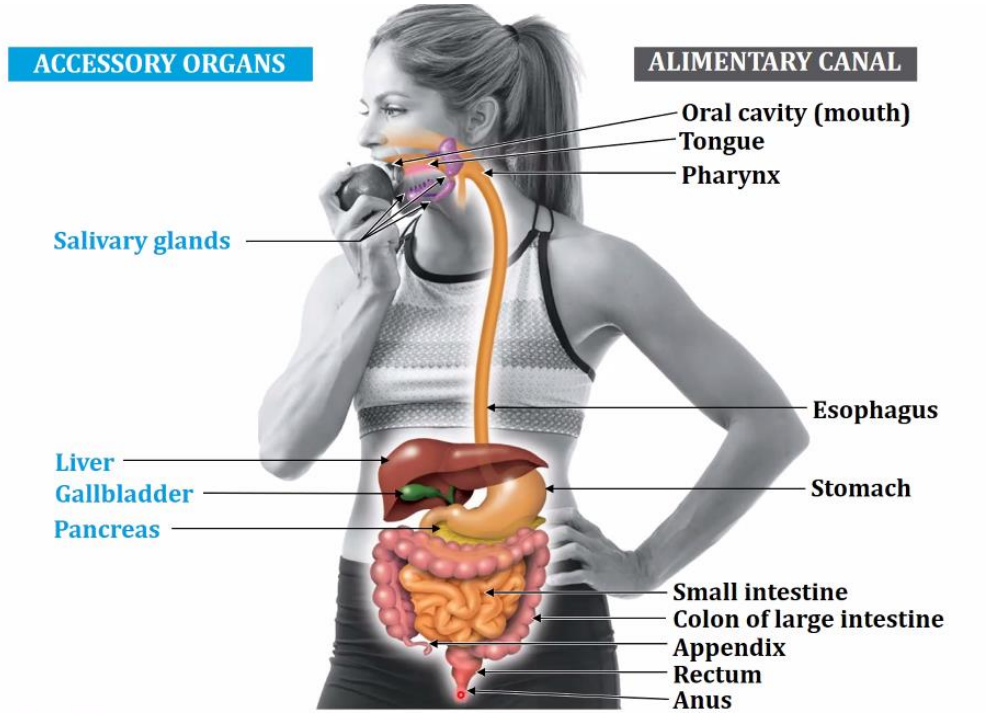
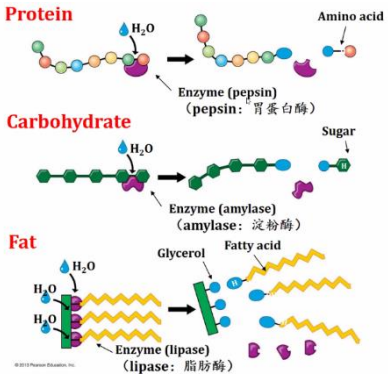
Lecture 15 – Digestive System



Four stages:

1. Ingestion: eating food
2. Digestion: breakdown food into small molecules
3. Absorption: absorb nutrients, molecules needed by the body
4. Elimination: dump the unwanted molecules

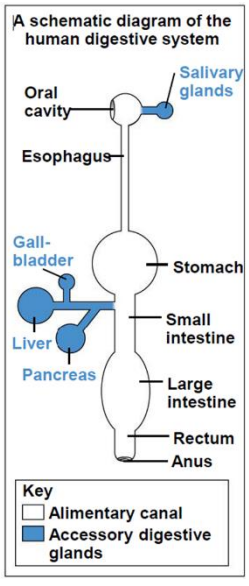


The dismantling of food molecule is necessary because it is too large to pass membrane and different from the molecule needed.

Two type of digestion

1. Chemical digestion using enzyme
2. Mechanical digestion involves physical processes e.g., chewing.

Digestive Compartments



- Food vacuole: The food vacuole fuses with a lysosome containing enzymes, forming a digestive compartment. Only in simple eukaryotic organisms, protists e.g.
- Gastrovascular cavity: A digestive compartment with a single opening that functions as both the entrance for food and the exit for undigested wastes.
- Alimentary canal/digestive tract: A digestive tube with two separate openings—a mouth at one end and an anus at the other end.

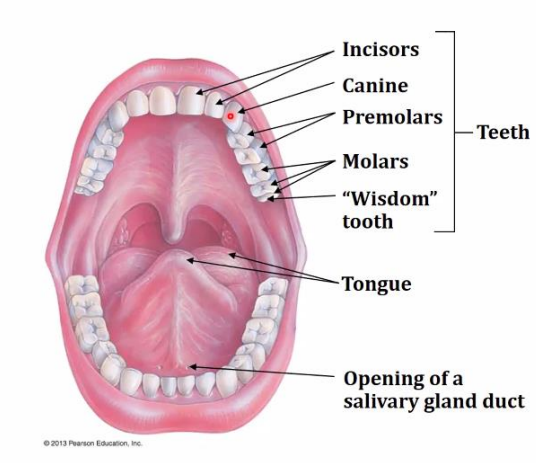
Digestive tube: Mouth (oral cavity) → pharynx → esophagus → stomach → small intestine → large intestine (colon and rectum) → anus).

Accessory organs: Salivary glands, Gall bladder, Liver, Pancreas.

Mouth

Teeth:

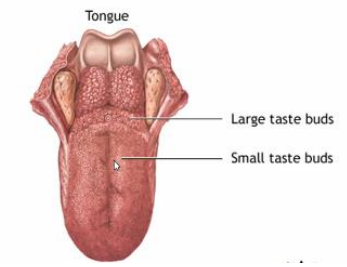
- Incisors: cutting
- Canine: tearing
- Premolars – molars: grinding



Wisdom teeth come up at age 30-40, total after wisdom teeth: 32, before wisdom teeth: 28

Teeth is the hardest part of the body, e.g. if body is burnt, the teeth is still can be found (not burnt)

Tongue: for chewing, swallowing, tasting and speaking



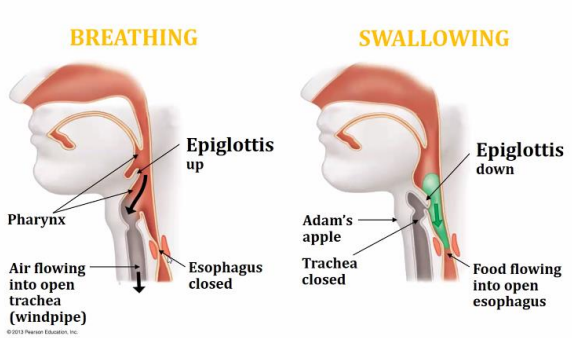
When we eat yummy foods, why is it so difficult to resist urge to swallow the foods?

