The Senses 29

We take it for granted that humans experience the world through the five senses—sight, hearing, touch, taste, and smell. Sometimes we say that an acutely intuitive individual has a "sixth sense," but in reality we all have a sixth sense, and a seventh, and an eighth. The sense of touch is actually a complex of senses—touch, pressure, and temperature. We even have separate sensory receptors for heat and cold. Our ears respond not only to sound but also to changes in body position. Additional senses monitor the interior of the body, collecting information on blood pressure and the positions of muscles and joints. Pain warns us of injury or disease. Other animals possess sensory ranges that we can only imagine. A dog is aware of sounds and smells beyond our sensory range. Bees see ultraviolet light; rattlesnakes see infrared. Some creatures can even feel the Earth's magnetic field. This chapter is about the senses and how they reveal the world.

Organizing Your Knowledge

Exercise 1 (Modules 29.1 - 29.2)

As you read these words, several different processes occur in your eyes and brain before you understand what the words mean. Match each of these processes (A–F) with its description (L–Q), and number the processes in the order in which they might occur.

Order	*Description*	
_____	_____	A. Transduction
_____	_____	B. Sensation
_____	_____	C. Transmission
_____	_____	D. Perception
_____	_____	E. Reception
_____	_____	F. Adaptation

L. Conscious understanding of sensory data
M. Conversion of a stimulus into electrical signals
N. Sending action potentials to the brain
O. Drop in sensitivity of receptors when stimulated repeatedly
P. Awareness of sensory stimuli by the brain
Q. Detection of stimuli by sensory cells

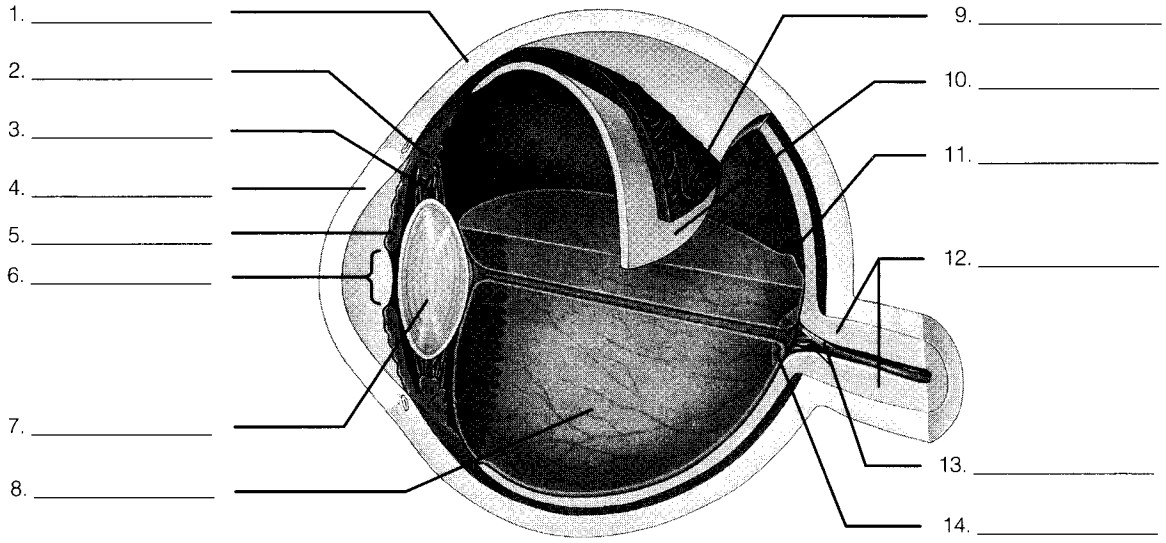
Exercise 2 (Module 29.3)

There are five general kinds of sensory receptors—pain receptors, thermoreceptors, mechanoreceptors, chemoreceptors, and electromagnetic receptors. To review them, complete this chart. Give the general category of receptors to which each example belongs, the kind of stimulus it responds to, and where you might find one of the receptors.

