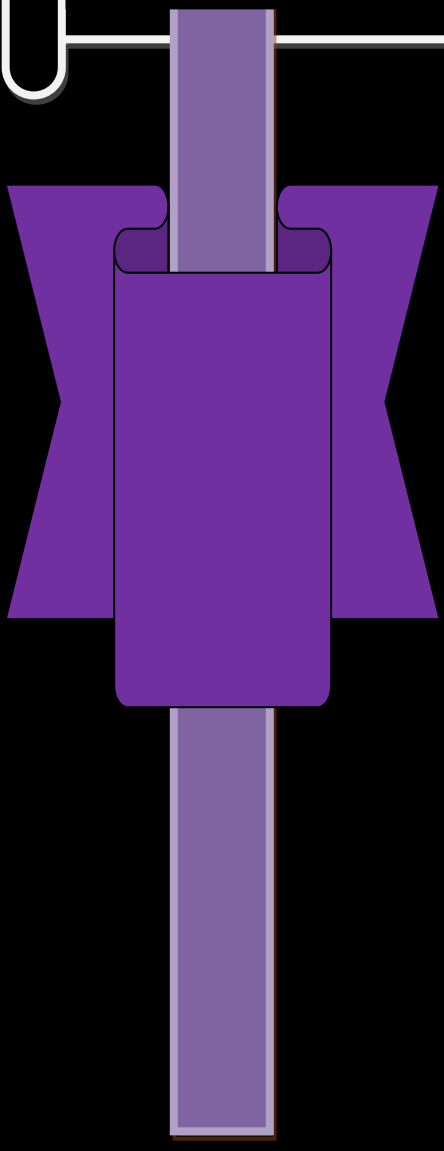
HAFEZ Review

FOUNDATIONS of DENTISTRY

Basic Sciences



Microbiology

Biology

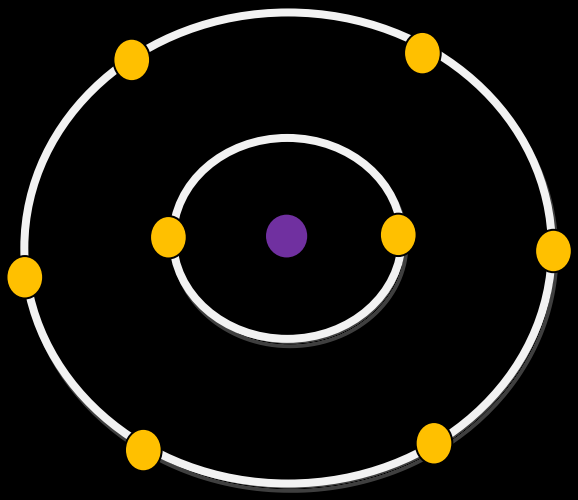
Physiology

Chemistry

Histology

Anatomy

Occlusion



Learn the basics ... become the scientist

Scholars Dental

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References:

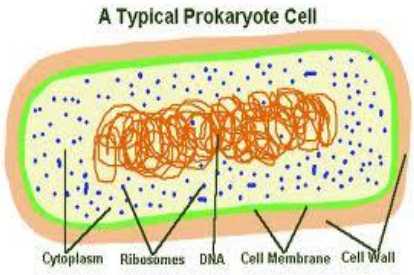
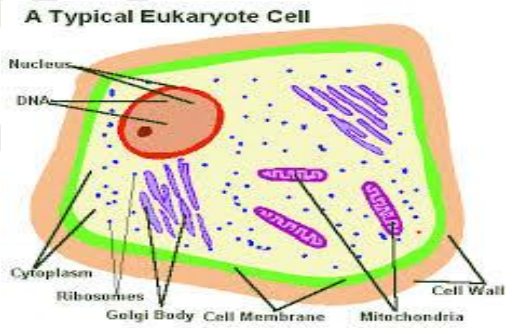
Kaplan USMLE Step 1
Dental Decks II 2011-2012
Functional Occlusion from TMJ to Smile Design
Sturdevant's Art and Science of Operative Dentistry 12th Edition
Ten Cate's Oral Histology
Junqueiras's Basic Histology
Robins Basic Pathology
Netter's Essential Physiology
Endodontics Principles and Practice 4th Edition
Aclands Head and Neck Anatomy
Oral Microbiology at a Glance
Color Atlas of Biochemistry 2005

Microbiology

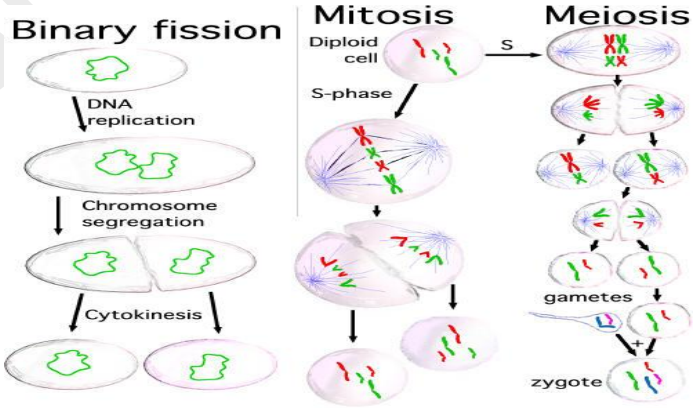
- **General Microbiology**
- **Bacteria Structure**
- **Bacteria Classification**
- **Virulence Factors**
- **Microbiology: Caries**
- **Microbiology: Periodontics**
- **Microbiology: Endodontics**

General Microbiology

Every living organism can be categorized as either a prokaryote or a eukaryote.
Prokaryote: a microscopic single-celled organism that has neither a distinct nucleus with a membrane nor other specialized organelles.
Eukaryote: an organism consisting of a cell or cells in which the genetic material is DNA in the form of chromosomes contained within a distinct nucleus.

	Prokaryote	Eukaryote
Nucleus	No nucleus	Yes nucleus
Size	Smaller	Bigger
Reproduction	Binary fission	Mitosis/Meiosis
		

Eukaryotic cells are more complex than prokaryotic cells. They have multiple chromosomes, whereas prokaryotes only have a single chromosome. Both types of cells undergo cellular division. **Mitosis** is the process by which eukaryotic cells reproduce; and **binary fission** takes place in prokaryotes.



Features	Viruses	Bacteria	Fungi	Parasites
Size	+	++	+++	++++
Cell type	Acellular	Prokaryote	Eukaryote	Eukaryote
DNA/RNA	Either	Both	Both	Both
Replication	Complex	Binary fission	Meiosis/mitosis	Meiosis/mitosis
Ribosomes	None	70s(30s + 50s)	80s(40s + 60s)	80s(40s + 60s)
Cell membrane	Enveloped	No sterols	Ergosterol	Cholesterol
Cell wall	None	peptidoglycan	Chitin	None

Notes from the table:

- There are no sterols in bacteria (except mycoplasma)
- Fungi has ergosterol (major target for antifungals)
- Parasites have cholesterol within the cell (similar to humans)
- Viruses have DNA or RNA (not both)
- Bacteria is the only prokaryote.