Because the large taste buds is located at the back of the mouth. Swallowing gives more pleasure because it push the food to the most sensitive taste buds.

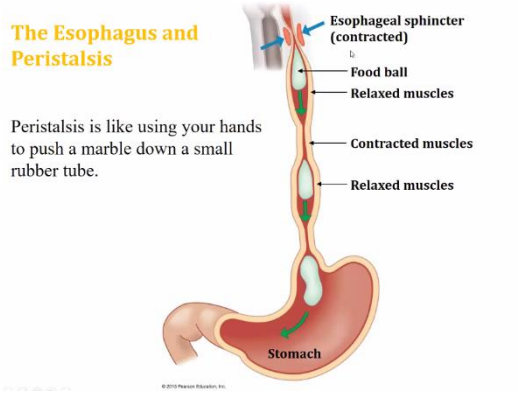
Secretion of **saliva glands**: chemical digestion (amylase)

Pharynx

- Connects the mouth to esophagus and trachea
- When swallowing, a reflex moves the opening of the trachea upward and tips a door-like flap called the epiglotis to close the trachea entrance
- When not swallowing, trachea is open for breathing
- Epiglottis is a cartilage to control the opening of the tube.



Esophagus



On esophagus there are mixture of skeletal and smooth muscle. Smooth muscle is useful for involuntary movement.

Stomach

- Can store food for several hours, and for churning (mixing food)
- Contains gastric juice made of strong acid, digestive enzymes, and mucus

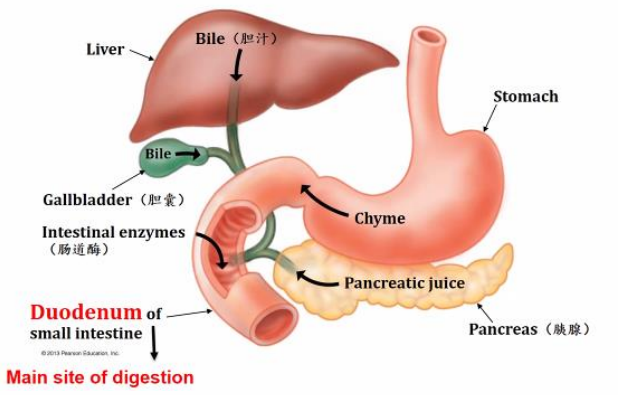
- Acid get rid of most of bacteria (except helicobacter pylori)
- The stomach can stretch to accommodate a lot of food eaten.

Stomach ailments:

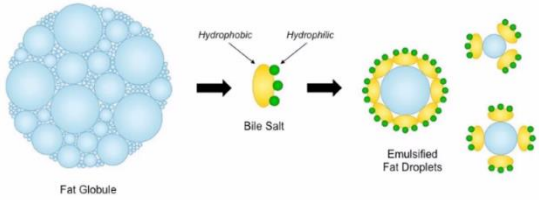
- Heartburn: is caused by backflow of chyme into esofagus (Gastroesophageal reflux disease/ GERD)
- Gastric ulcers: erosions of stomach lining, caused by *Helicobacter pylori*

Reduce alcohol in the stomach: drinking milk containing fat, forming layer in the stomach and reduce the absorbance

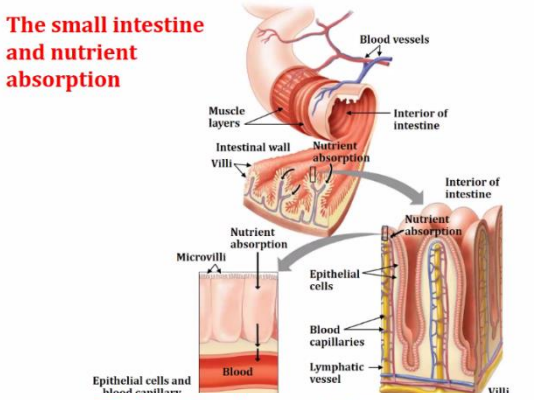
Small intestine



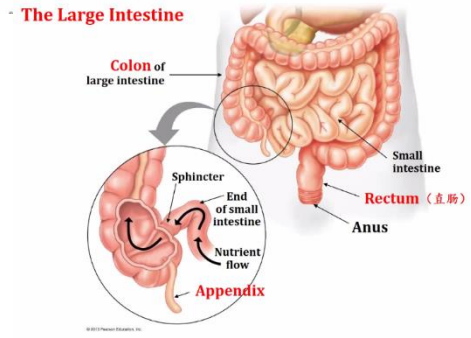
- The longest part of the alimentary canal (but only 2.5 cm diameter), major organ for chemical digestion and absorption of nutrients into the bloodstream
- Connected to some other accessory organ, e.g., pancreas, liver, and gallbladder
- First part: duodenum ("12 fingers").
- Pancreas secretes juice that **neutralizes stomach acids** (NaHCO3) and aids in digestion/enzymes)
- Liver secretes bile to help **digest fats** (emulsifies large fat globule), stored in gallbladder



- Gallstones can develop if the normal mix of bile is altered, and cholesterol is high can cause jaundice due to increasing level of bilirubin
- In **duodenum, nutrients are digested** and ready to be absorbed
- After passing through duodenum, **nutrients are absorbed (using structure called villi, with microvilli on it)**



Large intestine



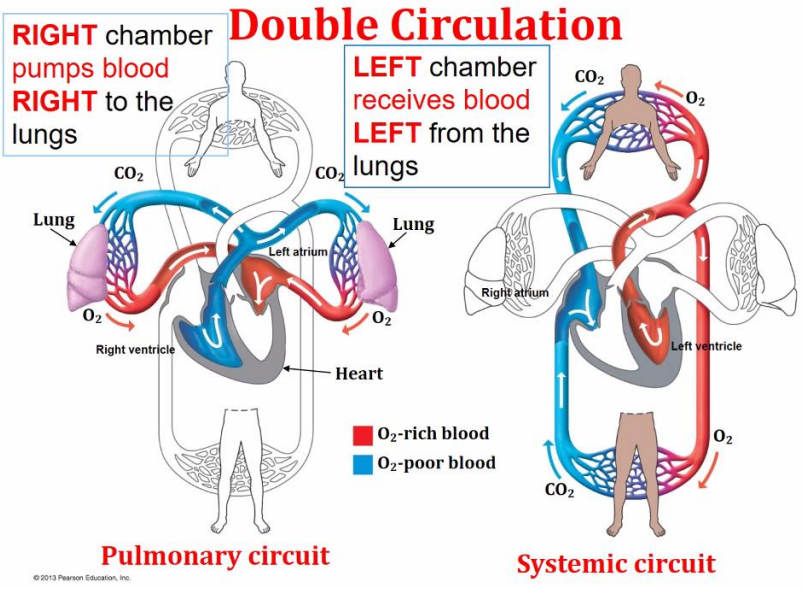
- **Sphincter**: It controls the passage of what's left of a meal.
- **Appendix**: It contains white blood cells that make minor contributions to the immune system. → appendicitis —a bacterial infection of the appendix
- **Colon**: The main portion of the large intestine. The primary function is to absorb water from the alimentary canal. → diarrhea —unable to reabsorb water efficiently; constipation—occurs when peristalsis moves feces along too slowly and the colon reabsorbs so much water that the feces become too compacted; Celiac disease and Crohn's disease.
- **Rectum**: The last 15cm of the large intestine, stores feces until they can be eliminated. Two rectal sphincters, one voluntary and the other involuntary, regulate the opening of the anus.

