RMS Exam Revision

Year 1, Part 1

Cells and their Components

Homeostasis

Breathing, Circulation and Blood

Information provided has been adapted from:
RMS Respiratory Revision Notes
RMS Cardiovascular Revision Notes
RMS Fundamentals of Medicine Revision Notes

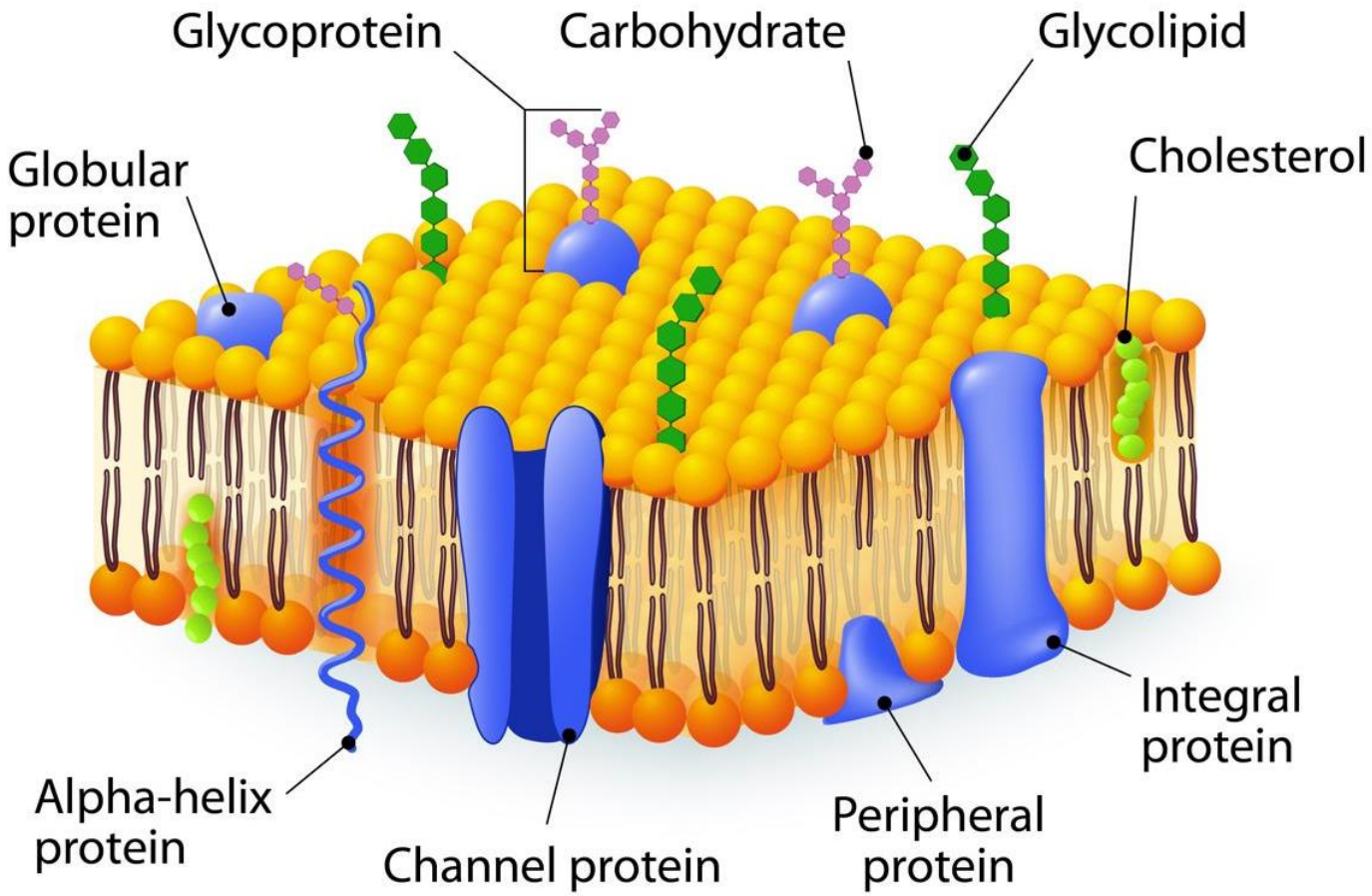
Cells and their Components

Homeostasis

Breathing, Circulation and Blood

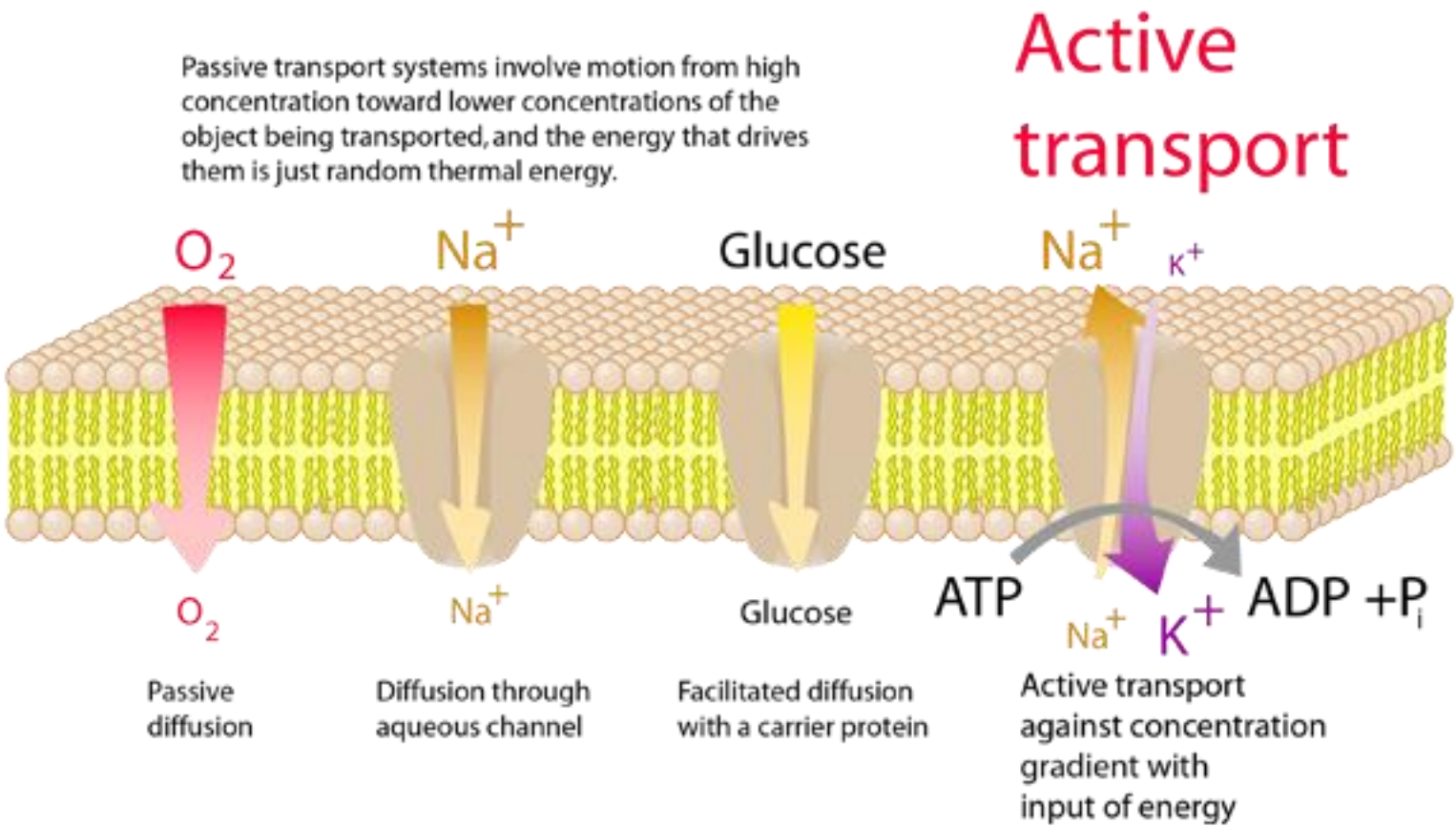
Cells and their Components

- Plasma membrane
- Hydrophilic
- Non-hydrophilic
- Symporter
- Anti-porter



Cells and their Components

- Plasma membrane



Cells and their Components

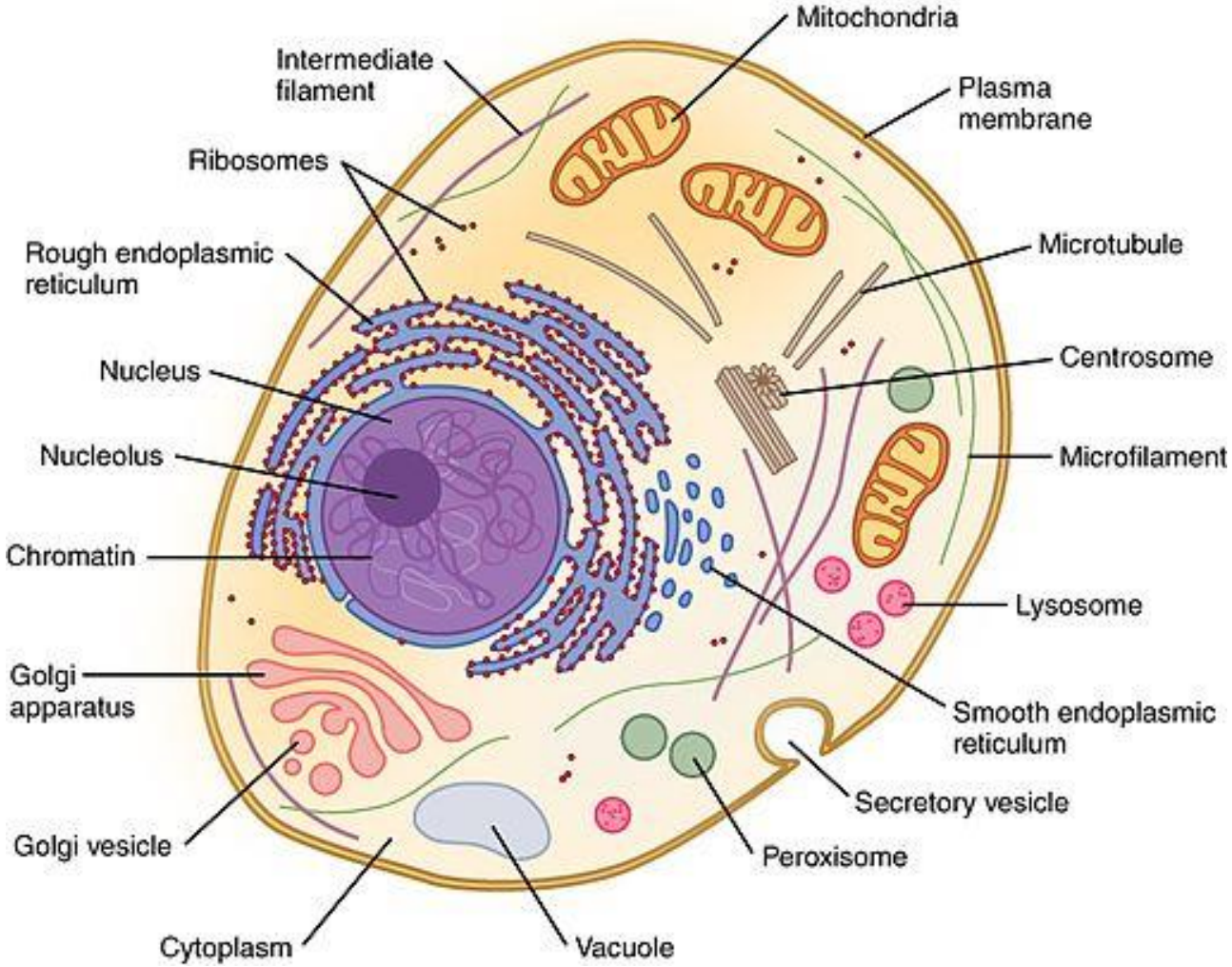
- Plasma membrane – Purpose

- **Physical protective barrier between living components and the outside environment**
- **Regulates membrane transport (molecule uptake or secretion) and hence controls internal environment**
- **Use of ion gradients across membrane in excitation, communication and transport**
- **Holds receptors for cell-cell recognition and detecting/responding to stimuli cytoskeleton and ECM**
- **Endo-membrane (“inside”) system forms compartments and stable binding /catalysis sites for enzyme processes**
- **Dynamic movement involving vesicles**

Cells and their Components

- **Membranous Structures**
- Nucleus
- Mitochondria
- Smooth Endoplasmic reticulum
- Rough Endoplasmic reticulum
- Golgi Apparatus
- Lysosome
- Peroxisomes

- **Non-membranous**
- Cillia
- Flagella
- Cytosol
- Centrosome
- Ribosomes



Cells and their Components

- Cytoskeleton
- Actin microfilaments
- Tubulin microtubules
- Intermediate filaments

Tissues – 4 Types

Tissues – 4 Types

- Epithelial
- Connective
- Muscle
- Nervous

Tissues – Epithelia

Tissues – Epithelia – Simple vs Stratified

- Simple squamous –
- Simple cuboidal -
- Simple columnar -
- Stratified squamous –
- Stratified cuboidal –
- Stratified columnar –

Tissues – Epithelia

- Simple squamous - Heart lining, blood vessels, lymphatics, alveoli, kidney glomerulus
- Simple cuboidal - Ovary, pigmented layer of retina, kidney tubules
- Simple columnar - GI tract lining, gall bladder, glandular ducts, fallopian tubes
- Stratified squamous - Skin (keratinised), mouth/oesophagus (non-keratinised), urinary tract (**transitional**)
- Stratified cuboidal - Ducts of sweat glands, oesophageal glands - RARE
- Stratified columnar - Urethra lining, large gland ducts

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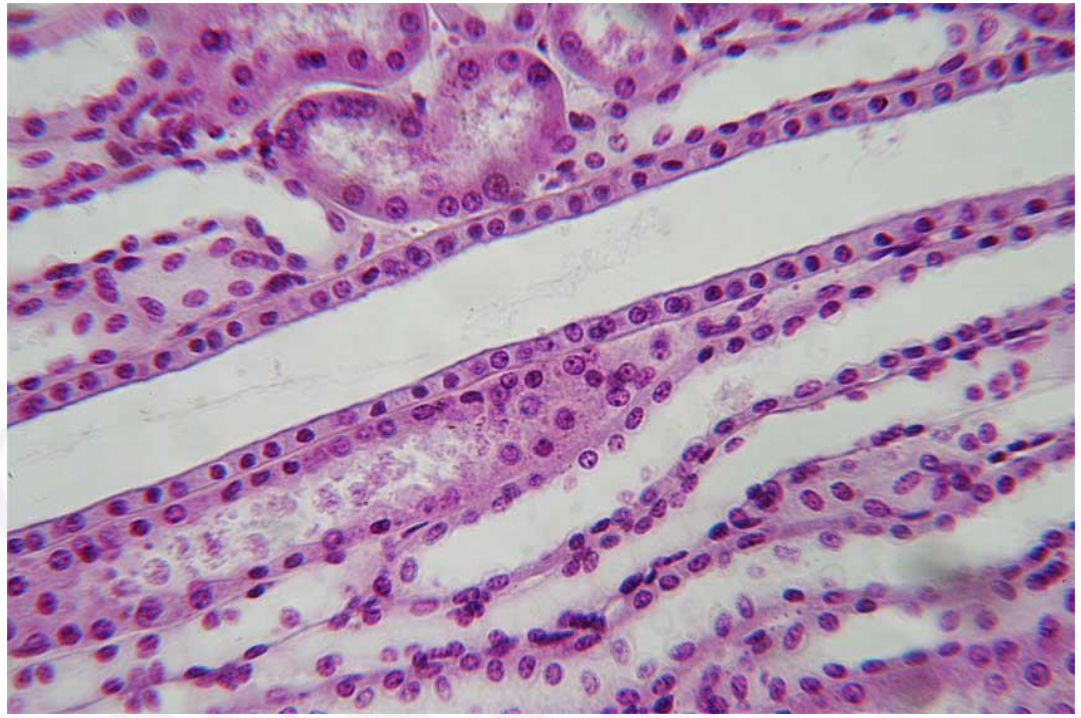
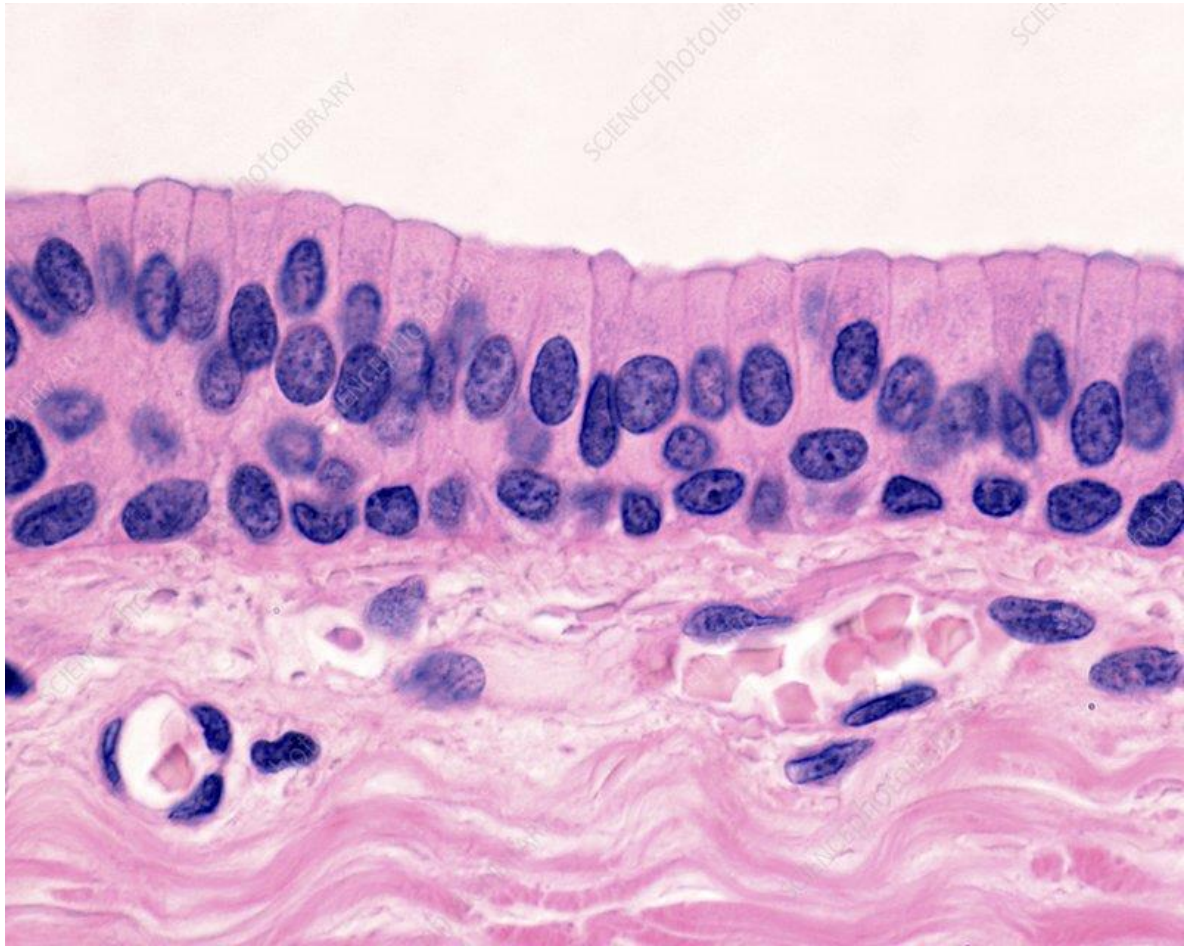
- Pseudostratified epithelium

Tissues – Epithelia





Tissues – Epithelia Function

- simple squamous epithelium…
- All stratified epithelia…
- All cuboidal and columnar epithelia permit secretion – bigger cells have more space to synthesise - and absorption (except stratified columnar; it does not carry out absorption)

Tissues – Epithelia Function

- simple squamous epithelium allows filtration, diffusion, osmosis and secretion but little protection due to its thin nature.

- All stratified epithelia afford protection due to their regenerative capacity and multiple layers.