Example	*General Receptor Type*	*Stimulus It Responds To*	*Locations*
Infrared receptor	1.	Infrared radiation	2.
Touch receptor	3.	Contact and movement	4.
5.	6.	Obstacles and animals in murky water	7.
8.	9.	10.	Eyes
Pain receptor	11.	Danger, injury, disease	Many body locations
12.	Mechanoreceptor	13.	Human ear
Heat receptor	14.	15.	16.
17.	18.	Body position	19.
Smell receptor	20.	21.	Nose
Magnetic orienting mechanism	22.	23.	Head of certain birds, fishes, mammals

Exercise 3 (Modules 29.4 – 29.6)

Eyes can be simple or complex. The single-lens vertebrate eye is a complicated and sensitive sensory organ. To familiarize yourself with the major parts of the eye, label and color the diagram below. Include the **sclera, choroid, retina, pupil, iris, lens, cornea, vitreous humor, aqueous humor, artery and vein, fovea, optic nerve,** and the **muscle** and **ligament** attached to the lens.



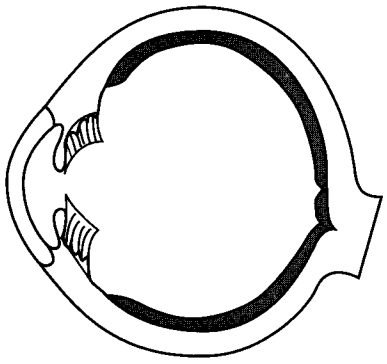
Now match each of the following functions with a part of the eye by placing its letter next to the correct label on the diagram.

A. Carries nerve signals to the brain
B. Covers the front of the eye but lets light in
C. Supplies nutrients and oxygen to the lens, iris, and cornea
D. Photoreceptor cells here transmit action potentials to the brain
E. Regulates the size of the pupil to let more or less light into the eye
F. Bends light rays and focuses them on the retina
G. Changes the shape of the lens
H. Photoreceptors are highly concentrated at this center of focus

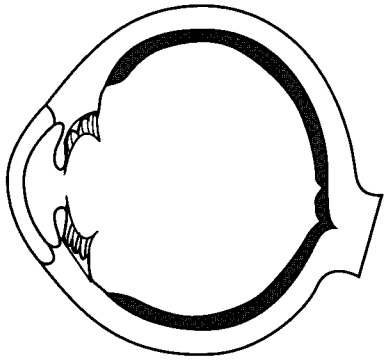
Exercise 4 (Module 29.6)

Web/CD Activity 29A *Structure and Function of the Eye*

The lenses in the eyes of a fish move back and forth to bring images into focus, but the lenses in human eyes focus by changing shape, a process known as accommodation. After studying Module 29.6, sketch the path of light rays and the shape of the lens when the eye focuses on a nearby object and a distant object.



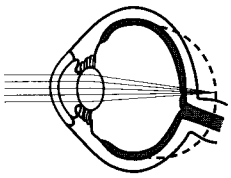
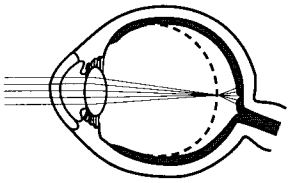
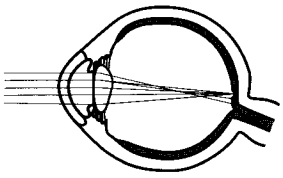
Nearby object



Distant object

Exercise 5 (Module 29.7)

There are a number of possible reasons for less-than-perfect vision. Some people are nearsighted, others farsighted. Some suffer from astigmatism. After reading about these vision problems, sort them out by completing the following chart.

Diagram			
Problem name	1.	2.	3.
Nearby or distant objects clear	4.	5.	6.
Nearby or distant objects unclear	7.	8.	9.
Cause(s)	10.	11.	12.
Lens used for correction	13.	14.	15.

Exercise 6 (Module 29.8)

This module discusses rods and cones, the sensory receptors of the retina. Indicate below the statements that relate to rods and those that relate to cones by placing check marks in the appropriate column. (Some statements relate to both.)

