Sensory Physiology

Sensory Lab

Goals

- Students will review the basic anatomy of the eye, ears, and skin.
- Students will understand the basics of seeing, hearing, and touch.
- Students will learn how to test vision, hearing, and touch.
- Students will learn about abnormalities in vision, hearing, and touch.

Summary

Review the sense organs: visual system, auditory system, and somatosensory system. To accomplish this, watch the recorded lab video and review all figures within this handout.

Review of Procedure

Background

Conventionally, there are five senses: sight, hearing, taste, smell and touch (visual, auditory, gustatory, olfactory and tactile senses, respectively). This is clearly an oversimplification. Additional sensory modalities include temperature, pain, vibration, joint position and proprioception.

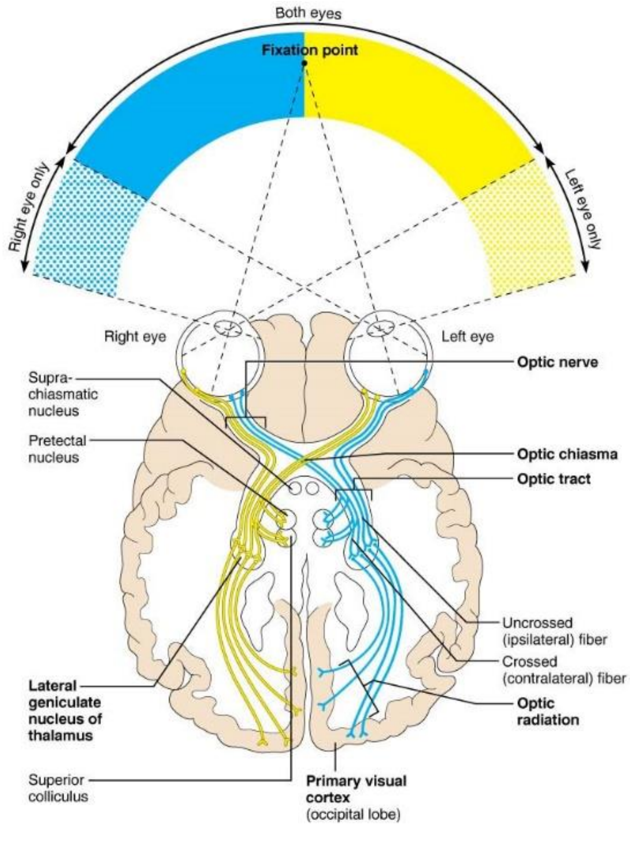
Vision

Equipment

- Light
- Pin or paperclip
- White paper
- Black pen
- Black item
- Red item

Protocols:

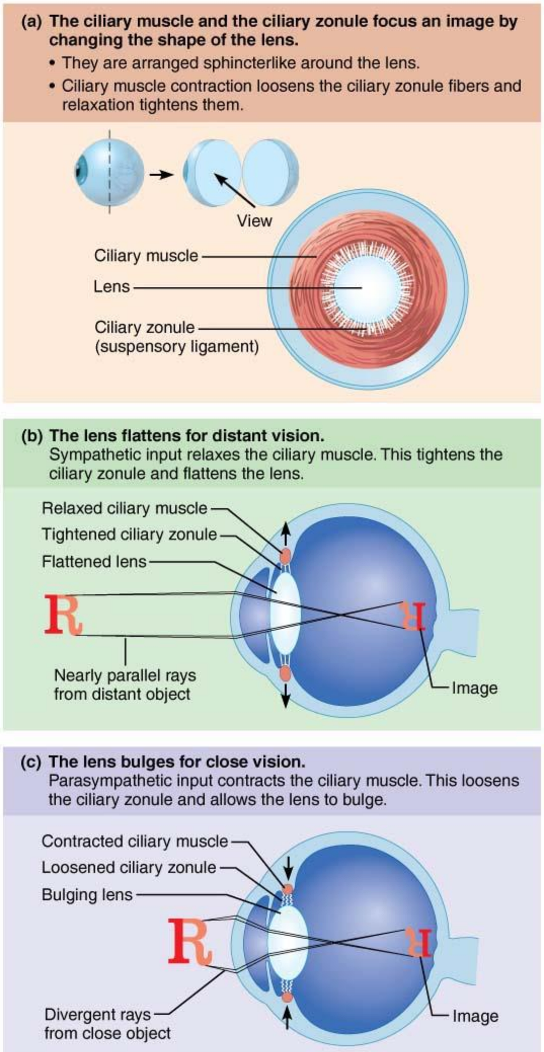
Vision-Convergence of gaze:

