2014 Anatomy -Training Handout

Karen L. Lancour
National Rules Committee Chairman – Life Science

DISCLAIMER - This presentation was prepared using draft rules. There may be some changes in the final copy of the rules. The rules which will be in your Coaches Manual and Student Manuals will be the official rules.

- ***BE SURE TO CHECK THE 2014 EVENT RULES*** for EVENT PARAMETERS and TOPICS FOR EACH COMPETITION LEVEL

TRAINING MATERIALS:

- **Training Power Point** presents an overview of material in the training handout
- **Training Handout** presents introductory topic content information for the event
- **Sample Tournament** has sample problems with key
- **Event Supervisor Guide** has event preparation tips, setup needs and scoring tips
- **Internet Resource & Training Materials** are available on the Science Olympiad website at www.soinc.org under Event Information.
- **A Biology-Earth Science CD, an Anatomy/A&P CD** as well as the **Division B and Division C Test Packets** are available from SO store at www.soinc.org

BASIC ANATOMY

- Nervous System
- **Integumentary System (new)**
- Major Diseases
- Treatment and prevention of diseases

PROCESS SKILLS - observations, inferences, predictions, calculations, data analysis, and conclusions.

The Nervous System

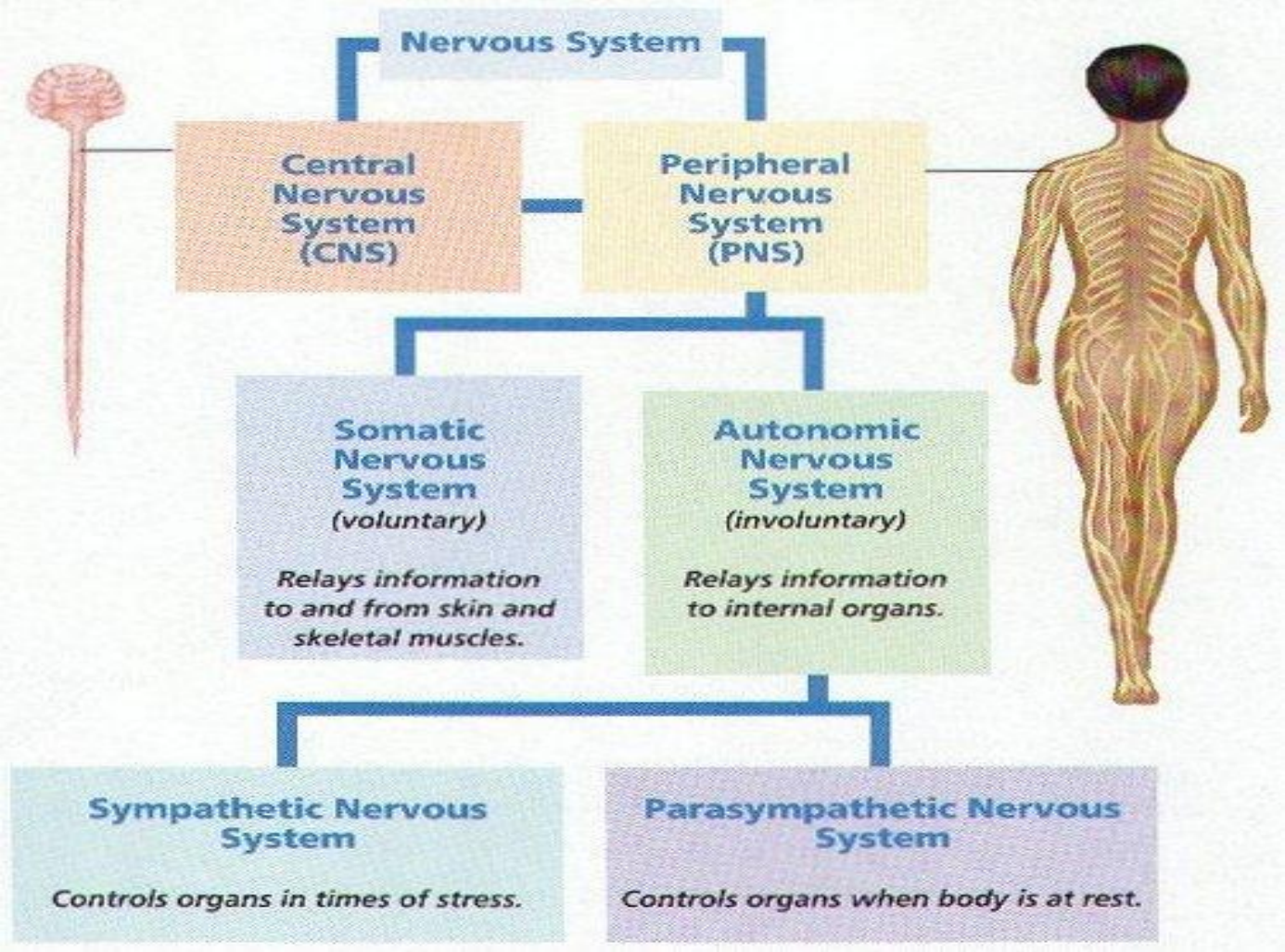
Functions of the Nervous System

1. Gathers information from both inside and outside the body - Sensory Function
2. Transmits information to the processing areas of the brain and spine
3. Processes the information in the brain and spine – Integration Function
4. Sends information to the muscles, glands, and organs so they can respond appropriately – Motor Function

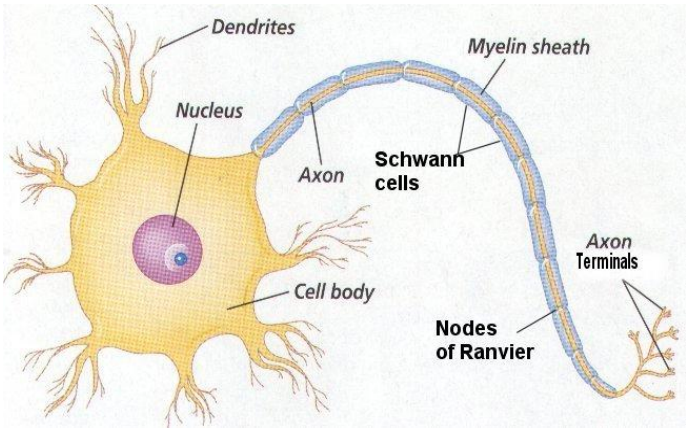
It controls and coordinates all essential functions of the body including all other body systems allowing the body to maintain homeostasis or its delicate balance.

The Nervous System is divided into **Two Main Divisions**: **Central Nervous System (CNS)** and the **Peripheral Nervous System (PNS)**

Divisions of the Nervous System



Basic Cells of the Nervous System



Neuron

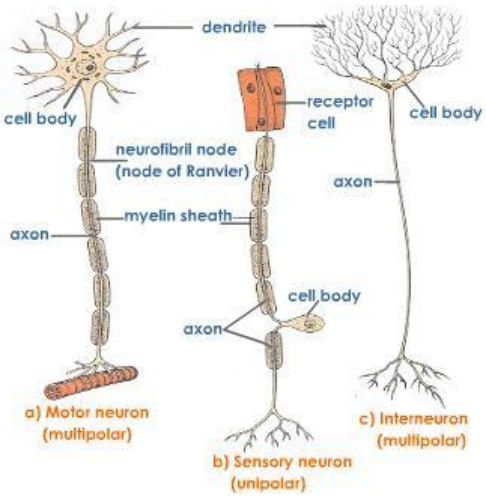
- Basic functional cell of nervous system
- Transmits impulses (up to 250 mph)

Parts of a Neuron

- **Dendrite** – receive stimulus and carries it impulses toward the cell body
- **Cell Body** with nucleus – nucleus & most of cytoplasm
- **Axon** – fiber which carries impulses away from cell body
- **Schwann Cells**- cells which produce myelin or fat layer in the Peripheral Nervous System
- **Myelin sheath** – dense lipid layer which insulates the axon – makes the axon look gray
- **Node of Ranvier** – gaps or nodes in the myelin sheath
- Impulses travel **from dendrite to cell body to axon**

Three types of Neurons

- **Sensory neurons** – bring messages to CNS
- **Motor neurons** - carry messages from CNS
- **Interneurons** – between sensory & motor neurons in the CNS



Impulses

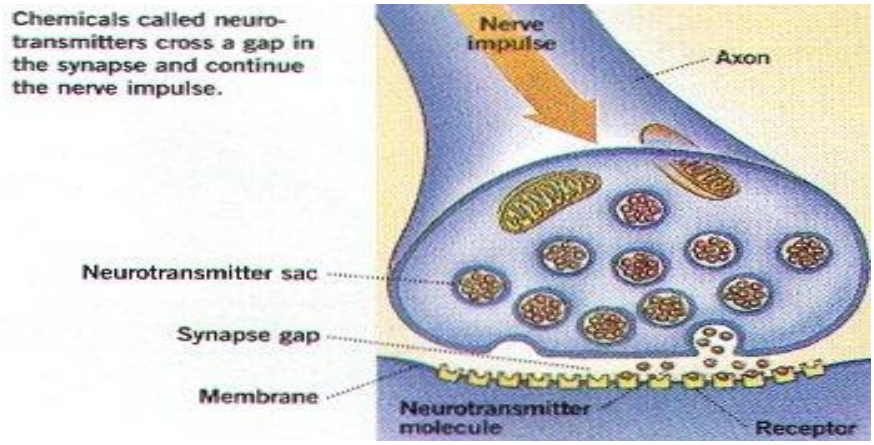
- A **stimulus** is a change in the environment with sufficient strength to initiate a response.
- **Excitability** is the ability of a neuron to respond to the stimulus and convert it into a nerve impulse
- **All of Nothing Rule** – The stimulus is either strong enough to start and impulse or nothing happens
- Impulses are always the **same strength along a given neuron** and they are **self-propagation** – once it starts it continues to the end of the neuron in only one direction- **from dendrite to cell body to axon**
- The nerve impulse causes a movement of ions across the cell membrane of the nerve cell.

Synapse

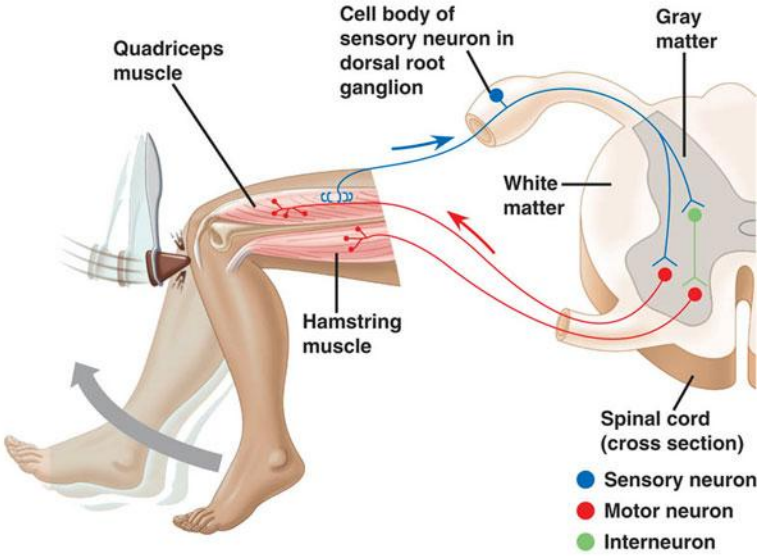
- **Synapse** - small gap or space between the axon of one neuron and the dendrite of another - **the neurons do not actually touch at the synapse**
- It is junction between neurons which uses neurotransmitters to start the impulse in the second neuron or an effector (muscle or gland)
- The synapse insures one-way transmission of impulses

Neurotransmitters

Neurotransmitters – Chemicals in the junction which allow impulses to be started in the second neuron



Reflex Arc



Components of a Reflex Arc

A. **Receptor** - reacts to a stimulus
B. **Afferent pathway (sensory neuron)** - conducts impulses to the CNS
C. **Interneuron** - consists of one or more synapses in the CNS (most are in the spine)
D. **Efferent pathway (motor neuron)** conducts impulses from CNS to effector.
E. **Effector** - muscle fibers (as in the Hamstring muscle) or glands responds by contracting or secreting a product.

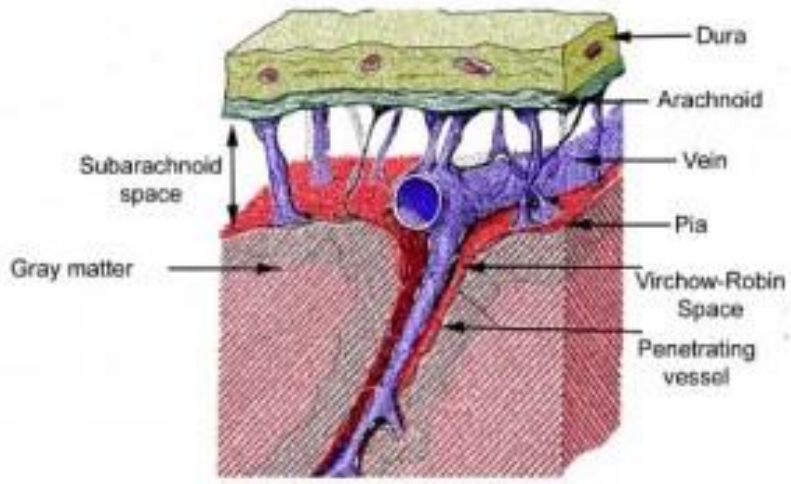
Spinal reflexes - initiated and completed at the spinal cord level. Occur without the involvement of higher brain centers.

