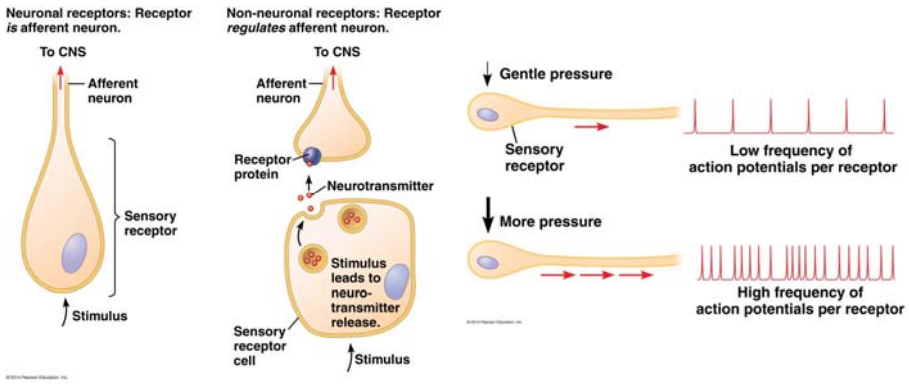
Sensory and Motor Systems.

Basics of Life Science

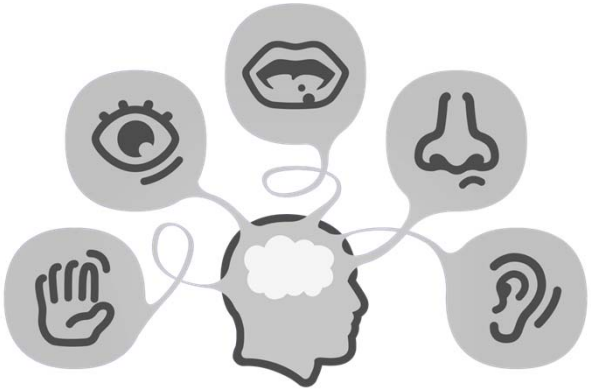
Thursdays 9-10:30

Ray Luo

Sensory reception and transmission transduces signals to nervous system.



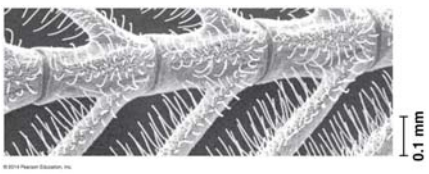
Sensory perception depends on pathway and source of sensation.



Reference URL

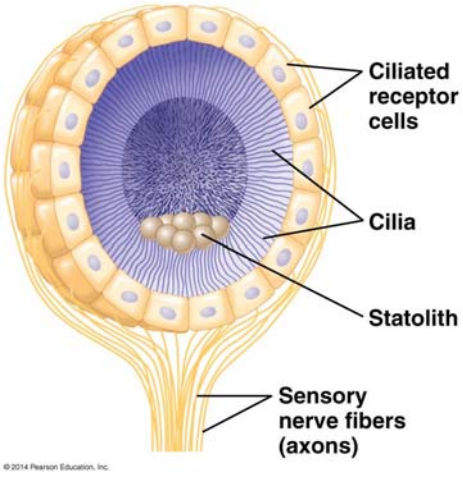
Sensory receptor types depend on the modality of the stimuli.

- Mechanoreceptor – pressure, touch, motion.
- Chemoreceptor – osmolarity, glucose, oxygen.
- Electromagnetic receptor – mag field, electric.
- Thermoreceptor – temperature, TRP capsaicin.
- Nociceptor – pain, amplified by prostaglandin.



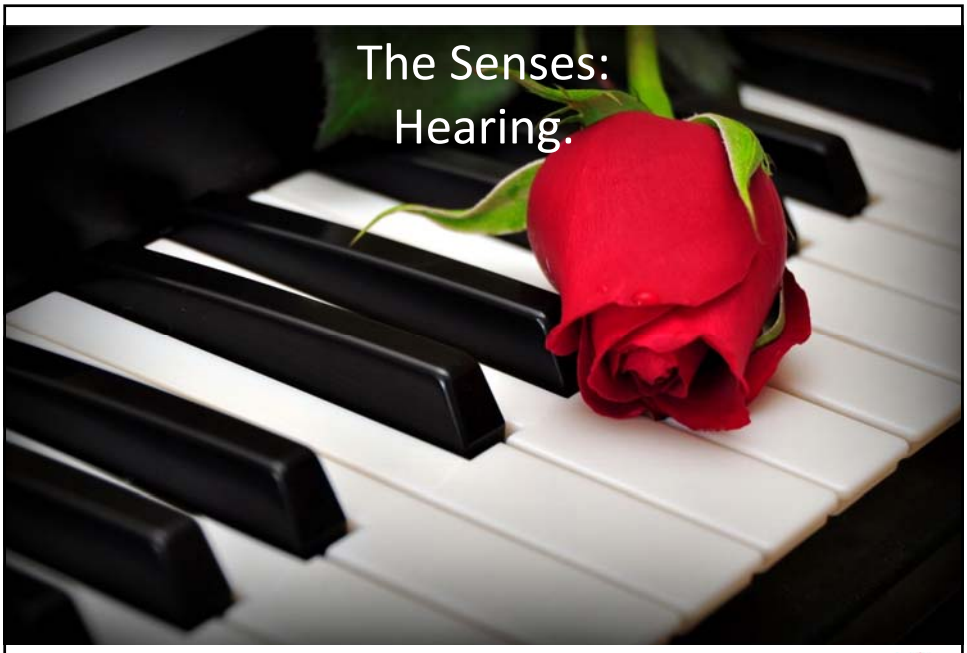
Chemical pheromone receptors on silkworm antennae

Statoliths inside statocyst mechano-receptors sense gravity, equilibrium.