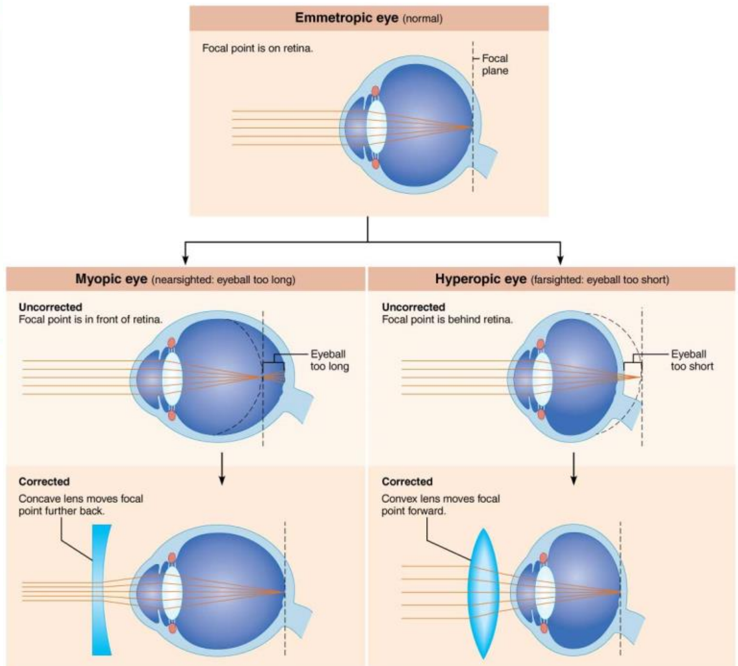


(a) The visual fields of the two eyes overlap considerably. Note that fibers from the lateral portion of each retinal field do not cross at the optic chiasma.

1. Binocular vision requires that the separate images in the right and left eyes be 'fused' to give a single view. Fusion of the images of an object is possible only if the images fall on corresponding parts of the right and left retinae. If they do not, a double view of the object results.
2. Hold one arm outstretched, with the index finger upright and in line with some distant object (for example a clock on a far wall). Look at the finger (keep it in focus) but concentrate all attention on the distant object. Note that the distant object is seen doubled: there are two images, side by side.
3. Cover the right eye. Note that the right image of the distant object disappears.
4. With both eyes open, look at the distant object. Note that your finger is seen doubled.
5. Cover the right eye. Note that the left image of your finger disappears.
6. Ask a volunteer to look first at a distant object, and then at an object held close up (15 cm from the face). Note that the volunteer's eyes are turned inwards when looking at a close object
7. Record your observations in the section labeled "Data Notebook."

Vision-Accommodation (focusing)





1. The eye can accommodate (change focus) for far or near vision, by varying the shape of the lens.
2. Cover or close one eye and hold a pin about 15 cm in front of the other eye, in line with some distant object.
3. Look at the distant object and note that the pin appears blurred and dim: it is out of focus.
4. Now look at the pin. Note that the distant object becomes dim and indistinct. Note also that accommodation for the near object (the pin) is accompanied by a feeling of effort.
5. Cover one eye and hold the pin at arm's length. While looking at the point of the pin, slowly bring it toward the face until it becomes blurred. The shortest distance at which the pin can be kept in focus is the 'near point'.
6. Record your observations in the section labeled "Sample Data & Data Analysis."

Vision-The blind spot

1. The visual field for each eye includes a blind spot, representing the optic disc — a part of the retina with no photoreceptors.
2. Obtain a pen that writes with black ink but has a white barrel. Alternatively, wrap some white paper around the barrel of a black fiber-tipped pen, leaving only the black writing tip exposed.
3. Mark a small cross on a piece of white paper. Close the left eye and look steadily at the cross, at a distance of about 25 cm. For the rest of this exercise, keep the head completely still and continue to look at the cross.
4. Move the pen out (to the right) from the cross. At a certain distance the tip will become invisible. Mark this place with a spot on the paper.
5. Carry the pen further to the right, until it becomes visible again. Mark this place with another spot.
6. Similarly, mark the upper and lower limits of the blind spot.
7. Record your observations in the section labeled "Data Notebook."

