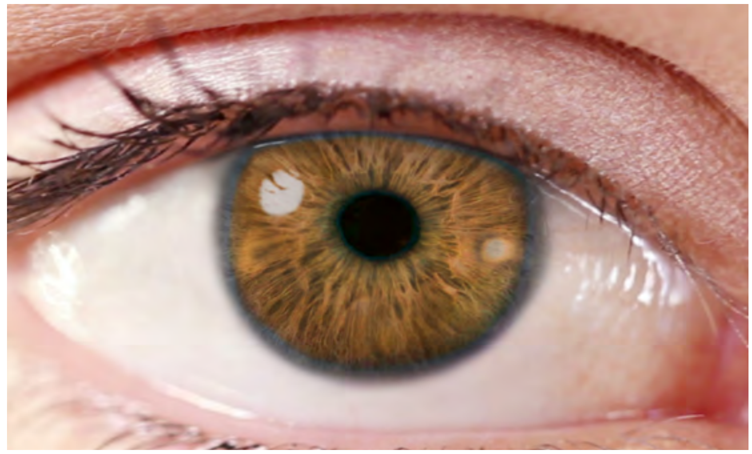
The Nervous System



12.7 The Senses

Your senses are your connection to the world. Each of your senses takes information from the environment—light, sound, touch, or molecules—and converts it into action potentials that are sent to the brain. As you will see, each sense accomplishes this in its own way.

Vision

Light enters your eyes (Figure 12.14a) through a tough, transparent layer called the *cornea*, which is continuous with the "whites" of your eyes. Light then passes through a small hole, the *pupil*. The *iris*, the part of the eye that gives you your eye color, surrounds the pupil and controls its size. In bright light, the pupil is small. In dim light, the pupil expands to let in more light. From the pupil, light passes through the lens. The *lens* focuses light on the **retina** at the back of the eyeball. The retina is covered with light-sensitive cells called rods and cones (Figure 12.14b). When light hits the rods and cones, it changes the action potentials they transmit to the brain. The bundle of neurons that takes visual information from the retina to the brain is called the *optic nerve*.

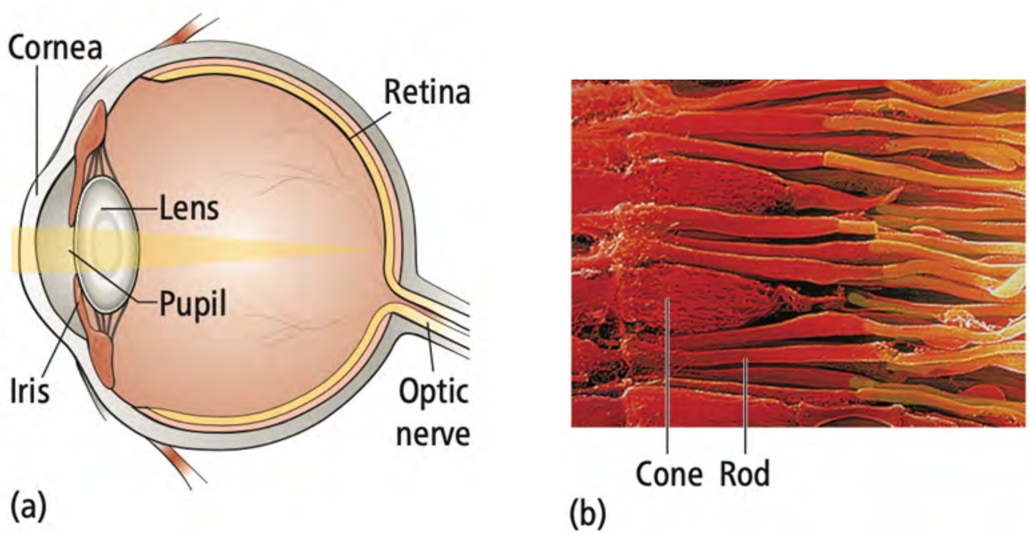


FIGURE 12.14

(a) The eyes convert light into action potentials. (b) Rods and cones are the light-sensitive cells in the eyes. As you can see, both rods and cones are named for their shape.

