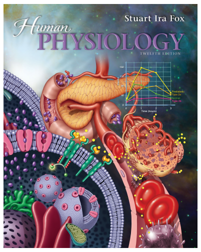
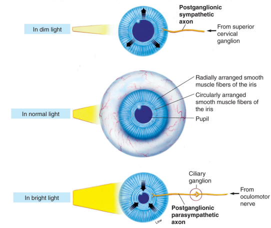


Chapter 10

Sensory Physiology

Lecture PowerPoint

I. Characteristics of Sensory Receptors



The Senses

- Sensory receptors transduce different forms of energy in the "real world" into nerve impulses.
- Different sensory perceptions (sound, light, pressure) arise from differences in neural pathways.
  - If the optic nerve delivers an impulse, the brain interprets it as light.

Functional Categories of Sensory Receptors

- Categorized according to the type of signal they transduce:
  - Chemoreceptors: sense chemicals in the environment (taste, smell) or blood
  - Photoreceptors: sense light
  - Thermoreceptors: respond to cold or heat
  - Mechanoreceptors: stimulated by mechanical deformation of the receptor (touch, hearing)

Sensory Receptors

Table 10.1 | Classification of Receptors Based on Their Normal (or "Adequate") Stimulus

Receptor	Normal Stimulus	Mechanisms	Examples
Mechanoreceptors	Mechanical force	Deforms cell membranes of sensory dendrites or deforms hair cells that activate sensory nerve endings	Cutaneous touch and pressure receptors; vestibular apparatus and cochlea
Pain receptors	Tissue damage	Damaged tissues release chemicals that excite sensory endings	Cutaneous pain receptors
Chemoreceptors	Dissolved chemicals	Chemical interaction affects ionic permeability of sensory cells	Smell and taste (exteroceptors) osmoreceptors and carotid body chemoreceptors (interoceptors)
Photoreceptors	Light	Photochemical reaction affects ionic permeability of receptor cell	Rods and cones in retina of eye

Nociceptors

- Pain receptors that depolarize when tissues are damaged
  - Stimuli can include heat, cold, pressure, or chemicals.
  - Glutamate and substance P are the main neurotransmitters.
  - Perception of pain can be enhanced by emotions and expectations.
  - Pain reduction depends on endogenous opioids.

Sensory Receptor Categories

- Receptors can be classified by the type of information they deliver to the brain:
  - Proprioceptors: found in muscles, tendons, and joints. Provide a sense of body position.
  - Interoceptors: respond to internal stimuli. Found in organs; monitor blood pressure, pH, and oxygen concentrations.

Sensory Receptor Categories

- Receptors can be classified by the type of information they deliver to the brain:
  - Exteroceptors: respond to stimuli from outside the body
    - Cutaneous receptors: deliver information from the skin and include touch, temperature, and pain
    - Special senses: sight, hearing, equilibrium, taste, and smell

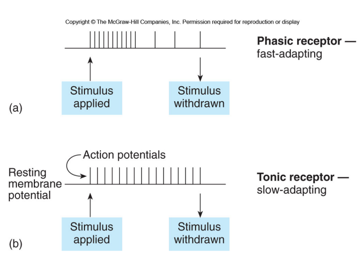
Tonic and Phasic Receptors

- Receptors can be categorized based on how they respond to a stimulus.
  - Phasic: respond with a burst of activity when stimulus is first applied but quickly adapt to the stimulus by decreasing response
    - May deliver another burst when stimulus is removed
    - Alert us to changes in the environment
    - Allow sensory adaptation
    - Smell, touch, temperature

Tonic and Phasic Receptors

- Receptors can be categorized based on how they respond to a stimulus.
  - Tonic: maintain a high firing rate as long as the stimulus is applied.

Tonic and Phasic Receptors



Law of Specific Nerve Energies

- Information from a given nerve fiber can only be experienced as one stimulus type.
- The sensation produced by the “adequate” or normal stimulus is the one the brain will perceive.
  - A punch to the eye is perceived as a flash of light.

Generator Potential

- Receptors behave very similarly to neurons.
- Stimuli produce depolarizations called *generator potentials.*
  - Light touch on a pacinian corpuscle in the skin produces a small generator potential.
  - Increasing the pressure increases the magnitude of the generator potential until threshold is met and an action potential occurs.

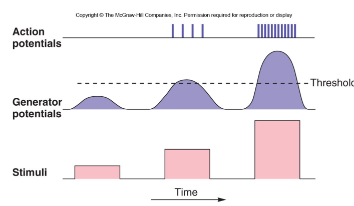
Generator Potential: Phasic Receptors

- Pacinian corpuscles are phasic receptors, so if pressure is maintained, generator potential is diminished.
  - This is a function of the structure of the receptor.

Generator Potential: Tonic Receptors

- In tonic receptors, the generator potential is proportional to the intensity of the stimulus.
  - Increased intensity results in increased frequency of action potential after threshold is reached.