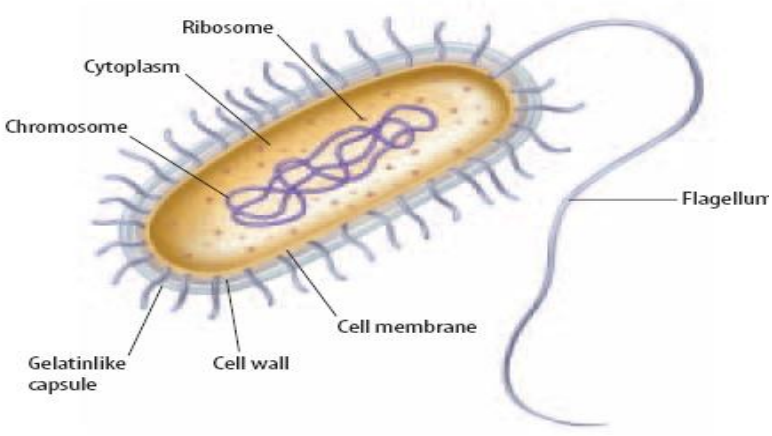
Antifungals that target ergosterol

- Polyenes: such as Amphotericin B, Nystatin.
  - These antifungals bind to ergosterol in the membrane and cause artificial pores.

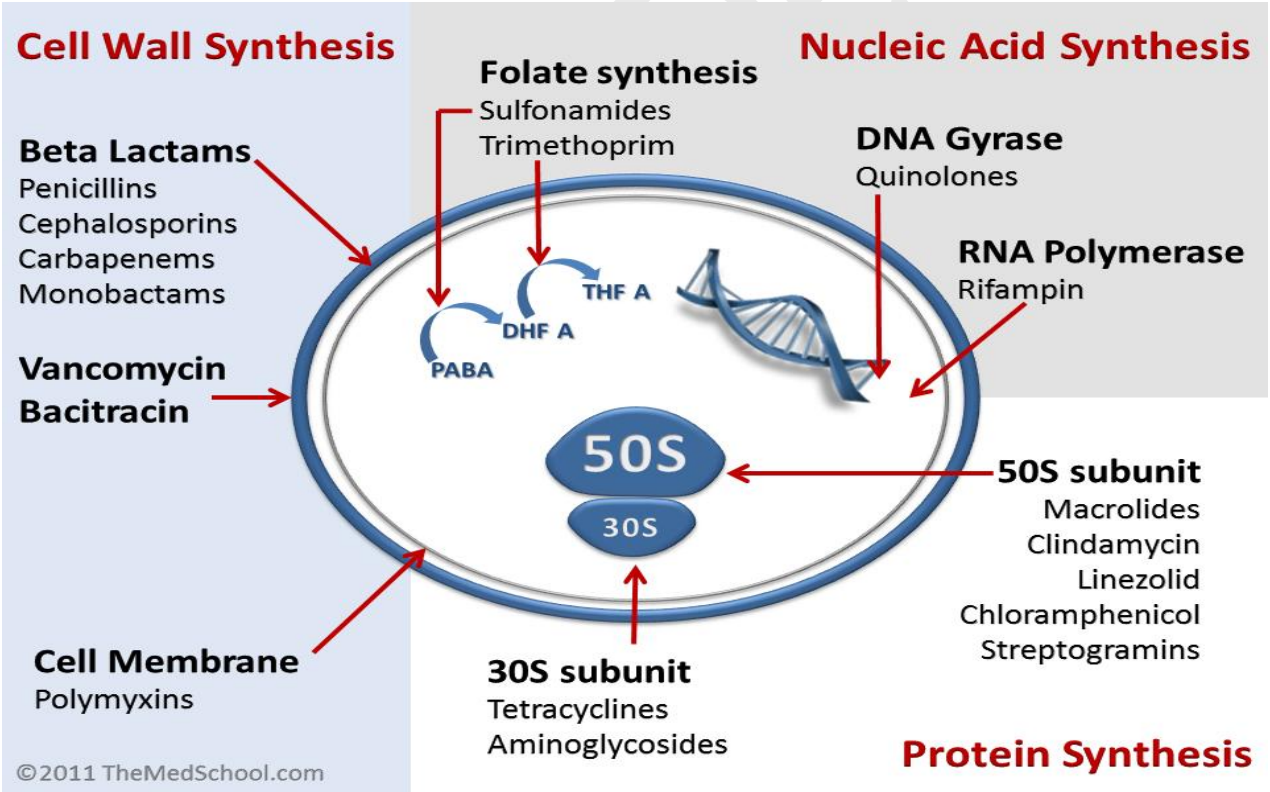
- Azoles: such as ketoconazole, fluconazole ....
  - These antifungals inhibit the synthesis of ergosterol

Bacteria structure

- Cell Wall
- Cell membrane
- Chromosome
- Cytoplasm
- Ribosome (30s + 50s)
- Other: flagellum, pili, capsule



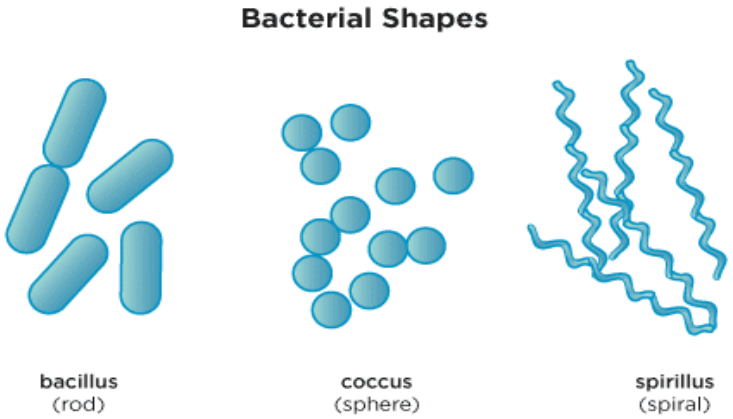
Understanding the structure of bacteria helps understand the mechanism of various antibacterials. The two major mechanisms work on the cell wall or protein synthesis.