- All cuboidal and columnar epithelia permit secretion – bigger cells have more space to synthesise - and absorption (except stratified columnar; it does not carry out absorption)

Tissues – Glands

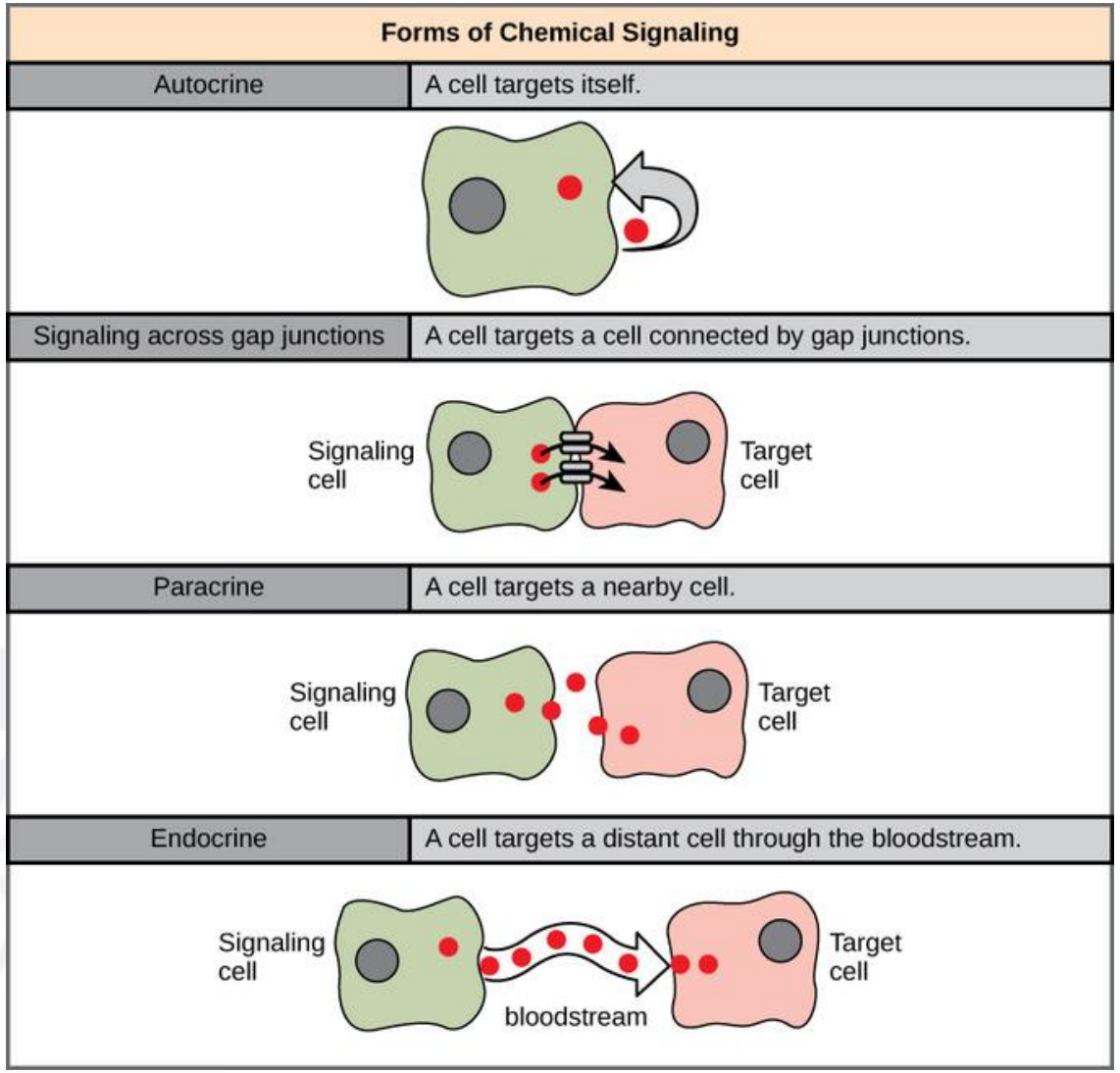
- Glands
- Endocrine glands
- Exocrine glands
- Merocrine:
- Apocrine:
- Holocrine:

Tissues – Glands

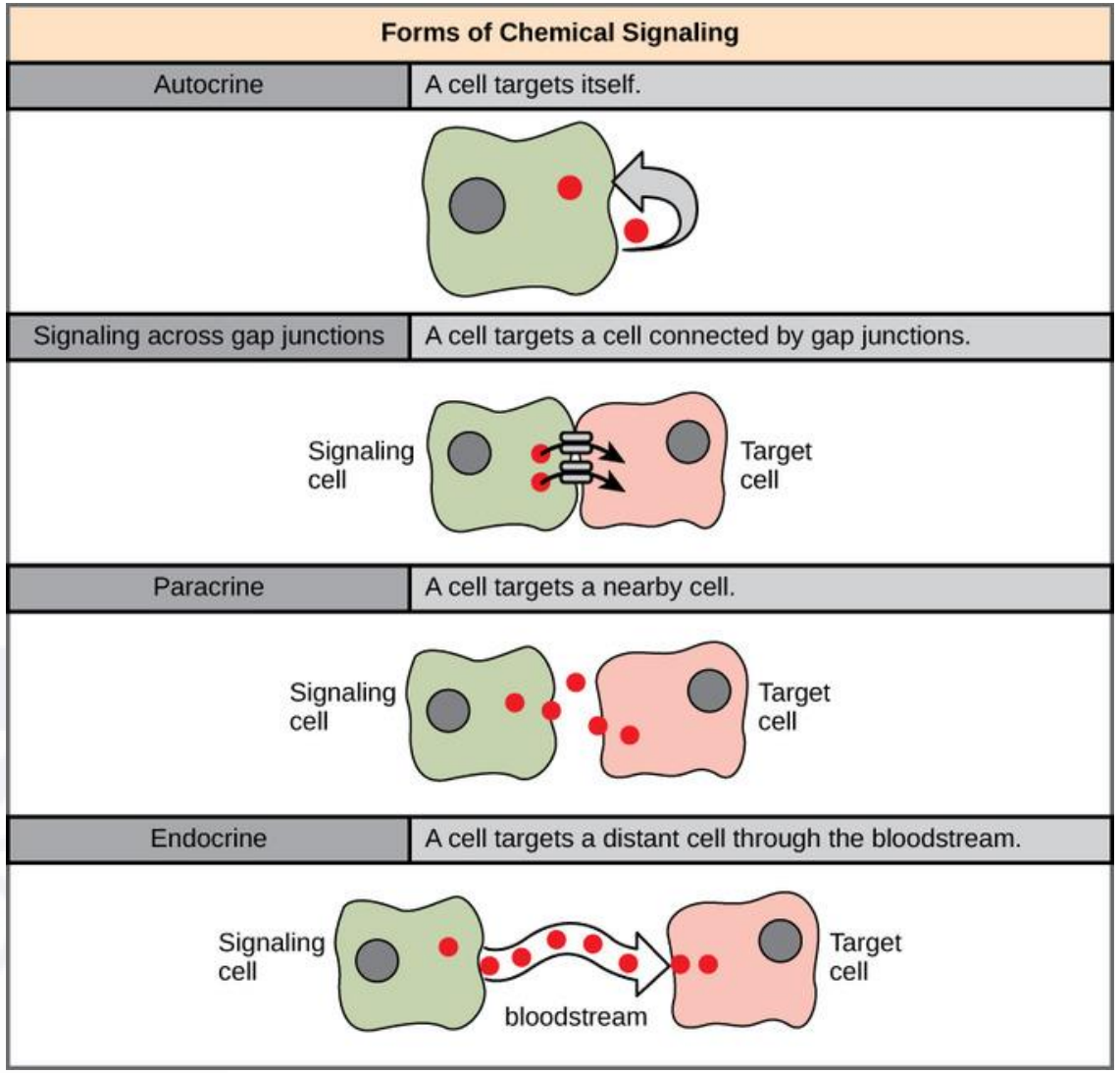
- Glands are epithelia that secrete and store products such as hormones. Goblet cells are unicellular glands.
- Endocrine glands are ductless so hormones are released directly into extracellular fluid or blood to travel to target organs.
- Exocrine glands secrete products through a duct onto epithelium. There are three types:
- Merocrine: secretory product released from glandular cell in exocytosis
- Apocrine: vesicle containing products is secreted from glandular cell
- Holocrine: glandular cell dies and becomes secretory product

Tissues – Glands

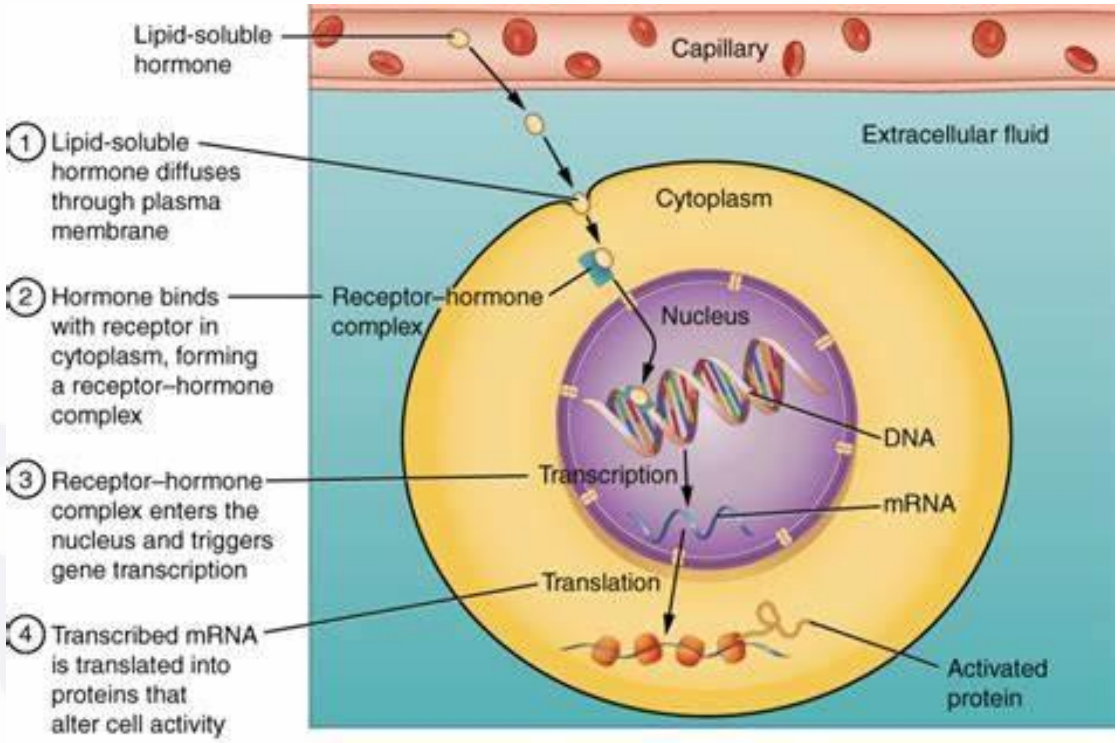
Other Forms of Cell Communication

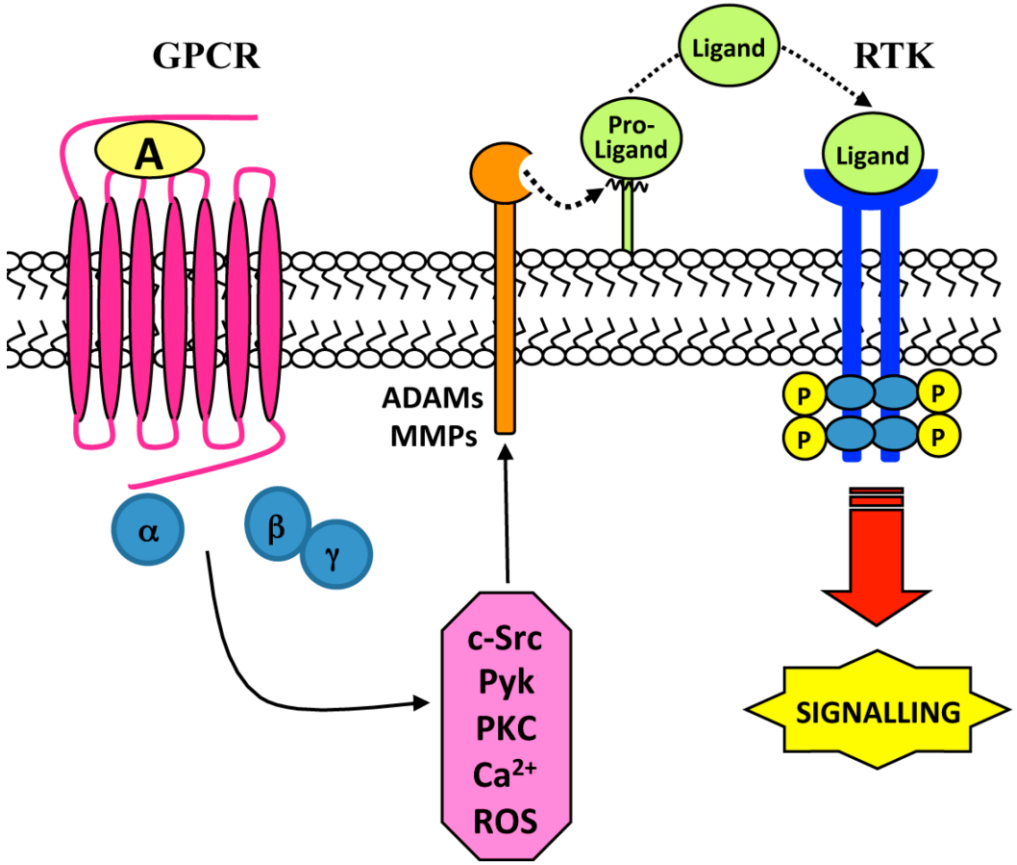


What is a hormone?



Two types of cell activation via hormones





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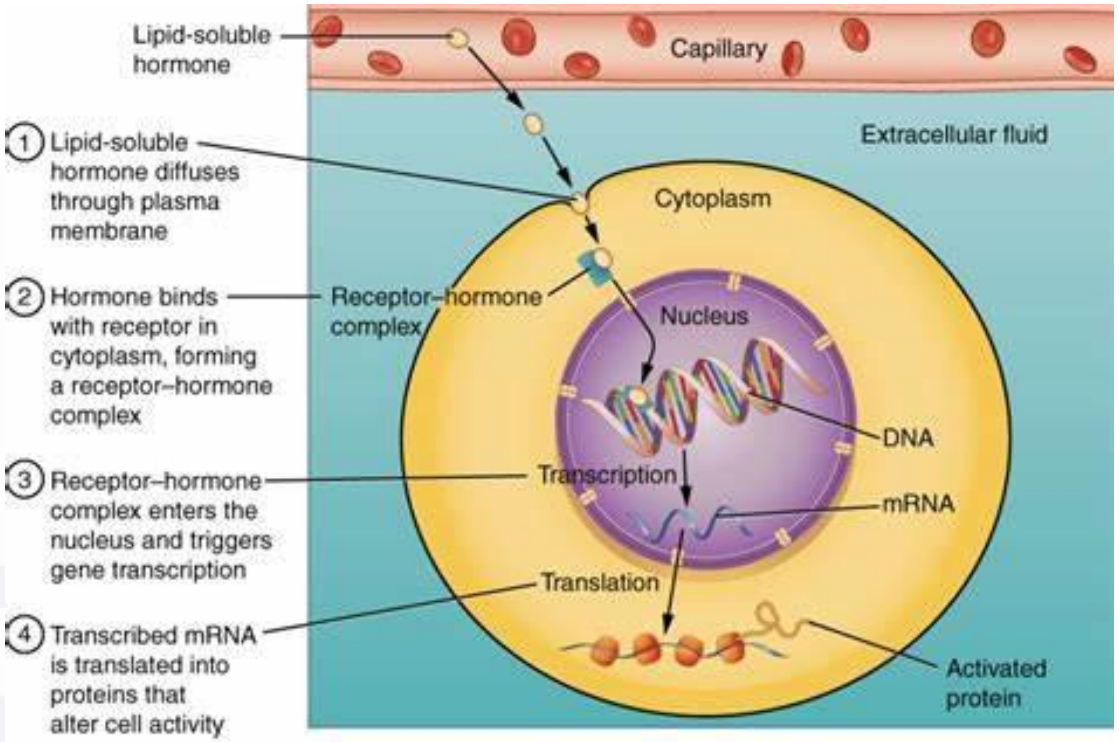
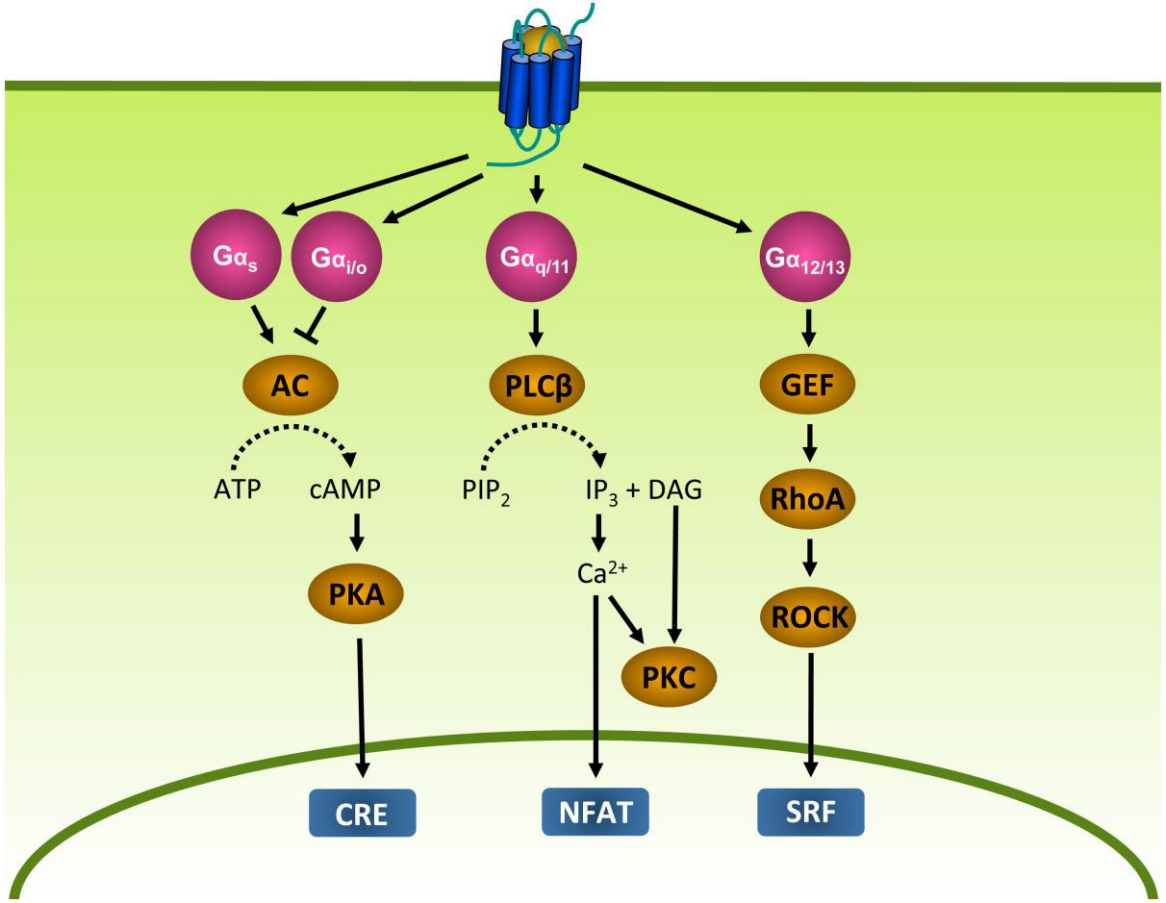
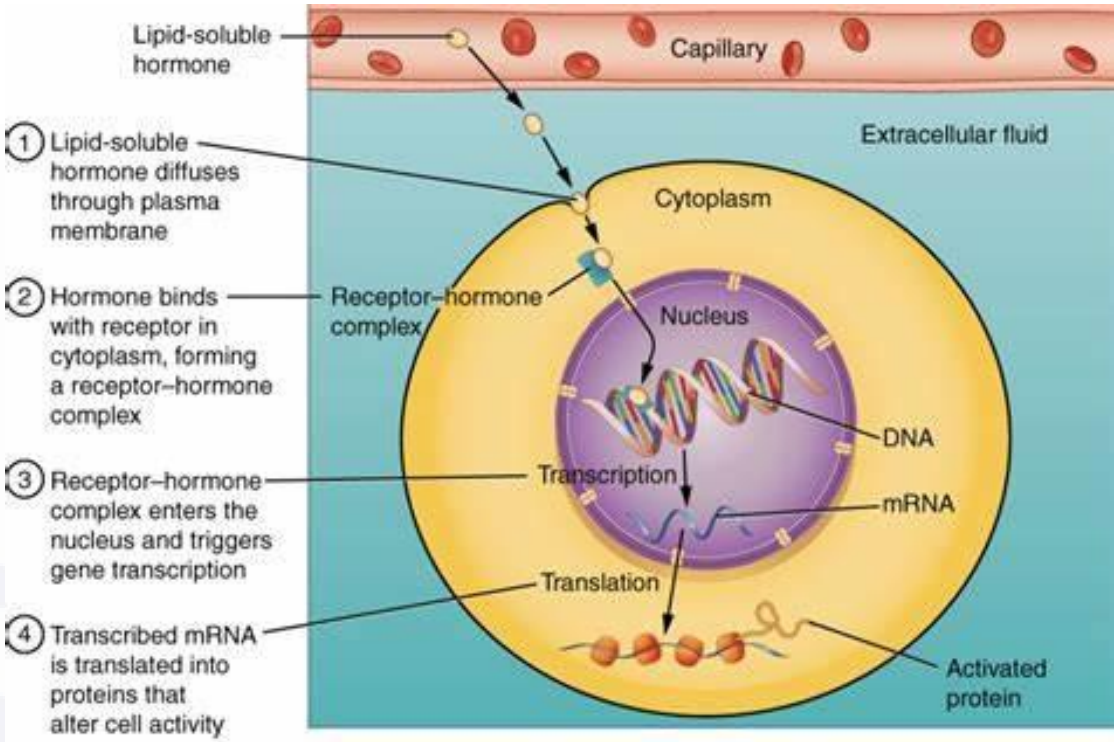
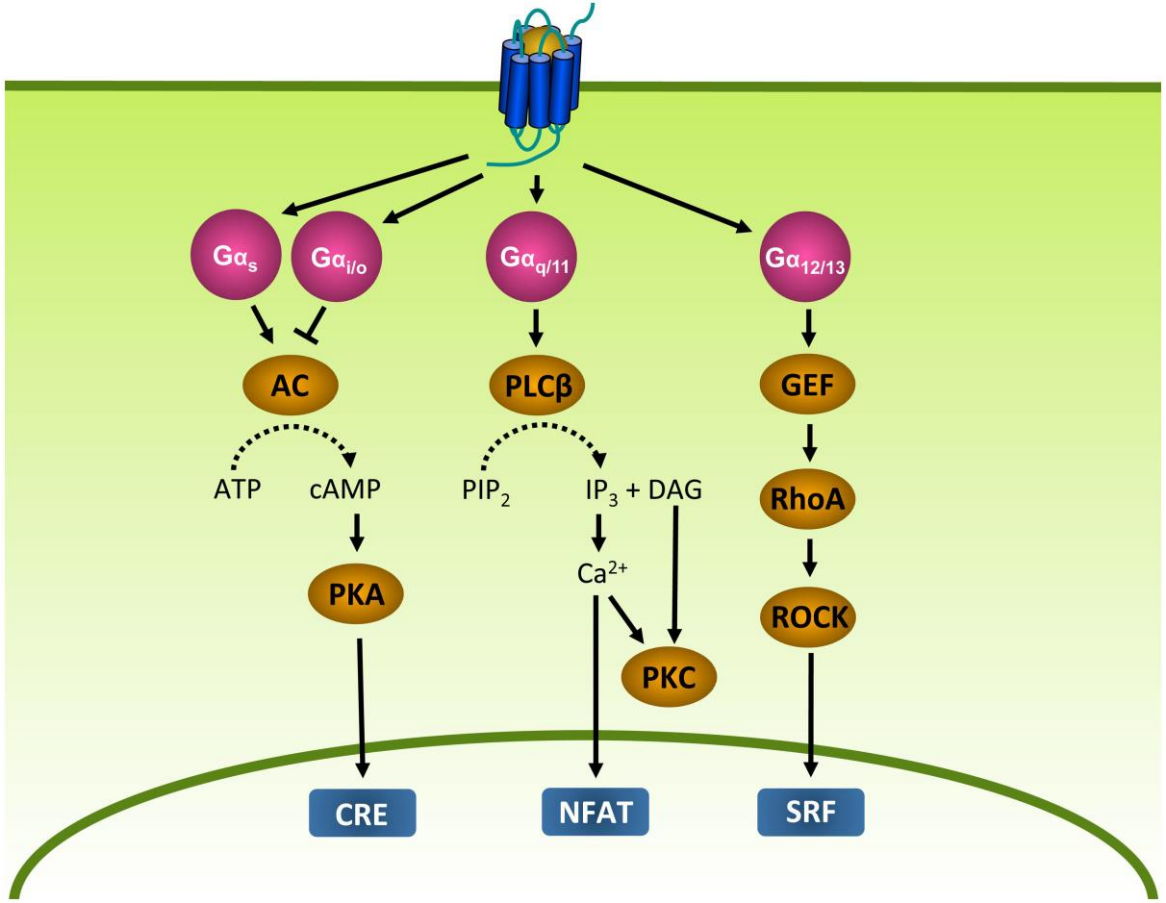




