I. Overview

A. Terms
- **sensation** - conscious or subconscious awareness of internal or external stimuli
  Requires:
  - stimulus → receptor → conduction pathway → CNS interpretation
  ex: pain, blood pressure
- **perception** - conscious awareness and interpretation of sensation
- **sensory modality** – distinct “type” of sensation
  -- one neuron carries only 1 modality
  -- avoids confusion

B. Classification is by multiple criteria
1. **By modality (stimulus detected)**
   - **mechanoreceptors** -- respond to pressure or stretching
     Ex: tactile corpuscles (touch)
     Hair cells in spiral organ (hearing)
   - **thermoreceptors** – free-nerve endings
   - **nociceptors** (pain – but not the same) – free-nerve endings
     “harm”
     - photoreceptors – rods & cones in retina (light)
     - chemoreceptors – taste buds; glucose receptors in pancreas

2. **By distribution**
   - **general senses** (somesthetic) – widely distributed over body
     - simple structure
     - **somatic**: touch, temperature, pain, body position
     or
     - **visceral**: information from internal organs
   - **special senses** – limited to one or two sites in head only
     - relatively complex structure
     - smell, taste, vision, hearing, equilibrium, & vomeronasal organ

3. **By origin of stimulus**
   - **exteroceptors** → at or near body surface
     -- provide information about external environment
     -- Ex: retina, taste buds, tactile corpuscles
- interoceptors → detect internal stimuli
  -- provide information about internal environment
  Ex: stretch receptors/pH detectors in blood vessels
  *often unconscious sensations, may be felt as pain or pressure

- proprioceptors → in muscle, joints, tendons, and inner ear
  “one’s own” ←  -- provide info about body position and movement
  Ex: stretch receptors in tendons, hair cells in semicircular ducts

II. General senses
- cutaneous sensation as an example: Fig. 17.1 & 5.1
  1. tactile (Meissner’s) corpuscles -- located in dermal papillae
     - sketch -
       -- very small
       -- branching dendrites throughout an oval
       mass of flattened Schwann cells
       -- detect light touch

  2. lamellated (Pacinian) corpuscles -- located in deep dermis and subcutaneous
     - sketch -
       (also in viscera & around joints)
       -- larger (1-2 mm)
       -- c.t. capsule, nervous core (like an onion)
       -- respond to pressure & vibrations

  3. Hair root plexus -- free nerve endings wrapped around root

III. Chemical senses
A. Gustation - KNOW FIG. 17.5 b & d
  1. Location: taste buds - ~ 4,000
     - tongue, soft palate, pharynx
  2. Cell types - all epithelial cells
     a. taste (gustatory) cells are actual receptors for taste
        - not neurons
        - live ~ 7-10 days
        - taste hairs (microvilli) protrude into taste pore
     b. supporting cells –
     c. basal cells - generate new gustatory cells
     d. dendrites from CN VII, IX, or X synapse at base of taste cells
B. Olfaction - **KNOW FIG. 17.7** (except detail in olfactory bulb)

1. Location: olfactory epithelium -- 5 cm²
   -- superior nasal septum and concha

2. Cell types
   a. olfactory cells are receptors
      - bipolar neurons, live ~ 60 days
      - dendrites called olfactory hairs, respond to odorants
      - axons form fascicles (collectively CN I) that extend through olfactory foramina of cribriform plate
   b. supporting cells - columnar epithelium
   c. basal cells- stem cells producing new olfactory receptor cells (UNUSUAL)

C. Vomeronasal organ (VNO)

1. Location:
   - 2 small cigar-shaped sacs at either side base of nasal septum
   - pit communicates with nasal cavity

2. Cell types
   a. receptor cells
      - bipolar neurons with microvilli
      - don’t respond to odorants, but do respond to other chemicals-pheromones?
   b. at least 2 other cells types present

-- If a tree falls in a forest does it make a sound?

**IV. Vision**

A. Accessory structures → **KNOW Fig. 17.20a**

1. protective bony orbit

2. eyelids (*palpebrae*), eyebrows and eyelashes shade and protect
   -- medial & lateral *commissures* → Fig. 17.19
   - orbicularis oculi – closes
   - levator palpebrae superioris – opens

3. conjunctiva is mucous membrane lining eyelid (*palpebral*) and anterior eyeball (*bulbar*)
   - inflammation = pinkeye (*conjunctivitis*)
   - blood vessels dilate = bloodshot eyes

4. **lacrimal apparatus** -
   tear
   - *lacrical gland* produces tears laterally,
   - drain medially via *nasolacrimal duct* into nasal cavity

5. extrinsic eye muscles **KNOW Fig. 17.21**
   - any eye movement requires coordinated activity of all six
   - KNOW names and cranial nerve to each:

<table>
<thead>
<tr>
<th>lateral rectus</th>
<th>superior rectus</th>
<th>superior oblique &amp; trochlea</th>
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<tbody>
<tr>
<td>medial rectus</td>
<td>inferior rectus</td>
<td>inferior oblique</td>
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B. Anatomy of the eyeball **KNOW** Fig. 17.22 & 17.23

