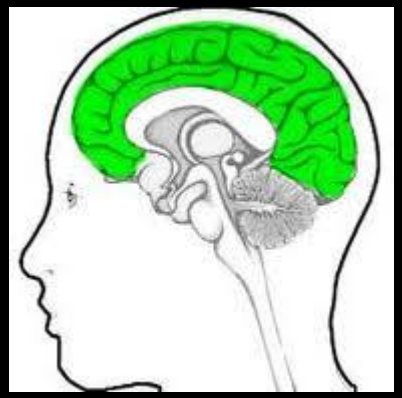
The Nervous System

The Nervous System

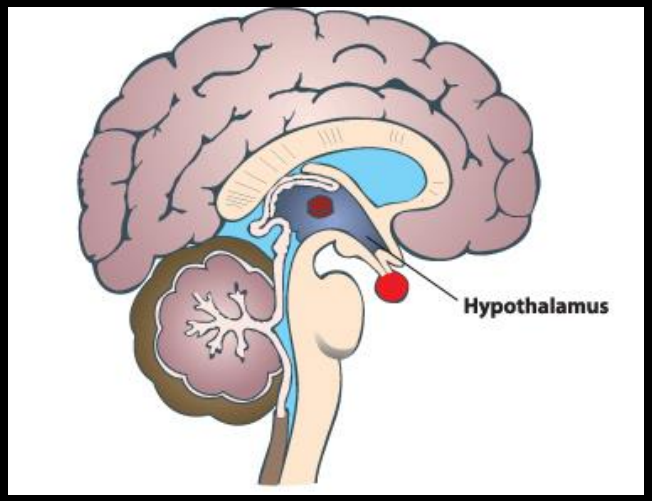


- Humans have the most complex nervous system of all organism on Earth. (Whale and Dolphin a close 2nd)

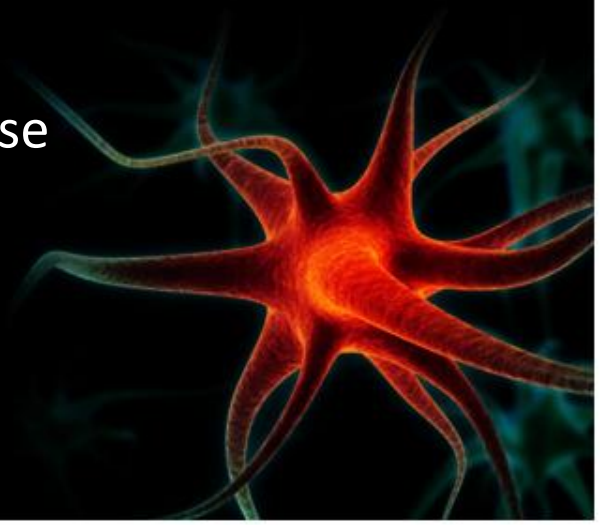
- Two reasons for evolution of a more complex vertebrate brain.
  - 1.) The ratio of Brain to body mass increases
  - 2.) A progressive increase in the size of the area of the brain (Cerebrum) that is involved in higher mental and intellectual abilities.

- Cerebrum is the dominant part of the brain in cats and chimpanzees but not in fish and reptiles.
- In Humans the cerebrum almost covers the rest of the brain. (very large)

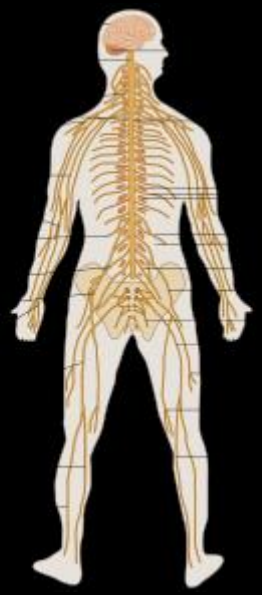
The Structure of the Nervous System



- How does the nervous system cope with changes both inside and outside the body?
- The nervous system provides a high speed communication system to and from almost every part of the body.
- Information about carbon dioxide, water, glucose levels and blood pressure are all monitored by the hypothalamus



The Structure of the Nervous System (cont)



- The Human nervous system is comprised of interconnected systems.

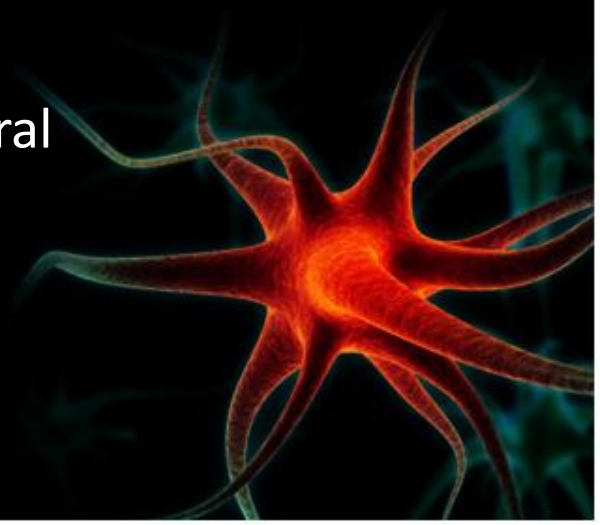
- **Two major parts comprise the human nervous system.**

  1.) The Central Nervous system

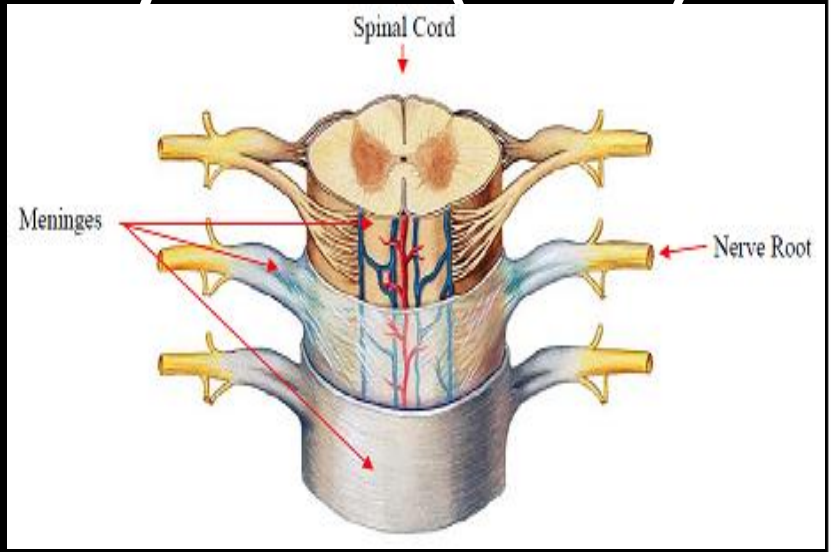
  - Brain and spinal cord

  2.) The Peripheral Nervous System

  - nerves that lead into and out of the central nervous system.

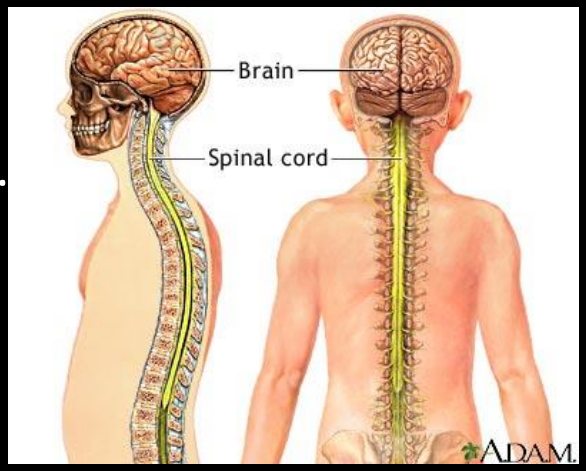


The Central Nervous System (CNS)



- Brain and Spinal cord.
- Protected by bone, with the skull forming an enclosure around the brain.
- Vertebrae enclosing the spinal cord.
- Meninges are protective membranes surrounding the spinal cord filled with Cerebrospinal fluid that provide cushion.

The Central Nervous System (cont)

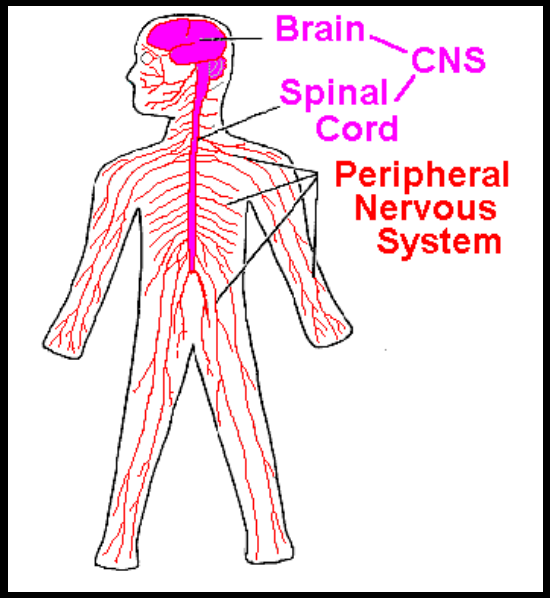


- The spinal cord extends from the vertebral canal formed by the vertebrae into the base of the brain.
- The spinal cord is the link between the brain and peripheral nervous system.
- The spinal cord contains a central canal, which is filled with cerebrospinal fluid, grey matter and white matter.

The Peripheral Nervous System (PNS)

- The peripheral nervous system consists of:
  1.) The autonomic nervous system
  2.) The somatic Nervous System

- Control some organs in the body.



1.) The Autonomic Nervous System

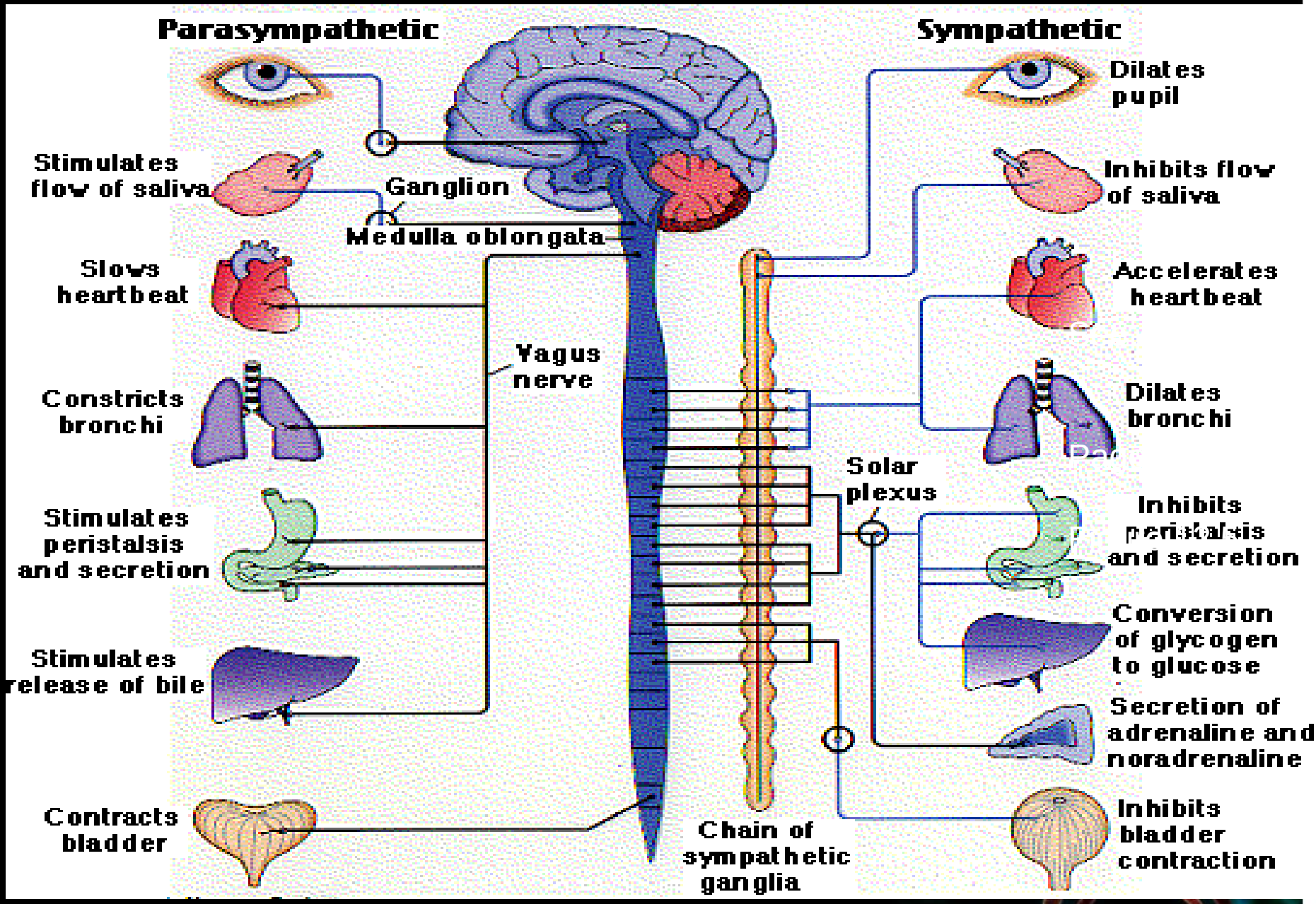
- Not consciously controlled
- Has two parts

  1.) Sympathetic Nervous System

  - Sets off the fight-or-flight response for the body to deal with an immediate threat.
  - Heart rate and breathing increases

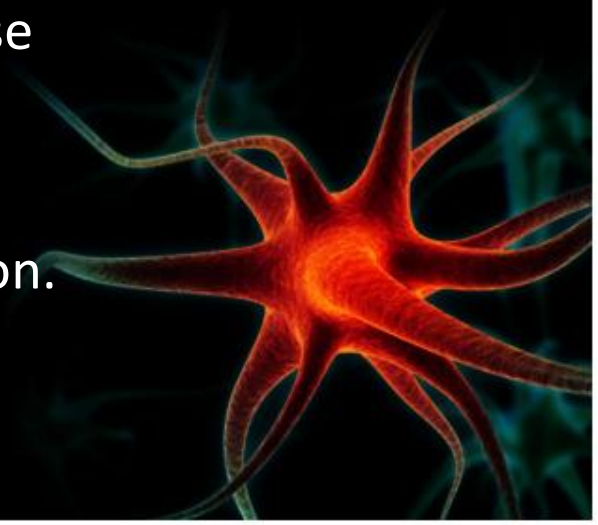
  2.) Parasympathetic nervous system.

  - Nerves slow heart rate and breathing after a threat has passed
  - Has motor nerves that transmit commands from the central nervous system to the muscles

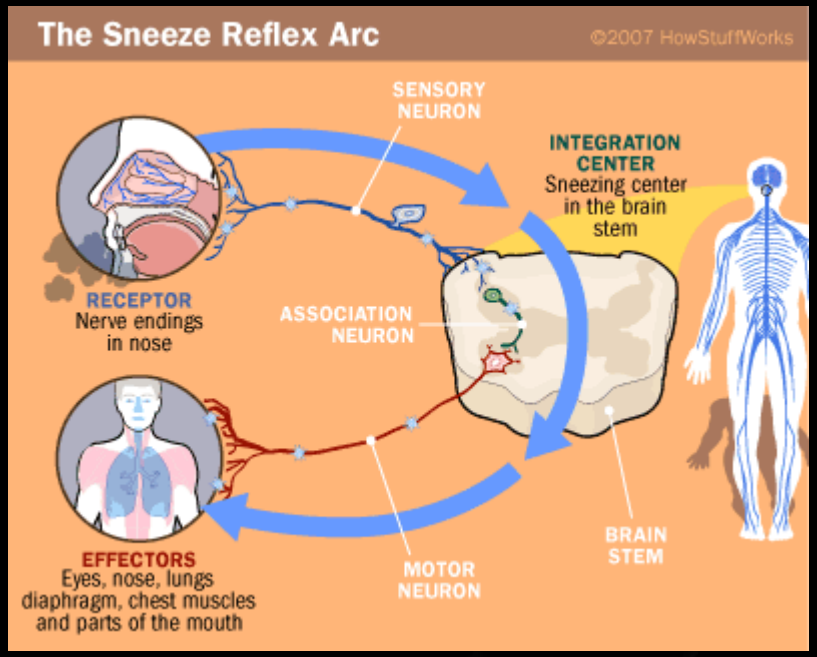

Parasympathetic
Sympathetic
Stimulates flow of saliva
Ganglion
Medulla oblongata
Slows heartbeat
Vagus nerve
Constricts bronchi
Stimulates peristalsis and secretion
Stimulates release of bile
Contracts bladder
Dilates pupil
Inhibits flow of saliva
Accelerates heartbeat
Dilates bronchi
Solar plexus
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Secretion of adrenaline and noradrenaline
Inhibits bladder contraction
Chain of sympathetic ganglia

2.) The Somatic Nervous System

- Somewhat under your conscious control.
- Information form eyes and ears is processed by the brain and then you make the decision to move your muscles.
- Reflex: A certain action sets off a specific reaction i.e. Your Eye blinks when something moves close to it.
- Such reflexes do not require a conscious decision.