Vision-Mechanical stimulation of the retina

1. The eye has properties similar to those of a camera, in that the image formed on the retina is inverted. Light falling on the retina on one side of the eye gives a visual response in the opposite side of the visual field. Mechanical stimulation of the retina, by pressure on the eyeball, also gives a visual response that is inverted.
2. Turn one's gaze to the left and shut both eyes. Keep looking to the left.
3. With a fingertip, press gently on the right side of the right eyeball, at the corner of the eye. Note the visual effect.
4. Slide a finger up and down and note the direction of movement of the visual response.
5. Turn one's gaze to the right, and similarly press on the left side of the right eyeball, at the corner of the eye. Again, note the visual effect.
6. The main visual response to stimulation is a bright circle or disc, on the opposite side of the visual field from the site of stimulation. Stimulation of the retina on the right side of the eye gives a response on the left, and vice versa.
7. Record your observations in the section labeled "Data Notebook."

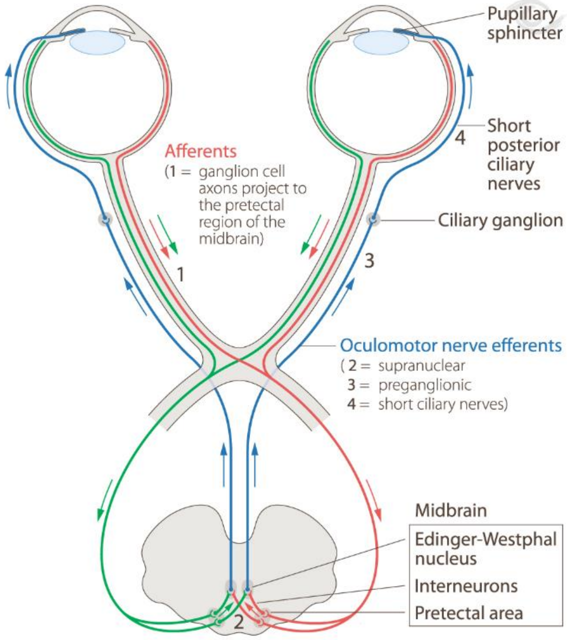
Vision-The positive after-image

1. Retinal photoreceptors have a surprisingly long and slow response to light. A brief visual stimulus gives rise to a response that outlasts the stimulus long enough to give an after-image.
2. Face a bright scene, such as a sunlit window or a strongly illuminated bench top.
3. Close both eyes and cover them with your hands. Wait for 30 seconds.
4. Remove your hands, and open the eyes for the shortest possible time, then close them again.
5. Note the afterimage. Bright features of the scene remain visible for an appreciable time (a substantial fraction of a second).
6. Record your observations in the section labeled "Data Notebook."

Vision-The negative after-image

1. The sensitivity of retinal photoreceptors decreases gradually while they are being stimulated by light and increases while they are not. This adaptation to light and dark allows visual function over a very wide range of light intensities. It has the side effect of giving rise to negative after-images.
2. Place a black object on a piece of white paper or draw a black square on the paper.
3. Look fixedly at the black object for 30 seconds. The volunteer may blink but should take care to keep their gaze fixed.
4. Shift the gaze to a piece of plain white paper and note the after-image of the black object. The image lasts for many seconds. The image is inverted in contrast (the black object gives a bright after-image), hence the name 'negative after-image'.
5. Repeat with a colored object and note the color change in the after-image. For example, a red object gives a green after-image.
6. Record your observations in the section labeled "Data Notebook."

Vision-Pupillary Light Reflex



Source: Schiefer, Wilhelm, Hart (Eds.). Clinical Neuro-Ophthalmology - A Practical Guide. Springer, Berlin/Heidelberg/New York, 2007.