Bacteria Classification

Based on shape:

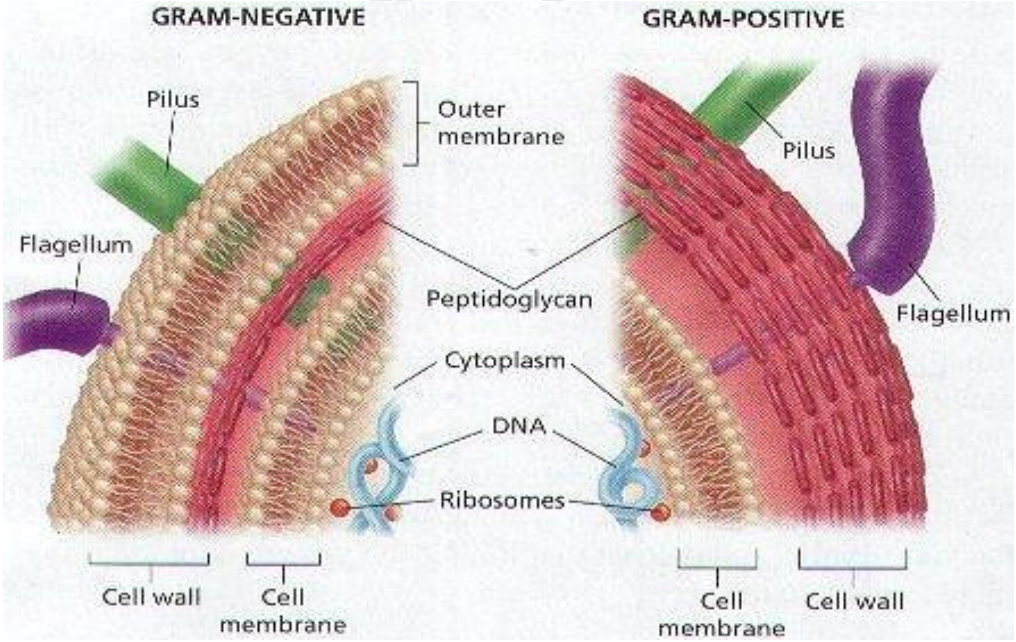
- Cocci (staph, strep, diplo)
- Rod/Bacilli
- Spiral/spirochete



Based on respiration:

- Obligate aerobic: needs oxygen to oxidize substances.
- Obligate anaerobic: will die in the presence of oxygen, uses other chemicals to oxidize substances (such as sulphate which is related to bad breath)
- Facultative anaerobic: Work both ways

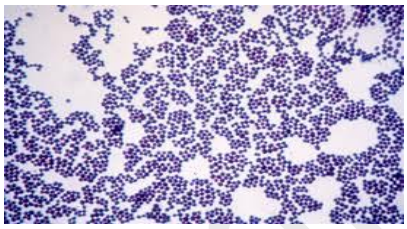
Based on Gram stain:



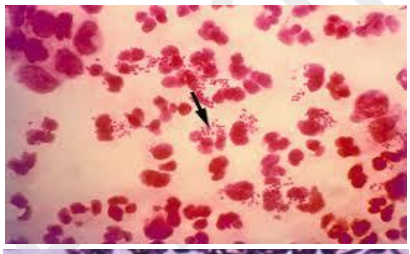
- **Obligate aerobes (non-fomenters):**
  - Mycobacterium Tuberculosis
  - Pseudomonas

- **Obligate anaerobes:**
  - **A**ctinomyces
  - **B**acteroides
  - **C**losteridium

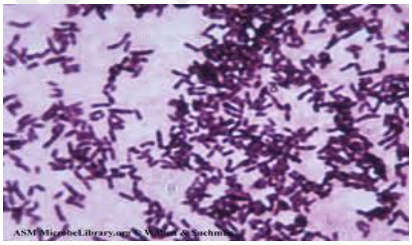
Cocci – Gram positive
- Staphylococci
- Streptococcus



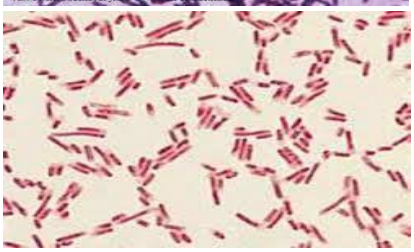
Cocci – Gram negative
- Neisseria
- Moraxella



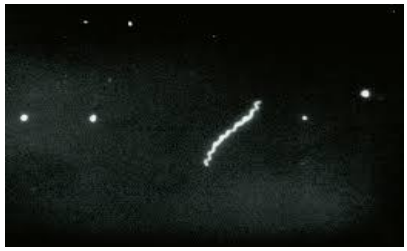
Rods - Gram positive
- **A**ctinomyces
- **B**acillus anthracis
- **C**lostridium



Rods - Gram negative
- Everything else



Spirochetes
- Borellia: causes Lyme disease
- Trepanoma pallidum: causes Syphilis
- Lepto spira: causes leptosporosis

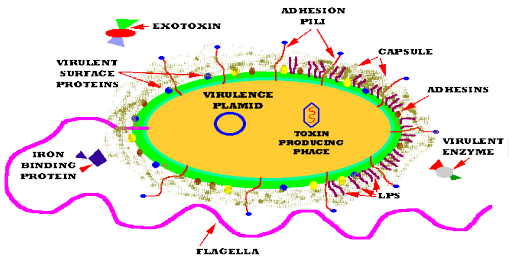


Spirochete activity is seen by observation with dark-field microscopy.
Spirochetes are not seen with gram stain.

Virulence Factors: Bacterial Virulence Factors are molecules synthesized by certain bacteria that increase their capacity to infect or damage human tissues.

Virulence factors that may help the bacteria to **attach** to host sites include pili, teichoic acids, and adhesins. Factors such as flagella(tail like structure) or axial filaments aid in **motility** enhancing the bacteria's movement to help it spread.

Antiphagocytic factors include:
- Capsules in H.influenza
- M-protein in Strep. pyogenes
- Protein A in Staph. Aureus
- Pili in Neisseria gonorrhoeae



Some bacteria produce **enzymes** that break connective tissue to create an easier pathway to spread. The intercellular substance in connective tissue contains fibers and ground substance. The fibers are most likely collagen or elastene. The ground substance contains Hyaluronic acid and glycosaminoglycan (GAGS). A sulfated glycosaminoglycan is chondroitin sulphate.

Why does this matter? ..... Dental Plaque bacteria produce enzymes such as hyaluronidase (breaks down hyaluronic acid), chondroitin sulfatase (breaks down chondroitin sulfate), collagenase (breaks down collagen), elastase (breaks down elastene) and proteases (breaks down proteins) that may initiate periodontal disease.

Toxins: Exotoxin vs Endotoxins

- Neurotoxin: an exotoxin created by clostridium (C. Tetanus, C. Botulinum)
- Enterotoxin: an exotoxin that targets the intestines.
- Free endotoxin is present in dental plaque, inflamed gingiva and diseased root cementum.
- Typically, LPS containing Gram-negative cell wall extracts are capable of promoting bone resorption, inhibiting osteogenesis, chemotaxis of neutrophils, and other events associated with active periodontitis.

