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BIOL 244L HUMAN ANATOMY AND PHYSIOLOGY LABORATORY
SENSORY ANATOMY AND HISTOLOGY: VISION, VESTIBULOCOCHLEAR SYSTEM, TASTE, OLFACTION, TOUCH, AND PROPRIOCEPTION

Sensory receptors vary greatly in complexity ranging from free nerve endings to small receptor organs to the special senses (vision, hearing, smell, taste, and equilibrium) that have highly complex organs. Sensory receptors respond to a specific kind of sensation (eg temperature, vibration, sound, light) called a **sensory modality**, and the receptor is a **transducer** of the stimulus into an electrical signal that can be transmitted as action potentials in the nervous system.

The anatomy of the eye and ear is complicated on a fine scale of size. It is important to use illustrations of this anatomy as you work on the histology slides of eye and ear and the sheep eye dissection. Good illustrations are in the laboratory and the lecture textbooks.

I. EYE

1. Histology

The eye contains a complexity of tissues, and you will need to refer to the diagrams in the text in Chapter 17 The Special Senses to identify these tissues and understand their relationships. Use the ordinary sized slides called "monkey eye," and be very careful with them. Producing a good thin section of the whole eye for the microscope is difficult, because the eye is big and contains both tough tissues and big open spaces. The slides are therefore expensive. For the most excellent preparations, look at the large size slides of the eye that will be available with a microscope at the front of the laboratory. These really big slides are old and may be considered antique biological specimens. They could "make 'em like they used to"…but they don't make them like this anymore. These slides have a thin stained section of the entire human eye on them, they are very carefully made, and as far as I can tell, they are irreplaceable. You can take the regular size monkey eye slides to your lab bench but treat them carefully as well. Keep the area around the microscope clear of clutter when you are working with them, and take care to gently close the slide clamps on the microscope stage so the corners of the slide do not get chipped (this is good practice for all microscopy work).

Hold the slide up to the light. Use the illustrations in Chapter 17 to find the **cornea, sclera, lens and iris**. Now, with the microscope, and first using the 4X objective lens in place, use the text illustrations to find the **cornea, sclera, and conjunctiva** (dilated conjunctiva blood vessels make "bloodshot" eyes). If you are having trouble getting oriented on these big tissue sections, take the slide up to the binocular dissecting microscope at the front of class. There you can see the whole eye in the field of view. Then find the **iris, ciliary body, and ciliary processes**. Both the iris and the ciliary body have a black surface border on the inner surface. Why do you think these tissues are so black pigmented? The iris has an opening called the **pupil**, and right behind the iris lies the **lens** of the eye. The lens may appear to be hollow on the slide, but it was not when alive. The lens is suspended from the ciliary processes by the **suspensory ligament**, and a few fibers of this ligament should be visible on the slide.

On the side of the eye opposite of the lens (the back of the eye), find the **retina**. The photoreceptor cells are of two kinds, rods and cones. Different colors represent light of different wavelengths. Rods detect light in a broad range of wavelengths and provide "black and white and

shades of grey" vision. Cones are sensitive to differing narrow ranges of wavelengths, and cones are responsible for color vision. Rods are more sensitive to dim light than cones, so night vision is not much for color. Cones are concentrated in the center of your visual field, so night vision is better off the center of the visual field. Sometime on a clear night find a faint star; do you see it more clearly looking directly at it or gazing slightly off to one side? On our slides we cannot see the difference between rods and cones; we would need special staining or better still, an electron microscope. However, look at the exhibit of photos and diagrams of the retina at the front of the lab as well as the text to learn the difference in structure between **rods and cones**. On the slide, find the **layer containing the rods and cones**. The bands of round, purple dots are **nuclei** of cells. The band of nuclei closest to the rods and cones are the nuclei of the rods and cones. The other layers of nuclei toward the center of the eye (left on most slides) are layers of **retinal neurons**. The eyes are outgrowths of the brain, and there is a lot of integration of signals from the photoreceptor rods and cones going on in these neuronal layers before the integrated signals are transmitted to the optic nerve. Does light for seeing have to pass through all these layers before it reaches the photoreceptor rods and cones? Further from the center of the eye, beyond the rods and cones, find the dark **choroid layer** with its **black pigmented melanocytes**. This pigment absorbs light and prevents internal reflections that would blur the image. Some animals have a highly reflective layer at the front of the pigment layer that reflects light passing through the retina directly back for a second pass through the rods and cones. This helps vision in dim light, and it is the basis of the "eye shine" you see in cats and other nocturnal mammals crossing the road in your headlights. This reflective layer will be seen in the sheep eye dissection below. Beyond the choroid is the pink (fading pink color in portions of these old slides), smooth-looking **sclera**.

