Chapter 15
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Senses
Points to ponder

• What are sensory receptors?
• How do we detect the sense of taste and smell?
• What is the anatomy of the eye?
• How do we focus images?
• What are some eye abnormalities?
• What is the anatomy of the ear?
• Which parts function in balance and which parts function in hearing?
Sensory receptors

- **Sensory receptors** – dendrites specialized to detect certain types of stimuli
  - **Exteroceptors**: detect stimuli from outside the body (e.g., taste, hearing, vision)
  - **Interoceptors**: receive stimuli from inside the body (e.g., change in blood pressure)
Types of sensory receptors

• **Chemoreceptors** – respond to nearby chemicals
  – **Nociceptors** (pain receptors) – chemoreceptors that respond to chemicals released by damaged tissue

• **Photoreceptors** – respond to light energy

• **Mechanoreceptors** – respond to mechanical forces such as pressure

• **Thermoreceptors** – stimulated by temperature changes
Senses and the receptors involved

Table 15.1 Exteroceptors

<table>
<thead>
<tr>
<th>Sensory Receptor</th>
<th>Stimulus</th>
<th>Category</th>
<th>Sense</th>
<th>Sensory Organ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste cells</td>
<td>Chemicals</td>
<td>Chemoreceptor</td>
<td>Taste</td>
<td>Taste bud</td>
</tr>
<tr>
<td>Olfactory cells</td>
<td>Chemicals</td>
<td>Chemoreceptor</td>
<td>Smell</td>
<td>Olfactory epithelium</td>
</tr>
<tr>
<td>Rod cells and cone cells in retina</td>
<td>Light rays</td>
<td>Photoreceptor</td>
<td>Vision</td>
<td>Eye</td>
</tr>
<tr>
<td>Hair cells in spiral organ of the inner ear</td>
<td>Sound waves</td>
<td>Mechanoreceptor</td>
<td>Hearing</td>
<td>Ear</td>
</tr>
<tr>
<td>Hair cells in semicircular canals of the inner ear</td>
<td>Motion</td>
<td>Mechanoreceptor</td>
<td>Rotational equilibrium</td>
<td>Ear</td>
</tr>
<tr>
<td>Hair cells in vestibule of the inner ear</td>
<td>Gravity</td>
<td>Mechanoreceptor</td>
<td>Gravitational equilibrium</td>
<td>Ear</td>
</tr>
</tbody>
</table>
How does sensation occur?

• Sensory receptors respond to environmental stimuli.

• Nerve impulses travel to the cerebral cortex and sensation (conscious perception of stimuli) occurs.

• Sensory adaptation, decrease in stimulus response, can occur with repetitive stimuli (i.e., odor).
How does sensation occur?

Figure 15.1 The role of the CNS and PNS in sensation and sensory perception.
Proprioceptors

- **Proprioceptors** - mechanoreceptors involved in reflex actions that maintain muscle tone, and thereby the body’s equilibrium and posture.
15.2 Somatic Senses

Proprioceptors

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Figure 15.2 The action of a muscle spindle.
Cutaneous receptors

- Receptors in the dermis that make the skin sensitive to touch, pressure, pain, and temperature.

**Figure 15.3** Sensory receptors of the skin.
• There are 4,000 taste buds located primarily on the tongue of adult humans.

• We have five main types of taste receptors: sweet, sour, salty, bitter, and umami (savory).

• 80-90% of what we perceive as taste is actually due to the sense of smell.
Taste receptors

Figure 15.4 The tongue and the sense of taste.
Anatomy of the eye

• Made of three layers/coats
  1. **Sclera**: mostly white and fibrous except the cornea
  2. **Choroid**: darkly-pigmented vascular layer
  3. **Retina**: inner layer containing photoreceptors
Anatomy of the eye

• Two compartments
  1. **Anterior compartment**: between the cornea and lens; filled with a clear fluid called **aqueous humor**
  2. **Posterior compartment**: most of the eye, behind the lens; contains a gelatinous material called **vitreous humor**
Anatomy of the eye

Figure 15.6 The structures of the human eye.