Central Nervous System

- Brain
  - Brain stem – medulla, pons, midbrain
  - Diencephalon – thalamus & hypothalamus
  - Cerebellem
  - Cerebrum
- Spine
  - Spinal Cord

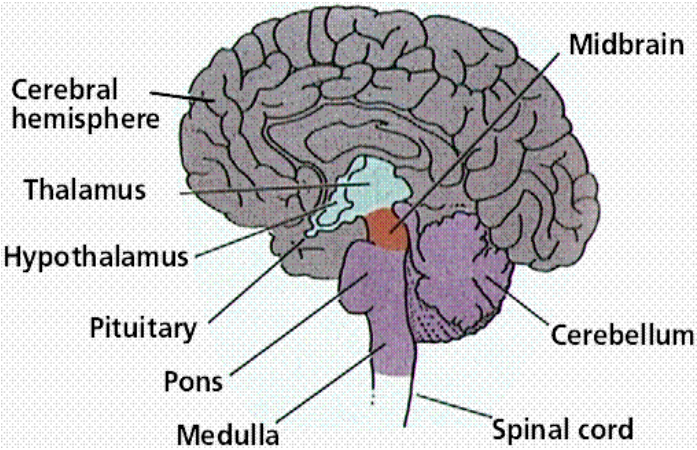
Meninges

Meninges are the three coverings around the brain & spine and help cushion, protect, and nourish the brain and spinal cord.



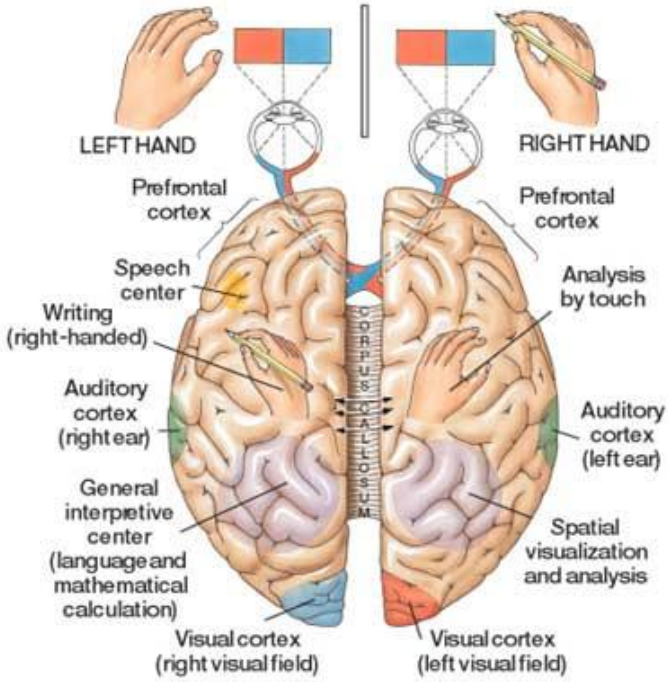
- dura mater is the most outer layer, very tough
- arachnoid mater is the middle layer and adheres to the dura mater and has weblike attachments to the innermost layer, the pia mater
- pia mater is very thin, transparent, but tough, and covers the entire brain, following it into all its crevices (sulci) and spinal cord
- cerebrospinal fluid, which buffers, nourishes, and detoxifies the brain and spinal cord, flows through the subarachnoid space, between the arachnoid mater and the pia mater

Regions of the Brain



Cerebellum – coordination of movement and aspects of motor learning
Cerebrum – conscious activity including perception, emotion, thought, and planning
Thalamus – Brain's switchboard – filters and then relays information to various brain regions
Medulla – vital reflexes as heart beat and respiration
Brainstem – medulla, pons, and midbrain (involuntary responses) and relays information from spine to upper brain
Hypothalamus– involved in regulating activities internal organs, monitoring information from the autonomic nervous system, controlling the pituitary gland and its hormones, and regulating sleep and appetite

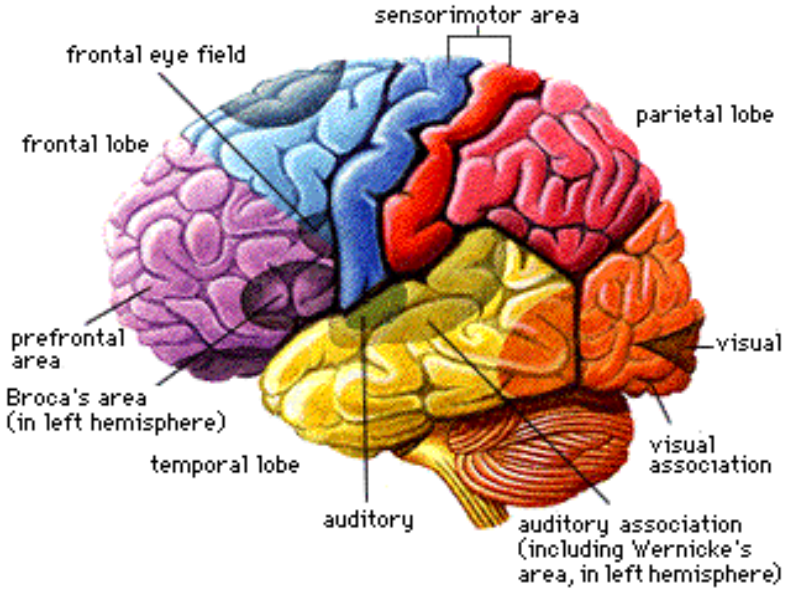
Cerebrum



- Is the largest portion of the brain encompasses about two-thirds of the brain mass -
- It consists of two hemispheres divided by a fissure – corpus callosum
- It includes the cerebral cortex, the medullary body, and basal ganglia
- **cerebral cortex** is the layer of the brain often referred to as gray matter because it has cell bodies and synapses but no myelin
    - The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation or white fatty myelin sheath that makes most other parts of the brain appear to be white.
    - The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerebellum
    - The cortex consists of folded bulges called **gyri** that create deep furrows or fissures called **sulci**
    - The folds in the brain add to its surface area which increases the amount of gray matter and the quantity of information that can be processed
- **Medullary body** – is the white matter of the cerebrum and consists of myelinated axons
    - Commisural fibers – conduct impulses between the hemispheres and form corpus callosum
    - Projection fibers – conduct impulse in and out of the cerebral hemispheres
    - Association fibers – conduct impulses within the hemispheres
- **Basal ganglia** – masses of gray matter in each hemisphere which are involved in the control of voluntary muscle movements

Lobes of the Cerebrum

- **Frontal –** motor area involved in movement and in planning & coordinating behavior
- **Parietal –** sensory processing, attention, and language
- **Temporal** – auditory perception, speech, and complex visual perceptions
- **Occipital –** visual center – plays a role in processing visual information



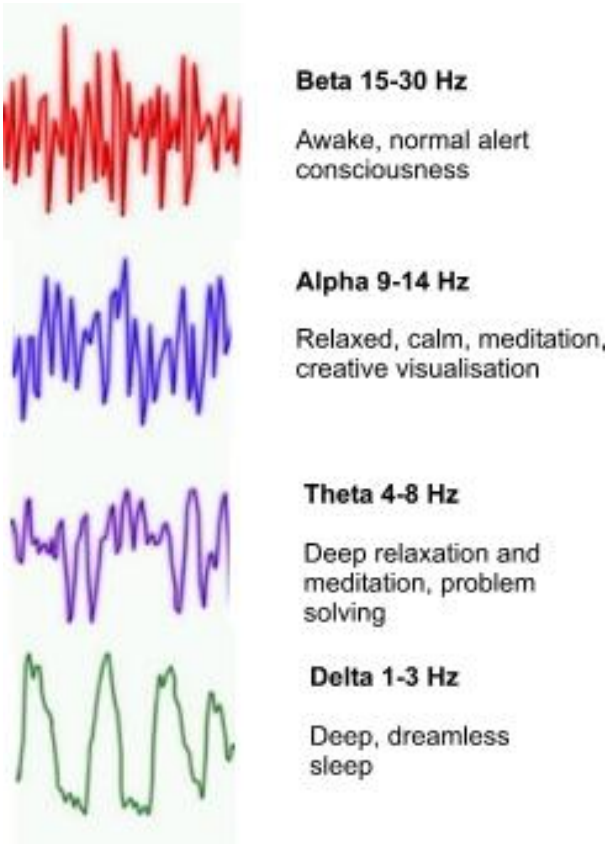
Special regions

- **Broca's area –** located in the frontal lobe – important in the production of speech
- **Wernicke's area –** comprehension of language and the production of meaningful speech
- **Limbic System** – a group of brain structures (aamygdala, hippocampus, septum, basal ganglia, and others) that help regulate the expression of emotions and emotional memory

Brain Waves

Brain waves are rhythmic fluctuation of electric potential between parts of the brain as seen on an **electroencephalogram** (EEG).

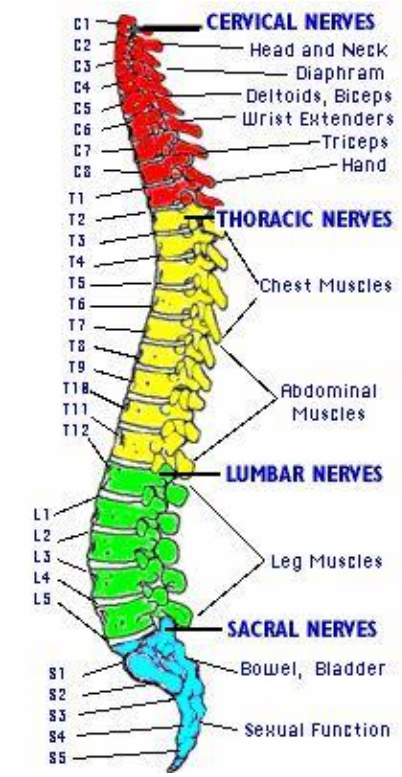
- To measure brain waves electrodes are placed onto the scalp using the EEG.
- There are four types of brainwaves:
    - Beta
    - Alpha
    - Theta
    - Delta



- **Peripheral Nervous System**

Cranial nerves
- 12 pair
- Attached to undersurface of brain

Spinal nerves
- 31 pair
- Attached to spinal cord

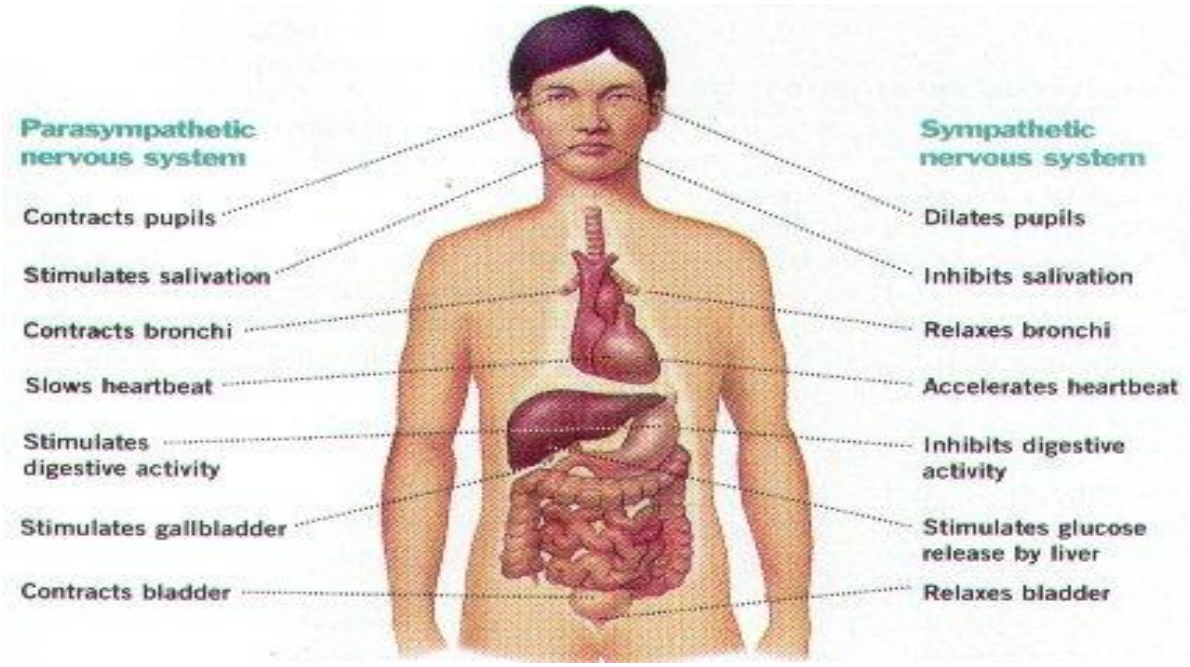


Somatic Nervous System (voluntary)

- Relays information from skin, sense organs & skeletal muscles to CNS
- Brings responses back to skeletal muscles for voluntary responses

Autonomic Nervous System (involuntary)

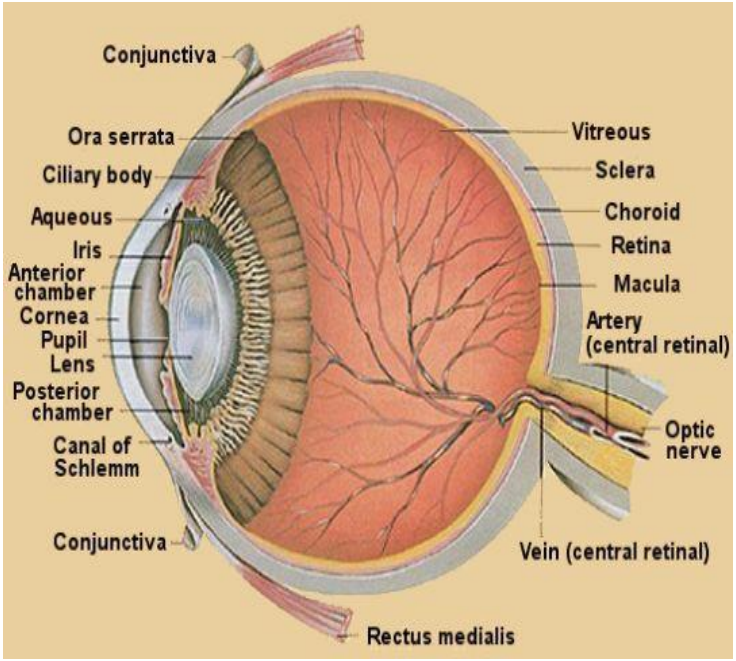
- Regulates bodies involuntary responses
- Relays information to internal organs
- Two divisions
  - Sympathetic nervous system – in times of stress
    - Emergency response
    - Fight or flight
  - Parasympathetic nervous system – when body is at rest or with normal functions
    - Normal everyday conditions