Lecture 16 – Circulation System

Circulation: facilitates exchange of materials

1. Heart
2. Blood vessels: arteries – away from heart, venules – back to heart, capillaries – side of exchange
3. Blood

Double circulation

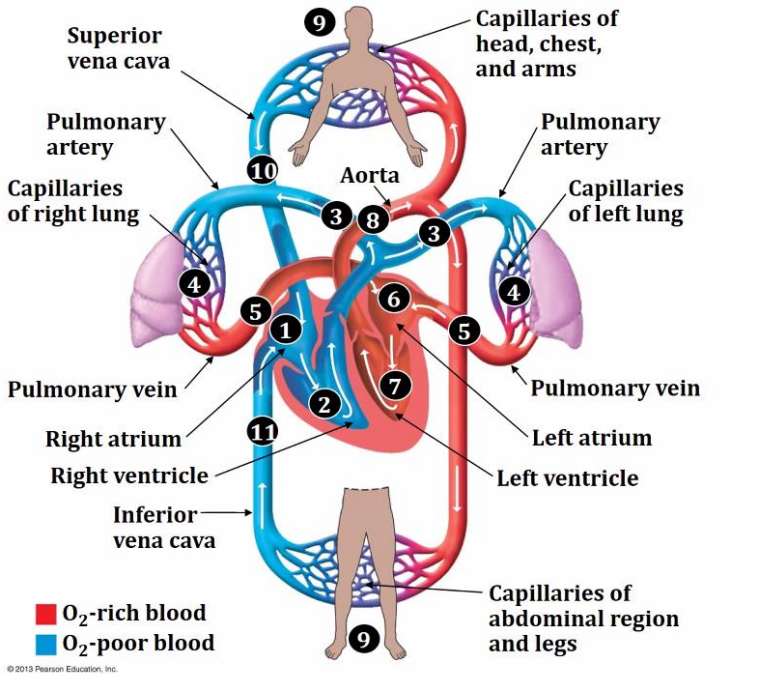


Muscle on left ventricle is thicker than right ventricle because it needs more power to pump the blood to all organs than just to lungs.

Cardio hypertroping: enlargement or thickening of heart muscle

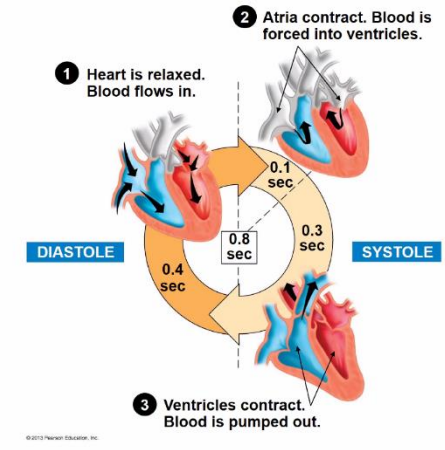
Path of Blood

10 (SVK), 11(IVK) → 1 (Right Atrium) → (Tricuspid) Valve → 2 (Right Ventricle) → (Pulmonary) Valve → 10 Pulmonary Artery → 4 Lungs → Capillary Lungs → 5 Pulmonary Vein → 6 Left Atrium → (Mitral) Valve → 7 Left Ventricle → (Aortic) Valve → 8 Artery → All body → Capillary of head, cheast, arms, etc, …



Valves prevent the backflow of the blood. The sound of the heartbeat comes from the closure of the valve.

Cardiac Cycle

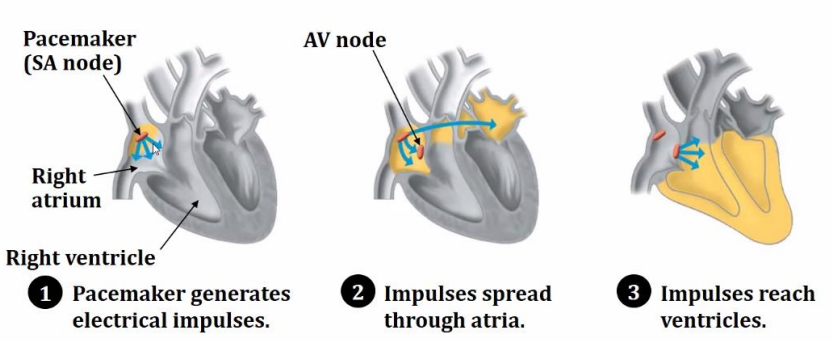


Diastole = relaxation process, blood come into the heart (atrium)

Systole = contraction process (0.1 s), blood is forced into ventricles, the atrium is empty.

The heart rate is controlled by the pacemaker (**SA node**/sinoatrial node). SA node, composed of specialized muscle tissue in the wall of right atrium, sets the tempo of the heartbeat.

AV node (atrioventricular node) is a relay point that delays the signal, sends impulses to the ventricles.



SA Node transmit signals to atrium → atrium contraction, blood out of atrium (0.1 s) → AV node → ventricle contraction, pump blood out of ventricle (0.3 s)

Optimal blood pressure 80/120 (systole < 120, diastole < 80 mmhg). Normal pulse rate ~ 60 – 100 bpm, for athlete 40-60 bpm

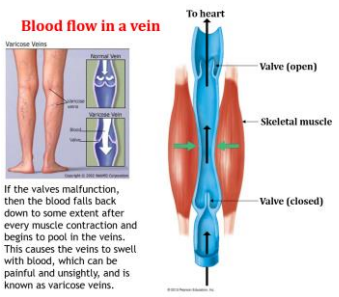
Blood Flow: 5-10% of the capillaries have a steady flow of blood. Total of blood in human: 5L.