Generator Potential: Tonic Receptors



II. Cutaneous Sensations

Cutaneous Receptors

- Pain, cold, and heat receptors are naked dendrites.
- Touch and pressure receptors have special structures around their dendrites.

Cutaneous Receptors

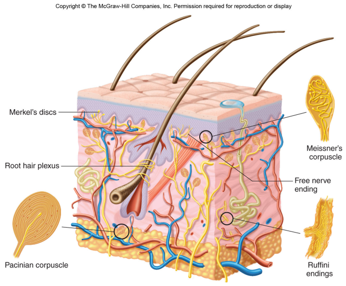
Table 10.2 | Cutaneous Receptors

Receptor	Structure	Sensation	Location
Free nerve endings	Unmyelinated dendrites of sensory neurons	Light touch; hot; cold; nociception (pain)	Around hair follicles; throughout skin
Merkel's discs	Expanded dendritic endings	Sustained touch and pressure	Base of epidermis (stratum basale)
Ruffini corpuscles (endings)	Enlarged dendritic endings with open, elongated capsule	Sustained pressure	Deep in dermis and hypodermis
Meissner's corpuscles	Dendrites encapsulated in connective tissue	Changes in texture; slow vibrations	Upper dermis (papillary layer)
Pacinian corpuscles	Dendrites encapsulated by concentric lamellae of connective tissue structures	Deep pressure; fast vibrations	Deep in dermis

Touch and Pressure Receptors

- Include:
  - Meissner's corpuscles
  - Pacinian corpuscles
  - Ruffini endings

Touch and Pressure Receptors



Cold Receptors

- There are many more receptors that respond to cold than to hot.
- Located close to the epidermis
- Stimulated by cold and inhibited by warm
- Some cold receptors also respond to menthol

Warm Receptors

- Located deeper in the dermis
- Excited by warming and inhibited by cooling
- Different from receptors that detect heat

Hot Receptors

- The pain experienced by a hot stimulus is sensed by a special nociceptor called a capsaicin receptor.
  - Serves as an ion channel for sodium and calcium
  - Also a receptor for the chemical found in chili peppers

Pain Receptors

- Nociceptors can be myelinated or unmyelinated.
  - Sudden, sharp pain is transmitted by myelinated neurons.
  - Dull, persistent pain is transmitted by unmyelinated neurons.
- Nociceptors may be activated by chemicals released by damaged tissues, such as ATP.

Neural Pathways for Somatesthetic Sensations

- From pressure receptors and proprioceptors:
  - Carried by large myelinated fibers that ascend the dorsal columns of the spinal cord on the ipsilateral side
  - Synapse in the medulla oblongata
  - The second tier of neurons cross sides as they ascend the medial lemniscus to the thalamus, where they synapse.
  - Third-order neurons go to the postcentral gyrus.

Neural Pathways for Somatesthetic Sensations

- From heat, cold, and pain receptors:
  - Carried into spinal cord by thin myelinated and unmyelinated neurons
  - Synapse within spinal cord onto second-order neuron.
  - Cross sides and ascend lateral spinothalamic tract
  - Synapse on third-order neurons in thalamus and continue to the postcentral gyrus

More About Pain

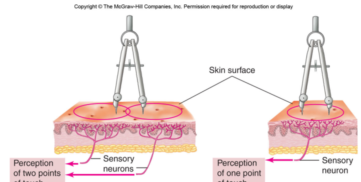
- Emotional response to pain occurs when information is sent from the thalamus to the cingulate gyrus (part of the limbic system).
- Sometimes somatic pain information can synapse on the same interneuron as a neuron carrying visceral pain information. The brain may interpret heart pain as arm pain, or gallbladder pain as back pain:
  - Referred pain

Receptive Fields

- The receptive field is the area of skin that, when stimulated, changes the firing rate of a neuron.
  - The size of a receptive field depends on the density of receptors in that region of skin.
  - There are few receptors in the back and legs, so the receptive fields are large.
  - There are many receptors in the fingertips, so the receptive fields are small.
  - A small receptive field = greater tactile acuity.

Two-point Touch Threshold

- Receptive fields can be measured by seeing at what distance a person can perceive two separate points of touch.



Two-Point Touch Threshold

Table 10.3 | The Two-Point Touch Threshold for Different Regions of the Body

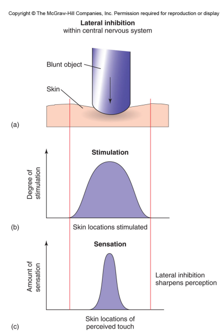
Body Region	Two-Point Touch Threshold (mm)
Big toe	10
Sole of foot	22
Calf	48
Thigh	46
Back	42
Abdomen	36
Upper arm	47
Forehead	18
Palm of hand	13
Thumb	3
First finger	2

Source: From S. Weinstein and D.R. Kenshalo, editors, *The Skin Senses*, © 1968. Courtesy of Charles C. Thomas, Publisher, Ltd., Springfield, Illinois.