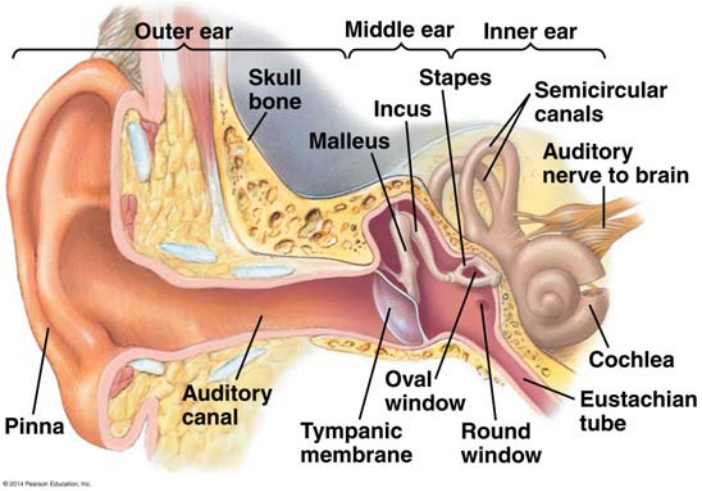


Hair cells: ciliated receptors

Invertebrates – tricked into upside down using magnetic statolith replacements

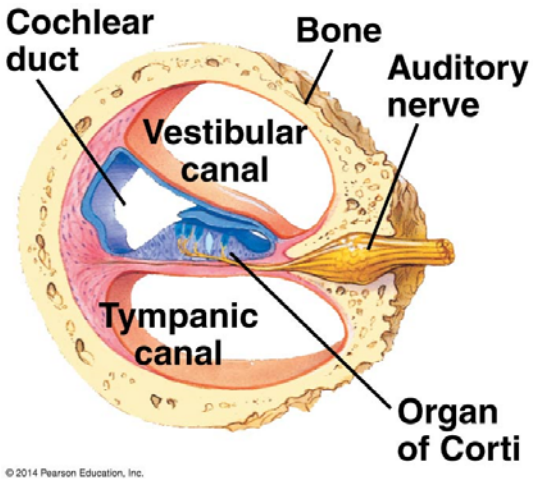


Sound is transduced by the eardrum to middle ear (hammer, anvil, stirrups).

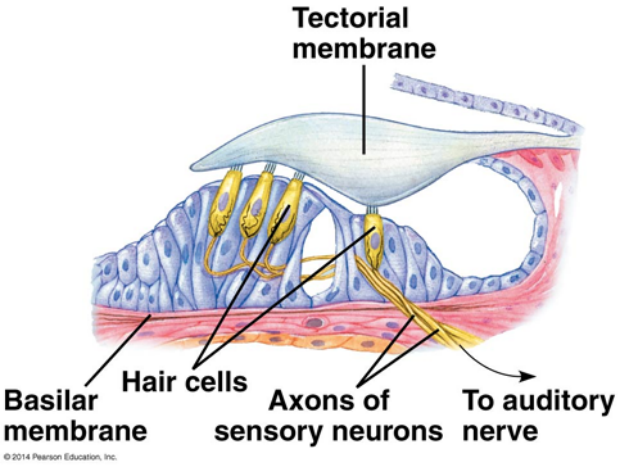


Stirrups transmit vibrations to oval window which opens to the cochlea.

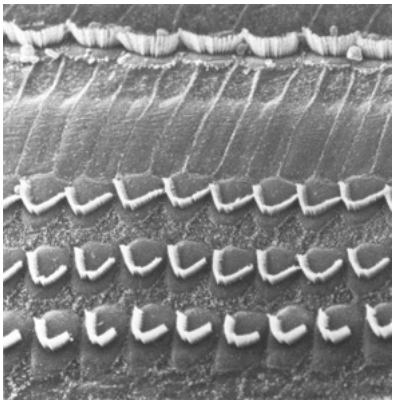
Fluid pressure in vestibular canal causes vibrations.



Organ of Corti on floor of the cochlear duct transduces sound to perception.



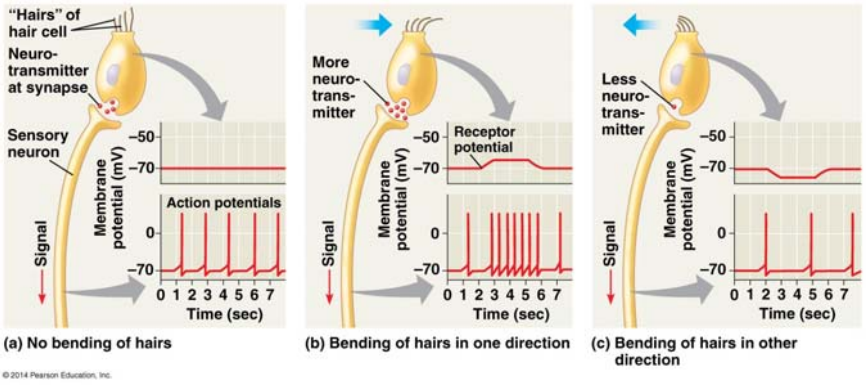
Hair cells on tectorial membrane are bent when basilar membrane vibrates.