When a signalling molecule binds to a membrane and alters it, what is that called?

Two types of cell activation via hormones

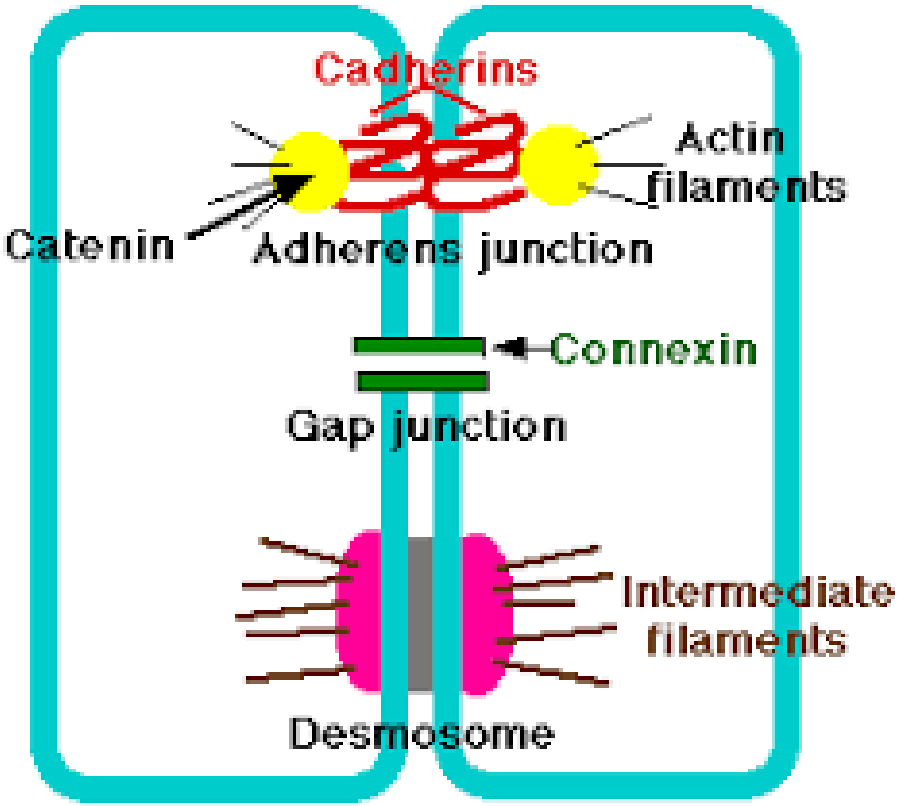




What are the key points of protein signalling:

- **A lipid insoluble molecule binds to a cell surface receptor causing a confirmational change**
- **Through the release of a secondary messenger there is an enzyme cascade/amplification and activtity**

Epithelial cells – Cell Junctions



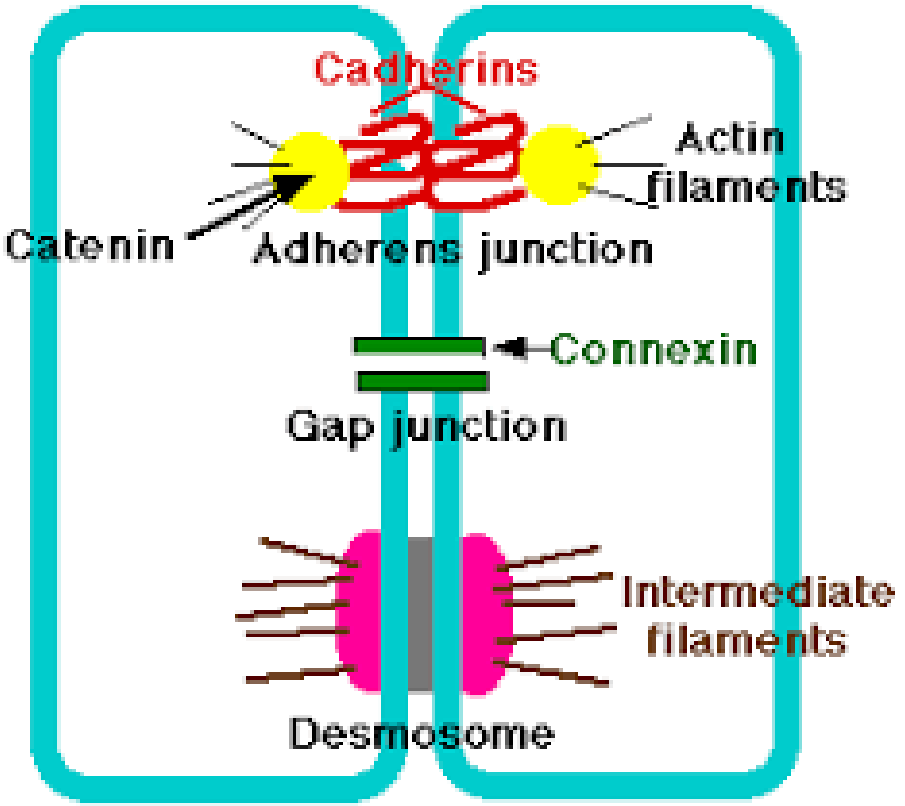
Epithelial cells function together as a tissue, so are tightly associated via intercellular junctions.

Junction type Structure Function
Tight – Made of Occludins (interconnecting membrane protein links)
Interlocking protein links fuse membranes to give small intercellular space that limits permeability between cells

Gap – Made of Connexins (protein tubes) : Protein channels through plasma two membranes or intercellular space allow transport between cells

Desmosome- Made of Cadherins (cell adhesion molecules) - Cadherins bind to the basal lamina of cells at adhering junctions, giving stability to the tissue.

Epithelial cells – Cell Junctions



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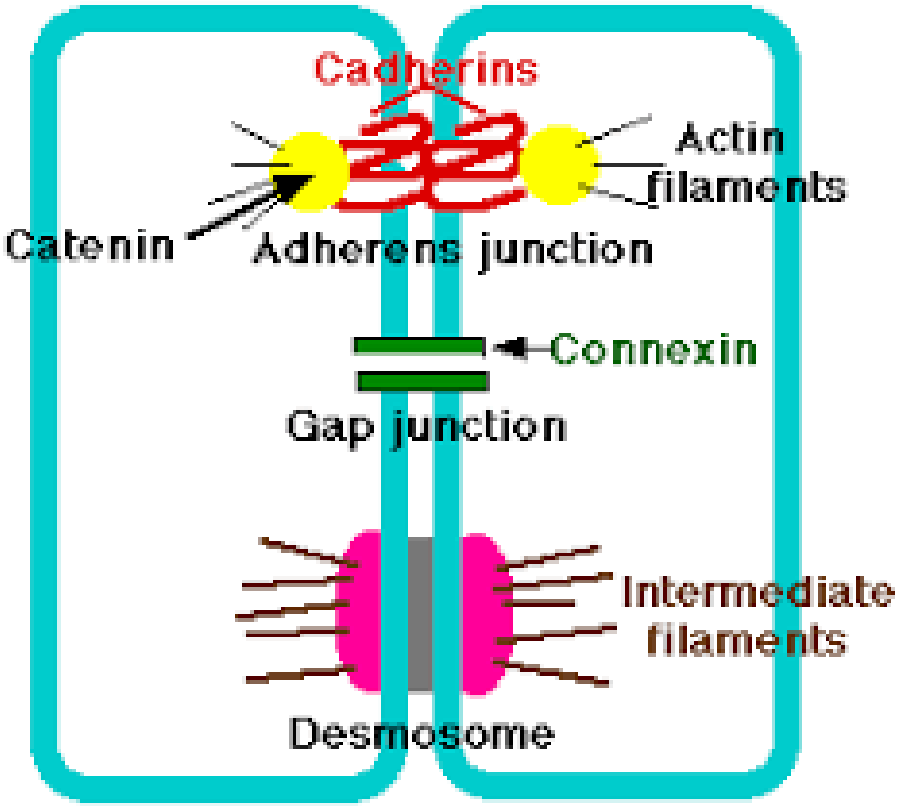

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These are all Communicating Cells Junctions, So what is missing?

Tissues – Connective Tissue

Loose (alveolar) connective tissue:

Adipose tissue- Alveolar tissue matrix containing adipocytes. Adipocytes contain large fat globules.

- White adipose tissue- about 20-25% BMI in healthy adults and is a thermal insulator and energy store.
- Brown adipose tissue- found in newborn, highly vascularised and vastly reduced as you develop.

Reticular tissue- found in lymph nodes and organs of the lymphatic system. Matrix consists of reticular fibres. Cells-present are reticular cells and white blood cells

Tissues – Connective Tissue

Dense connective tissue-

Fibrous vs Elastic

Hyaline cartilage-

Fibrocartilage-

Elastic fibrocartilage-

Osteocytes-

Osteoblast-

Osteoclast-

Compact bone-

Spongy/cancellous bone-

Tendons-

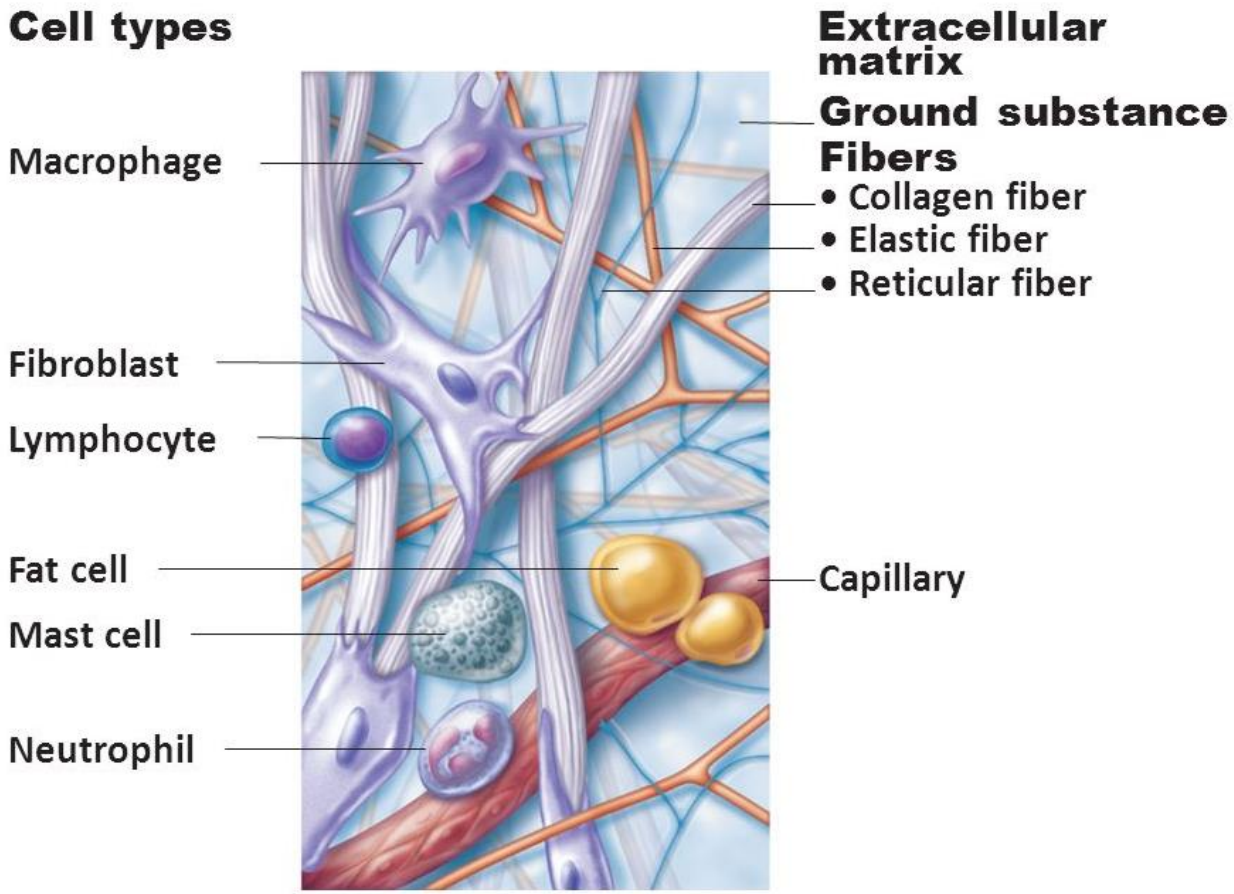
Ligaments-

Tissues – Extracellular Matrix

The ECM consists of a framework of extracellular fibres (collagen, elastic fibres and reticular fibres) with ground substance (proteoglycan molecules) filling in the gaps between the framework and any other structures present (cells, nerves, blood vessels and fluid). The connective tissue is therefore a complex mesh with a range of properties depending on the proportion of different components:

- Collagens give tensile strength to the network
- Elastic fibres give elasticity
- Reticular fibres are thinner and branching
- Proteoglycans are highly hydrated molecules allowing compressive strength, as water can be pushed out of the tissue under weight
- Integrins are proteins that signal between the ECM and metabolic systems, allowing it to react to its environment e.g. wound healing. Cartilage thickening with exercise is an example of an ECM adaptive response to mechanical stress.

