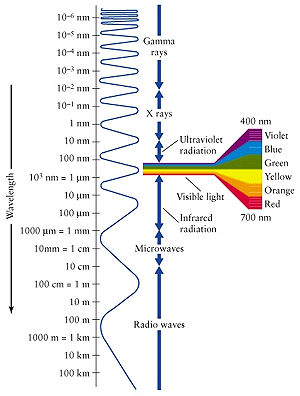
**Vision**

Four steps to vision:

* First we have to gather light into our eye.
* The light has to be channeled to the back of the eye.
* Transduction occurs.
* The information goes to our brain where we interpret it.

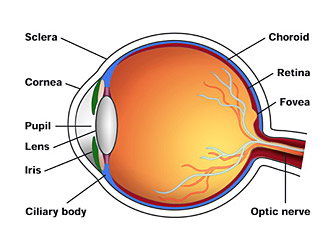
*Step One: Gathering Light*

There are all kinds of light waves out there from long ones (infrared, microwaves or radio waves) to short ones (ultraviolet waves X-rays or even gamma waves). The light we can see is in what we call the visible light spectrum, and from shortest to longest goes violet, indigo, blue, green, yellow, orange and red.  The height of the light wave determines it's intensity or brightness.  While the length of the wave determines it's hue (color).  So when we look at an object, these light waves enter our eye.



*Step Two: Light Channeled within the Eye*

Once the light hits the eye it goes through a variety of structures.  Take a look at the diagram below.



The white part of our eye is called the cornea and basically protects the eye and helps reflect light.  The light goes through a hole in our eye called a pupil.  The pupil is like the shutter on a camera, it opens or closes to let light in.  The colored part of your eye is called the iris.  The iris is a muscle that sole job is to open (dilate) or close (constrict) the pupil.  So when the light goes through the pupil it first hits the lens.  The lens is almost like a magnifying glass that reflects the light toward the back of our eye.  The lens is constantly changing shape depending on whether we are looking at objects close to us or far away.  The bending of the lens is called accommodation.  When adults become old, their lens becomes rigid and they cannot reflect light properly to the back of their eye and need reading glasses.  A really cool thing about the lens is that it reflects the light upside down and inverted toward the back of the eye (retina).  Our brain must switch the image back right side up or we would have serious perception issues.

*Step Three: Transduction*

Our eye turns the light into neural impulses that our brain can understand.  Most of the process occurs on the back of the eye called the retina.  The retina is made up of several layers of cells and the light must pass through all of them to experience transduction.

The first layer of cells to be activated by light are called the rods and cones.  Rods see only black and white and are spread throughout the outside of the retina.  Cones see color and are located in the center of the retina known as the fovea.  Rods out number cones by about 20 to 1.  Since the cones are located in the fovea (in the center of the retina) we see color objects better if they are directly in front of us.   Since rods are located on the periphery of the retina- we see black and white better in out peripheral vision.

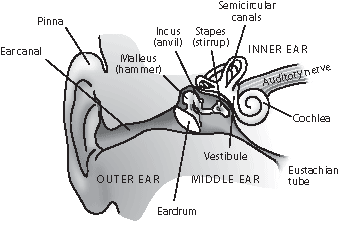
The lens reflects the light back to the retina and it hits the rods and cones.  If/when the rods and cones fire, they send the information to a second layer of cells called bipolar cells (cones often have a one-on-one connection with a single bipolar cell, which allows for more recognition of fine details).  So the bipolar cells give the information to a layer of cells called the ganglion cells.  The axons of the ganglion cells make up our optic nerve which sends the information to the thalamus in our brain. *(the specific part on the thalamus that attaches to the optic nerve is called the lateral geniculate nucleus (LGN) and the area that the optic nerves crosses/intersects in our head called the optic chiasm)*  This is a very simplified version of transduction in the eye.