-- 3 layers

1. Fibrous layer (tunica fibrosa) - outermost
   - sclera – “whites” of eye
     -- posterior $\frac{2}{3}$
     -- fibrous c.t. $\Rightarrow$ protective shell; maintains focal length
   - cornea -- transparent (avascular)
     -- anterior $\frac{1}{3}$
     -- curvature helps focus light

2. Vascular layer (tunica vasculosa or uvea) - middle
   - choroid - vascular membrane lining sclera
     $\leftarrow$ provides internal blood supply
     - darkly pigmented $\Rightarrow$ absorbs light, prevents reflection
   - ciliary body
     - ciliary muscle – the anterior, donut-like ring of muscle which alters lens thickness for focusing
     - ciliary processes – vascular projections that secrete aqueous humor
   - iris - anterior colored flap from ciliary body that defines pupil
     - pupillary constrictor = circular muscle
     - pupillary dilator = radial muscle
     - two pigmented layers (Iris was the Greek goddess of the rainbow)
     - functions as adjustable “light shade”

3. Nervous layer (tunica interna or retina) - innermost
   - lines posterior $\frac{2}{3}$
   - ora serrata -- jagged anterior margin of retina
   - pigment epithelium -- layer adjacent to choroid
   - neural portion - highly organized layers of cells
     * photoreceptor layer -- rods (black and white)
       - cones (color)
     * ganglion cell layer -- axons form CN II
   **NOTE** Fig 17.27b: light goes “into” retina; visual information comes “out” of retina

   - macula lutea - pigmented center of retina (Fig. 17.25)
     $\text{spot} \quad \text{yellow}$
   - fovea centralis - depression in center of macula lutea.
     -- has only cones $\Rightarrow$ point of sharpest vision
   - optic disc (blind spot) - point of exit of CN II
     - no photoreceptors
4. Interior of eyeball
   - lens divides into - anterior cavity with aqueous humor
   \[\downarrow\]
   - posterior cavity (vitreous chamber) with vitreous humor (vitreous body)
   held in position by suspensory ligament (fig. 17.24)

   - iris divides anterior cavity into
     - posterior chamber -- produces aqueous humor
     - anterior chamber -- reabsorbs it every 90 minutes

C. Visual pathway – Fig. 17.30
   optic nerves (ganglion cell axons)
   \[\downarrow\]
   optic chiasm (1/2 cross to other side)
   \[\downarrow\]
   optic tracts
   \[\downarrow\]
   thalamus
   \[\downarrow\]
   cerebrum

V. Hearing and balance
   -- Ear contains receptors for 2 special senses
   - hearing (audition)
   - balance (equilibrium)

A. Outer (external) ear – KNOW FIG. 17.10
   - designed to collect and direct sound waves

   1. Pinna (auricle) - elastic cartilage and skin
   2. external acoustic meatus (auditory canal)
      - skin-lined bony tunnel with ceruminous & sebaceous glands & hair

B. Middle ear (tympanic cavity) \[\rightarrow\] size of an aspirin
   1. separated from outer ear by tympanic membrane (eardrum)
      - thin partition of fibrous c.t.
   2. connected with nasopharynx by auditory (pharyngotympanic or eustachian) tube
   3. contains 3 ossicles \[\rightarrow\] transmits sound waves to inner ear
      * malleus (hammer) - connected to eardrum
      \[\downarrow\]
      * incus (anvil)
      \[\downarrow\]
      * stapes (stirrup) - attached to oval window
   4. two skeletal muscles dampen vibrations
      *tensor tympani
      *stapedius
C. Internal (inner) ear
   - complex structure: **KNOW Fig. 17.11b & c** (with some exceptions)

1. **bony** labyrinth - series of cavities in temporal bone
   "maze"

2. **membranous** labyrinth - series of fluid-filled sacs lying within bony labyrinth

3. perilymph - fluid outside membranous
4. endolymph - fluid inside membranous

   **Bony** labyrinth $\rightarrow$ contains $\rightarrow$ **Membranous** labyrinth
   
   - semicircular canals
   - vestibule
   - utricle and saccule
   - cochlea

5. membranous labyrinth contains patches of hair cells (**epithelial**), the receptor cells for hearing and equilibrium
   - long microvilli at apex
   - nerve fibers synapse at base $\rightarrow$ CN VIII vestibulocochlear
     balance $\leftrightarrow$ hearing

   **Hair cells in**
   
   - ampulla of semicircular ducts (6) $\rightarrow$ **Stimulated by**
     changes in rate and direction of movement (angular acceleration)

   - macula of utricle and saccule (4) $\rightarrow$ **Detect**
     gravity (body position with respect to gravity)
     linear acceleration **dynamic** equilibrium

   - spiral organ of Corti in cochlear duct $\rightarrow$ vibrations sound

D. Thin bony partition separates inner ear from middle: 2 holes play a role in hearing:
   - **oval window** - stapes fills
   - **round window** – covered by secondary tympanic membrane;
     $\checkmark$ dissipates pressure