BIOH111

○ Cell Module
○ Tissue Module
○ Skeletal system
○ Muscle system
○ Nervous system
○ Endocrine system
○ Integumentary system
Textbook and required/recommended readings

- Sensations: Principles of anatomy and physiology. Tortora et al; 14th edition: Chapter 16; sections 16.1 and 16.2

- Special senses: Principles of anatomy and physiology. Tortora et al; 14th edition: Chapter 17; sections 17.1, 17.2, 17.3 and 17.4
BIOH111 – NERVOUS SYSTEM MODULE

- Session 15 (Lectures 27 and 28) – Organisation and histology of the nervous system
- Session 16 (Lectures 29 and 30) – Function of neurons: conduction of nerve impulses
- Session 17 (Lectures 31 and 32) – CNS: Brain anatomy and function
- Session 18 (Lectures 33 and 34) – Sensations and special senses
- Session 19 (Lectures 35 and 36) – Spinal cord anatomy and physiology
- Session 20 (Lectures 37 and 38) – Spinal nerves and somatic sensory and motor pathways
- Session 21 (Lectures 39 and 40) – Autonomic nervous system: anatomy and function
Objectives

Lecture 33:
- Sensation
  - Explain the concept of sensation and sensory modalities
  - Describe the different types of somatic sensations

Lecture 34:
Special Senses:
- Olfaction
  - Describe anatomy of olfaction and relate it to its physiology and olfactory pathway
- Gustation
  - Describe anatomy of gustation and relate it to its physiology and gustatory pathway
- Vision
  - Describe anatomy of eye and accessory organs
  - Describe image formation and relate it to vision physiology and vision pathway
- Hearing and equilibrium
  - Describe ear anatomy
  - Relate ear anatomy to physiology of hearing and hearing pathways
  - Define different equilibrium states and relate the ear anatomy and physiology to each state
SENSATION

- Sensation is a conscious or unconscious awareness of external or internal stimuli.
- The components of the brain interact to receive sensory input, integrate and store the information, and transmit motor responses.
- Perception is the conscious awareness & interpretation of a sensation.

Are there any sensations we cannot perceive? If yes – which ones and why not?
SENSORY MODALITIES

- Sensory Modality: unique type of sensation; property by which one sensation is distinguished from another.

- 2 classes of sensations
  1. General senses: include both somatic and visceral senses
     - Somatic: tactile, thermal, pain and proprioceptive sensations
     - Visceral: provide information about conditions within internal organs (e.g. stretch, pressure)
  2. Special senses: smell, taste, vision, hearing and equilibrium (balance); anatomically distinct
PROCESS OF SENSATION

- Sensory receptors are selective for only one type of stimulus
- Steps in process of sensation:
  1. stimulation of the receptor - e.g. touch
  2. conversion of stimulus into a graded potential
  3. generation of AP – when does this happen?
  4. integration of sensory input by the CNS
Steps in process of sensation

Sensory Receptors

1. Chemical stimulus
   - Receptor protein
   - Ion channel
   - Signal transduction pathway
   - Change in membrane potential
   - Signal to integrating center

2. Pressure stimulus
   - Receptor protein
   - Ion channel
   - Signal transduction pathway
   - Change in membrane potential
   - Signal to integrating center

3. Light stimulus
   - Receptor protein
   - Ion channel
   - Signal transduction pathway
   - Change in membrane potential
   - Signal to integrating center

To central nervous system

Direction of action potential

Afferent neuron

Voltage-gated calcium channel

Receptor protein for transmitter

Transmitter

Sensory receptor cell

Calciumions (Ca²⁺)

Promotes transmitter release

Stimulus
SENSORY RECEPTOR CLASSIFICATIONS

1. **Structural classification**: based on nerve appearance; 3 types:
   a) *First-order sensory neuron with free nerve endings* – e.g. pain, tickle, itch, temperatures
   b) *First-order sensory neuron with encapsulated nerve endings*: e.g. touch, pressure & vibration
   c) *Sensory Receptors synapse with the first order sensory neuron*: e.g. vision, hearing, taste and smell

2. **Functional classification**: based on stimulus detected; several types:
   - mechanoreceptors, thermoreceptors, nociceptors, photoreceptors; chemoreceptors

3. **Classification by location**: 3 types:
   a) *Exteroceptors*: near surface of body, receive external stimuli; e.g. hearing, vision, pressure and pain
   b) *Interoceptors*: monitors internal environment (BV or viscera); not conscious except for pain or pressure
   c) *Proprioceptors*: senses body position & movement; found in muscle, tendon, joint & internal ear
1. Structural classification