Tissues – Extracellular Matrix

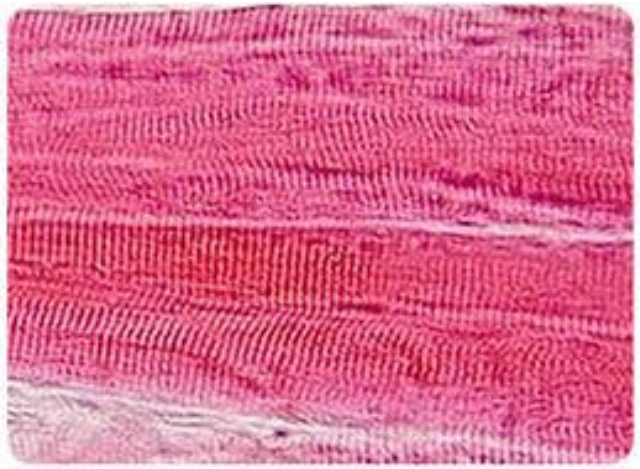


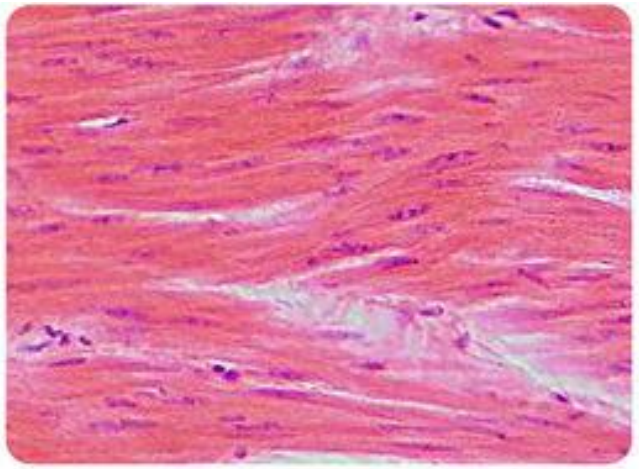
Tissues – Muscle Cells

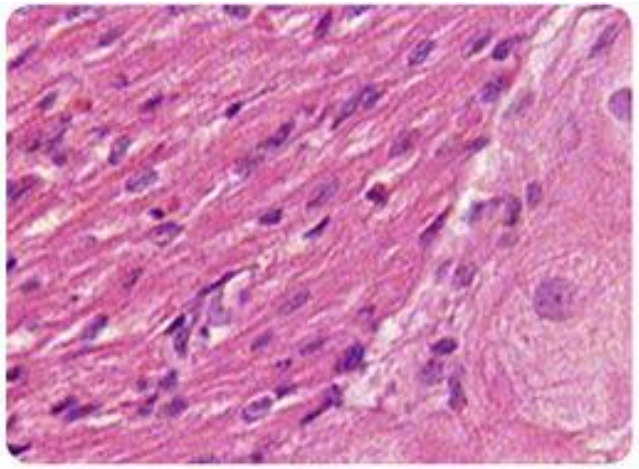
Skeletal

Smooth

Cardiac







Striated

Multinucleated/Mononucleated

Volutary/Involuntary control

Myogenic

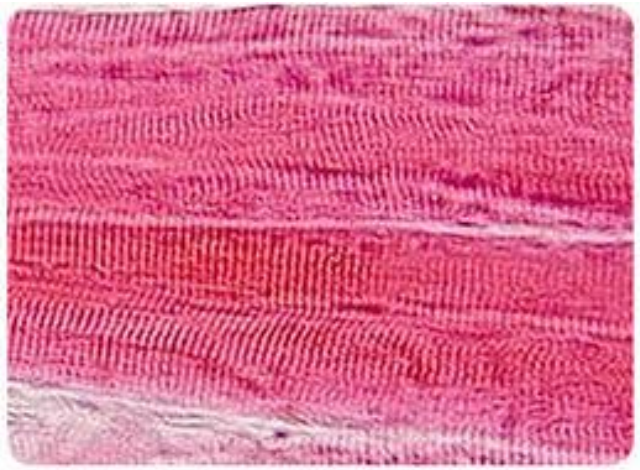
Tissues – Muscle Cells

Skeletal

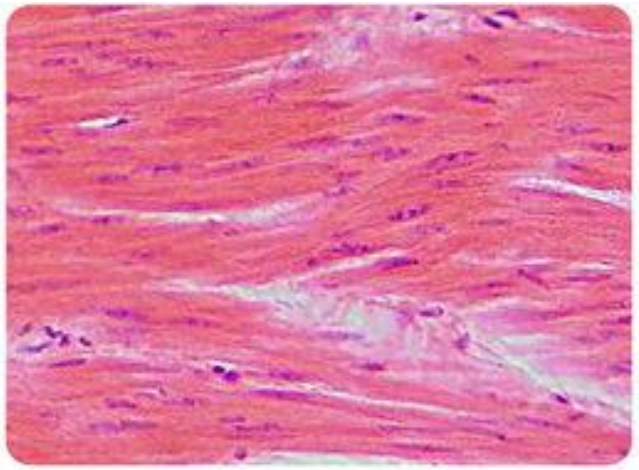
Smooth

Cardiac

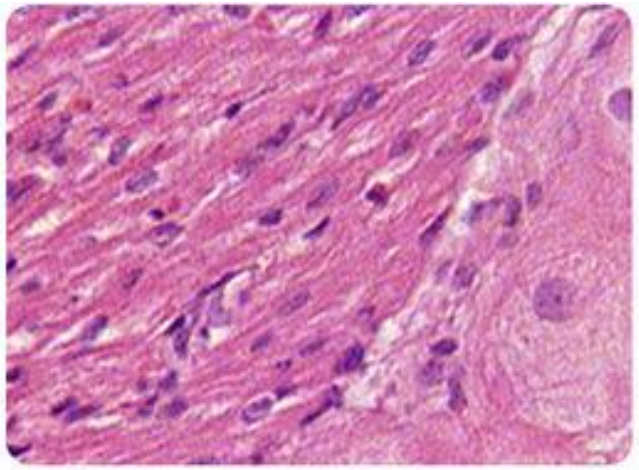
Striated



Skeletal muscle



Smooth muscle



Cardiac muscle

Multinucleated/Mononucleated

Volutary/Involuntary control

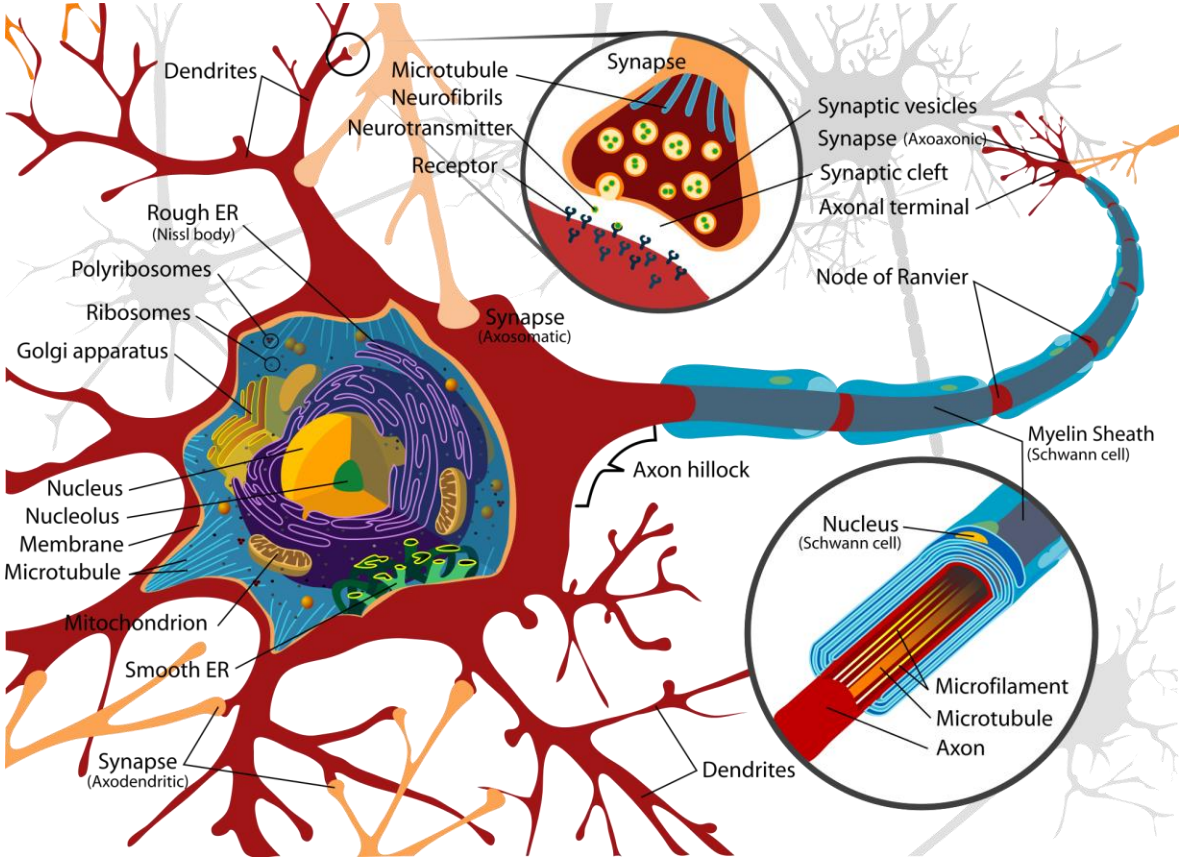
Myogenic

Tissues – Nerve Cells

Schwann cell vs oligodendrocyte

Node of Ranvier – What is it and why?

Neuron vs glia



Breathing, Circulation and Blood

- What is Respiration?
- Anatomy
- Physiology
- How do we control breathing?
- Gas exchange
- How is oxygen carried in the blood
- How does blood pick up oxygen
- How does it deposit oxygen?

Breathing, Circulation and Blood

- What is Respiration?

External Respiration

Internal Respiration

Breathing, Circulation and Blood

- Why is Respiration?

The primary function of the respiratory system is to obtain oxygen for use by body's cells & eliminate carbon dioxide that cells produce. It includes respiratory airways leading into the lungs and the lungs themselves

Breathing, Circulation and Blood

- Anatomy and Physiology

Pathway of air: nasal cavities (or oral cavity) > pharynx > trachea > primary bronchi (right & left) > secondary bronchi > tertiary bronchi > bronchioles > alveoli (site of gas exchange

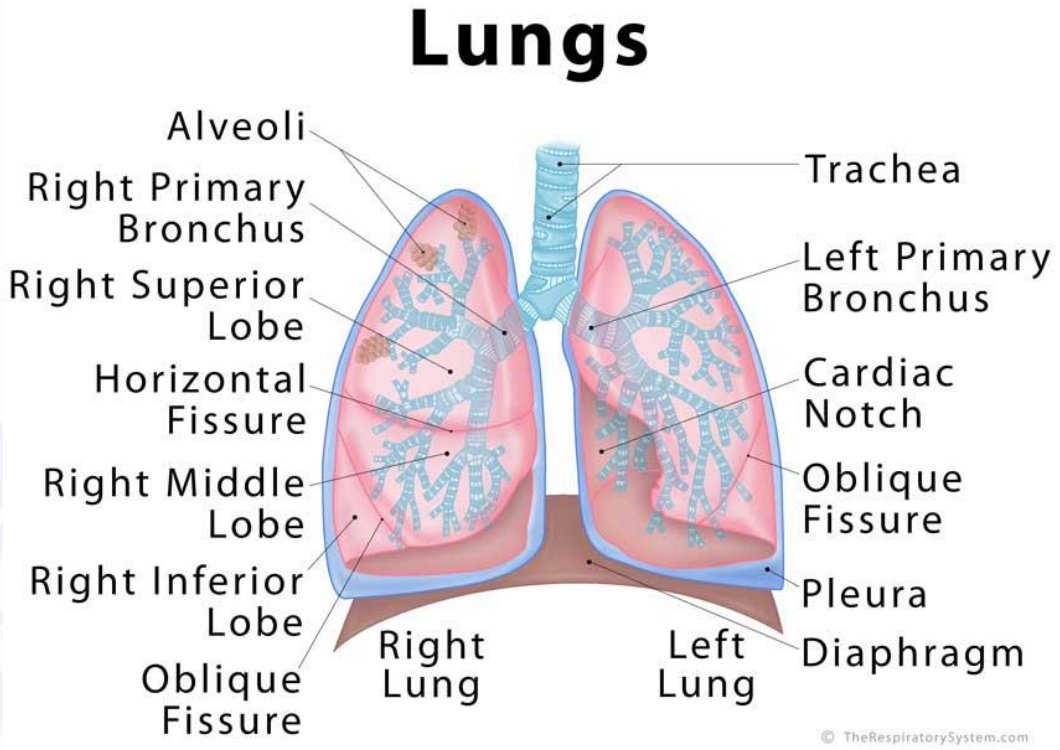
Breathing, Circulation and Blood

- Anatomy – Fill in the blanks

Pathway of air: nasal cavities (or oral cavity) > > > primary bronchi (right & left) > > > bronchioles > (site of gas exchange)

Breathing, Circulation and Blood

- Why do we need to alveoli?



Breathing, Circulation and Blood

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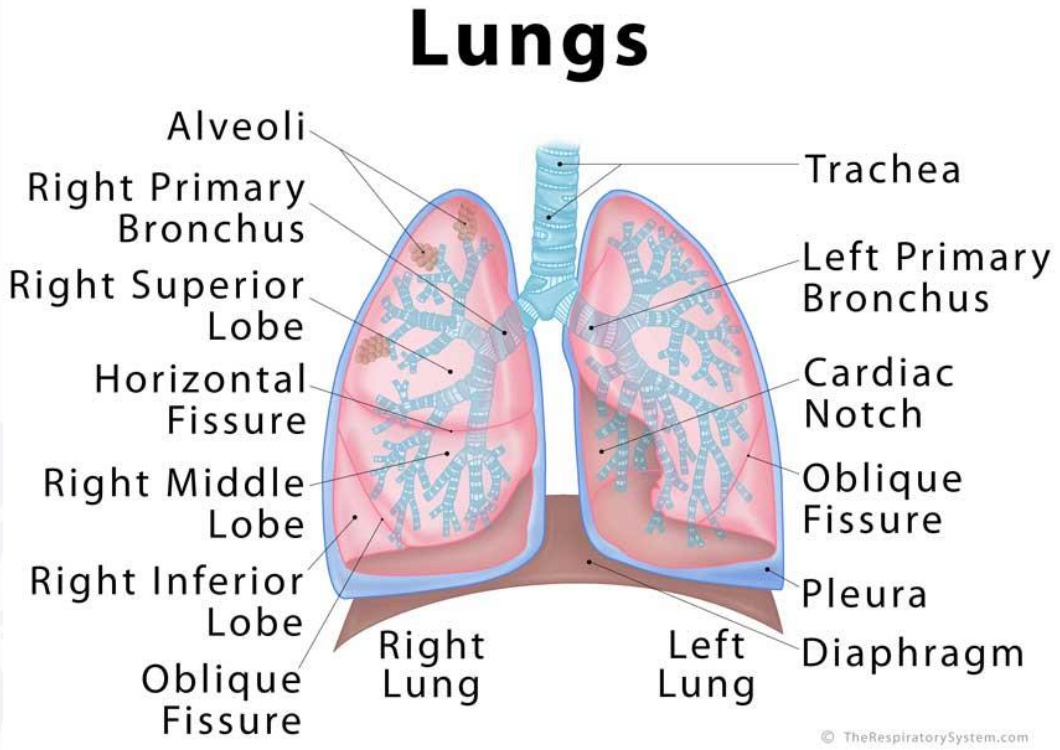
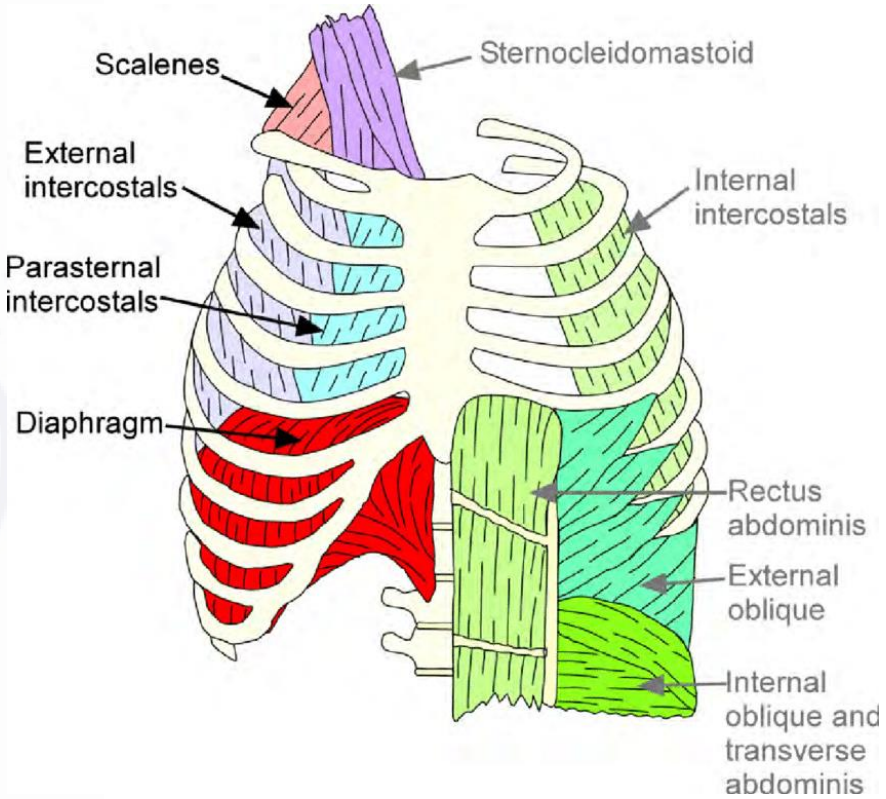


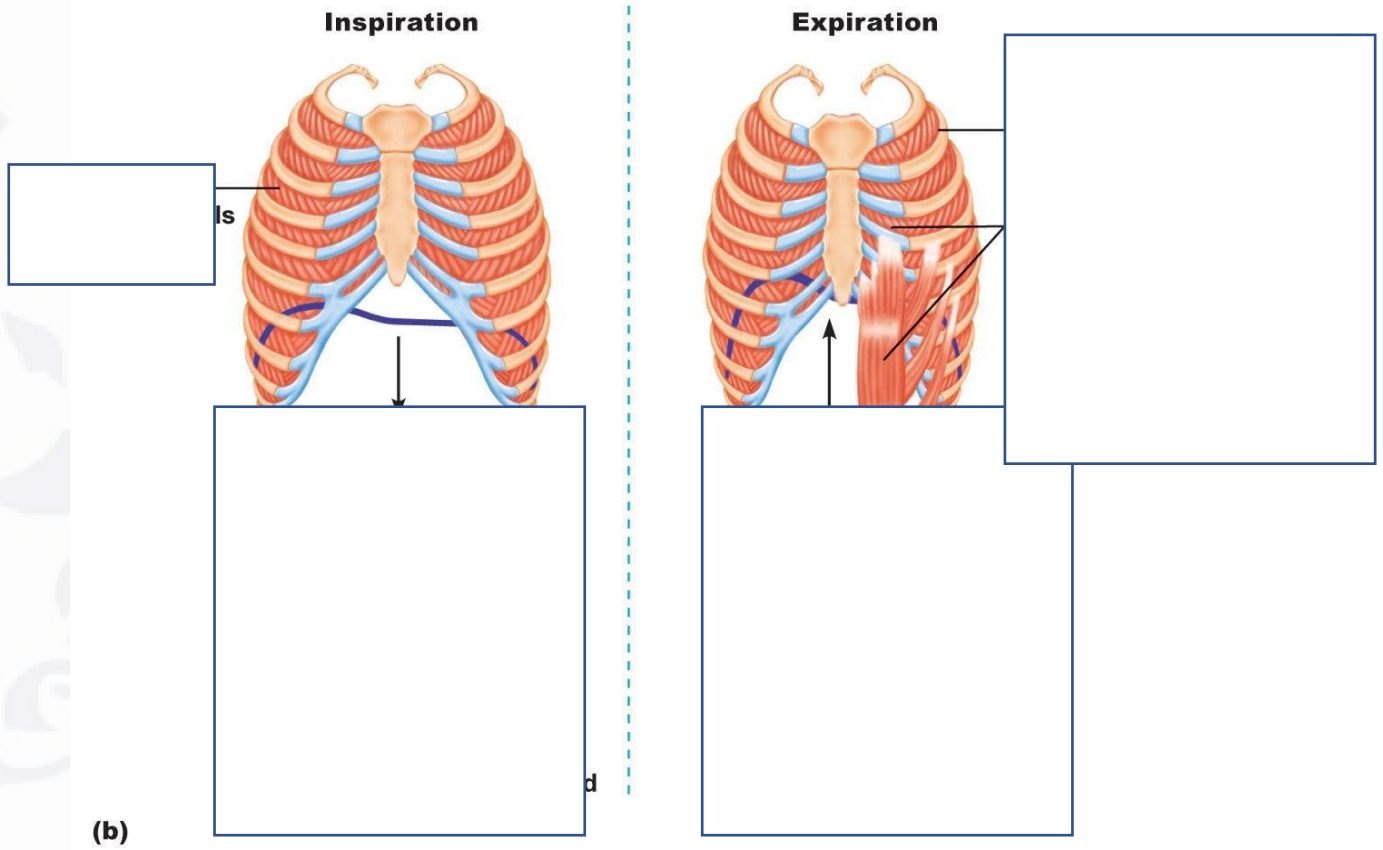
Breathing, Circulation and Blood

- Anatomy – Chest wall - Which of these are important for the mechanism of breathing?



Breathing, Circulation and Blood

- Mechanism of breathing



Breathing, Circulation and Blood

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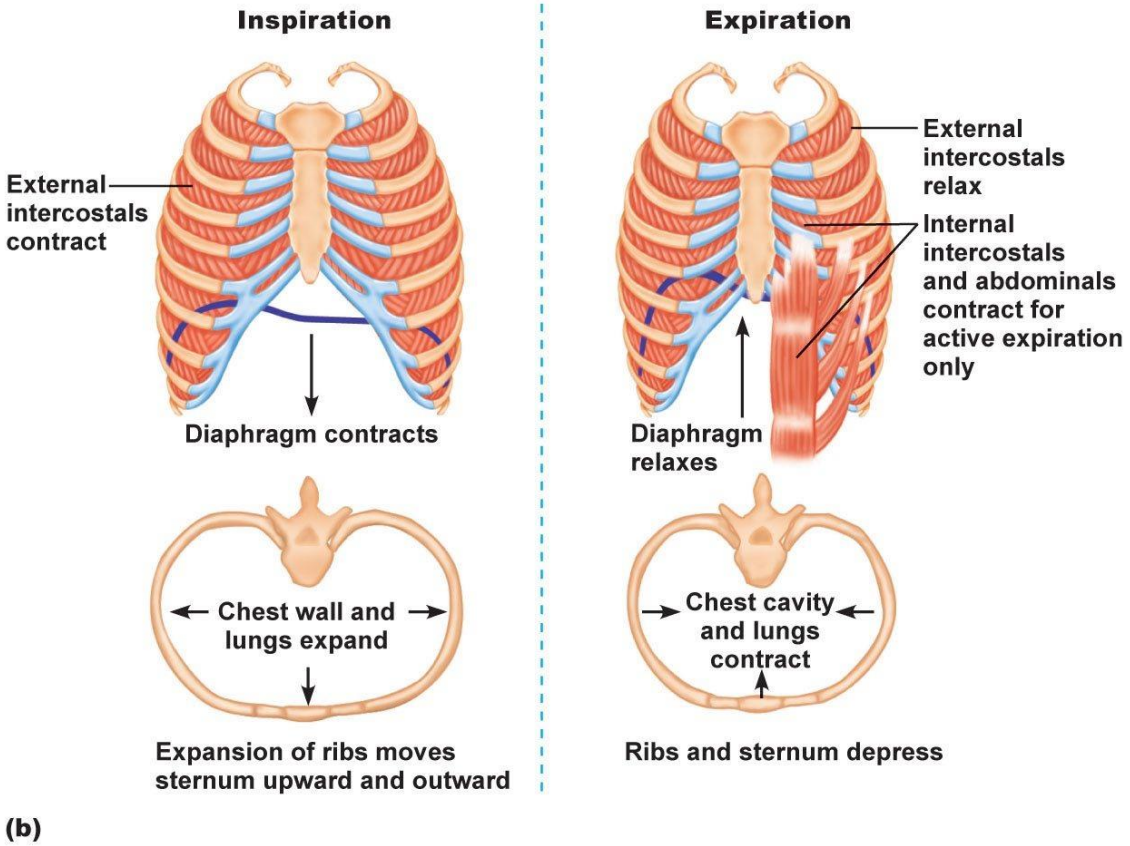
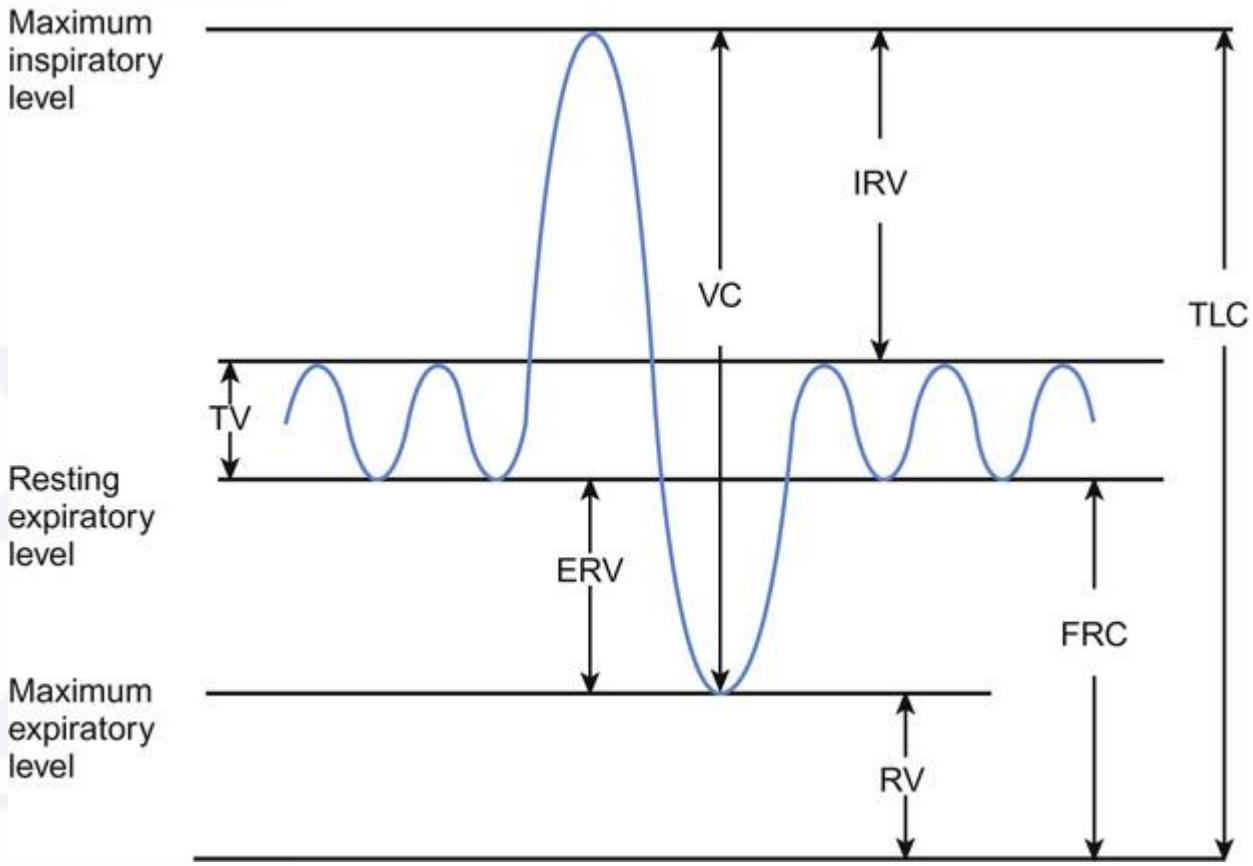


Breathing, Circulation and Blood

- A funny diagram – what is this diagram called and for?