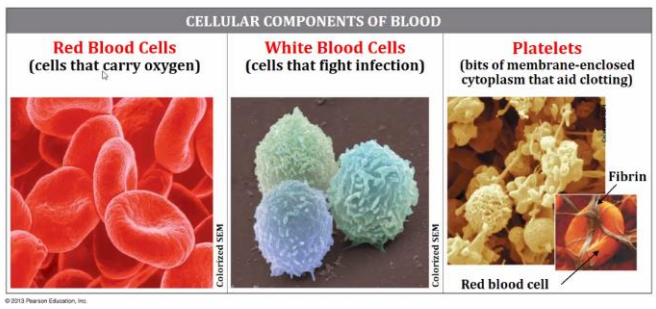
Blood flow in capillaries controlled by precapillary sphincters, e.g., after meal, blood supply to digestive tract increases, and during strenuous exercise, blood is diverted from digestive tract to skeletal muscle.

Arteries: carry blood away from heart.

Veins: carry blood back to heart.

Capillaries: exchange components between blood and interstitial fluid.

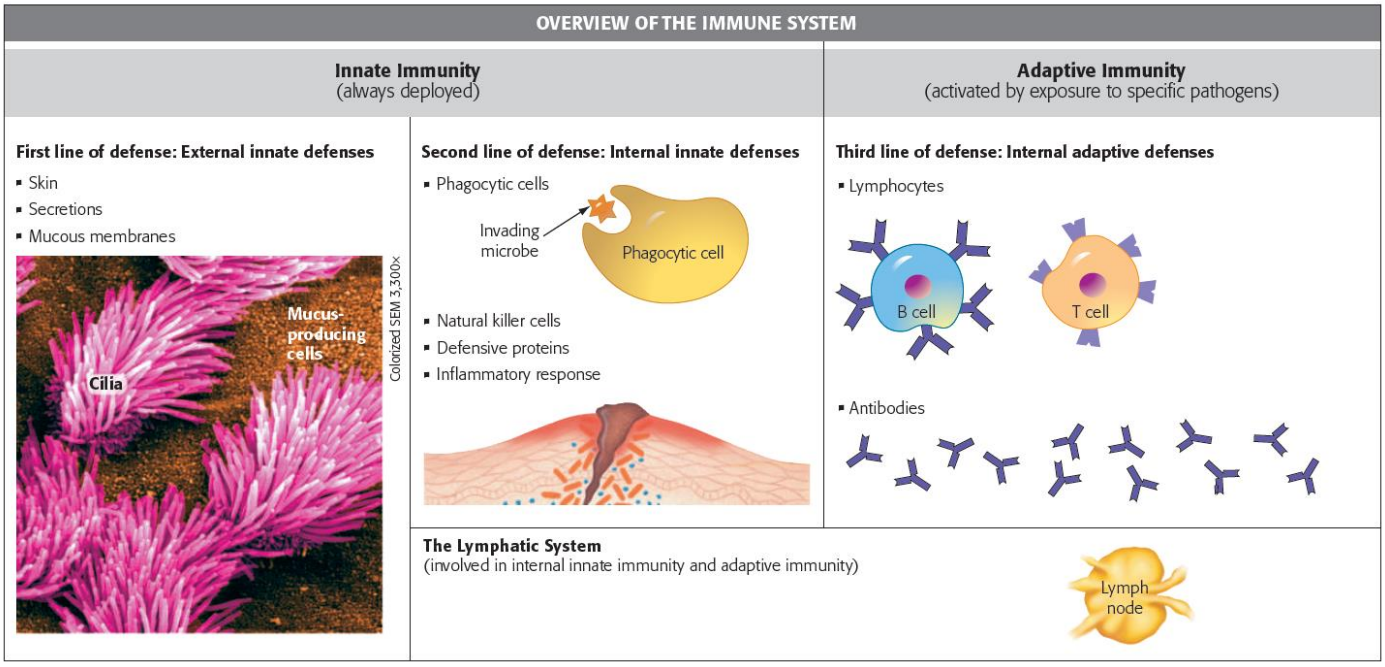




Lecture 17 – Immune System

Immune system = defense against infectious diseases caused by pathogens including viruses and microorganisms

First vaccine: for small-pox virus from cow-pox virus (harmless can enough to trigger immune system)

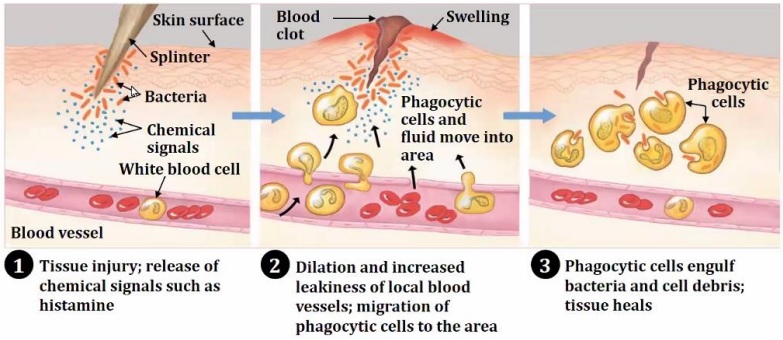


Innate Defenses

Non-specific, in-born, immediate and always ready to respond (remain unchanged). There are two lines of innate defense:

1. **External barriers**: block and filter our pathogens, e.g., skin, nostril hairs, ear wax traps, secretions such as tears, sweat and saliva with antimicrobial chemicals, stomach acid, and mucous membranes
2. **Internal barriers**: white blood cells, and defensive protein.
   - *Phagocytic cell*: engulf foreign cells or molecules and debris from dead cells
   - *Natural killer cells*: recognize virus-infected cell and cancerous cell the release molecules to kill the cell.
   - *Interferon*: infected cell release interferon and the interferon bind with healthy cell to stimulates production of antiviral proteins.
   - *Complement proteins*: release chemical to create hole on the membrane

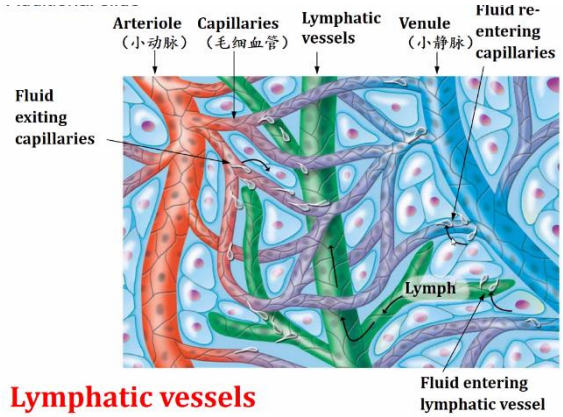
   Inflammatory response:



Damaged cell release chemicals that increase blood flow to the damaged area and turn the wound red and warm. Sever inflammation is dangerous. Anti-inflammatory drugs such as aspirin and ibuprofen is needed to make inflammation less sever.