Following along the curving **retina**, you can find the only place where it is interrupted by the exit of the **optic nerve**. Rods and cones cannot be fit into this exit point, and this is the "blind spot" or **optic disk** where images cannot be seen. If you cover one eye, you still do not perceive a black spot at this point, because your brain blocks it out of your perception (brains are good at enforcing denial!). To trap your brain into revealing this blind spot, close your left eye, and stare at the bold zero below. Beginning with the paper a few inches from your eye, slowly increase the distance while you continue to stare at the zero. Watch for the X to disappear when it enters the field of the optic disk.

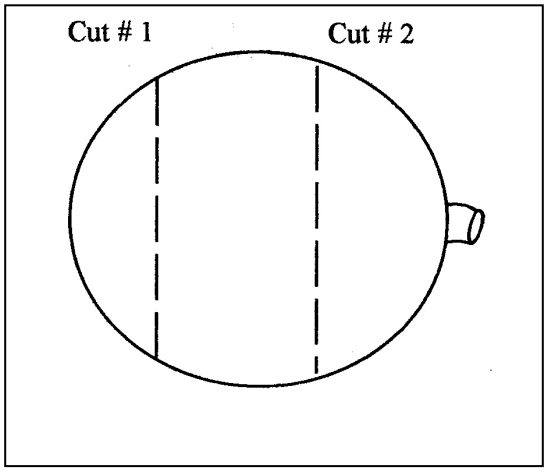
0 **X**

Another denial game you can play with your brain is to try to see your eyes move in a mirror. Look straight into a mirror and move your eyes back and forth to look first at one eye, then the other. You know that your eyes are moving in order to look back and forth, but can you see this motion happening? The brain in integrating visual perception edits this motion out of your perceptive experience. I wonder what else our brains are hiding from us?

2. EYE MODELS.

Using the models and the figures in your textbook, learn the **cornea, lens, iris, sclera,**

extrinsic muscles of the eye (superior and inferior obliques, lateral rectus, medial rectus, superior rectus, and inferior rectus), and the optic nerve. The **optic nerve** is **Cranial Nerve II**. We learned this during the brain dissection laboratory, and here we review the cranial nerves associated with special senses again.



3. SHEEP EYE DISSECTION.

A. If the cornea is not too cloudy, the **pupil** and the **iris** can be seen. Familiarize yourself with the external anatomy, the following instructions, and the figure at the right before doing any cutting. Using sharp pointed fine scissors, make a cut (#1) around the outer edge of the **cornea** but stay in front of the **iris**. Be careful not to exert a lot of pressure in making your initial cut, because the eye is fluid-filled and **the fluid can squirt if under pressure** when the point of the scissors penetrates to the interior. Alternatively use the point of a scalpel or dissecting needle to make the initial penetration through the tissue. It may be necessary to trim fat off the back of the eye to get oriented. Do not cut behind the iris. You will then be able to see into the **anterior cavity** of the eye and identify the **iris**, whose inner edge surrounds and defines the **pupil**. The iris divides the anterior cavity into an **anterior chamber** and a **posterior chamber**. The pupil is an opening in the iris that connects the anterior and posterior chambers, and both are filled with a watery fluid, the **aqueous humor**. At the back of the anterior and posterior chambers, you will see the **lens**. The lens and the cornea are usually both opaque because of the effects of the preservative fluid. The aqueous humor is secreted by the **ciliary body**. This fluid circulates to the **posterior chamber** behind the lens, and like the cerebrospinal fluid, eventually exits this fluid space via a venous sinus. The balance of flows maintains an intraocular fluid pressure supporting the retina. Glaucoma is a condition of excessive intraocular pressure and can lead to blindness.

B. A second cut (#2), through the **sclera** farther toward the rear of the eye, will enable you to see the back side of the **ciliary body** (black, with radiating line-like ridges). Before making cut 2 around the sclera, it may be useful to make a cut perpendicular to cut # 1 to the initial position of cut 2. Then turn the scissors perpendicular and follow the path of cut 2 around the sclera. The jelly-like **vitreous humor** is usually present in the **posterior cavity** behind the lens. The **retina** is a pale color. It usually has become at least partially detached, and it may be wrinkled and bunched together. It is typically still attached at least where the optic nerve leaves the posterior of the eye. Remove the retina, and look for an iridescent coating behind the retina. If present, this the **tapetum lucidum**, the reflective layer that enables some animals to see better at night. What is the black layer of the wall of the eye?

