

- Five special senses: Olfaction = smell, Gustation = taste, Vision = sight, Hearing & Equilibrium
- Special sensory receptors: Distinct cells & Complex organ / unique epithelium

I. Olfaction – Sense of smell (chemical). Propagate in limbic system and provoke strong emotional responses (memories).

A. Anatomy – Olfactory Receptors

1. Olfactory epithelium – contains extremely vast amount of receptors; covers inferior portion of cribriform plate & superior nasal concha. 3 kinds of cells:

- a. Olfactory receptor cells - Bipolar neurons thru cribriform plate. Have olfactory hairs responsible for detecting odorants by transduction (conversion of stimulus to graded potential).
- b. Supporting cells – Simple columnar epithelium. **Function?** ANS – CN VII (eye & nasal glands)
- c. Basal cells – Stem cells

2. Lamina propria – Areolar connective tissue; Olfactory (Bowman's) glands produce mucus. **Functions?**

B. Physiology – low threshold (additive to natural gas); Rapid adaptation (decreasing sensitivity)

1. Odorant + odorant binding protein, cilia
2. G protein → adenylate cyclase
3. ATP → cAMP
4. Na<sup>+</sup> channels open → depolarization
5. Action potential → olfactory bulbs
6. → olfactory tracts →
  - a. Olfactory cortex – without thalamus for conscious awareness
  - b. Hypothalamus & limbic system – emotions & memory
  - c. Frontal lobe – discrimination & identification

C. Disorders – **how does smoking effect smell & why?**

1. Uncinate fits
2. Anosmias

II. Gustation – sense of taste (chemical); much less sensitive than olfaction. **Explain how allergies/ cold effects gustation.** Threshold varies; bitter is lowest. **Why?** Complete adaptation to specific taste within 1-5 min of continuous stimulation.

A. 5 Primary taste sensations: Cravings:

1. Sweet – Carbohydrates
2. Sour – Vitamin C
3. Salty – Minerals
4. Bitter – Defense
5. Umami (Glutamate - MSG) – Protein

B. Taste buds – Located on tongue, soft palate, pharynx & epiglottis. 3 kinds of cells:

1. Basal cells – stem cells product supporting cells
2. Supporting cells which develop into gustatory cells
3. Gustatory cells with gustatory hair thru taste pore –detect tastants; 10 day life span.
4. Tongue Papillae – elevations used to increase SA & roughen surface; 4 types.
  - a. Vallate (Circumvallate) – inverted V-shaped row posterior tongue; 100-300 taste buds each
  - b. Fungiform – mushroom shaped; scattered; 5 taste buds each.
  - c. Foliate – lateral margins; most taste buds degenerate in early childhood.
  - d. Filiform – entire surface of tongue; tactile receptors NO taste buds. **Function?**

C. Physiology of Gustation – Different for different tastes:

1. Tastants → dissolved in saliva → taste pore
  - a. Salty (Na<sup>+</sup>) & Sour (H<sup>+</sup>): enter gustatory receptor cells thru ion channel = depolarization
  - b. Sweet, bitter, umami receptors: G protein → second messenger = depolarization
2. Neurotransmitter release → sensory dendrites
3. Action potentials → CN VII, IX, & X → gustatory nucleus in medulla
  - a. → thalamus → 1° gustatory cortex
  - b. Hypothalamus & limbic system

III. Vision – more than ½ of all sensory receptors are in the eyes. Also a large portion of cerebral cortex is devoted to visual information.

A. Accessory structures:

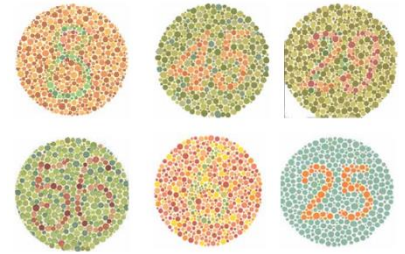
1. Eyelids (palpebrae) – shades, protects & spreads lubricating secretions.
  - a. Lacrimal caruncle – Sebaceous & sweat glands
  - b. S→D: epidermis, dermis, sub Q, muscle, tarsal plate, tarsal gland & conjunctiva. **List functions of following?**
    - i. Tarsal plate –
    - ii. Tarsal (Meibomian) gland –
      - Chalazion
    - iii. Conjunctiva – NK stratified squamous with goblet cells (mucous membrane) & ACT; lines back of eyelids and covers the sclera (vascular) but not the \_\_\_\_\_.
      - Conjunctivitis
      - Bloodshot eyes
2. Eyebrows & Eye Lashes
  - a. Sebaceous ciliary glands – base of eyelashes; sty.
3. Lacrimal apparatus – produces & drains liquid fluid (tears)
  - a. Lacrimal glands – lateral upper lid; tears pass medially → puncta → canals → sac → nasolacrimal duct.
    - i. Innervated by ANS – P CN VII; lacrimation.
    - ii. Tears – contain salt, mucus & lysosomes
      - Dacryocystitis
4. Extrinsic Eye Muscles – surrounded by periorbital fat. 6 muscles *refer to p. 379 & Fig. 11.5 p. 380*. CN III, IV, VI
  - a. Only 2 or 3 muscle fibers – fewer than any other part of the body except \_\_\_\_\_.  
**What's the significance of this arrangement?**
  - b. Brain stem & cerebellum – coordinate & synchronize movements. **Define diplopia & Strabismus.**

