The Special Senses

• Smell, taste, vision, hearing and equilibrium
• Housed in complex sensory organs
Chemical Senses

• Interaction of molecules with receptor cells
• Olfaction (smell) and gustation (taste)
• Both project to cerebral cortex & limbic system
  – evokes strong emotional reactions
Olfactory Epithelium

• 1 square inch of membrane holding 10-100 million receptors
• Covers superior nasal cavity and cribriform plate
• 3 types of receptor cells
Cells of the Olfactory Membrane

- Olfactory receptors
  - bipolar neurons with cilia or olfactory hairs
- Supporting cells
  - columnar epithelium
- Basal cells = stem cells
  - replace receptors monthly
- Olfactory glands
  - produce mucus
- Both epithelium & glands innervated cranial nerve VII (facial nerve)
Olfaction: Sense of Smell

- Odorants bind to receptors
- Na+ channels open
- Depolarization occurs
- Nerve impulse is triggered
Adaptation & Odor Thresholds

- Adaptation = decreasing sensitivity
- Olfactory adaptation is rapid
  - 50% in 1 second
  - complete in 1 minute
- Low threshold
  - only a few molecules need to be present
  - methyl mercaptan added to natural gas as warning
Olfactory Pathway

- Axons from olfactory receptors form the olfactory nerves (Cranial nerve I) that synapse in the olfactory bulb
  - pass through 40 foramina in cribriform plate
- Neurons within the olfactory bulb form the olfactory tract that synapses on primary olfactory area of temporal lobe
  - conscious awareness of smell begins
- Other pathways lead to the frontal lobe where identification of the odor occurs
Gustatory Sensation: Taste

- Taste requires dissolving of substances
- Five classes of stimuli--sour, bitter, sweet, salty, and umami (meaty or savory)
- 10,000 taste buds found on tongue, soft palate & larynx
- Found on sides of circumvallate & fungiform papillae
- 3 cell types: supporting, receptor & basal cells
Anatomy of Taste Buds

- An oval body consisting of 50 receptor cells surrounded by supporting cells
- A single gustatory hair projects upward through the taste pore
- Basal cells develop into new receptor cells every 10 days.
Physiology of Taste

• Complete adaptation in 1 to 5 minutes
• Thresholds for tastes vary among the 5 primary tastes
  – most sensitive to bitter (poisons)
  – least sensitive to salty and sweet
• Mechanism
  – dissolved substance contacts gustatory hairs
  – receptor potential results in neurotransmitter release
  – nerve impulse formed neuron
Gustatory Pathway

• Gustatory fibers found in cranial nerves
  – VII (facial) serves anterior 2/3 of tongue
  – IX (glossopharyngeal) serves posterior 1/3 of tongue
  – X (vagus) serves palate & epiglottis

• Signals travel to thalamus or limbic system & hypothalamus

• Taste fibers extend from the thalamus to the primary gustatory area on parietal lobe of the cerebral cortex
  – providing conscious perception of taste
Accessory Structures of Eye

- Eyelids or palpebrae
  - protect & lubricate
  - epidermis, dermis, CT, orbicularis oculi m., tarsal plate, tarsal glands & conjunctiva

- Tarsal glands
  - oily secretions keep lids from sticking together

- Conjunctiva
  - palpebral (eyelids) & bulbar (sclera)
  - stops at corneal edge
  - dilated BV--bloodshot
Eyelashes & Eyebrows

Eyeball = 1 inch diameter

5/6 of Eyeball inside orbit & protected

- Eyelashes & eyebrows help protect from foreign objects, perspiration & sunlight
- Sebaceous glands are found at base of eyelashes (sty)
- Palpebral fissure is gap between the eyelids
Lacrimal Apparatus

• About 1 ml of tears produced per day. Spread over eye by blinking. Contains bactericidal enzyme called lysozyme.
Extraocular Muscles

- Six muscles that insert on the exterior surface of the eyeball
- Innervated by CN III, IV or VI.
- 4 rectus muscles -- superior, inferior, lateral and medial
- 2 oblique muscles -- inferior and superior
Tunics (Layers) of Eyeball