Lymphatic System

- A lot of white blood cell in lymphatic nodes.
- Lympathic vessels contain lymph, travelling in lymphatic system slowly.
- Lymph can go back to circulatory system

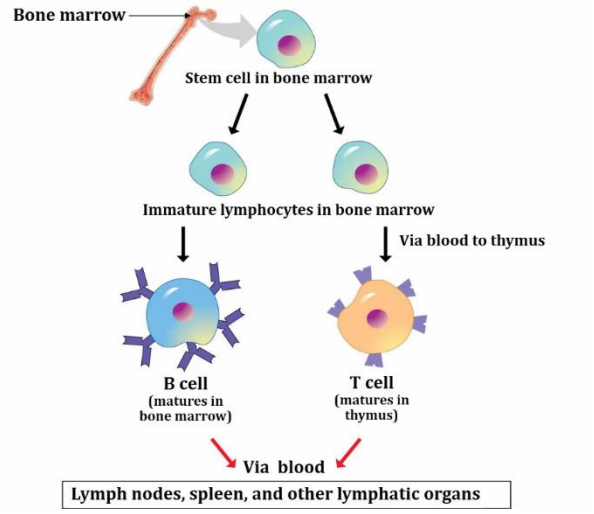


Lymphatic vessels

Adaptive Defences

- Acquired immunity with exposure and delayed response
- Third line of defense.
- Depend upon lymphocytes that recognize and respond to specific invading pathogens.
- Two types of lymphocytes:
  1) **B cells**: mature in the bone marrow [antibody-mediated immunity]
  2) **T cells**: mature in the thymus, a gland in the chest. [cell-mediated immunity]

  Both derive from bone marrow stem cell.



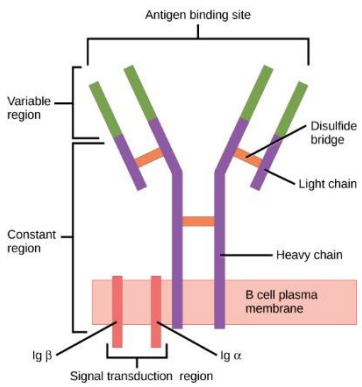
Antigens: molecules on the surfaces of viruses or foreign cells and elicit a response from a lymphocyte (Ag receptor)

Step 1: Recognizing the invaders

- Each cell has ~ 100,000 copies of antigen receptor that detects only a single type of antigen.
- **B cell** Ag receptors: antibodies (Ab/Immunoglobulin/Ig)
  - Membrane bound antibody
  - Secreted antibody (secreted by effector B cells)

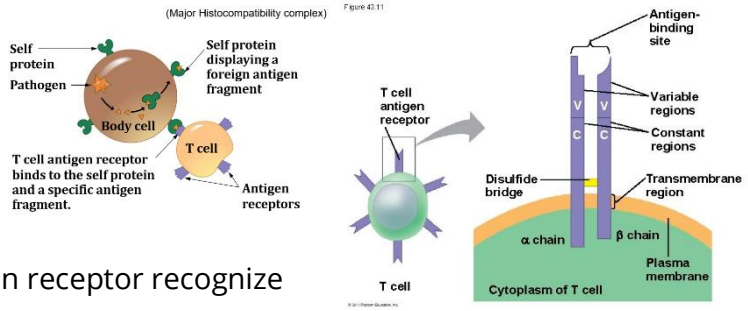
  O = Ig domain, V = variable region (change this region to make different antibodies), C = constant region

  Binding site can be found in the variable region.



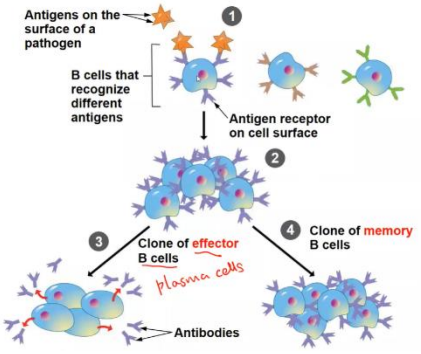
Class	Distribution	Function
IgG	Main antibody type in circulation The only antibody can cross the placenta.	Binds to pathogens, activates complement, and enhances phagocytosis
IgM	Antibody type found in circulation; largest antibody	Activates complement; clumps cells
IgA	Main antibody type in secretions such as saliva and milk	Prevents pathogens from attaching to epithelial cells in digestive and respiratory tract
IgD	Antibody type found on surface of immature B cells	Presence signifies readiness of B cell to respond to antigens
IgE	Antibody type found as antigen receptors on eosinophils in blood and on mast cells in tissues	Responsible for immediate allergic response and protection against certain parasitic worms

- **T cells** need interaction with antigen receptor, body cell and self-protein (MHC)
- Infected body cell displays the fragment of the antigen through self-protein (MHC/Major Histocompatibility Complex). The antigen receptor recognize antigen through self-proteins.



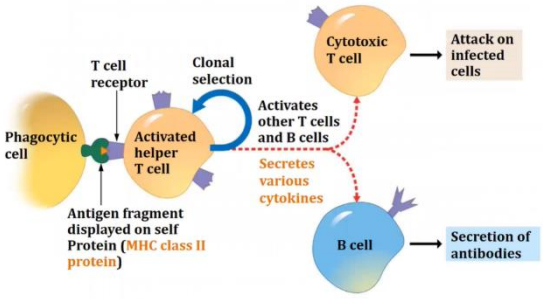
Step 2: Cloning the Responders

- Antigens on its surface bind with a B cell that has complementary antigen receptors (specific B-cell)
- B-cell will grow, divide and develop.
- Clonal selection: produce two clones of cell
  1. Effector cells (short-live cells)
  2. Memory cells (long-live cells)



Step 3: Responding to Invaders

- **Cytotoxic T cells** destroy pathogens within body cells (kill infected cells). It uses similar mechanism with the body cell and MHC class I protein. Cytotoxic T cells then will release **perforin** to form pores in the plasma membrane (similar to complement protein) and **granzymes** to break down the proteins and lysing the cell.