(a) First-order sensory neuron with free nerve endings
Cold stimulus → Bare dendrites → Nerve impulses → Propagate into CNS

(b) First-order sensory neuron with encapsulated nerve endings
Pressure stimulus → Dendrites enclosed in connective tissue capsule → Nerve impulses → Propagate into CNS

(c) Sensory receptor synapses with first-order sensory neuron
Sugar molecule → Separate sensory cells that respond to sensation
2. Functional classification

- **Mechanoreceptors**: detect pressure or stretch; touch, pressure, vibration, hearing, proprioception, equilibrium & blood pressure.

- **Thermoreceptors**: detect temperature.

- **Nociceptors**: detect damage to tissues.

- **Photoreceptors**: detect light.

- **Chemoreceptors**: detect molecules; e.g. taste, smell & changes in body fluid chemistry.
Adaptation: tendency for the generator or receptor potential to decrease in amplitude during a maintained constant stimulus.

- decrease in responsiveness of a receptor: e.g. bad smells disappear, very hot water starts to feel only warm
- potential amplitudes decrease during a maintained, constant stimulus
Variability in tendency to adapt:

- Rapidly adapting receptors: specialized for detecting changes; e.g. smell, pressure, touch
- Slowly adapting receptors nerve impulses continue as long as the stimulus persists; e.g. pain, body position
Considering the structure-function-location relationships of sensory receptors, comment on what do you think the nerves to the right are doing.
SOMATIC SENSATIONS

- **Sensation** from the *skin, muscles, bones, tendons and joints*. Initiated due to activation of a number of distinct **somatic** receptors that respond specifically to changes in *heat, cold, touch, pressure, limb position, limb movement or pain*.

- Classification of somatic sensations:
  1. Tactile sensations – touch, pressure, vibration, itch and tickle
  2. Pain
  3. Proprioceptive
Touch

- Crude touch: ability to perceive that something has simply touched the skin

- Discriminative (fine) touch: provides specific information about a touch sensation such as location, shape, size, and texture of the source of stimulation.

- Rapidly adapting receptors: corpuscles of touch (Meissner’s corpuscles) and hair root plexuses

- Slowly adapting receptors: Type I cutaneous mechanoreceptors (tactile or Merkel discs) and type II cutaneous mechanoreceptors (end organs of Ruffini)
Pressure and Vibration

- **Pressure**: sustained sensation that is felt over a larger area than touch; longer lasting; less variation in intensity
  - Receptors: type II cutaneous mechanoreceptors and lamellated (Pacinian) corpuscles

- **Vibration** sensations: result from rapidly repetitive sensory signals from tactile receptors
  - Receptors: corpuscles of touch and lamellated corpuscles
Itch and Tickle

- **Itching** is chemical stimulation of free nerve endings.

- **Tickle** is stimulation of free nerve endings only by someone else.

- Itch and tickle receptors are **free nerve endings**.
PAIN

- Provides information about noxious and damaging stimuli; helps protect from greater damage
- Receptors: nociceptors (free nerve ending); sensory neurons transmitting messages of painful stimuli, secrete glutamate and substance P.

- Types of pain:
  1. Acute pain
  2. Chronic pain
  3. Nerve pain
  4. Referred pain
Acute pain – occurs rapidly after stimulus applied; no feeling in deeper tissues; sharp/fast/pricking pain; impulses conducted by A fibres

Chronic pain – begins after a second and gradually increases in intensity; longer and deeper; burning/arching/throbbing; impulses conducted by C fibres
Nerve pain – no stimulus needed; sharp, shooting pain; nerves damaged in some way and initiate nerve impulses from that point down; no treatment available
Referred pain

- Visceral pain that is felt just deep to the skin overlying the stimulated organ or in a surface area far from the organ.
- Skin area & organ are served by the same segment of the spinal cord.
  - Heart attack is felt in skin along left arm since both are supplied by spinal cord segment T1-T5
PAIN RELIEF

- Multiple sites of analgesic action:
  - Aspirin and ibuprofen block formation of prostaglandins that stimulate nociceptors
  - Novocain blocks conduction of nerve impulses along pain fibers
  - Morphine lessen the perception of pain in the brain.
Using the above diagram:

