LAB: "SENSE AND SENSIBILITY"—TESTING YOUR SENSORY ORGANS

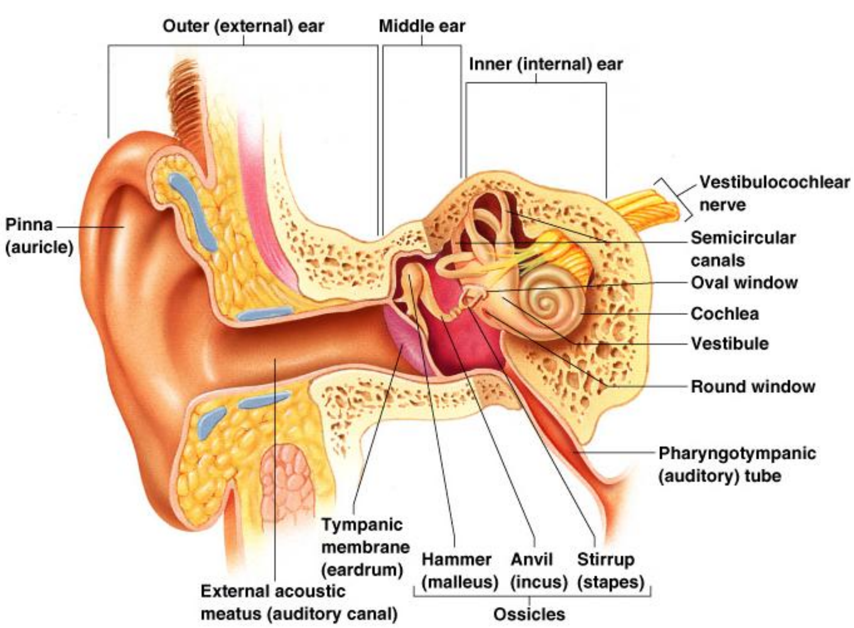
INTRODUCTION

Have you ever wondered why many doctors wear pale green or blue scrub suits in the operating room? These colors are often chosen because they reduce the perception of the after-image produced when a person stares at one color for long periods of time. The perception of an after-image occurs because the photosensitive pigments have bleached or degraded to the components that make up the color being stared at. So, for example, if a surgeon were to look at someone dressed in a white scrub suit after looking for a long period of time at something red, the person in white would appear to be wearing an intense blue-green color. However, since the scrub suits are usually blue or green, the after-image, although still present, is almost unnoticeable.

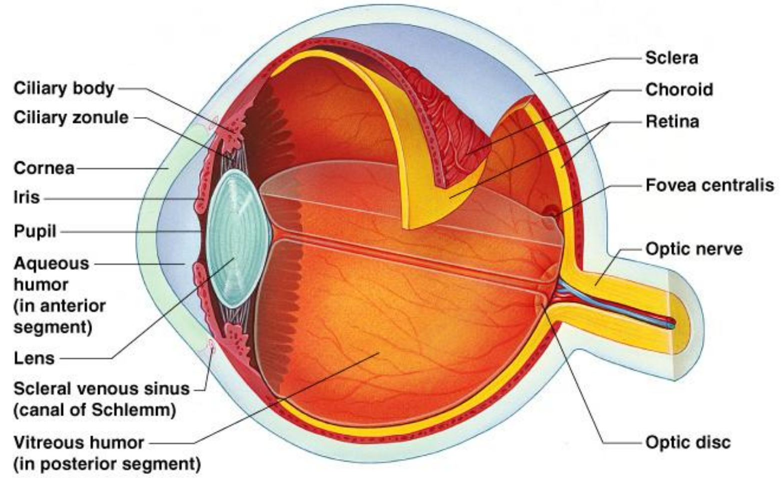
This is just one example of the tremendous ability of the human body to adapt to the surrounding environment. The ability to adapt to our surroundings is the underlying basis behind the study of sensory perception. However, in order to understand how sensory perception works, you must first begin to understand how the sensory organs work.