Major Sense Organs

Sensation and perception

- Vision – Eye
- Hearing – Ear
- Taste – Taste receptors (new)
- Smell – Olfactory system
- Skin – Hot, cold, pressure, pain



Sense Organs

Eye – the organ used to sense light

Three layers –

1. Outer layer consists of sclera and cornea
2. Middle layer consists of choroid, ciliary body and iris
3. Inner layer consists of retina

Functions of the major parts of the eye:

Sclera or Scleroid Layer – (white of eye) a tough protective layer of connective tissue that helps maintain the shape of the eye and provides an attachment for the muscles that move the eye

Cornea - the clear, dome-shaped part of the sclera covering the front of the eye through which light enters the eye

Anterior Chamber – a small chamber between the cornea and the pupil

Aqueous Humor - the clear fluid that fills that anterior chamber of the eye and helps to maintain the shape of the cornea providing most of the nutrients for the lens and the cornea and involved in waste management in the front of the eye

Choroid Layer - middle layer of the eye containing may blood vessels

Ciliary Body - the ciliary body is a circular band of muscle that is connected and sits immediately behind the iris- produces aqueous humor, changes shape of lens for focusing, and

Iris - the pigmented front portion of the choroid layer and contains the blood vessels - it determines the eye color and it controls the amount of light that enters the eye by changing the size of the pupil (an albino only has the blood vessels – not pigment so it appears red or pink because of the blood vessels)

Lens - a crystalline structure located just behind the iris - it focuses light onto the retina

Pupil - the opening in the center of the iris- it changes size as the amount of light changes (the more light, the smaller the hole)

Vitreous - a thick, transparent liquid that fills the center of the eye - it is mostly water and gives the eye its form and shape (also called the **vitreous humor**)

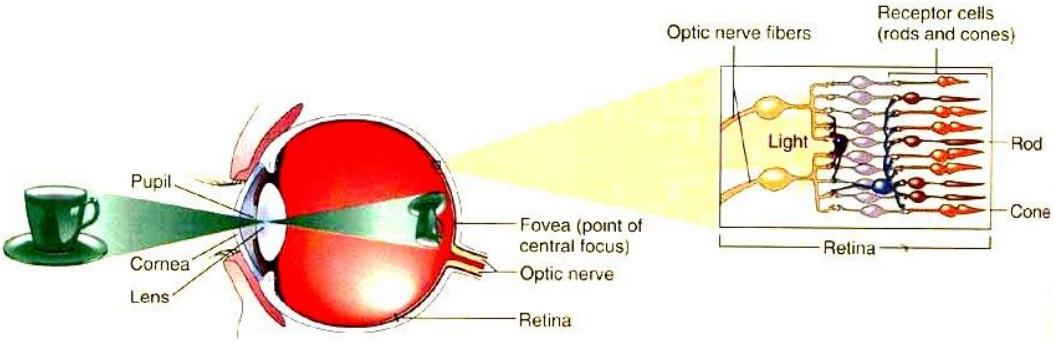
Retina - sensory tissue that lines the back of the eye. It contains millions of photoreceptors (**rods for black & white and cones for color**) that convert light rays into electrical impulses that are relayed to the brain via the optic nerve

Optic nerve - the nerve that transmits electrical impulses from the retina to the brain

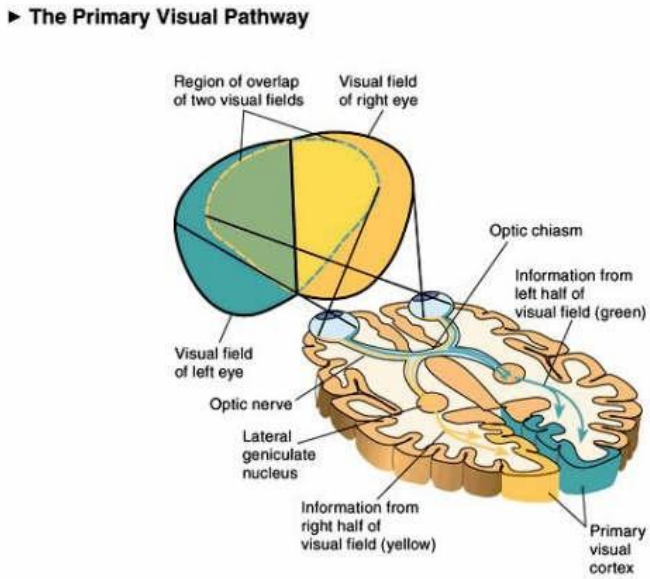
Common eye defects include – **myopia** or nearsightedness where the eyeball is too long or the cornea is too steep; **hyperopia** or far sightedness where the eyeball is short or lens cannot become round enough: **cataracts** where the lens becomes fogged; **presbyopia** where the muscles controlling the bulging of the lens become weak as we age; **nyctalopia** or night blindness where vision is impaired in dim light and in the dark due to pigment rhodospin in the rods not functioning properly

Images

- the cornea and the lens help to produce the image on the retina
- images formed by the lens are upside down and backwards when they reach the retina
- two types of receptors on the retina
- **Rods** – 125 million on a single retina – extremely sensitive to all wavelengths of visible light but do not distinguish different color – in dim light only rods are activated where one can see objects but not as sharp images and are not able to distinguish their color – most dense in peripheral view – **nighttime vision** Rods have a pigment called rhodospin
- As amount of light increases, the **cones** – 7 million on a single retina – mainly in central view are stimulated and the color becomes clear – **daytime vision**
- There are three types of cones which distinguish the three colors – blue, red, green
- **Fovea** – point of central focus – great density of cones - center of the eye's sharpest vision and the location of most color perception - the layers of the retina spread aside to let light fall directly on the cones



- Light stimulates rods and cones and sends impulse via optic nerve to brain areas for vision
- The Optic Nerve exits the eye just off center near the Fovea - the Optic Nerve exits is referred to as the Blind Spot due to the lack of the receptors in this area
- The two Optic Nerves come together at the **Optic Chiasm** located just under the hypothalamus - a crucial part of vision and perception must happen - cross-over of information from the right eye crosses over to the left side and visa versa happens here at the Optic Chiasm
- Information from each eye must be processed in both halves of the brain
- Information leaves the chiasm via the optic tract.
- Reorganized optic tract leaves the Optic Chiasm and passes onto the lateral geniculate nucleus
- At the lateral geniculate nuclei the information is separated, organized, and relayed to different areas of the visual cortex
- The different zones of the visual cortex process the different aspects of vision and information, taken from both visual fields, is processed and an image is perceived



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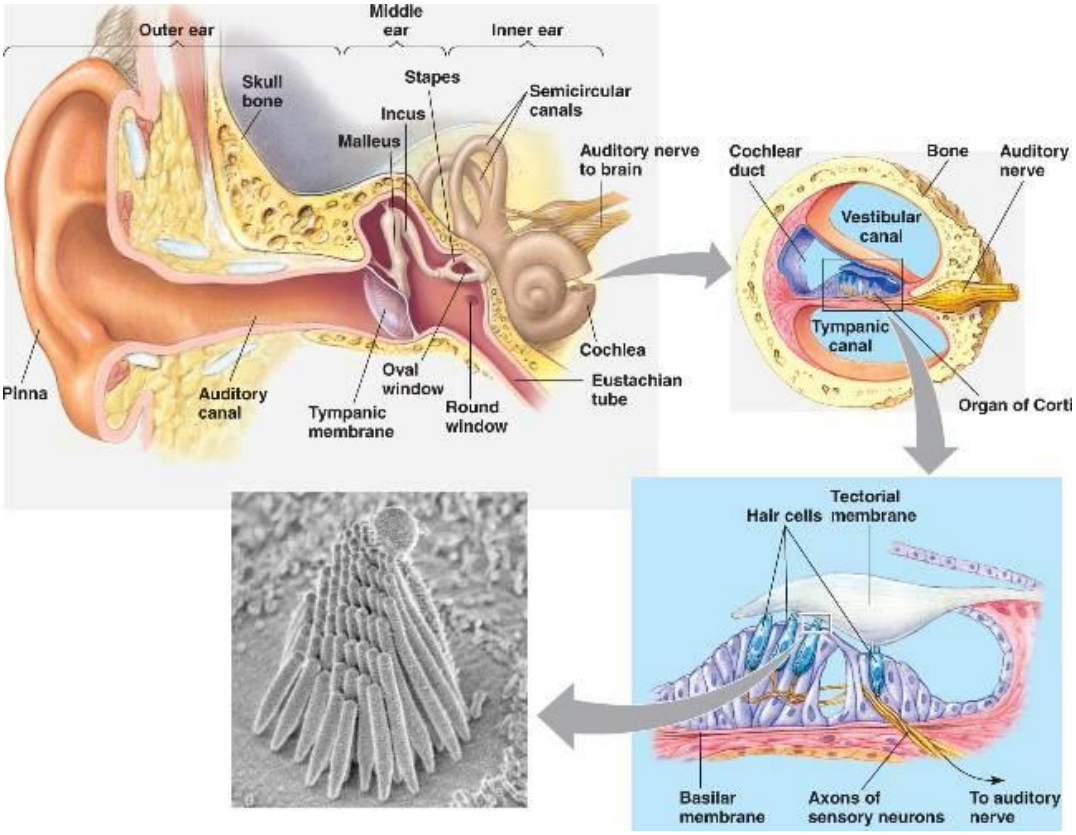
EAR

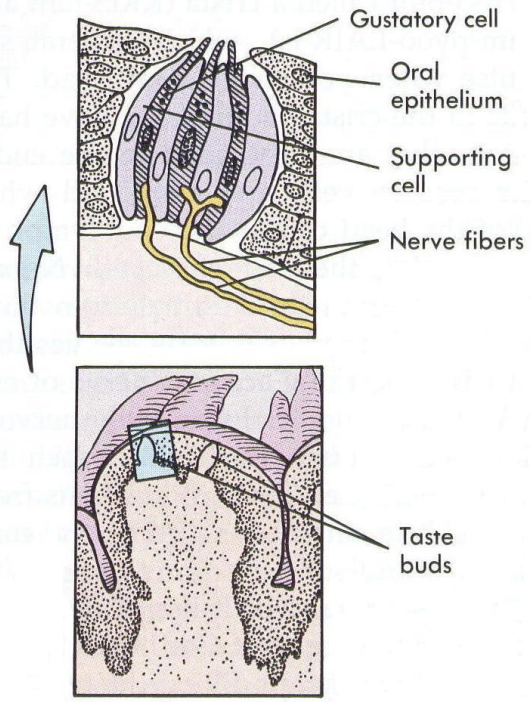
Outer Ear & ear canal – brings sound into eardrum
Eardrum – vibrates to amplify sound & separates inner and middle ear
Middle ear has 3 small bones or **Ossicles =** anvil, stirrup, stapes – amplify sound (small bones) which vibrate sound
Eustachian tube – connects middle ear to throat and equalizes pressure on eardrum
Cochlea – in inner ear – has receptors for sound & sends signals to brain via Auditory Nerve

<u>Process of hearing:</u>

- Sound waves enter your outer ear and travel through your ear canal to the middle ear.
- The ear canal channels the waves to your eardrum, a thin, sensitive membrane stretched tightly over the entrance to your middle ear.
- The waves cause your eardrum to vibrate.
- It passes these vibrations on to the hammer, one of three tiny bones in your ear. The hammer vibrating causes the anvil, the small bone touching the hammer, to vibrate. The anvil passes these vibrations to the stirrup, another small bone which touches the anvil. From the stirrup, the vibrations pass into the inner ear.
- The stirrup touches a liquid filled sack and the vibrations travel into the cochlea, which is shaped like a shell.
- Inside the cochlea, a vestibular system formed by three semicircular canals that are approximately at right angles to each other and which are responsible for the sense of balance and spatial orientation. It has chambers filled with a viscous fluid and small particles (**otoliths**) containing calcium carbonate. The movement of these particles over small hair cells in the inner ear sends signals to the brain that are interpreted as motion and acceleration. The brain processes the information from the ear and lets us distinguish between different types of sounds.



Taste and Smell – Chemical Receptors

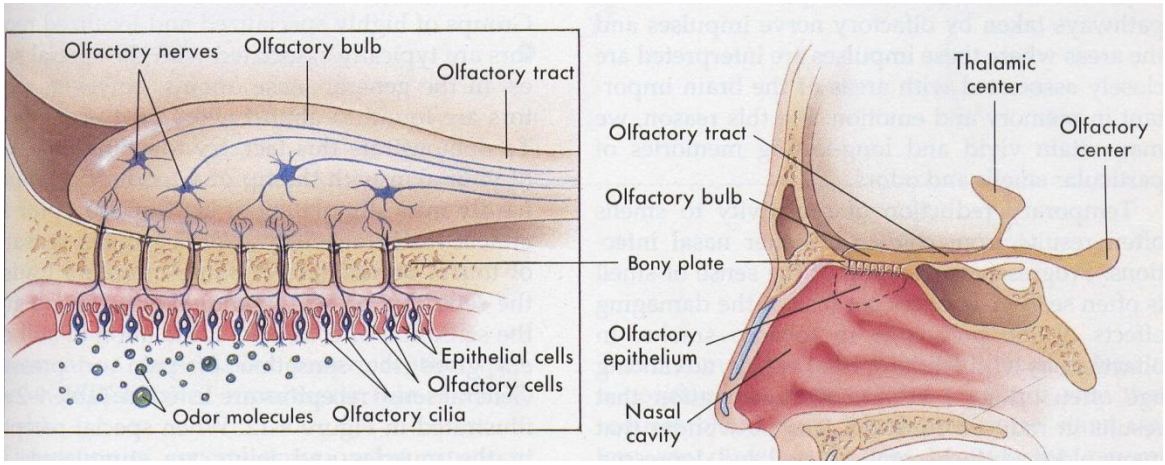


Taste buds

- The mouth contains around 10,000 taste buds, most of which are located on and around the tiny bumps on your tongue. Every taste bud detects **five primary tastes**:
  - Sour
  - Sweet
  - Bitter
  - Salty
  - Umami - salts of certain acids (for example monosodium glutamate or MSG)
- Each of your taste buds contains 50-100 specialised receptor cells.
- Sticking out of every single one of these receptor cells is a tiny taste hair that checks out the food chemicals in your saliva.
- When these taste hairs are stimulated, they send nerve impulses to your brain.
- Each taste hair responds best to one of the five basic tastes.