B. Eyeball – anterior 1/6 exposed; 3 layers

1. Fibrous tunic – superficial layer; **Locate the scleral venous sinus & aka.**
  - a. Sclera – “white” of the eye; DCT (collage & fibroblasts). **Functions?**
  - b. Cornea – clear, NK stratified squamous, collagen & fibroblast, simple squamous; covers iris. Receives O<sub>2</sub>. **Function?** Repairs itself easily; the only human tissue that can be transplanted without fear of rejection. **Why?**
2. Vascular tunic (Uvea) – middle layer; blood & lymphatic vessels. 3 parts:
  - a. Choroid – posterior portion; highly vascular; melanocytes – **Function?**
  - b. Ciliary body – anterior portion
    - i. Suspensory ligaments (zonular fibers) - Fluid → anterior chamber; attach to lens.
    - ii. Ciliary muscle – circular smooth muscle; alters shape of lens. **Cataract?**
  - c. Iris – colored portion; suspended between cornea & lens; melanin – eye color
    - i. Circular & radial smooth muscle & elastic fibers – adjusts size of pupil & regulates amount of light entering pupil.
    - ii. CN III: Parasympathetic = pupillary constriction; Sympathetic = pupillary dilation
  - d. Pupil – hole in iris. “Red eye”
3. Retina (Neural tunic) – line posterior ¾ of eyeball; beginning of visual pathway. 2 layers.
  - \_\_\_\_\_ is the instrument used to view b.v. (HTN, diabetes mellitus, cataracts, & AMD). *Refer to p. 647 Fig. 17.9*. Viewable structures: Optic Disc – optic nerve exit, Macula Lutea & Fovea Centralis. Composed of 2 layers:
    - a. Pigmented layer – simple cuboidal epithelium; melanin – absorbs stray light rays.
    - b. Neural layer – 3 layers
      - i. Photoreceptor Layer
        - a. Rods – see in dim light (moonlight); all photons = gray; convergence (grainy)
        - b. Cones – stimulated by light = color vision; blue, green & red; little convergence (sharp)

**Define color blindness - Ishihara Cards. Why does it occur most often in males?**

- ii. Bipolar Cell Layer
  - a. Horizontal cells
  - b. Amacrine cells
- iii. Ganglion Cell Layer
  - a. Optic disc – no cones or rods = blind spot



- 4. Macula lutea – flat spot in center of posterior retina
- 5. Fovea centralis – depression in macula lutea; only cones. Highest visual acuity.

**Define macular degeneration & detached retina.**

- 6. Lens – behind pupil & iris; crystallin proteins (onion) refractory media; avascular. Helps focus images on retina for clear vision. Biconvex crystal-like structure
  - a. Held in place by a suspensory ligament attached to the ciliary body
  - b. Refracts light greatly

7. Cavities / Segments – interior Eye

- A. Anterior cavity - anterior to lens; contains \_\_\_\_\_ – nourishes lens & cornea; constant replacement. **Define glaucoma.** 2 chambers:
  - 1. Anterior chamber – b/w cornea & iris
  - 2. Posterior chamber – b/h iris & anterior to zonular fibers & lens.
- B. Vitreous Chambers – larger posterior cavity b/w lens & retina
  - 1. Vitreous body – jellylike; holds retina flush against choroid = even surface; not replaced. Phagocytic cells.

**What maintains shape of eyeball & prevent it from collapsing?**

IV. Image Formation –

- A. Refraction of Light Rays – bending of light by lens & cornea. *Refer to Fig. 17.12 p. 651.*
  - 1. Images on retina are \_\_\_\_\_ with R-to-L reversal. Brain orients images,
  - 2. \_\_\_\_\_% total refraction occurs at cornea. **What does the lens do?**
  - 3. Light refracts parallel > 6m (20 ft); diverge if closer causing accommodation.