Breathing, Circulation and Blood

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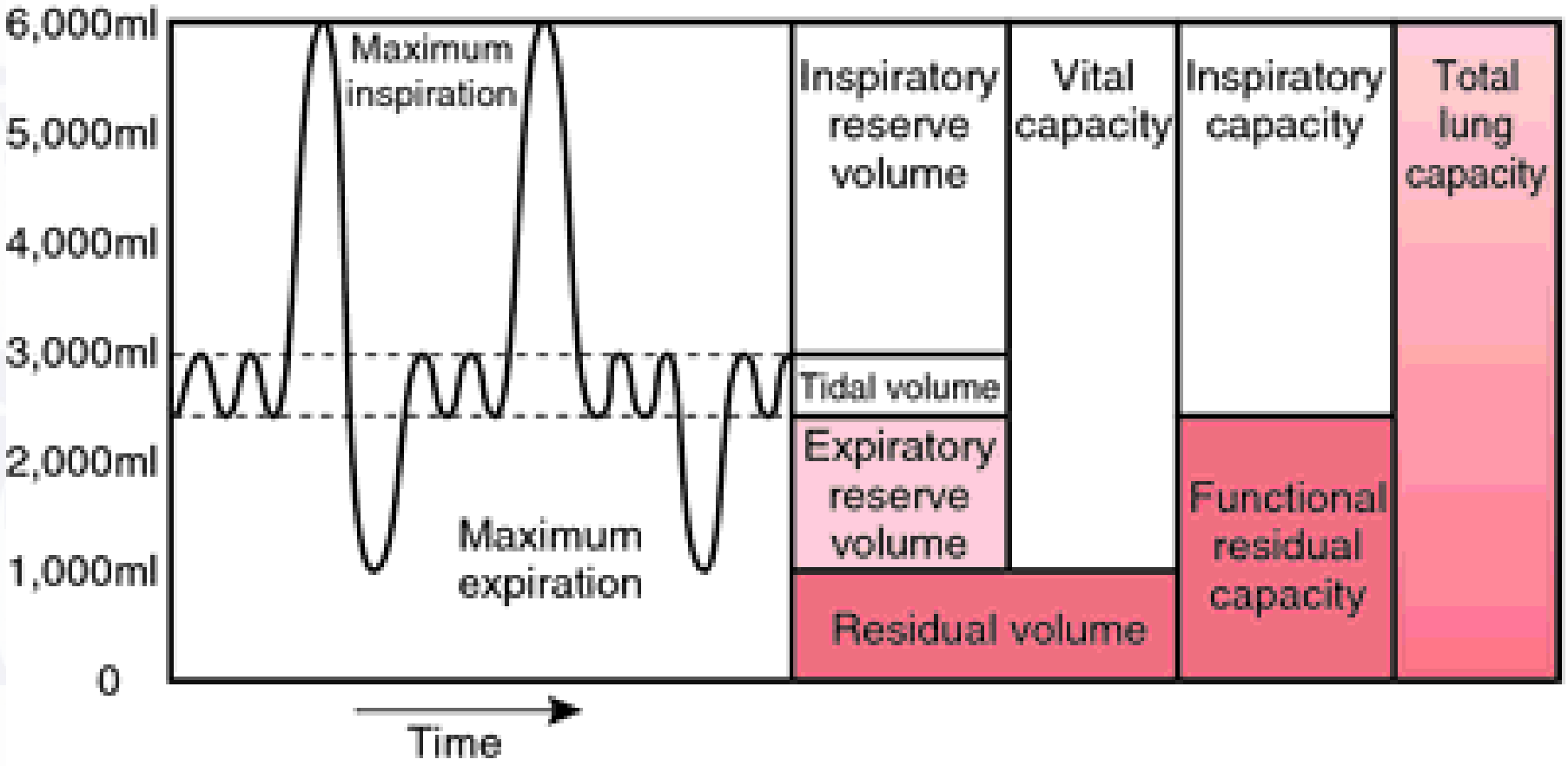

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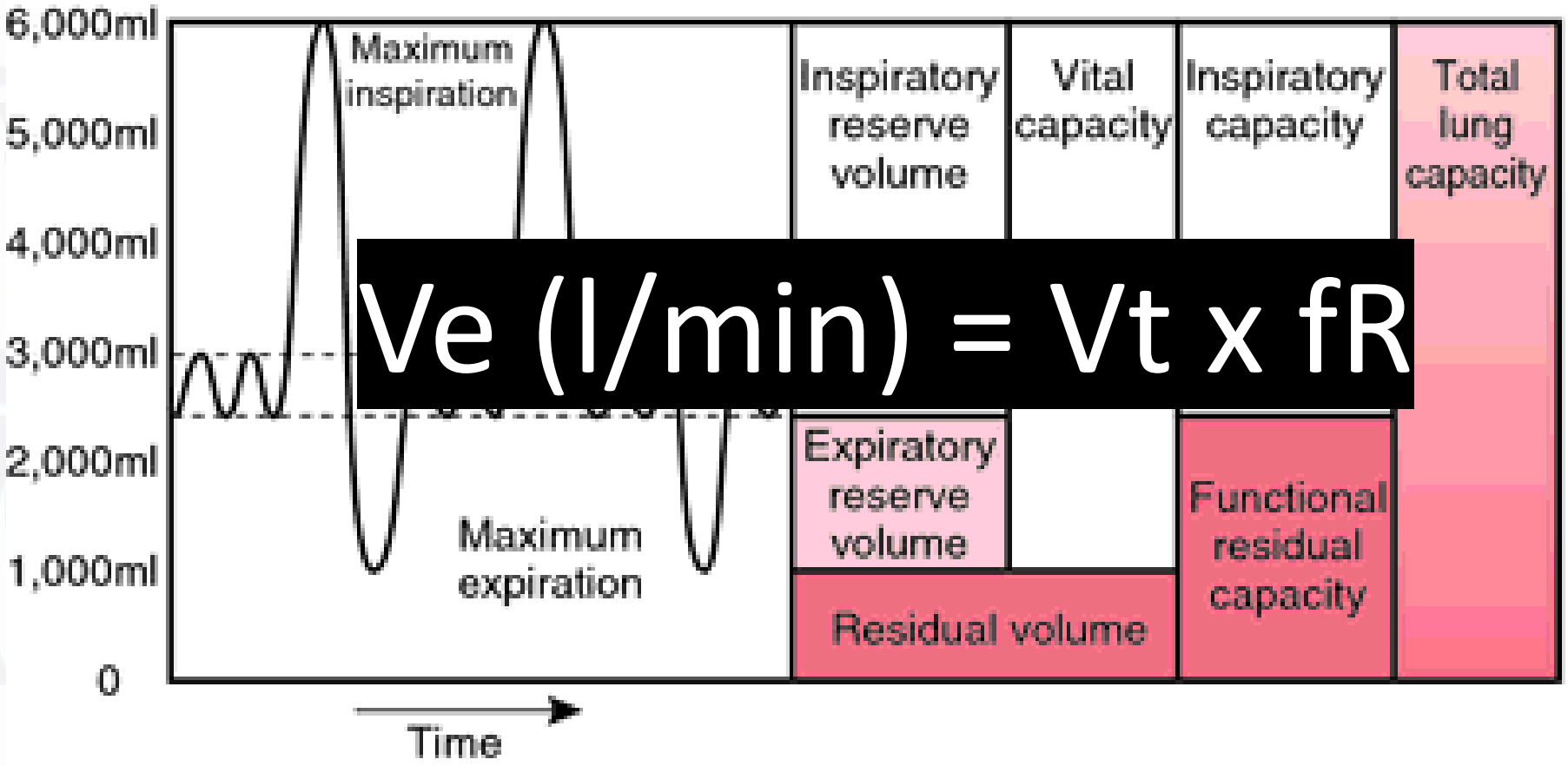
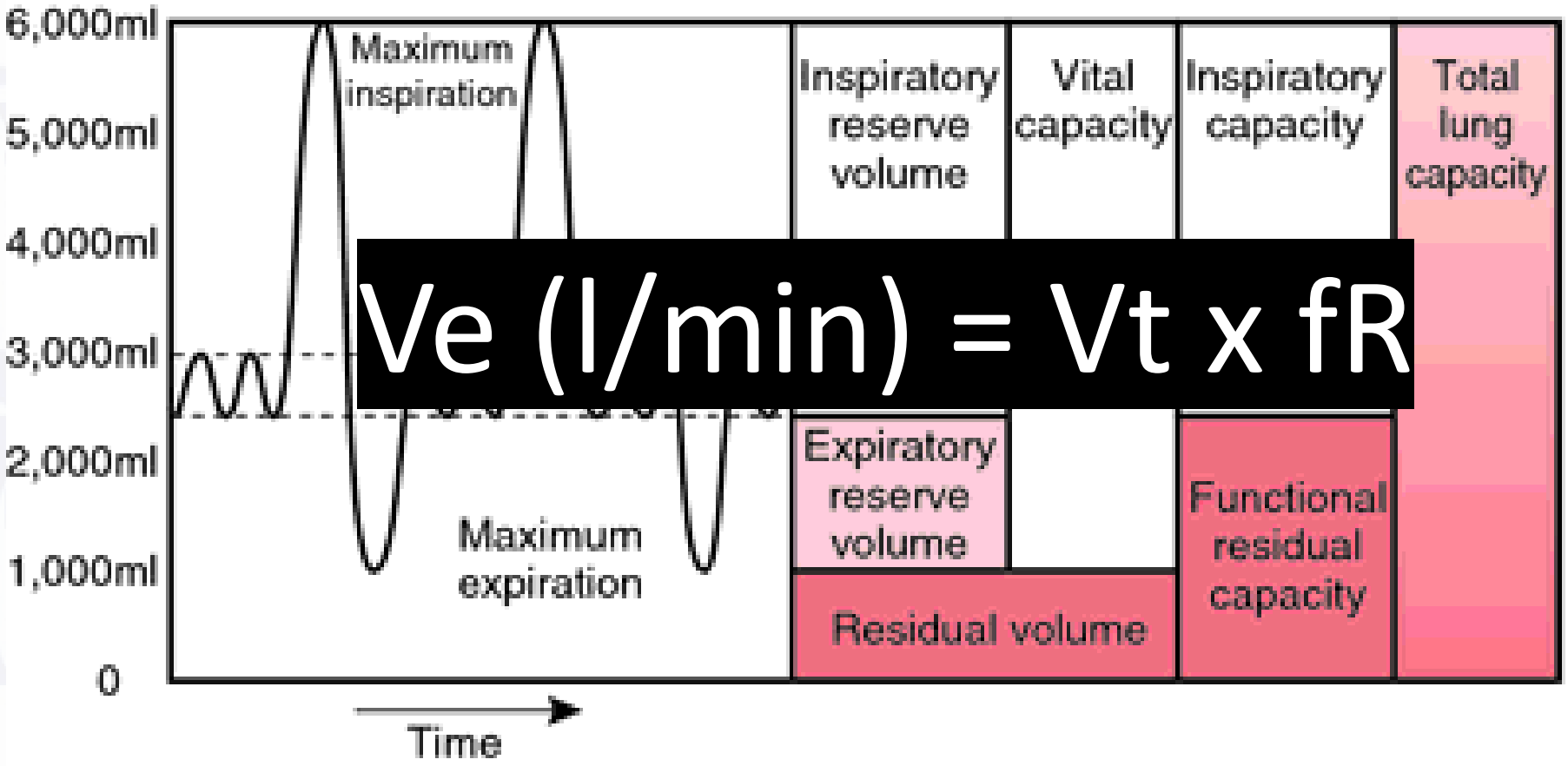


Breathing, Circulation and Blood



$$Ve\ (l/min) = Vt \times fR$$

Breathing, Circulation and Blood

- How do we control breathing?

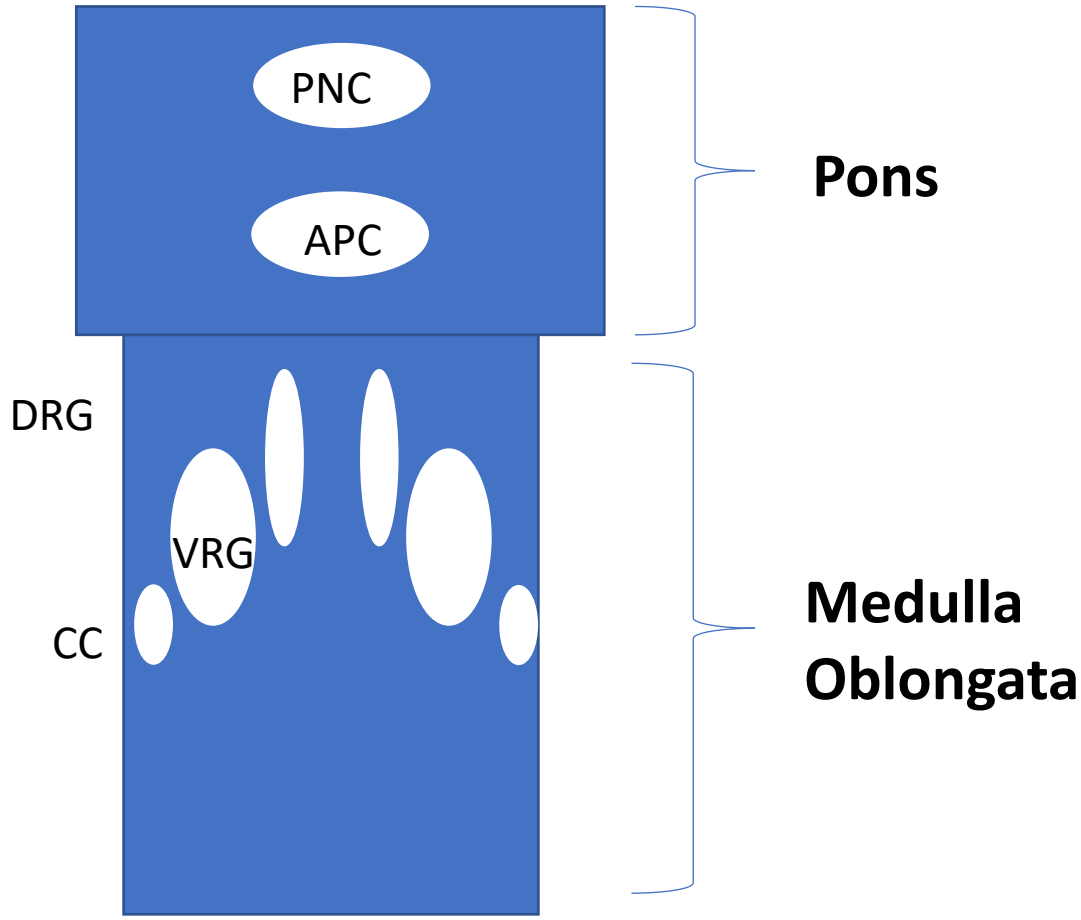
Central Regulation

Chemoreceptors

Lung Receptors

Breathing, Circulation and Blood

- How do we control breathing? Central Regulation



Breathing, Circulation and Blood

- How do we control breathing? Central Regulation

DRG – Dorsal Respiratory Groups Composed mainly of inspiratory neurones located in the floor of the 4th ventricle. It controls the generation of basic rhythms by triggering inspiratory muscles such as the diaphragm and the external intercostals.

VRG – Ventral Respiratory Groups Contain inspiratory and expiratory neurones, located in the ventrolateral side of the medulla – primarily active during exercise and stress (actions requiring forced expiration).

Pontine (pneumotaxic) Respiratory Groups Contain neurones active in both inspiratory and expiratory phases. Pneumotaxic centre (PNC) involved in inhibiting inspiratory neurones from the medulla, therefore sectioning of the upper pons results in slow, gasping breaths. Has synaptic connections between all respiratory neurons, as well as to higher (cortical) brain centres and respiratory muscles.

APC - Apneustic centre
Stimulates the inspiratory neurons of the DRG and VRG. Its function only identified by cutting connection to medullary centres

Breathing, Circulation and Blood

- How do we control breathing? Lung Receptors

Rapidly Adapting (irritant) receptors

Slowing Adapting (Stretch) receptors

C fibres

Breathing, Circulation and Blood

- How do we control breathing? Lung Receptors

Rapidly Adapting (irritant) receptors

Slowing Adapting (Stretch) receptors

C fibres

Breathing, Circulation and Blood

- How do we control breathing? Lung Receptors

Rapidly Adapting (irritant) receptors

sub epithelial mechanoreceptors in the trachea and bronchi stimulated by inhaled irritants or mechanical factors, such as smoke, dust and chemicals such as histamine. They cause coughing, mucus production and bronchoconstriction. Their afferent fibres are myelinated

Slowing Adapting (Stretch) receptors

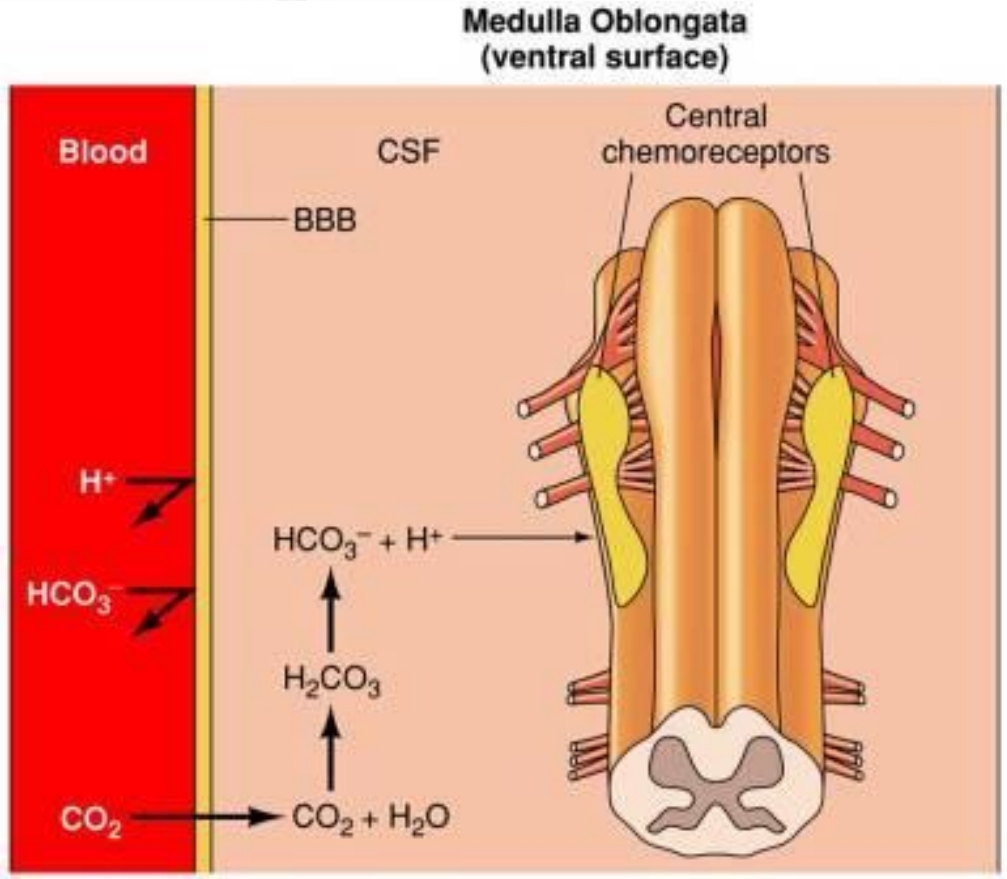
These are mechanoreceptors located close to airway smooth muscle, which are stimulated by stretching of airway walls during inspiration. This help prevent over-inflation by initiating expiratory rhythms. This has an important role in the Hering-Bruer reflex (prolonged inspiration causes prolonged expiration). Afferent fibres are also myelinated