15.4 Sense of Vision
1. Layers of the eye: Sclera

- **Sclera** – the white of the eye that maintains eye shape
  - **Cornea**: transparent portion of the sclera that is important in refracting light
  - **Pupil**: a hole that allows light into the eyeball
2. Layers of the eye: Choroid

- **Choroid** – middle layer that absorbs light rays not absorbed by the retina
  - **Iris**: donut-shaped, colored structure that regulates the size of the pupil
  - **Ciliary body**: structure behind the iris that contains a muscle that controls the shape of the lens

- **Lens** – attached to the ciliary body; refracts and focuses light rays
The lens

- The lens is a flexible, transparent, and concave structure.

- **Visual accommodation** occurs when the lens changes shape to focus light on the retina and form an image.

- As we age, the lens loses elasticity, and we use glasses to correct for this.
15.4 Sense of Vision

The lens

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

![Diagram of the eye showing focusing on distant and near objects]

a. Focusing on distant object
   - Ciliary muscle relaxed
   - Lens flattened
   - Suspensory ligament taut

b. Focusing on near object
   - Ciliary muscle contracted
   - Lens rounded
   - Suspensory ligament relaxed

Figure 15.7 Focusing light on the retina of the eye.
3. Layers of the eye: Retina

- The retina contains photoreceptors called rods and cones.

- **Rods** are sensitive to light.

- **Cones** require bright light and respond to wavelengths of light (color).

- The **fovea centralis** is an area of the retina densely packed with cones where images are focused.
15.4 Sense of Vision

3. Layers of the eye: Retina

- Sensory receptors from the retina form the **optic nerve** that takes impulses to the brain.

- The **blind spot** is where the optic nerve attaches; it lacks photoreceptors.
15.4 Sense of Vision

Anatomy of the retina

Figure 15.9 The structure of the retina
Photoreceptors of the retina

• **Rods**
  – They contain a visual pigment called *rhodopsin*.
  – Rods are important for peripheral and night vision.
  – Vitamin A is important for proper functioning.

• **Cones**
  – They are located mostly in the fovea.
  – Cones allow us to detect fine detail and color.
  – There are three different kinds of cones containing red, green, and blue pigments.
15.4 Sense of Vision

Rods and cones in the retina

Figure 15.8 The two types of photoreceptors in the eye.
### 15.4 Sense of Vision

**Summary of eye structures**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclera</td>
<td>Protects and supports the eye</td>
</tr>
<tr>
<td>Cornea</td>
<td>Refracts light rays</td>
</tr>
<tr>
<td>Pupil</td>
<td>Admits light</td>
</tr>
<tr>
<td>Choroid</td>
<td>Absorbs stray light</td>
</tr>
<tr>
<td>Ciliary body</td>
<td>Holds lens in place, accommodation</td>
</tr>
<tr>
<td>Iris</td>
<td>Regulates light entrance</td>
</tr>
<tr>
<td>Retina</td>
<td>Contains sensory receptors for sight</td>
</tr>
<tr>
<td>Rod cells</td>
<td>Make black-and-white vision possible</td>
</tr>
<tr>
<td>Cone cells</td>
<td>Make color vision possible</td>
</tr>
<tr>
<td>Fovea centralis</td>
<td>Makes acute vision possible</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Lens</td>
<td>Refracts and focuses light rays</td>
</tr>
<tr>
<td>Humors</td>
<td>Transmit light rays and support the eye</td>
</tr>
<tr>
<td>Optic nerve</td>
<td>Transmits impulses to brain</td>
</tr>
</tbody>
</table>

Copyright © McGraw-Hill Education. Permission required for reproduction or display.
Abnormalities of the eye

• Color blindness – genetic abnormality in which colors, usually red and green, cannot be distinguished; most common in males

• Cataracts – lens of the eye is cloudy

• Glaucoma – fluid pressure builds up in the eye
15.4 Sense of Vision

Abnormalities of the eye

- **Astigmatism** – condition in which the cornea or lens is uneven, leading to a fuzzy image.

- **Nearsightedness** – eyeball is too long, making it hard to see far away objects.

- **Farsightedness** – eyeball is too short, making it hard to see near objects.
Abnormalities of the eye that are corrected with lenses

Figure 15.11 How corrective lenses correct vision problems.

a. Nearsightedness

Long eye; rays focus in front of retina when viewing distant objects.

Concave lens allows subject to see distant objects.

b. Farsightedness

Short eye; rays focus behind retina when viewing close objects.

Convex allows subject to see close objects.

c. Astigmatism

Uneven cornea; rays do not focus evenly.

Uneven lens allows subject to see objects clearly.

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Anatomy of the ear

- The ear functions in hearing and balance.