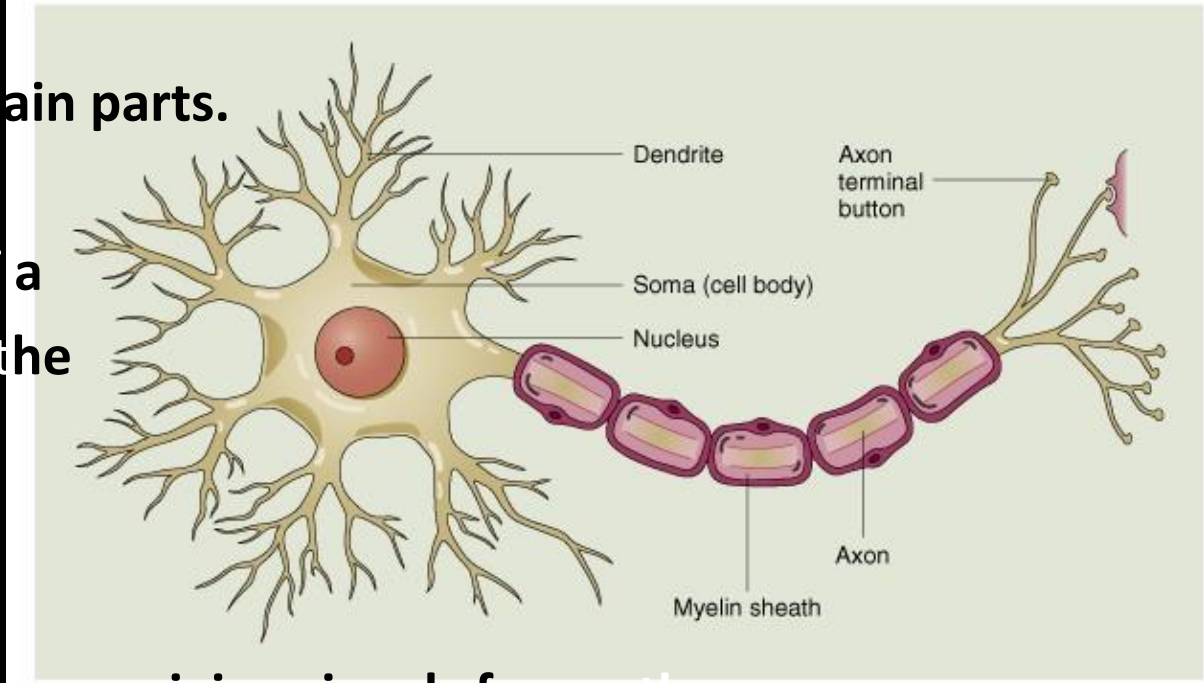


Neurons and Reflex Responses



- The structural and functional unit of the nervous system is the neuron
- The PNS contains nerves which are numerous neurons held together by connective tissue.
- 90% of the bodies neurons are found in the CNS
- A reflex arc is the nerve pathway the leads from stimulus to reflex action.

The Neuron



- **Consists of three main parts.**
- 1.) Cellbody
  - The main part of a neuron containing the nucleus and other organelles.

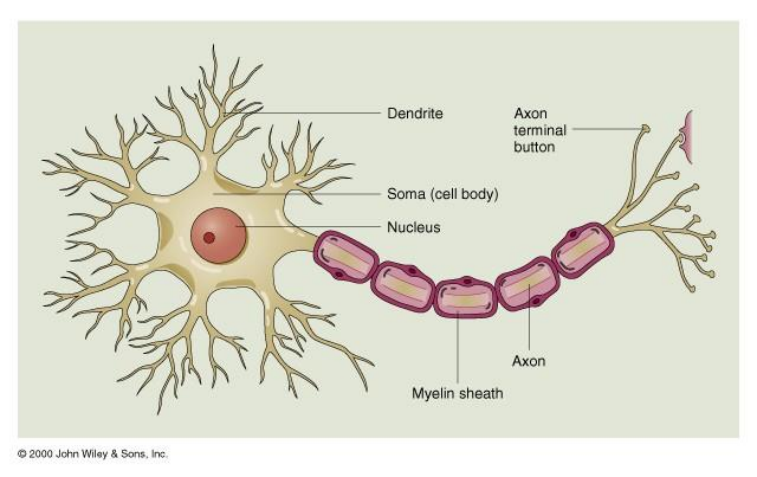
  2.) Dendrites

  -the primary site for receiving signals from neurons. One to thousands depending on function.

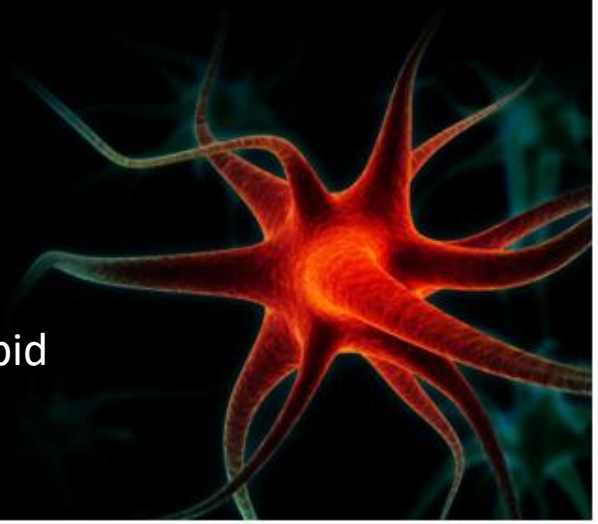
  3.) Axon

  - Transmits impulses or waves of depolarization along its length from stimulus. (1 mm to 1m in length)

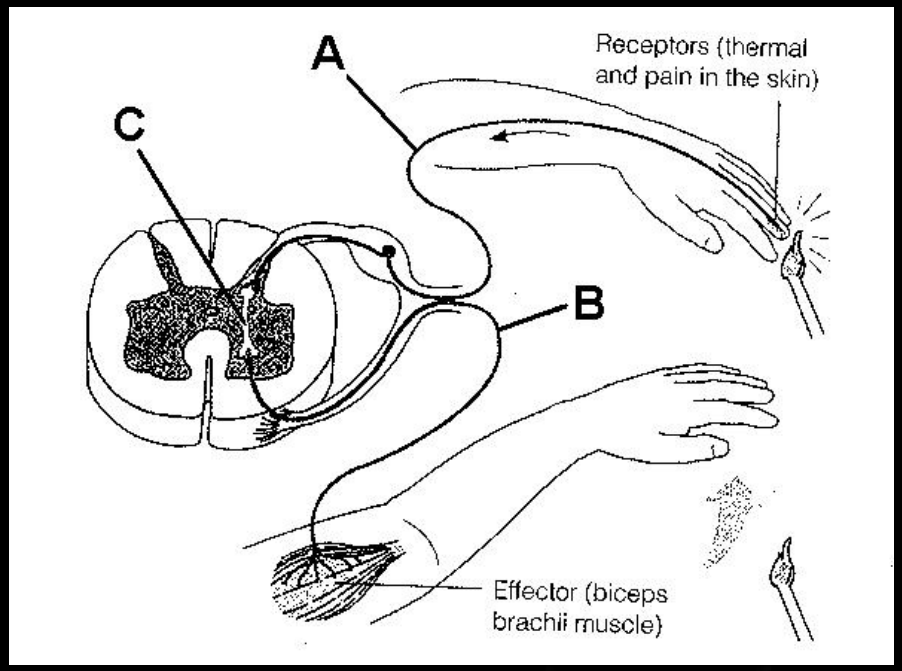
The Neuron



- Axon terminal
  - At the end of the axon, it forms a synapse with another neuron
- Schwann cells
  - Conduct nervous impulses along the axon
- Myelin sheath
  - Fat-containing cells that insulate the axon from electrical activity
- Nodes of Ranvier
  - periodic gap in the insulating sheath (myelin) on the axon of certain neurons that serve to facilitate the rapid conduction of nerve impulses



Neuron Classes



- Three classes

A.) Sensory Neurons

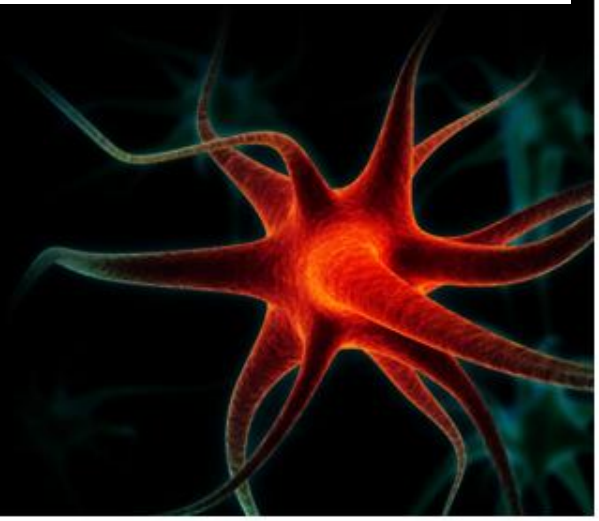
- Takes information (I.e. pain) from a sensory receptor to the CNS.

B.) Motor Neurons

- Takes information form the CNS to the effector such as a muscle fibre or gland.

C.) Interneurons

- receives information among neurons and exchanges information among neurons in the CNS



Technologies

- Electroencephalograph (EEG)
  - Invented in 1924 by Austrian psychiatrist Dr. Hans Borger. It measures electrical activity of the brain and produces a printout that allows doctors to diagnose disorders such as epilepsy and locate brain tumours.

- Computerized Tomography (CAT)
  - Take a series of cross-sectional X-rays to create a computer-generated, three dimensional image of a part of the body.

Technologies (cor

- Positron emission tomography (PET)
  - is a nuclear medicine imaging technique that produces a three-dimensional image or picture of the body. A radioactive particle is injected into the body that emits gamma rays.

- Magnetic Resonance Imaging (MRI)
  - is a medical imaging technique used in radiology to visualize detailed internal structures. MRI makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body.

- Scanning technologies have produced information about the functions of each part of the brain.

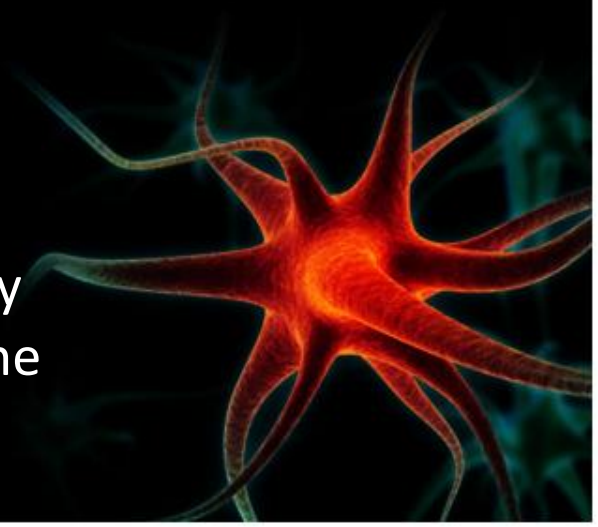
The Brain and Homeostasis

- Homeostasis - the body's maintenance of a stable internal environment that remains constant.

- The human brain makes up about 2% of the body's weight
- It contains 15% of the body's blood and consumes 20% of the body's oxygen and glucose.

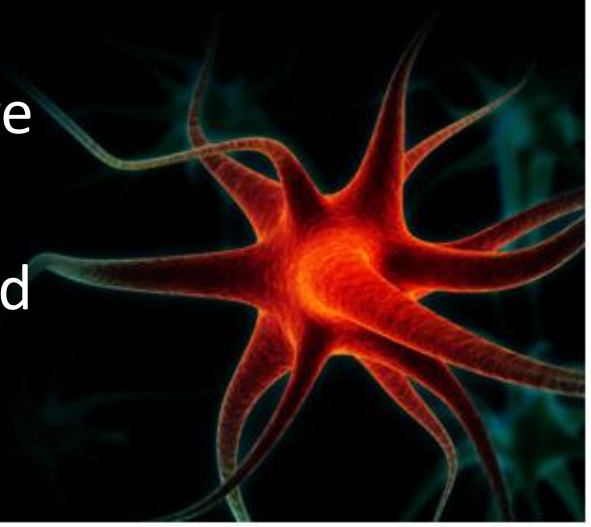
- It contains about 100 billion neurons.

- The brain has no pain receptors so brain surgery can be carried out without anaesthesia while the patient is fully awake.



The Brain: Medulla Oblongata

- Attached at the base of the brain to the spinal cord.
- Number of functions related to its structure.
- Cardiac Center controls heart rate and the force of its contractions.
- Vosmotor center adjusts blood pressure and size of blood vessels.
- Respiratory center controls the rate and depth of breathing.



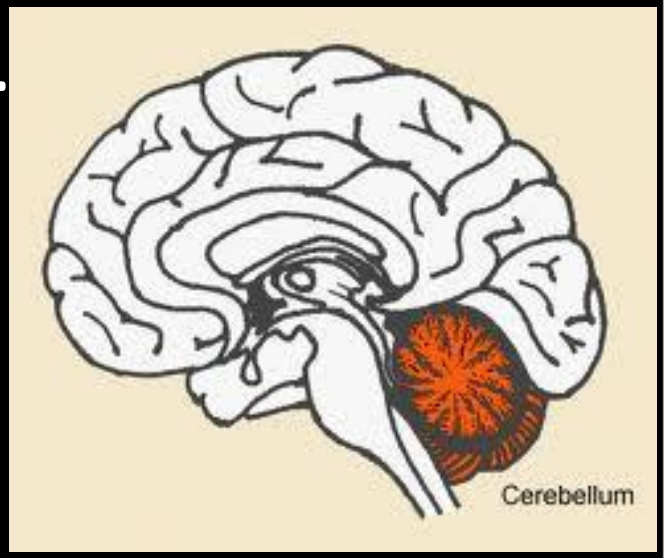
Medulla Oblongata (cont)

- Also contains reflex centers for vomiting, coughing, hiccupping, and swallowing.

- Any damage to the Medulla Oblongota is often fatal.

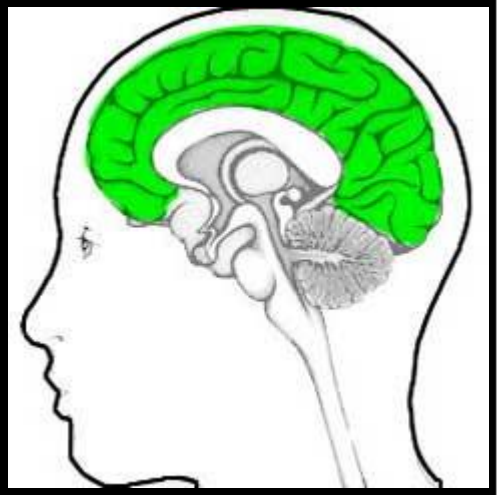
Cerebellum

- Controls muscle co-ordination.
- Motor area of the brain
- 10% volume of the brain
- 50% of the brains neurons



Cerebrum

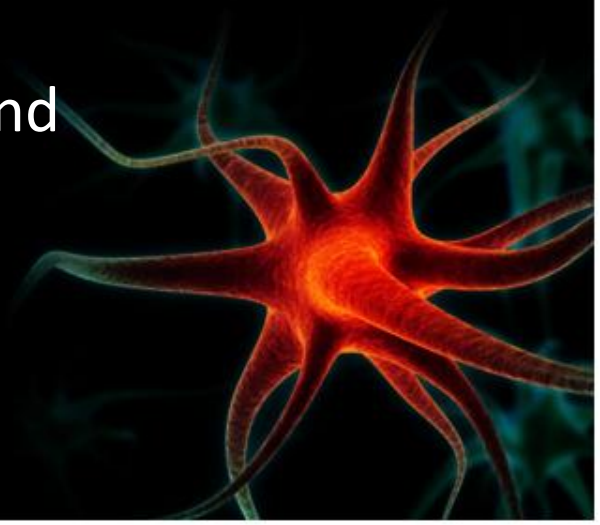
- Responsible for complex behaviour and intelligence; interprets sensory inputs and initiates motor impulses.



- All information from our senses are interpreted and sorted here.

- Controls muscles for speech, memories and decision making.

- The center of human consciousness.