Lateral Inhibition

- Receptors that are most strongly stimulated inhibit those around them.
- This allows us to perceive well-defined sensations at a single location.

Lateral Inhibition



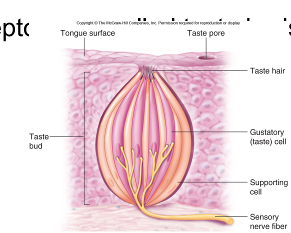
III. Taste and Smell

Chemoreceptors

- Interoceptors detect chemical changes within the body.
- Exteroceptors include taste and smell.
  - Taste responds to chemicals dissolved in food and drink.
  - Smell responds to chemical molecules in the air.

Taste

- Also called gustation
- Recept 's



Taste Buds

- Located in bumps on the tongue called *papillae*
- Types of papillae:
  - Fungiform: anterior surface
    - Information travels via facial nerve.
  - Circumvallate: posterior surface
  - Foliate: sides
    - Information travels via glossopharyngeal nerve.

Taste Pathways

Facial and glossopharyngeal nerve →

Medulla oblongata →

Thalamus →

Primary gustatory cortex of insula, somatosensory cortex of parietal lobe, and prefrontal cortex

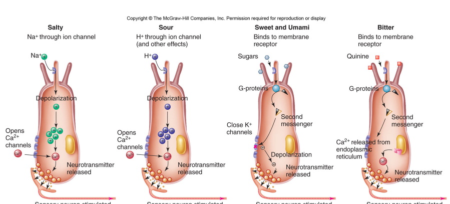
Taste Cells of Taste Buds

- Specialized epithelial cells
  - Cells behave like neurons by depolarizing and producing action potentials.
  - Cells release neurotransmitters onto sensory neurons.
  - Microvilli come into contact with chemicals.
  - Each taste bud has taste cells sensitive to each category of tastes.

Five Categories of Taste

- Salty
- Sour
- Sweet
- Umami
- Bitter

Five Categories of Taste



How Taste Works

- Salty: Na^+ enters taste cell and depolarizes it.
- Sour: H^+ enters cell and depolarizes it.
- Sweet and umami: Sugar or glutamate binds to receptor and activates G-proteins/2nd messengers to close K^+ channels.
- Bitter: Quinine binds to receptor, activates G-protein/2nd messenger to release Ca^{2+} into the cell.

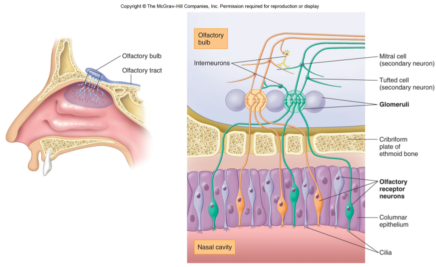
Taste G-proteins and 2nd Messengers

- G-proteins are called gustducins.
- In the sweet system, sugar activates adenylate cyclase, which produces cAMP.
- Other molecules may activate IP3 and DAG.

Smell

- Smell is also called *olfaction.*
- Olfactory receptors are located in the olfactory epithelium of the nasal cavity.
- Sustentacular cells oxidize hydrophobic volatile odors.
- Basal stem cells replace receptors damaged by the environment.

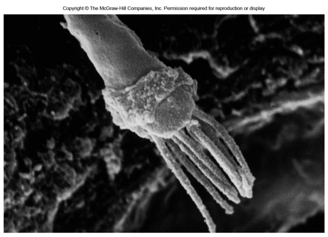
Smell



Olfactory Receptors

- Olfactory receptors are bipolar neurons with ciliated dendrites projecting into the nasal cavity.
- Proteins in the cilia bind to odors.
- ~350 genes code for ~350 different olfactory receptors.

Olfactory Receptors

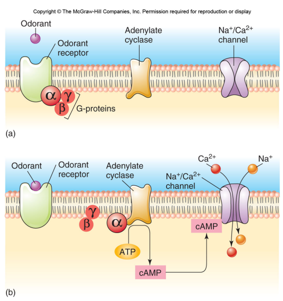


Courtesy of Dean E. Hillman;

Olfactory Receptors

- G-protein coupled
- Odor binding activates adenylate cyclase to make cAMP.
- Opens Na^+ and Ca^{2+} channels

Olfactory Receptors



Olfactory Pathways

- Olfactory neurons are unmyelinated and synapse on a glomerulus in the olfactory bulb.
  – Each type of olfactory receptor synapses on a particular glomerulus.
  – A flower (complex array of odor molecules) may excite several types of odor receptors.
  – This is coded according to which glomeruli are stimulated.