Bundled hairs projecting from a single mammalian hair cell (SEM)

Mainly up and down motion of basilar

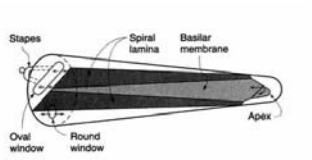
Basilar membrane vibrations cause hair cells to fire and refract -> sense.

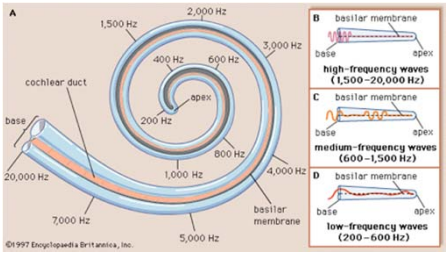


Mechanical distortion -> hair cell channels open or close

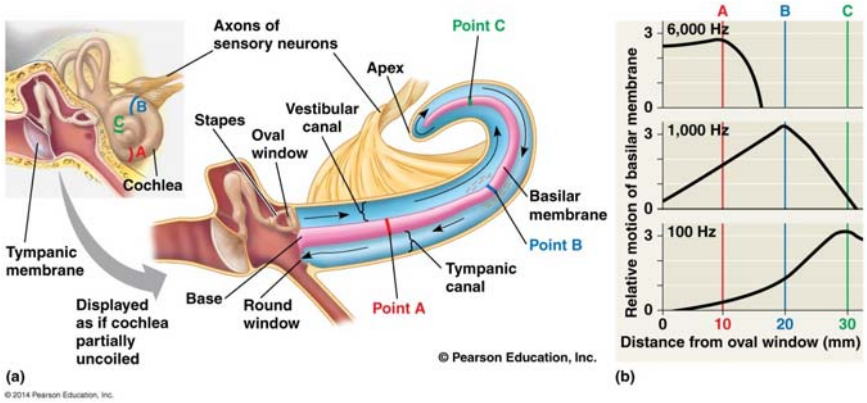
Volume - amplitude of hair cell deflect; pitch - location of deflect on cochlea.

Basilar membrane unrolled

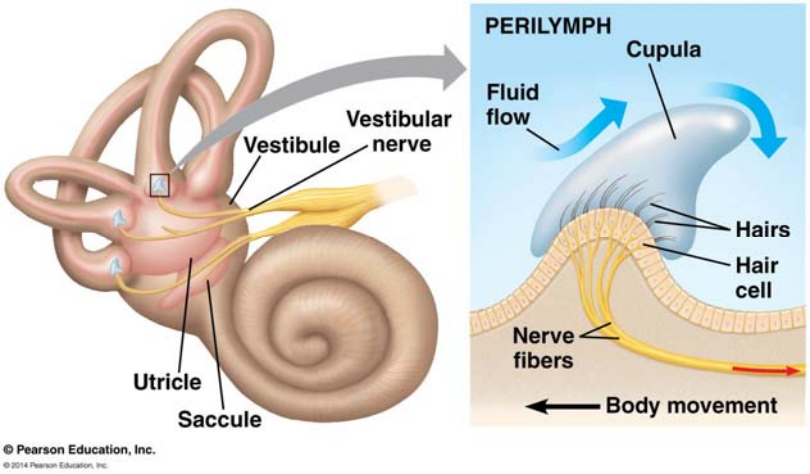




Pressure waves travel: oval window through cochlea to round window.



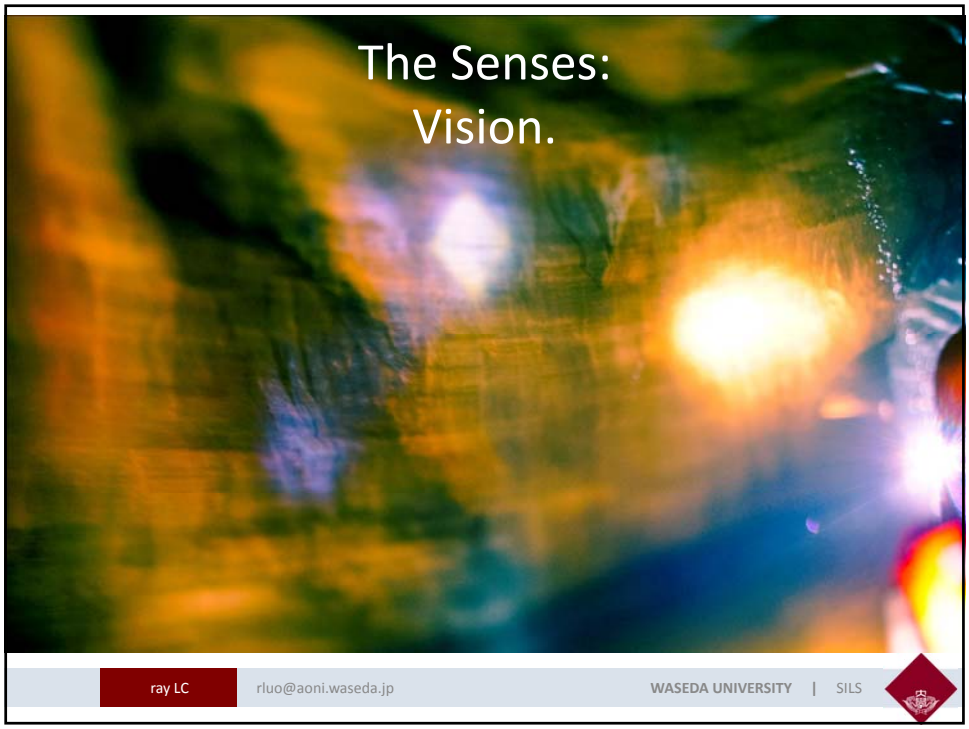
Utricle and saccule of semicircular canals sense equilibrium in humans.