**Define emmetropia, myopia, hyperopia & astigmatism.**

- B. Accommodation – change in shape of the lens & cornea; 6m - 10cm. ANS-P CN III
  - 1. Convex lens = refraction towards each other (converge) vs. concave lens = refract away from each other (diverge). Ex. For viewing objects close up; ^ lens curvature (accommodation) & pupil constricts. **Why?**
  - 2. **Define near point of vision.**
  - 3. Distant object – ciliary muscle of ciliary body are \_\_\_\_\_ & lens is \_\_\_\_\_.
- C. Constriction – narrowing of the pupil
- D. Convergence – binocular vision; rotate eyes medially to view object.

V. Vision Physiology –

- A. Photoreceptors - transduction of light energy into a receptor potential occurs in outer segments of both rods & cones. *Refer to Fig. 17.14 p. 653*
  - 1. Outer segments - replenish rapidly.
  - 2. Inner segments – contain nucleus, Golgi, & many mitochondria
- B. Process – Begins when Photopigments (rods & cones) absorbs light = production of receptor potential; contain 2 parts: a glycoprotein known as \_\_\_\_\_ & the derivative of vitamin \_\_\_\_\_ called \_\_\_\_\_. **List good sources for better vision.** Uses Isomerization (cis-to-trans), bleaching & regeneration.
  - 1. Rod photopigment – Rhodopsin.
  - 2. Cone photopigments - 3 different types; responsible for color vision.
    - a. Regenerates much quicker than rods and less dependent on pigmented layer.
- C. Adaptation – **Give example of each. What accounts for some (not all) of the sensitivity changes during adaptation?**
  - 1. Light – Increase light = more bleaching. **Why do rods contribute little to daylight vision?**
  - 2. Dark – Decrease light = sensitivity increases rapidly at first then more slowly. **Why do objects look shades of gray at very low levels of light?**

D. NT Release –

1. Absence of light – LG Na<sup>+</sup> channels open via cGMP = “dark current”. Rods NT is glutamate = IPSP = hyperpolarization of bipolar cells prevents signal release.
2. Light Strikes – isomerization & enzymes breakdown cGMP = v glutamate release = EPSP of bipolar cells (depolarization).

VI. Visual Pathway – key factors

- Convergence predominates.
  - Cone vision, although less sensitive is \_\_\_\_\_ because of the one-to-one synapse b/w cones and *bipolar* cells.
  - *Horizontal* cells – causes lateral inhibition of bilateral cells. **What does this do?** They also assist in color differentiation.
  - *Amacrine* cells are excited by bipolar cells changing the level of illumination in retina.
- A. Impulses from ganglion cells are conveyed to optic (II) nerve → optic chiasm (some cross; some do not) → optic track → thalamus (lateral geniculate) → optic radiations → cerebral cortex 1<sup>o</sup> visual areas (occipital lobe) = visual perception.
  - B. Axon collaterals extend to midbrain & hypothalamus. **What do the superior colliculi and pretectal nuclei control?**
  - C. Visual Field – everything that can be seen by one eye; overlap considerably. **What does this arrangement provide?**
  - D. Visual information from the *right* half of each visual field is conveyed to the *left* side of the brain and vice versa.
  - E. 3 systems involved in Information related to:
    - a. Shape
    - b. Color
    - c. Movement, location & spatial organization.

**What part of the brain is responsible for coordinating head & eye movements? Which nucleus establishes patterns of sleep and daily schedule to intervals of light & darkness & where is it located?**

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HEARING & EQUILIBRIUM

▪ **Define hearing & equilibrium.**

I. Anatomy of ear – 3 main regions

A. External (Outer) Ear – collects sound waves & channels them inward.

1. Auricle – aka. \_\_\_\_\_. **Locate helix & lobule. What holds the auricle to the head?**
2. EAC – 2.5 cm (1”) lies in \_\_\_\_\_ bone. Contains hairs and cerumen to prevent dust & foreign objects from entering. **What else does cerumen do?**
3. Eardrum – aka. \_\_\_\_\_ thin, semitransparent; covered by epidermis & lined by \_\_\_\_\_ epithelium w/ CT. Tearing of the eardrum is referred to as \_\_\_\_\_. **What instrument is used to view the eardrum?**

B. Middle Ear – conveys sound vibrations to \_\_\_\_\_ window. Air-filled cavity in petrous portion of temporal bone. **The eardrum separates it from the external ear, what separates it from the internal ear?**

1. Auditory ossicles – smallest bones; \_\_\_\_\_ joints. Names by shape.
  - a. Malleus – internal surface of eardrum
  - b. Incus – middle
  - c. Stapes – oval window above the round window (closed by 2<sup>o</sup> tympanic window).
2. Muscles – these muscles protect inner ear from prolonged loud noises. **Why not from a gunshot?**
  - a. Tensor tympani – CN V<sub>3</sub>; **Action?**
  - b. Stapedius – CN VII; smallest muscle. Protects \_\_\_\_\_ & decreases sensitivity of hearing. **What is paralysis of this muscle called?**
3. Auditory (pharyngotympanic) tube – aka. \_\_\_\_\_. Connects middle ear with nasopharynx. Equalizes pressure; route of passage for pathogens from nose & throat causing the most common type of ear infection referred to as \_\_\_\_\_.