Olfactory Pathways

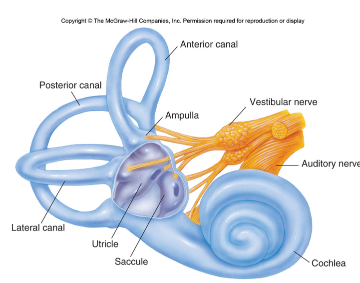
- Neurons from the olfactory bulb synapse on the prefrontal cortex, medial temporal lobes, hippocampus, and amygdala.

IV. Vestibular Apparatus and Equilibrium

Vestibular Apparatus

- Provides a sense of equilibrium
- Located in the inner ear
- Consists of:
  – Otolith organs
    - Utricle and saccule
  – Semicircular canal

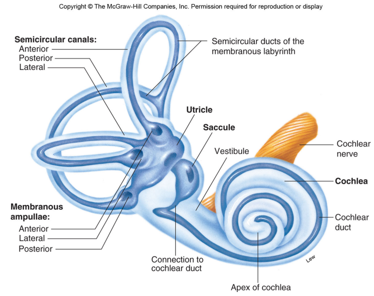
Vestibular Apparatus



Inner Ear

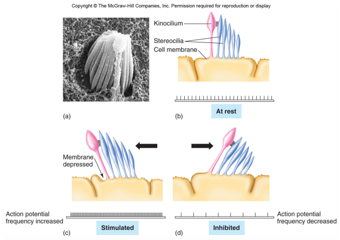
- Consists of a bony labyrinth surrounding a membranous labyrinth
  – Between the two is fluid called perilymph.
  – Within the membranous labyrinth is fluid called endolymph.
  – Endolymph has an unusually high K^+ concentration.

Inner Ear



Sensory Hair Cells

- Modified epithelial cells with 20–50 hairlike extensions called stereocilia (not true cilia) and one kinocilium (true cilium)



(a) Courtesy of Dean E. Hillman

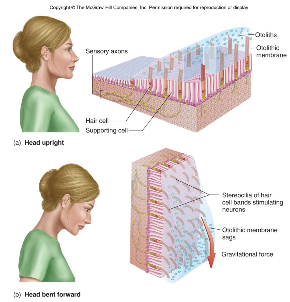
Sensory Hair Cells

- When stereocilia bend toward the kinocilium, K^+ channels open, and K^+ rushes into the cell.
- Cells release a neurotransmitter that depolarizes sensory dendrites in the vestibulocochlear nerve.
- Bending away from the kinocilium hyperpolarizes sensory dendrites.
- Code for detection of direction

Utricle and Saccule

- Provide information about linear acceleration:
  – Utricle: horizontal
  – Saccule: vertical
- Specialized epithelium called the macula houses hair cells.
  – Stereocilia are embedded in a gelatinous otolithic membrane.

Otolithic Organ

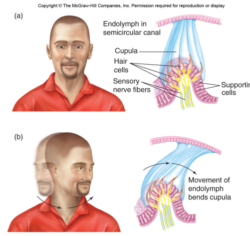


Semicircular Canals

- Project along three planes to detect rotation:
  - Each canal contains a semicircular duct filled with endolymph.
  - At the base of each duct is an enlarged area called the ampulla.
  - Hair cells are embedded in the crista ampullaris, with stereocilia stuck into a gelatinous cupula.

Semicircular Canals

- Rotation makes the endolymph circulate, pushing the cupula and bending the hair cells.



Neural Pathways

- The vestibulocochlear nerve synapses in the medulla.
- The medulla sends neurons to the oculomotor area of the brain stem to control eye movements and down the spinal cord to adjust body movements.

Nystagmus

- When a person's body is spinning, eye movements are toward the opposite direction of the spin to maintain a fixation point.
- When the body comes to a stop, the cupula is bent by fluid inertia and eye movements are still affected.
- The jerky eye movement produced is called nystagmus.

Vertigo

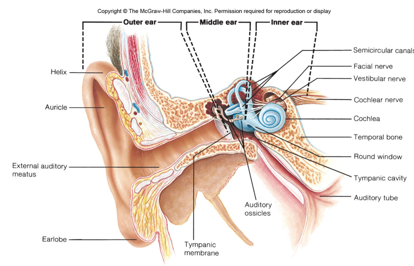
- Nystagmus can cause a loss of equilibrium called vertigo
  - Can be accompanied by dizziness, pallor, sweating, nausea, and vomiting

V. The Ears and Hearing

Sound Waves

- Characterized by:
  - Frequency, measured in hertz (Hz). Higher frequencies have higher pitches.
    - Human range is 20−20,000 Hz.
  - Intensity or loudness, measured in decibels

The Ear



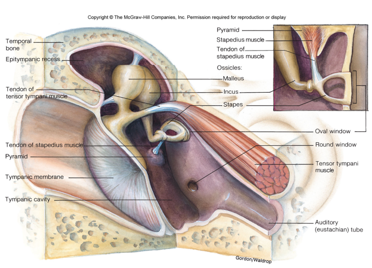
Outer Ear

- Sound waves are funneled by the pinna (or auricle) into the external auditory meatus, which channels them to the tympanic membrane (eardrum).