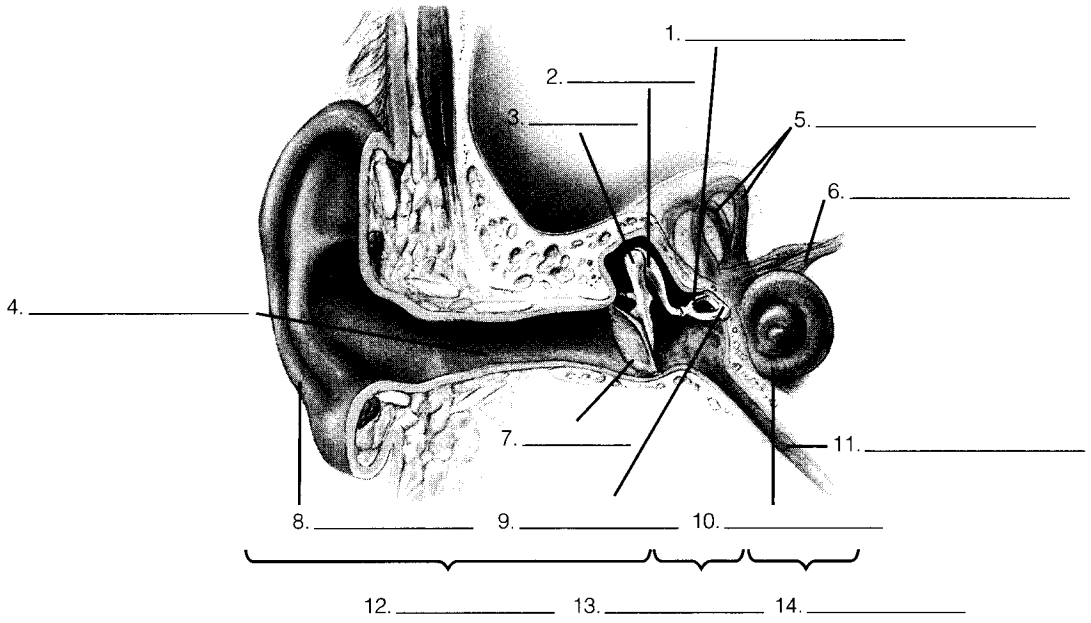
	Rods	*Cones*
1. Come in three types		
2. Stimulated by bright light		
3. Function in night vision		
4. Most numerous in the fovea		
5. Located in the back layer of the retina		
6. Contain a visual pigment called rhodopsin		
7. Can see different colors		
8. Stimulus transducers		
9. Absent from the fovea		
10. Most numerous at the outer edges of the retina		
11. Contain pigments called photopsins		
12. See only shades of gray		
13. Transmit signals to the visual cortex		
14. Deficient in color blindness		
15. Synapse with retinal neurons		
16. Most numerous receptors		
17. Most sensitive receptors		
18. Concentrated in fovea of a hawk		
19. More numerous in animals active at night		

Exercise 7 (Module 29.9)

The ear is a mechanical marvel, catching and amplifying sound waves and transforming them into action potentials. As you review the structure and function of the ear, label the following parts on the diagram at the top of the next page: **auditory nerve, eardrum, cochlea, oval window, anvil, semicircular canals, inner ear, auditory canal, stirrup, outer ear, pinna, hammer, Eustachian tube,** and **middle ear.** Color all structures of the outer ear red, the middle ear yellow, and the inner ear blue.

Now match each of the following functions with a part of the ear by placing its letter next to the correct label on the diagram.

A. Its hair cells transduce motion into action potentials
B. Equalizes pressure outside and inside eardrum
C. Other animals, such as dogs and horses, can turn it toward sounds
D. Transmits action potentials from ear to brain
E. Transmits vibrations to middle-ear bones
F. Collects and channels sound waves to eardrum
G. Transmits vibrations from eardrum to cochlea
H. Function in balance



Exercise 8 (Modules 29.10 – 29.13 and Summary)

Modules 29.10 – 29.12 discuss the senses of balance, smell, and taste, and Module 29.13 reviews the role of the senses in the overall function of the nervous system. Review the senses (including vision and hearing) by matching each of the phrases on the right with a sensory structure from the list on the left. Some answers are used more than once.

