to the heart without problem? Hint: What structure do veins have that arteries do not have?