Review: Hearing.

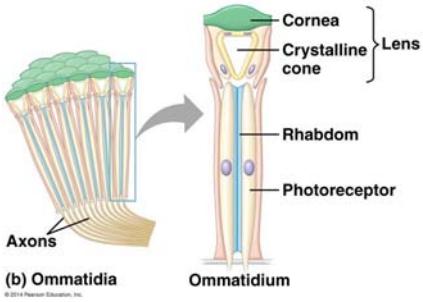
- Which sensory cells are common to the senses of hearing and equilibrium in humans?
  - A) otolithocytes
  - B) vestibular cells
  - C) ocelli
  - D) tectorial cells
  - E) hair cells

- The function of the basilar membrane is to
  - A) transmit vibrations from the tympanic membrane to the oval window.
  - B) vibrate up and down in response to the fluid pressure waves in the vestibular canal.
  - C) vibrate in response to moving air reaching the outer ear.
  - D) create pressure waves in the perilymph (fluid inside the cochlea).



Insects: motion-sensitive compound eyes with many ommatidia detectors.

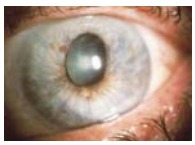
Makes it VERY hard to sneak up on insects!

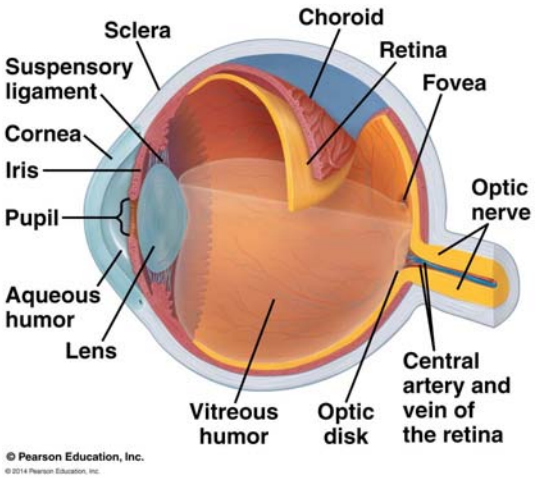


The human eye focuses by changing the shape of its single lens.

Pupil: light entry

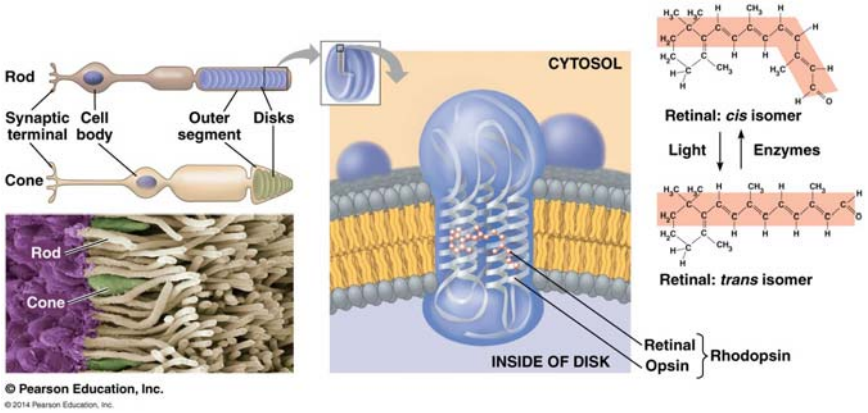
Glaucoma: failing to drain aqueus humor



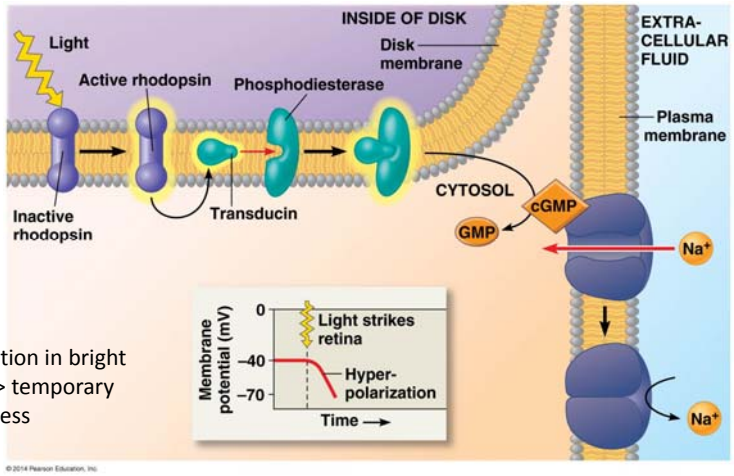


Two types of photoreceptors sensitive to light and colors are on the retina.