1. Define the fibromyalgia
2. Looking from your own interests – think about how you would approach a patient in your clinic with this condition. Link the treatment into the pain pathway you defined in #1.
PROPRIOCEPTIVE SENSATIONS

- **Proprioceptors** allow us to perceive the position of the body and its parts. Three main types of proprioceptors:
  1. **muscle spindles**: detect muscle movement
  2. **Golgi tendon organs**: determine stretch in tendons
  3. **joint receptors**: detect movement in ligaments

- Sensory information is sent to cerebellum & cerebral cortex
  - signals project from muscle, tendon, joint capsules & hair cells in the vestibular apparatus
1. Muscle spindles

- **Structure**: specialized intrafusal muscle fibers enclosed in a connective tissue capsule and innervated by A-type gamma motor neurons

- **Function**: spindle sensory fiber monitors changes in muscle length

- Stretching of the muscle → stretches the muscle spindles → sending sensory information back to the CNS → activation of gamma motor neuron → contraction
2. Golgi tendon organs

- **Structure**: encapsulated bundle of collagen fibers laced with sensory fibers; found at junction of tendon & muscle

- **Function**: when the tendon is overly stretched, sensory signals head for the CNS & resulting in the muscle’s relaxation
3. Joint receptors

- **Ruffini corpuscles**: found in joint capsule: respond to pressure; slowly adapting

- **Pacinian corpuscles**: found in connective tissue around the joint: respond to acceleration & deceleration of joints; rapidly adapting
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SPECIAL SENSES

- Smell, taste, vision, hearing and equilibrium
- Housed in complex sensory organs

- Chemical senses:
  - Interaction of molecules with receptor cells
  - Olfaction (smell) and gustation (taste)
  - Both project to cerebral cortex & limbic system, so evoke strong emotional reactions
ANATOMY OF OLFACCTION (SMELL)

- **Receptors**: first-order, bipolar neurons in the nasal epithelium in the superior portion of the nasal cavity of the olfactory pathway.
- **Supporting cells**: epithelial cells of the mucous membrane lining the nose
- **Basal cells**: stem cells (replace receptors monthly)
- **Olfactory (Bowman’s) glands**: produce mucus
- Both epithelium & glands innervated by cranial nerve VII.
Stimulus (molecule) triggers graded potential that can develop into action potential.

Adaptation (decreasing sensitivity) to odours occurs quickly, and the threshold of smell is low: only a few molecules of certain substances need be present in air to be smelled.

cAMP as secondary messenger
ANATOMY OF GUSTATION (TASTE)

- Taste requires dissolving of substances
- Four classes of stimuli—sour, bitter, sweet, and salty
  - Other “tastes” are a combination of the four taste sensations plus olfaction.
- 10,000 taste buds found on tongue, soft palate & larynx; Found on sides of circumvallate & fungiform papillae
- 3 cell types: supporting, receptor & basal cells
Anatomy of taste buds

- An oval body consisting of 50 receptor cells surrounded by supporting cells
- A single gustatory hair projects upward through the taste pore
- Basal cells develop into new receptor cells every 10 days.
PHYSIOLOGY OF GUSTATION

- Receptor potentials developed in gustatory hairs cause the release of neurotransmitter that gives rise to nerve impulses; mechanism:
  - dissolved substance contacts gustatory hairs
  - receptor potential results in neurotransmitter release
  - nerve impulse formed in 1st-order neuron

- Complete adaptation in 1 to 5 minutes; thresholds for tastes vary among the 4 primary tastes (most sensitive to bitter (poisons); least sensitive to salty and sweet)
ANATOMY OF VISION

Accessory structures of the eye:

1. Eyelids or palpebrae
   - protect & lubricate
   - epidermis, dermis, CT, orbicularis oculi m., tarsal glands (oily secretions), conjunctiva (palpebral & bulbar; stops at corneal edge)

2. Lacrimal Apparatus
   - about 1 ml of tears produced per day that spread over eye by blinking
   - contains bactericidal enzyme called lysozyme

3. Extrinsic eye muscles
Extrinsic eye muscles

- Six muscles that insert on the exterior surface of the eyeball
  - Innervated by CN III, IV or VI.