Cerebrum (cont)

- Frontal lobe
  - Contains primary motor area, premotor area, Bronca's area (motor speech), and pre-frontal area (association)

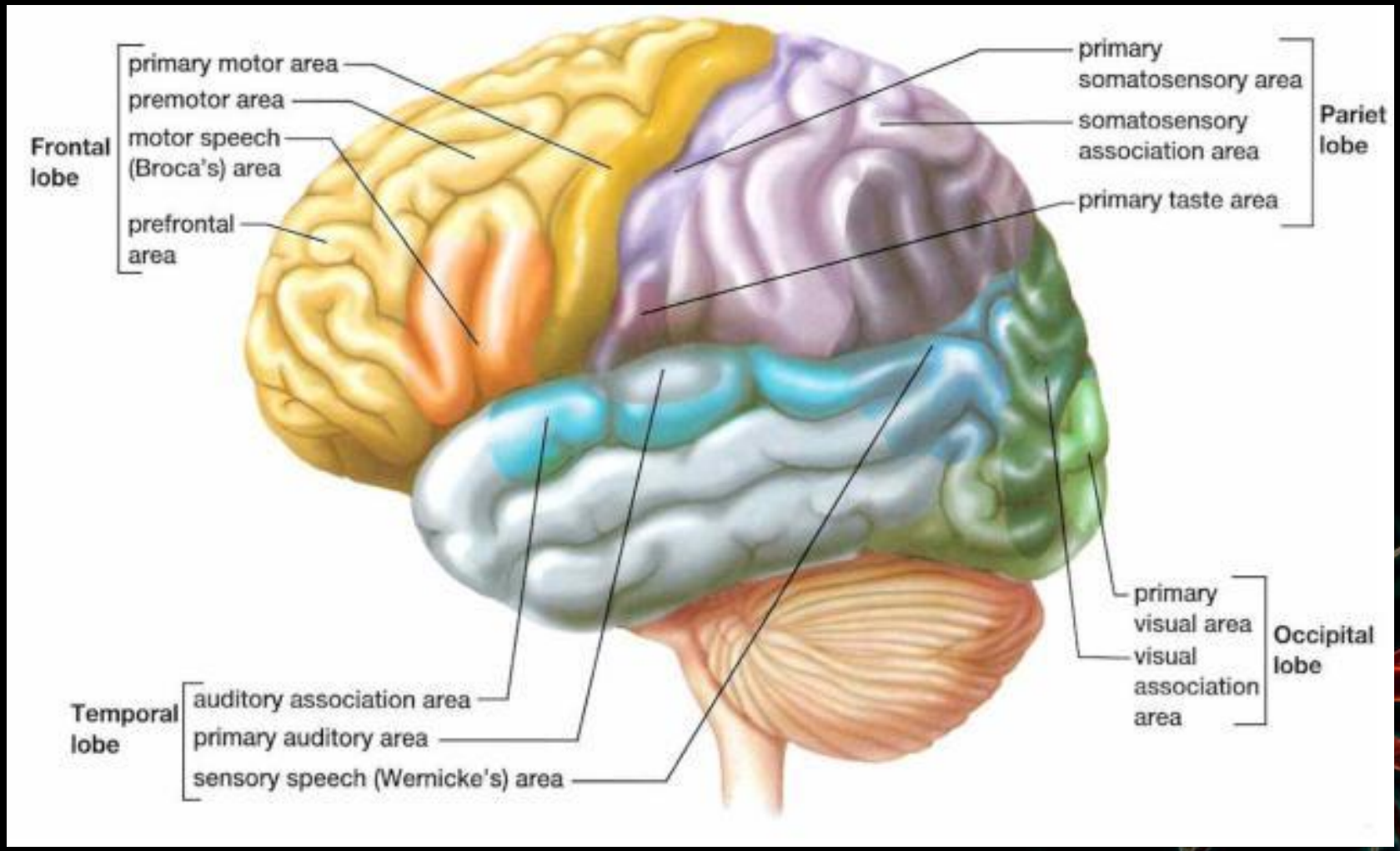
- Temporal lobe – located at sides of head
  - Contains auditory association area, primary auditory area, and sensory speech (Wernche's area)

Cerebrum (cont)

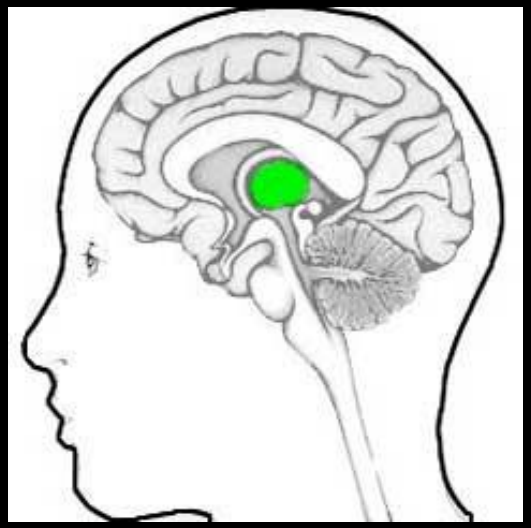
- Parietal lobe – located near top of brain
  - contains primary somatosensory area, somatosensory association area and primary taste area

- Occipital lobe – located at back of cerebrum
  - contains primary visual area and visual association area
- The Cerebrum is divided into two hemispheres, right and left.

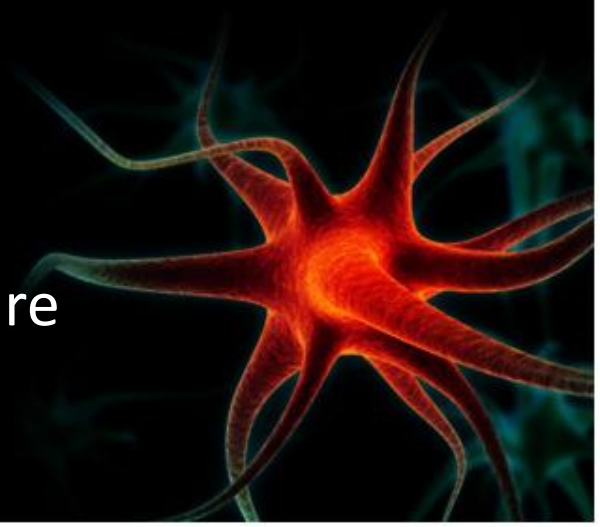
Cerebrum (cont)



Thalamus

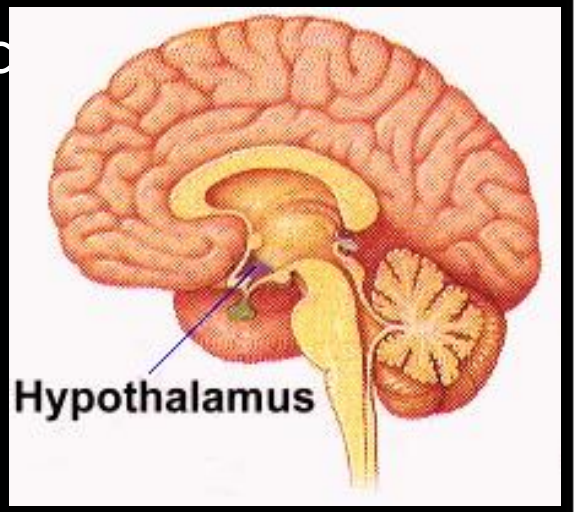


- Is a sensory relay center.
- It receives sensations of touch, pain, heat, and cold. As well as information from the muscles.
- Mild sensations are relayed to the appropriate part of the cerebrum.
- Strong sensations trigger a reaction and are relayed to the hypothalamus.



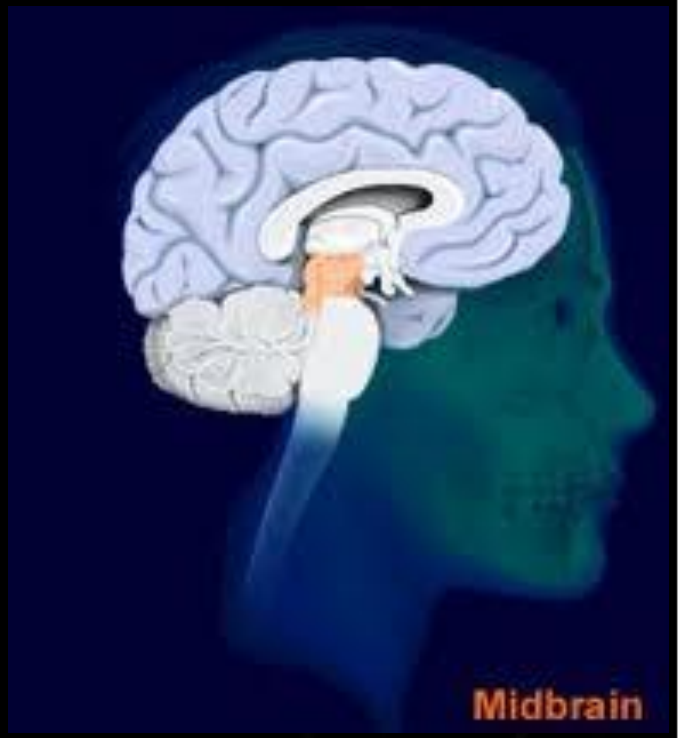
Hypothalamus

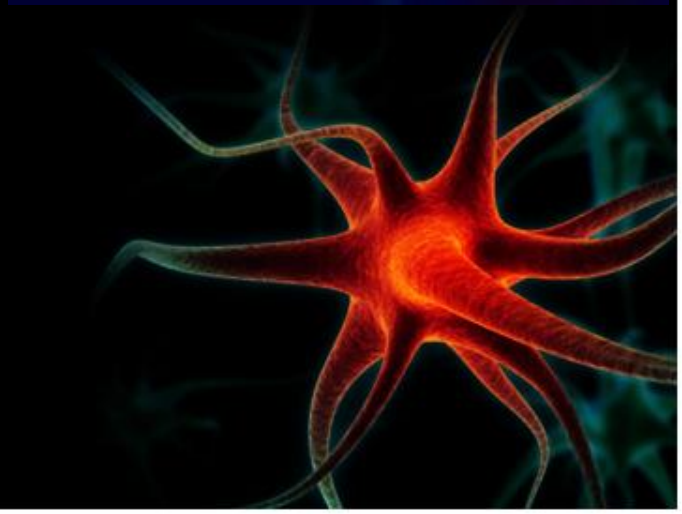
- The main control center for the autonomic nervous system.
- Enables the body to respond to external threats
- Sends impulses to internal organs via the sympathetic nervous system.
- Re-establishes homeostasis after the threat is passed by stimulating the parasympathetic nervous system.



Midbrain

- Is a portion of the central nervous system associated with vision, hearing, motor control, sleep/wake, arousal (alertness), and temperature regulation



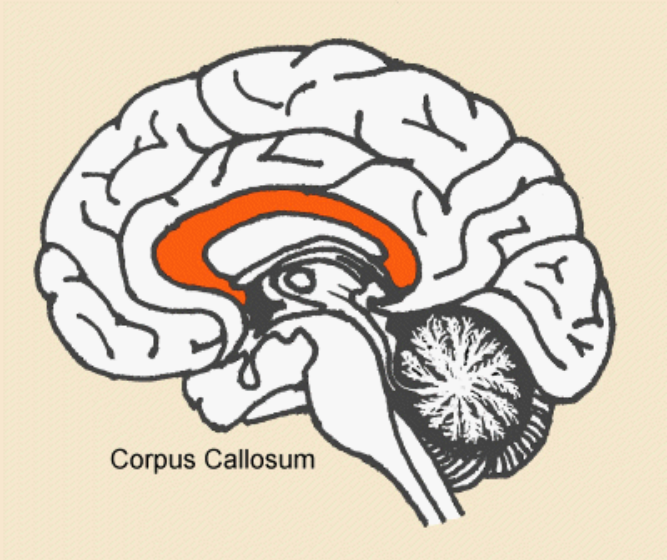


Pons

- The pons contains nuclei that relay signals from the forebrain to the cerebellum, along with nuclei that deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation, and posture.

Corpus Callosum

- It connects the left and right cerebral hemispheres and facilitates inter-hemispheric communication.

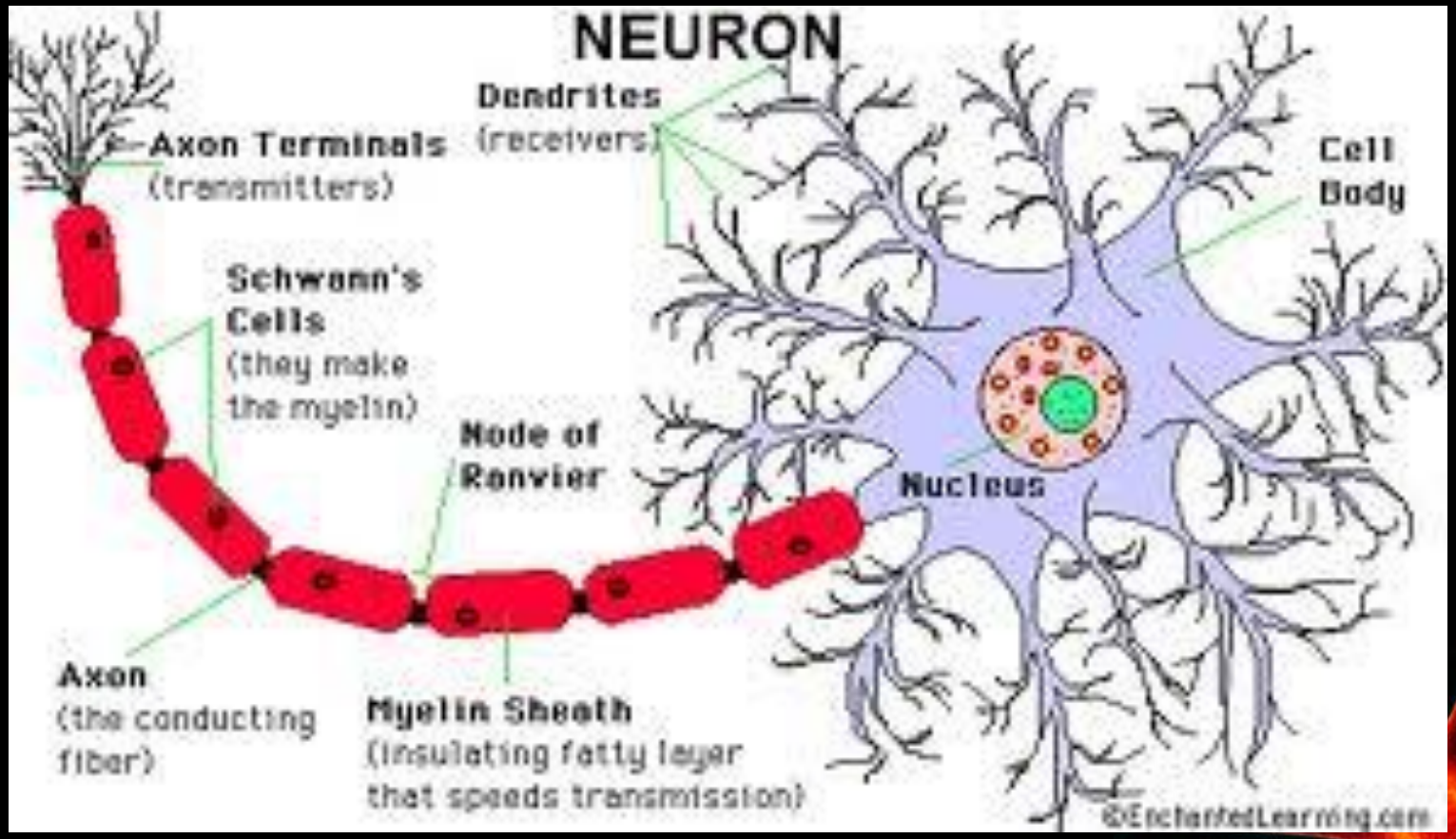


- It is the largest white matter structure in the brain.

Cerebral Cortex

- The thin layer that covers each hemisphere of the brain, contains over one billion cells.
- Enables us to experience sensation, voluntary movement and thought processes associated with consciousness.
- Made of grey matter, composed mostly of cell bodies and dendrites.
- The human cerebral cortex is 2–4 mm thick.

How the Neuron Works

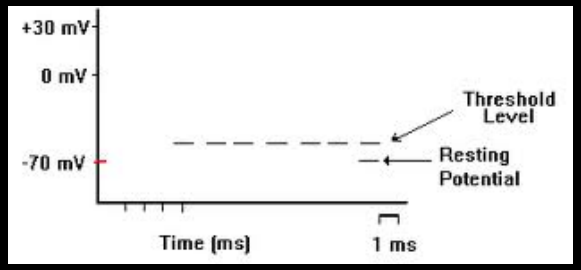


The All or None Response

- The impulse which travels down a neuron is electrical, and it has to be stimulated or started somehow.
- If a neuron is given a mild stimulus, there is a brief and small change in the charge of the cell membrane in the area of the stimulus but this does not continue down the length of the neuron.
- However, a larger stimulus will cause the impulse to travel the length of the axon.

All or None Principle

- If an axon is stimulated sufficiently (above the threshold), the axon will trigger an impulse down the length of the axon. If not, the impulse is not triggered.



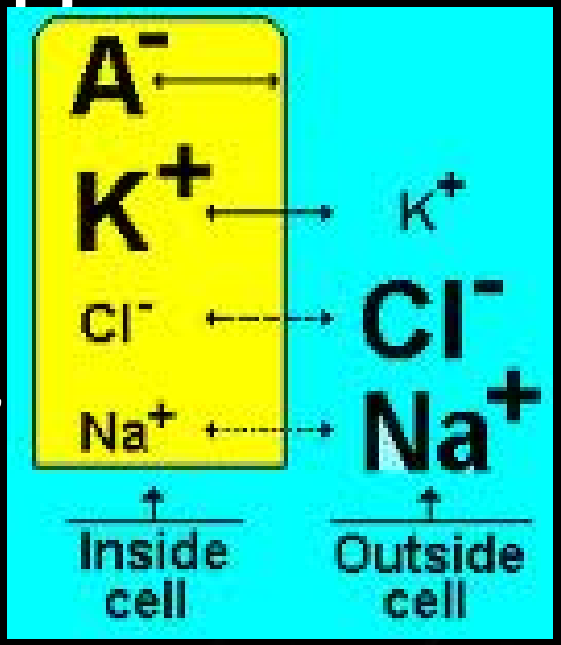
- With neurons, axons cannot send strong or weak responses.
- Strong environmental stimuli are determined by other things: for example, the number of neurons activated and the type of neurons activated (some neurons have higher thresholds than others)

How the Neuron Works: At Rest - Polarization

- When a neuron is at rest the outside is positively charged compared to the inside.
- Positively charged ions = cations (sodium NA^+ and potassium K^+)
- High concentration of NA^+ outside the cell and low inside.
- High concentration of K^+ inside the cell and low outside.

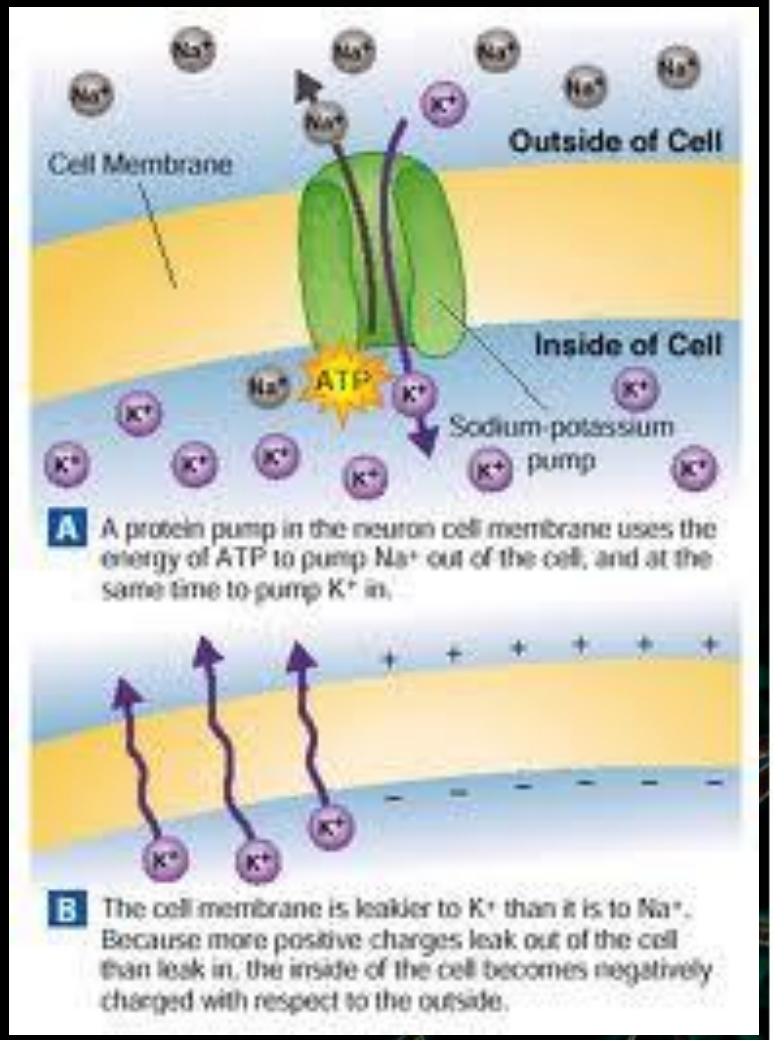
How the Neuron Works: At Rest – Polarization (cont)

- Cl^- is the dominant anion outside the cell.
- Inside the cell the dominant anions are negatively charged proteins , amino acids, phosphates and sulfates.
- At rest the cell membrane is 50 times more permeable to K^+ than to Na^+.