Property	Exotoxin	Endotoxin
Source	G+ and G-	G- only
Secreted	Yes	No (cell wall)
Chemistry	Polypeptide	Lipopolysaccharides
Active portion	"A" portion is active "B" portion binds to receptor	Lipid A
Toxicity	High	Low
Antigenecity	High(antibody production)	Poor
Vaccines	Yes (toxoids)	No
Heat stability	No	yes
Clinical effects	Various	Fever shock
Methods of action	Various	Overactivate immune system

Notes:
- All bacteria have a cell wall except Mycoplasma pneumonia. B-lactams are not effective here.
- Acid fast staining us used for tuberculosis.
- Best way to differentiate between staph and strep is Catalase test. Staph is catalase positive.

Microbiology: Caries

Streptococcus mutans

- Gram-positive cocci in chains. Mutans streptococci possess adhesins for salivary receptors allowing attachment to saliva-coated smooth surfaces.
- In addition, these organisms produce extracellular polysaccharides from sucrose that facilitate retention on surfaces.
- Mutans streptococci are associated with all forms of caries.

Lactobacilli

- Gram-positive rods. lactobacilli are efficient producers of lactic acid and are tolerant to low pH values (two important caries associated traits)
- However, lactobacilli are poor colonizers of smooth surfaces and probably do not initiate caries at these sites. Most likely lactobacilli are secondary colonizers of

established caries lesions, where their aciduric properties allow them to out compete other organisms. Acid production will then exacerbate the lesion and facilitate extension into the dentin.

- If lactobacilli become embedded in pits and fissures they may be able to initiate caries at these sites.

Actinomyces species

- Gram-positive rods. Actinomyces, especially A. naeslundii, are frequently isolated from root caries lesions and can cause root caries in experimental animals. However, the organisms are also commonly found on healthy root surfaces so the role of actinomyces in the disease process has been unclear.

Bacteria that first colonize salivary pellicle present on the tooth surface are designated primary colonizers, and are mainly streptococci, S. sanguis being the earliest. S. sanguis is low risk for caries because it is alkali producing (not acidogenic).

Virulence of S. Mutans

- Initial Attachment to tooth surface.
- Polysaccharide production.
- Acid production (Acidogenic). Demineralization occurs when PH < 5.5
- Acid tolerance (Aciduric)

Microbiology: Periodontics

Healthy periodontium

- Oral streptococci:
  - S. oralis, S. mitis,
  - S. gordonii,
  - S. sanguinis
- Actinomyces
- Veillonella
- Haemophilus
- Neisseria
- Fusobacteria

Gingivitis

- Actinomyces
- Prevotella intermedia
- Bacteroides
- Fusobacterium nucleatum

Chronic Periodontitis

- Porphyromonas gingivalis
- Tannerella forsythia
- Treponema denticola
- Prevotella intermedia
- Campylobacter rectus
- Fusobacterium nucleatum
- Eikenella corrodens
- Eubacterium nodatum
- Selenomonas noxia

Comparing the microbiota in health, gingivitis, and periodontitis, the following microbial shifts can be seen:

- From gram positive to gram negative
- From facultative anaerobes to obligate anaerobes
- From cocci to rods
- From nonmotile to motile organism
- From fermenting to proteolytic species

Localized aggressive periodontitis

- Aggregatibacter actinomycetemcomitans(Aa), a Gram-negative.

Generalized aggressive periodontitis

- GAP is associated with a subset of organisms involved in chronic periodontitis: P. gingivalis, Tannerella forsythia, P. intermedia, …

Necrotizing ulcerative Gingivitis

- P. intermedia, Fusobacterium species, and spirochete microorganisms.

Microbiology: Endodontics

Dentin is most quickly infected by bacteria that are not necessarily main components of the root canal microbiota. For example S. mutans and S. gordoniireadily infect dentinal tubules, and can penetrate to depths of 0.2 mm or more over several days.

The most prevalent cultivable taxa from root canals are: F. nucleatum, P. gingivalis, Pseudoramibacter alactolyticus, Parvimonas micra (Peptostreptococcus micros), S. mitis, S.

intermedias, other streptococci and Candida. The microbiota is dominated by anaerobic bacteria, but the most prevalent genus is Streptococcus.

The most common organisms detected by molecular studies, independently of symptoms are Porphyromonas endodontalis, Filofactor alocis,P. gingivalis, T. forsythia, and P. alactolyticus

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Biology and Physiology

Cell Structure

Chemistry Review and acid/base reactions

Membrane Transport

Cell signalling

Fluid distribution

Excitable tissue and action potential

Peripheral Nervous System

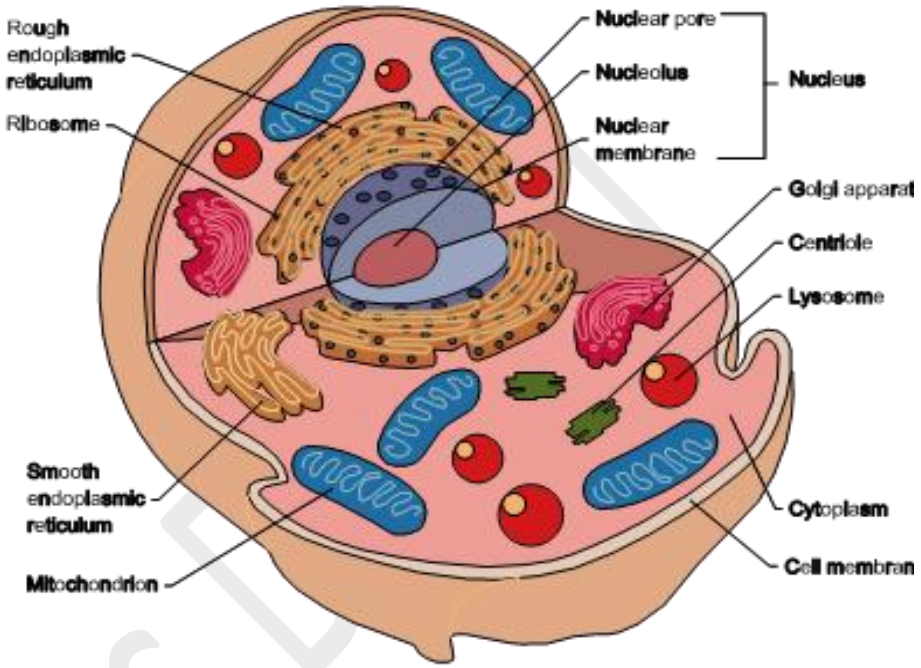
- **Autonomic Nervous System**
- **Somatic Nervous system**

Central Nervous System

Biology & Physiology

Cell Structure

- Cell membrane
- Endoplasmic Reticulum
- Golgi apparatus
- Mitochondria
- Lysosomes
- Peroxisomes
- Ribosomes
- Cytoskeleten
- Nucleolus



Endoplasmic reticulum
- Rough ER: makes proteins that leave the cell.
- Smooth ER: makes lipids.

