Special Senses

I. Olfaction

A. Anatomy and general info

The olfactory epithelium is located at the roof of the nasal cavity

Nasal conchae cause turbulance of incoming air

Olfactory glands secrete a thick mucous, which traps debris and provides a water and lipid soluble medium for odorants (molecules that can be recognized and perceived as scent; typically small organic molecules)

B. Olfactory receptors-

1. Olfactory neurons are chemoreceptors

2. They extend from the olfactory bulbs and innervate the olfactory epithelium

3. The dendrites are highly branched and contain odorant binding proteins, which bind specific odorants

4. Binding of odorants causes depolarization

C. The perception of smell

1. Messages from olfactory nerves travel to the olfactory bulbs (through what part of the braincase?). There they will synapse with interneurons that travel to other parts of the brain (olfactory cortex and the limbic system).

2. Olfaction is the only sense not filtered by the thalamus, but central adaptation (inhibition at one or more synapses) can reduce your perception of a scent.

II. Gustation

Gustatory receptors- located in 2 of the 3 types of papillae (bumps) on the tongue. Similar to olfaction in function. Different receptors are depolarized by different tastes (sweet, salty, etc), so the perception of taste depends on which nerves are activated. Olfaction, in addition to gustation, is necessary for taste to be fully experienced.

III. Vision (I'm going to use the term "altered" to describe the activity of photoreceptors in response to light, because their activity is somewhat different than typical sensory receptors. But the ultimate effect is the same: perception of vision in response to a stimulus)

A. Eyeball anatomy- hollow, fluid-filled balls

1. Iris- the "colored" or pigmented part of the eye. In the center of the iris is the pupil, an opening. Includes 2 layers of smooth muscle that surround the pupil and cause constriction and dilation (opening and closing) of the pupil.

2. Cornea- clear covering of the iris; connective tissue

3. Lens- Located behind the iris/pupil. Light travels through the pupil and is focused by the lens. Composed of cells filled with transparent proteins.

4. Sclera- white of the eye. Connective tissue. Covered by a clear, thin connective tissue, the conjuctiva.

5. Retina- the inner connective tissue lining of the eye. Interior to the retina is a viscous fluid that fills the inside of the eyeball. Within the retina are photoreceptors, or visual sensory receptors.

B. The path of light- Light bounces off objects towards us. It travels through the pupil, is focused by the lens, and travels to the back of the retina, where it will alter photoreceptors and cause the perception of vision. The lens changes shape to focus objects that are closer (gets round) or further away (gets flatter).

C. Receptors of the eye

1. Photorecptors: very specialized cells, located in the retina. They are altered by light energy (photons)

2. Some of these cells respond to both bright and dim light and produce gray-toned (black and white) vision: Rod cells. Some of them respond only to bright light and produce color vision: Cone cells.

3. Rods and cones house thousands of special pigments. These pigments change conformation (shape) in response to light energy.

4. The visual pigments: Rhodopsin (rods) and Iodopsin (cones)- consist of retinal (a form of vitaminA) bound to the protein, opsin. Opsin exists in a

few different forms, and black/white vs. color vision is determined by the form of opsin in the rods/cones. In the absence of light, retinal is in a cis (bent) conformation, and is folded into opsin. Light energy causes cis-retinal to spring open to a trans (straight) conformation, and retinal then detaches from opsin. This event causes changes in membrane permeability, and a sensory message will be sent that will be perceived as vision.

D. The perception of vision- Rod and cone cells are restricted to the retina. They communicate with other sensory neurons that will bring the messages to the brain (visual cortex) via the optic nerves.

*Interesting information that may show up as extra credit: In the dark, rods and cones are constantly "depolarized;" Na+ channels are open and they continuously release glutamate onto their associated sensory neurons. When rhodopsin/iodopsin are transformed by light, Na+ channels CLOSE, the cells hyperpolarize, and STOP sending Nt! It is the absence of Nt from rods and cones that will end up being interpreted as vision (what happens from there, from what I understand, is not entirely known). Cool, huh?

IV. Hearing and Equilibrium

A. Ear anatomy-

1. External ear- includes the pinna, or ear flap, and the external auditory canal, which we are advised not to put anything smaller than an elbow into. The external auditory canal leads to the tympanic membrane (tympanum), or eardrum, which is a thin layer of cartilage covered by skin.

2. Middle ear- separated from the external ear by the tympanum. Contains tiny auditory ossicles (bones): the malleus, incus and stapes. [For your interest, evolutionarily these bones are derived from jaw components of fishes.] The auditory ossicles run between (and contact) the typanum and the opening to the inner ear (the oval window). The malleus contacts the typmpanum. The incus contacts the malleus on one side and the stapes on the other. The stapes contacts the incus on one side and the oval window on the other.

3. Inner ear- the oval window marks the entrance to the inner ear. Consists of two interconnected structures:

i. The semicircular canals/vestibule, which house receptors that transmit information about equilibrium

ii.The cochlea, which trasmits information about sound waves

Both the semicirucular canals and the cochlea consist of series of curved fluid-filled tubes that are surrounded by bone. Again, these two structures are connected to one another.

B. General information about BOTH equilibrium and sound perception-

1. Receptors are mechanoreceptors. Consist of ciliated cells ("hair cells") that are associated with sensory neurons. As with vision, it is the associated sensory neurons that will transmit the information to the brain (via the vestibulocochlear nerve). What two areas of the brain do we know that information about equilibrium goes?

2. Fluid movement in the tubes causes the cilia to bend. Bending of the cilia causes changes in membrane permeability, and they release more or less Nt onto their associated neurons. *The process of cilia bending differs for equilibrium and hearing, but ultimately both depend on fluid movement.

3. Fluid in the tubes is either endolymph or perilymph: slightly different consistency and found in different tubes of the inner ear components. Endolymph movents bends hair cells in the semicircular canals; perilymph movement bends hair cells in the cochlea.

C. Equilibrium- Hair cells are located in clusters in two swollen areas of the semicircular canals: the utricle and the saccule. When you move your head, or accelerate, endolymph in the canals moves, and causes cilia of hair cells to bend.

Some hair cells are covered by a thick gelatinous substance, and provide information about movement of the head.

Some are covered by a thick gelatinous substance which is in turn covered by calcium carbonate rocks (otoliths). The otoliths press on the hair cells even without movement, and bend the cilia when the head tilts. The hair cells that are covered with otoliths send constant messages about head position, regardless of movement (but do also provide information about movement).

D. Hearing-

1. Background physics: when sound is produced, pockets of molecules vibrate and bump into adjacent molecules which start to vibrate and bump into their neighbors, and so forth (the book actually describes this well). When vibrating molecules bump into the typanum, the tympanum vibrates. The vibration causes the auditory ossicles to move. The stapes transmits this movement to perilymph at the oval window. It literally

causes a wave of perilymph through the cochlear tubes, like a wave in the ocean.

If you wiggle your finger in water, or push on a log of Jello, you will see a similar effect.

2. The receptor set-up (organ of Corti): Hair cells lie atop one of the flexible tubes that carries perilymph. Thier flat ends are adjacent to that tube, and their cilia stick up. Above their cilia lies a shelf of thick, immovable membrane: the tectorial membrane.

3. The process: When movement of the stapes starts a wave of perilymph at the oval window, the wave travels through the curved tubes of the cochlea. As it does so, the hair cells literally rise and fall with the wave (remember that they sit atop a flexible tube of perilymph). When they rise, their cilia press against the tectorial membrane and bend. A change in membrane permeability ensues, and the information is relayed to associated sensory neurons that bring the info to the brain!