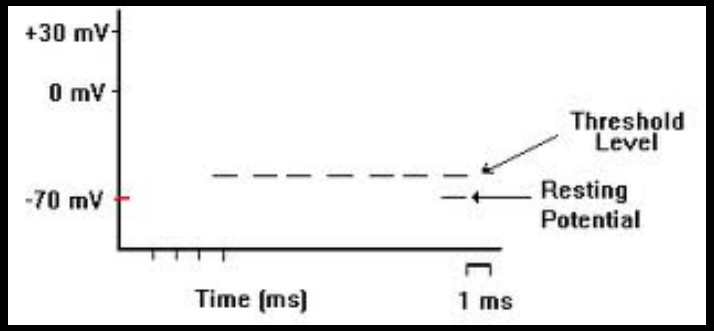
How the Neuron Works: 1.) At Rest – Polarization (cont)

- As this happens the inside of the cell becomes more negative due to the larger negative anions trapped inside.
- This larger negative charge inside the cell attracts both sodium and potassium ions to the cell membrane.
- However, the sodium potassium pump ensures that the inside of the cell maintains a negative charge compared to outside.



$Na^{+/}K^{+}$ Pump

- Uses active transport to pull three Na^{+} cations out of the cell and pull two K^{+} cations into the cell with the aid of **Adenosine triphosphate (ATP)**

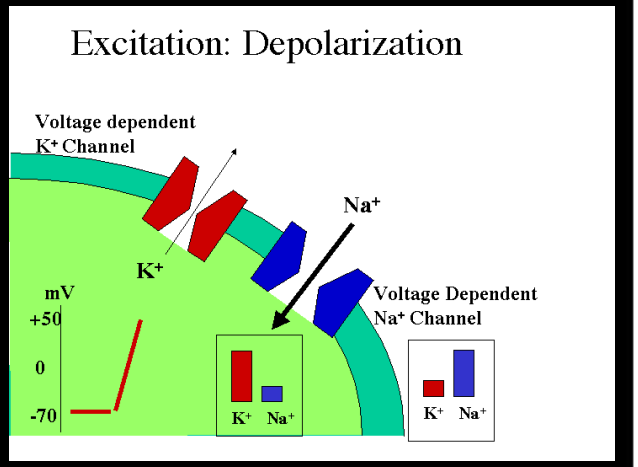


- **The sodium potassium pump continues to work through both polarization and depolarization.**

- Na+/K+ Pump

How the Neuron Works – 2.) Excitation or Depolarization

- When a neuron is sufficiently stimulated, a wave of depolarization is triggered.
- The potassium channels close and the sodium channels open in the cell membrane



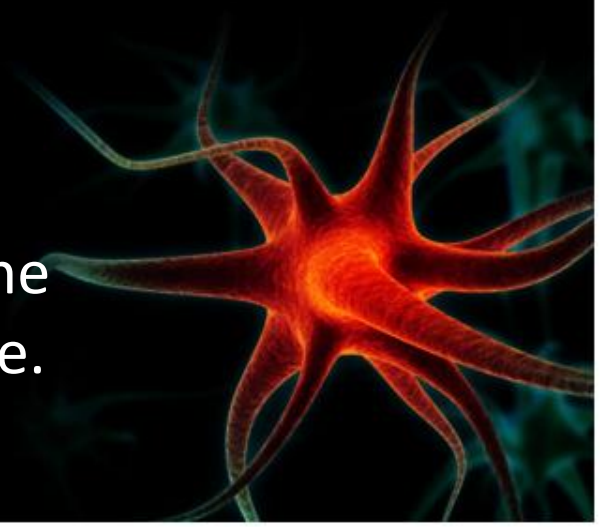
- Sodium ions then move into the axon to and neutralize the negative charge making the inside of the axon positively charged.
- This change in the charge is known as the Action Potential

How the Neuron Works – 3.) Repolarization

- Almost immediately after the sodium channels open during depolarization they close and the potassium channels open.

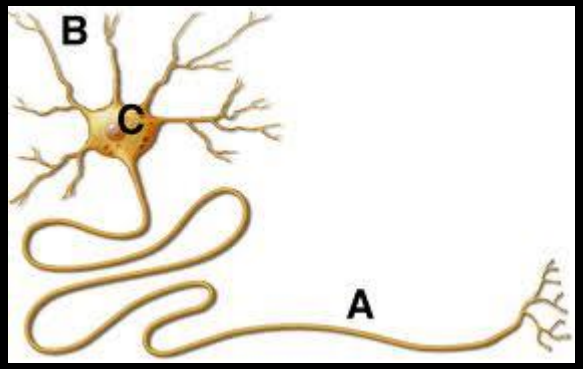
- This is to re-establish the polarity by allowing the potassium ions to move out of the axon.

- During this refractory period (0.001 seconds) the neuron is unable to fire as the axon is prepares itself for the next impulse.
- Complete Process Interactive Model



How the Neuron Works (cont)

- Myelinated neurons transmit impulses much quicker than unmyelinated ones.



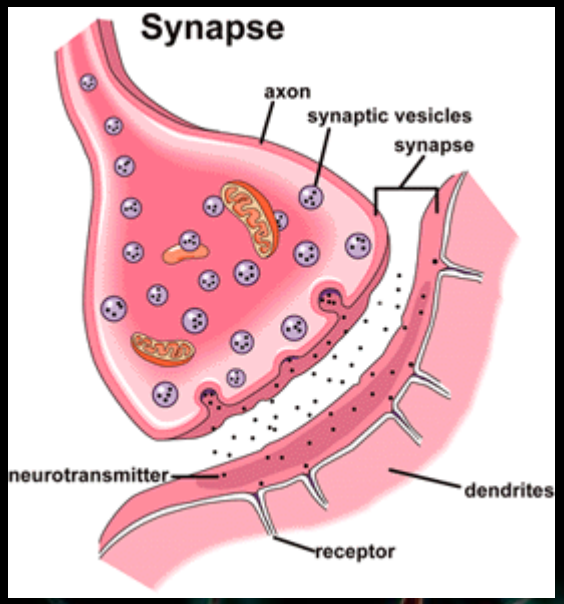
- This is due to the fact that depolarization only occurs at the nodes of Ranvier.

- In a sense, the impulse jumps from node to node until it reaches the end of the neuron. Speeds of impulses on myelinated neurons can reach 120 m/s

How the Neuron Works: The Synapse

- Synapse: junction between a neuron and another neuron or muscle cell.

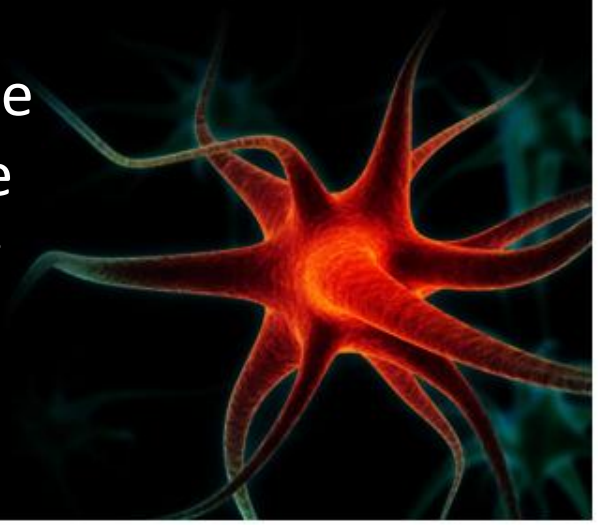
- Neurons do not directly connected with other neurons. Instead, there are spaces which allow impulses to be spread to several surrounding neurons, not simply one.



How the Neuron Works: The Synapse (cont)

- When a wave of polarization reaches the end of the axon of a neuron, it causes special calcium ion (Ca^{2+}) gated channels to open.

- This calcium causes the release of neurotransmitters from synaptic vesicles.
- These neurotransmitters diffuse across the gap and attach to special receptors on the dendrites of neighboring neurons causing either an excitatory response or an inhibitory response.



How the Neuron Works: The Synapse (cont)

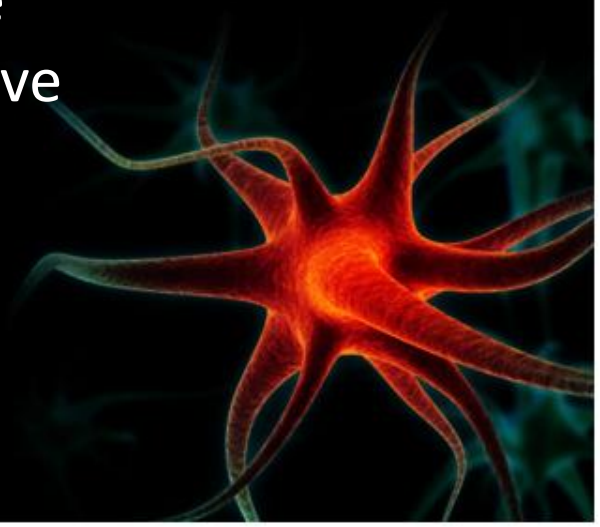
- Neurotransmitter: chemicals that are secreted by neurons to stimulate motor neurons and central nervous system neurons.

- Synaptic vesicles: specialized vacuole in the bulb-like end of the axons of a nerve cell containing neurotransmitters that are released into the synapse when a nerve impulse is received.

How the Neuron Works: The Synapse (cont)

- Excitatory response: process in which the neurotransmitter reaches the dendrites of a postsynaptic neuron and a wave of depolarization is generated by the resultant opening of sodium gated channels.

- Inhibitory response: process in which the postsynaptic neuron is made more negative on the inside to raise the threshold of stimulus (usually by opening of chloride channels)

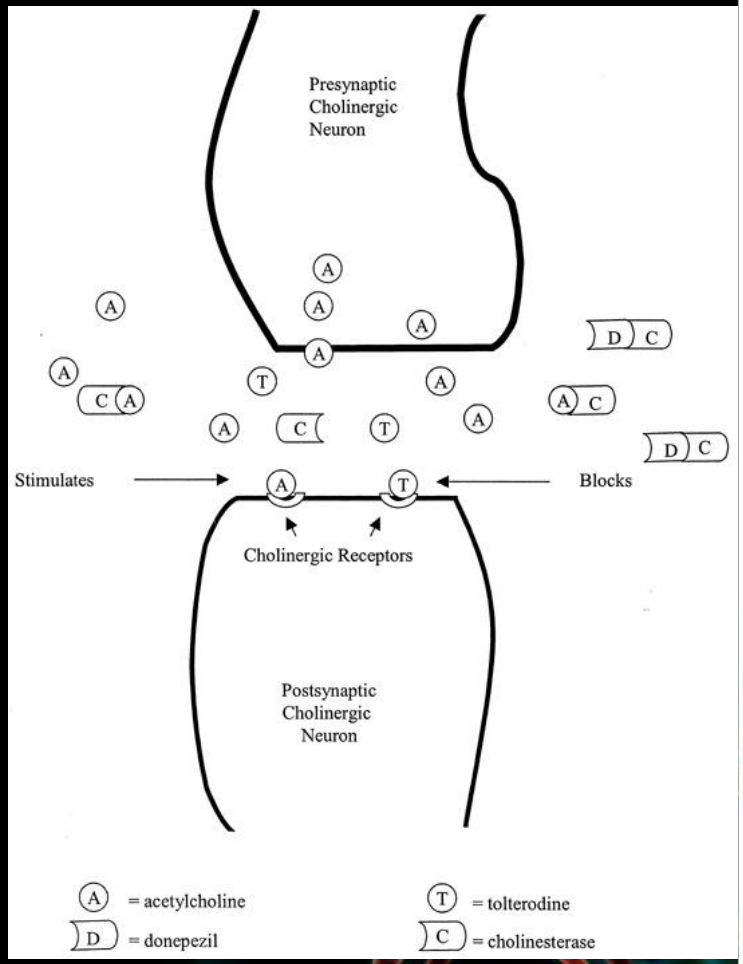


Neurotransmitters

- Neurotransmitters may also be found in the endocrine system as hormones. For example, the neurotransmitters noradrenaline and adrenaline are used as hormones as well.
- Synapse Video
- (1) Acetylcholine
- Primary neurotransmitter of both the somatic nervous system and the parasympathetic nervous system
- Can be excitatory or inhibitory. It excites skeletal muscles but inhibits cardiac muscle

(1) Acetylcholine (cont)

- Cholinesterase breaks down acetylcholine into choline and acetic acid, and returns. It to the pre synaptic neuron to be reused



Neurotransmitters (cont)

- (2) Noradrenaline (norepinephrine)
- → Primary neurotransmitter of the sympathetic nervous system (excitatory)

- (3) Glutamate
- → An amino acid
- → found in the cerebral cortex, and it accounts for 75% of all excitatory transmission in the brain

Neurotransmitters (cont)

- (4) gamma amino butyric acid (GABA)
- → most common inhibitory neurotransmitter in the brain

- (5) dopamine

→ neurotransmitter that elevates mood and controls skeletal muscles

- (6) serotonin

→ formed from tryptophan (an amino acid)

- → involved in alertness, sleepiness, thermoregulation, and mood

Drugs and the Nervous System

- **<u>Classes of drugs:</u>**
- 1. <u>Depressants</u>
- → slow down the CNS; relaxes and causes people to feel less pain. Also decreases coordination and movement

- → ex. Alcohol, heroin, morphine, Valium, anesthetics
-

Drugs and the Nervous System (cont)

- Prescription Drugs
- → the drug Valium increases GABA levels to reduce anxiety

- Anesthetics can be general or local
- local: affect only a small area
- general: affect all nervous system activity

Drugs and the Nervous System (cont)

- 2. Stimulants

  → speed up the CNS; increase energy and confidence

  → ex. Caffeine, cocaine, MDMA (ecstasy) and nicotine

  → Ecstasy depletes serotonin supply, and long term use may permanently alter neurotransmitter levels in the CNS

Drugs and the Nervous System (cont)

- 3. Hallucinogens
- → cause an altered state or reality; affect memory or pleasure centers as well as perception
- → Marijuana, LSD (acid)

Disorders of the Nervous System

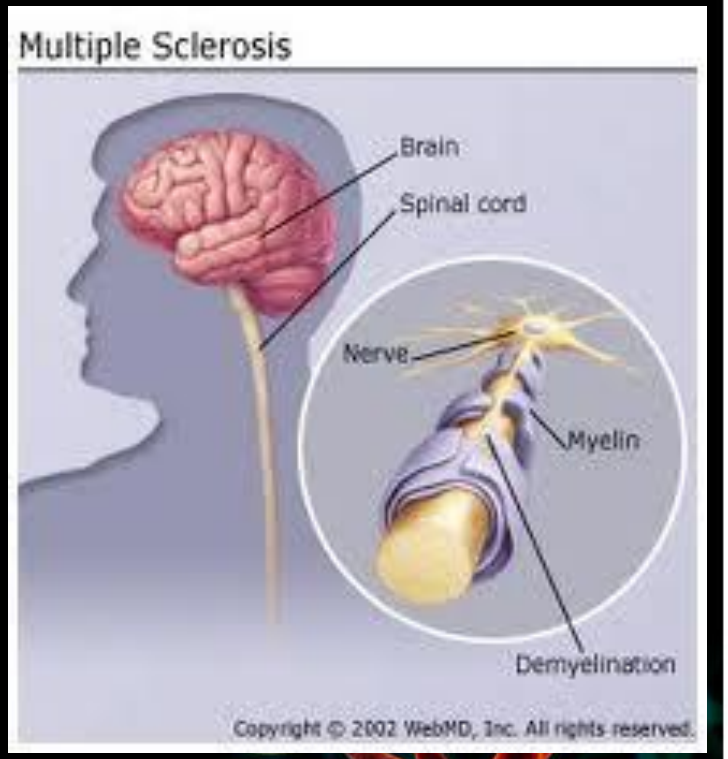
- (1) Multiple Sclerosis (MS)
- → A serious progressive disease of the central nervous system. The myelin sheath surrounding the nerve cells becomes inflamed or damaged. This disrupts the nerve impulses that are normally produced.