Golgi apparatus
- Modification of lipid and proteins.
- Makes carbohydrates, combines it with proteins from Rough ER, and packages the products as globules of glycoprotein ready to leave the cell.

Ribosomes: Makes proteins that stay in the cell.
Mitochondria: Makes energy (glycolysis), the cell "Power Plant".
Nucleolus : Essential role in formation of ribosomes.
Cytoskeleton: Framework to support the cell.
Lysosomes and Peroxisomes: break things down, defense.

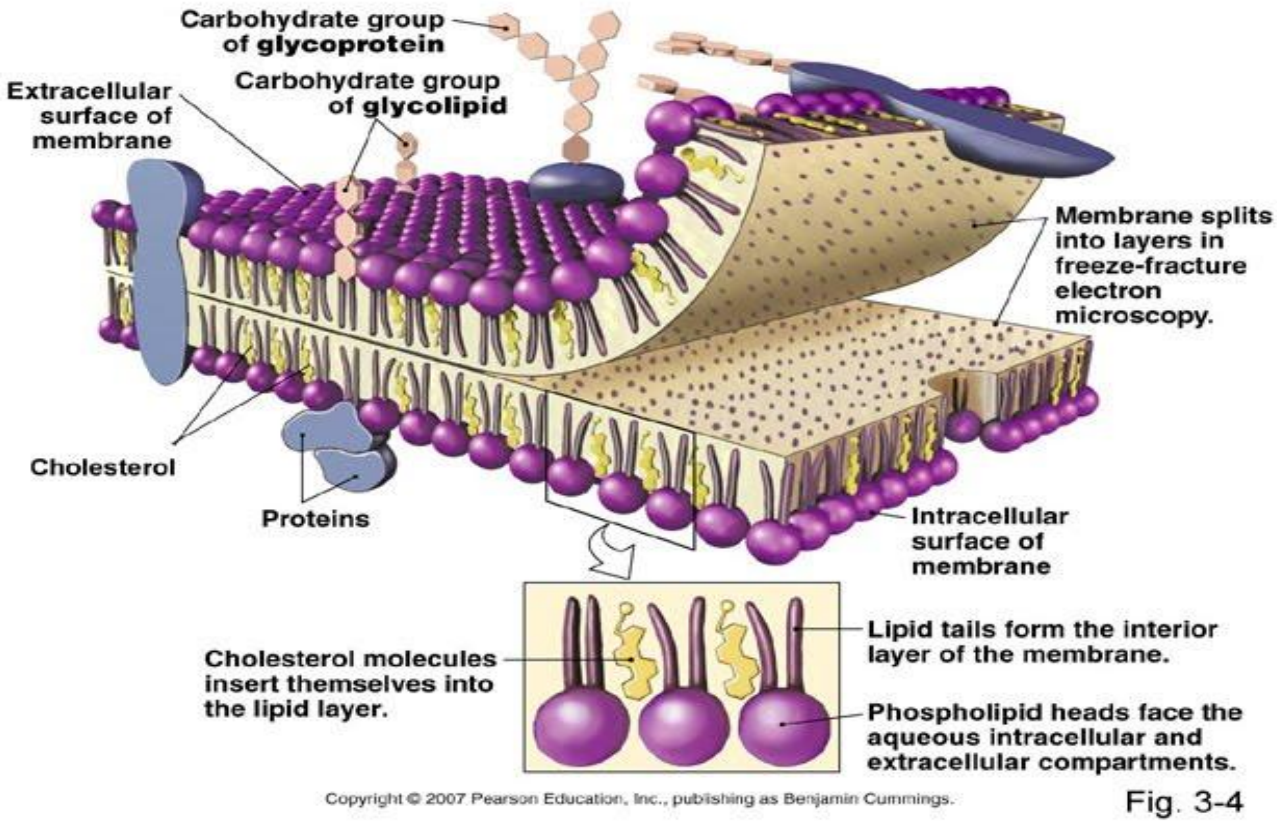


Fig. 3-4

Cell membrane:

- Consists of a two layers of phospholipid
- Each phospholipid has a polar (hydrophilic) side and a non-polar(hydrophobic/lipid) side.
- The hydrophobic portion is directed inward creating a hydrophobic layer mid membrane.
- Other components: protein carriers, protein channels.

Thought:

The hydrophilic sides of the two layers are in contact with the inside of the cell (mostly water) and outside of the cell (mostly water) which keeps the cell stable within the environment. The central part of the membrane consists of the lipid portion from both layers creating a barrier against hydrophilic components. Lipid soluble substances can pass the membrane. Water soluble substance could only pass through the protein channels or protein carries.

Chemistry Review

Plasma Protein Binding

- Lipid soluble substances bind to protein in plasma until it reaches the target cells.

A + Protein ⟶ A-Protein complex
(Free active form) ⟵ (Inactive, bond)

Note:

Non-ionized = Non-polar = hydrophobic = lipid soluble
Ionized = Polar = hydrophilic = water soluble

Lipid solubility determines the potency of a local anaesthetic.

Potency is the minimum amount of a drug required to produce a given effect. A local anaesthetic that is more lipid soluble will have more of its molecules penetrate the nerves; therefore less drug is required to give the same blockade.

Protein binding affects the duration of action of a local anaesthetic. The sites of action for local anaesthetics are sodium channels, which are protein molecules, therefore highly bound drugs have a long duration of action.

Acid/Base Reactions

- Most drugs are either weak acids or weak bases.
- Weak acids and weak bases can exist in either ionized or non-ionized forms.
- Non-ionized form crosses biomembranes
- Ionized form does not cross membranes and is easier to be excreted from the kidneys.

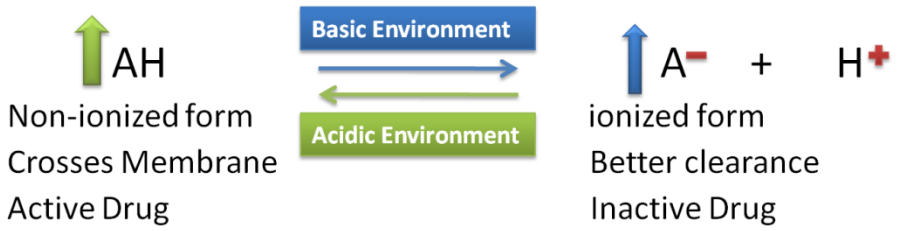
- Factors that determine inionized/non-ionized split of a weak acid or weak base:
  - PH environment
  - Pka of substance (Drug)
- pKa of a chemical compound represents the pH at which its ionized and non-ionized forms are in equilibrium

We have two effects to study:

- How the pH of the environment affect weak acids/weak bases.
- What is the pKa and how it affects weak acids/weak bases.