Rod: low acuity, high sensitivity, peripheral, BW
Cone (three types): high acuity, low sensitivity, central (foveal), color

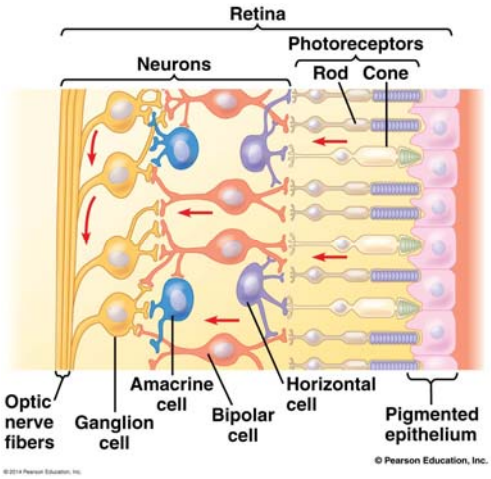


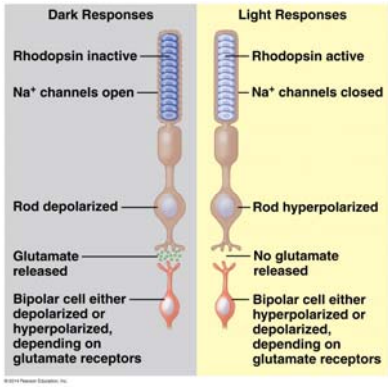
Light -> cis-to-trans retinal conversion -> hydrolyze cGMP -> close Na channel



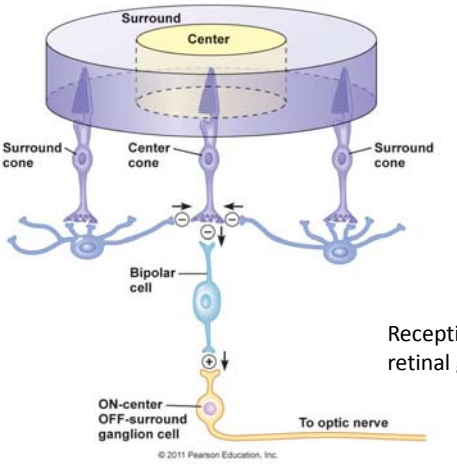
Saturation in bright light -> temporary blindness

Bipolar and ganglion cells integrate photoreceptor info at the retina.



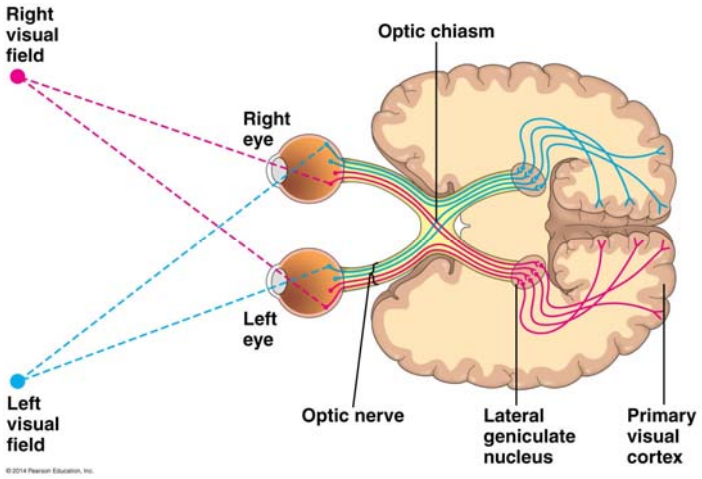


Lateral inhibition by horizontal and amacrine cells enhance contrast.

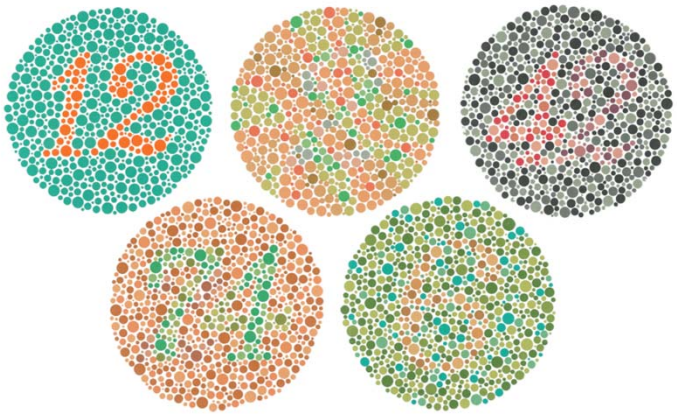


Receptive field of the retinal ganglion cell

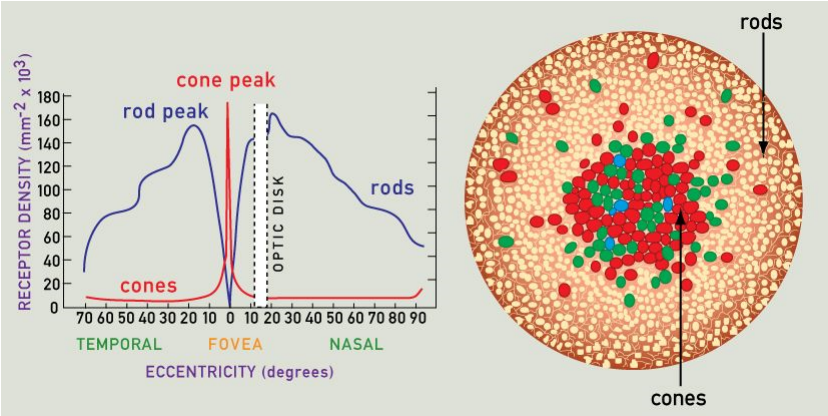
Ganglion cell axons exit the optic disk and form the optic nerve to the LGN.