The first organ to be discussed is the ear. The ear serves an important role in two types of sensory perception. The first is the detection of sound and the second is the maintenance of equilibrium. Sound waves originate from the compression and decompression of air as an object vibrates. They travel outward from the object in much the same way that a stone causes ripples when dropped in a pond. In addition, the velocity or force with which the object is vibrating affects the volume of the sound wave in much the same way that the size of the rock affects the size of the ripples in the pond. For example, when you blow a whistle, the air being forced from your lungs is pushed into the whistle and around the ball inside. This causes ball to Vibrate, which in turn causes the molecules of air around the ball to begin to vibrate. If the force of air due to the velocity of breath is small, the whistle will emit a lower, or weaker, sound wave. However, as the force of air entering the whistle is increased, the ball will vibrate more rapidly and, thus, the air around the ball will vibrate more quickly causing a stronger sound wave.

When these vibrations hit the tympanic membrane inside the ear, the tympanic membrane begins to vibrate as well. The vibrations of the tympanic membrane are transferred to the auditory bones, which in turn conduct the sound wave to the oval window. The oval window transmits the sound wave into a fluid filled chamber where the receptors, called hair cells, are sandwiched between two specialized membranes. These membranes move as the fluid is disturbed and activate the hair cells. As the hair cells are activated, they transmit electrical impulses to the brain. Hair cells in humans are activated at frequencies ranging from 20 to 20,000 cycles per second or hertz (Hz). Compression waves at frequencies above 20,000 Hz are in the ultrasonic range and waves at frequencies below 20 Hz are in the infrasonic range.

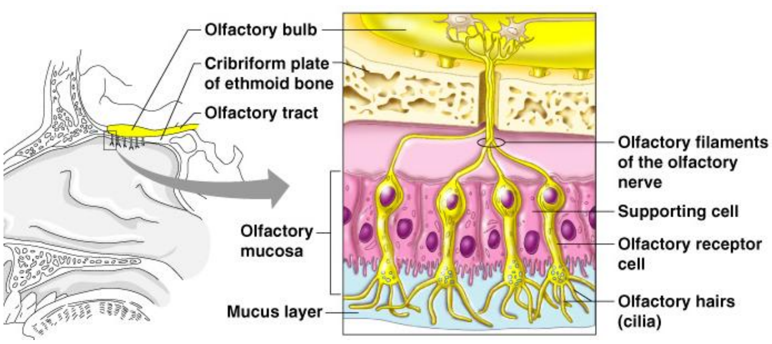


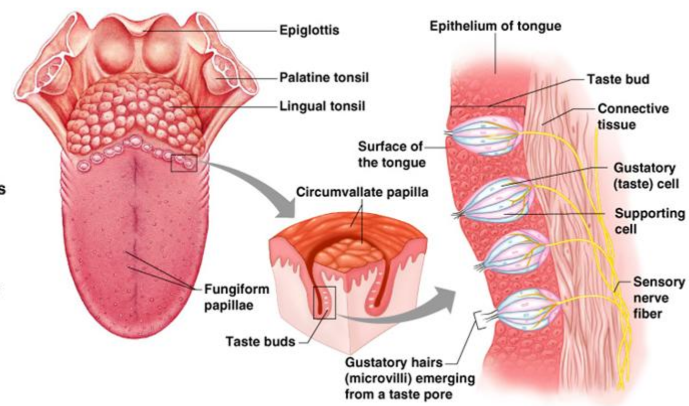
The components of the ear responsible for maintaining equilibrium are found in the middle and inner ear. The most important of these structures is found in the inner ear and is called the semicircular canal. There are three in each ear and they are responsible for providing sensory information regarding changes in orientation of primarily the head.



The eye is responsible for the detection of visual images. The detection of visual sensations occurs at the back of the eye on the retina. An image is projected onto the retina, which is then converted into nerve impulses through degradation of photosensitive pigments in structures called rods and cones. Rods are the receptors which are most operable in night vision. They are responsible for black and white vision, while cones are the receptors for bright and colored light. The human eye possesses three types of cones, each containing a different combination of retinal and photopsin. Each cone type is characterized by a sensitivity to a different colored light, which is dependent upon varying proportions of retinal and photopsin. One cone type is sensitive to blue light; another is sensitive to green light; and the third type is sensitive to red light. We are able to see more than these three colors because each color stimulates a different combination of the three different types of cones. Rods and cones are found in varying densities across the retina, however, they are not found at all where the optic nerve enters the eye. This area is called the blind spot, since no image can be registered here.