Smell Receptors or Olfactory receptors

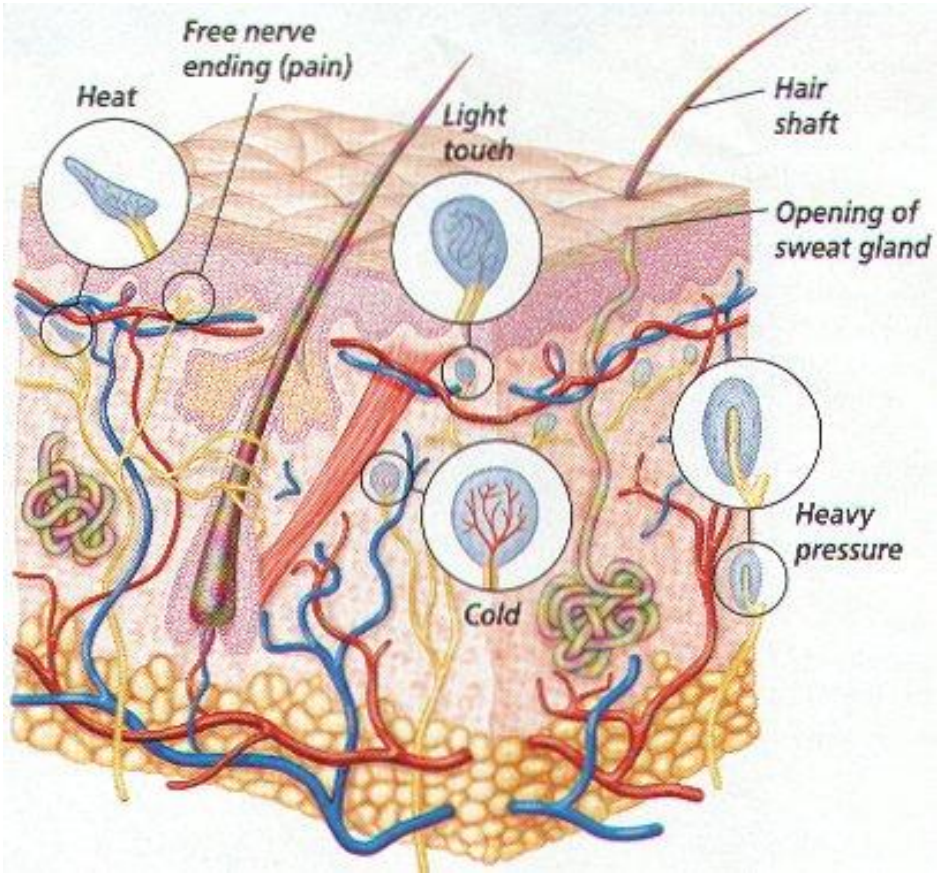
- Humans able to detect thousands of different smells
- Olfactory receptors occupy a stamp-sized area in the roof of the nasal cavity, the hollow space inside the nose
- Tiny hairs, made of nerve fibers, dangle from all your olfactory receptors. They are covered with a layer of mucus.
- If a smell, formed by chemicals in the air, dissolves in this mucus, the hairs absorb it and excite your olfactory receptors.
- A few molecules are enough to activate these extremely sensitive receptors.
- Olfactory Hairs easily fatigued so you do not notice smells
- Linked to memories - when your olfactory receptors are stimulated, they transmit impulses to your brain and the pathway is directly connected to the limbic system - the part of your brain that deals with emotions so you usually either like or dislike a smell
- Smells leave long-lasting impressions and are strongly linked to your memories
- **Much of what we associate as taste also involves smell – that is why hot foods "taste" different than "cold" foods**



Skin receptors:

Your skin and deeper tissues contain millions of sensory receptors.

Most of your touch receptors sit close to your skin's surface.



Light touch

- Meissner's corpuscles are enclosed in a capsule of connective tissue
- They react to light touch and are located in the skin of your palms, soles, lips, eyelids, external genitals and nipples
- these areas of your body are particularly sensitive.

Heavy pressure

- Paccinian corpuscules sense pressure and vibration changes deep in your skin.
- Every square centimeter of your skin contains around 14 pressure receptors

Pain

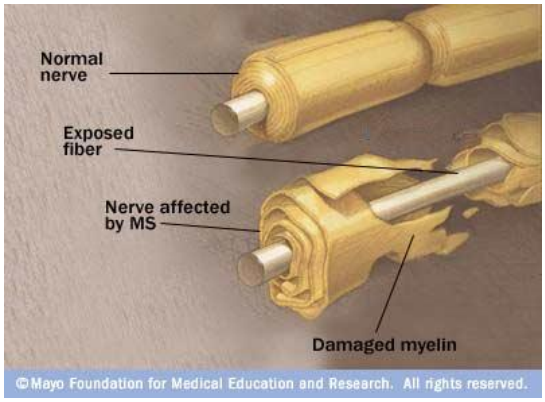
- skin receptors register pain
- pain receptors are the most numerous
- each square centimeter of your skin contains around 200 pain receptors

Temperature

- skin receptors register warmth and cold
- each square centimeter of your skin contains 6 receptors for cold and 1 receptor for warmth
- **Cold receptors** start to perceive cold sensations when the surface of the skin drops below 95 º F. They are most stimulated when the surface of the skin is at 77 º F and are no longer stimulated when the surface of the skin drops below 41 º F. This is why your feet or hands start to go numb when they are submerged in icy water for a long period of time.
- **Hot receptors** start to perceive hot sensations when the surface of the skin rises above 86 º F and are most stimulated at 113 º F. Beyond 113 º F, pain receptors take over to avoid damage being done to the skin and underlying tissues.
- thermoreceptors are found all over the body, but cold receptors are found in greater density than heat receptors – most of the time of our environment is colder than our body temperature
- The highest concentration of thermoreceptors can be found in the face and ears so your nose and ears always get colder faster than the rest of your body on a chilly winter day

Disorders of the Nervous System – symptoms, prevention, treatment

- **Epilepsy** - common and diverse set of chronic neurological disorders characterized by seizures.
- **Seizures** - the physical findings or changes in behavior that occur after an episode of abnormal electrical activity in the brain and are caused by abnormal electrical discharges in the brain
- **Alzheimer's Disease** - a degenerative **disease** of the brain that **causes** dementia, which is a gradual loss of memory, judgment, and ability to function. - the most common form of dementia- affects an estimated 1 in 10 people over age 65
- **Multiple Sclerosis** - an autoimmune disease that affects the brain and spinal cord (central nervous system) - body's immune system eats away at the protective myelin sheath that covers the axons of the neurons and interferes with the communication - MS can affect vision, sensation, coordination, movement, and bladder and bowel control.



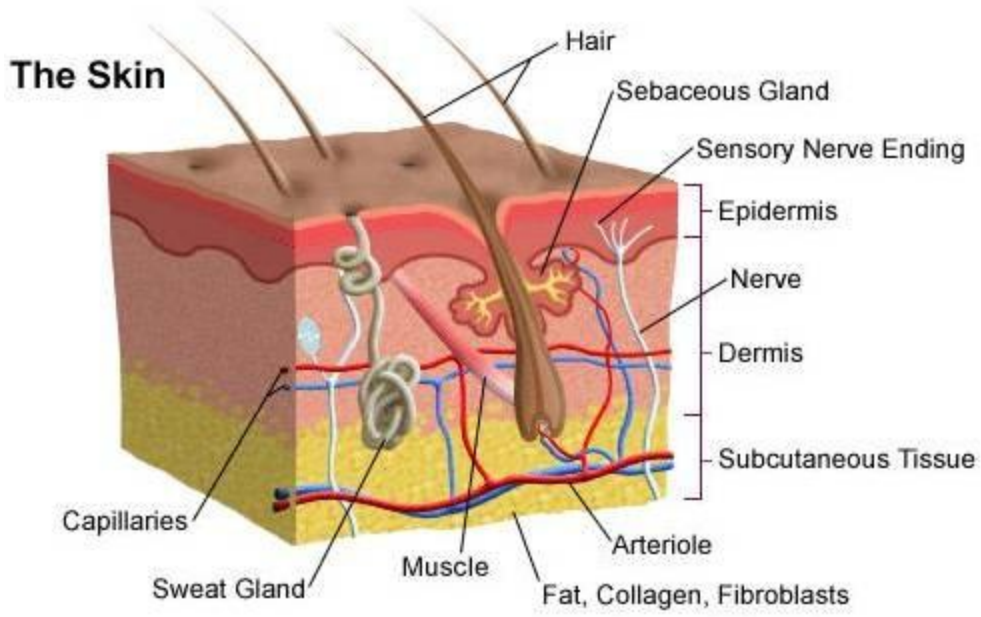
- **Parkinson's Disease** - disorder of the brain that leads to shaking (tremors) and difficulty with walking, movement, and coordination. People with Parkinson's disease have low brain dopamine concentrations.
- **Shingles (herpes zoster)** - painful, blistering skin rash due to the varicella-zoster virus, the virus that causes chickenpox – the virus remains inactive (becomes dormant) in certain nerves in the body. Shingles occurs after the virus becomes active again
- **Cerebral Palsy** - group of disorders that can involve brain and nervous system functions such as movement, learning, hearing, seeing, and thinking resulting from damage to certain parts of the developing brain
- **Glaucoma** - a group of eye conditions that lead to damage to the optic nerve due to increased pressure in the eye - the eye's drainage system becomes clogged so the intraocular fluid cannot drain and as the fluid builds up, it causes pressure to build within the eye. High pressure damages the sensitive optic nerve.
- **Pink eye (Conjunctivitis)** – infection of the conjunctiva of the eye

Effects of Drugs on the Nervous System

- **Alcohol** - central nervous system **depressant** – cell membranes are highly permeable to alcohol so once in the bloodstream it can diffuse into almost all body tissues. It is absorbed in the stomach so it gets into the blood stream quickly and slows down function of the nervous system
- **Caffeine** - acts as a central nervous system **stimulant** - caffeine suppresses melatonin for up to 10 hours and also promotes adrenalin. Melatonin is strongly associated with quality sleep, while adrenalin is the neurotransmitter associated with alertness.
- **Nicotine** - small doses of nicotine have a stimulating action on the central nervous system – it is highly addictive nicotine's effects on the brain cause an increased release of neurotransmitters associated with pleasure. The brain quickly adjusts to repeated nicotine consumption by decreasing the amount of neurotransmitters released. The effect of this increased tolerance is that the smoker must continue to use nicotine in order to avoid the feelings of discomfort associated with withdrawal from the drug. Irritability and anxiety often ensue during nicotine withdrawal.
- **Marijuana** - THC, the main active ingredient in marijuana, binds to membranes of nerve cells in the central nervous system that have protein receptors. After binding to nerve cells, THC initiates a chemical reaction that produces the various effects of marijuana use. One of the effects is suppression of memory and learning centers (called the hippocampus) in the brain.

The Integumentary System

The **integumentary system** consists of the skin, hair, nails, the subcutaneous tissue below the skin, and assorted glands.



Functions of the Integumentary System

- Protection against injury and infection
- Regulates body temperature
- Sensory perception
- Regulates water loss
- Chemical synthesis

Protection – covers and protects the entire body against injury and infection

Physical barriers - continuity of the skin and hardness of keratinzed cells

- Due to the skin's physical characteristics such as the keratinized cells and waterproofing properties of the glycolipids.
- Keratin helps waterproof the skin and protects from abrasions and bacteria
- Glycolipids prevent diffusion of water and water-soluble substances between cells
- Continuity prevents bacterial invasion
- Substances that are able to penetrate the skin:
  - Lipid-soluble substances (i.e., oxygen, carbon dioxide, steroids, and fat-soluble vitamins)
  - Oleoresins of certain plants (ex. poison ivy and poison oak)
  - Organic solvents (ex. acetone, dry cleaning fluid, and paint thinner)
  - Salts of heavy metals (ex. lead, mercury, and nickel)
  - Topical medications as motion sickness patch
- Penetration enhancers

Chemical barriers - (skin secretion and melanin)

- Skin secretions such as sebum, human defensins (antimicrobial peptides), acid mantle of the skin retards bacteria growth and/or kills them
- Melanin provides protection from UV damage

- Skin secretions (acid mantle)
- Low pH and sebum slow bacterial growth on skin surface
- Human defensin – natural antibiotic
- Cathelicidins – proteins that prevent Strep A infection in wounded skin
- Melanin – chemical pigment that prevents UV damage

Biological Barriers

- Langerhans' cells, macrophages, and DNA
- Langerhans' cells in epidermis present antigens to lymphocytes
- Dermal macrophages (2^{nd} line of defense) – attack bacteria and viruses that have penetrated the epidermis
- Langerhan's cells and macrophages present in the skin helps activate the body's immune system.
- DNA structure – the electrons in DNA absorb UV radiation and converts it to heat

Temperature regulation

- Production of copious amounts of sweat to dissipate heat
- When body temperature rises and is hotter than the external environment the blood vessels in the dermal area dilates and sweat glands are stimulated into activity.
- Evaporation of the sweat from skin's surface helps dissipate heat from the body.
- Constriction of dermal blood vessels to retain heat
- When it is cold outside, the dermal blood vessels constrict and pull the blood away from the skin and keeps it close to the body core to protect crucial internal organs.