Middle Ear

- Cavity between the tympanic membrane and the cochlea
- Contains three bones called ossicles:
  - Malleus → incus → stapes
  - Vibrations are transmitted and amplified along the bones.
  - The stapes is attached to the oval window, which transfers the vibrations into the inner ear.

Structures of the Middle Ear



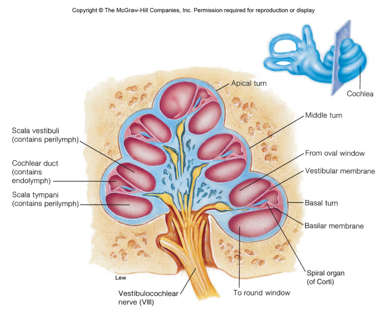
The Cochlea: Bony Labyrinth

- The cochlea is the hearing part of the inner ear.
- Three chambers:
  - The upper chamber is a portion of the bony labyrinth called the scala vestibuli.
  - There is also a lower bony chamber called the scala tympani.
  - Both chambers are filled with perilymph.

The Cochlea: Membranous Labyrinth

- The cochlea also contains a portion of the membranous labyrinth called the scala media, or cochlear duct, filled with endolymph.
  - Middle chamber

The Cochlea: Membranous Labyrinth



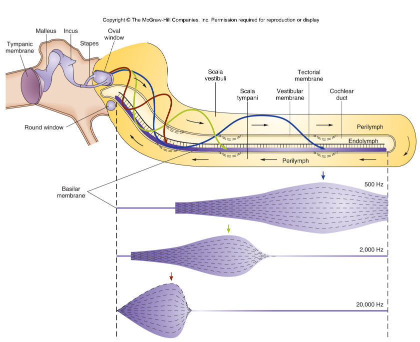
Sound Transmission

- Vibrations from the oval window of the middle ear displace perilymph in the scala vestibuli.
- Vibrations pass into the cochlear duct through the endolymph.
- Next, vibrations pass into the perilymph of the scala tympani.
- Vibrations leave the inner ear via the round window.

Sound Transmission

- Where along the cochlear duct sound waves are transmitted depends on the frequency of the sound.
  - Low-frequency sounds travel further down the spiral of the cochlea.

Sound Frequency and Hearing



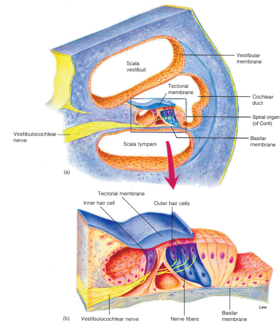
Spiral Organ (Organ of Corti)

- Sensory hair cells are located on the basilar membrane of the scala media.
  - Inner hair cells: form one row that runs the length of the basilar membrane. Each is innervated by 10−20 sensory neurons.
  - Outer hair cells: arranged in rows. They are innervated by motor neurons that make them shorten when depolarized and elongate when hyperpolarized

Sensory Hair Cells

- Stereocilia are embedded in a gelatinous tectorial membrane.
- When sound waves enter the scala media, the tectorial membrane vibrates, bending stereocilia.
  - Opens K^+ channels
  - K^+ rushes in, depolarizing the cell
  - Releases glutamate onto sensory neurons

Organ of Corti



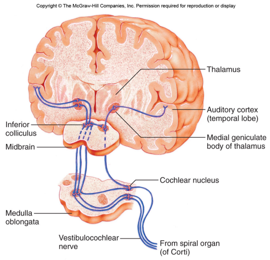
Detecting Sound Frequency

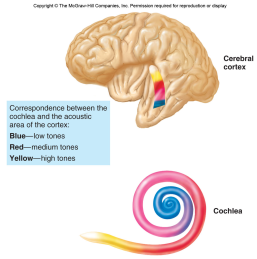
- Hair cells located closest to where the vibrations are displaced into the scala media are stimulated more often.
- Outer hair cells magnify this effect, which allows us to differentiate between very similar pitches.

Neural Pathways

Vestibulocochlear nerve →
Medulla oblongata →
Inferior colliculus of midbrain →
Thalamus →
Auditory cortex of temporal lobe; said to be tonotopic = areas represent different sound frequencies.

Neural Pathways





Hearing Impairment

- Conduction deafness: Sound waves are not conducted from the outer to the inner ear.
  - May be due to a buildup of earwax, too much fluid in the middle ear, damage to the eardrum, or overgrowth of bone in the middle ear
  - Impairs hearing of all sound frequencies
  - Can be helped by hearing aids

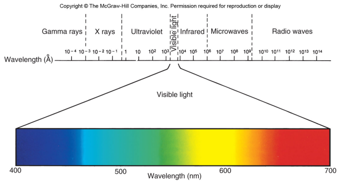
Hearing Impairment

- Sensorineural/perceptive deafness: Nerve impulses are not conducted from the cochlea to the auditory cortex.
  - May be due to damaged hair cells (from loud noises)
  - May only impair hearing of particular sound frequencies and not others
  - May be helped by cochlear implants

VI. The Eyes and Vision

The Eyes

- Transduce light energy into nerve impulses
  - Only a limited part of the electromagnetic spectrum can excite photoreceptors.