- Fibrous Tunic (outer layer, cornea and sclera)
- Vascular Tunic (middle layer)
- Nervous Tunic (inner layer)
Fibrous Tunic -- Description of Cornea

- Transparent
- Helps focus light (refraction)
  - astigmatism
- 3 layers
  - nonkeratinized stratified squamous
  - collagen fibers & fibroblasts
  - simple squamous epithelium
- Transplants
  - common & successful
  - no blood vessels so no antibodies to cause rejection
- Nourished by tears & aqueous humor
Fibrous Tunic -- Description of Sclera

- “White” of the eye
- Dense irregular connective tissue layer -- collagen & fibroblasts
- Provides shape & support
- At the junction of the sclera and cornea is an opening (Canal of Schlemm)
- Posteriorly pierced by Optic Nerve (CNII)
Vascular Tunic -- Choroid & Ciliary Body

- **Choroid**
  - pigmented epithelial cells (melanocytes) & blood vessels
  - provides nutrients to retina
  - black pigment in melanocytes absorb scattered light

- **Ciliary body**
  - ciliary processes
    - folds on ciliary body
    - secrete aqueous humor
  - ciliary muscle
    - smooth muscle that alters shape of lens
Vascular Tunic -- Iris & Pupil

- Colored portion of eye
  - Contains melanin
- Shape of flat donut suspended between cornea & lens
- Hole in center is pupil
- Function is to regulate amount of light entering eye
- Autonomic reflexes
  - circular muscle fibers contract in bright light to shrink pupil
  - radial muscle fibers contract in dim light to enlarge pupil
Vascular Tunic -- Muscles of the Iris

Circular muscles contract

Bright light

Pupil

Normal light

Radial muscles contract

Dim light
Vascular Tunic -- Description of lens

- Avascular
- Crystallin proteins arranged like layers in onion
- Clear capsule & perfectly transparent
- Lens held in place by suspensory ligaments
- Focuses light on fovea (back surface of eye)
Vascular Tunic -- Suspensory ligament

- Suspensory ligaments attach lens to ciliary process
- Ciliary muscle controls tension on ligaments & lens
Nervous Tunic -- Retina

- Posterior 3/4 of eyeball
- Optic disc
  - optic nerve exiting back of eyeball
- Central retina BV
  - fan out to supply nourishment to retina
  - visible for inspection
    - hypertension & diabetes
- Detached retina
  - trauma (boxing)
    - fluid between layers
    - distortion or blindness

View with Ophthalmoscope
Layers of Retina

- Pigmented epithelium
  - nonvisual portion
  - absorbs stray light & helps keep image clear

- 3 layers of neurons (outgrowth of brain)
  - photoreceptor layer
  - bipolar neuron layer
  - ganglion neuron layer
Rods & Cones--Photoreceptors

- **Rods** ---- rod shaped
  - shades of gray in dim light
  - 120 million rod cells
  - discriminates shapes & movements
  - distributed along periphery

- **Cones** ---- cone shaped
  - sharp, color vision
  - 6 million
  - fovea of macula lutea
    - densely packed region
    - at exact visual axis of eye
    - 2nd cells do not cover cones
    - sharpest resolution or acuity
Pathway of Nerve Signal in Retina

- Light penetrates retina
- Rods & cones transduce light into action potentials
- Rods & cones excite bipolar cells
- Bipolars excite ganglion cells
- Axons of ganglion cells form optic nerve leaving the eyeball (blind spot)
- To thalamus & then the primary visual cortex
Cavities of the Interior of Eyeball

• Anterior cavity (anterior to lens)
  - filled with aqueous humor
    • produced by ciliary body
    • continually drained
    • replaced every 90 minutes
  - 2 chambers
    • anterior chamber between cornea and iris
    • posterior chamber between iris and lens

• Posterior cavity (posterior to lens)
  - filled with vitreous body (jellylike)
  - formed once during embryonic life
  - floaters are debris in vitreous of older individuals
Aqueous Humor

- Continuously produced by ciliary body
- Flows from posterior chamber into anterior through the pupil
- Scleral venous sinus
  - canal of Schlemm
  - opening in white of eye at junction of cornea & sclera
  - drainage of aqueous humor from eye to bloodstream
- Glaucoma
  - increased intraocular pressure that could produce blindness
  - problem with drainage of aqueous humor
Major Processes of Image Formation