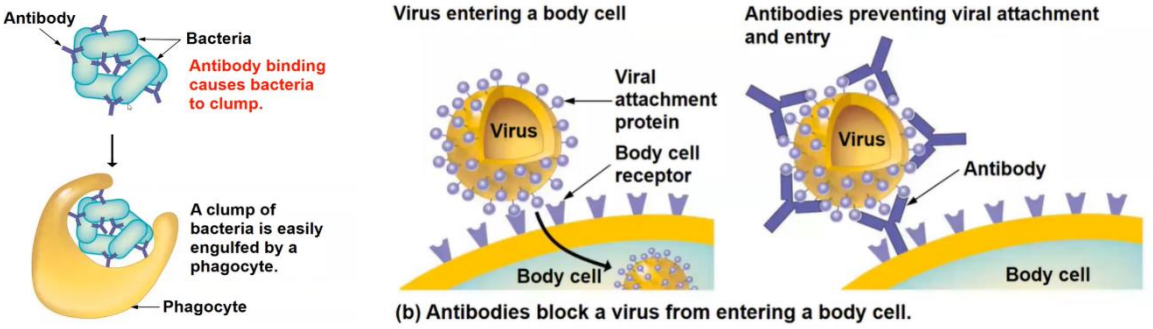


- **Helper T cells** recognize the antigen from infected cells (from MHC Class II) activate the helper T cell to proceed to clonal selection and secretes cytokines to activate other T cells and B cells.

Case: HIV infects helper T cells causes helper T cell decline significantly causing AIDS.

- Antibody response from **B cells** help to eliminate pathogens in the blood and lymph (release antibodies and bind with the antigens)
  1) Antibodies enhance phagocytosis

2) Antibodies block a virus from ent ering body cell



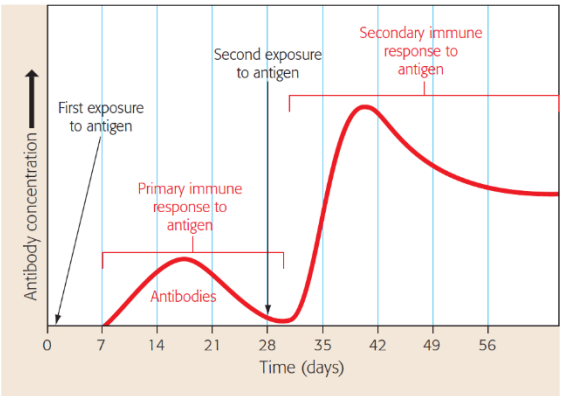
(b) Antibodies block a virus from entering a body cell.

Step 4: Remembering The Invaders

- Memory cell (memory about the invaders) last decades in the lymph nodes ready to be activated. → principle of vaccination.

	Primary	Secondary
Lag	5-10 days	1-3 days
Magnitude	smaller	larger
Antibodies affinity	weaker	tighter

- **Vaccination**: confronts immune with a harmless version of a disease-causing microbe/one of its parts to trigger the primary immune response that produces memory cells.



Lecture 18 – Hormone and Nervous System

Endocrine system: utilizes glands that secrete hormone to the blood (chemical signaling), slow and prolonged response

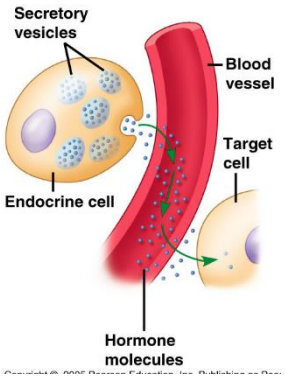
Nervous system: electrical signaling (neural impulses), fast and short-lived response

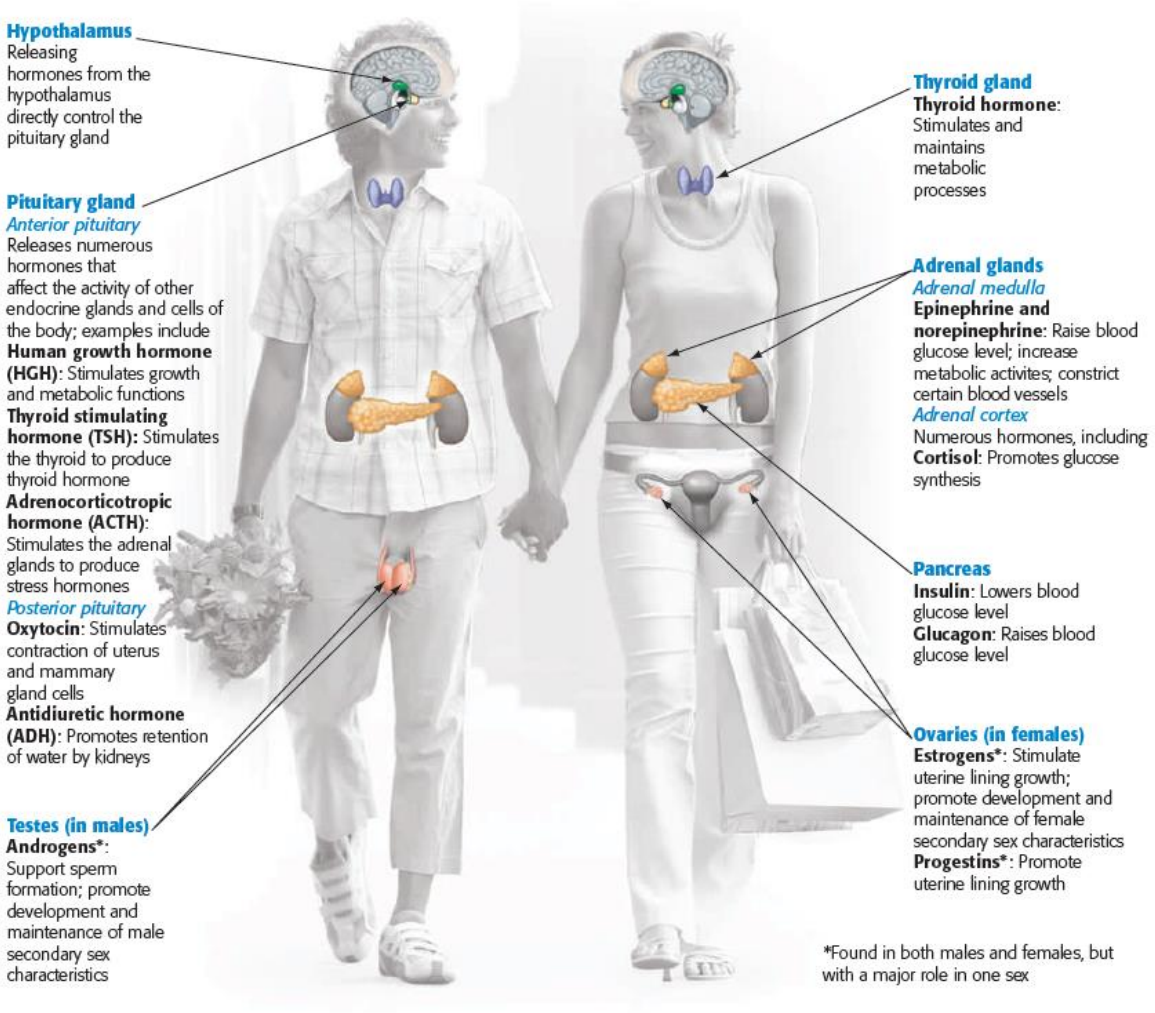
Types of Glands:

1. **Endocrine** function: release the products e.g., hormones into the blood stream
2. **Exocrine** function: export the products from the gland via duct e.g., salivary gland, pancreas

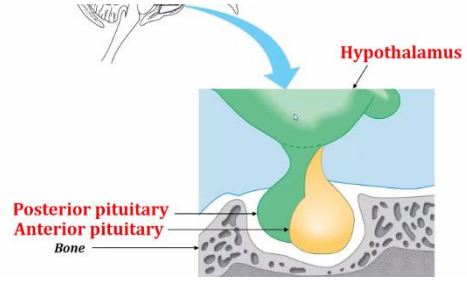
How endocrine system works:

1) Hormones go to circulation system by merging the membrane sacs containing hormones with plasma membrane
2) Receptor (for specific hormones) in the target cells interact with the hormones. Some hormones bounded with the plasma membrane (water soluble hormones e.g., epinephrine and norepinephrine) and some bounded inside the cells (lipid-hormones/steroid-like hormones.





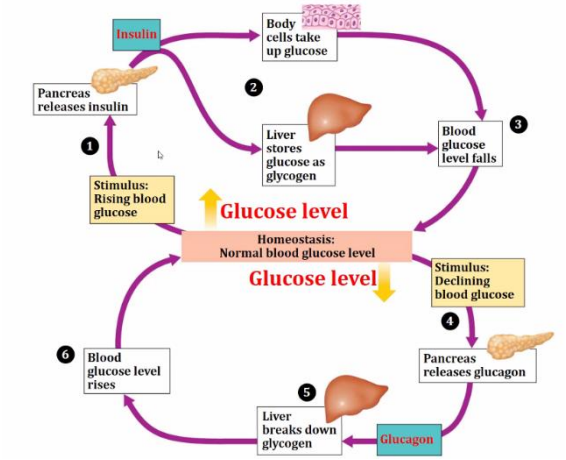
1. **Hypothalamus**:
   - Part of the brain, control center of the endocrine system
   - The link between endocrine system and nervous system (receives information from nerves about internal condition and external environments)
   - Contains neurosecretory cell, a long cell that connect to posterior pituitary gland. The hormone from the hypothalamus, hormones move down to axons endings and it will be secreted from axon endings into the bloodstream (in posterior pituitary gland)
   - Also contains neurosecretory cells and produce hypothalamic releasing and hypothalamic inhibiting hormones. It will be secreted into a portal system, do to anterior pituitary gland.



2. **Pituitary gland**:
   - Divided into two parts: posterior (extension of hypothalamus) and anterior
   - Posterior pituitary produce: ADH, oxytocin

- Anterior pituitary produce: Thyroid stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), prolactin (PRL), growth hormone (GH), and gonadotropic hormones (FSH, LH)

3. **Pancreas**:
   - Produces two antagonistic hormones that control energy supplies (blood sugar)
   - Insulin reduces blood sugar levels, produced in β cells
   - Some cells can store glucose in the form of glycogen (liver, muscle) and in the form of fat (adipose cells)
   - Glucagon increases blood sugar levels, produced in α cells



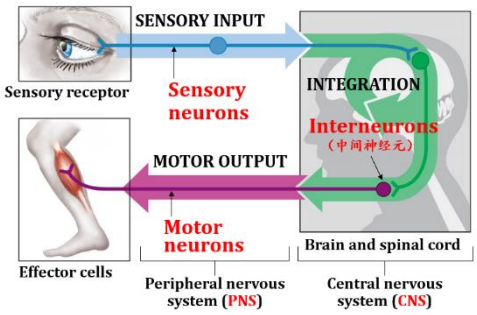
   - In liver glycogen is broken down to glucose and in adipose tissue, fat is broken down into glucose
   - Diabetes: type-1 – problem in insulin production e.g., autoimmune disease attacking beta cells, type-2 – target cells do not respond normally to insulin (related to overweight/underactive).

Nervous system contains two divisions

1. **Central Nervous System (CNS)**, is made up of brain and spinal cord
2. **Peripheral Nervous System (PNS)**, made up mostly nerves that carry signals into and out of the CNS

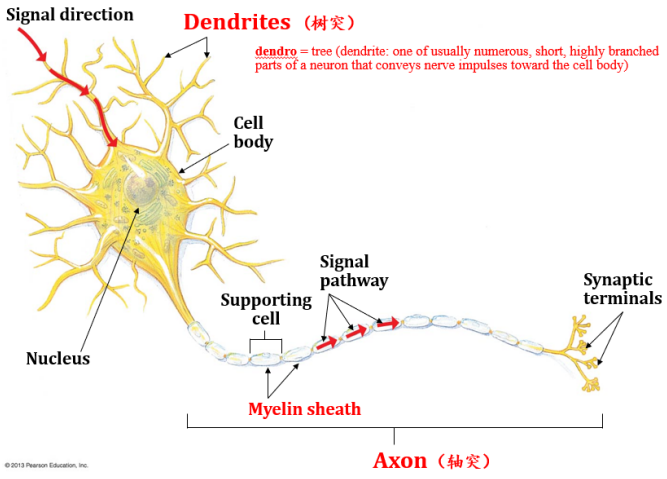
Three type of neuron based on the function

- **Sensory neurons** functions in sensory input, sending signals from sensory receptors to the CNS.
- **Interneurons** integrate sensory signals and formulate appropriate responses.
- **Motor neurons** function in motor output, the process of sending signals from integration centers to effector cells.



Neurons are functional un its of the nervous system

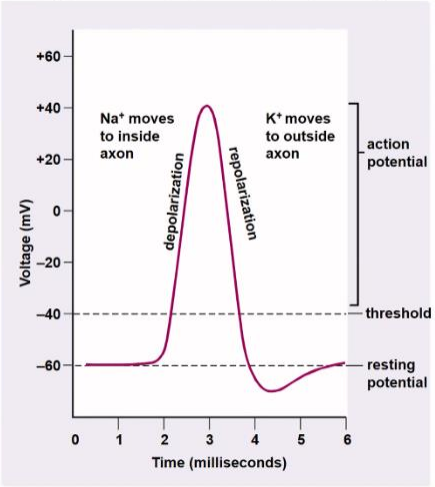
- **Dendrites**: receives the signal
- **Axon**: integrate the information and transmit it to the long axon.
- **Myelin sheath:** forms an insulating material around an Axon and helps speed electrical transmission along an Axon.
- **Synaptic terminals**: ending of the axon, secrete neurotransmitter to the next neuron