A. Retina
B. Semicircular canal
C. Utricle and saccule
D. Hair cell
E. Olfactory receptor
F. Taste bud
G. Organ of Corti
H. Cone

____ 1. Receptors here detect changes in head movement
____ 2. Receptors here sense sour, salty, sweet, bitter
____ 3. Chemicals dissolve in mucus and bind to its cilia
____ 4. Site of receptors for hearing
____ 5. Light receptor of the retina
____ 6. Receptors here sense position of head relative to gravity
____ 7. Receptor of hearing
____ 8. Site of photoreceptors
____ 9. Balance receptor
____ 10. Chemoreceptor of the nasal cavity

Testing Your Knowledge

Multiple Choice

1. Insect eyes are much better at seeing _____ than are our eyes.
   a. colors
   b. in dim light
   c. movement
   d. fine detail
   e. distant objects

2. A thermoreceptor in the skin converts heat energy into action potentials. This conversion process is called
   a. sensation.
   b. transduction.
   c. reception.
   d. integration.
   e. perception.

3. Which of the following correctly traces the energy of sound waves into the ear?
   a. auditory canal–eardrum–ear bones–cochlea
   b. eardrum–auditory canal–cochlea–ear bones
   c. auditory canal–ear bones–eardrum–cochlea
   d. eardrum–auditory canal–ear bones–cochlea
   e. eardrum–ear bones–auditory canal–cochlea

4. Which of the following are *not* correctly paired?
   a. mechanoreceptor—stretch receptor
   b. electromagnetic receptor—photoreceptor
   c. chemoreceptor—taste bud
   d. mechanoreceptor—touch receptor
   e. electromagnetic receptor—hair cell

5. When you focus your eyes on a nearby object, the lenses
   a. decrease in diameter.
   b. move forward.
   c. become more rounded.
   d. become flatter.
   e. move backward.

6. As light passes into the eye, it goes through which of the following first?
   a. lens
   b. pupil
   c. aqueous humor
   d. cornea
   e. vitreous humor

7. The brain determines the loudness of a sound from
   a. the part of the organ of Corti stimulated by the sound.
   b. the frequency of action potentials received.
   c. the size of air pressure changes in the middle ear.
   d. the part of the brain receiving nerve impulses from the ear.
   e. the size of the action potentials received.

8. Josh is color blind, so he has a lot of trouble picking out clothes. Which sensory structures below are affected in a color-blind person?
   a. organ of Corti
   b. cones
   c. hair cells
   d. rods
   e. utricle and saccule

9. Which of the following is *not* a mechanoreceptor?
   a. taste bud
   b. hair cell
   c. touch receptor
   d. pressure receptor
   e. stretch receptor

10. Eating carrots really is good for your eyes. Carrots contain vitamin A, which is used to make a substance called rhodopsin, which
    a. is a visual pigment that absorbs light.
    b. provides energy for the function of rods and cones.
    c. colors the iris of the eye.
    d. stimulates the neurons in the retina to form branches and connections.
    e. keeps the lens clear and transparent.

Essay

1. Bats can navigate in total darkness by listening to the echoes of their high-pitched clicks. In a few sentences, describe three other examples of animal sensory capabilities beyond the range of human senses.

2. Explain the difference between sensation and perception.

3. What is farsightedness? What eye defect causes it? How is farsightedness corrected?

4. Explain how a stimulus (light, chemical, temperature change, movement) triggers a nerve impulse in a sensory receptor.

5. How are the sense of smell and sense of taste similar? What are the differences between the senses of taste and smell?

Applying Your Knowledge

Multiple Choice

1. You look all over for your glasses and then find them pushed back onto your forehead. This error could be attributed to
   a. perception.
   b. transduction.
   c. sensation.
   d. sensory adaptation.
   e. accommodation.

2. Michael and Laura are both looking at an illustration in her psychology textbook. Michael says, "It is an old woman looking down toward the left." Laura says, "I see a young woman looking away from us." How can they look at the same picture and see different things?
   a. Perhaps one of them has astigmatism.
   b. Their sensations differ.
   c. They sense the same thing, but their perceptions differ.
   d. It may take some time before their eyes accommodate to the picture.
   e. They perceive the same thing, but their sensations differ.

3. Whales and dolphins are known to send out clicking sounds and listen to the echoes. This suggests that they might find their prey in the same way
   a. a rattlesnake finds a mouse in total darkness.
   b. a salmon locates its home stream.
   c. an owl locates a mouse in a dark barn.
   d. an electric eel finds its prey in a muddy river.
   e. bats navigate in dark caves.

