The Energy Senses
Objectives

- Describe sensory processes for the energy senses of vision and hearing
- Explain common disorders associated with vision and hearing
- Explain how the “energy senses” are related
Vision

Vision

- The process from light reflecting off of something to how the brain turns it into an “image”
- What strikes our eyes is not color, but pulses of electromagnetic energy that our visual system perceives as color
Vision (cont.)

Two physical characteristics of light that help determine how we sense them

- **Wavelength**
  - The distance from one wave peak to the next – determines the *hue* (the color we experience)

- **Amplitude**
  - The wave’s height – determines *intensity* (brightness)
Visible Spectrum
• Part of the electromagnetic spectrum to which eyes respond
The human eye:
Light passes through cornea, pupil, and lens and falls on light-sensitive surface of retina -- images of objects are reflected upside down. Lens adjusts curvature to focus images falling on retina. The pupil regulates amount of light passing into rear chamber of eye.
Structure and Function of Eye

**Lens**: focuses light rays

**Pupil**: opening through which light passes

**Iris**: ring of muscle that controls size of pupil

**Cornea**: Transparent membrane covering the front of the eye; bends light rays inward

**Retina**: Light-sensitive layer of cells in the back of the eye

**Photoreceptors**: Light-sensitive cells in the eye

**Optic Nerve**: Carries electrical impulse from retina to the brain to be interpreted
Photoreceptors & Light Control

**Cones**: Visual receptors for colors and bright light (daylight)

**Rods**: Visual receptors for dim light; only produce black and white

**Fovea**: Area of the retina containing only cones; Images are most clear when falling here

**Blind Spot**: Area of the retina lacking visual receptors

[Video Clip: Vision Process]
The human eye, a simplified view.
Light Control (cont.)

**Visual Acuity**: Sharpness of visual perception

**Peripheral Vision**: Vision at edges of visual field; side vision

**Tunnel Vision**: Loss of peripheral vision
Close up of the retina
Typical course of *dark adaptation*

- Green line shows that cones adapt first, but they soon cease adding to light sensitivity.
- Rods, shown by the red line, adapt more slowly. However, they continue to add to improved night vision long after the cones are fully adapted.
Experiencing the blind spot

(a) With your left eye closed, hold the paper out in front of you and stare at the upper left cross. Move the paper slowly move it back and forth. You should be able to locate a position that causes the elephant to disappear. When it does, it has fallen on the blind spot.

(b) Switch eyes. Stare at the lower right cross with the right eye closed. Repeat the procedure described. When the white space falls on the blind spot, the black lines will appear to be continuous. Why do you think this is?
Color Vision

Trichromatic Theory: Color vision theory that states we have three cone types: red, green, blue
• Other colors produced by a combination of these
• Black and white produced by rods

Opponent Process Theory: Color vision theory based on three “systems”: red or green, blue or yellow, black or white
• Exciting one color in a pair (red) blocks the excitation in the other member of the pair (green)

Afterimage: Visual sensation that remains after stimulus is removed (seeing flashbulb after the picture has been taken)
The color circle and complementary colors

Colors opposite each other on this color circle are complements, or "opposites." Additively mixing complementary colors produces gray.
Negative afterimages

Stare at the dot near the middle of the flag for at least 30 seconds.
Reduced sensitivity to blue and black in the visual system, caused by prolonged staring, results in the appearance of complementary colors.
On the left is a “star” made of redlines. On the right, the red lines are placed on top of longer black lines. Now, in addition to the red lines, you will see a glowing red disk, with a clear border. Of course, no red disk is printed on this page. No ink can be found between the red lines. The glowing red disk exists only in your mind.
Color Blindness

**Color blindness:** The inability to perceive colors; lacks cones or has malfunctioning cones

- Total color blindness is rare

**Color Weakness:** Inability to distinguish some colors

- Red-green is most common; much more common among men than women
- Recessive, sex-linked trait on X chromosome
Ishihara Test:
Test for color blindness and color weakness
Color blindness and color weakness

First photograph illustrates normal color vision

Second photograph is printed in blue and yellow and gives an impression of what a red-green color-blind person sees

Third photograph simulates total color blindness. If you are totally colorblind, all three photos will look nearly identical.
Firing rates of blue, green, and red cones in response to different colors

The taller the colored bar, the higher the firing rates for that type of cone

Color sensations are coded by activity in all three types of cones in the normal eye.
An artificial visual system
CNN – Visual Impairment & Artificial Eye
Vision Problems

Hyperopia: Difficulty focusing nearby objects (farsightedness)

Myopia: Difficulty focusing distant objects (nearsightedness)

Astigmatism: Corneal, or lens defect that causes some areas of vision to be out of focus; relatively common
Visual defects and corrective lenses

(a) A myopic (longer than usual) eye. The concave lens spreads light rays just enough to increase the eye’s focal length

(b) A hyperopic (shorter than usual) eye. The convex lens increases refraction (bending), returning the point of focus to the retina

(c) An astigmatic (lens or cornea not symmetrical) eye. In astigmatism, parts of vision are sharp and parts are unfocused. Lenses to correct astigmatism are nonsymmetrical.
In Closing…

• Describe the process for the energy sense of vision
• Explain common disorders associated with vision
Initiation: What sense to humans rely on more? (sight)
What would be #2 for you? Why? (Accept all student answers until someone mentions hearing. Transition into mosquito tone toward end. Play dumb for a while.)
http://www.freemosquitoringtones.org/

Initiation
“Boy Hears Mom’s Voice For First Time” clips in Word document (1:42 and/or 2:51)
Hearing

- The sense that makes us aware of changes in the environment by detecting changes in air pressure
Hearing (cont.)