- 4 rectus muscles: superior, inferior, lateral and medial

- 2 oblique muscles: inferior and superior
ANATOMY OF THE EYEBALL

- The eye is constructed of three layers:
  1. Fibrous Tunic (outer layer)
  2. Vascular Tunic (middle layer)
  3. Nervous Tunic (inner layer)
FIBROUS TUNIC – the cornea

- Transparent and avascular
- **Structure**: 3 layers
  - Nonkeratinized stratified squamous epithelium
  - collagen fibers & fibroblasts
  - simple squamous epithelium
  - Nourished by tears & aqueous humor
- **Function**: helps focus light (refraction)
  - astigmatism
FIBROUS TUNIC – the sclera

- “White” of the eye
- **Structure**: dense irregular connective tissue layer
  - collagen & fibroblasts
- At the junction of the sclera and cornea is an opening (scleral venous sinus)
- Posteriorly pierced by Optic Nerve (CNII)

- **Function**: Provides shape & support
VASCULAR TUNIC - choroid & ciliary body

- **Choroid**
  - **Structure**: pigmented epithelial cells (melanocytes) & blood vessels; black pigment in melanocytes absorb scattered light
  - **Function**: provides nutrients to retina

- **Ciliary body**
  - ciliary processes
    - folds on ciliary body
    - secrete aqueous humor
  - ciliary muscle
    - smooth muscle that alters shape of lens
VASCULAR TUNIC - iris & pupil

- **Structure**: colored portion of eye; shape of flat donut suspended between cornea & lens; hole in center of iris is called pupil
- **Function**: regulation of amount of light entering eye
- **Autonomic reflexes**:
  - Parasympathetic: circular muscle fibers contract in bright light to shrink pupil
  - Sympathetic: radial muscle fibers contract in dim light to enlarge pupil
NERVOUS TUNIC - retina

- Pigmented and vascular
- Posterior 3/4 of eyeball
- Optic disc
  - optic nerve exiting back of eyeball
- Central retina blood vessels
  - fan out to supply nourishment to retina
  - visible for inspection

View with Ophthalmoscope

TEMPORAL SIDE

Central fovea

Macula lutea

NASAL SIDE

Optic disc

Retinal blood vessels

Right eye

Fibrous tunic
- Sclera
- Cornea

Vascular tunic
- Iris
- Ciliary body
- Choroid

Retina
- Pigmented layer
- Neural layer
Layers of retina

- Retina has two layers:
  1. Pigmented epithelium
     - nonvisual portion
     - absorbs stray light & helps keep image clear
  2. Neural layer: 3 layers of neurons (outgrowth of brain)
     - photoreceptor layer
     - bipolar neuron layer
     - ganglion neuron layer

- 2 other cell types: found within bipolar neuron layer; form lateraly directed neural circuits; modify the signal
  - horizontal cells
  - amacrine cells
2 photoreceptor cells that differ in the shapes of their outer segments differ:

1. Rods: specialized for black-and-white vision in dim light and permit us to see shapes and movement

2. Cones: specialized for color vision and sharpness of vision (high visual acuity) in bright light; blue, green and red cones
Layers of retina – fovea, lutea and optic disc

- **Macula lutea**: in the exact center of the posterior portion of the retina, corresponding to the visual axis of the eye.
- **Central fovea**: area of sharpest vision because of the high concentration of cones (NO rods present)
- **Optic disc**: area that contains no cones or rods; blind spot
THE LENS

- Avascular; clear capsule & perfectly transparent
- Crystallins: crystalline proteins arranged like layers in onion
- Lens held in place by suspensory ligaments
- Focuses light on fovea
CAVITIES OF THE INTERIOR OF EYEBALL

1. Anterior cavity (anterior to lens)
   - filled with aqueous humor
   - 2 chambers
     - anterior chamber between cornea and iris
     - posterior chamber between iris and lens

2. Posterior cavity (posterior to lens)
   - filled with vitreous body (jellylike)
   - formed once during embryonic life
AQUEOUS HUMOUR

- Continuously produced by ciliary body

- Flows from posterior chamber into anterior through the pupil

- Scleral venous sinus
  - canal of Schlemm
  - opening in white of eye at junction of cornea & sclera
  - drainage of aqueous humor from eye to bloodstream
EYE ANATOMY

- The pressure in the eye, called intraocular pressure, is produced mainly by the aqueous humor.
- The intraocular pressure, along with the vitreous body, maintains the shape of the eyeball and keeps the retina smoothly applied to the choroid so the retina will form clear images.
- Glaucoma
  - increased intraocular pressure
  - problem with drainage of aqueous humor
  - may produce degeneration of the retina and blindness
MAJOR PROCESSES OF IMAGE FORMATION

- Refraction of light (bending)
  - by cornea & lens
  - light rays must fall upon the retina

- Accommodation of the lens
  - changing shape of lens so that light is focused

- Alteration of the pupil size
  - Constriction or dilation to alter amount of light entering the posterior chamber
REFRACTION ABNORMALITIES

- **Myopia** is nearsightedness.