- → Believed to be an autoimmune disorder, where the body's own immune cells attack myelin

(1) Multiple Sclerosis (MS) (cont)

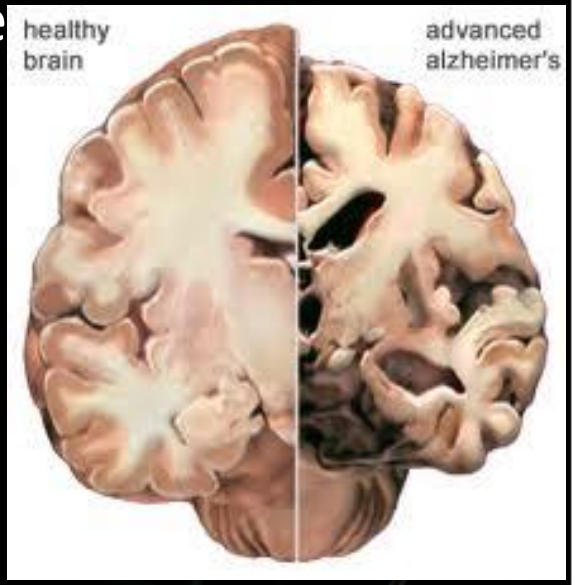
- → No cure presently known

- → Various symptoms depending on where disruptions occur such as blurred or double vision, slurred speech, loss of coordination, weaknesses, and possibly seizures



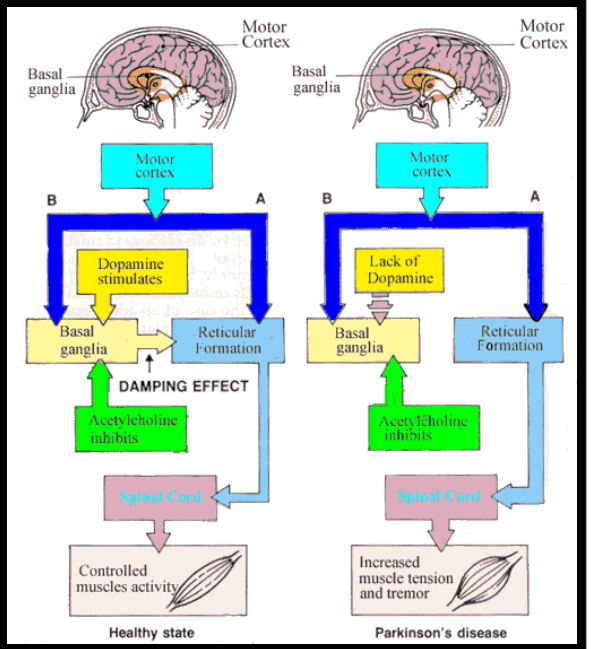
(2) Alzheimer's disease

- → A degenerative disorder that affects the brain and causes dementia, which is an impairment of the brain's intellectual function such as memory and orientation, especially late in life
- → It results from deposits of a protein called amyloid which disrupts communication between nerve cells. As well, acetylcholine levels drop
- → People may also suffer personality changes
- → No cure, and limited treatments



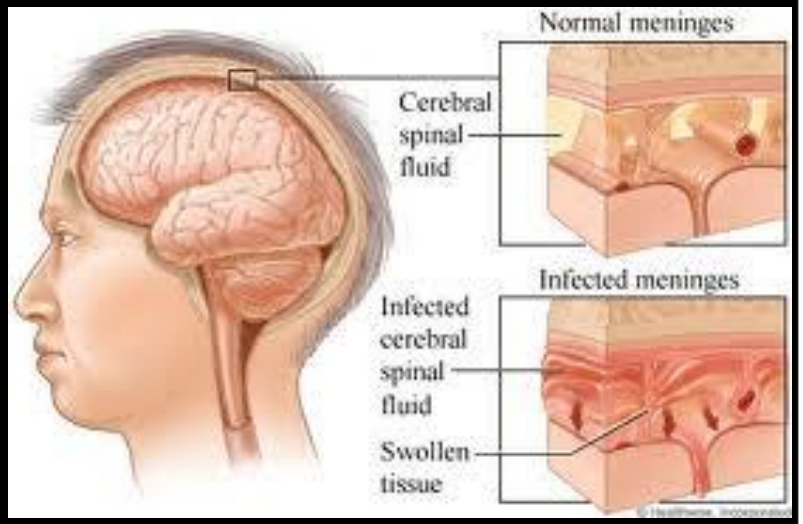
(3) Parkinson's disease

- → A chronic movement disorder caused by gradual decline of the neurons that produce dopamine
- → Symptoms begin as slight tremors and stiffness of limbs on one side of the body. Over time, the tremors spread to both sides of the body and movements become slow.
- → No cure, but symptoms can be treated with drugs or surgery (if necessary)



(4) Meningitis

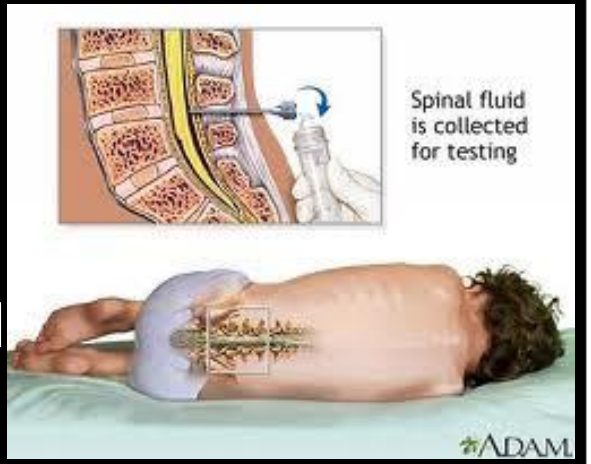
- → A bacterial or viral infection of the meninges, the three membranes that cover and protect the brain and spinal cord



- → Viral meningitis is more common, but bacterial meningitis is fatal (10% fatality, and survivors often suffer from complications like hearing impairment)

(4) Meningitis (cont)

- → Symptoms include headache, fever, stiff neck, light sensitivity, vomiting, and drowsiness

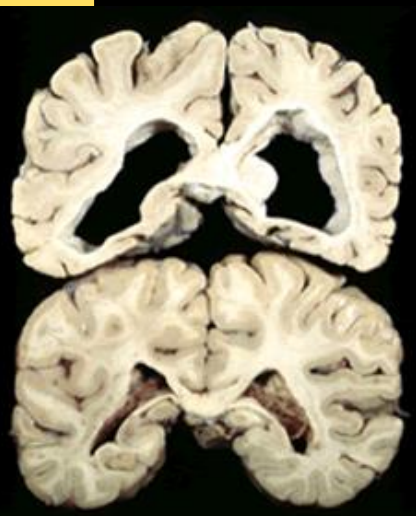


- → Testing of meninges is done via a spinal tap or Lumbar puncture.

- → There are vaccines available for some bacterial meningitis, but none for viral meningitis

(5) Huntington's disease (Huntington's cholera)

- → a lethal disorder in which the brain progressively deteriorates over a period of 15 years; symptoms typically appear after age 35
- → Causes progressive decrease in mental and emotional abilities and loss of control of major muscle movements
- → no cure
- → Symptoms include memory loss, dementia, involuntary twitching, chorea (jerky movements) and personality changes

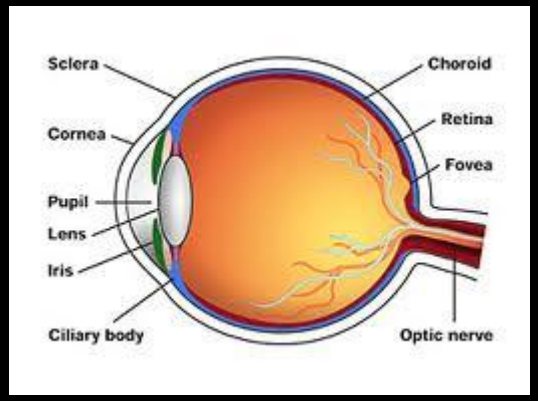


The human brain, showing the impact of HD on brain structure in the basal ganglia region of a person with HD (top) and a normal brain (bottom).

http://isobil.jrk.msu.edu

The Sense Organs

- The Eye
- Lens: a transparent, bi-convex body situated behind the iris of the eye to focus an image on the retina

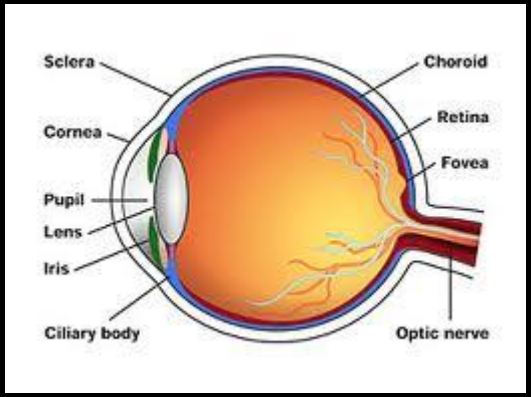


- Iris: the muscle that adjusts the pupil to regulate the amount of light that enters the eye.

- Retina: the innermost layer of the eye; contains rods and cones, bipolar cells and ganglion cells

(1) The Eye (cont)

- Cornea: the clear part of the sclera at the front of the eye



- Choroid layer: the middle layer of the eye, which absorbs light and prevents internal reflection. This layer forms the iris at the front of the eye

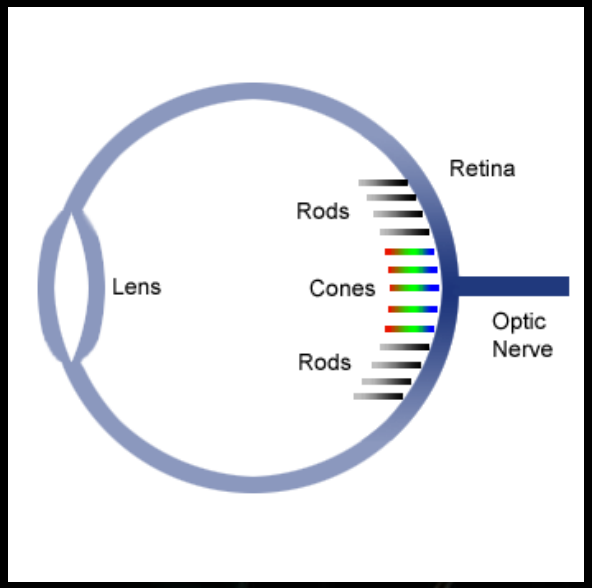
- Fovea Centralis: concentration of cones on the retina located directly behind the center of the lens. Vision is the most acute here

(1) The Eye (cont)

- Rods: photoreceptors in the eye; more sensitive to light than cones, but unable to distinguish color

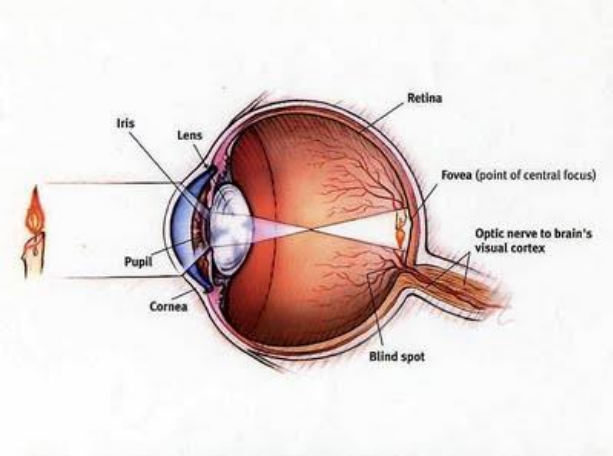
- Cones: color receptors in the eye (red, green, blue)

- Pupil: the aperture in the middle of the iris of the eye. The size of the aperture can be adjusted to control the amount of light



(1) The Eye (cont)

- Blind spot: an area on the retina where there are no rods or cones present; locate where blood vessels enter the eye



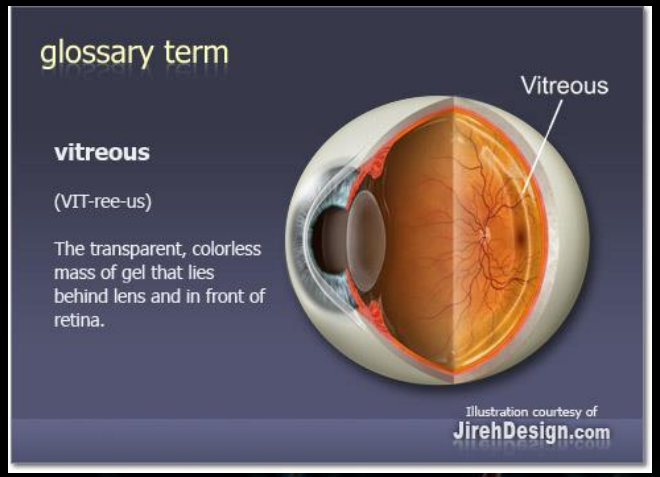
- Optic nerve: conducts information received from rods and cones to the brain for interpretation.

- Aqueous humour: is a thick watery substance filling the space between the lens and the cornea

(1) The Eye (cont)

- Don’t confuse with the Above/Below!

- Vitreous Humour: is the clear gel that fills the space between the lens and the retina of the eyeball of humans and other vertebrates. It is often referred to as the vitreous body or simply "the vitreous".



- Sclera: the thick, white outer layer that gives the eye its shape

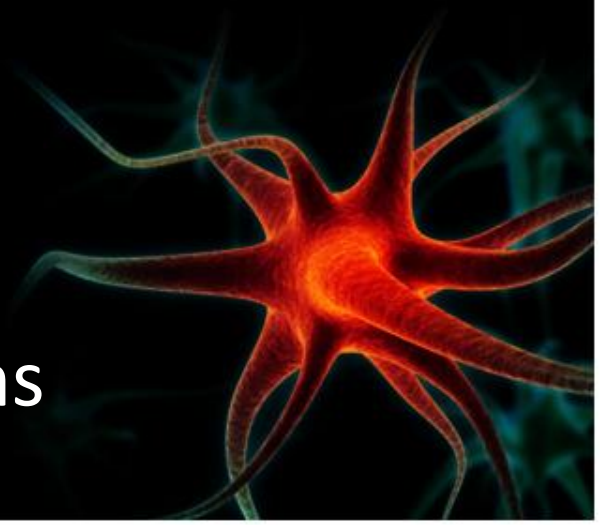
How the eye works

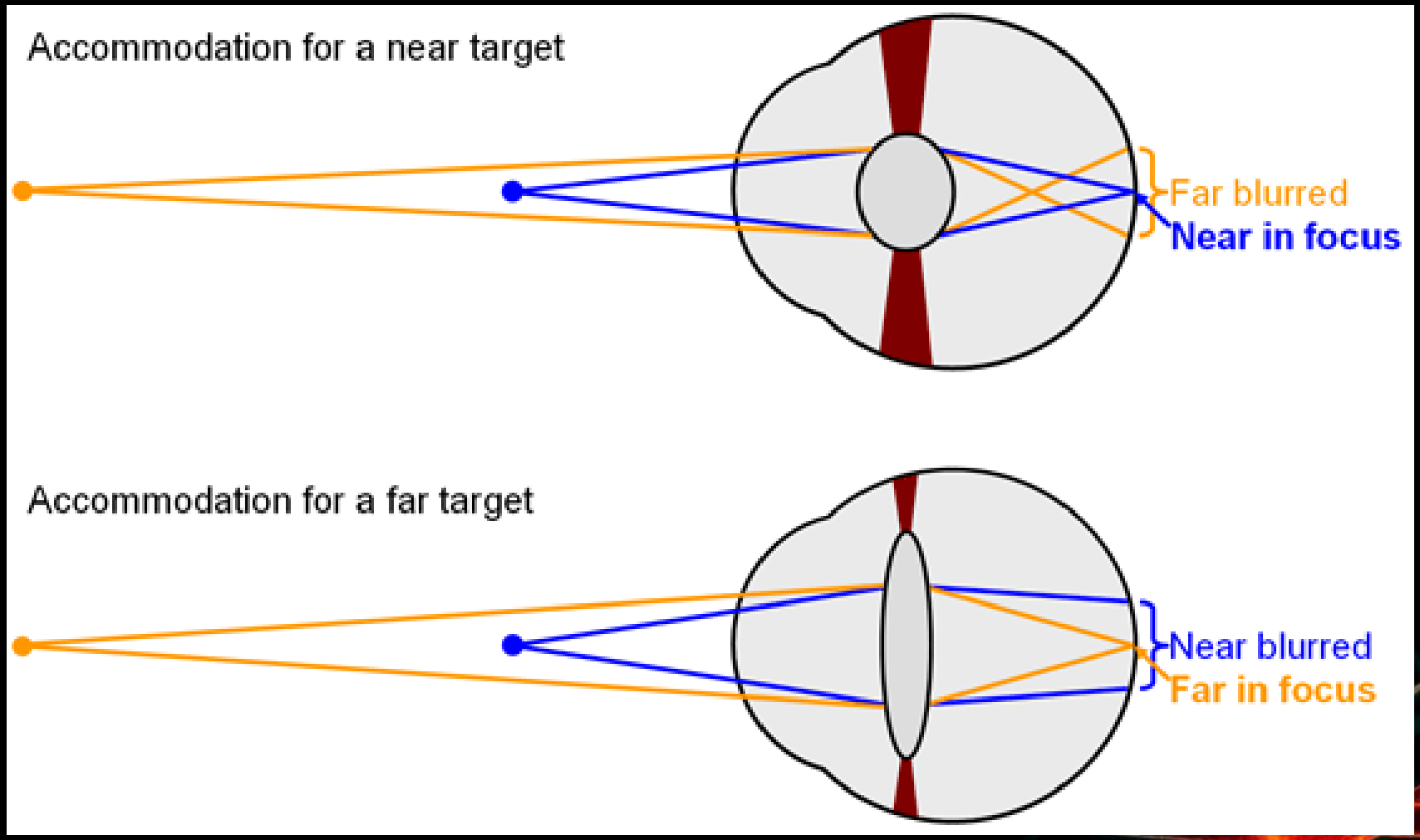
- As light enters the eye, the pupil will dilate if there isn't enough light or it will constrict if there's too much.
- The shape of the lens changes depending on how far away the object is.

How the eye works (cont)

- Accommodation: in the eye, adjustment that the ciliary body makes to the shape of the lens to focus on objects at varying distances

- When the object is far away, the lens is flattened
- When the object is close, the lens is rounded




Accommodation for a near target
Far blurred
Near in focus
Accommodation for a far target
Near blurred
Far in focus

How the eye works (cont)

- Light enters the eye through the pupil.