4. As you read this sentence, how do the photoreceptors of your retina tell the brain whether an area is light (the paper) or dark (the print)?
   a. Either rods or cones send signals to the brain.
   b. Nerve signals are sent to different areas of the brain.
   c. Signals are sent to the brain at different frequencies.
   d. Accommodation adjusts for light and dark areas.
   e. Larger (white) or smaller (dark) action potentials are sent to the brain.

5. A fish detects vibrations in the water around it by means of its "lateral lines," rows of sensory receptors along each side of the body. Based on what you know about sensory receptors, the lateral line receptors are probably most similar to
   a. receptors in the organ of Corti.
   b. rods and cones.
   c. receptors in taste buds.
   d. receptors in the retina.
   e. olfactory receptors.

6. Damage to the nerve from the saccule and utricle to the brain could result in
   a. loss of sense of taste.
   b. blindness.
   c. dizziness.
   d. loss of sense of smell.
   e. deafness.

7. There may be as many as 50 different kinds of smell receptors, each activated by different molecules. We can differentiate among thousands of different smells because each substance stimulates a different combination of these receptors. In much the same way,
   a. our eyes can distinguish many different colors.
   b. our ears can differentiate between sounds of many different pitches.
   c. pain receptors can distinguish between mild and severe pain.
   d. our eyes can adjust to light of differing intensities.
   e. our ears can determine how loud a sound is.

8. It is said that if you are seasick, it is better to look out at the water than at the boat. Why?
   a. It fools your brain into thinking that you are not really moving.
   b. This stimulates the saccule and utricle, organs of equilibrium.
   c. Seeing that you are moving reduces conflict between vision and equilibrium.
   d. Keeping your head level reduces activity of the semicircular canals.
   e. Actually, looking at the water just makes seasickness worse.

9. The eyes of a nocturnal animal, such as an owl, could be expected to have a larger proportion of _____ than do our eyes.
   a. chemoreceptors
   b. cones
   c. rods
   d. hair cells
   e. mechanoreceptors

10. The carotid body is a structure in the wall of the main artery carrying blood to the head. In it are special receptors that monitor blood pressure. These receptors would belong to which of the following groups?
    a. chemoreceptors
    b. thermoreceptors
    c. photoreceptors
    d. mechanoreceptors
    e. electromagnetic receptors

Essay

1. Theresa is suffering from a mysterious disorder called Ménière's disease. Her symptoms are quite debilitating: loud roaring sounds and dizziness. Why do these symptoms occur together? What part of the body must be affected by Ménière's disease?

2. The eyes contain three kinds of cones—green, blue, and yellow. Which are stimulated when we see blue? Yellow? White? Black?

3. Some researchers believe that human beings might have an ability to sense direction that is distinct from the traditional "five senses." The human brain contains magnetite, a magnetic mineral, and it has been suggested that perhaps we have some ability to find our way by sensing the Earth's magnetic field. Describe an experiment that could test this suggestion.

4. Most sensory receptors are sensitive to a sudden change in a stimulus, but soon adapt—become less sensitive—to a continuing stimulus. For example, thermoreceptors quickly adapt, and a very hot bath soon feels comfortable. How might this be useful? Pain receptors are an exception; they do not readily adapt. Why do you think this is the case?

5. There are many different kinds and causes of deafness. Explain how each of the following would result in deafness: damage to hair cells from repeated loud sounds, brain injury, arthritis of the middle-ear bones, a torn eardrum, buildup of earwax in the auditory canal.

Extending Your Knowledge

1. Anosmia is loss of the sense of taste or smell. It sometimes results from a brain injury or as a side effect of medication. Do you think anosmia could be inconvenient or dangerous in any way? Do you think it would be worse to lose your sense of smell or your sense of taste? Why?

2. Have you ever felt your ears ringing after listening to loud music from a stereo or at a concert? What do you think about the possibility that listening to loud music could permanently damage your hearing? Are your friends aware of this danger to their hearing? What, if anything, should be done to warn people about this danger or protect them from it?

3. Most people and animals are attracted to sweet and fatty foods. They find many poisonous substances bitter and undesirable. How do you think such taste preferences might have evolved?