- **Hyperopia** is farsightedness.

- **Astigmatism** is a refraction abnormality due to an irregular curvature of either the cornea or lens.
PHYSIOLOGY OF VISION

- **Photopigments**: integral membrane proteins *(opsin)* + derivative of vitamin A *(retinal)*; undergo structural changes upon light absorption.

- There are four different opsins (3 total for cones RGB – 1 per cone; 1 for rods - rhodopsin)

- Retinal is the light absorbing part of all visual photopigments.
1. Light penetrates retina
2. Light leads to conformational change in photopigment in rods & cones; these cells transduce light into membrane potential and release neurotransmitters
3. Rods & cones excite bipolar cells; bipolar cells excite ganglion cells; axons of ganglion cells form optic nerve leaving the eyeball (blind spot)
4. Optic nerve leaving the eyeball to thalamus & then the primary visual cortex
Retinal processing of visual information

- **Convergence**
  - one cone cell synapses onto one bipolar cell produces best visual acuity
  - 600 rod cells synapse on single bipolar cell increasing light sensitivity although slightly blurry image results
  - 126 million photoreceptors converge on 1 million ganglion cells

- **Horizontal and amacrine cells**
  - horizontal cells enhance contrasts in visual scene because laterally inhibit bipolar cells in the area
  - amacrine cells excite bipolar cells if levels of illumination change
CONVERGENCE OF THE EYES

- Binocular vision in humans has both eyes looking at the same object.
- As you look at an object close to your face, both eyeballs must turn inward.
  - In convergence, the eyeballs move medially so they are both directed toward an object being viewed.
  - Required so that light rays from the object will strike both retinas at the same relative point.
  - Extrinsic eye muscles must coordinate this action.
HEARING AND EQUILIBRIUM

One organ 2 major functions
ANATOMY OF THE EAR REGION

Frontal plane

Temporal bone
Malleus
Incus
Semicircular canal
Internal auditory canal
Vestibulocochlear (VIII) nerve
Vestibular branch
Cochlear branch
Cochlea

Helix
Auricle
Lobule
Elastic cartilage
Cerumen
Eardrum
Round window (covered by secondary tympanic membrane)
To nasopharynx

External ear
Middle ear
Internal ear

External auditory canal
Auditory tube

Frontal section through the right side of the skull showing the three principal regions of the ear
External ear

- **Structure:**
  - **auricle or pinna:** elastic cartilage covered with skin
  - **external auditory canal:** curved 1” tube of cartilage & bone leading into temporal bone; ceruminous glands produce cerumen = ear wax
  - **tympanic membrane or eardrum:** epidermis, collagen & elastic fibers, simple cuboidal epithelia

- **Function:** external (outer) ear collects sound waves and passes them inwards
Middle ear cavity

- Air filled cavity in the temporal bone
- Separated from external ear by eardrum and from internal ear by oval & round window
- 3 ear ossicles connected by synovial joints
  - *malleus* attached to eardrum, *incus* & *stapes* attached by foot plate to membrane of oval window
- Auditory tube leads to nasopharynx
  - helps to equalize pressure on both sides of eardrum
Inner ear - bony labyrinth

- **Structure**: set of tubelike cavities in temporal bone: semicircular canals (at approximately right angles), vestibule and cochlea lined with periosteum & filled with perilymph

- **Function**: surrounds & protects Membranous Labyrinth
Inner ear - membranous labyrinth

- **Structure**: set of membranous tubes containing sensory receptors for hearing & balance: utricle, saccule, ampulla, 3 semicircular ducts & cochlea

- **Function**: hearing and balance
Cochlear anatomy

- Cochlea is divided into three channels by partitions that together have the shape of the letter Y:
  - Scala vestibule
  - Scala tympani
  - Scala media

- **Organ of Corti**: organ of hearing; structure: Microvilli make contact with tectorial membrane (gelatinous membrane); basal sides of inner hair cells synapse with 1st order sensory neurons whose cell body is in spiral ganglion.
Nerve