- As it does, light rays become bent at the cornea and the lens in such a way that an inverted and reversed image of the object focuses on the retina.

How the eye works (cont)

- Information from this image is captured by rods and cones, which transmit their info to bipolar cells and then ganglion cells (optic nerve).
- Cones transmit information to a single bipolar cell, but require more light to become stimulated.

How the eye works (cont)

- As a result, cones see more detail and are best suited for lighted situations (daytime).

- Rods, however, are very sensitive to light and cannot distinguish color.

How the eye works (cont)

- As well, many rods connect to a single bipolar cell (up to 100 rods per bipolar cell). This causes images to be blurry. As a result, rods are best suited to situations where there isn't much light and details are not important.

Disorders of the Visual System

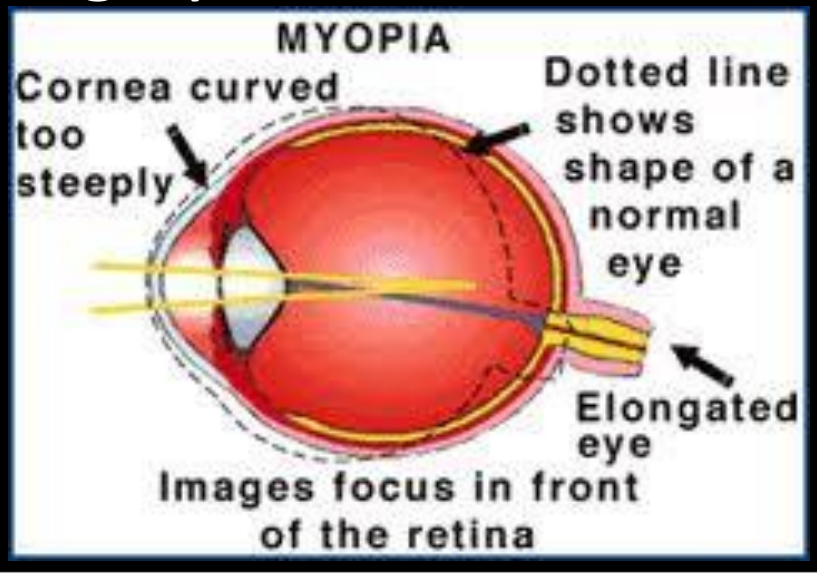
- (1) cataracts- cloudy or opaque areas on the lens of the eye that increases in size over time and can lead to blindness if not medically treatment

Disorders of the Visual System

- (2) Glaucoma – build-up of the aqueous humor in the eye that irreversibly damages the nerve fibers responsible for peripheral vision

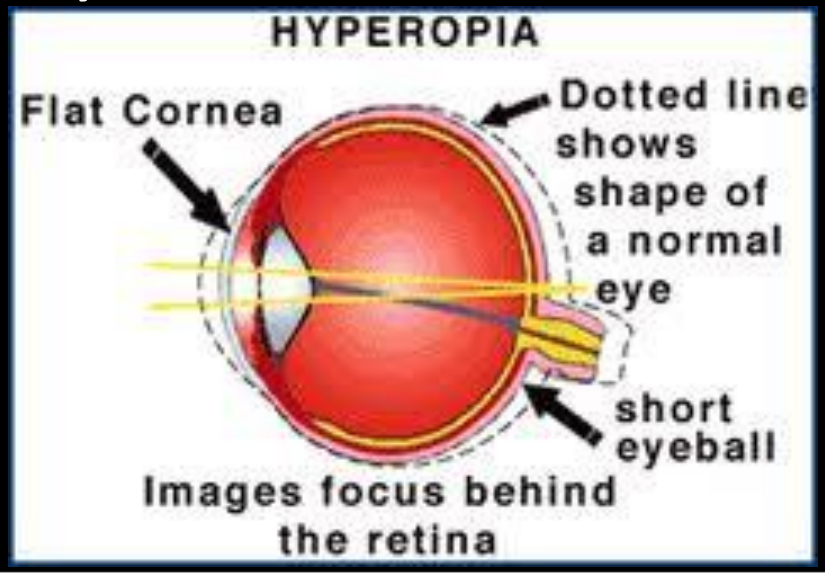
Disorders of the Visual System

- (3) Myopia – near-sightedness, or difficulty in seeing things that are far away. The condition is caused by too strong ciliary muscles or a too-long eyeball



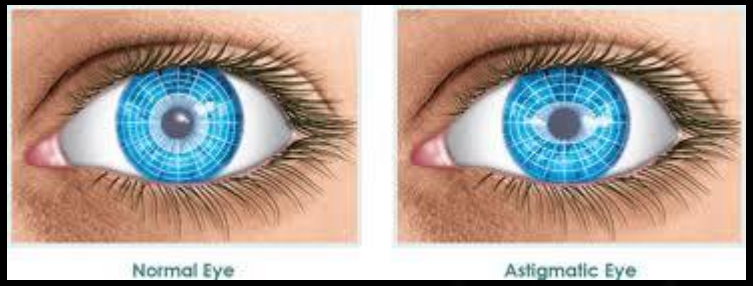
Disorders of the Visual System

- (4) Hyperopia – far-sightedness, or difficulty in seeing near objects. This condition is caused by weak ciliary muscles or a too short eyeball



Disorders of the Visual System

- (5) Astigmatism – abnormality in the shape of the cornea or lens that results in uneven focus



Treatments of Eye Disorders

- (1) Corrective lenses – glasses, contact lenses (see. Fig 12.22, p. 414)
- → with near-sightedness, the image focuses in front of the retina. This can be fixed using a concave lens
- → with far-sightedness, the image focuses behind the retina. This can be fixed using convex lenses
- → astigmatisms are unique and may require combinations of convex and/or concave lenses to bring images into focus on the retina

Treatments of Eye Disorders (cont)

- (2) Laser surgery – two types
- → Photorefractive keratectomy (PRK): non-invasive, simple procedure
- → LASIK surgery: more complex, some surgery required (corneal)
- → Both surgeries may diminish eyesight

Treatments of Eye Disorders (cont)

- (3) Corneal transplant
- → Corneas come from organ donors; no need to match blood types
- → Recovery long; most patients do well though
- → Recurrence of disease unusual

Treatments of Eye Disorders (cont)

- Lens Replacement – Replace the lens in your eye with an artificial one.

The Ear

- The human ear has three sections:

- 1. Outer ear
- → consists of the pinna (earlobe and ear) and the auditory canal
- → auditory canal contain hairs and sweat glands, some of which are modified to secrete wax to trap foreign particles

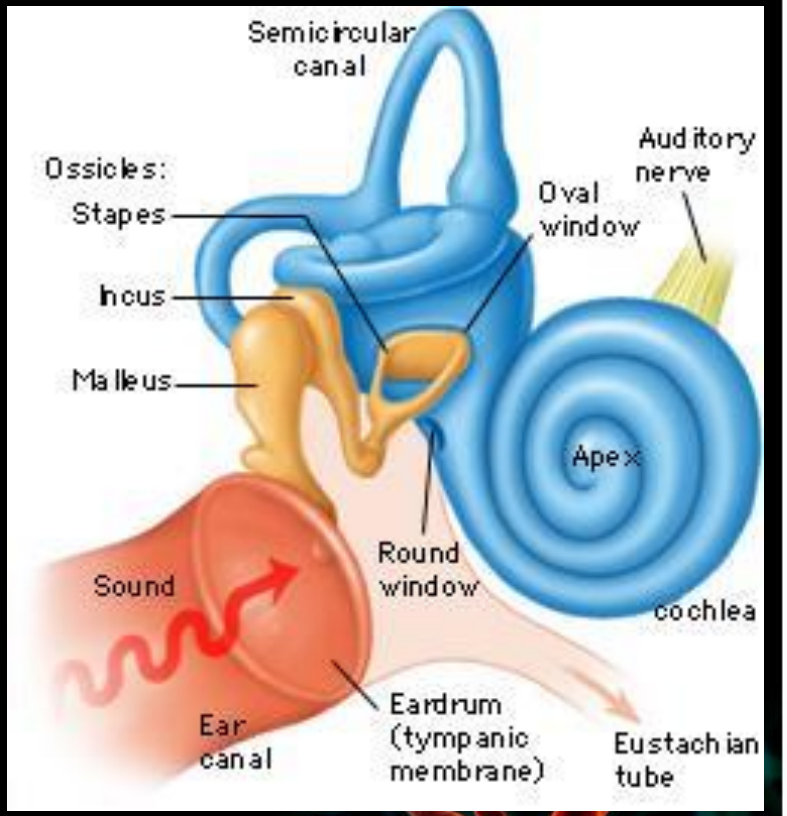
The Ear

- 2. Middle ear
- → tympanic membrane: the eardrum; a membrane of thin skin and fibrous tissue that vibrates in response to sound waves, located between the outer ear and the middle ear
- → Ossicles: the group of three small bones between the eardrum and the oval window of the middle ear; transmit sound waves from the eardrum to the inner ear

Middle ear (cont)

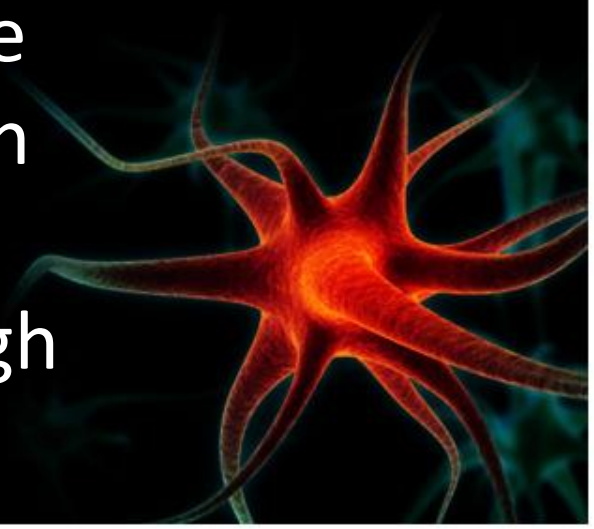
- malleus - hammer
- incus – anvil
- stapes – stirrup

- → round window: one of the two small openings at the end of the middle ear



Middle ear (cont)

- → Oval window: same as round, except it is located behind the stapes
- → Eustachian tube: bony passage extending from the middle ear to the nasopharynx that plays a role in equalizing air pressure on both sides of the eardrum. Yawning can cause the air to move through the tubes and the ear will “pop”

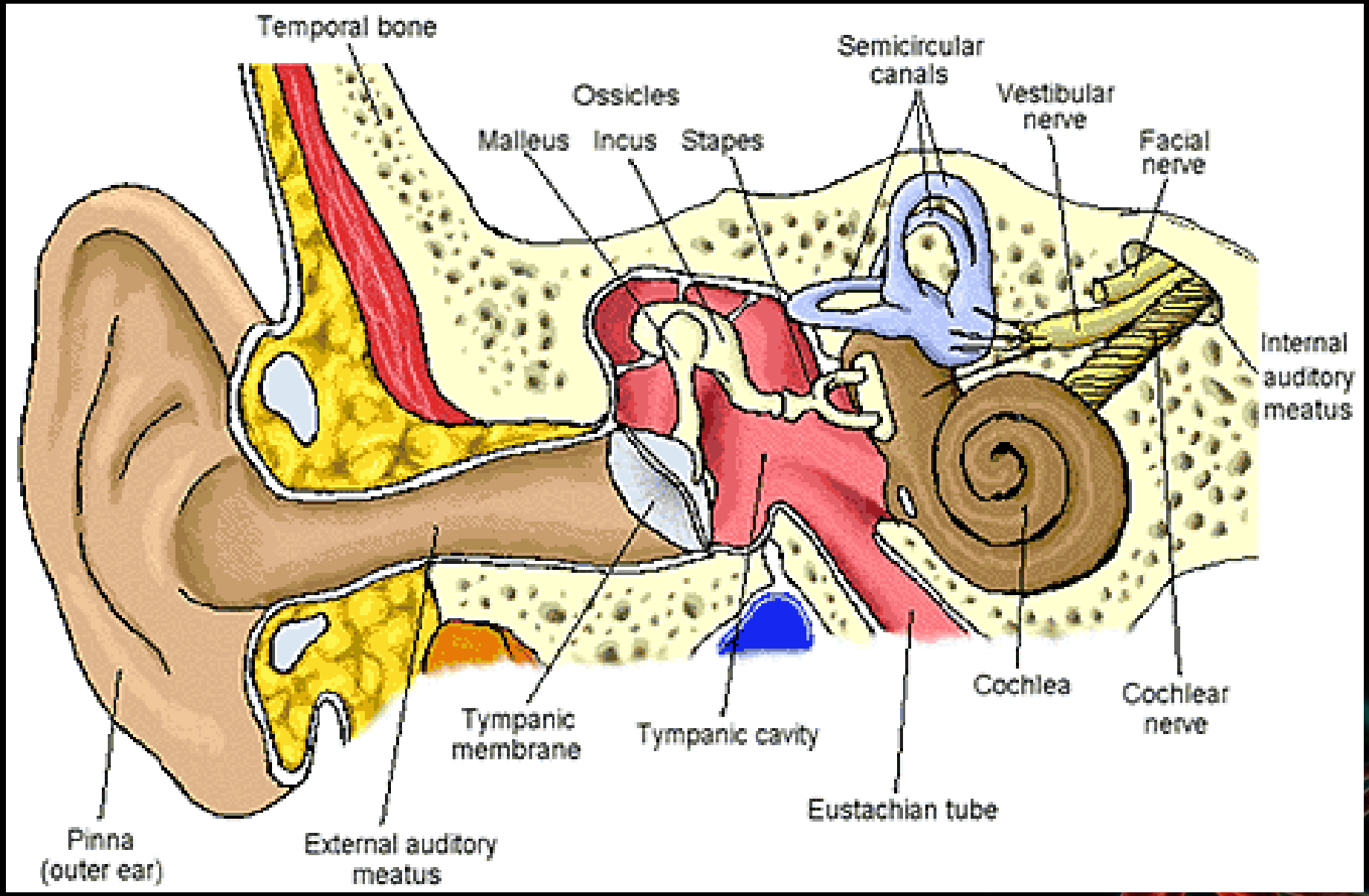


3. Inner Ear

- → Semicircular canals: three tubes involved in balance and equilibrium
- → Cochlea: involved in hearing. Have several parts (see. Fig. 12.24, p. 416)

Cochlea (cont)

- Hair cells in the cochlear canal synapse with fibres from the cochlear or auditory nerve.


Temporal bone
Ossicles
Malleus
Incus
Stapes
Semicircular canals
Vestibular nerve
Facial nerve
Internal auditory meatus
Cochlea
Cochlear nerve
Tympanic membrane
Tympanic cavity
Eustachian tube
Pinna (outer ear)
External auditory meatus

- How the ear transmits sound

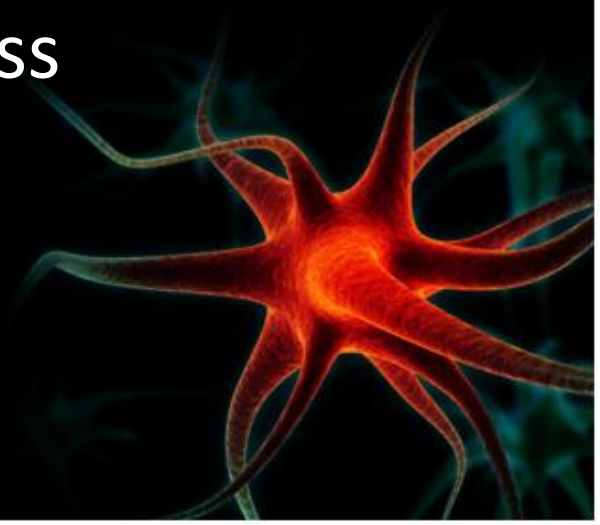
- http://www.youtube.com/watch?v=tkPj4IGbmQQ&feature=related

Disorders of the Auditory System

- (1) Nerve Deafness
- → caused by damage to hair cells in the spiral organ
- → typically found with aging and cannot be reversed
- → hearing loss uneven, some frequencies more affected than others

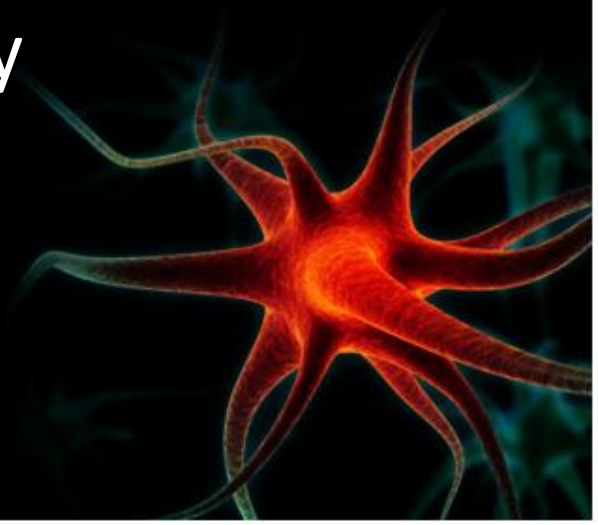
Disorders of the Auditory System

- (2) Conduction Deafness
- → usually caused by damage to the outer or middle ear that affects transmission to the inner ear
- → not usually a total loss of hearing; can be helped with hearing aids



Disorders of the Auditory System

- (3) Ear Infections
- → caused by fluid build-up behind the eardrums, common in children
- → fluid builds up because of the shallow angle of the auditory tube