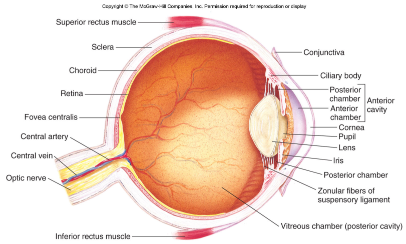


Structures of the Eye

Table 10.4 | Structures of the Eyeball

Tunic and Structure	Location	Composition	Function
Fibrous tunic	Outer layer of eyeball	Avascular connective tissue	Gives shape to the eyeball
Sclera	Posterior outer layer; white of the eye	Tightly bound elastic and collagen fibers	Supports and protects the eyeball
Cornea	Anterior surface of eyeball	Tightly packed dense connective tissue—transparent and convex	Transmits and refracts light
Vascular tunic (uvea)	Middle layer of eyeball	Highly vascular pigmented tissue	Supplies blood; prevents reflection
Choroid	Middle layer in posterior portion of eyeball	Vascular layer	Supplies blood to eyeball
Ciliary body	Anterior portion of vascular tunic	Smooth muscle fibers and glandular epithelium	Supports the lens through suspensory ligament and determines its thickness; secretes aqueous humor
Iris	Anterior portion of vascular tunic; continuous with ciliary body	Pigment cells and smooth muscle fibers	Regulates the diameter of the pupil, and hence the amount of light entering the vitreous chamber
Internal tunic	Inner layer of eyeball	Tightly packed photoreceptors, neurons, blood vessels, and connective tissue	Provides location and support for rods and cones
Retina	Principal portion of internal tunic	Photoreceptor neurons (rods and cones), bipolar neurons, and ganglion neurons	Photoreception; transmits impulses
Lens (not part of any tunic)	Between posterior and vitreous chambers; supported by suspensory ligament of ciliary body	Tightly arranged protein fibers; transparent	Refracts light and focuses onto fovea centralis

Structures of the Eye



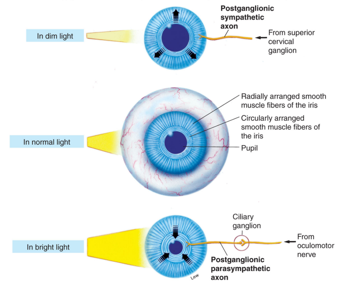
Structures of the Eye

- Light passes through the cornea and into the anterior chamber of the eye.
- Next, it passes through the pupil, which can change shape to allow more or less light in.
- Then it passes through the lens, which can change shape to focus the image.
- Finally, it hits the retina, where photoreceptors are found.

Pupil and Iris

- The iris can increase or decrease the diameter of the pupil.
  - Constriction: contraction of circular muscles via parasympathetic stimulation
  - Dilation: contraction of radial muscles via sympathetic stimulation

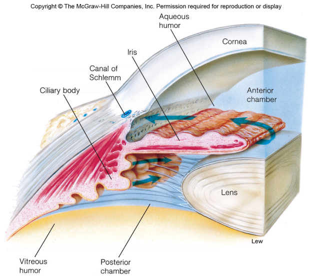
Pupil and Iris



Aqueous Humor

- Fills anterior chamber
- Secreted by ciliary bodies to provide nourishment to lens and cornea
- Drains into scleral venous sinus
- Inadequate drainage leads to glaucoma

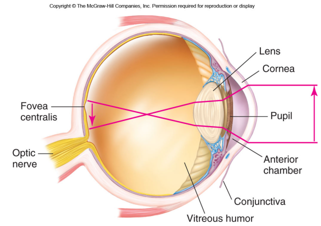
Aqueous Humor



Light Refraction

- When light passes from one medium to another, it bends.
  - Curvature at the point of refraction can also bend light.
  - Changing the curvature of the lens allows fine control of focus.
  - The image is flipped upside down in this process.

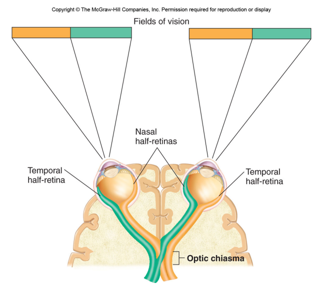
Light Refraction



Visual Fields

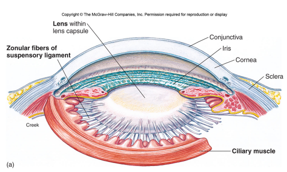
- Visual fields are the part of the external world projected onto the retina.
  - The right side is projected onto the left side of the retina.
  - The left side is projected onto the right side of the retina.