C fibres

These are unmyelinated nerve endings stimulated by oedema and various inflammatory mediators such as histamine and bradykinin. They cause rapid, shallow breathing and dyspnoea

Breathing, Circulation and Blood

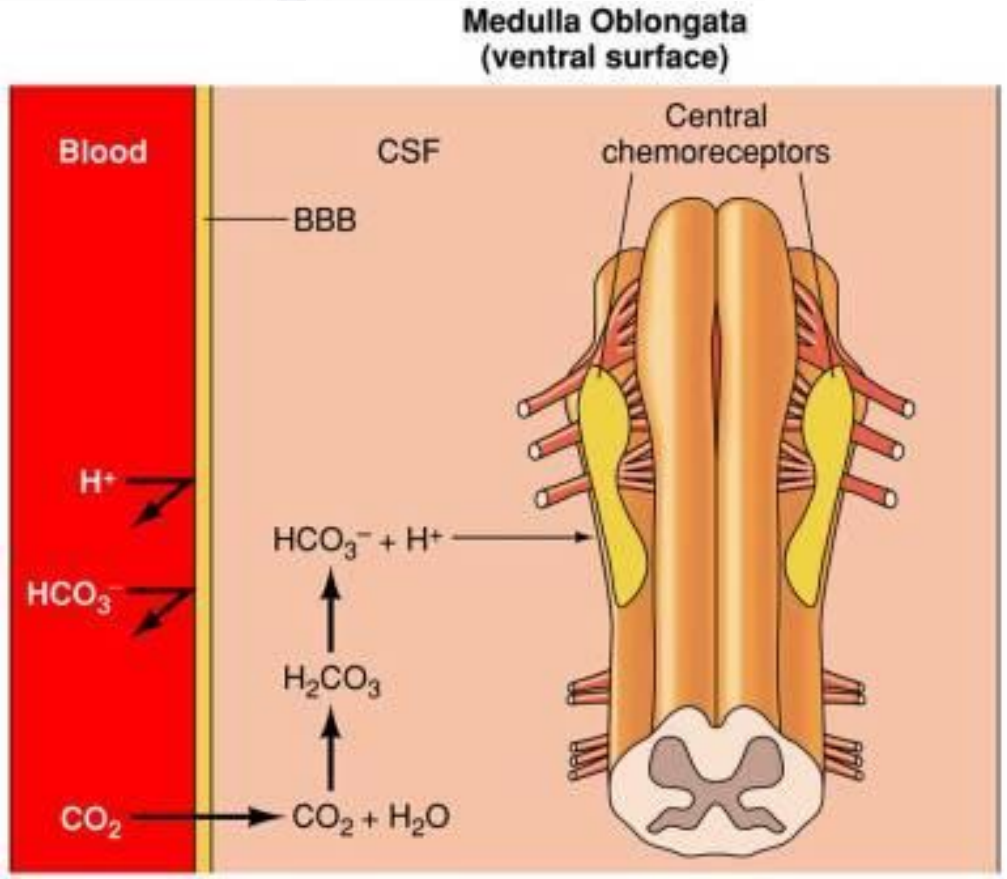
- How do we control breathing? Chemoreceptors



Why does CO2 reach the chemreceptor, and not H+ or HCO3- ?

Breathing, Circulation and Blood

- How do we control breathing? Chemoreceptors



Peripheral Chemoreceptors: Major receptors are located in the carotid sinus (IX - glossopharyngeal nerve) and the aortic arch (X - vagus nerve).

Breathing, Circulation and Blood

- What would happen to ventilation?
- Hypoxia
- Hypercapnia
- Hypocapnia
- Hyperoxia

Breathing, Circulation and Blood

- What would happen to ventilation?
- Hypoxia – Little change until pO2 has fallen about 8 kPa then a sharp increase
- Hypercapnia – Linear increase in minute ventilation
- Hypocapnia – Little change in ventilation
- Hyperoxia – Small decrease in ventilation

Breathing, Circulation and Blood

- What would happen to ventilation?
- Opiods
- Doxapram
- Beta agonist
- Benzodiazepams

Breathing, Circulation and Blood

- What would happen to ventilation?
- Opiods - Depress
- Doxapram – Stimulate
- Beta agonist - Stimulate
- Benzodiazepams - Depress

Breathing, Circulation and Blood

- Gas Exchange – How does it work?

Breathing, Circulation and Blood

- Gas Exchange – How does it work?

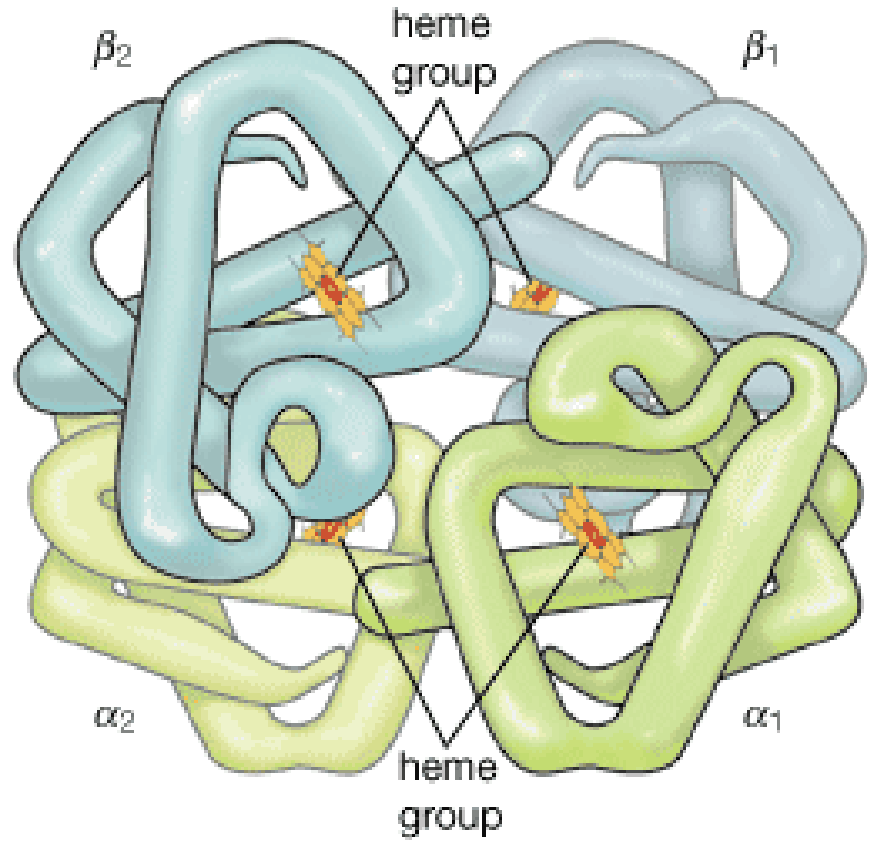
Differences in partial pressure across the alveolar membrane; inspired air has a higher PO_2 and lower PCO_2 than in the plasma

Gas exchange is so rapid that equilibrium is reached.

What about nitrogen?

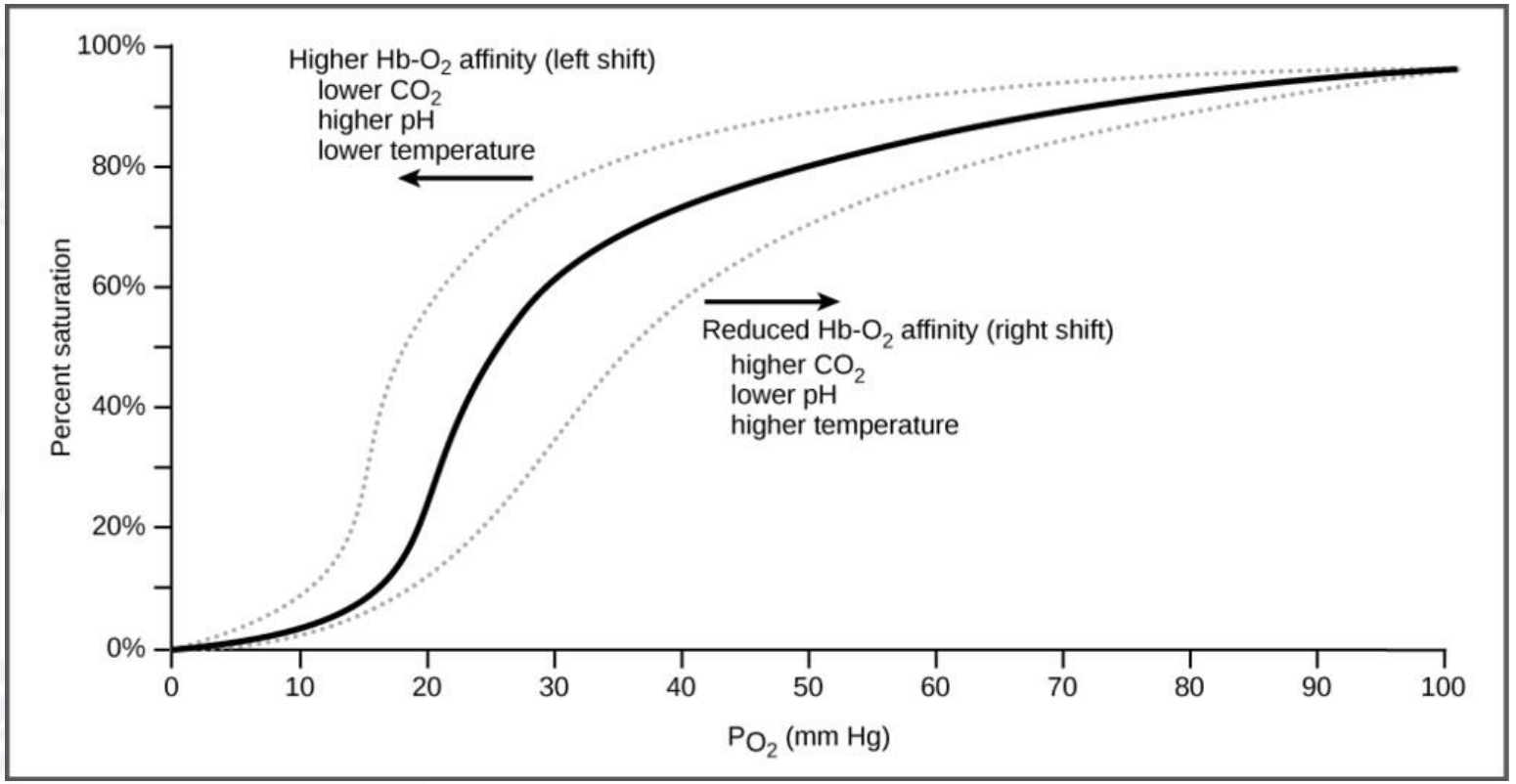
Breathing, Circulation and Blood

- How is oxygen carried in the blood?



Breathing, Circulation and Blood

- How is oxygen carried in the blood?

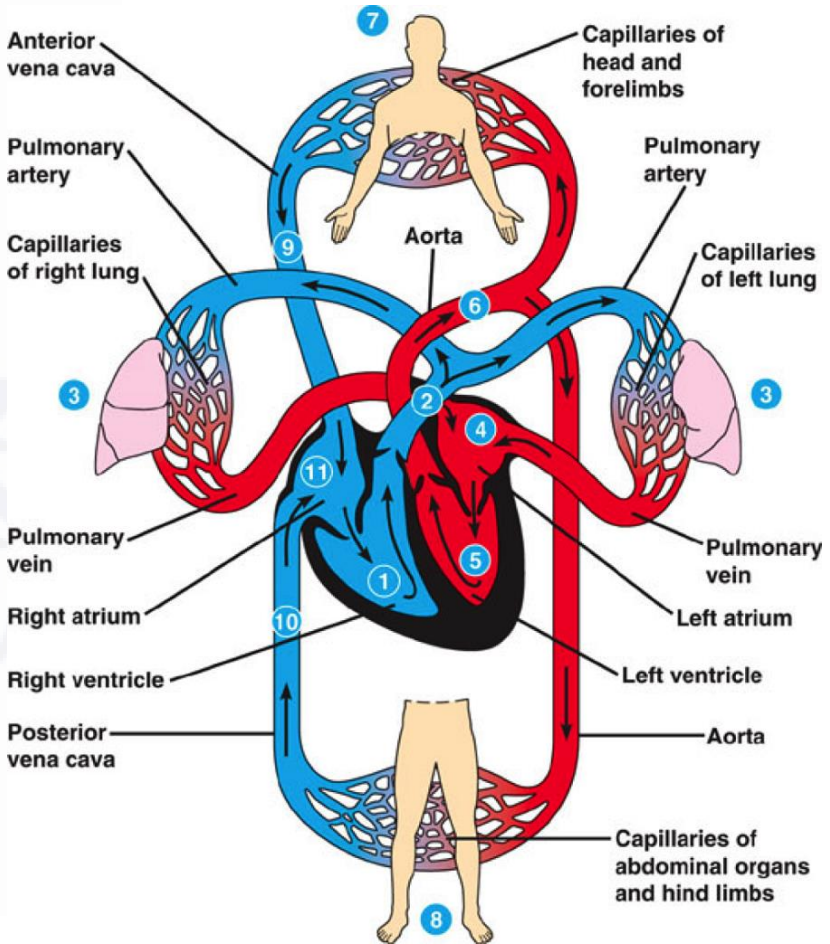


Breathing, Circulation and Blood

- The CV system and Circulation
- Vasculature
- Capillary exchange
- The Heart
- The Cardiac Cycle
- Influences on Cardiac Output
- CVS System and Oxygenation
- What can go wrong?

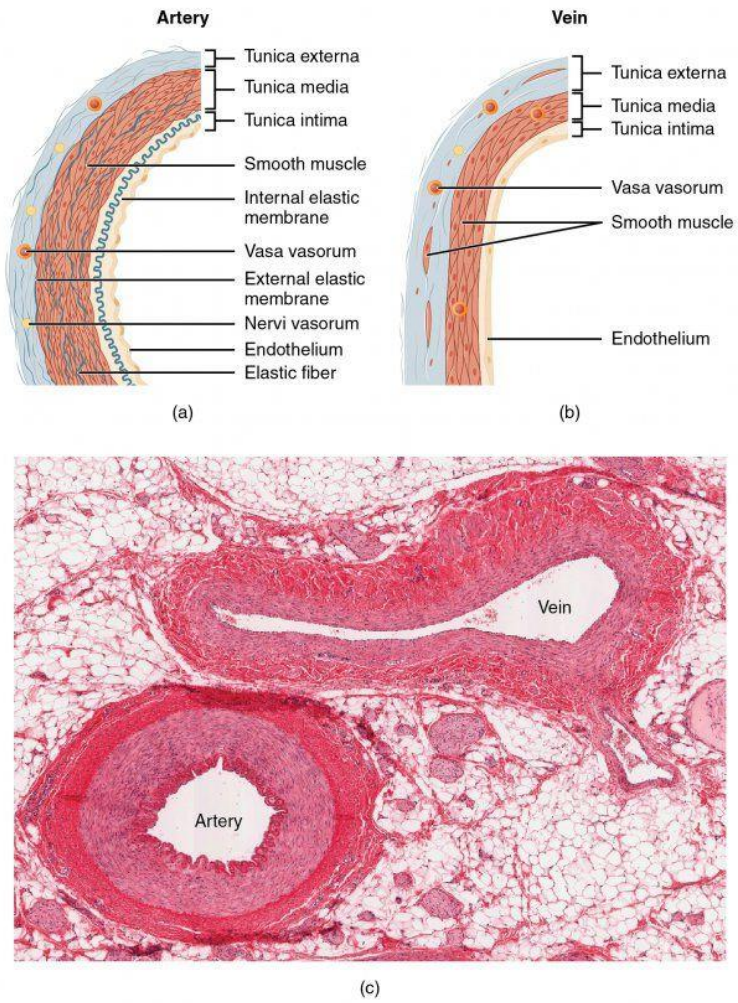
Breathing, Circulation and Blood

- The CV system and Circulation



Breathing, Circulation and Blood

- Vasculature



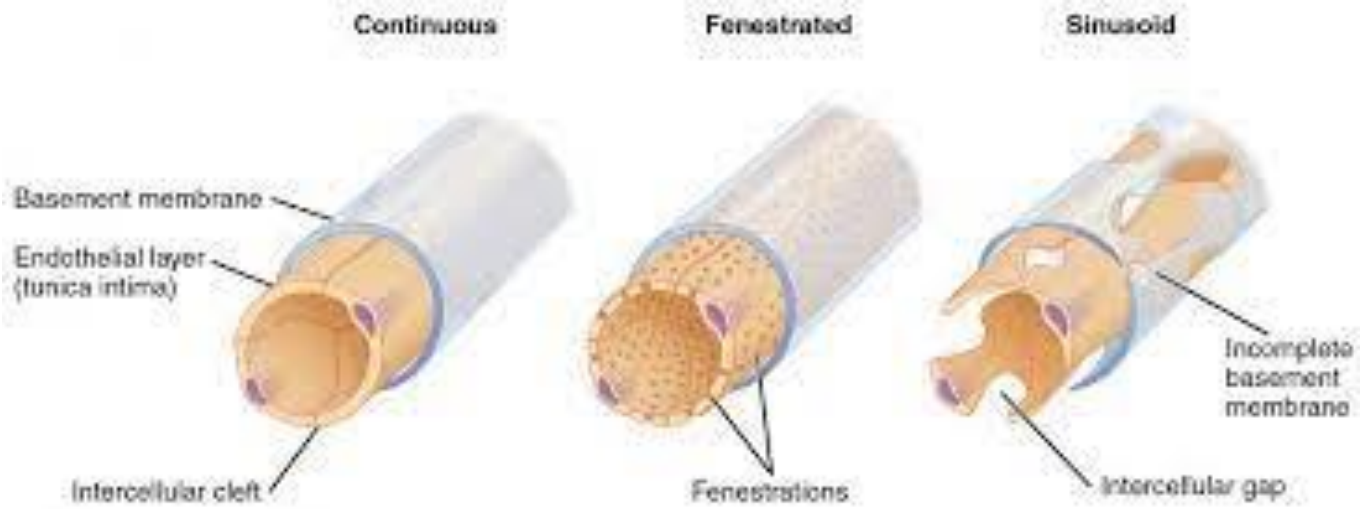
Breathing, Circulation and Blood

- Capillary Exchange

Continuous
- Continuous cytoplasm
- Bidirectional transport via transcytosis
- Continuous basal lamina
- E.g. muscle, brain, thyroid, bone and lung

Fenestrated
- Discontinuous cytoplasm - fenestrations may have a diaphragm
- Unidirectional filtration
- Continuous basal lamina
- E.g. vili, choroid plexus, kidneys

Discontinuous
- Discontinuous cytoplasm
- Bidirectional filtration
- Discontinuous basal lamina
- E.g. spleen (for erythrocytes to exit)



Pinocytosis?

Transcytosis?