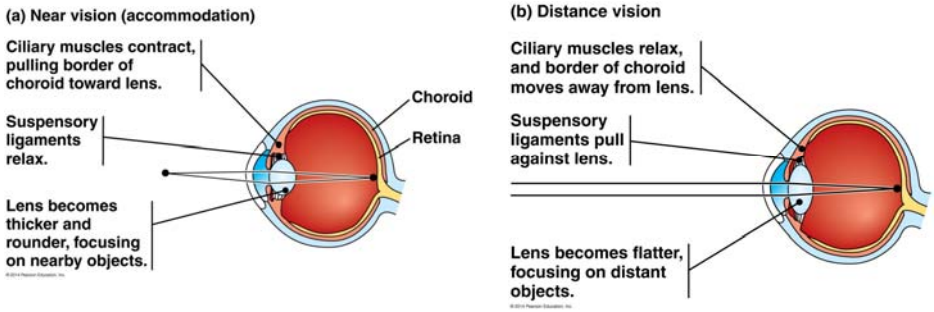
Defects in red or green photopsins of cones on X-chrom leads to color blind.



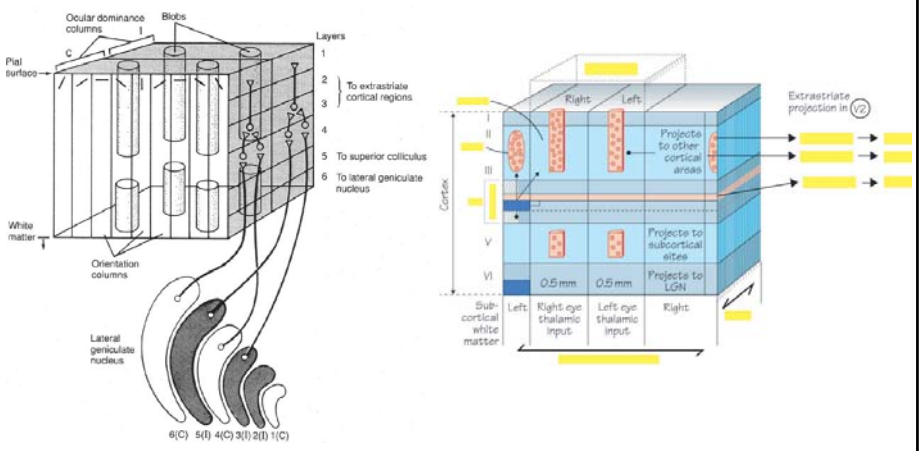
Day time vision relies on high acuity cones in the fovea; night time on rods.



Lens is thickened in order to see near objects; flattened for distant.



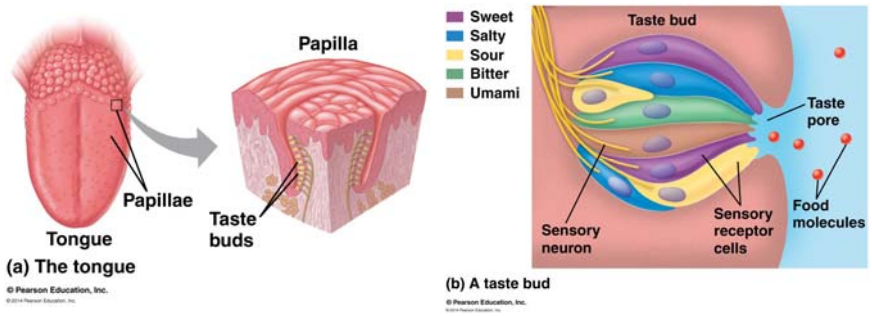
Visual cortex is organized into columns specific for orientations of vis scene.



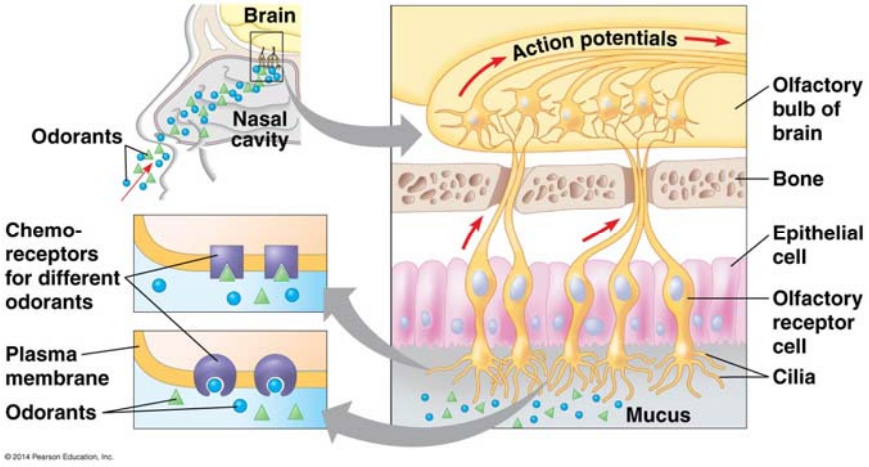
Review: Vision.

- In vertebrate eyes, the conversion of light energy to chemical energy occurs most directly as the result of changes to
  - A) phosphodiesterase.
  - B) Cyclic GMP (cGMP).
  - C) opsin.
  - D) retinal.
  - E) phosphodiesterase.
- Rod photoreceptors exposed to light will
  - A) depolarize due to the opening of sodium channels.
  - B) depolarize due to the opening of potassium channels.
  - C) hyperpolarize due to the opening of sodium channels.
  - D) hyperpolarize due to the closing of sodium channels.
  - E) hyperpolarize due to the opening of potassium channels.