The related senses of taste and smell are dependent upon chemoreceptors, which detect different chemical molecules in the substances we eat and smell. In humans, these receptors are located on the roof of the nasal cavity, on the tongue, and on the surfaces of the soft palate, pharynx and epiglottis. A taste or a smell is perceived when a chemical molecule comes into contact with the appropriately shaped chemoreceptor.





The final sense, touch, is dependent upon receptors that are located in the skin called mechanoreceptors. These receptors are sensitive to mechanical stimuli, such as pressure and gravity. There are three types of mechanoreceptors. They are free nerve endings, Meissner corpuscles, and Pacinian corpuscles. Free nerve endings and Meissner's corpuscles are located in the upper layers of skin and are usually sensitive to light touch, while Pacinian corpuscles are located in the deeper layers of skin and respond only to heavy pressure. Thermoreceptors are also involved in the sense of touch. These include heat receptors, which respond to temperatures between 25 and 45°C; cold receptors, which respond to temperatures between 10 and 20°C; and pain receptors, which are activated at temperatures greater than 45°C and temperatures below 1o°C.

For any of the five senses, continuous stimulation of the receptor cells at a constant level results in sensory adaptation. This may occur in one of two ways. The first is that the receptor itself has adapted to the stimuli and stops transmitting the signal to the brain. The second way sensory adaptation may occur is that the lower parts of the brain adapt to the information being received and decide that the information is not important enough to relay to the areas of the brain where you would be consciously aware of the sensation. However, regardless of where the stimulus stops being transmitted, any large increase in the intensity of the stimulus will generally bring the stimulus back to your attention. **This phenomenon of sensory adaptation is what the following lab activity will be focusing on.**

OBJECTIVE

You should be able to test various aspects of perception, such as to observe after-images, the blind spot, the taste regions of the tongue, the density of heat and cold receptors on the skin, and to experience the intertwined sensations of smell and taste.

PROCEDURE

PART 1: VISION—"DO YOU SEE WHAT I SEE?"

TEST A: AFTER-IMAGES

1) Working with your partner, **select** one colored sticker. **Place** this sticker on the left side of the plain white sheet of paper. **Write** your names at the top of the paper.
2) Next to the sticker, **write** your prediction about the color and shape of the after-image you expect to see after focusing on the sticker for approximately 30 seconds.
3) Focus on the colored sticker for approximately 30 seconds while your partner times you. When your partner indicates that time is up, **shift** your gaze to a plain white section on the same sheet of paper. **Record** what you see to the right of your prediction. *(Keep this sheet of paper for later!)*
4) **Repeat** steps 1-3 two more times using two other stickers of different colors.
5) **Switch** roles with your partner, and **repeat** the previous steps.

MATERIALS

- ✓ Colored stickers
- ✓ Plain white paper

TEST B: BLIND SPOTS

1) **Hold** the paper marked with a black plus sign (**+**) and a black dot (·) at arm's length, with the dot on the left and the plus sign on the right.
2) **Cover** your left eye and **focus** your right eye on the dot.
3) As you continue to look at the dot, slowly **move** the paper toward yourself. (Note: the plus sign is visible at first, then disappears completely, and then reappears. The point at which the plus sign was no longer visible was the blind spot for your right eye.)
4) Repeat steps 1-3, covering your right eye and focusing on the dot with your left eye.

MATERIALS

- ✓ (+)/(·) blind spot paper

TEST C: MAPPING YOUR BLIND SPOT

MATERIALS

- ✓ (+)/(·) blind spot paper
- ✓ Blank white paper
- ✓ Tape or glue
- ✓ Beads
- ✓ Pipe cleaners

1) **Tape** or **glue** a (**+**)/(·) strip vertically on a blank white sheet of paper so that there is white space on all sides of the symbols (**See Figure 1**.)
2) **Cover** your left eye and stand so that your right eye is about 25 cm from either the (·) or the (**+**).
3) **Focus** on your chosen symbol. Meanwhile have your partner **move** a small bead on a pipe cleaner along the surface of the paper toward your chosen symbol from the right side.
4) As soon as the bead disappears from your vision, **tell** your partner to stop. Your partner will **mark** this position on the white paper. This is the outer edge of your blind spot.
5) Have your partner continue to move the bead toward your chosen symbol. **Stop** your partner when the bead reappears. Your partner will **mark** this spot on the white paper. This is the inner edge of your blind spot.
6) **Repeat** this procedure several times, moving the bead along the paper toward your chosen symbol from different directions, until your blind spot is well mapped.
7) **Connect** the outer dots on the white paper to draw the outline of the outer edge of your blind spot. **Repeat** this procedure for the inner dots to draw the outline of the inner edge of your blind spot.
8) **Change** roles and **map** your partner's blind spot.