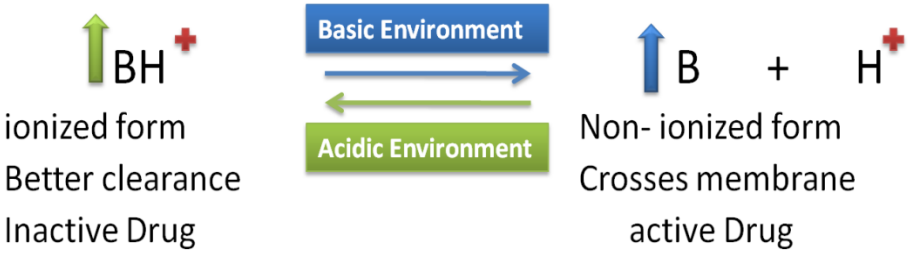
Effect of pH on weak acids (RCOO-H)

- If a weak acid is placed in an acidic solution, the equation will shift towards the left.
- If a weak acid is placed in a basic solution, the equation will shift towards the right.
- For a weak acid to cross membranes, we want most of it to exist in its non-ionized form.
- **<u>Conclusion:</u> An acid in an acidic environment will pass membranes.**



Effects of pH on weak bases (RNH3)

- If a weak base is placed in an acidic solution, the equation will shift towards the left.
- If a weak base is placed in a basic solution, the equation will shift towards the right.
- For a weak base to cross membranes, we want most of it to exist in its non-ionized form.
- **<u>Conclusion:</u> A weak base in a basic environment will pass membranes.**



Effects of pKa

- If we put lidocaine in a PH = 7.7 , 50% of the lidocaine will be Ionized, and 50% will be non-ioinized.
- Pka of Lidocaine = 7.7 (not the PH)
- PH of body = 7.4

- The closer the pKa of the drug is to physiological pH (7.4), the greater the amount of free base or non-ionized drug present and the faster the onset of the block.
- The higher the pKa the less non-ionized drug is available and the slower the onset of block.
- For example, at pH 7.4, lidocaine (pKa 7.7) is 35% non-ionized and bupivacaine (pKa 8.4) is 12–13% non-ionized, therefore lidocaine has a faster onset of action than bupivacaine in equipotent doses.

Clinical Application:

- Local anesthetics are weak bases.
- Infection area is acidic environment.
- If LA injected in infection area, it will be mostly in its Ionized form(inactive form), and will not cross the membranes of the nerves >>> anesthesia will fail.

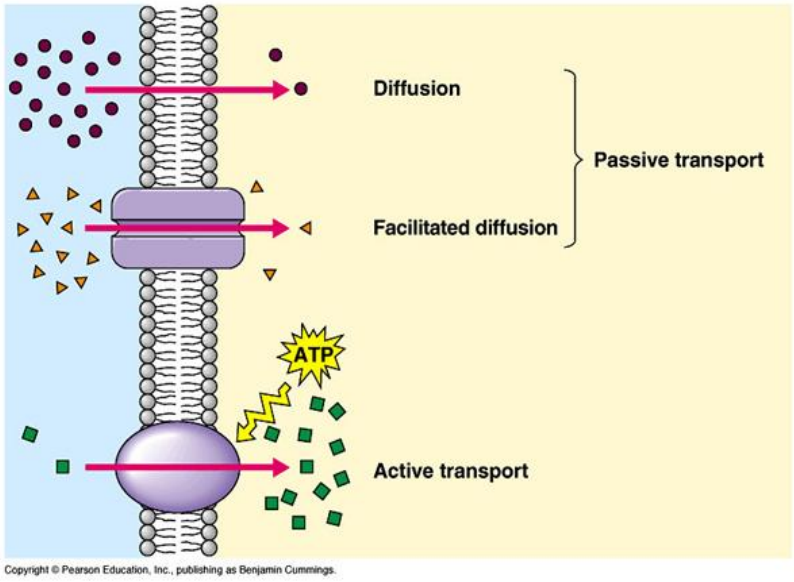
Membrane Transport

Passive Transport

- Simple Diffusion
- Facilitated Diffusion

Active Transport

Filtration



Passive Transport

Simple Diffusion:

- Move down concentration gradient
- No energy required
- No carrier (system cannot be saturated)
- Lipid soluble substances (gases, some hormones, cholestrol) move across the membrane by this process.

Facilitated Diffusion:

- Move down concentration gradient
- No energy required
- Needs carrier or gated channels (system can be saturated)
- Examples include Ca, K, Na

Active Transport

- Against concentration gradient
- Needs energy (ATP)
- Needs carrier/gated channel (saturated)
- Example: Na/K pump (3Na,2K)

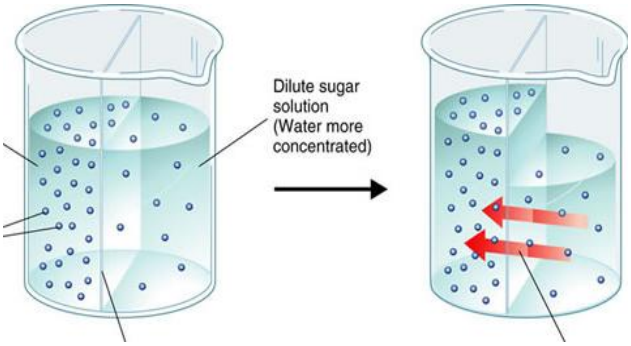
- Digoxin blocks Na/K pump in cardiac muscle cells.
- Digoxin is used in Cardiac arrhythmias and in CHF.

Filtration

- Water soluble molecules small enough to pass through membrane channels may be bcarried through the pores by the bulk flow of water.
- Alcohol(ethanol)

Osmosis:

Movement of a solvent (such as water) through a semipermeable membrane (as of a living cell) into a solution of higher solute concentration that tends to equalize the concentrations of solute on the two sides of the membrane.



Cell Signaling

Receptors as enzymes (cell surface protein kinases):
These kinases exert their regulatory effects by phosphorylating proteins within the cell which alters the cellular biochemical activities. By binding to these kinases, drugs can also cause the alteration in biochemical activities resulting in a drug effect.

Ion channels:
Substances can bind to ion channels in cell membranes to cause opening or closing. This alters the cell's membrane potential to result in an effect.
Examples: LA, Digoxin.