1. Obtain a penlight.
2. Have the patient stare keep both eyes open and have them look forward the entire experiment.
3. Turn on the penlight and hold it out to the right of the patient. You will test their right pupillary reflex first.
4. Continuously look at their RIGHT eye.
5. Move the light in front of their RIGHT eye until you see their RIGHT pupil constrict.
6. Quickly move the penlight away and allow the pupil to dilate.
7. Continuously look at their LEFT eye.
8. Move the light in front of their RIGHT eye until you see their LEFT pupil constrict.
9. Quickly move the penlight away and allow the pupil to dilate.
10. You are done testing their right pupillary reflex.
11. Test their left pupillary light reflex by running steps ii-x and modify as needed.
12. Use the figure above to help you understand your results.
13. Record your observations in the section labeled “Sample Data & Data Analysis

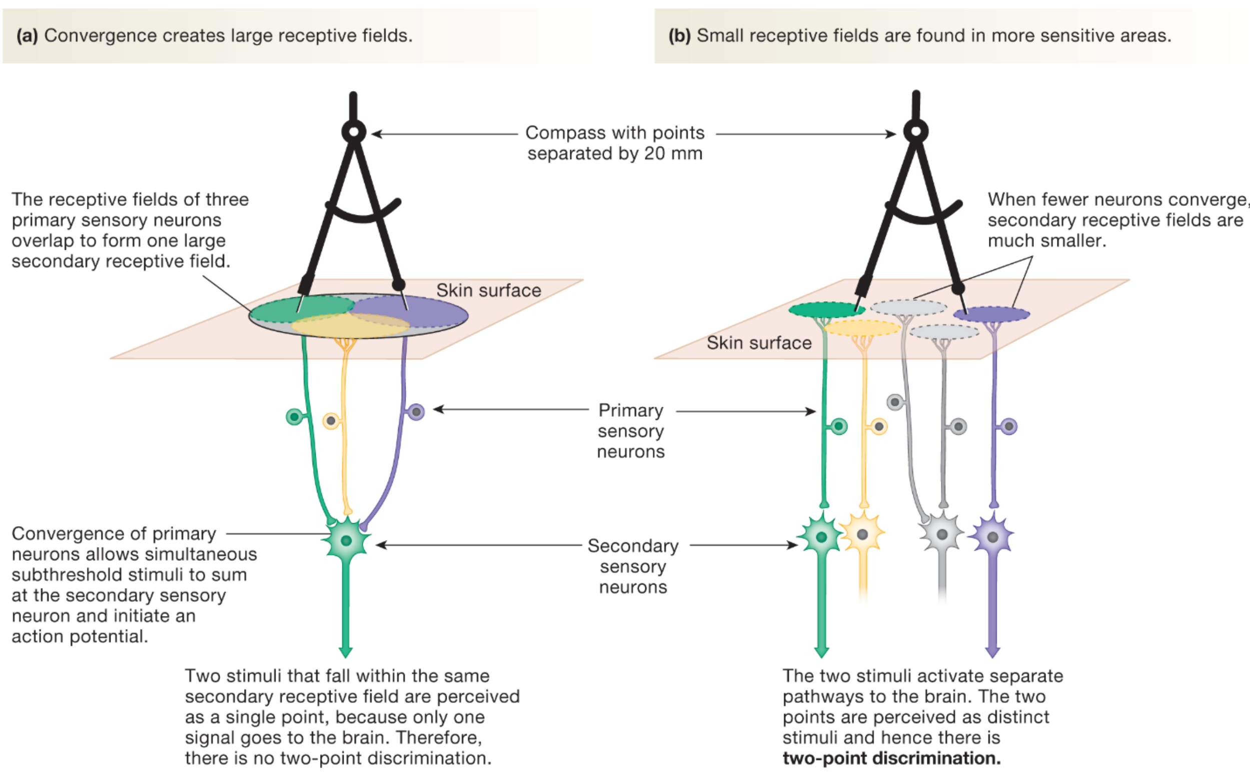
Somatosensory

Equipment

- paperclip
- ruler

Protocols:

Somatosensory-Two-point discrimination



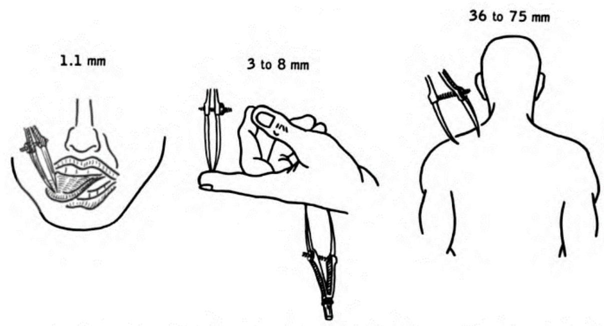


Table 10.3 The Two-Point Touch Threshold for Different Regions of the Body

Body Region	Two-Point Touch Threshold (mm)
Big toe	10
Sole of foot	22
Calf	48
Thigh	46
Back	42
Abdomen	36
Upper arm	47
Forehead	18
Palm of hand	13
Thumb	3
First finger	2