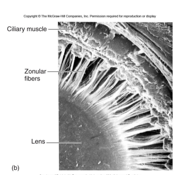
Visual Fields



Lens

- Suspended from suspensory ligaments
- Attached to muscles called ciliary bodies





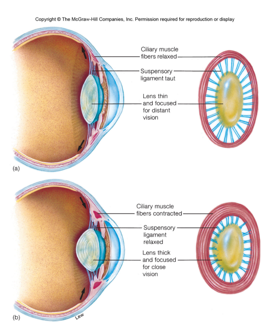
Lens Accommodation

- Accommodation is the ability of the lens to keep an object focused on the retina as the distance between the eye and the object moves.
  - Contraction of the ciliary muscle allows the suspensory ligaments to relax and the lens to thicken.
    - This is good for close vision.

Lens Accommodation

- Relaxation of the ciliary muscle pulls on the suspensory ligaments, causing the lens to thin.
  - This is good for distant vision

Lens Accommodation



Myopia

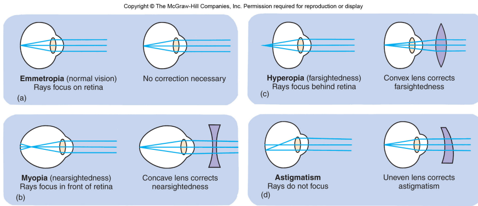
- Nearsightedness
- Distant images are brought to a point of focus in front of the retina.
  - Often due to an elongated eyeball
  - Corrected by concave lenses in eyeglasses

Hyperopia

- Farsightedness
- Distant images are brought to a point of focus behind the retina.
  - Often due to a short eyeball
  - Corrected by lenses that are convex

Astigmatism

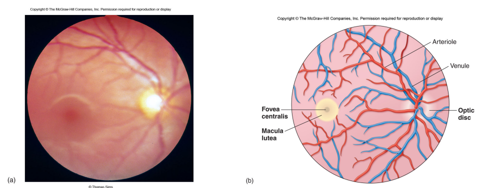
- Asymmetry between the cornea and lens
  - Corrected by cylindrical lenses



VII. The Retina

Retina

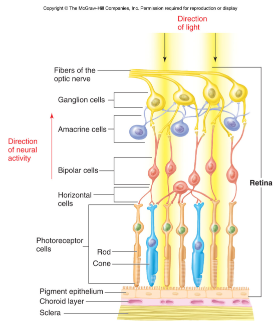
- Neuron axons in the retina are gathered at a point called the optic disc (blind spot).
- Blood vessels also enter here.



Layers of the Retina

- Photoreceptors (rods and cones) are in the inner layer.
- These synapse on a middle layer of bipolar cells, which synapse on the outer layer of ganglion cells.

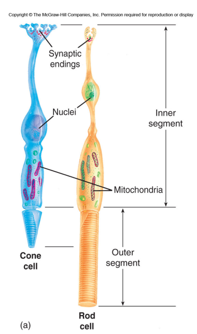
Layers of the Retina



Rods and Cones

- Consist of:
  - Outer segment; full of flattened discs with photopigment molecules
  - Inner segment

Rods and Cones



Retinal Pigment Epithelium

- Located under the rods and cones
- Help vision by:
  - Phagocytizing shed outer discs
  - Absorbing scattered light
  - Delivering nutrients to rods and cones
  - Suppressing immune attack in retina
  - Participating in visual cycle of retina
  - Stabilizing ionic concentrations in area

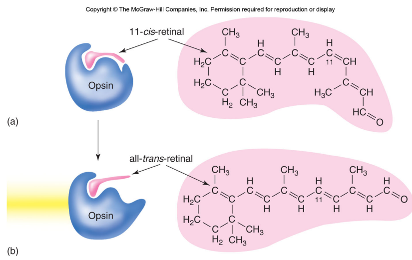
Rods

- Allow black-and-white vision in low light
- Contain the pigment rhodopsin, which absorbs green light best
  - Absorption causes rhodopsin to dissociate into retinaldehyde and opsin.
    - Retinaldehyde (also called retinal) is derived from vitamin A.
  - Called the bleaching reaction

Visual Cycle of Retinal

- In rhodopsin, retinal exists in an 11-*cis* form.
- After bleaching, the retinal is in an all-*trans* form.
- To be reincorporated into retinal, it must be converted back into 11-*cis.*
- This occurs in the pigment epithelial cells.

Bleaching



Dark Adaptation

- When a person enters a dark room after being in the light, there are fewer photopigments in the rods and cones.
- After about 20 minutes, more visual pigments are produced, and the person's eyes adapt to the dark.