- Ungated channels (concentration gradient) (always open)
- Gated channels: (close/open)
  - Ligand gated channels. (binds to a protein)
  - Voltage gated channels. (depend on charge)

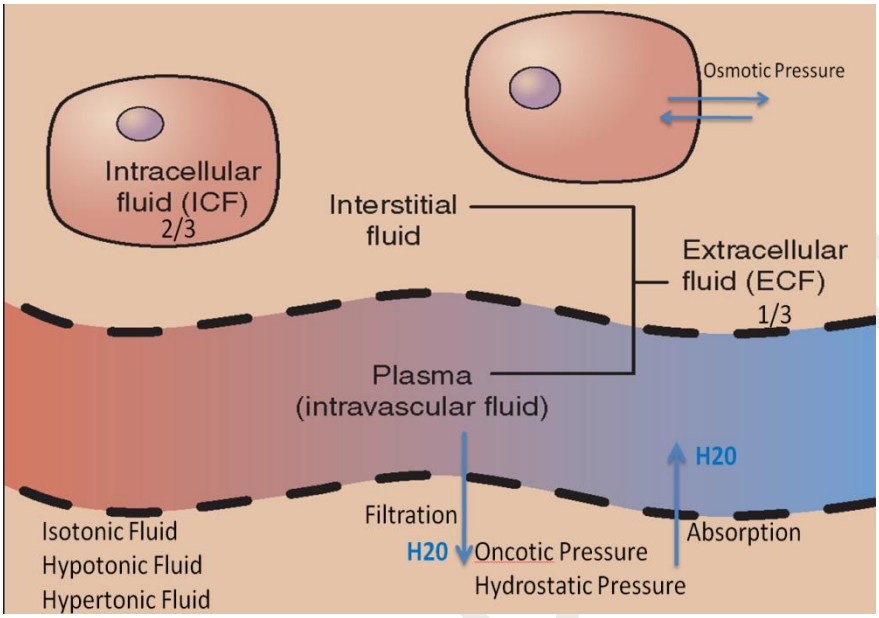
G protein-coupled receptors:
When substance binds to these receptors, second messengers are produced such as cAMP, cGMP, Ca, to produce an effect within the cell.
Examples: Peptide hormones, Neurotransmitters.

Nuclear Receptor:
Substances bind to nuclear receptors, interact with DNA, and increase or decrease transcription of mRNA from target genes.
Examples: Steroid hormones, thyroid hormone.

Fluid Distribution

- 2/3 of body fluid is intracellular
- 1/3 is extracellular (interstitial fluid + intravascular fluid)
- Fluid leaves the blood into interstitial area via oncotic pressure, hydrostatic pressure.
- Fluid may enter the cell from the interstitial area or leave the cell via osmotic pressure.
- Fluid may be absorbed back into the intravascular area.

- Isotonic fluid = 0.9% concentration (normal saline)
- Hypotonic = low sodium
- Hypertonic = high sodium



Loss of isotonic fluid

- Hemorrhage, diarrhea, vomit

Loss of hypotonic fluid

- Sweating(dehydration), diabetes insipidus, alcoholism(inhibits ADH affect, hangover is caused by dehydration to brain cells)

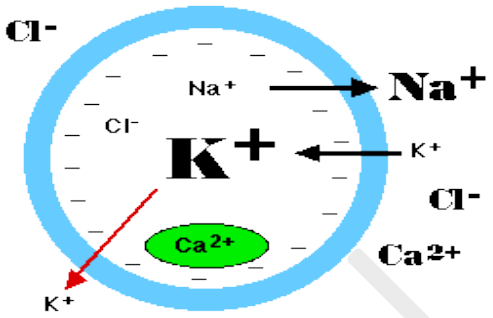
Edema

- Congestive heart failure. CHF may lead to pulmonary edema.
- Cirrhosis (low albumin)
- Nephrotic (low albumin)
- All cause low vascular volume and hypotension >> renin from kidney >> angiotensin >> Aldosterone >> retention of water and sodium
- Edema could be caused by surgery.

Excitable Tissue

Electrical force
Concentration force

Potassium is higher inside the cell
Sodium is higher outside the cell



Efflux/leakage of potassium is passive and key factor contributing to the resting membrane potential. The resting membrane potential is -70 to -90 mV.
Bringing potassium into the cell requires energy (ATP) to overcome the concentration gradient.
Influx of Na will depolarize membrane.
Excessive efflux of K >> hyperpolarized membrane.

Resting membrane potential is not much sensitive to changes in extracellular Na, but very sensitive to changes in extracellular K, because Na channels are normally closed, K channels are non gated channels.
High or low potassium could cause arrhythmias conduction disturbances and ECG abnormalities.

Action Potential

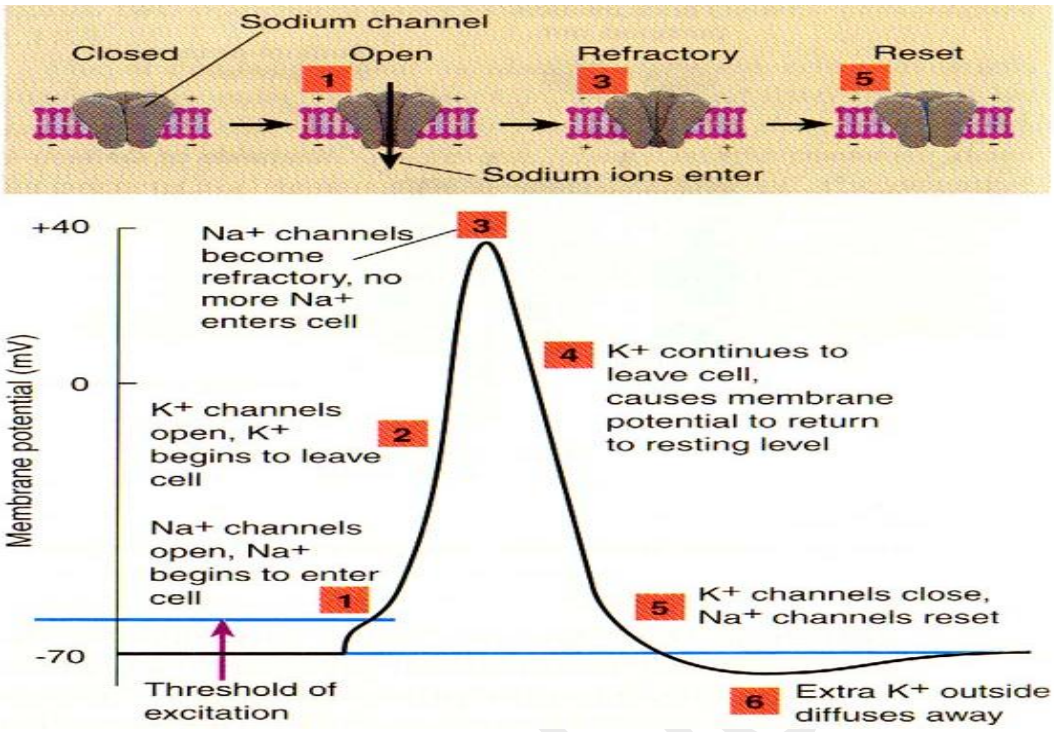
Channels involved in action potential

- Non gated K channels (always open, concentration gradient)
- Voltage gated Na channels (fast Na channels) (opening based on charge, affected by AP)
- Voltage gated K channels (opening based on charge, affected by AP)

Action potential is passive, no ATP usage.