The two types of light-sensitive cells in your eyes, rods and cones, have different functions. *Rods* are very sensitive to light and are especially important for seeing in dim light. Rods cannot discriminate colors and allow you to see only black, white, and shades of gray. This is why, in a dark room, you cannot see the difference between a navy-blue shirt and a maroon shirt. (Most people are so used to this, however, that they don't even realize they've lost their color vision!) Rods also are not very good at making out fine details, which is why your night vision is grainy and not very sharp. *Cones* detect color. Your eyes have three types of cones that respond most strongly to red, green, and blue light. All the shades you see are made up of different combinations of these three colors. Color-blindness results from having a nonfunctioning version of one or more cone type. Rods and cones make up 70% of the sense cells in the body—evidence that vision is our best-developed sense.

Hearing

The ear consists of three parts: the outer ear, middle ear, and inner ear (Figure 12.15a). Sound waves move through the air to the *pinna*, the cartilaginous flap on the side of the head. The pinna funnels the waves in, and they move toward a thin membrane of skin—the *eardrum*. Sound waves make the eardrum vibrate, similar to how blowing on a piece of paper makes the paper vibrate. The eardrum's vibrations move three middle ear bones—the hammer, the anvil, and the stirrup—in sequence. These bones amplify the vibrations, making them more powerful. The stirrup then transfers the vibrations to the fluid-filled inner ear.