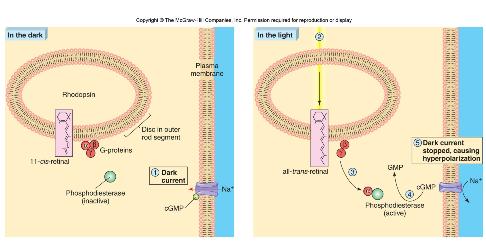
Dark Current

- In the dark, photoreceptors inhibit (hyperpolarize) bipolar cells.
- Na^+ channels in rods and cones are always open, depolarizing the photoreceptor.
- This allows the photoreceptor to release inhibiting neurotransmitter in the dark.

When Light Hits Photoreceptors

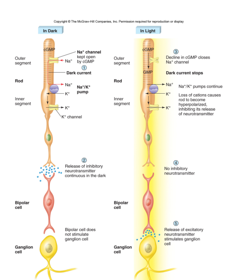
- Dissociation of rhodopsin activates a G-protein/2nd messenger system, which closes Na^+ channels.
  - G-proteins are called transducins.
  - Activation of the enzyme phosphodiesterase converts cGMP to GMP.
  - This closes Na^+ channels.
- Photoreceptors are hyperpolarized, and inhibition on bipolar cells is lifted.

Dark Current/Light



Effects of Light on Retinal Cells

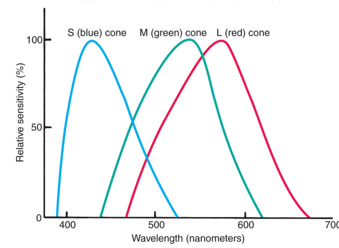
- Bipolar cells can now stimulate ganglion cells.



Cones

- Cones are less sensitive to light, but allow color vision and greater visual acuity.
  - Trichromatic vision involves three types of cones.
    - S: short wavelengths, blue
    - M: medium wavelengths, green
    - L: long wavelengths, red

Cones



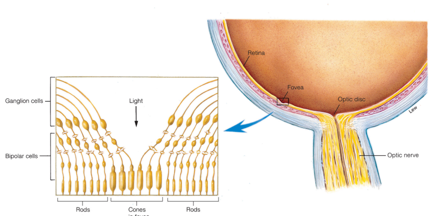
Cones

- Instead of opsins, photopigments have photopsins.
- Photopsins vary in each type of cone.

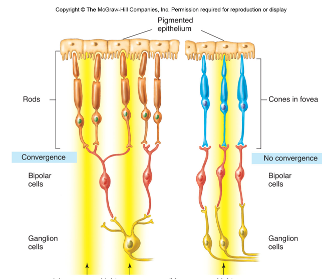
Visual Acuity and Sensitivity

- Vision is best at one point in the retina, called the fovea centralis.
  - Here, other layers of the retina are pushed aside, so light falls directly on a group of cones.
  - Each cone has a 1:1 relationship with a ganglion cell (usually it is 105:1), which allows great visual acuity.
  - Only works in good light.
- Convergence of lots of rods onto a single ganglion cell increases light sensitivity.

Fovea Centralis



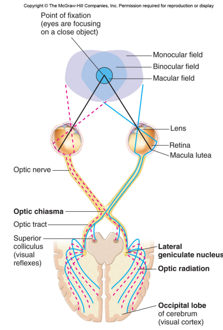
Retinal Convergence and Light Sensitivity



Neural Pathways

- Axons from ganglion cells synapse on the lateral geniculate nucleus of the thalamus.
  - Information from the lateral portion of the retinas does not cross sides, but information from the medial portion does.

Neural Pathways



Neural Pathways

- Neurons from the thalamus synapse on the striate cortex of the occipital lobe.
- 20−30% of the ganglion cell axons synapse on the superior colliculus of the midbrain, which helps with eye and body movements.

Control of Eye Movement

- Produced by contraction of extrinsic eye muscles
- Three types of movement
  1. Saccadic eye movement: high-velocity movements that keep the image focused on the fovea centralis (good when reading)
  2. Smooth pursuit movements: match the speed of a moving object
  3. Vergence movements: allow both eyes to converge so image is at the fovea of both eyes

Ganglion Cells

- Have a photopigment of their own called melanopsin:
  - Sends information about illumination (brightness of light)
  - Helps control pupillary reflex (constriction in bright light)
  - Sets circadian rhythms in suprachiasmatic nucleus of hypothalamus

VIII. Neural Processing of Visual Information

Ganglion Cell Receptive Fields

- Area of the retina with photoreceptors that send input to that ganglion cell
- Some ganglion cells have on-center fields:
  - A light in the center of the receptive field stimulates the ganglion cell strongly.
  - A light toward the edge of the receptive field inhibits the ganglion cell.

Ganglion Cell Receptive Fields

- Some ganglion cells have off-center fields:
  - A light in the center of the receptive field inhibits the ganglion cell.
  - A light toward the edge of the receptive field stimulates the ganglion cell.

Ganglion Cell Receptive Fields

- This allows enhancement of edges, improving visual clarity