A. Internal (Inner) Ear – aka. \_\_\_\_\_. Houses receptors for hearing & equilibrium. 2 divisions:

1. Outer bony portion enclosing inner membrane – series of cavities in petrous (temporal bone). Lined with periosteum & filled w/ \_\_\_\_\_.
2. Inner membranous labyrinth – epithelial sacs filled with \_\_\_\_\_ (^ K<sup>+</sup>); houses receptors for hearing & balance. Contains 3 areas:
  - a. Semicircular Canals – 3 bony canals @ ~90° angles. **Which of the 3 are vertically vs. horizontally oriented?**
    - i. Ampulla – swollen enlargements

- ii. Semicircular ducts – connect utricle with vestibule.
- b. Vestibule – oval, central portion. Includes semicircular ducts and 2 sacs called utricle & saccule; Vestibular branch (CN VIII) – consists of ampullary, utricular & saccular nerves.
- c. Cochlea – anterior to vestibule; bony spiral canal with a central core called \_\_\_\_\_. 3 channels:
  - i. Cochlear duct ( \_\_\_\_\_ ) – continuation of membranous labyrinth filled with \_\_\_\_\_.
  - ii. Scala vestibule – ends at \_\_\_\_\_ window; part of cochlea filled w/ perilymph.
  - iii. Scala tympani – ends at \_\_\_\_\_ window; part of cochlea filled w/ perilymph.
  - iv. Spiral organ (organ of Corti) – organs of hearing; stereocilia, hair cells produce receptor potential; hearing receptors; cochlear branch CN VIII

II. Physiology of Hearing – refer to Fig 17.22 p. 664.

- \_\_\_\_\_ directs sound waves into EAC → strikes \_\_\_\_\_ causing vibration (low frequency = slow; high frequency = rapid)
- To Ossicles – **list in order.** → Oval window. Vibrations \_\_\_\_\_ times more vigorous than tympanic membrane.
- Sets up waves in perilymph of the \_\_\_\_\_ → scala tympani → \_\_\_\_\_ window causing bulge into middle ear = increasing pressure in \_\_\_\_\_.
- Vibrates basilar membrane → stimulates hair cells on the \_\_\_\_\_. **How is the basilar membrane “tuned” for pitch and loudness? Define frequency, intensity & decibels.** Workers in the US must wear hearing protectors when occupational noise levels exceed \_\_\_\_\_ dB.

III. Auditory Pathway

- Bending of stereocilia → release of glutamate → spiral ganglia → cochlear branch → cochlear nuclei (in the \_\_\_\_\_) →
  - Some decussate → inferior colliculus (in \_\_\_\_\_) → medial geniculus nucleus (in \_\_\_\_\_) → 1° Auditory area in temporal lobe.
  - Superior olivary nucleus (in \_\_\_\_\_) to locate source of sound.
  - **What allows hearing in both ears simultaneously?**

IV. Physiology of Equilibrium – Define static vs. dynamic equilibrium.

A. Receptor organ for equilibrium is \_\_\_\_\_.

1. Semicircular ducts – contains cristae, cupula & endolymph; site of hair cells for dynamic equilibrium **Give examples.**
2. Utricle & saccule – contains macula: hair bundle (hair cells+ kinocilium) & supporting cells (otoliths), site for static equilibrium relative to gravity. **Give examples.**

B. Hair bundles → Vestibular ganglia → Vestibular branch → Vestibular nuclei (MO & pons) → \*receive input from eyes & proprioceptors) → cerebellum (inferior peduncle) →

- CN III, IV, VI
- XI
- Vestibulospinal tract
- Thalamus (ventral posterior nucleus)

→ Vestibular area of parietal lobe = conscious awareness of position & movements of head & limbs.

**What can cause motion sickness?**

V. Aging & Special Senses

A. Disturbance of smell & taste not until 50 y/o. **Why?**

B. Eyes – **List changes associated with aging of eyes.**

C. Ears – age associated hearing loss is referred to as \_\_\_\_\_. **What can it be related to?**

Review all Clinical Connections, Disorders: Homeostatic Imbalances & Medical Terminology (back of chapter).

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*This is only a general outline. There may be material that has been discussed in lecture that is not included in this outline and there may be material on this outline that has not been discussed in lecture. Any material discussed in lecture or listed in this outline is "fair game" for the test.*