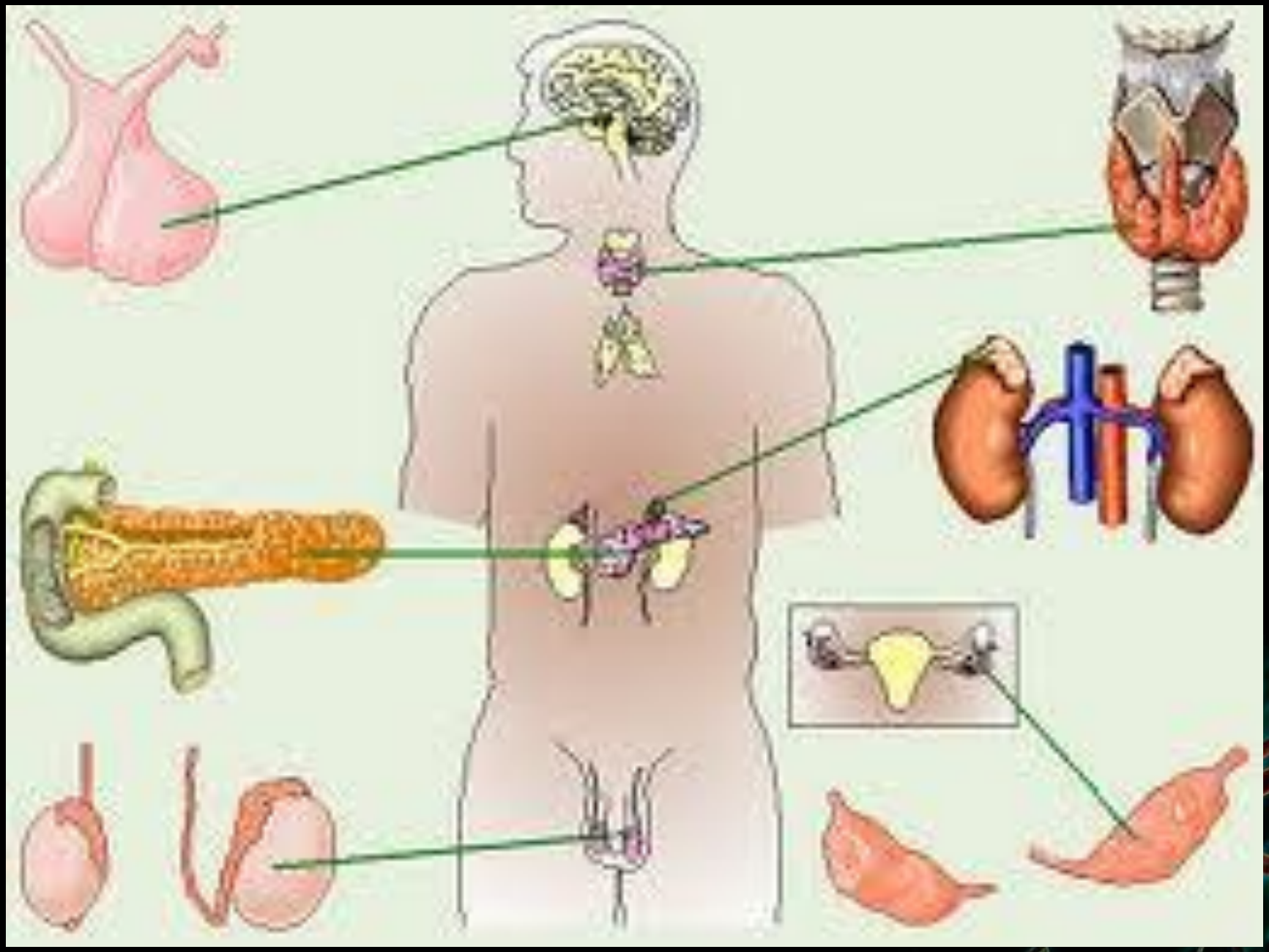


Treating Auditory Disorders

- (1) Hearing Aids

- (2) Eustachian tube implants
- → also called tympanostomy tube surgery; used to treat infections
- → tiny plastic tubes are placed in a slit in the eardrum, relieving the pressure from the built-up fluid and allowing in to drain

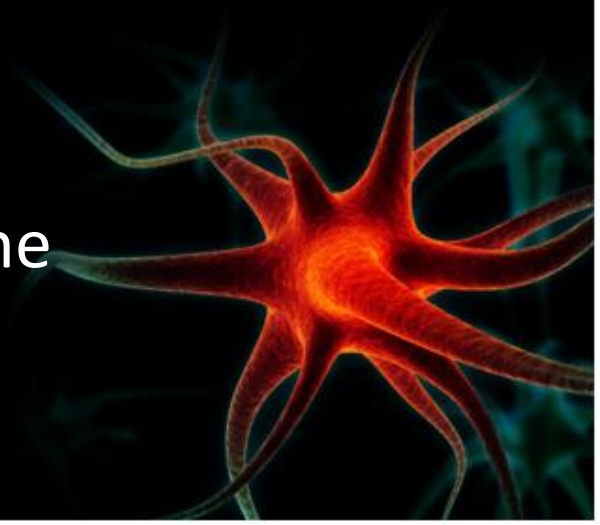
The Endocrine System



Endocrine system

- endocrine system: body system that works in parallel with the nervous system to maintain homeostasis by releasing chemical hormones from various glands. The system is comprised of the hormone producing glands and tissues of the body
- “ductless” system; glands secrete hormones directly into the bloodstream
- usually for maintaining longer term processes

- exocrine glands: glands that have ducts and secrete substances such as sweat, saliva, tears, milk, or digestive enzymes
-
- hormones: chemical signals that are sent to many parts of the body; examples are adrenaline and noradrenaline from the neurons of the adrenal glands



- Target organ: organ that contains receptors for a particular hormone

- Hormones produced by the endocrine system influence the activity of every organ and tissue in the body.
- Hormones act as chemical messengers which initiate some type of specialized biochemical processes in the target organ.

- Specific hormones act on specific target organs because the target organs have specific receptors for that hormone.

Types of Hormones

- (1) Steroid hormones
- → hormones produced from cholesterol (see fig. 13.4, p. 424)
- → all have 4 carbon ring structure with different side groups
- → ex. Cortisol, progesterone, testosterone, aldosteron
- → made in the rough ER

Types of Hormones (cont)

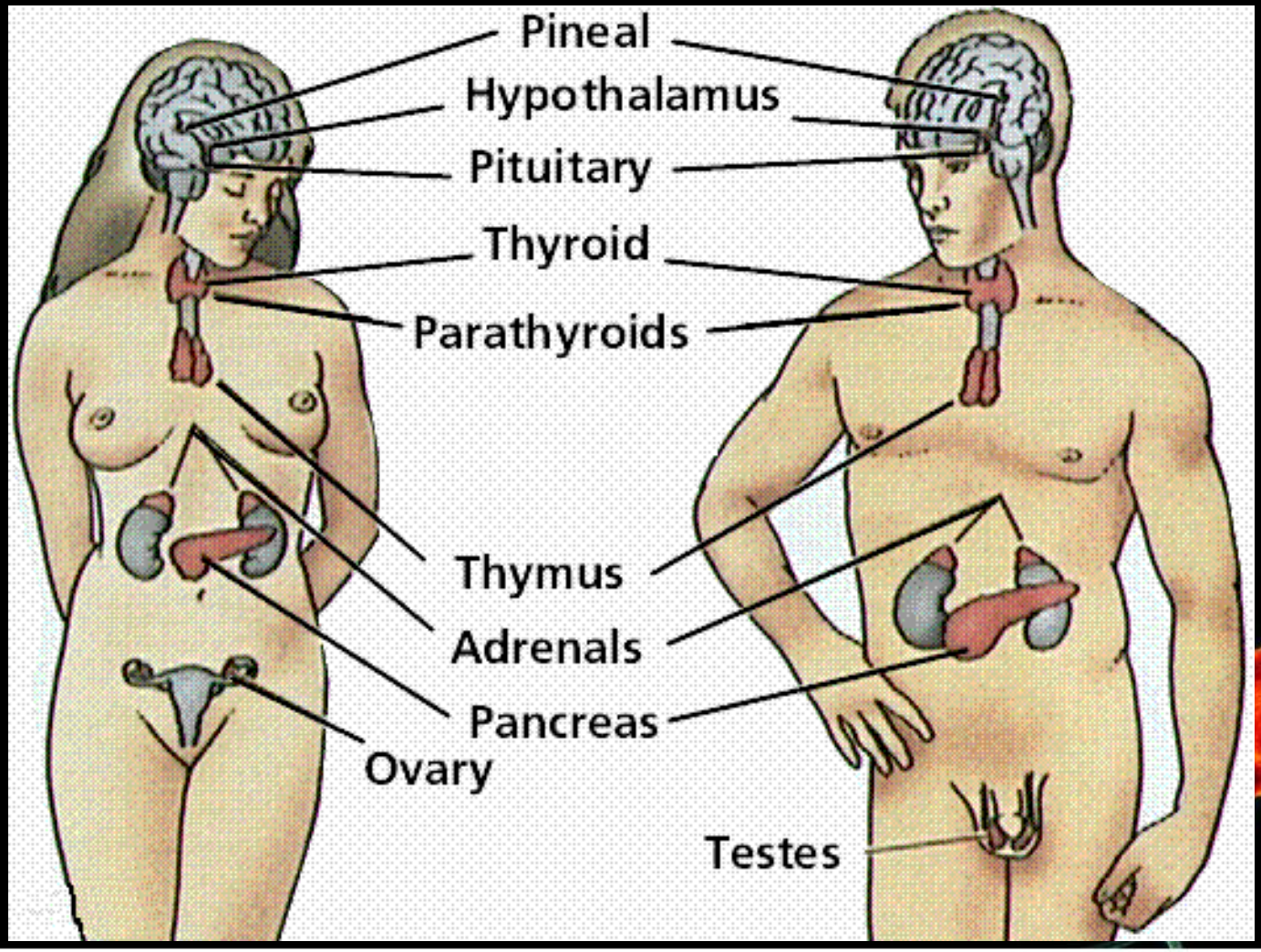
- → have to be carried in blood by a protein carrier (fat soluble)

- → works by binding to receptor, enter the nucleus and binds to a specific part of the cell's DNA, activating a gene. This gene produces an enzyme which causes the desired changes (see fig. 13.5, p. 425)

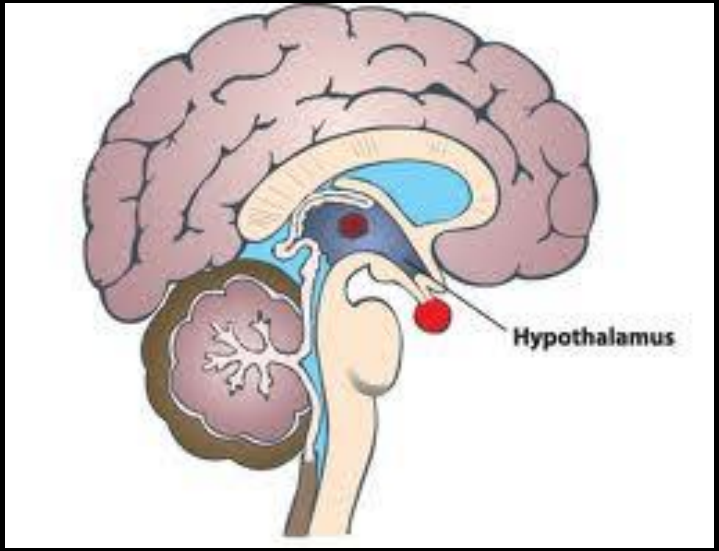
Types of Hormones (cont)

- (2) Non-steroid hormones
- → composed of protein, peptides or amino acids
- → water soluble
- → ex. Adrenaline, thyoxine, glucagons, etc.
- → unlike steroid hormone they do not enter cells. Instead they bond to receptors and cause ATP to cAMP (cyclic AMP) or second messenger.
- This cAMP activates an entire series of enzyme reactions called a cascade which results in the desired changes.

Endocrine Glands



Endocrine Glands



- (1) <u>Hypothalamus</u>
- → controls the endocrine hormone system (as well as the autonomic nervous system). Maintains the body's internal environment

- → produces 2 hormones (both stored and secreted from the posterior pituitary gland)

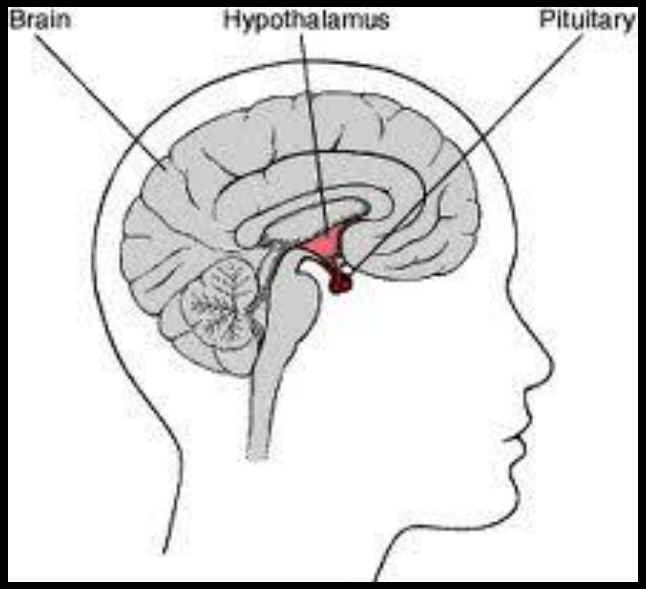
(1) Hypothalamus (cont)

- 1. ADH (anti-diuretic hormone): controls water levels

- 2. oxytocin: triggers muscle contractions in childbirth and promotes lactation

- → interacts constantly with the pituitary gland

(2) Pituitary gland



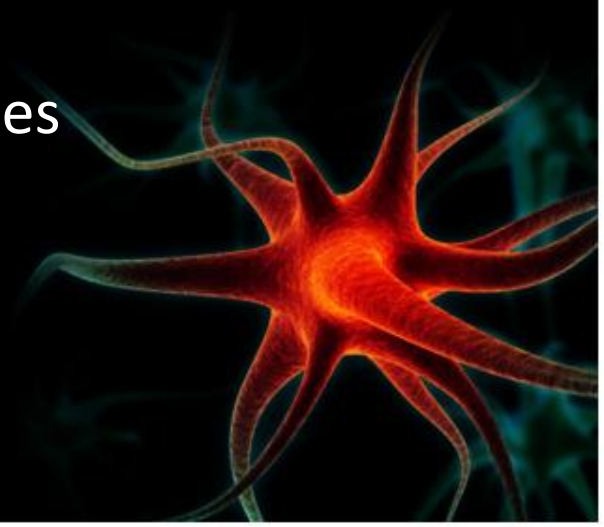
- → called the "master gland"
- → actually two glands: anterior and posterior
- → anterior pituitary produces several hormones:
- 1. HGH (human growth hormone) – controls growth; also known as somatotropin (non-steroid)
-

(2) Pituitary gland (cont)

- 2. prolactin – stimulates mammary gland tissue and milk production (non-steroid)

- 3. TSH (thyroid stimulating hormone) – controls secretion of thyroxine in the thyroid gland (non-steroid)

- 4. adrenocorticotrophin (ACTH) – regulates production of cortisol and aldosterone in the adrenal cortex



(2) Pituitary gland (cont)

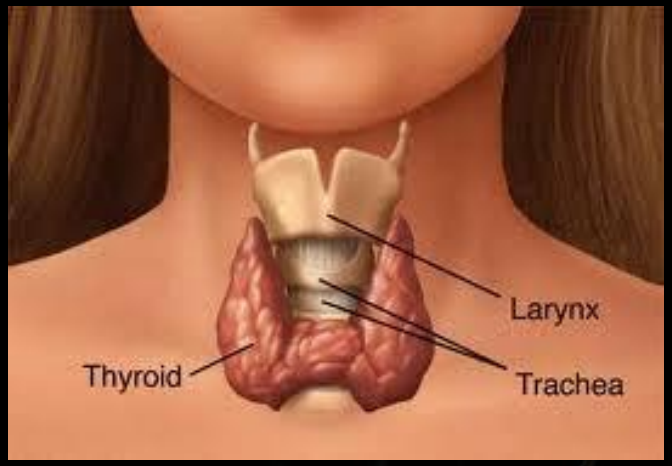
- 5. FSH (follicle stimulating hormone) – stimulates development of gametes (sperm and egg)

- 6. LH (lutenizing hormone) – in females, stimulates ovulation; in males, helps stimulates testosterone production

- → posterior pituitary gland stores and releases ADH and oxytocin made by the hypothalamus

(3) Thyroid gland

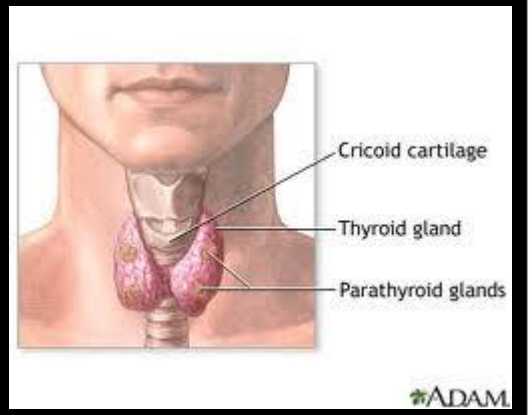
- → "butterfly" shaped gland located between the larynx and the neck



- → produces thyroxine
- non-steroid

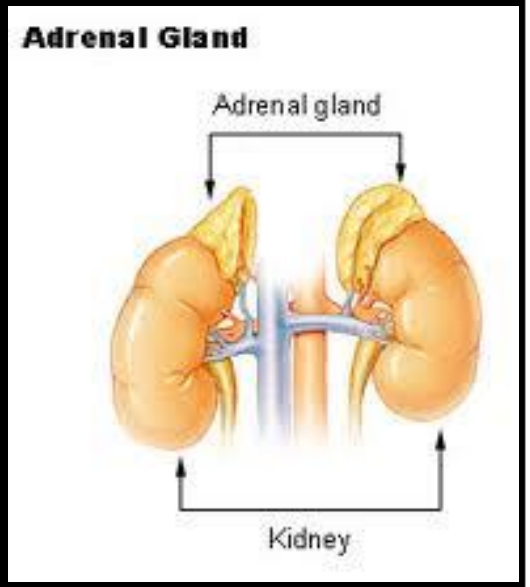
- contains iodine
- increases metabolic rate especially in the heart, skeletal muscle, liver and kidney
- → produces calcitonin (causes calcium levels to drop in blood by reabsorbing it into bones)