WHEN FINISHED WITH THE DISSECTION:

***Place the sections of the sheep eyes in the plastic bag at the front of the lab**
***Throw any small scraps of tissue in the scraps can at the back of the lab.**
***Wash out the dissecting trays and return them to the back of the lab**
***Clean your dissecting tools, blot them dry, return them in their boxes to the front of the lab.**

II. VESTIBULOCOCHLEAR SYSTEM

The vestibulocochlear system consists of two different senses and actually three different organs in the ear. Audition is hearing and the organ that senses sound is the **cochlea**. The other

sense in the ear is the vestibular or equilibrium sense. Dynamic equilibrium (or sense of motion) is monitored with the **cristae** in the ampullae of the **semicircular canals**, and static equilibrium (or sense of up and down in the earth's field of gravity) is monitored with **otoliths** in specialized chambers of the ear. All of these sensory modalities are routed to the brain via **Cranial Nerve VIII, the vestibulocochlear nerve**.

1. COCHLEA HISTOLOGY. Hold the slide of **cochlea** up to the light. Most of the purple color is bone. Embedded in this bone is a very tiny slice through several turns of the snail-shaped **cochlea**. See Chapter 17 The Special Senses for a diagram that includes a section of the cochlea.

Place the slide on the microscope so the cochlea will be beneath the objective lens. Find one "turn" of the cochlea's spiral so you can view the **organ of corti** with its component parts. Use the diagrams in the text with the slides, but the structures, as seen on the slides, will not be nearly as clear as on the diagrams. Learn the **tectorial membrane, outer hair cells, and the basilar membrane**. There are also inner hair cells closer to the origin of the tectorial membrane, but these are difficult to locate. The hair cells bear projections called **stereocilia**. They are not really hairs, and they are not even really cilia. They are not motile like cilia, but they are more like elongated microvilli. Sound waves strike the eardrum and are communicated to the cochlea where they cause pressure vibrations in the fluid filled ducts of the cochlear coils. Vibration displacement of the basilar membrane varies along its length depending on the frequency of sound. Bending of the **stereocilia** on the outer hair cells sandwiched between the basilar membrane and the tectorial membrane is transduced to electrical signals leading to the generation of nerve impulses in the cochlear nerve fibers and the perception of sound.

On the slide, it is not easy to cut a section through both the hard and delicate tissues of the cochlea. On many turns of the cochlea, the tectorial membrane appears jammed down onto the hair cells, but this was not true when it was alive. On most of the slides, the **cochlear nerve** shows fairly well coming out from the center of the cochlea (color coded yellow in the diagrams in the text). It may appear to be discontinuous on the slide, but that is only because of the way it happened to be sectioned for the slide.

2. CRISTA. The slide of "Crista Ampullaris" shows a receptor for dynamic equilibrium. Hold the slide up to the light, and note that the purple material is bone. The larger of the two cavities is a slice through the **ampulla** of a **semicircular canal**. Search this cavity with low power, and find an object that is shaped somewhat like the end of a tongue, a club, or a horseshoe. This object is the **crista**. It is usually still covered with **columnar hair cells**, but the hairs do not usually show well. The text diagram shows the organization of the semicircular canals and cristae. The three semicircular canals are oriented in 3 different dimensions and are filled with fluid. Different movements of your head will cause the fluid to slosh around to different degrees in the canals and make different displacements of the microvilli-like stereocilia (the "hairs") in the cristae. These displacements are transduced, and nerve impulses communicate the sense of dynamic equilibrium to the brain. If you spin 'round and 'round quickly, you can confuse this system and get dizzy.

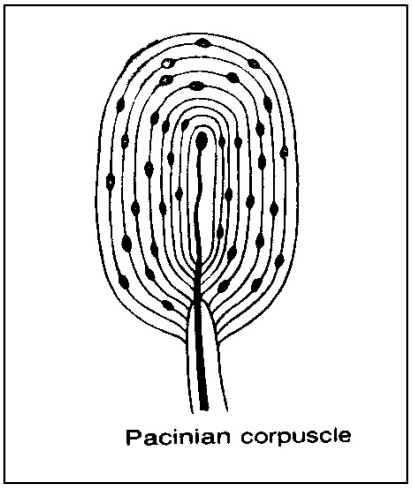
3. EAR MODEL AND PLASTIC EMBEDDED AUDITORY OSSICLES.