*Step Four: Vision in the Brain*

From Unit III, you should recall that the thalamus sends the visual information to the occipital lobe in the cerebral cortex.  We interpret this information that is sent via the optic nerve in the visual cortex in the occipital lobe.  When your visual cortex is interpreting this information, you see shape, motion, colors and all kinds of other cool stuff at the same time.  Scientists say that in our visual cortex we have specific cells that all have specific jobs.  Some of these cells may just see shape.  While other cells have the sole job to see motion.  We call these types of cells feature detectors. These feature detectors do their specific jobs simultaneously, which is called parallel processing.

**Hearing (audition)**

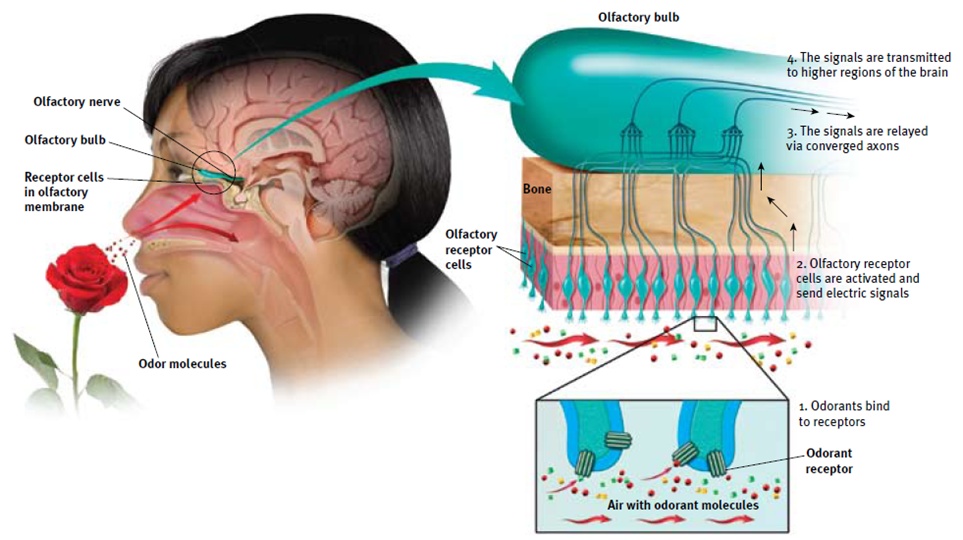
The ear has three basic parts: the outer ear, the middle ear, and the inner ear.



The pinna (part of the ear we can see) collects sound waves and passes them along the auditory canal to a membrane called the eardrum. When sound waves hit the eardrum, it vibrates. The eardrum transmits the vibration to three bones, or ossicles, in the middle ear, which are called the hammer, the anvil, and the stirrup. In response to the vibration, these ossicles move one after another in order to amplify the sound vibrations. Next, the vibrations travel to the cochlea of the inner ear. Inside the cochlea are receptors called cilia (hair cells). Vibrations that reach the inner ear cause the fluid in the cochlea to move in waves. These waves in turn make the hair cells move. The movement causes transduction, and the neurons that connect with the hair cells to fire. The axons of these neurons come together to form the auditory nerve, which sends impulses from the ear to the brain. In the brain, the thalamus and the auditory cortex, which is in the temporal lobe of the cerebrum, receives & processes auditory information.

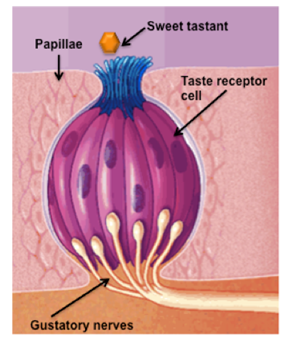
**Smell (olfaction)**

Odor molecules from a given substance enter your nose & they travel to the top of each nasal cavity. At this location sits about 20 million olfactory receptor cells. These receptor cells respond selectively to different odor molecules. The molecules bind to the selected receptors, causing transduction, activating those cells, and causing action potentials to send electric signals down their axons towards the olfactory bulb. The olfactory bulb furthers these electrical signals, via the olfactory nerve to the temporal lobe, bypassing the thalamus.