Breathing, Circulation and Blood

- Capillary Exchange – 3 Mechanisms and 4 Starling Forces

3 Mechanisms

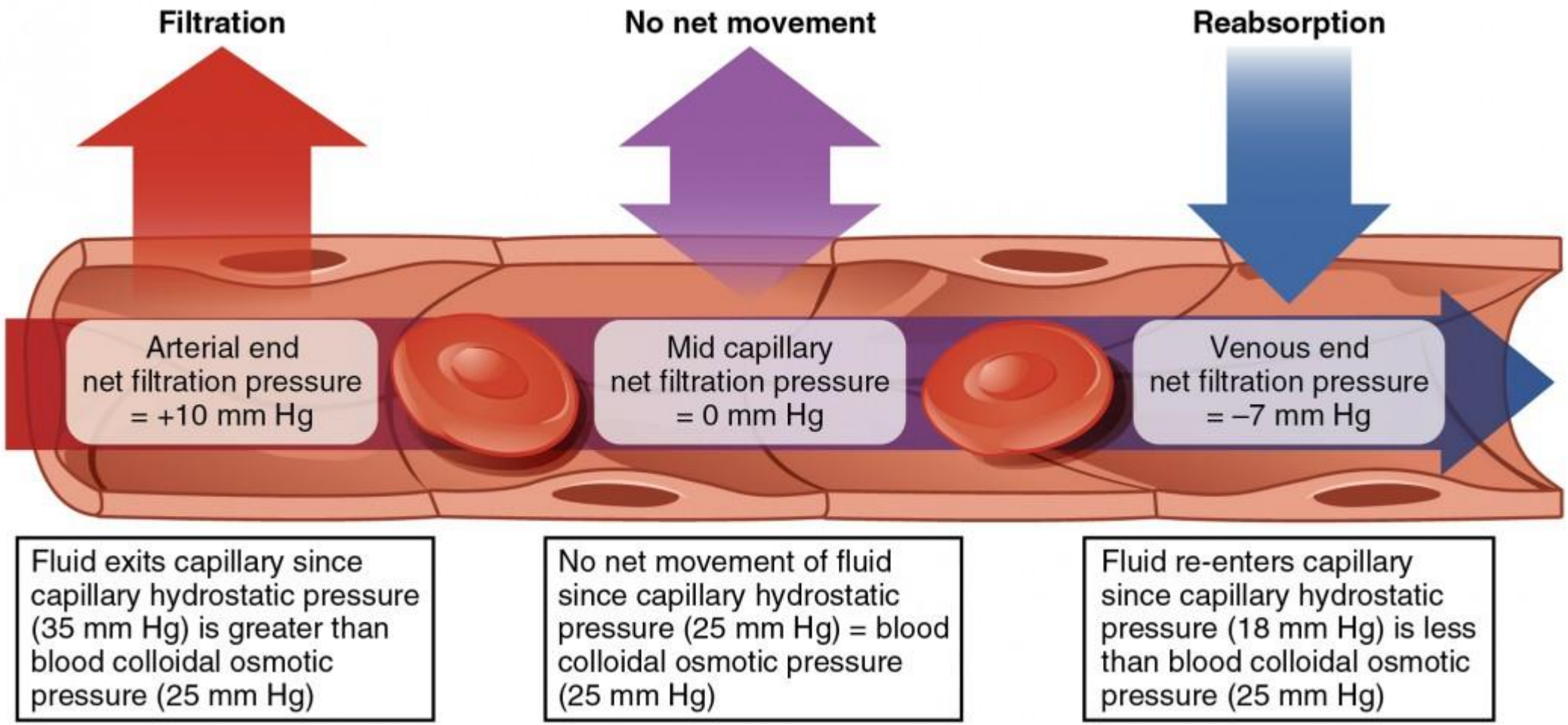
Diffusion
Transcytosis
Bulk Flow

4 Starling Forces

Oncotic or colloid osmotic pressure – pressure exerted by proteins

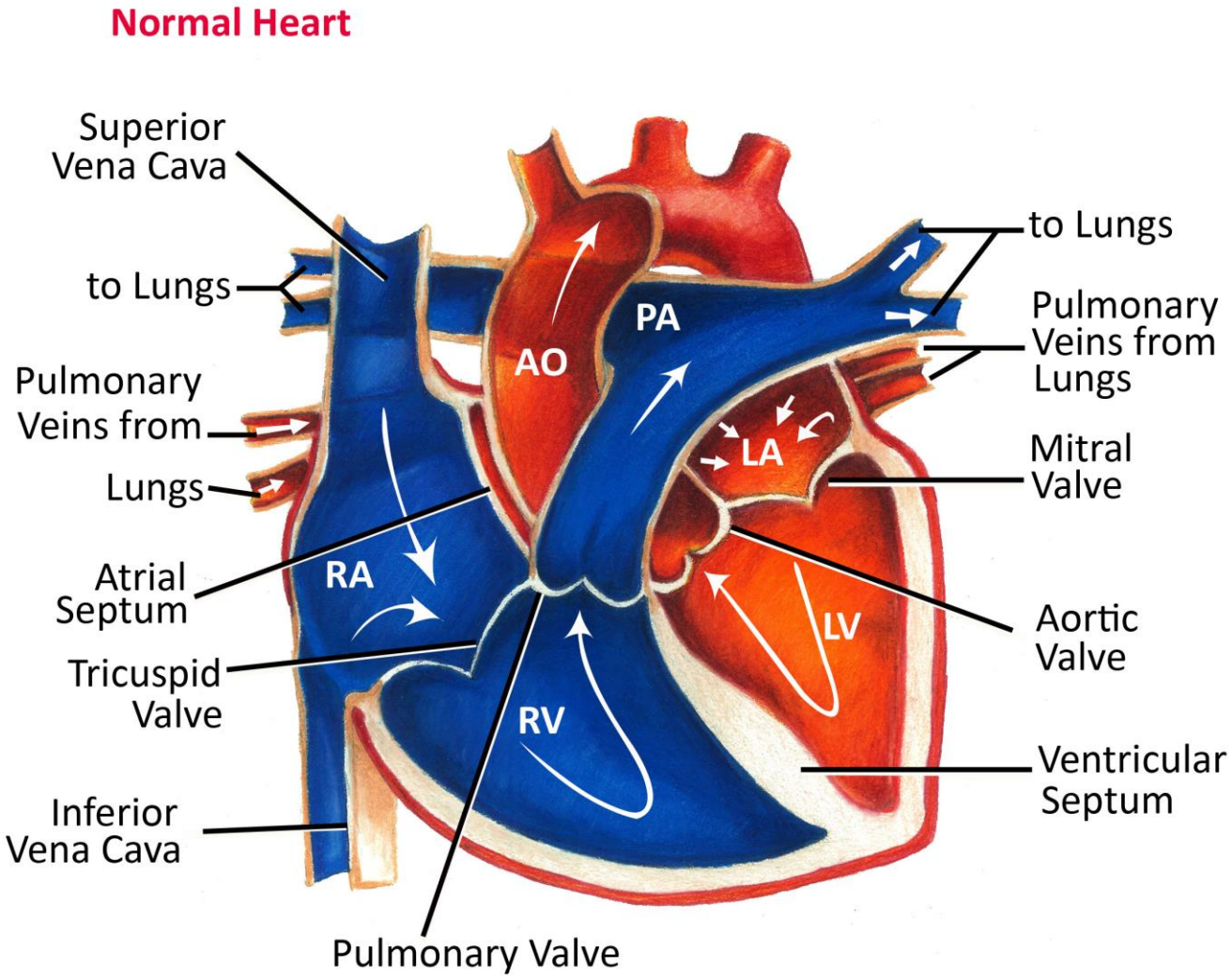
Hydrostatic pressure - fluid within or outside of capillary

Breathing, Circulation and Blood



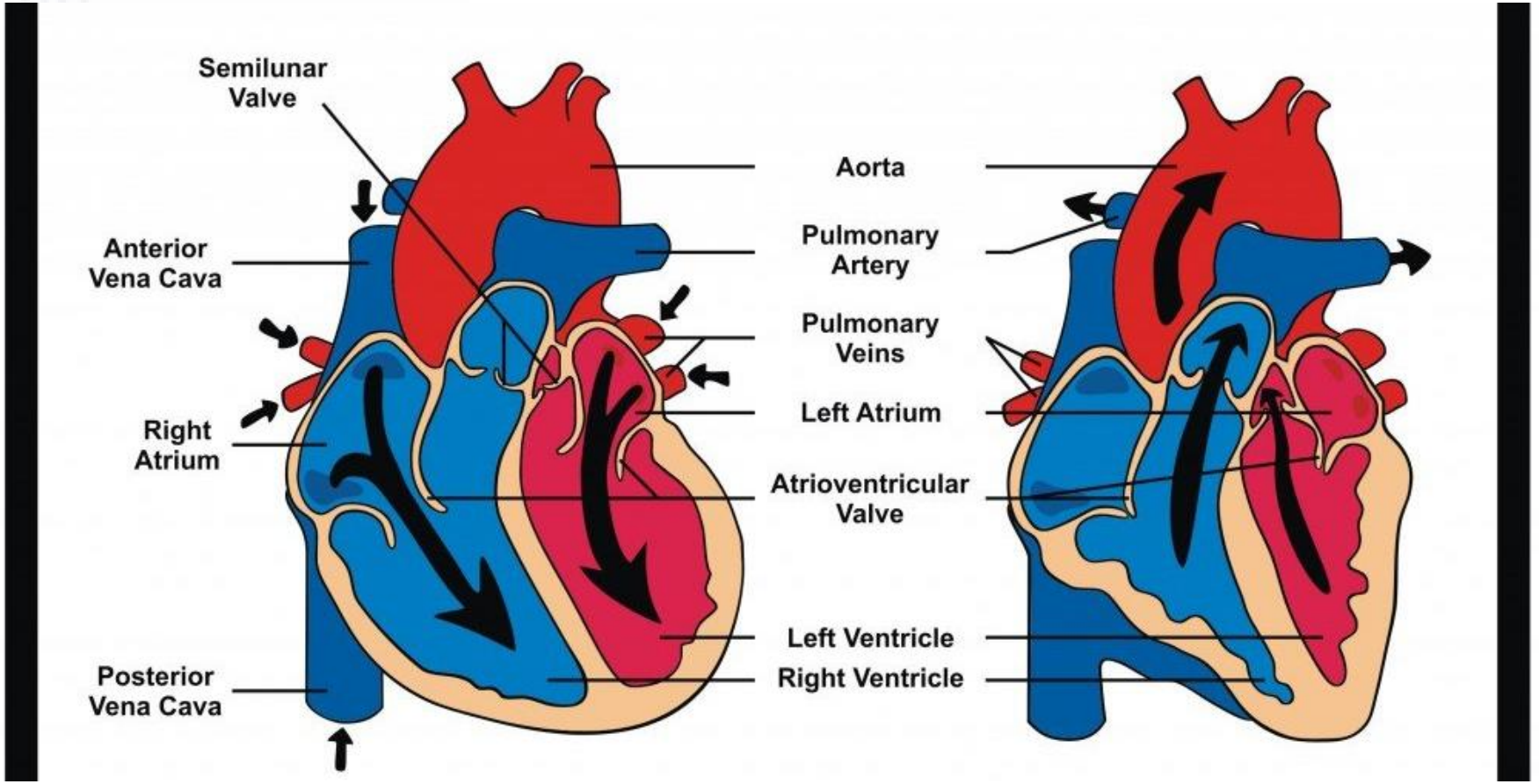
Breathing, Circulation and Blood

- The Heart



Breathing, Circulation and Blood

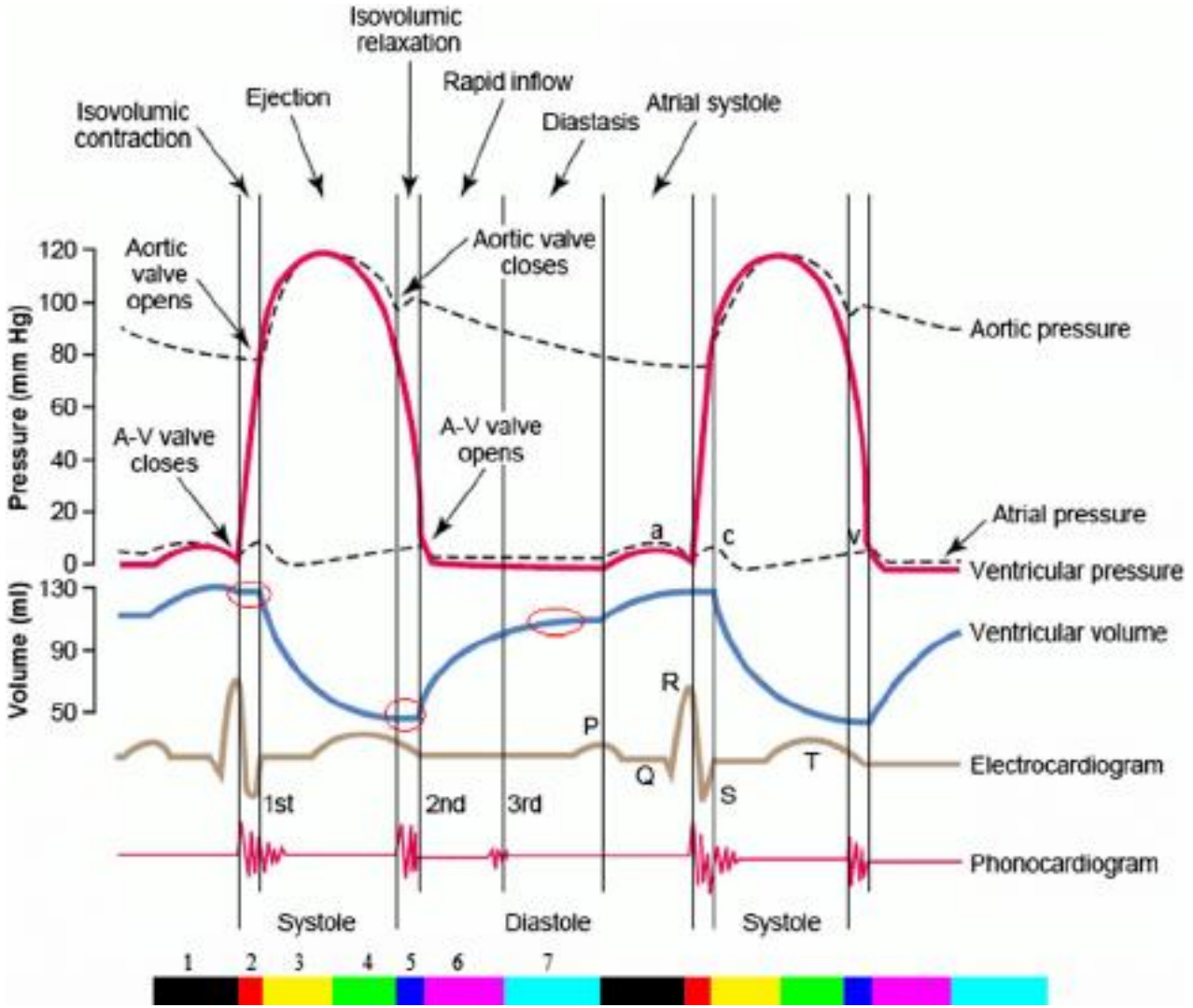
- The Cardiac Cycle – Systole vs Diastole



Breathing, Circulation and Blood

- The Cardiac Cycle

1. **Atrial systole**
2. **Isovolumetric contraction**
3. **Rapid ventricular ejection**
4. **Reduced ventricular ejection**
5. **Isovolumetric relaxation**
6. **Rapid ventricular filling**
7. **Reduced ventricular filling**