Source: From S. Weinstein and D. R. Kenshalo, editors, *The Skin Senses*, © 1968. Courtesy of Charles C. Thomas, Publisher, Ltd., Springfield, Illinois.

10-25

1. The density of tactile receptors in the skin differs greatly in different parts of the body.
2. Take a metal paperclip and unfold it. Bend it into a U shape, with the wire points about 10 mm apart.
3. Touch the two points gently on the palm of a volunteer's outstretched hand and ask if one point or two is felt. With a separation of 10 mm, the double stimulus from the two points can be easily felt.
4. Ask the volunteer to close both eyes. Bend the paperclip so as to bring the points closer together. By repeated trials with different point separations, find the smallest separation that the volunteer can distinguish as two points. Test the truthfulness of the volunteer's responses, from time to time, by turning the paperclip slightly, and pressing only one of the points down.
5. Measure the separation of the points with a ruler.
6. Repeat steps 3 and 4 with trials on different parts of the body (for example, a fingertip, the back of the hand and the back of the forearm).
7. Record your observations in the section labeled "Sample Data & Data Analysis"

Somatosensory-A thermal illusion

1. Many sensory systems show adaptation: a declining response to a continued steady stimulus. Temperature sensors in the skin adapt in this way, and so thermal sensations of warmth or cold are determined more by changes in temperature than by the temperature itself.
2. Obtain three containers (small buckets or large beakers). Fill one container with hot, but not painfully hot, water. Fill another with cold water and fill the third with lukewarm water.
3. Place one hand in hot water and the other hand in cold water. Leave them there for 30 seconds.
4. Now place both hands in the lukewarm water. Note any sensations.
5. Record your observations in the section labeled "Data Notebook.