Cutaneous Sensations - cutaneous sensory receptors (**see - nervous system**)

- Meissner's corpuscles: light touch
- Merkel discs: light touch
- Pascinian receptors – lies in deeper dermis/hypodermis & detect deep pressure contacts
- Hair root plexus: sensations from movement of hairs
- Hair follicle receptors – movement across the surface of the skin
- Bare nerve endings: painful stimuli (chemicals, heat, cold)

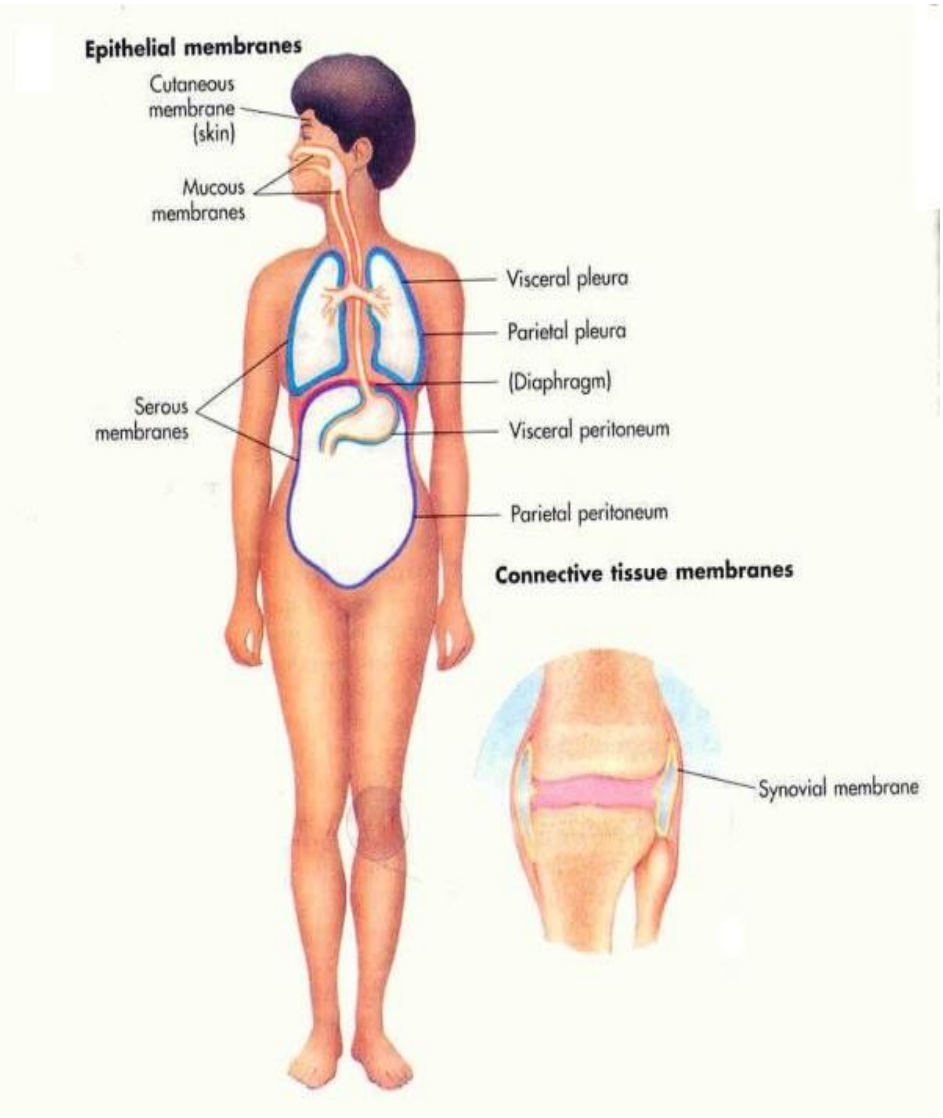
Excretion/Absorption

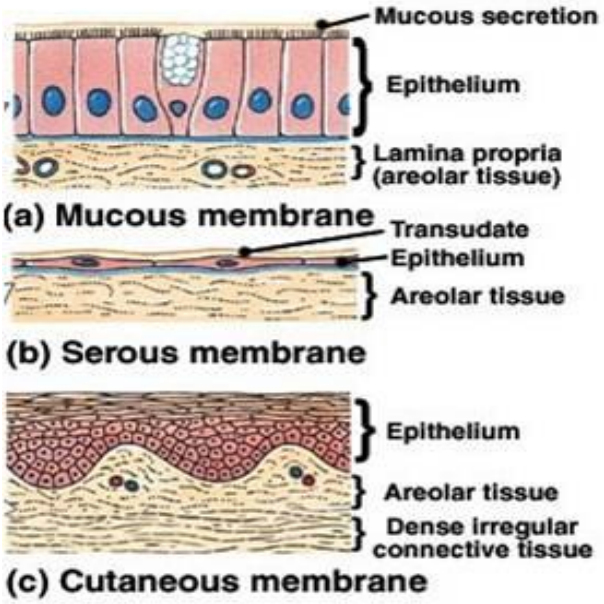
- Elimination of nitrogen-containing wastes (ammonia, urea, uric acid), sodium chloride, and water. It regulates water loss

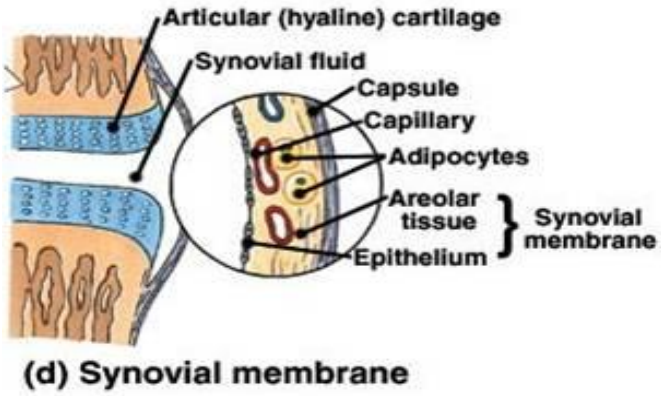
Metabolic Functions

- Synthesis of Vitamin D – increases calcium absorption in the body
- Vitamin D is a fat-soluble vitamin that may be absorbed from the intestines or may be produced by the skin when the skin is exposed to ultraviolet light (particularly sunlight).It is converted to its active form by the body in 2 steps, occurring first in the liver and completed in the kidneys. In its active form, vitamin D acts as a hormone to regulate calcium absorption from the intestine and to regulate levels of calcium and phosphate in the bones. Vitamin D deficiency causes Rickets
- When the body is deficient in vitamin D, it is unable to properly regulate calcium and phosphate levels. If the blood levels of these minerals becomes low, the other body hormones may stimulate release of calcium and phosphate from the bones to the bloodstream.
- Chemical conversion of many substances
- Blood Reservoir – preferential shunting of blood as needed

Types of Membranes - thin sheet-like structures that protect parts of the body







Serous Membranes

- Line body cavities that have no opening to the outside
- Secrete a watery fluid called serous fluid that lubricates surfaces.

Mucous Membranes

- Line cavities and tubes that open to the outside

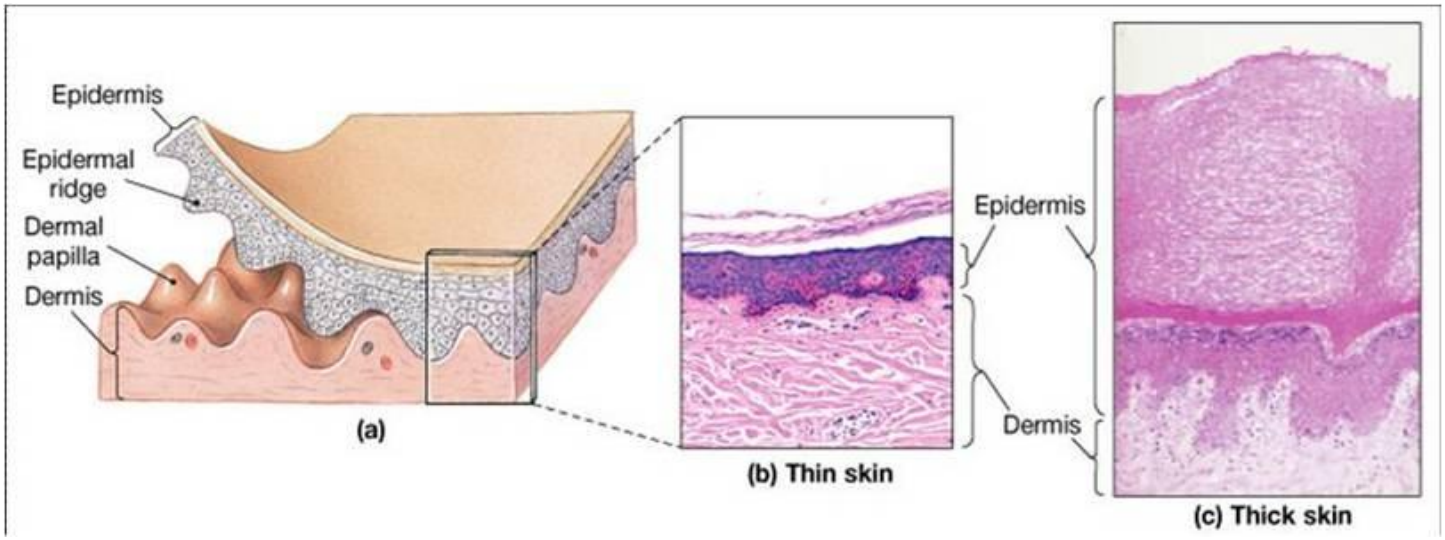
Synovial Membranes

- Form the inner lining of joint cavities
- Secrete a thick fluid called synovial fluid

Cutaneous Membrane – also known as skin

Characteristics of Skin

- The integument covers the entire body and is the largest organ ~ 2 meters and heaviest organ 16% of body mass of the body.
- Composed of the epidermis and dermis
- Pliable, yet durable
- Thickness: 1.5 to 6.0 mm



Types of Skin

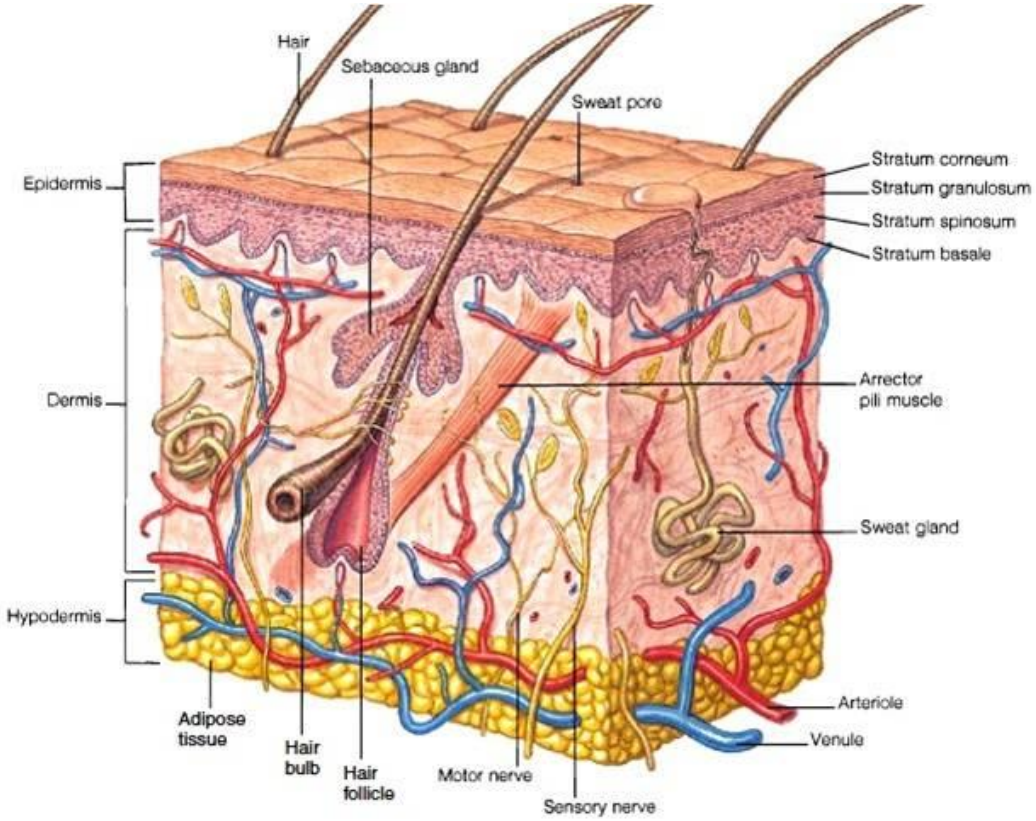
Thin - 1-2 mm on most of the body and 0.5 mm in eyelids

- Hairy
- Covers all parts of the body *except* palms of hands and soles of feet
- Thin epidermis and lacks stratum lucidum
- Lacks dermal papillae
- Has more sebaceous glands
- Fewer sweat glands, sensory receptors than thick skin

Thick - up to 6 mm thick on palms of hands and soles of feet

- Hairless
- Covers palms of hands and soles of feet
- Thick epidermis and a distinct stratum lucidum
- Epidermal ridges are present due to well-developed, numerous dermal papillae.
- Lacks sebaceous glands, has more sweat glands
- Sense receptors are also more densely packed.