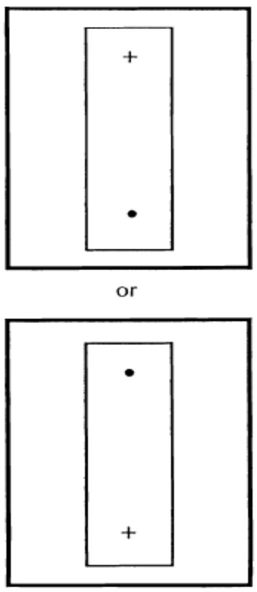


Figure 1. Blind spot symbols

PART 2: CHEMORECEPTION—“DO YOU TASTE AND SMELL WHAT I TASTE AND SMELL?”

TEST A: FLAVOR DISCRIMINATION

MATERIALS

- ✓ Potato cubes
- ✓ Apple cubes
- ✓ Gloves (optional)

1) **Close** your eyes and pinch your nose shut.
2) Have your partner **place** either a slice of potato or a slice of apple on your tongue <u>without telling you what it is</u>.
3) **Leave** the slice on your tongue for 10 seconds without sucking, chewing, or moving the slice around in your mouth. Try to **detect** which slice your partner placed on your tongue. Your partner will then **record** whether your guess was correct or incorrect in DATA TABLE 1.
4) **Repeat** steps 1-2 again. This time, however, **chew** on the slice. Have your partner **record** your guess for this trial in the appropriate space in the data table.
5) **Repeat** steps 1-2 for the last time. This time, however, **<u>do not</u> pinch** your nose shut during the trial. Additionally, you may also **chew** the slice. Again, have your partner **record** your guess for this trial in the appropriate space in the data table.
6) **Change** roles with your partner, **recording** your partner’s data in the data table.

TEST B: MAPPING YOUR TASTE RECEPTOR

MATERIALS

- ✓ Sterile cotton swabs
- ✓ Clean paper towels
- ✓ “Solutions A-D”
- ✓ Cup with clean tap water

IMPORTANT! *Always use clean swabs and paper towels for each trial and each partner!*
After each trial, dispose of all materials properly.

1) Have your partner **dip** a clean cotton swab into "Solution A" and **touch** the swab to each of the seven areas of your tongue (as shown in **Figure 2**). **Rate** your sensitivity with regard to the taste of each applications using the rating system below:

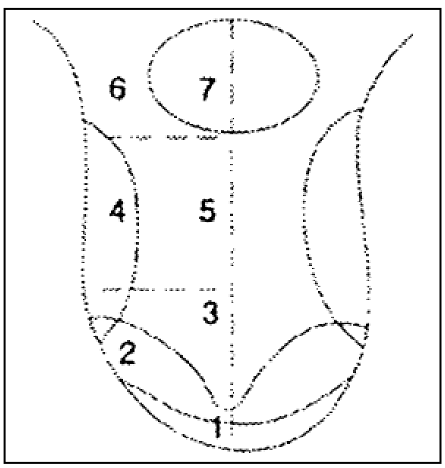


Figure 2. Taste receptor locations of the tongue.

TASTE SENSITIVITY	RATING MARK
"The taste is *absent* or *indistinguishable.*"	**-**
"The taste is *faint* or *mild*."	**+**
"The taste is *strong*."	**++**

Also, **indicate** whether the sensation was *sweet*, *salty*, *bitter*, or *sour*. Have your partner **record** your answers for you in the appropriate space in DATA TABLE 2.

2) **Repeat** step 1 for "Solution B," "Solution C," and "Solution D." (**NOTE**: Make sure to **rinse** your mouth out with tap water and **blot** your tongue dry with a paper towel between trials.)
3) **Change** roles with your partner and **repeat** using clean swabs, a clean cup for rinsing, and clean paper towels.