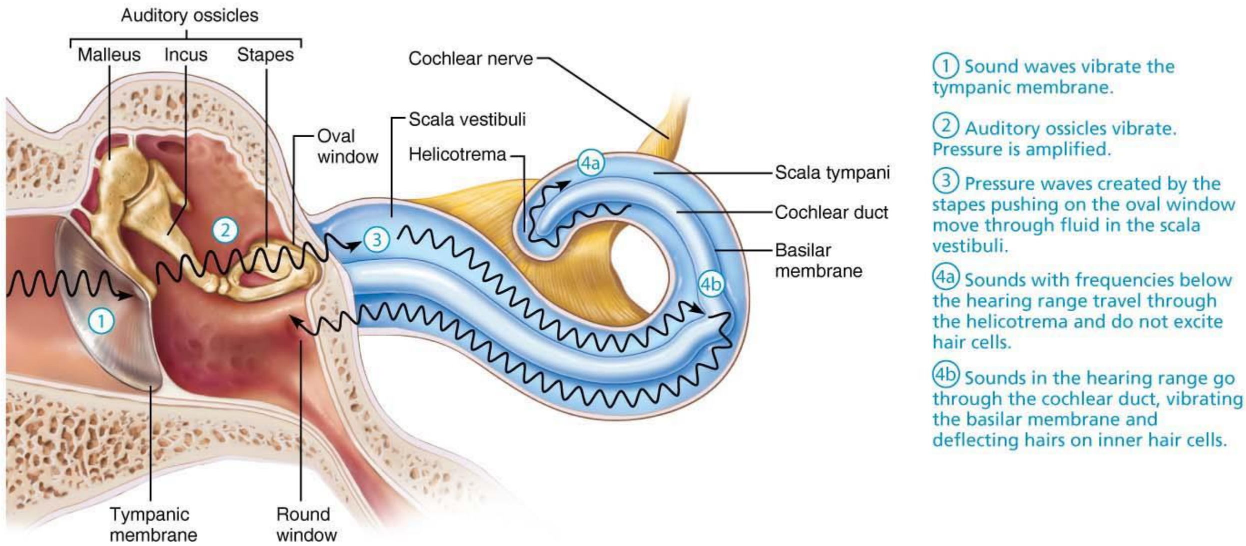
Hearing

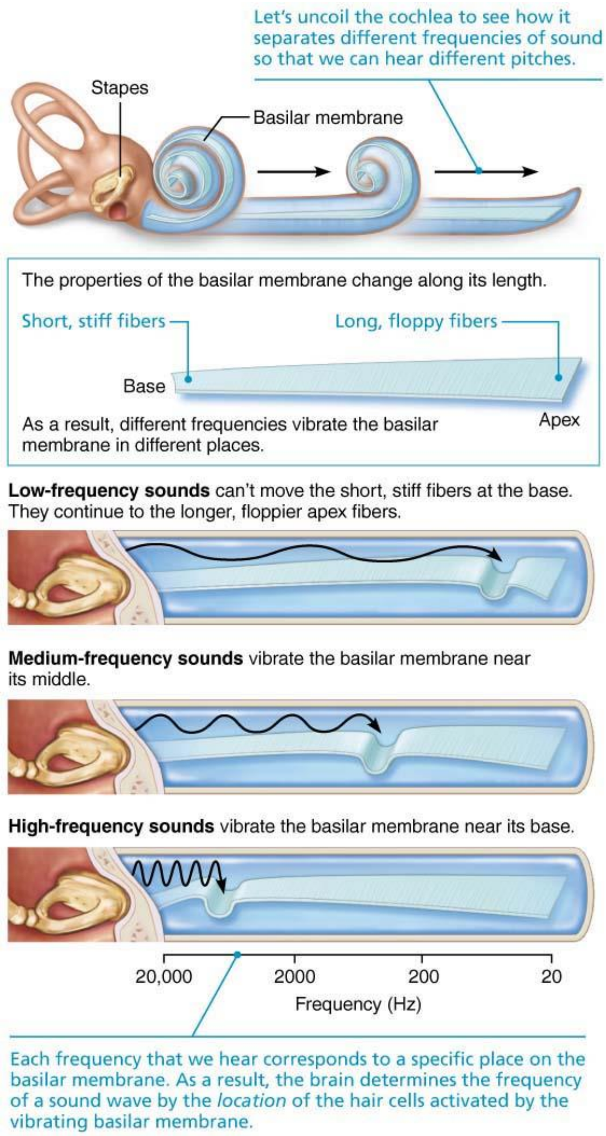
Equipment

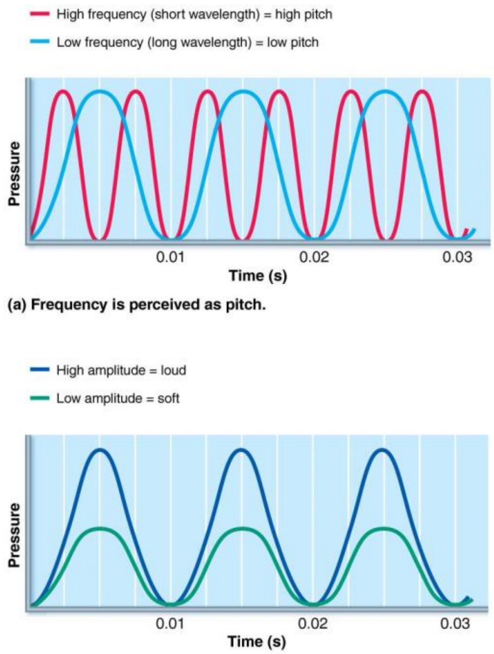
- Turning fork set
- Rubber mallet
- Ear plugs

Protocols

Note: you will be unable to complete the following protocol at home. However, you must still understand the procedure and complete the corresponding section under "Sample Data & Data Analysis"