The **external ear** is a canal that leads to the **tympanic membrane**. Behind this membrane is the **middle ear**. The middle ear is an air filled chamber with a connection, the **auditory tube** (eustachian tube) to the pharynx. It contains a set of 3 small bones in series called the **auditory ossicles** that connect the tympanic membrane to the **inner ear** at the **oval window**. These bones are successively the **malleus, incus, and stapes**. There is a set of these bones

embedded in a block of plastic available to see with the ear model. Sound vibrations in the air are transmitted to the auditory ossicles. These in turn are transmitted to the inner ear at the stapes connection to the oval window. They are then transmitted as pressure vibrations in the fluid-filled **organ of Corti** to produce the relative displacement of the **tectorial membrane** and **basilar membrane** as described above in the study of the **cochlea** histology. Other structures to learn on the model are the **semicircular canals, ampullae, cochlea, vestibular nerve, cochlear nerve, vestibulocochlear nerve (Cranial Nerve VIII), utriculus, and sacculus**. The utriculus and sacculus contain hair cells with stereocilia in a gelatinous layer under a hard layer of $CaCO_3$ crystals called otoliths. Gravity and other accelerations move the otolith layer, bending the hairs and providing a sense of static equilibrium (which way is up) and also a degree of dynamic equilibrium.

III. PACINIAN (LAMELLATED) CORPUSCLES:

The slide of "Lamellate Corpuscles", also called **pacinian corpuscles**, shows these pressure-touch receptors. LOW POWER is plenty to use in finding at least one of these on the slide labeled "Vater-Pacinian Corpuscles". The **pacinian corpuscle** consists of a dendrite enclosed in layers of connective tissue. They are broadly distributed in subcutaneous tissues, connective tissues underlying mucous and serous membranes, and in joints, tendons, muscles, and some visceral organs.


Pacinian corpuscle

IV. TASTE BUDS:

Use the slide labeled "Tongue with taste buds" or "vallate papillae" and the diagram in Chapter 17 to find these receptors. Through the microscope the **circumvallate papilla** will appear at the top of the field. The **taste buds** are located in these as well as other tongue papillae and will appear as rounded clusters of cells along the lower and narrower stalk of the papilla. If the section cuts a taste bud through the center, you will be able to see the taste pore to the surface of the papilla. The sense of **gustation** (taste) has receptors distributed over the tongue and over adjacent parts of the pharynx and larynx as well. The neural sensory pathways for gustation include cranial nerves **VI Facial, IX Glossopharyngeal, and X Vagus**. Irritating "flavors" like hot peppers are not technically gustation. This sense and the sensation of food texture in the mouth are mediated by different receptors with pathways in the **Trigeminal nerve (cranial nerve V).** Finally, gustation sense interacts profoundly with olfaction (below). This is why wine tasters first swirl the wine and inhale air nasally from the top of the glass and then quietly and politely slurp and then slosh the liquid in the mouth to envelop both oral and nasal cavities in the experience.

V. OLFACTORY EPITHELIUM: The slide is of nasal passages, and includes cartilage and other type of tissues. The present edition of your textbook does not have a photograph, but there is a diagram of **olfactory epithelium** (Chapter 17 again). There are a few types of epithelium in the nose as a whole. The olfactory epithelium must be quite thick (pseudostratified columnar) before it is true olfactory epithelium. Scan the slide until you find some that is thick enough, and then ask for confirmation. Bundles of axons from olfactory receptor cells in the epithelium pass through the multiple foramina of the cribriform plate as **olfactory nerves (Cranial Nerve I)** and connect to the olfactory bulb of the brain.

VI. TOUCH SENSITIVITY

Work in groups to test how precisely contact can be located at different surfaces of the body with different densities of sensory receptors.

Student A touches firmly the skin on the back of **student B's forearm** with the blunt probe from a dissecting kit. During the touch, a small, visible depression on the skin should result without causing pain. Then student B, **WITHOUT LOOKING**, tries to touch the same spot with another probe, entirely on the basis of where it felt like student A touched. Using metric rulers at the front of the lab, measure the distance in mm between where A actually touched, and where B thinks she/he was touched. Student B is allowed to move the probe around to find what seems like the right spot.

Write down the measurement, and repeat four more times for the forearm.

Record the data:

Average the result for five trials. Average of five trials: _____
Do the same test for another student in your group. Average of five trials: _____

Do five trials on the back of the outer segment of the index finger. Average of five trials: _____
Do the same test for another student in your group. Average of five trials: _____

Do five trials on the palm side of the outer segment of the index finger. Average of five trials: _____
Do the same test for another student in your group. Average of five trials: _____

List the three test areas in order of best to poorest sensitivity, as based on the average error for each area.

BEST: _____
MIDDLE: _____
POOREST: _____