- Three divisions
  1. **Outer ear**: functions in hearing; filled with air
  2. **Middle ear**: functions in hearing; filled with air
  3. **Inner ear**: functions in hearing and balance; filled with fluid
1. Divisions of the ear: Outer ear

- Includes
  - **Pinna**: the external ear flap that catches sound waves
  - **Auditory canal**: directs sound waves to the tympanic membrane
    - Lined with fine hairs and modified sweat glands that secrete ear wax
2. Divisions of the ear: Middle ear

- Includes
  - **Tympanic membrane** (eardrum): membrane that vibrates to carry sound waves to the bones
  - **Ossicles** (*malleus, incus, stapes*): three small bones that amplify sound waves
  - **Auditory tube** (Eustachian tube): a tube that connects from the throat to the middle ear and is used to equalize pressure so the eardrum does not burst
15.5 Sense of Hearing

Following the sound wave

Figure 15.12 The three divisions of the human ear.
3. Divisions of the ear: Inner ear

- Important for both hearing and balance

- Three areas: cochlea, semicircular canals, vestibule

- **Stapes** (middle ear bone) – vibrates and strikes the membrane of the oval window causing fluid waves in the **cochlea**

- **Vestibule** – functions in gravitational equilibrium

- **Semicircular canals** – functions in rotational equilibrium
The inner ear: The cochlea

- The cochlea converts vibrations into nerve impulses.

- It contains the spiral organ (organ of Corti) which is the sense organ containing hairs for hearing.
  - Bending of embedded hairs causes vibrations that initiate nerve impulses which travel to the cochlear nerve and then to the brain.
  - Pitch is determined by varying wave frequencies that are detected by different parts of the spiral organ.
  - Volume is determined by the amplitude of sound waves.
15.5 Sense of Hearing

The inner ear: Hearing

Figure 15.13 How the spiral organ (organ of Corti) translates sound waves into nerve signals.
15.5 Sense of Hearing

The inner ear: The spiral organ

Figure 15.13 How the spiral organ (organ of Corti) translates sound waves into nerve signals.
Noise pollution

• Loud noises (>85 decibels) or chronic noise can damage inner ear cells.

• Environmental noise can cause mental health issues such as inability to concentrate, an increase in irritability, and anxiety.

• Noise can cause loss of sleep and productivity, and can lead to anxiety.

• What should be done about noise pollution?
# Noise pollution

15.5 Sense of Hearing

<table>
<thead>
<tr>
<th>Type of Noise</th>
<th>Sound Level (Decibels)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Boom car,” jet engine, shotgun, rock concert</td>
<td>Over 125</td>
<td>Beyond threshold of pain; potential for hearing loss high</td>
</tr>
<tr>
<td>Nightclub, thunderclap</td>
<td>Over 120</td>
<td>Hearing loss likely</td>
</tr>
<tr>
<td>Earbuds in external ear canal</td>
<td>110–120</td>
<td>Hearing loss likely</td>
</tr>
<tr>
<td>Chain saw, pneumatic drill, jackhammer, symphony orchestra, snowmobile, garbage truck, cement mixer</td>
<td>100–200</td>
<td>Regular exposure of more than 1 min risks permanent hearing loss.</td>
</tr>
<tr>
<td>Farm tractor, newspaper press, subway, motorcycle</td>
<td>90–100</td>
<td>Fifteen minutes of unprotected exposure potentially harmful</td>
</tr>
<tr>
<td>Lawn mower, food blender</td>
<td>85–90</td>
<td>Continuous daily exposure for more than 8 hr can cause hearing damage.</td>
</tr>
<tr>
<td>Diesel truck, average city traffic noise</td>
<td>80–85</td>
<td>Annoying; constant exposure may cause hearing damage.</td>
</tr>
</tbody>
</table>
The inner ear: Semicircular canals and vestibule

- Detects angular movement (rotational equilibrium)
  - Depends on hair cells at the base of each semicircular canal (ampulla)

- Detects movement of the head in the vertical and horizontal planes (gravitational equilibrium)
  - Depends on hair cells in the utricle and saccule
15.6 Sense of Equilibrium

The inner ear: Balance

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Figure 15.14 The mechanoreceptors of the inner ear and the sense of balance.

a. Rotational equilibrium: receptors in ampullae of semicircular canal

b. Gravitational equilibrium: receptors in utricle and saccule of vestibule