(4) Parathyroid gland



- → found near the thyroid gland
- → produces parathyroid hormone (PTH) which causes bones to release calcium into the blood from bones
- → calcitonin and parathyroid hormone work together to maintain calcium levels in the blood (see fig. 13.16, p. 434)

(5) adrenal gland



- → two distinct sections; adrenal cortex and adrenal medulla

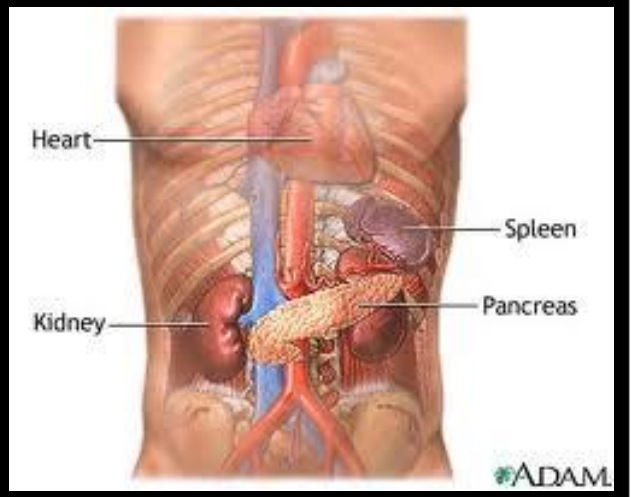
- → adrenal cortex
- produces glucocorticoids (cortisol) and mineralcorticoids (aldosterone) and small levels of sex hormones
- cortisol stimulates carbohydrate synthesis, breaks down fats, and reduces immune system abilities (inflammatory response)

(5) adrenal gland (cont)

- aldosterone regulates water balance by increasing sodium reabsorption in the colon, which causes the hypothalamus to release ADH

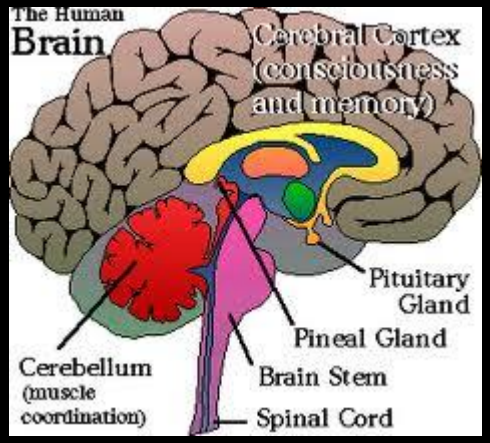
- → adrenal medulla
- secretes adrenaline and noradrenaline
- both hormones act to increase heart rate and blood pressure
- also involved in the “fight or flight” response

(6) Pancreas (islets of Langerhans)

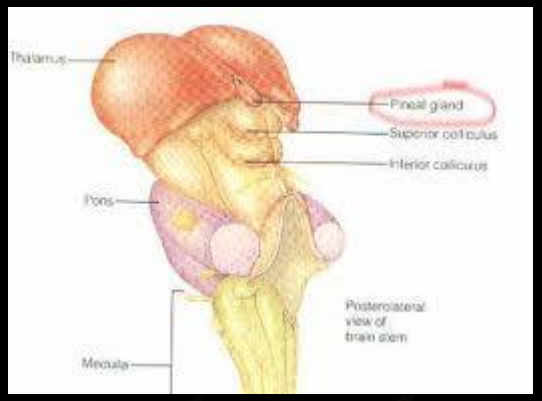


- → as an endocrine gland, it produces insulin and glucagon
- → insulin causes excess blood sugar to be stored as glycogen in the liver, and as fat in adipose tissue
- → glucagon has the opposite effect of insulin. It causes glucose to be released from glycogen and fatty acids and amino acids and released into the blood stream

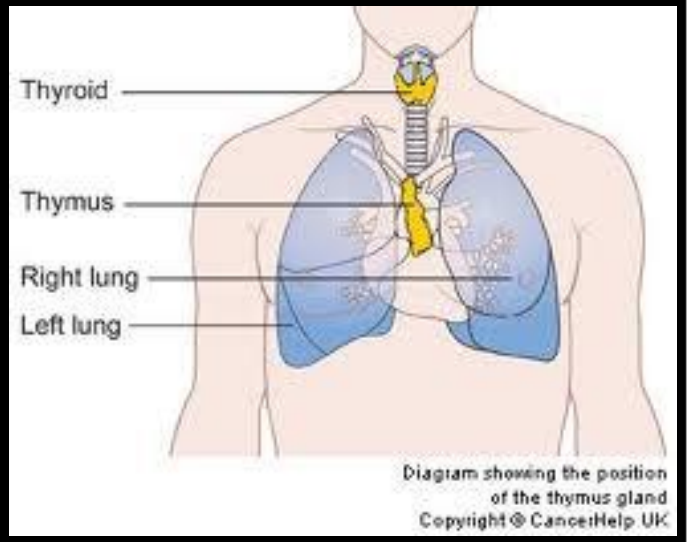
(7) Pineal gland



- → small cone-shaped structure located deep within the brain
- → produces melatonin, involved in sleep
- → melatonin has a circadian rhythm, a daily biological cycle or regular pattern. Melatonin levels increase as the day goes on, producing the feeling of sleepiness
-



(8) Thymus gland

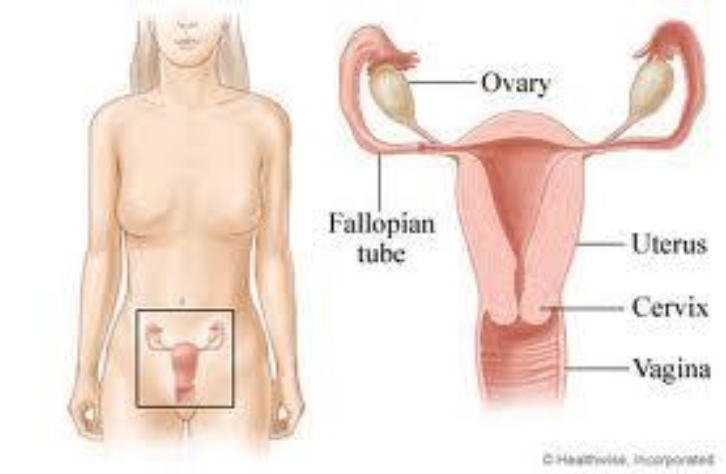


- → lymphatic tissue located between the lobes of the lungs and the upper chest cavity
- → produces thymosin and usually disappears during puberty
- → thymosin stimulates production and materials of lymphocytes into T-cells
-

(9) Ovaries

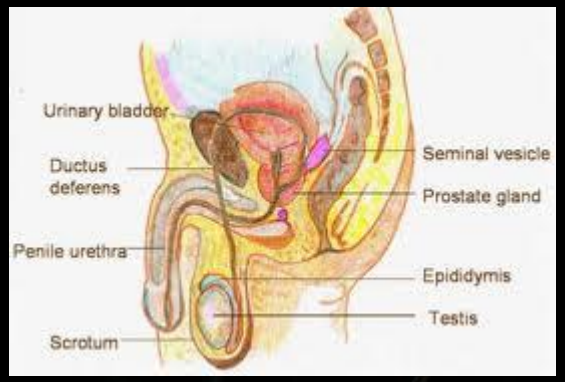
- The ovaries are a pair of oval or almond-shaped glands which lie on either side of the uterus and just below the opening to the fallopian tubes.

- In addition to producing eggs or "ova," the ovaries produce female sex hormones called estrogen and progesterone.



(10) Testes

- Testosterone is primarily secreted in the testes of males although small amounts are also secreted by the adrenal glands.



- It is the principal male sex hormone and an anabolic steroid.

The Discovery of Insulin

- Insulin was discovered by two Canadian scientists: Fredrick Banting and Charles Best. They worked with dogs and first discovered the link between the pancreas and diabetes in that dogs that had their pancreas removed developed symptoms of diabetes. In addition, they found the islet cells of the pancreas were responsible for preventing diabetes.
- Later on, they did an experiment. They extracted the islet secretions from a healthy dog and put them in the system of

The Discovery of Insulin (cont)

- a diabetic dog (removed pancreas). As expected, the diabetic dog's blood sugar did go back to normal.
- After several tests and modifications, this extract was given to a human patient with success. It was named insulin after the Latin word for island.

Disorders of the Endocrine System

- 1. Pituitary dwarfism
- → abnormally short stature caused by insufficient HGH production during childhood
- → unlike genetic dwarfism, body parts are in proportion
- → puberty may be delayed or not occur at all
- → treatments now include HGH therapy during childhood

2. Gigantism

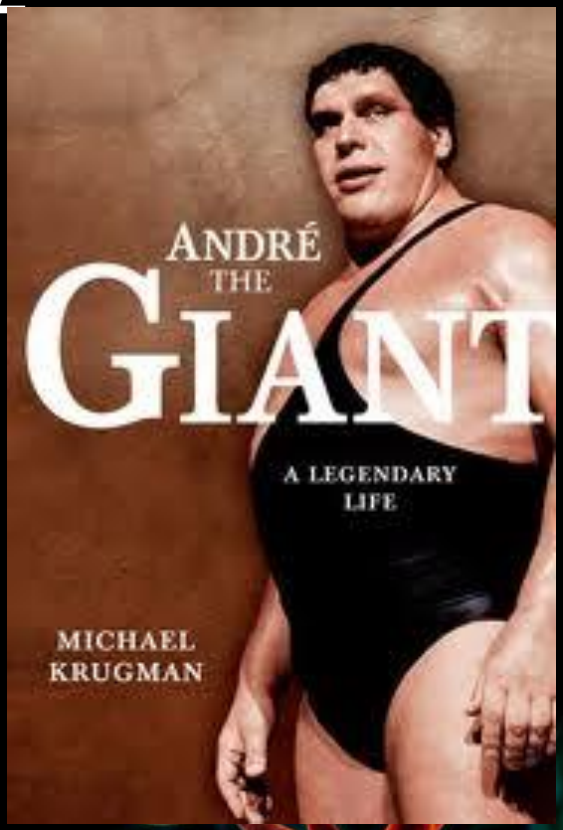
- → an excess of HGH production prior to puberty; causes uncontrolled growth (long bones in the skeleton)

- → usually caused by a tumor on the pituitary gland
- → can be treated with surgery on the pituitary gland

3. Acromegaly

- → excess HGH production during adult years

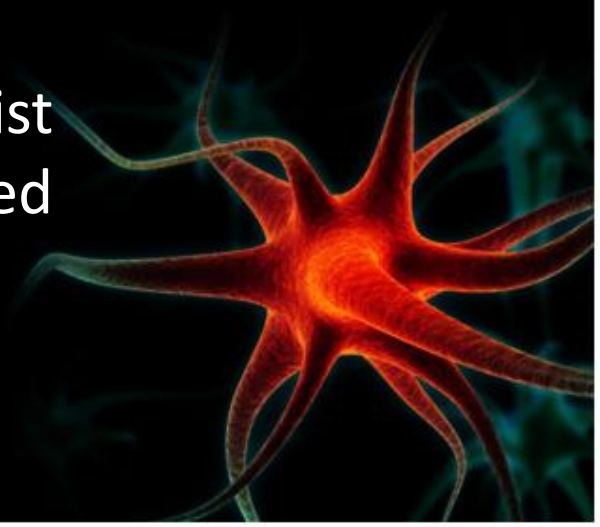
- → symptoms include excessive thickening of bone tissue (see fig. 13.10, p. 430)
- → usually caused by a tumor on the pituitary gland
- → treatments include removal of tumor, drugs, etc.



4. Hyperthyroidism

- → also called Grave's disease
- → an autoimmune disorder caused by an excess of thyoxine

- → antibodies attach to TSH receptors on thyroid cells, causing the thyroid gland to produce more thyroxine
- → causes enlarged thyroid, sweating, moist skin, excess heat production, and increased metabolic rate



5. Hypothyroidism

- → a deficiency of thyroxine production

- → causes low metabolic rate, reduced tolerance to cold temperatures, weight gain but decreased appetite, decreased mental capacity, weakness/fatigue, and so on

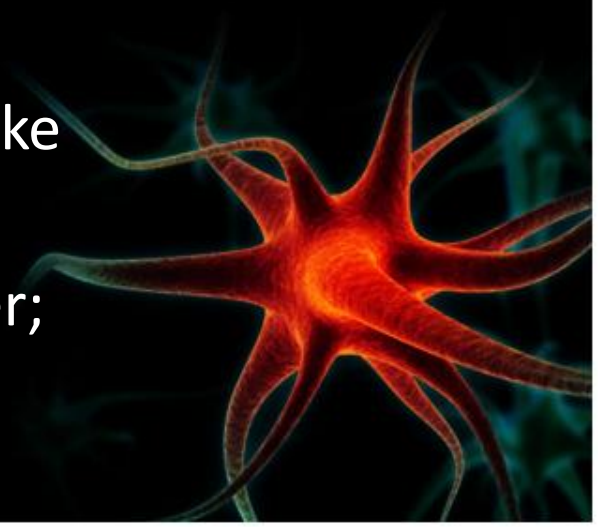
6. Goiter

- → a swelling of the thyroid gland due to a lack of iodine (see fig. 13.15, p. 433)
- → reduced iodine means less thyroxine produced so metabolic rate decreases, and pituitary increases TSH secretions which causes the thyroid to swell
- → goiters are not much of a health problem thanks to “iodized salt”

7. Diabetes

- → a disorder where blood sugar levels are elevated constantly. Can cause circulatory disorders, blindness, and/or weight loss

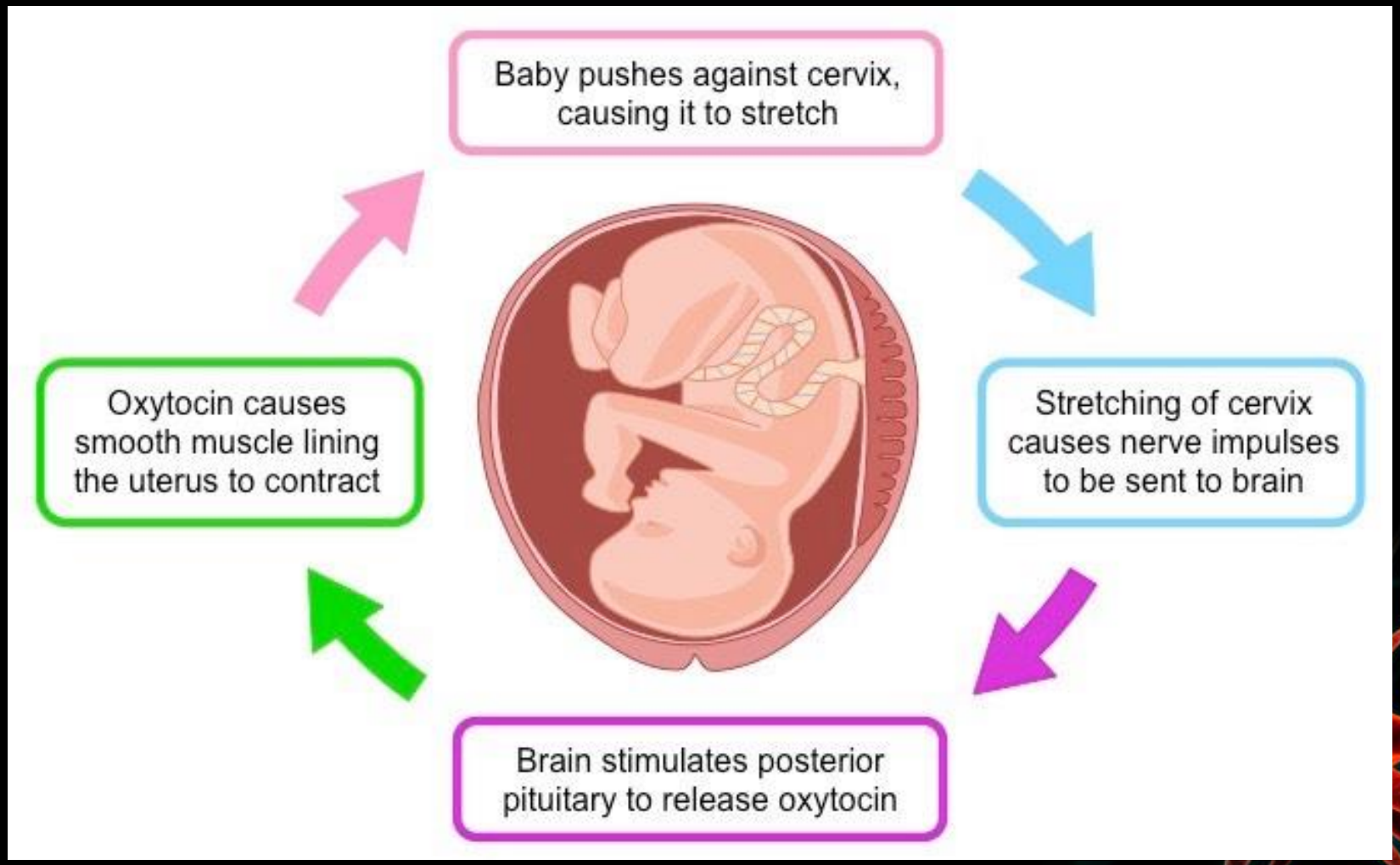
- → two types:
- (1) Type 1 Diabetes (Diabetes Mellitus)
- - also called juvenile diabetes
- - insulin dependent (pancreas doesn't make any insulin)
- - suggested to be an autoimmune disorder; body's own cells attack the pancreas and destroy the cells which make insulin



7. Diabetes (cont)

- (2) Type 2 Diabetes
- - adult-onset diabetes
- - insulin produced but body less sensitive to it or it is not produced enough
- - 90% of all diabetics are type 2
-

Positive Feedback Loop



Negative Feedback Loop