Layers of the Skin



Epidermis

Types of Cells

Keratinocytes

- 90 % of epidermal cells are keratinized
- contains keratin (fibrous protein)
- protects and waterproofs the skin

Melanocytes

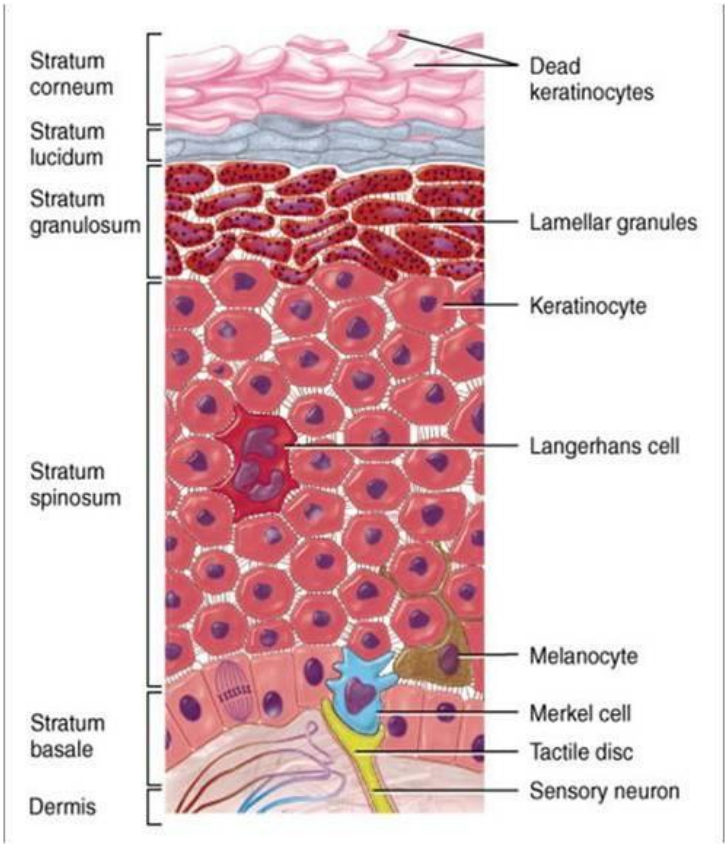
- 8% of the epidermal cells
- produces melanin
- contributes to skin color and absorbs UV light

Langerhans cells

- Arise from red bone marrow and migrate to the epidermis
- Constitute small portion of epidermal cells
- Participate in immune responses
- Easily damaged by UV light

Merkel cells

- Least numerous of the epidermal cells
- Found in the deepest layer of the epidermis
- Along with tactile discs, they function in sensation of touch



Layers of epidermis

Stratum corneum

- 25-30 layers of dead flat keratinocytes
- Shed continuously and replaced by cells from the deeper strata
- Serves as a water, microbe, injury barrier

Stratum lucidum

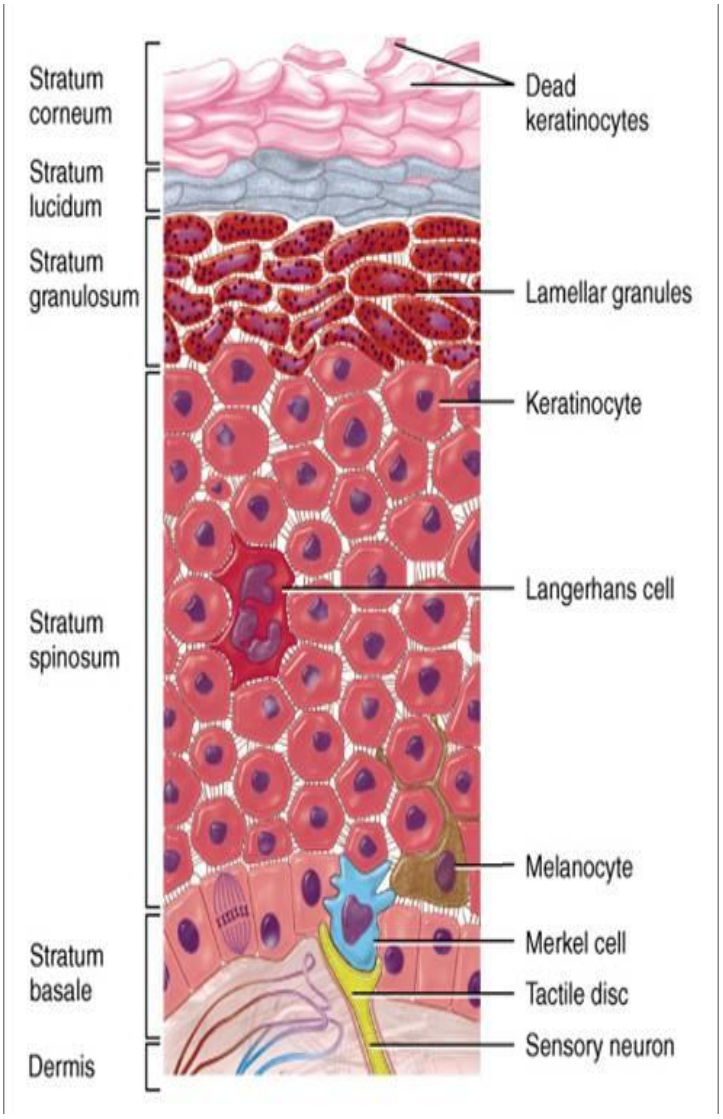
- Present only in ***thick skin***
- 3-5 layers of clear, flat, dead keratinocytes
- Dense packed intermediate filaments
- Thick plasma membranes

Stratum granulosum

- Located above the stratum spinsosum
- 3-5 layers of flattened keratinocytes undergoing apoptosis
- Organelles begin to disintegrate becomes non-living cells
- Marks the transition between deeper metabolically active strata and the dead cells of the superficial strata.
- Contains lamellar granules
- Secretes lipid-rich secretion that acts as a water sealant

Stratum spinosum

- Located above the stratum basale
- 8-10 layers of keratinocytes
- Some cells retain their ability for cell division
- Cells have spinelike projections (bundles of filaments of the cytoskeleton) tightly joins cells to each other.
- Provides skin both strength and flexibility

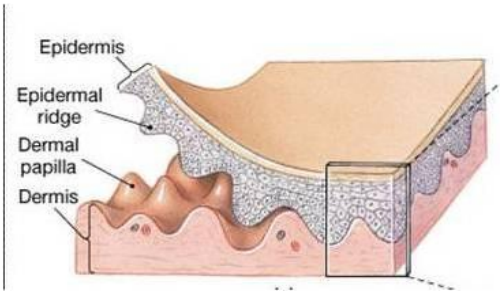


Stratum basale

- Also referred to as stratum germinatum because this is where new cells are formed
- Deepest layer of the epidermis
- Single row of cuboidal or columnar keratinocytes

Growth of epidermis

- Newly formed cells in the stratum basale undergo keratinazation as they are pushed to the surface.
- They accumulate more keratin during the process
- Then they undergo apoptosis
- Eventually they slough off and are replaced
- The process takes about 4 weeks
- Rate of cell division in the stratum basale increases during injury



Dermis -

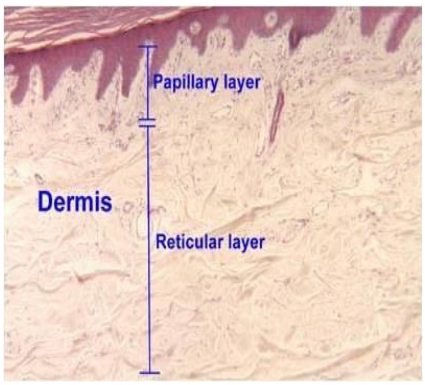
- Second deepest part of the skin
- Blood vessels, nerves, glands and hair follicles are embedded here
- Composed mainly of connective tissues (collagen and elastic fibers)
- Collagen fibers make up 70% of the dermis and give structural toughness and strength. Elastin fibers are loosely arranged in all directions and give elasticity to the skin
- Has two layers – Papillary Layer and Epidermal layer.

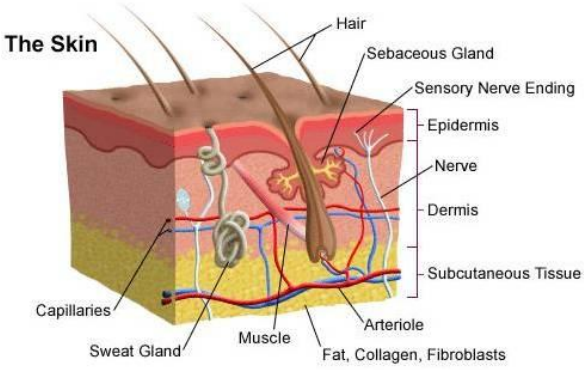
<u>Papillary layer</u>

- Superficial portion of the dermis
- Consist of areolar connective tissue containing elastic fiber
- Surface area is increased due to projections called dermal papillae which contains capillaries or tactile receptors
- Epidermal ridges conforms to the dermal papillae

<u>Reticular layer</u>

- Deeper portion of the dermis
- Consist of dense irregular connective tissue containing collagen/elastic fibers
- Provides skin with strength and elasticity
- Contains hair follicles, nerves, sebaceous and sudoriferous glands





Hypodermis – (subcutaneous) Attaches the skin to underlying organs and tissues

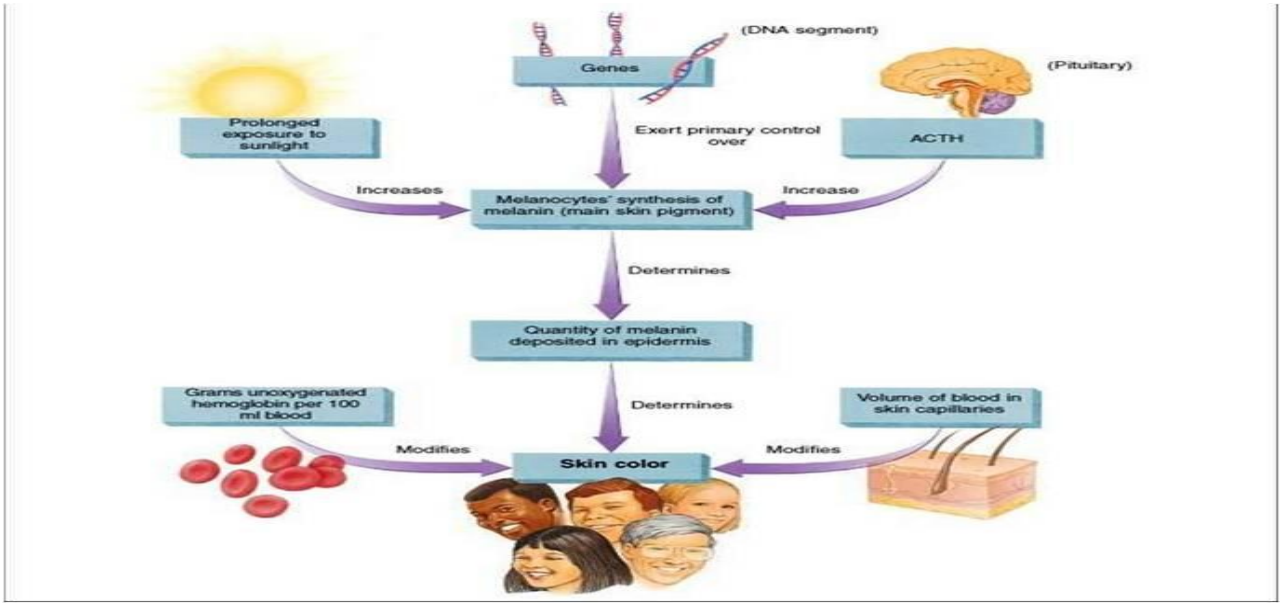
- Not part of the skin - lies below the dermis
- Contains connective tissue and adipose tissues (subcutaneous fat) for insulation
- Infants and elderly have less of this than adults and are therefore more sensitive to cold

Skin Appearances

- Epidermis appears translucent when there is little melanin or carotene
- **White skin** appears pink to red depending on amount and oxygen content of blood moving in the capillaries of the dermis.
- **Albinism** is an inherited trait where a person can't produce melanin. The have melanocytes but are unable to make tyrsinase (the enzyme which initiates melanin production) so. melanin is missing in their hair, eyes, and skin.
- Skin color as diagnostic clues for medical conditions
  - **Cyanotic** (cyan = blue) Ex: someone who has stopped breathing and the skin appears bluish
  - because the hemoglobin is depleted of oxyen
  - **Jaundice** (jaund = yellow) - Buildup of bilirubin (yellow pigment) in the blood gives a yellowish appearance of eyes and skin indicating liver disease Bilirubin is produced when red blood cells get old and are broken down by the body. Normally it is processed in the liver and then deposited in the intestine so it can come out in the stool.
  - **Erythema (ery = red) -** Engorgement of capillaries in the dermis indicating skin injury, infection, heat exposure, inflammation, allergies, emotional state, hypertension
  - **Pallor** - paleness, emotional state, anemia, low blood pressure
  - **Bronzing** - Addison's disease, adrenal cortex

- **Bruising** (hematoma)- escaped blood has clottedhematomas , deficiency in Vitamin C or hemophilia
- **leathery skin** - overexposure clumping of elastin fibers depressed immune system
- can alter DNA to cause skin cancer
- **photosensitivity** - to antibiotics & antihistamines

Skin Color – genetic factors, environmental factors and volume of blood



Skin Pigments - three pigments are responsible for skin color- melanin, carotene, hemoglobin

Melanin

- Located mostly in epidermis
- Number of melanocytes are about the same in all races
- Difference in skin color is due to the amount of pigment that melanocytes produce and disperse to keratinocytes.
- Freckles are caused by the accumulation of melanin in patches
- Liver spots are also caused by the accumulation of melanin
- Melanocytes synthesize melanin from an amino acid called tyrosine along with an enzyme called tyrosinase. All this occurs in the melanosome which is an organelle in the melanocyte.
- Two types of melanin: eumelanin which is brownish black and pheomelanin which is reddish yellow
- Fair-skinned people have more pheomelanin and dark skinned people have more eumelanin

Environmental Factors

- UV light increases enzymatic activity in the melanosomes and leads to increased melanin production.
- A tan is achieved because the amount of melanin has increased as well as the darkness of the melanin. (Eumelanin provides protection from UV exposure while pheomelanin tends to break down with too much UV exposure)
- The melanin provides protection from the UV radiation but prolonged exposure may cause skin cancer.