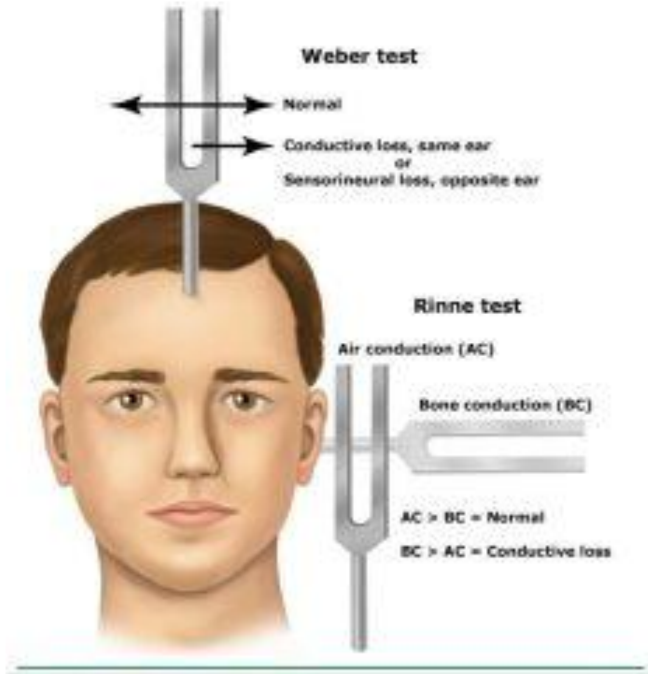

Auditory ossicles
Malleus
Incus
Stapes
Oval window
Scala vestibuli
Helicotrema
Cochlear nerve
Scala tympani
Cochlear duct
Basilar membrane
Tympanic membrane
Round window
1 Sound waves vibrate the tympanic membrane.
2 Auditory ossicles vibrate. Pressure is amplified.
3 Pressure waves created by the stapes pushing on the oval window move through fluid in the scala vestibuli.
4a Sounds with frequencies below the hearing range travel through the helicotrema and do not excite hair cells.
4b Sounds in the hearing range go through the cochlear duct, vibrating the basilar membrane and deflecting hairs on inner hair cells.

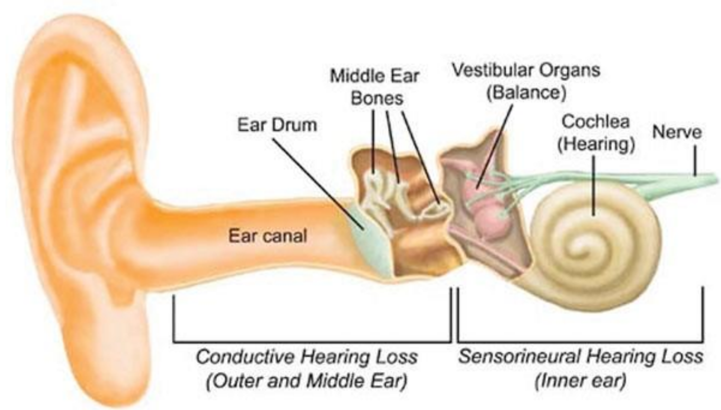

Let's uncoil the cochlea to see how it separates different frequencies of sound so that we can hear different pitches.
Stapes
Basilar membrane
The properties of the basilar membrane change along its length.
Short, stiff fibers
Long, floppy fibers
Base
Apex
As a result, different frequencies vibrate the basilar membrane in different places.
Low-frequency sounds can't move the short, stiff fibers at the base. They continue to the longer, floppier apex fibers.
Medium-frequency sounds vibrate the basilar membrane near its middle.
High-frequency sounds vibrate the basilar membrane near its base.
20,000
2000
200
20
Frequency (Hz)
Each frequency that we hear corresponds to a specific place on the basilar membrane. As a result, the brain determines the frequency of a sound wave by the location of the hair cells activated by the vibrating basilar membrane.



(a) Frequency is perceived as pitch.

(b) Amplitude (size or intensity) is perceived as loudness.





Preferred frequency for your patient:

1. Have the patient sit in a chair and stand behind them.
2. Use any 128Hz tuning fork and strike it behind them. Then use the 256Hz tuning fork and strike it behind them. Ask them which one they hear best.
3. Use the one they hear best and then test another tuning fork (512, 1012, 2048Hz) to find out which tuning fork they hear best.
4. Use the tuning fork that they hear best with and run all the following tests.

Weber Test (test for general deafness; non-specific).

1. Strike the tuning fork and place the base of the handle at the top (middle) of the patient's skull.
2. Ask the patient if they hear the sound equally in both ears. Normally they should. Abnormal results happen when patients hear the sound louder on one side. Record you results.