**Sound Waves**: Rhythmic movement of air molecules

**Pitch**: Higher or lower tone of a sound; determined by wavelength

**Loudness**: Sound intensity; determined by amplitude…

“Sound” familiar?” (pun intended)
Sound energy transmitted by waves just like light energy; quality and intensity determined by the same properties.
Parts of the Ear

**Pinna:** External part of the ear

**Tympanic Membrane:** Eardrum

**Auditory Ossicles:** Three small bones inside ear that vibrate; link eardrum with the cochlea
  * Malleus a.k.a. “hammer”
  * Incus a.k.a. “anvil”
  * Stapes a.k.a. “stirrup”

**Cochlea:** Organ that makes up inner ear; snail-shaped; this is the organ of hearing

**Hair Cells:** Receptor cells within cochlea that turn vibrations into nerve impulses
  * Once hair cells are dead they are never replaced
Anatomy of the Inner Ear
A closer view of the hair cells shows how movement of fluid in the cochlea causes the bristling “hairs” or cilia to bend, generating a nerve impulse.
Simplified side view of the cochlea “unrolled”.

*Basilar membrane* is the elastic “roof” of the lower chamber of the cochlea.

*Organ of Corti*, with its sensitive hair cells, rests atop the basilar membrane.

*Hair cells* respond most in the area of greatest movement, which helps identify sound frequency.
How Do We Detect Higher and Lower Pitches?

*Frequency Theory*: As pitch rises, nerve impulses of a corresponding frequency are fed into the auditory nerve

*Place Theory*: Higher and lower tones excite specific areas of the cochlea
Deafness

**Conductive Deafness:** Poor transfer of vibrations from tympanic membrane to inner ear

- Compensate with amplifier (hearing aid)

**Sensorineural Deafness:** Caused by damage to hair cells or auditory nerve

- Hearing aids useless in these cases, since auditory messages cannot reach the brain
- Caused by disease, age, or preventable reasons like sitting in front of the speaker at a concert
- **Cochlear Implant:** Electronic device that stimulates auditory nerves
A cochlear implant, or “artificial ear”
A highly magnified electron microscope photo of the cilia (orange bristles) on the top of human hair cells. (Colors are artificial.)
Loudness ratings and potential hearing damage

<table>
<thead>
<tr>
<th>Typical Decibel Level</th>
<th>Dangerous Time Exposure</th>
<th>Examples</th>
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</thead>
<tbody>
<tr>
<td>180</td>
<td>Space Shuttle launch</td>
<td></td>
</tr>
<tr>
<td>170</td>
<td>Shotgun blast</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>Jet airplane</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>Siren at 50 feet</td>
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<tr>
<td>150</td>
<td>Stereo headset (full volume)</td>
<td></td>
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<tr>
<td>140</td>
<td>Threshold of pain</td>
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<tr>
<td>Extremely loud 130</td>
<td>Hearing loss certain</td>
<td></td>
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<tr>
<td>Very loud 120</td>
<td>Immediate danger</td>
<td>Thunder, rock concert</td>
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<tr>
<td>Very loud 110</td>
<td>Less than 8 hours</td>
<td>Basketball or hockey crowd</td>
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<tr>
<td>Very loud 100</td>
<td>More than 8 hours</td>
<td>Riveter</td>
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<tr>
<td>Quiet 90</td>
<td></td>
<td>Factory noise, chain saw</td>
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<tr>
<td>Quiet 80</td>
<td></td>
<td>Subway, tractor, power mower</td>
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<tr>
<td>Quiet 70</td>
<td></td>
<td>Screaming child</td>
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<tr>
<td>Quiet 60</td>
<td></td>
<td>Bus, motorcycle, snowmobile</td>
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<tr>
<td>Quiet 50</td>
<td></td>
<td>Loud home stereo, food blender</td>
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<tr>
<td>Quiet 40</td>
<td></td>
<td>Heavy traffic</td>
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<tr>
<td>Quiet 30</td>
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<td>Average automobile</td>
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<tr>
<td>Very quiet 20</td>
<td>Normal conversation</td>
<td></td>
</tr>
<tr>
<td>Very quiet 10</td>
<td>Quiet auto</td>
<td></td>
</tr>
<tr>
<td>Just audible 0</td>
<td>Quiet office</td>
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</tbody>
</table>

- Whisper at 5 feet
- Broadcast studio when quiet
- Studio for making sound pictures
How Are The Energy Senses Related?

1. Both transduce energy from the environment into neural impulses

2. The energy transduced is similar
   - Electromagnetic light waves vs. sound waves
   - The wavelength determines the quality (color vs. pitch)
   - The amplitude determines intensity (brightness vs. loudness)
In Closing…

Describe sensory processes for the energy sense of hearing

Say (insert student to pick on her) likes to fall asleep with his MP3 player blasting every night. What might he experience later in life? What is that condition called?

What’s the difference between conductive deafness and sensorineural deafness?

Why can you hear the mosquito tones but I can’t?

• “Because you’re old” is not a complete answer :P
• What happened to my ears as they aged? Why can’t I hear high pitches any more?

How are the two energy senses related?