Carotene (carot = carrot)

- yellow-orange pigment
- precursor for Vitamin A which is used to make pigments needed for vision
- found in stratum corneum and fatty areas of dermis and hypodermis layer

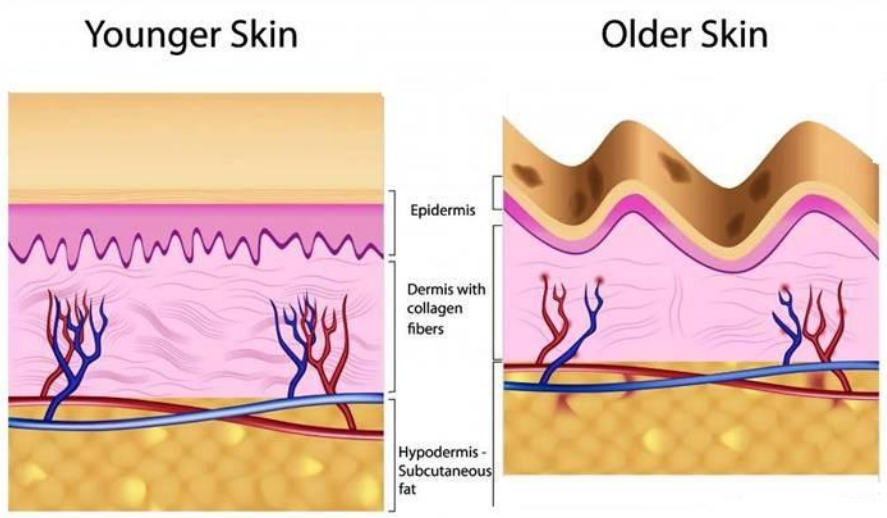
Hemoglobin

- Oxygen-carrying pigment in red blood cells

Skin Markings - skin is marked by many lines, creases and ridges

- **friction ridges:** markings on fingertips characteristic of primates
- allow us to manipulate objects more easily - **fingerprints** are friction ridge skin impressions
- **flexion lines:** on flexor surfaces of digits, palms, wrists, elbows etc skin is tightly bound to deep fascia at these points
- **freckles:** flat melanized patches vary with heredity or exposure to sun
- **moles:** elevated patch of melanized skin, of the with hair mostly harmless, beauty marks

Aging



- Beginning in our 20s, the effects of aging begin to be visible in the skin.
- Stem cell activity declines: skin thin, repair difficult
- Epidermal dendritic cells decrease: reduced immune response
- Vitamin D3 production declines: calcium absorption declines and brittle bones
- Glandular activity declines: skin dries, body can overheat
- Blood supply to dermis declines: tend to feel cold
- Hair follicles die or produce thinner hair
- Dermis thins and becomes less elastic – wrinkles
- Sex characteristics fade: fat deposits spread out, hair patterns change
- Genetically programmed chronologic aging causes biochemical changes in collagen connective tissues that give skin its firmness and elasticity.
- The genetic program for each person is different, so the loss of skin firmness and elasticity occurs at different rates and different times in one individual as compared with another.
- As skin becomes less elastic, it also becomes drier.
- Underlying fat padding begins to disappear.
- With loss of underlying support by fat padding and connective tissues, the skin begins to sag. It looks less supple and wrinkles form.
- The skin may be itchy with increased dryness. A cut may heal more slowly.

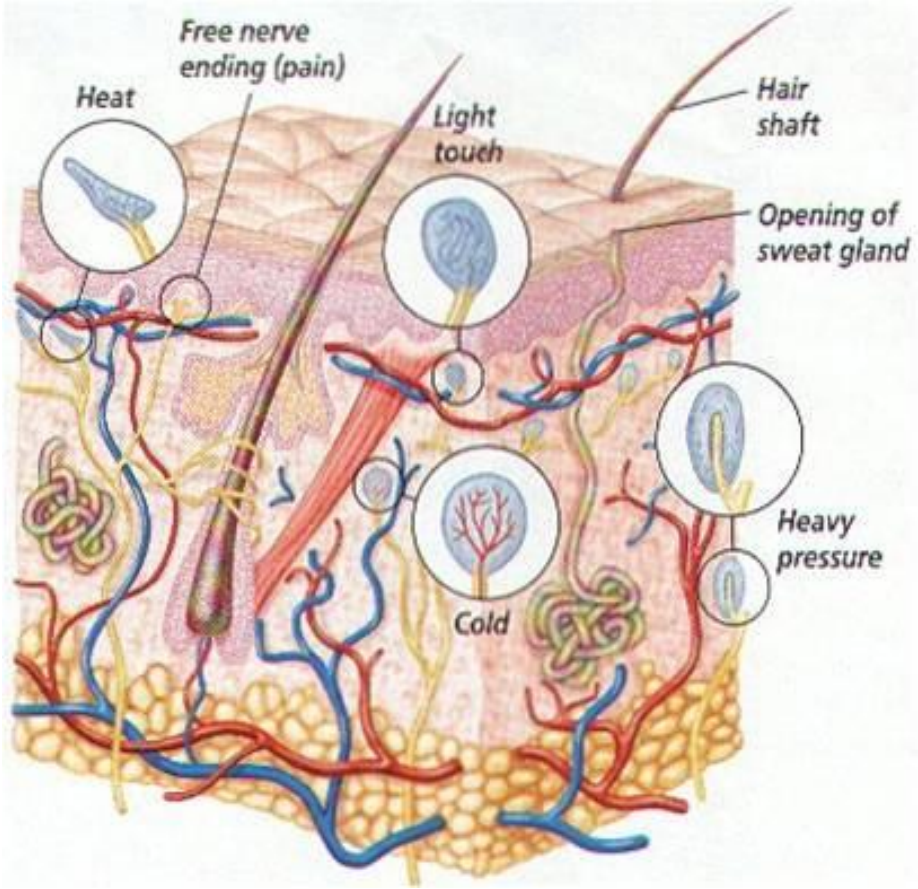
Derivatives of skin - during embryonic development thousands of small groups of epidermal cells from stratum basale push down into dermis to form hair follicles and glands

Skin receptors*:*

Your skin and deeper tissues contain millions of sensory receptors.
Most of your touch receptors sit close to your skin's surface.

Light touch

- ***Meissner's corpuscles*** are enclosed in a capsule of connective tissue
- They react to light touch and are located in the skin of your palms, soles, lips, eyelids, external genitals and nipples
- These areas of your body are particularly sensitive



Heavy pressure

- ***Paccinian corpuscules*** sense pressure and vibration changes deep in your skin.
- Every square centimeter of your skin contains around 14 pressure receptors

Pain

- skin receptors register pain
- pain receptors are the most numerous
- each square centimeter of your skin contains around 200 pain receptors

Temperature

- Skin receptors register warmth and cold
- Each square centimeter of your skin contains 6 receptors for cold and 1 receptor for warmth
- ***Cold receptors*** start to perceive cold sensations when the surface of the skin drops below 95 º F. They are most stimulated when the surface of the skin is at 77 º F and are no longer stimulated when the surface of the skin drops below 41 º F. This is why your feet or hands start to go numb when they are submerged in icy water for a long period of time.
-
- ***Hot receptors*** start to perceive hot sensations when the surface of the skin rises above 86 º F and are most stimulated at 113 º F. Beyond 113 º F, pain receptors take over to avoid damage being done to the skin and underlying tissues.
- ***Thermoreceptors*** are found all over the body, but cold receptors are found in greater density than heat receptors – most of the time our environment is colder than our body temperature
- The highest concentration of thermoreceptors can be found in the face and ears so your nose and ears always get colder faster than the rest of your body on a chilly winter day

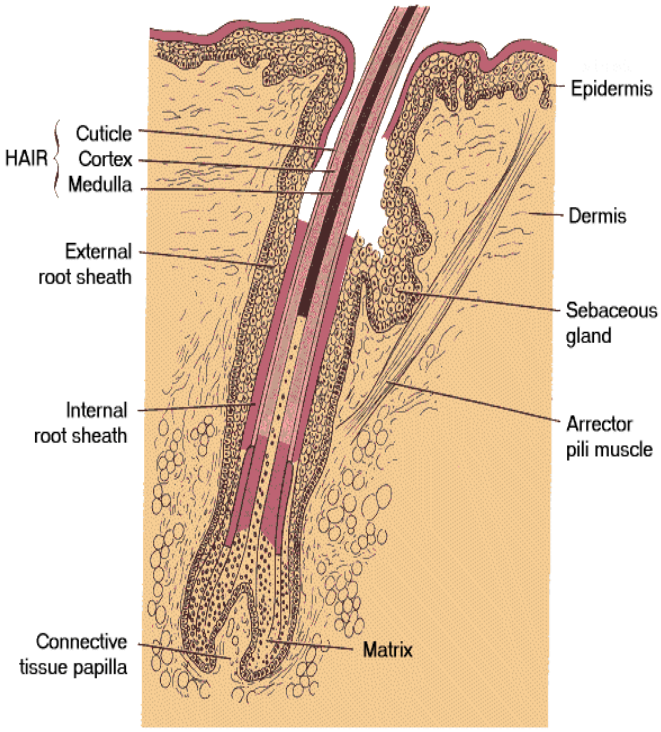
Accessory Structures of the Skin

Hair

Anatomy of Hair Follicle

***Shaft*:** portion of hair that projects from skin surface
- Straight hair has a round shaft
- Curly hair is oval

***Root*:** portion of hair deep to the shaft penetrating the dermis
- Has ***3 layers***:
  medulla: contains pigment granules and air spaces
  cortex*:* middle layer
  in dark hair contains pigment
  in gray or white hair contains air bubbles
  cuticle: outer layer
  heavily keratinized cells that lie like shingles



Base of the hair follicle
- **Bulb**: houses the papilla which contains the blood vessels that nourishes the growing hair follicle.
- **Matrix*:*** responsible for hair growth and produces new hair

***Arrector pili:* smooth muscle**
- Extends from the dermis to the side of hair follicle.
- Hair grows at an angle to the surface of the skin
- Arrector pili muscles contract and pulls hair straight causing **goose bumps**.

***Hair root plexus* -** dendrites of neurons which are sensitive to touch

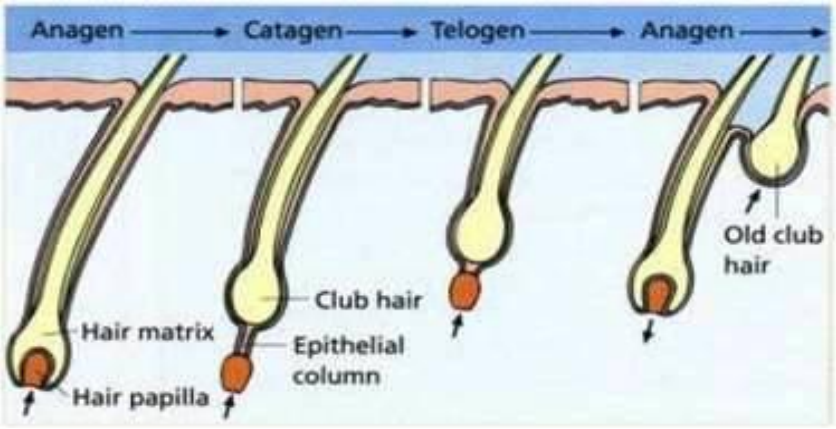
Important Features and Texture
- Roughly 5 million hairs cover the body of an average individual
- About 100,000 are on the scalp
- Almost every part of body is covered with hair except palms of hands, soles of feet, sides of fingers and toes, lips and parts of genitals.
- Hair shafts differ in size, shape, and color. In the eyebrows they are short and stiff while on the scalp they are longer and more flexible. Over the rest of the body they are fine and nearly invisible
- Oval shaped hair shafts produce wavy hair, flat or ribbon-like hair shafts produce curly or kinky hair, and round hair shafts produce straight hair.

The Hair Growth Cycle

- Hair follicles grow in repeated cycles.
- One cycle can be broken down into three phases.

    1. **Anagen** - Growth Phase
    2. **Catagen** – Transitional Phase
    3. **Telogen** - Resting Phase

- Each hair passes through the phases independent of the neighboring hairs



Anagen Phase - Growth Phase

- Approximately 85% of all hairs are in the growing phase at any one time. The Anagen phase or growth phase can vary from two to six years. Hair grows approximately 10cm per year and any individual hair is unlikely to grow more than one meter long. Each hair on your body grows from its own individual hair follicle. Inside the follicle, new hair cells form at the root of the hair shaft. As the cells form, they push older cells out of the follicle. As they are pushed out, the cells die and become the hair we see.
- A follicle will produce new cells for a certain period of time depending on where it is located on your body. This period is called the growth phase.

Catagen Phase - Transitional Phase

- At the end of the Anagen Phase the hairs enters into a Catagen Phase which lasts about one or two weeks, during the Catagen Phase the hair follicle shrinks to about 1/6 of the normal length.
- The lower part is destroyed and the dermal papilla breaks away to rest below.

Telogen Phase - Resting Phase

- The Resting Phase follows the Catagen Phase and normally lasts about 5-6 weeks. During this time the hair does not grow but stays attached to the follicle while the dermal papilla stays in a resting phase below. Approximately 10-15 percent of all hairs are in this phase at any one time.
- When the hair follicle enters the **Resting Phase**, the hair shaft breaks, so the existing hair falls out and a new hair takes its place. Therefore, the length of time that the hair is able to spend growing during the growth phase controls the maximum length of the hair.
- The cells that make the hairs on your arms are programmed to stop growing every couple of months, so the hair on your arms stays short. The hair follicles on your head, on the other hand, are programmed to let hair grow for years at a time, so the hair can grow very long.
- Animals that shed have hair follicles that synchronize their rest phase so that all of the follicles enter the rest phase at once.
- Some factors that affect the rate of growth and replacement of hair are illness, diet, stress, gender, radiation therapy, and medication.
- At the end of the Telogen phase the hair follicle re-enters the Anagen Phase. The dermal papilla and the base of the follicle join together again and a new hair begins to form. If the old hair has not already been shed the new hair pushes the old one out and the growth cycle starts all over again.

Functions of Hair

- Hair on the head protects scalp from injury and sunlight
- Eyelashes and eyebrows protect eyes
- Nostril and ear hairs protect from foreign particles
- Help in sensing light touch due to the touch receptors associated with the hair root plexuses.

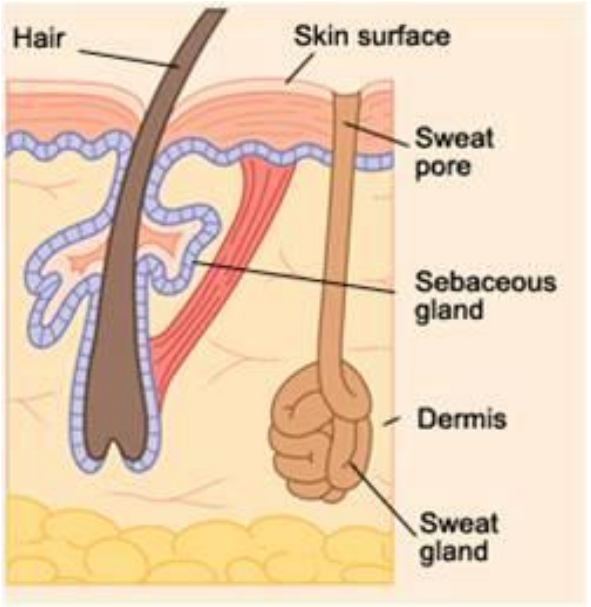
Hair Color

- Hair color is due to amount and type of melanin in the keratinized cells.
- Melanocytes in the matrix of the bulb synthesizes melanin.
- Melanin passes into the cortex and medulla of the hair.
- **Dark hair** contains true melanin
- **Blond and red hair** have variants of melanin in which there is iron/sulfur.
- **Gray hair resuls from a** decline in tyrosinase (enzyme which initiates melanin production).
- **White hair** results from the accumulation of air bubbles in the medullary shaft.