PART 3: TESTING YOUR THERMORECEPTORS—"DO YOU FEEL WHAT I FEEL?"

TEST A: SENSORY ADAPTATION

1) **Place** the index finger of one hand in a beaker containing warm water and **place** the index finger of the other hand in a beaker of cold water.
2) **Hold** your fingers in their respective beakers for 60 seconds.
3) **Place** both index fingers in a beaker containing water at room temperature.
4) **Answer** the questions listed in DATA TABLE 3.

MATERIALS

- ✓ Warm water beaker
- ✓ Cold water beaker
- ✓ Room temperature beaker

TEST B: MAPPING YOUR THERMORECEPTORS

1) Using the grid stamp and ink pad provided, **stamp** a grid on the hairless part of your anterior forearm.
2) While looking away, have your partner **randomly select** either a warm or cold probe from the corresponding beaker and lightly **touch** the probe to one point on the grid of your forearm.
3) **Indicate** whether you think the probe is warm or cold. Your partner should **record** your response in the appropriate section of your data table. This should be indicated by **writing** a (+) if you guessed correctly and a (-) if you guessed incorrectly. For example, if your partner chose the warm probe, but you indicated that you felt a sensation of cold, your partner would write a (-) in the corresponding section of the warm grid in DATA TABLE 4.
4) **Repeat** steps 2-3 until all the positions on both grids have been filled.
5) **Change** roles, **recording** heat and cold sensitive data for your partner.

MATERIALS

- ✓ Ink pad
- ✓ Grid stamp
- ✓ Steel probe in warm water beaker
- ✓ Steel probe in cold water beaker

__40__ (total pts possible)
- ______ (pts missed)
______ (total pts earned)

Name ________________________________

STUDENT WORKSHEET

DATA TABLES

DATA TABLE 1.

			RESULTS: CORRECT OR INCORRECT
Trial 1	No sucking and no breathing	Apple	
		Potato	
Trial 2	Chewing but no breathing	Apple	
		Potato	
Trial 3	Breathing and chewing	Apple	
		Potato	

DATA TABLE 2.

	POSITION ON TONGUE							OVERALL TASTE (SWEET, SALTY, BITTER OR SOUR)
	FRONT			SIDE		BACK		
RECEPTOR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
"Solution A"								
"Solution B"								
"Solution C"								
"Solution D"								

DATA TABLE 3.

QUESTION	ANSWER
Which finger was in the warm water?	Right or Left (circle one)
Which finger was in the cold water?	Right or Left (circle one)
What sensation do you feel with your left finger after placing it in the room temperature water?	
What sensation do you feel with your right finger after placing it in the room temperature water?	

DATA TABLE 4.

CONCENTRATION OF WARMTH RECEPTORS

_________ / cm^2

CONCENTRATION OF COLD RECEPTORS

_________ / cm^2

HINT: *In order to calculate the number of thermoreceptors per cm^2, you'll need to count the number of (+) markings ONLY in each grid and divide it by 5, which is the total surface area (in cm) of the grid.*

POST-LAB QUESTIONS

1) If humans hear sound emitted in a frequency range of 20 to 20,000 cycles per second, why are we unable to perceive the sound of a dog whistle?

2) Did your predictions in the after-image exercise match the actual outcomes and did you and your partner produce similar results with different colored circles?

3) In testing your blind spot, what did you see when the (+) disappeared?

   a. Does each eye have a blind spot? Explain your answer.

   b. Would you expect the blind spot for your untested eye to be the same size and shape as the blind spot for the eye tested in this lab?

   c. How could you test your answer?

   d. Name some instances where it would be beneficial to be aware of your blind spots.

4) While chocolate, derived from the cacao plant, is quite bitter in its natural state, it is altered by the addition of sugar to make it palatable to humans. In which two regions of the tongue are the chemoreceptors located that are primarily responsible for detecting the flavors associated with chocolate? Which flavor is detected in each region?

5) Do you think the tongue also possesses pain receptors? Explain.

6) Explain the results of Part 3, Test A. Why did you experience different sensations in each finger?

7) In Part 3, Test B, which temperature were you more accurate in predicting (hot or cold)?

   a. Do you think that the density of thermoreceptors had anything to do with this?

   b. Would the ability to accurately predict the sensation of temperature change in different spots on your body?