**Taste (gustation)**

The human tongue contains specialized cells, called taste buds, which sense tastants (taste molecules). The taste buds transduce this chemical energy into neural energy, which is sent via the gustatory nerves to the thalamus, then to the sensory cortex in the parietal lobe, where taste information is processed. There are five main tastes: bitter, salty, sweet, sour, & umami (savory). *\*\* taste is closely linked to our sense of smell\*\**



**Touch**

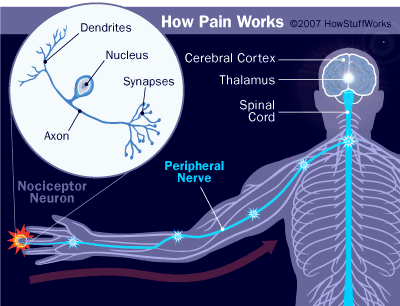
The somatosensory system allows the human body to experience pressure, texture, temperature, and pain, and to perceive the position and movement of the body's muscles and joints.

Receptor cells in the skin can be broken down into three functional categories: mechanoreceptors that sense pressure and texture, thermoreceptors that sense temperature, and **nociceptors** that sense pain. Receptor cells in the muscles and joints called proprioceptors also aid in the somatosensory system with regards to balance and body position/movement.

These receptors collect physical stimuli and convert it into electrical and chemical signals through the transduction process and send these impulses to the nervous system for processing. Our sense of touch encompasses virtually our entire body (internal & external), so there’s no 1 specific area of the brain responsible for processing this information, but most impulses are routed by the thalamus to the sensory cortex in the parietal lobe.

**Pain**

Painful (noxious) stimuli is registered by nociceptors. When the nociceptor is activated, it fires off an action potential, sending an electrical along it’s’ axon. The electrical signal travels along peripheral nerves to reach the spinal cord. The electrical signals are transmitted from one neuron to another across junctions (synapses) by means of chemical messengers (neurotransmitters). Signals are then passed up the spinal cord to the brain. In the brain, the signals reach the thalamus, which relays the signals on to different parts of the brain. Signals are sent to the somatosensory cortex (responsible for physical sensation), the frontal cortex (in charge of thinking), and the limbic system (linked to emotions).



The end result is that you feel a sensation of pain in your finger, think ‘Ouch! What was that?’ or something similar, and react emotionally to the pain; e.g. you feel annoyed or irritated. However, you will probably have reacted involuntarily even before you were consciously aware of the injury. In sudden strong pain like that generated by pricking your finger, interneurons within the spinal cord trigger a reflex response. Motor neurons are activated and the muscles of your arm contract, moving your hand away from the sharp object. This occurs in a fraction of a second — before the signal has been relayed on to the brain — so you will have pulled your arm away before even becoming conscious of the pain.

The gate control theory of pain proposes that there was a ‘gate’ mechanism in the central nervous system that opened to allow pain messages through to the brain & closed to prevent them getting through.

When we feel pain, such as when we touch a hot stove, sensory receptors in our skin send a message via nerve fibers to the spinal cord and brainstem and then onto the brain where the sensation of pain is registered, the information is processed and the pain is perceived.

The gate theory says that as these pain messages come into the spinal cord and the central nervous system (before they even get to the brain), they can be amplified, turned down or even blocked out. This allows the brain (when busy doing other things) to shut the gate until it can attend to the messages.

Large diameter nerve fibers responsible for transmitting signals of touch to the brain have the ability to close the pain gate and so block signals from other smaller diameter nerve fibers which transmit pain.

An example of this would be when a child falls over and hurts her knee — if she rubs her knee, the signal from that sensation of touch temporarily blocks the pain signal travelling from the injured knee to the brain.