Rinne Test (test for conduction deafness)

1. You will test the RIGHT ear first.
2. Tap the tuning fork and place the base of the handle on your patient's right mastoid process. Hold it in this position until they indicate that they cannot hear the sound any longer.
3. Quickly move the tuning fork near the right ear. Make sure the prongs of the tuning fork are parallel to the ear. Normally you should hear sound.
4. Tap the tuning fork and place the prongs of the tuning fork near the right ear. Hold it in this position until they indicate that they cannot hear the sound any longer.
5. Quickly move the base of the tuning fork onto the right mastoid process. Normally you should not hear sound.

Simulate Conduction Deafness

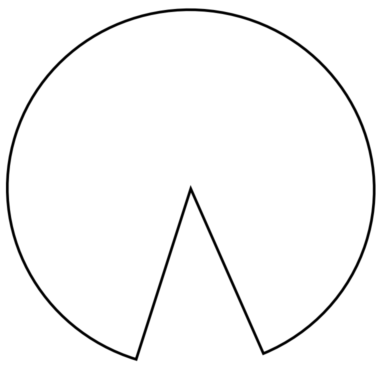
1. Wear an earplug or place cotton in one ear.
2. Run the Weber Test and record the results.
3. Run the Rinne's Test and record the results.

Sample Data & Data Analysis:

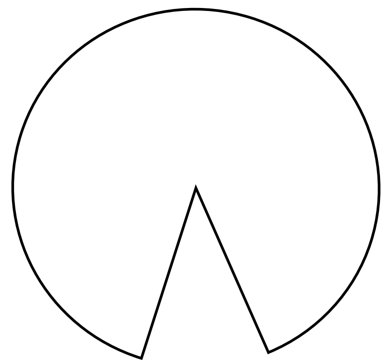
Vision

- Monocular and Binocular Field of View
  - Label the vision disk using the following data:
    - Left eye ranges from 30-100 degrees
    - Right eye ranges from 60-110 degrees.

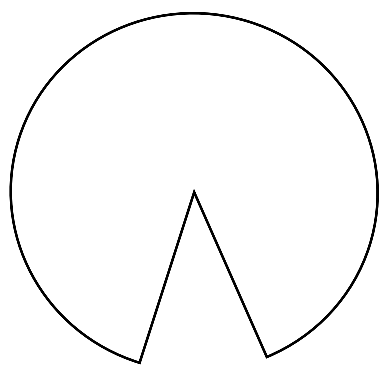
Left eye open:



Right eye open:



- Overlap your results from both tests. Color the monocular field of views and the binocular field of view different colors.



- Accommodation
  - Do you wear glasses/contacts? If so, are you far (hyperopia) or near (myopia) sighted?

- Right eye distance: _______________
- Left eye distance: ________________

- Pupillary light reflex

  - Did your patient/you have a normal response? _________________
    - What happened to the RIGHT pupil when you shined the light in the RIGHT eye?

    - What happened to the LEFT pupil when you shined the light in the RIGHT eye?

    - What happened to the LEFT pupil when you shined the light in the LEFT eye?

    - What happened to the RIGHT pupil when you shined the light in the LEFT eye?

  - If possible, draw the pathway showing a right CNII lesion. What would be the results if you ran the pupillary light reflex test?

  - If possible, draw the pathway showing a right CNIII lesion. What would be the results if you ran the pupillary light reflex test?

Hearing and Equilibrium

- Normal-Preferred frequency: _____________________
  - Weber Test Results:_____________________
  - Rinne Test Results: _____________________

- Simulation-Conduction Deafness
  - Weber Test Results:______________________
  - Rinne Test Results: ______________________
- Compare and contrast conduction deafness and sensorineural deafness. Which type of hearing impairment would benefit from using a cochlear implant?

Touch

- Two-point discrimination test
  - What is the threshold for the tip of the finger? ______________
  - What is the threshold for the back of the hand? ______________
  - What is the threshold for the back of the neck? ______________
  - Which site is more sensitive?_____________________________
    Which site is least sensitive? _____________________________ Explain.

Data Notebook:

Record observations for each exercise in the spaces below.

Exercise 1: Convergence of gaze

Exercise 3: The blind spot

Exercise 4: Mechanical stimulation of the retina

Exercise 5: The positive after-image

Exercise 6: The negative after-image

Exercise 9: A thermal illusion