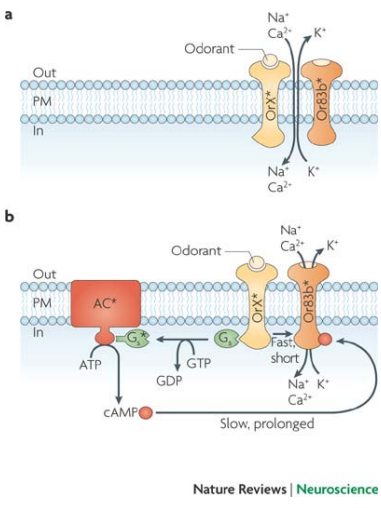
Taste buds contain sensory cells for each taste (sweet umami bitter GPCR)

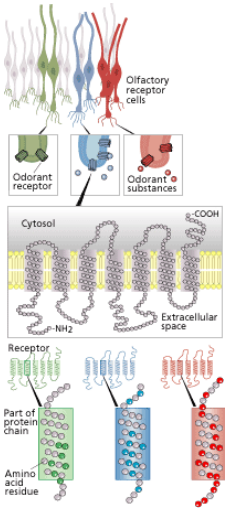


Odor sensors are neurons that go directly to the olfactory bulb.



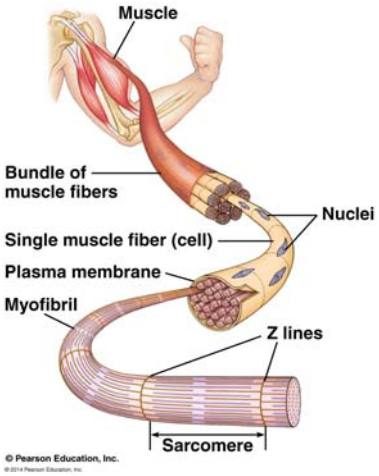
Odors bind to one of thousands of receptors -> cAMP -> Na Ca enter.

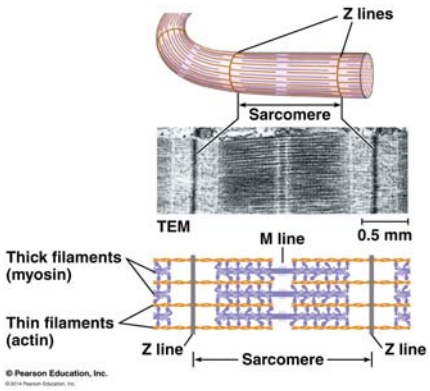




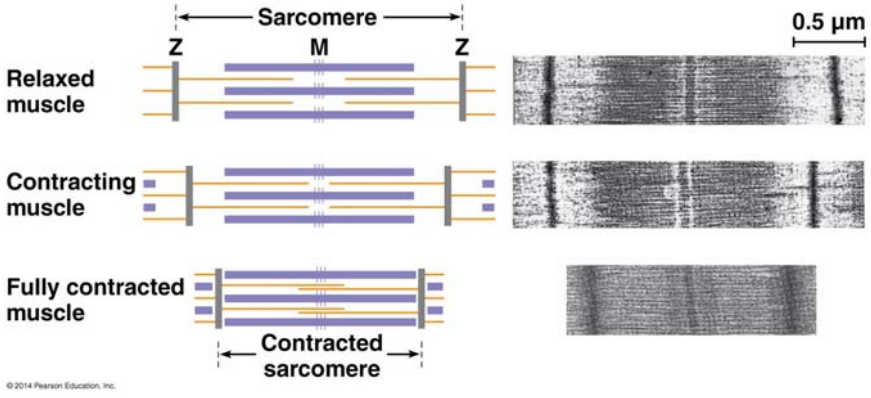
Effectors:
Muscular and Skeletal systems.

Muscle is made up of sarcomeres (M line of myosin, Z line of actin).

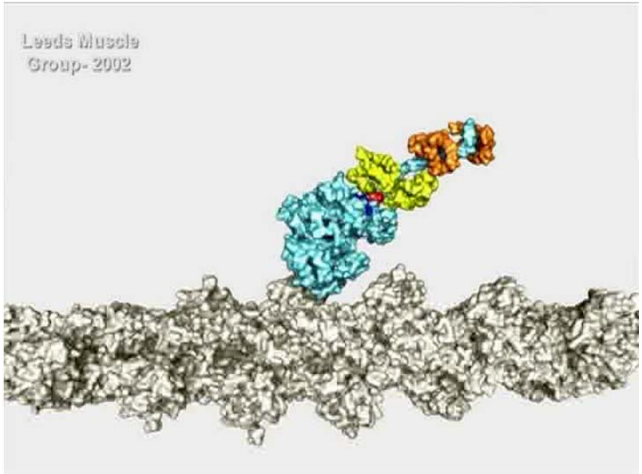




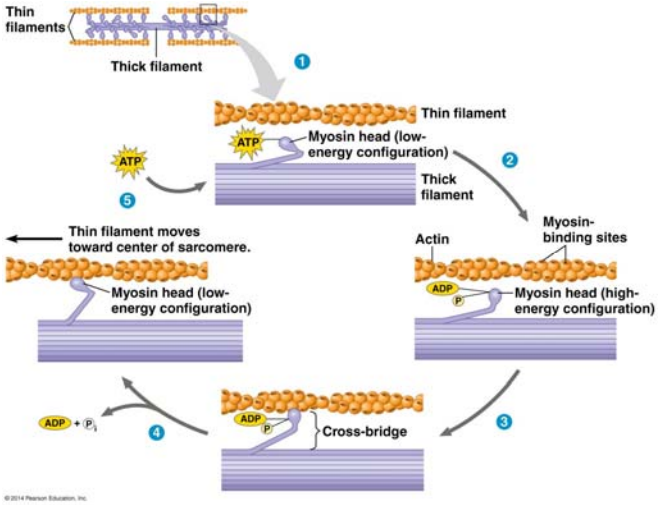
Myosin and actin stay the same length during muscle contraction.