• Refraction of light
  – by cornea & lens
  – light rays must fall upon the retina

• Accommodation of the lens
  – changing shape of lens so that light is focused

• Constriction of the pupil
  – less light enters the eye
External Ear

- **Function** = collect sounds
- **Structures**
  - auricle or pinna
    - elastic cartilage covered with skin
  - external auditory canal
    - curved 1” tube of cartilage & bone leading into temporal bone
    - ceruminous glands produce cerumen = ear wax
  - tympanic membrane or eardrum
    - epidermis, collagen & elastic fibers, simple cuboidal epith.
- **Perforated eardrum** (hole is present)
  - at time of injury (pain, ringing, hearing loss, dizziness)
  - caused by explosion, scuba diving, or ear infection
Middle Ear Cavity

- Malleus
- Incus
- Superior ligament of malleus
- Posterior ligament of stapes
- Stapes in oval window
- Facial (VII) nerve
- Lateral ligament of malleus
- Anterior ligament of malleus (cut)
- Eardrum
- Stapedius muscle
- Middle ear
- Round window
- Tensor tympani muscle
- External auditory canal
- Auditory tube
Middle Ear Cavity

• Air-filled cavity in the temporal bone
• Separated from external ear by eardrum and from internal ear by oval & round window
• 3 ear ossicles connected by synovial joints
  – malleus attached to eardrum, incus, stapes attached to membrane of oval window
• Auditory tube leads to nasopharynx
  – helps to equalize pressure on both sides of eardrum
Inner Ear---Bony Labyrinth

- Bony labyrinth = set of tubelike cavities in temporal bone
  - semicircular canals, vestibule & cochlea lined with periosteum & filled with perilymph
  - surrounds & protects Membranous Labyrinth
Membranous labyrinth = set of membranous tubes containing sensory receptors for hearing & balance and filled with endolymph
- utricle, saccule, ampulla, 3 semicircular ducts & cochlea
Cranial nerves of the Ear Region

- Vestibulocochlear nerve = CN VIII
Cochlear Anatomy

• 3 fluid filled channels found within the cochlea
  – scala vestibuli, scala tympani and cochlear duct
• Vibration of the stapes upon the oval window sends vibrations into the fluid of the scala vestibuli
Tubular Structures of the Cochlea

- Stapes pushes on fluid of scala vestibuli at oval window
- At helicotrema, vibration moves into scala tympani
- Fluid vibration dissipated at round window which bulges
- The central structure is vibrated (cochlear duct)
Section thru one turn of Cochlea

- Partitions that separate the channels are \( \text{Y} \) shaped
  - vestibular membrane above & basilar membrane below form the central fluid filled chamber (cochlear duct)
- Fluid vibrations affect hair cells in cochlear duct
Anatomy of the Organ of Corti

- 16,000 hair cells have 30-100 stereocilia (microvilli)
- Microvilli make contact with tectorial membrane (gelatinous membrane that overlaps the spiral organ of Corti)
- Basal sides of inner hair cells synapse with 1st order sensory neurons whose cell body is in spiral ganglion
Physiology of Hearing

- Auricle collects sound waves
- Eardrum vibrates
  - slow vibration in response to low-pitched sounds
  - rapid vibration in response to high-pitched sounds
- Ossicles vibrate since malleus attached to eardrum
- Stapes pushes on oval window producing fluid pressure waves in scala vestibuli & tympani
  - oval window vibration 20X more vigorous than eardrum
- Pressure fluctuations inside cochlear duct move the hair cells against the tectorial membrane
- Microvilli are bent producing receptor potentials
Overview of Physiology of Hearing
Physiology of Equilibrium (Balance)

• Static equilibrium
  – maintain the position of the body (head) relative to the force of gravity
  – macula receptors within saccule & utricle

• Dynamic equilibrium
  – maintain body position (head) during sudden movement of any type—rotation, deceleration or acceleration
  – crista receptors within ampulla of semicircular ducts
Vestibular Apparatus

- Notice: semicircular ducts with ampulla, utricle & saccule