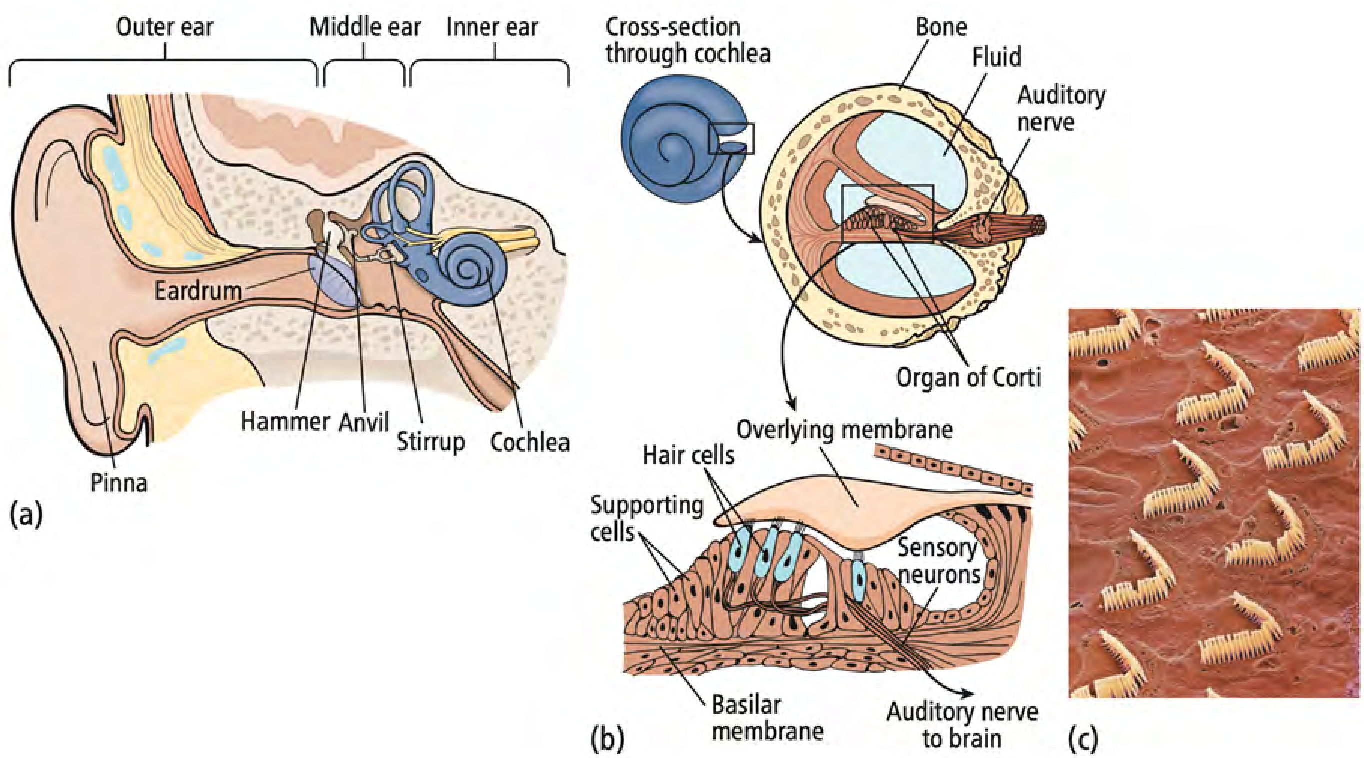


FIGURE 12.15

(a) The ear includes the structures of the outer ear, middle ear, and inner ear. (b) Sound-sensitive cells are contained in the organ of Corti. Fluid vibrations in the inner ear vibrate the basilar membrane of the organ of Corti, causing sensory "hairs" to brush against the overlying membrane and bend. The bending opens ion channels, starting action potentials. (c) This microscope photo shows the "hairs" (yellow) in the organ of Corti.

In the inner ear, sound vibrations enter the cochlea, a coiled tube that holds the organ of Corti. The **organ of Corti** contains the sensory cells responsible for hearing. Fluid vibrations in the inner ear move the organ of Corti's basilar membrane, causing sensory "hairs" embedded in it to brush against an overlying membrane and bend (Figure 12.15b). This bending causes ion channels to open, initiating action potentials that are transmitted by the auditory nerve to the brain. Note that the "hairs" of hearing cells are not like the hairs on your head; they are long extensions of sensory cells that happen to be shaped like hairs (Figure 12.15c). You can distinguish different noises— the high pitch of a siren versus the low pitch of a jackhammer—because different parts of the organ of Corti respond to different pitches.

Smell and Taste

The senses of smell and taste work through chemoreception. In **chemoreception**, chemicals bind to receptors in the cell membrane of chemosensory cells. The binding causes ion channels to open, and that initiates action potentials (Figure 12.16).

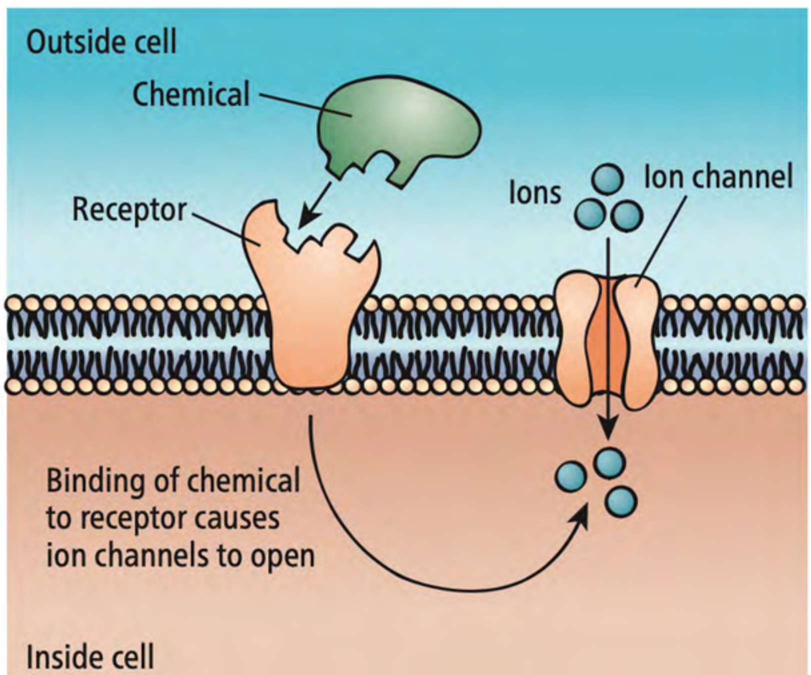


FIGURE 12.16

Smell and taste are examples of chemoreception. Chemicals bind to receptors on the cell membrane of chemosensory cells, causing ion channels to open. The ions initiate action potentials.

The sensory cells for smell lie in two patches at the top of your nasal passages. Each patch is about the size of a dime. Humans have more than 1000 different kinds of chemosensory cells for smell, each containing only one or a few different kinds of receptors. Because different chemicals trigger different combinations of sensory cells, however, you can distinguish well over 10,000 distinct odors.

One interesting thing about the sense of smell is that smells are sometimes linked to emotionally powerful memories. Have you ever had a smell bring back a memory? The part of the brain that processes smells is very close to two important parts of the brain: the hippocampus and the amygdala. The hippocampus is responsible for memory. The amygdala is involved with emotion. Using fMRI experiments, scientists have shown that smells can trigger memories and experiences in special ways. This is not the case for our other senses.