ATP hydrolysis and release triggers myosin release and bind to actin.



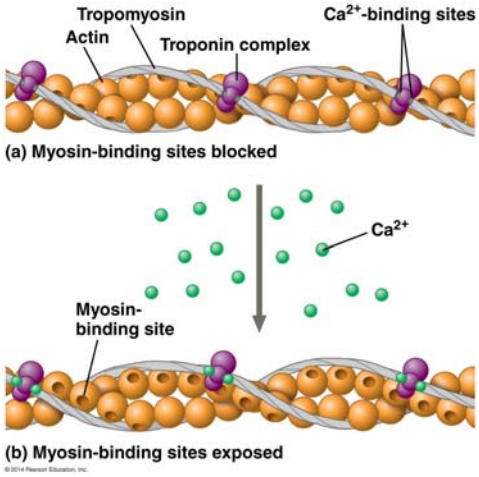
ATP hydrolysis leads to myosin head cross linked to actin, then ADP release.



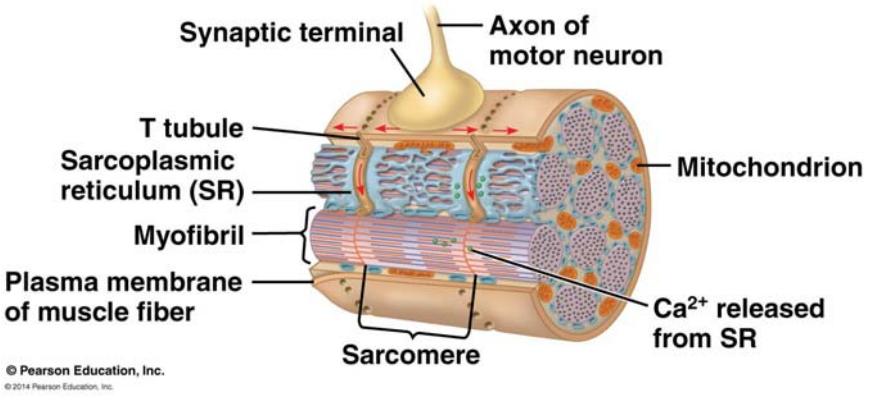
Regulation of muscle contraction at the level of the sarcomere.

- Creatine phosphate and glycogen breakdown to glucose provide phosphates to ATP.
- Intense activity -> lactic acid fermentation.
- Tropomyosin and troponin bound to actin.
- Calcium binds to troponin and moves tropomyosin away from myosin binding sites.
- Motor neuron degeneration => ALS; antibodies to mus AChR => myasthenia gravis.

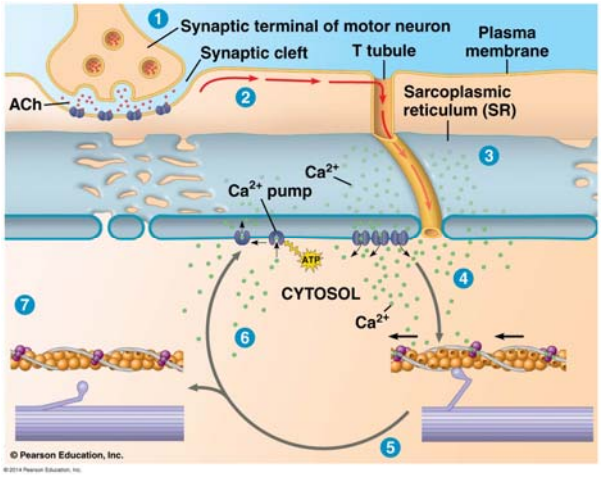
Calcium exposes myosin binding sites, allowing muscle contraction.



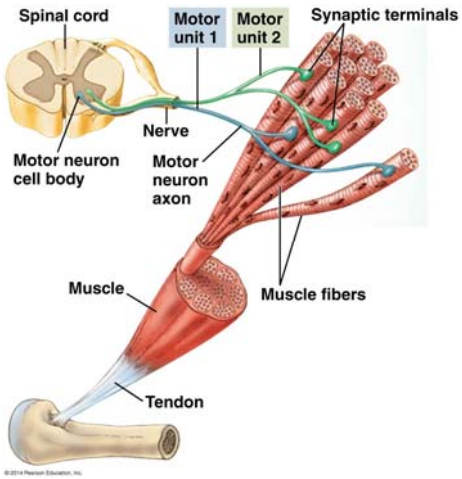
Action potential at the terminal of motor neuron -> acetylcholine release.



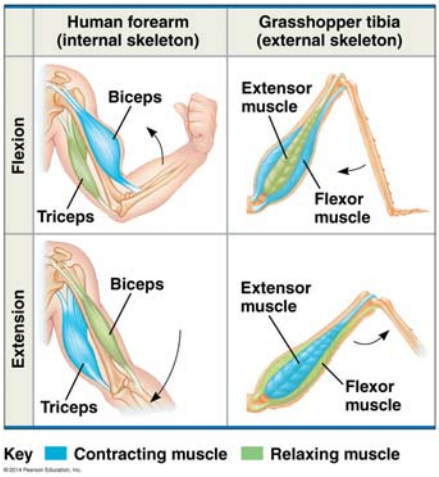
Action potential at the fiber along T tubules -> calcium release from SR.



Motor unit is the motor neuron and all fibers it synapses on (one cell a fiber).



Actual movement requires flexing and relaxing antagonistic muscle pairs.



Locomotion example: tube feet of echinoderms (starfish).