- Vestibulocochlear nerve CN VIII
  - vestibular branch consists of 3 parts: ampullary, utricular, and saccular nerves
  - cochlear branch has spiral ganglion in bony modiolus
1. Auricle collects sound waves
2. Eardrum vibrates (e.g. slow vibration in response to low-pitched sounds)
3. Ossicles vibrate since malleus is attached to the eardrum
4. Stapes pushes on oval window producing fluid pressure waves (4a)
5. Pressure fluctuations inside cochlear duct move the hair cells against the tectorial membrane; microvilli on hair cells are bent producing receptor potentials and release of neurotransmitters to the underlying nerves
SOUND WAVES

• Sound waves result from the alternate compression and decompression of air molecules.
  • The sounds heard best by human ears are at frequencies between 1000 and 4000 Hertz (Hz; cycles per second), but many people perceive a range of 20 to 20,000 Hz
  • speech is 100 to 3000 Hz

• Frequency of a sound vibration is perceived as pitch
  • higher frequency is higher pitch

• The volume of a sound is its intensity (the greater the size of the vibration, the louder the sound, measured in decibels, dB).
  • Conversation is 60 dB; pain above 140dB
  • OSA requires ear protection above 90dB
Deafness is significant or total hearing loss. It is classified as sensorineural (caused by impairment of the cochlear or cochlear branch of the vestibulocochlear nerve) or conduction (caused by impairment of the external and middle ear mechanisms for transmitting sounds to the cochlea).

COCHLEAR IMPLANTS

- If deafness is due to destruction of hair cells
- Microphone, microprocessor & electrodes translate sounds into electric stimulation of the vestibulocochlear nerve
  - artificially induced nerve signals follow normal pathways to brain
- Provides only a crude representation of sounds
EQUILIBRIUM (BALANCE)

- **Static equilibrium**
  - maintain the position of the body (head) relative to the force of gravity
  - **macula receptors** within saccule & utricle

- **Dynamic equilibrium**
  - maintain body position (head) during sudden movement of any type—rotation, deceleration or acceleration
  - **crista receptors** within ampulla of semicircular ducts
ANATOMY OF EQUILIBRIUM

- Semicircular ducts with ampulla, utricle & saccule
The maculae of the utricle and saccule are the sense organs of static equilibrium.

Cell types in the macula region
- hair cells with stereocilia (microvilli) & one cilia (kinocilium)
- supporting cells that secrete gelatinous layer

Gelatinous otolithic membrane contains calcium carbonate crystals called otoliths that move when head is tipped.
PHYSIOLOGY OF STATIC EQUILIBRIUM

- Movement of stereocilia or kinocilium results in the release of neurotransmitter onto the vestibular branches of the vestibulocochlear (VIII) nerve
- E.g. tilting and keeping head upright
ANATOMY OF DYNAMIC EQUILIBRIUM - MEMBRANOUS SEMICIRCULAR DUCTS

- The three semicircular ducts, along with the saccule and utricle maintain **dynamic equilibrium**.
  - anterior, posterior & horizontal ducts detect different movements (combined 3-D sensitivity)
- The crista in the semicircular ducts are the primary sense organs of dynamic equilibrium. Crista = hair cells covered with cupula (gelatinous material)
Nerve signals to the brain are generated indicating which direction the head has been rotated.

E.g.: detection of rotational movement.
Work in groups of 3-4 and identify processes you learned about in each of the spots labelled 1-6. HINT: you should now be able to identify all points and describe them in detail.
Clinical application

DISORDERS: HOMEOSTATIC IMBALANCES

- Meniere’s syndrome is a malfunction of the inner ear that may cause deafness and loss of equilibrium.

- Otitis media is an acute infection of the middle ear, primarily by bacteria. It is characterized by pain, malaise, fever, and reddening and outward bulging of the eardrum, which may rupture unless prompt treatment is given. Children are more susceptible than adults.
AGING AND THE SPECIAL SENSES

- Age related changes in the eyes
  - Presbyopia
  - Cataracts
  - Weakening of the muscles that regulate the size of the pupil
  - Diseases such as age related macular disease, detached retina, and glaucoma
  - Decrease in tear production
  - Sharpness of vision as well as depth and color perception are reduced.
AGING AND THE SPECIAL SENSES

- After age 50 some individuals experience loss of olfactory and gustatory receptors.
- Age related changes in the ears
  - Presbycusis – hearing loss due to damaged or loss of hair cells in the organ of Corti
  - Tinnitus (ringing in the ears) becomes more common
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