Skin Glands

***Sudoriferous* - sweat glands (sudori = sweat) (ferous = bearing)**

- 3- 4 million glands in your body empties onto the skin thru pores or into hair follicles
- Two main types of sweat glands
- **Eccrine sweat glands**
  - Secretes cooling sweat
  - Secretes directly onto the skin
  - Began to function soon after birth
  - Sweat is composed of 98 percent water and two percent dissolved salts and nitrogenous wastes, such as urea and uric acid
  - Helps regulate body temperature/aids in waste removal
- **Appocrine sweat glands**
  - Stimulated during emotional stress/excitement
  - Secretes into hair folicle
  - Begins to function at puberty
  - Slightly more viscous than eccrine secretions
  - Composed of the same components as eccrine sweat plus
  - lipids and proteins.
  - Referred to as "cold sweat".

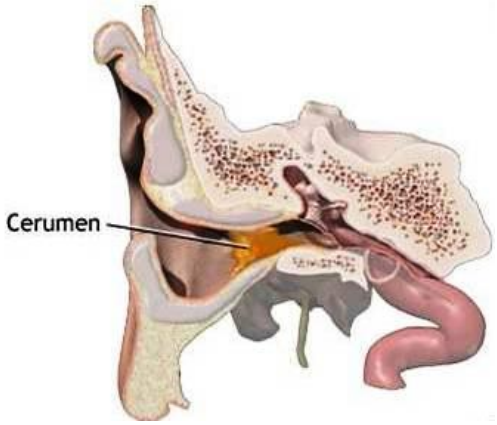


***Sebaceous* -** oil glands (sebace = grease)

- They are mostly connected to hair follicles.
- Sebaceous glands are embedded in the dermis over most of the body.
- Absent in the palms and soles.
- Vary in size, shape and numbers in other areas of the body.
- Secrete an oily substance called sebum. which lubricates the hair and skin
- Mixture of fats, cholesterol, proteins, inorganic salts, pheromones.
- Coats surface of hair
- Prevents excessive evaporation of water from skin

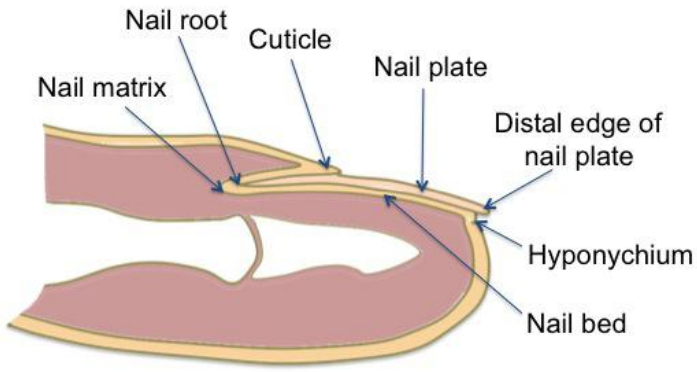
- Keeps skin soft and pliable
- Inhibits growth of some bacteria.
- Sebaceous gland activity increases with puberty, due to the male and female hormone activity
- Accumulation of sebum in the ducts = white pimples – if the sebum darkens -black heads form
- **Acne -** inflammation of sebaceous gland ducts

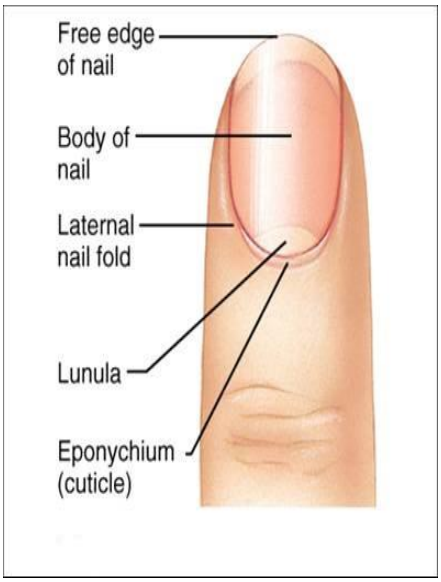
Ceruminous **-** modified sweat glands of the external ear that produce ear wax (cer = wax)



- Open directly onto the surface of the external auditory canal (ear canal) or into ducts of sebaceous glands.
- Earwax is the combination of secretion of ceruminous and sebaceous glands.
- Earwax and the hair combine to provide a sticky barrier against foreign items.

Nails





- Made of tightly packed, hard, keratinized epidermal cells
- Consist of:

  Nail body: portion of the nail that is visible
  - Free edge: part that extends past the distal end of the digit
  - Nail root: portion buried in a fold of skin

  Lunula : means little moon
  - Crescent shaped area of the nail

  Hyponychium: secures the nail to the fingertip
  - Thickened stratum corneum

  Eponychium or cuticle: narrow band of epidermis
  - Growth of nails is in the nail matrix.

- Nail cells multiply under the skin. Each cell keeps dividing and creating more cells. The new cells push the old cells above the skin surface.
- Once the nail cells are out on the surface, they are pushed from below by new nail cells, towards your finger or toe. However, once they come out they lose the ability to multiply. They become dead cells.
- **Functions of the nails**:
  - Grasping objects
  - Manipulating objects
  - Protects ends of digits from trauma
  - Scratching

Imbalances of Homeostasis

Skin Imbalances - The skin can develop >1000 different ailments. the most common skin disorders result from allergies or infections less common are burns and skin cancers

Skin lesions – any measurable variation from normal structure of the skin

- **Elevated lesions –** cast a shadow outside the edges as warts, plaque, blister
- **Flat lesions –** do not cast a shadow as a scab, elevated lesion with pus, hive
- **Depressed lesions –** cast a shadow within their edges as lacerations, ulcers, fissures

Infections

- **Viral -** eg. cold sores, herpes simplex especially around lips and oral mucosa
  Warts – benign neoplasms caused by papillomavirus (HPV)
- **Fungal -** eg. athletes foot, Tinea
- **Bacterial-** eg. boils and carbuncles inflammation of hair follicle and sebaceous glands especially on face or dorsal side of neck , impetigo *Streptococcus* infection

Contact dermatitis is a condition in which the skin becomes red, sore, or inflamed after direct contact with a substance. There are two kinds of contact dermatitis: **irritant or allergies**

Irritant dermatitis is the most common type. It's caused by contact with acids, alkaline materials such as soaps and detergents, fabric softeners, solvents, or other chemicals. The reaction usually looks like a burn.

Other irritants may include:

- Cement
- Hair dyes
- Long-term exposure to wet diapers
- Pesticides or weed killers
- Rubber gloves
- Shampoos

Allergic contact dermatitis is caused by exposure to a substance or material to which you have become extra sensitive or allergic.

Common allergens include:

- Adhesives, including those used for false eyelashes or toupees
- Antibiotics such as neomycin rubbed on the surface of the skin
- Balsam of Peru (used in many personal products and cosmetics, as well as in many foods and drinks)
- Fabrics and clothing
- Fragrances in perfumes, cosmetics, soaps, and moisturizers
- Nail polish, hair dyes, and permanent wave solutions
- Nickel or other metals (found in jewelry, watch straps, metal zips, bra hooks, buttons, pocketknives, lipstick holders, and powder compacts)
- Poison ivy, poison oak, poison sumac, and other plants
- Rubber or latex gloves or shoes

Treatment

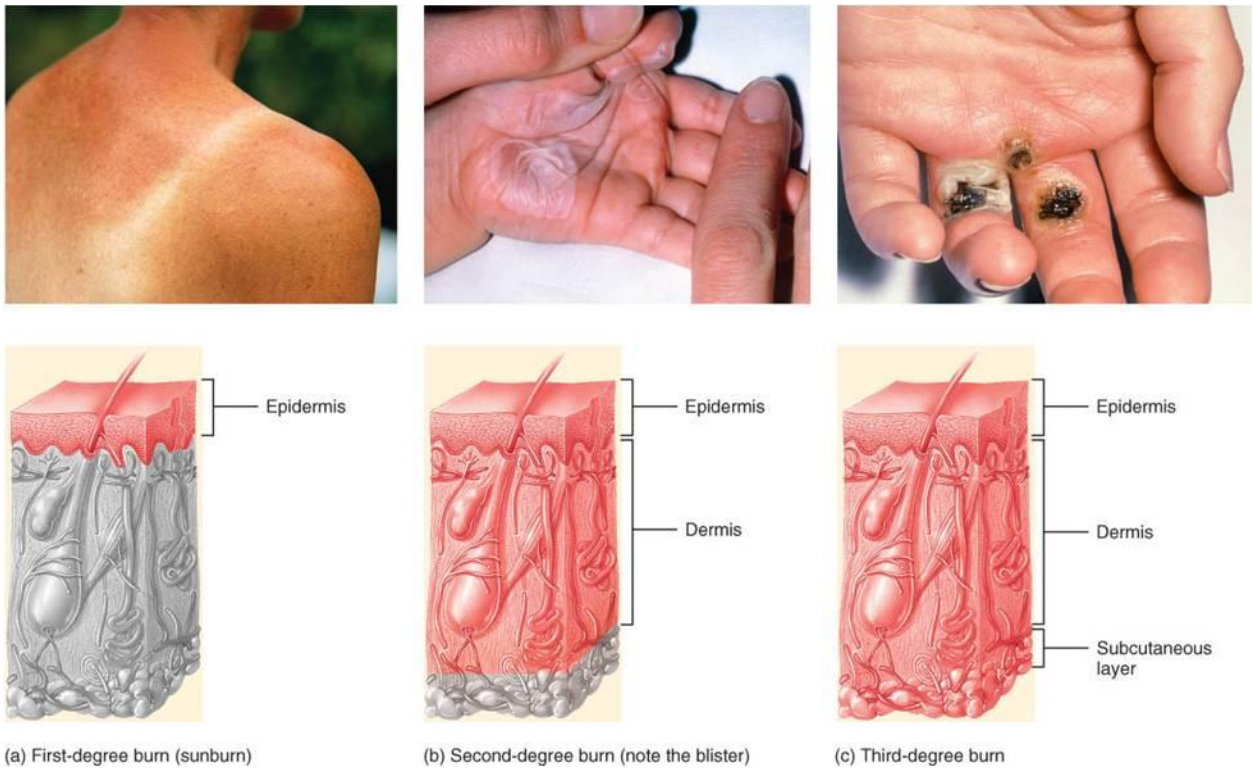
- Washing with lots of water to remove any traces of the irritant that may remain on the skin
- Avoid further exposure to known irritants or allergens
- Anti-itch (antipruritic) or drying lotions may be recommended to reduce other symptoms
- Corticosteroid skin creams or ointments may reduce inflammation
- Corticosteroid pills or a corticosteroid shot from the doctor may be needed in severe cases

Genetic Diseases

- **Psoriasis**
  - chronic, noninfectious skin disease
  - skin becomes dry and scaly, often with pustules and many varieties
  - cycle of skin cell production increases by 3-4x's normal
  - stratum corneum gets thick as dead cells accumulate
  - seems to be a genetic component
  - often triggered by trauma, infection , hormonal changes or stress

- **Vitiligo** – a autoimmune pigmentation disorder where melanocytes in the epidermis are destroyed eg Michael Jackson

Burns - too much sunlight or heat - categorized by degree of penetration of skin layer



- **<u>1st degree burns</u>**
  - skin is inflamed, red - surface layer of skin is shed
- **<u>2nd degree burns</u>**
  - deeper injury - blisters form as fluid builds up beneath outer layers of epidermis
- **<u>3rd degree burns</u>**
  - full thickness of skin is destroyed -sometimes even subcutaneous tissues results in ulcerating wounds
  - typically results in catastrophic loss of fluids:
    - dehydration
    - electrolyte imbalances
    - also highly susceptible to infections
    - slow recovery (from cells of hair follicles if they survive;
    - otherwise must heal from margins of wound)
    - may require: autografts, cadaver skin, pig skin
    - prognosis may depend on extent of damage
- A **<u>fourth- degree burn</u>** additionally involves injury to deeper tissues, such as muscle or bone

"rule of 9's"- extend of burn damage estimated by

- head, arms ~9% of skin surface
- front and back of torso, each leg ~18% of skin surface
- groin ~1% of skin surface

Skin Cancer

- Cells have a built-in mechanism that causes contact inhibition. Healthy cells stop growing when they come in contact with one another. In damaged cells, contact inhibition is lost and therefore the cells continue to grow until they start lumping up on one another.
- Cancer cells do not exhibit contact inhibition.
- Excessive or chronic exposure UV radiation , x-rays or radiation' chemicals or physical trauma are predisposing factors to cancer.
- most forms progress slowly and are easily treated but a few are deadly

Basal Cell Carcinoma

- least malignant
- most common -78% of all skin cancers
- stratum basale can't form keratin
- lose boundary layer between epidermis and dermis
- results in tissue erosion and ulceration
- 99% of these cancers are fully cured

Squamous Cell Carcinoma -20% of all skin cancers

- cancer of the cells in stratum spinosum
- arise from squamous cells of the epidermis
- usually induced by sun
- cells grow rapidly and grow into the lymphatic tissues
- hardened small red growth
- spreads rapidly if not removed
- good chance of recovery if detected and treated early

Malignant Melanoma

- cancer of pigment cells = melanocytes
- rare ~1% of skin cancers
- deadly, poor chance of cure once it develops
- often begins with moles
- spreads rapidly
- early detection and treatment is the key to survival