Breathing, Circulation and Blood

- The Cardiac Cycle – Heart Sounds

1st heart sound ('lub') –

2nd heart sound ('dub') -

3rd heart sound –

4th heart sound –

Breathing, Circulation and Blood

- The Cardiac Cycle – Heart Sounds

1st heart sound ('lub') – Closing AV valves

2nd heart sound ('dub') – Closing semilunar valves

3rd heart sound – Rapid ventricular filling: Ventricular gallop

4th heart sound – Pathological. Turbulent blood flow due to stiffening walls

Breathing, Circulation and Blood

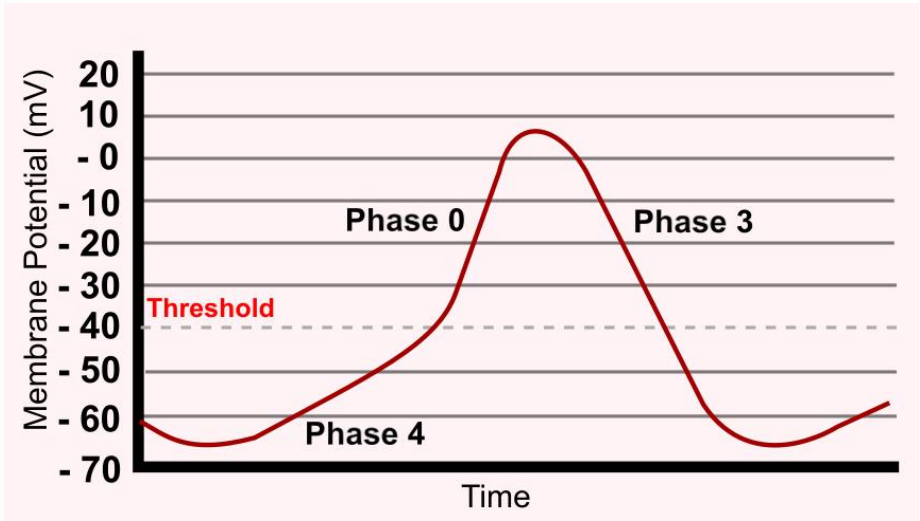
- The Cardiac Cycle – Action Potentials

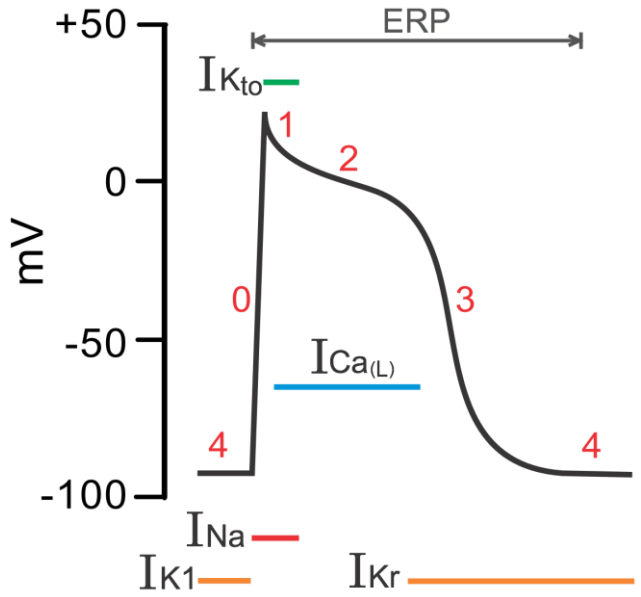
Sinoatrial node

Myogenic

SA Node – Ca+

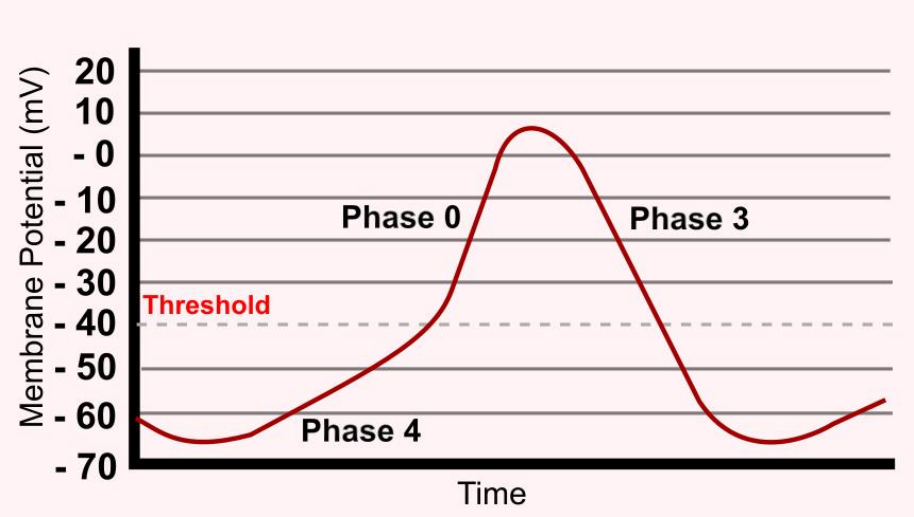
Non-pacemaker Cells – Na+

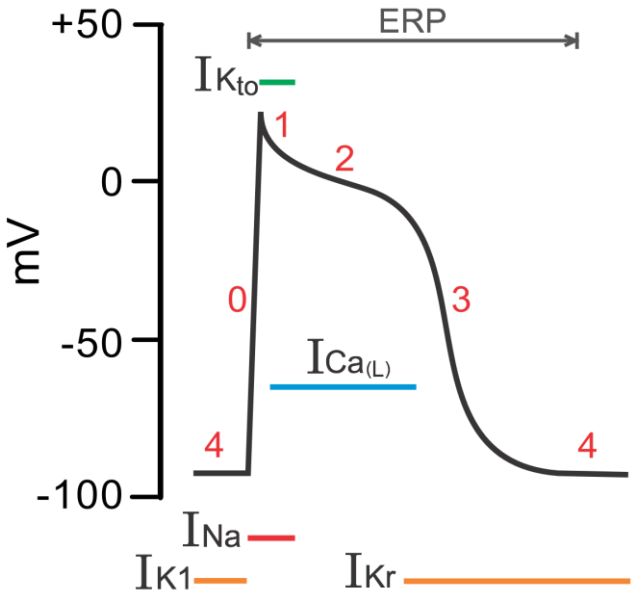


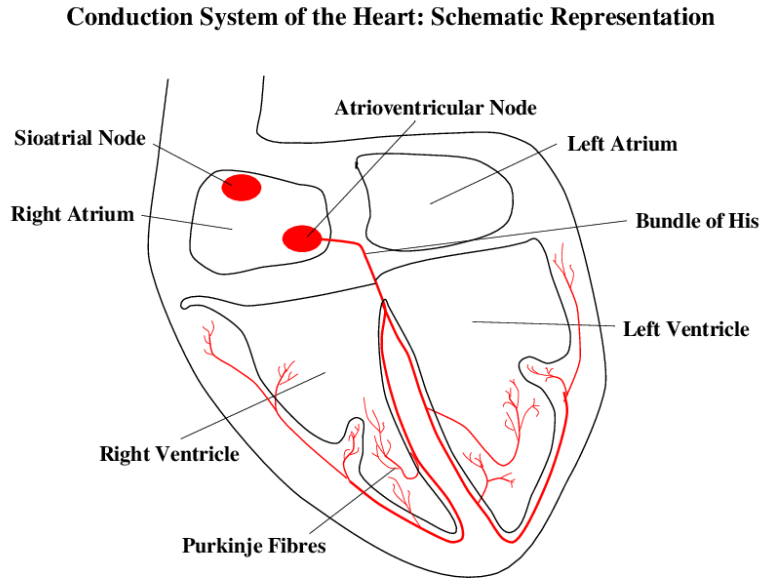


Breathing, Circulation and Blood

- The Cardiac Cycle – Action Potentials

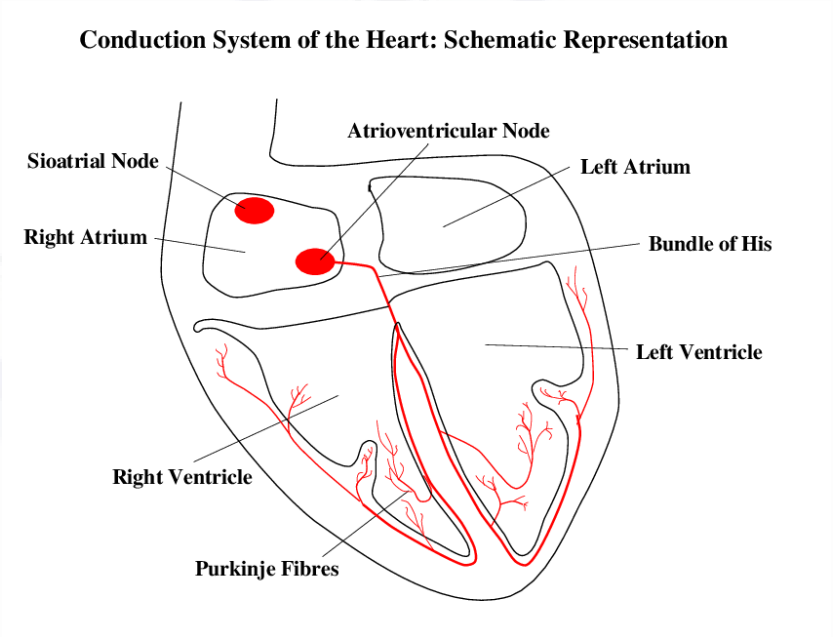


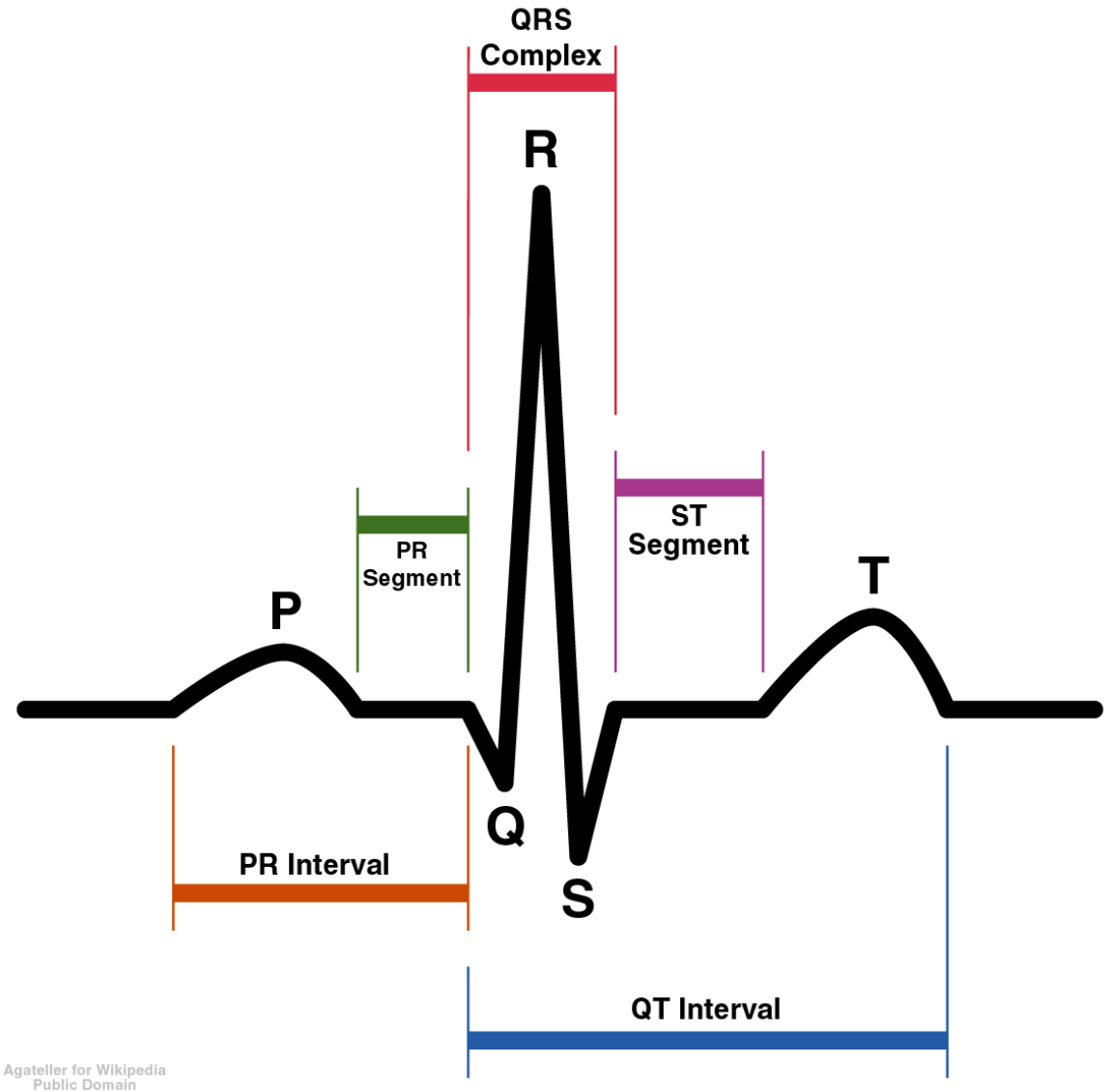




Breathing, Circulation and Blood

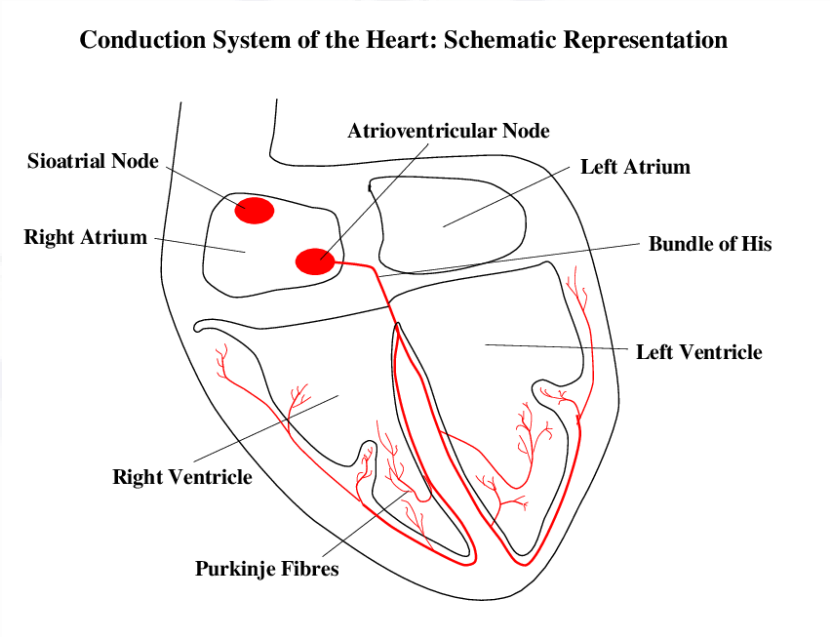
- The Cardiac Cycle – ECG

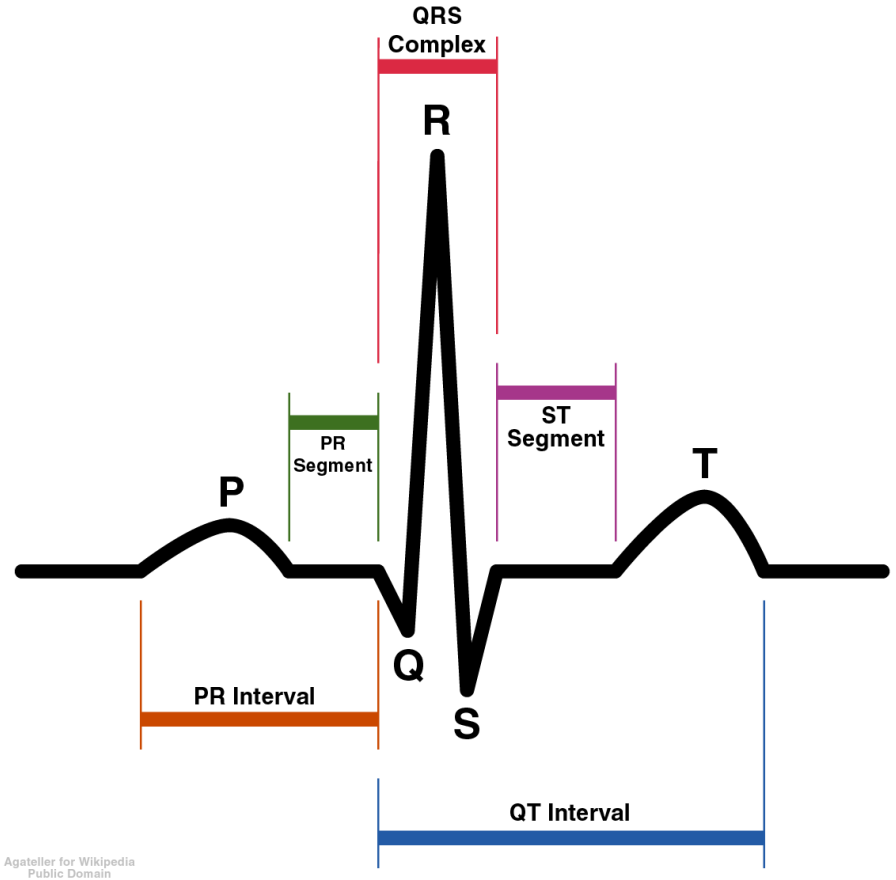




Breathing, Circulation and Blood

- The Cardiac Cycle – ECG – Why is the T wave positive? (Order of repolarisation)





Breathing, Circulation and Blood

- The Cardiac Cycle – Output Control

Arterial blood pressure = cardiac output x peripheral vascular resistance

Control of blood vessels – the radius of vessel determines the resistance. This is determined by the tone of the smooth muscle in the medial layer. It is directly innervated by postganglionic sympathetic neurones

o Noradrenaline acts at alpha 1 adrenoceptors and causes vasoconstriction

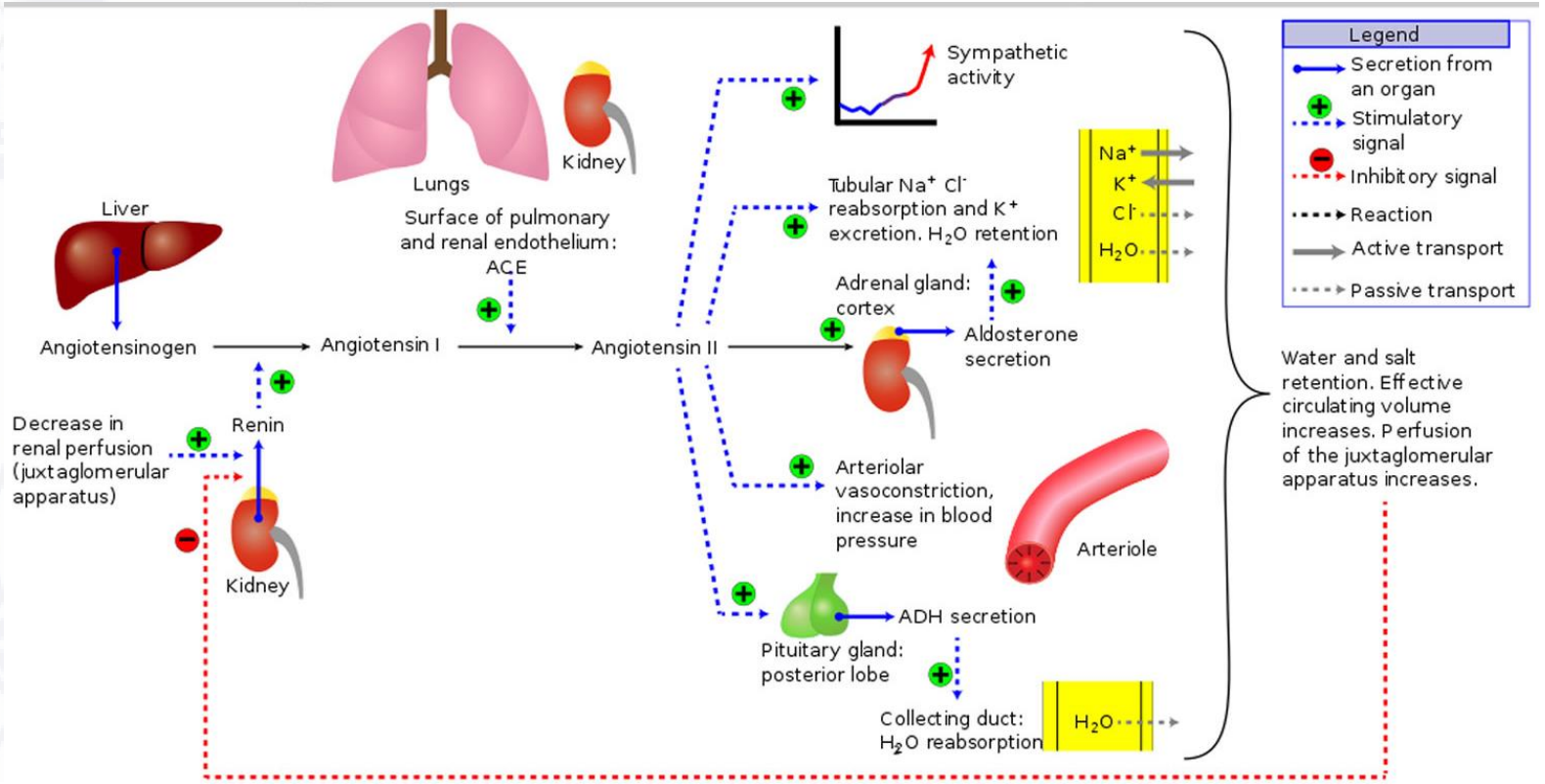
o Adrenaline acts at beta 2 adrenoceptors and causes vasodilation

o Other circulating factors such as angiotensin II and vasopressin cause vasoconstriction
o Local factors can also be released, such as Nitric oxide which causes vasodilation, and endothelin, which causes vasoconstriction

Breathing, Circulation and Blood

- The Cardiac Cycle – Output Control (Renin-Angiotensin-Aldosterone System)

Arterial blood pressure = cardiac output x peripheral vascular resistance



Breathing, Circulation and Blood

- The Cardiac Cycle – What can go wrong?

Atheroma

VLDL

Chylomicron

LDL

HDL

Deep vein thrombosis (DVT)

Virchow's Triad

Breathing, Circulation and Blood

- The Cardiac Cycle – What can go wrong?

Atheroma

VLDL

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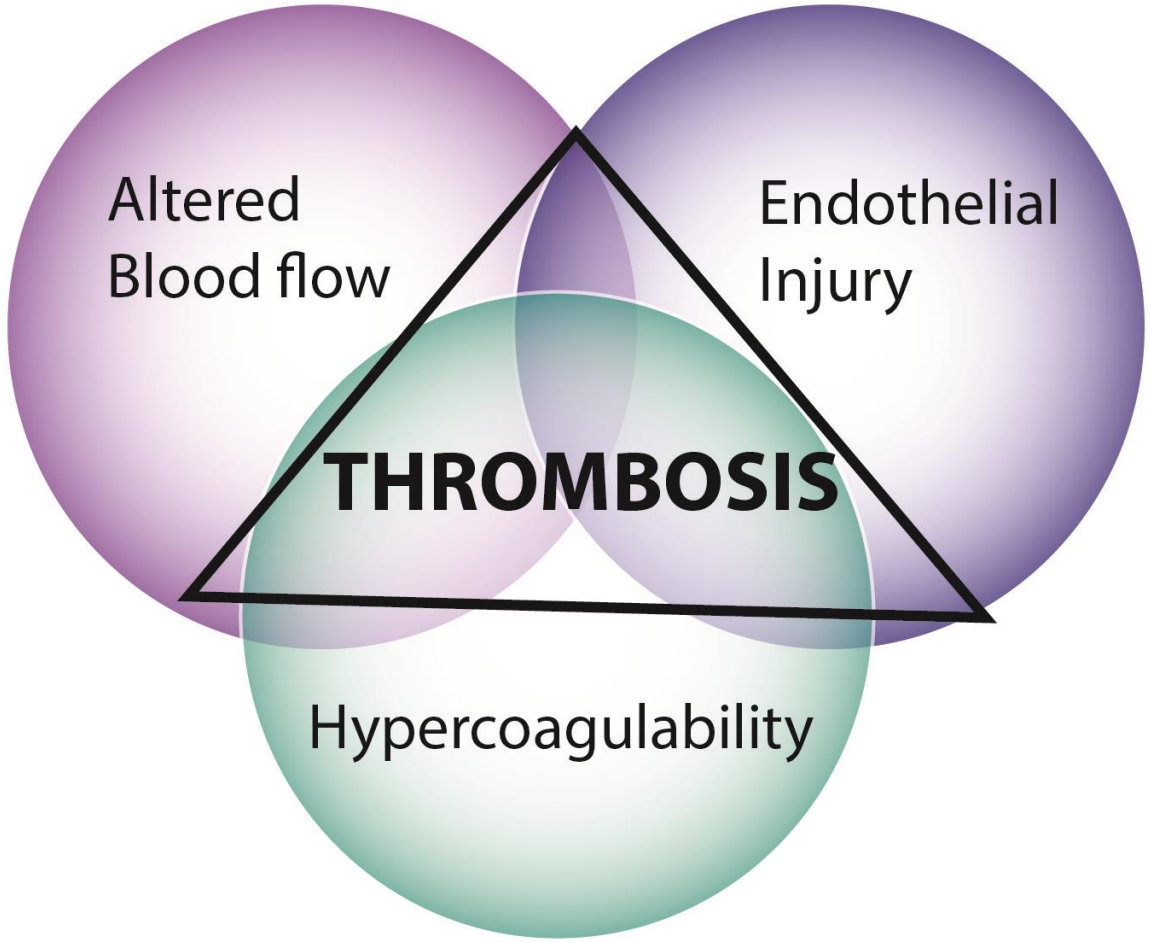
HDL

Deep vein thrombosis (DVT)

Virchow's Triad



Breathing, Circulation and Blood

- The Cardiac Cycle – What can go wrong?

Pulmonary Embolism

Systemic Embolism

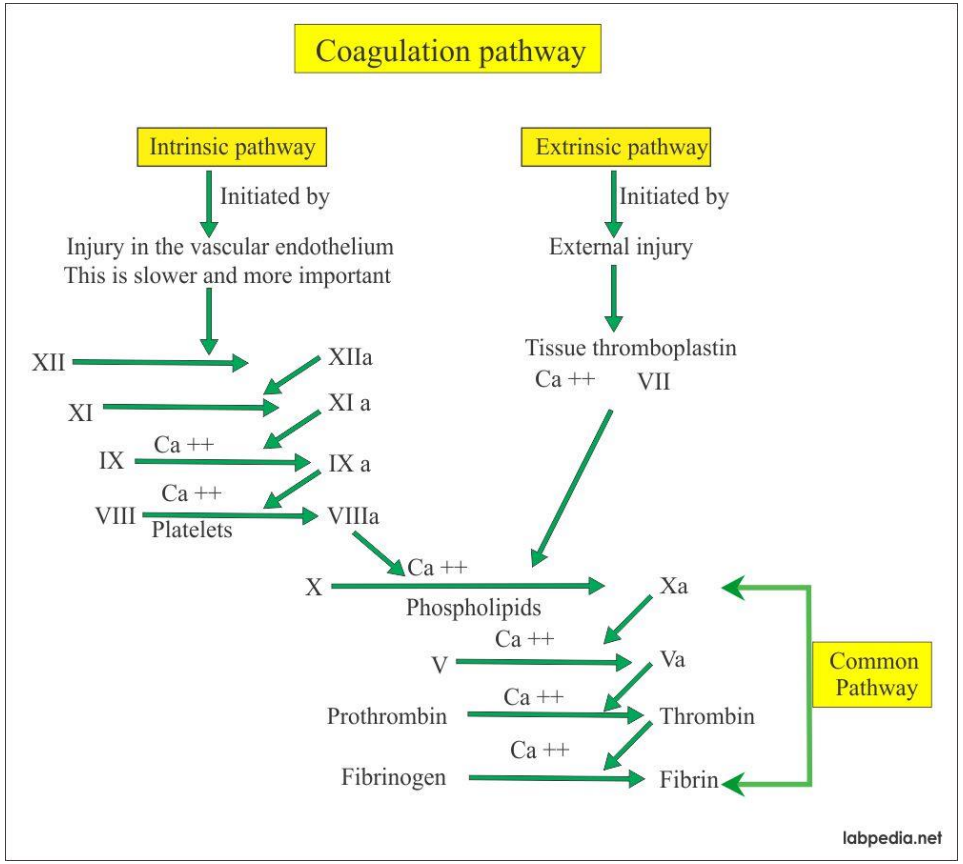
Red (haemorrhagic) infarct

White (anaemic) infarct

Waterfall of coagulation

Prothrombin time

ST Elevated MI vs NSTEMI (Which is worse?)



Breathing, Circulation and Blood + Breathlessness

- What is breathlessness?
- Why do people get breathless?
- How can we help breathless people?

Homeostasis

- What is homeostasis?

Homeostasis

- What is homeostasis?
- Types of homeostasis?
- Positive feedback
- Negative feedback