Taste cells cluster in small bumps called taste buds. Taste buds are located on your tongue, on the insides of your cheeks, and on the roof of your mouth. Humans distinguish five basic tastes: sweet, salty, sour, bitter, and umami. *Umami* is the Japanese word for "delicious," and it describes the flavor found in foods such as meat, mushrooms, cheese, and asparagus. Monosodium glutamate, or MSG, has a strong umami taste.

It is interesting that, when you are hungry, your taste buds become more sensitive to salt and sugar, and this in turn makes food taste better. Hunger does not affect your ability to taste bitterness, which helps you identify toxic foods. In addition, your experience of food—what you think of as "taste"—comes partly from your sense of smell. This is why food doesn't have nearly as much "taste" when you have a stuffy nose.

Touch

Your sense of touch is actually several different senses. These senses tell you about stimuli such as pressure, temperature, and pain. Your skin's sensory cells for touch are shown in Figure 12.17. Pressure causes the "hairs" on sensory cells to bend, opening ion channels and initiating action potentials. You have separate sensory cells for detecting light touch and heavy pressure. Temperature-sensing cells have ion channels that are affected by heat or cold. Some temperature sensors respond to heat, others to cold. The chemical menthol (found in peppermint) also stimulates cold receptors—it is this coincidence, not an actual cold temperature, that explains the cool feeling you get from eating a mint.

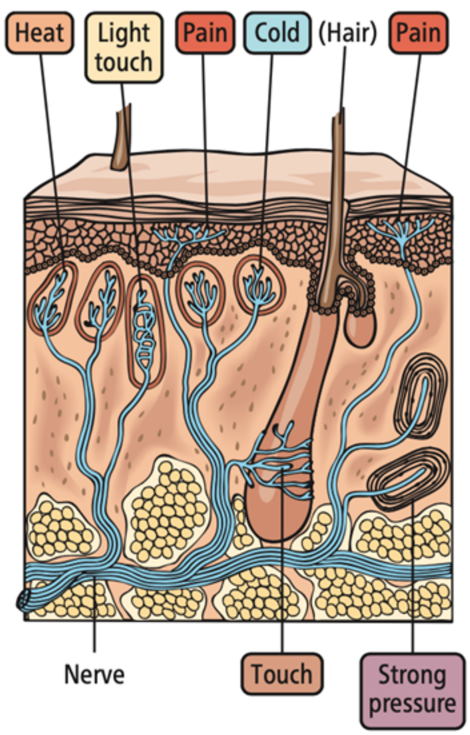


FIGURE 12.17

Sensory cells in the skin are responsible for the various senses of touch.

Pain sensors respond to stimuli that damage the body. These sensory cells require strong stimulation before they respond. However, damaged tissues release chemicals called *prostaglandins* that increase the sensitivity of pain receptors. Aspirin and similar drugs provide pain relief by interfering with prostaglandin production. Pain sensors also become more sensitive with continued stimulation. This makes pain receptors different from most other sensory cells, which become less sensitive with repeated stimulation. (This is why you stop noticing the smells in your house or feeling the weight of your backpack as you walk.) Scientists believe that some types of chronic pain result from pain receptors that have become abnormally sensitive.

Other Senses

You have other senses in addition to the big five. *Proprioceptors* in your muscles, tendons, and joints tell you where different parts of your body are. You can try out this sense by closing your eyes and touching your nose with your finger. (You may be too used to this ability to be impressed, but consider the fact that you can't easily touch *another* person's nose with your eyes closed!) Finally, the *vestibular senses* tell you about body rotation and movement as well as which way is up.

READING CHECK

1. **When you are outside at night, looking at a starry sky, are you using your rods or your cones?**
2. **Deafness can result from a number of problems, including a ruptured eardrum or damaged sensory cells in the organ of Corti. Why would each of these problems make hearing difficult?**

CHECK YOUR ANSWERS

1. You are primarily using your rods, which allow you to see in dim light. However, when you see some color to a star, then your cones are also being activated. But because the light is so dim, this color can be hard to discern.
2. If the eardrum is ruptured, sound waves cannot be conducted to the middle ear and no vibrations reach the organ of Corti. If sensory cells in the organ of Corti are damaged, they are unable to send signals to the brain.

For more on the senses, check out the great visualizations at the following website:

https://www.visiblebody.com/learn/nervous/five-senses