Signal generation in a neuron

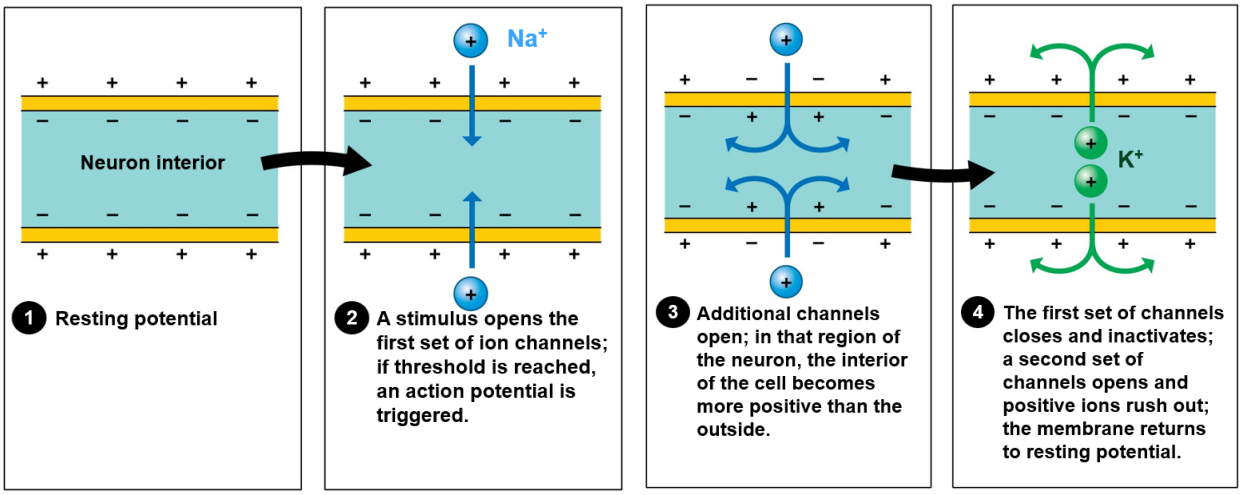
- Signal = action potential = ion movement

- All cells have membrane potential, uneven concentration of ions.
- Normally**, outside the cell**: + charge, high [Na+] ion and low [K+]. **inside the cell**: - charge, low [Na+], high [K+] = resting potential ~ -70 mV
- A stimulus **opens the Na+ channels, Na+ go in**, raising the membrane potential up to threshold potential [reaching threshold potential ~ -55mV is needed to make potential to go up],
- More Na+ channel is then opened until maximum potential ~+40mV. And triggers action potential
- Then, **K+ channels open K+ go out**, decrease the potential
- Na+ and K+ pump to restore the potential to the resting state



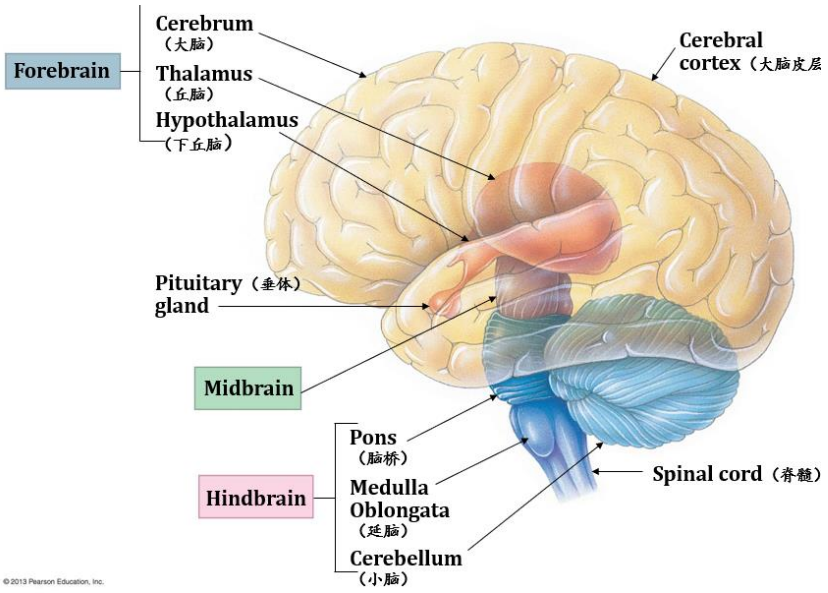
An action potential can be visualized if voltage changes are graphed over time.

- All or none event: reach to the threshold, potential go to 40mV, doesn't reach threshold den nothing happens. To detect the strength of the signal we depend on the frequency.



Human Brain

- Consists up to 100 billion intricately organized neurons with many more supporting cells
- Midbrain: sensory filter to select information to be passed
- Cerebellum: for balance
- Corpus callosum: bridge between left and right cerebral hemisphere.



- In the cerebrum there's cerebral cortex, outermost layer about 4mm thick account over 80% total of the brain mass

Parts of cerebrum:

- **Frontal lobe** (frontal association area): reasoning and movement
- **Parietal lobe** (somatosensory association area): somatic sensing and taste
- **Temporal lobe** (auditory association area: hearing
- **Occipital lobe** (visual association area): vision

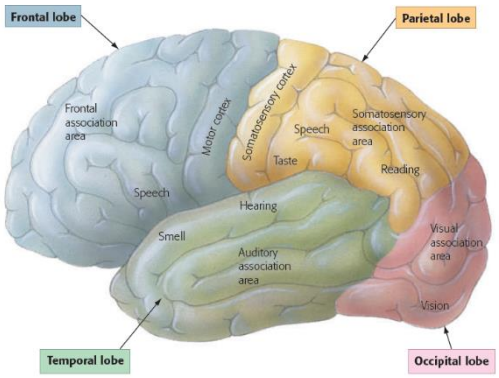


Table 27.1	Structure and Function of the Human Brain
Brain Structure	**Major Functions**
Brainstem	Conducts data to and from other brain centers; helps maintain homeostasis; coordinates body movement
Medulla oblongata	Controls breathing, circulation, swallowing, digestion
Pons	Controls breathing
Midbrain	Receives and integrates auditory data; coordinates visual reflexes; sends sensory data to higher brain centers

Table 27.1	Structure and Function of the Human Brain
Brain Structure	**Major Functions**
Cerebellum	Coordinates body movement; learns and remembers motor responses
Thalamus	Serves as input center for sensory data going to the cerebrum and as output center for motor responses leaving the cerebrum; sorts data
Hypothalamus	Serves as homeostatic control center; controls pituitary gland; acts as biological clock
Cerebrum	Performs sophisticated integration; involved in memory, learning, speech, emotions; formulates complex behavioral responses