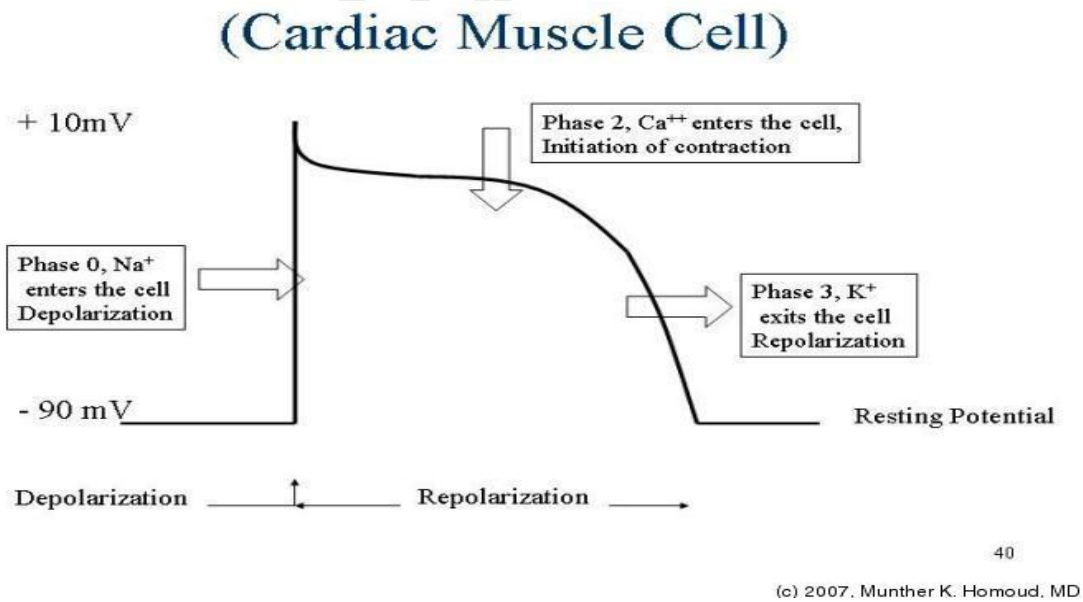
Rest membrane : Efflux of K

1. Stimulus reaches threshold
2. Depolarization : Influx of Na
3. Repolarization : Efflux of K (Na closed)
4. Hyperpolarization : Efflux of K (Na closed)



Because of the concentration gradient for K^+ that exists across cellular membranes, the opening of K_V channels results in an efflux of positive charge, which can serve to repolarize or even hyperpolarize the membrane.

Pharmacological activation of K^+ channels in excitable cells consequently reduces excitability whereas channel inhibition has the opposite effect and increases excitability.



Peripheral Nervous System

Neurotransmitters:

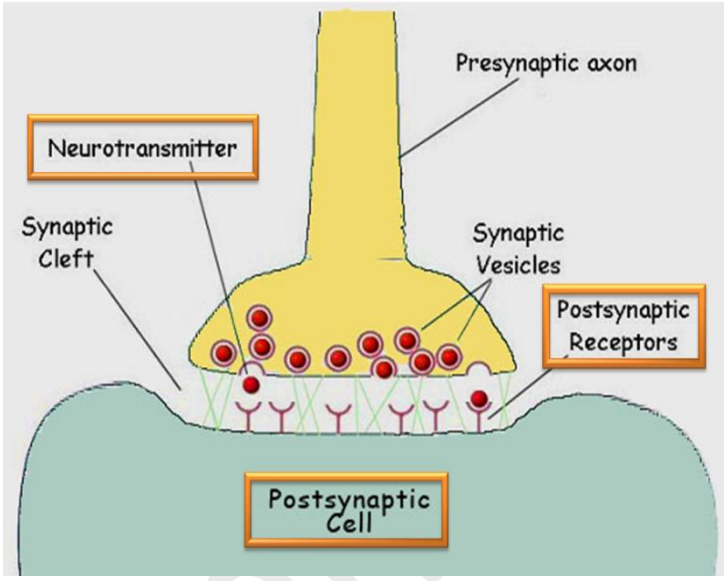
- Acetylcholine(Ach)
- Norepinephrine(Ne)

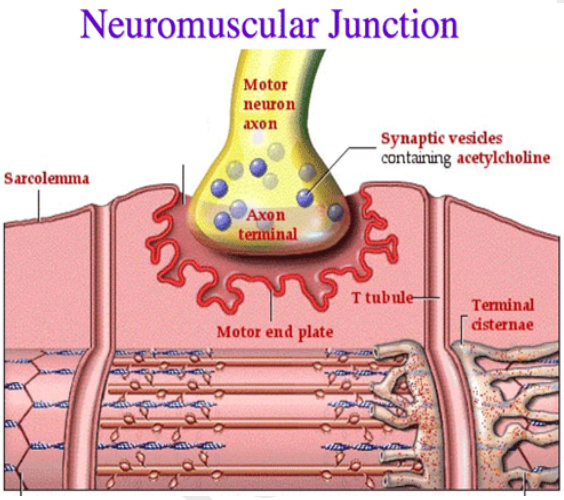
Postsynaptic Cell:

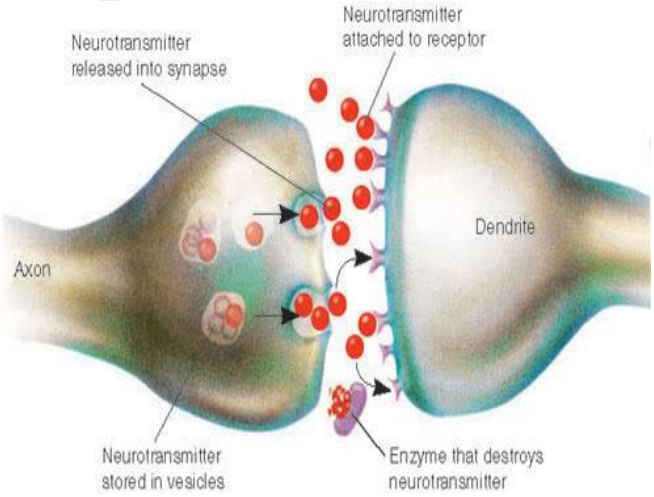
- Gland cell
- Muscle Cell

Receptors:

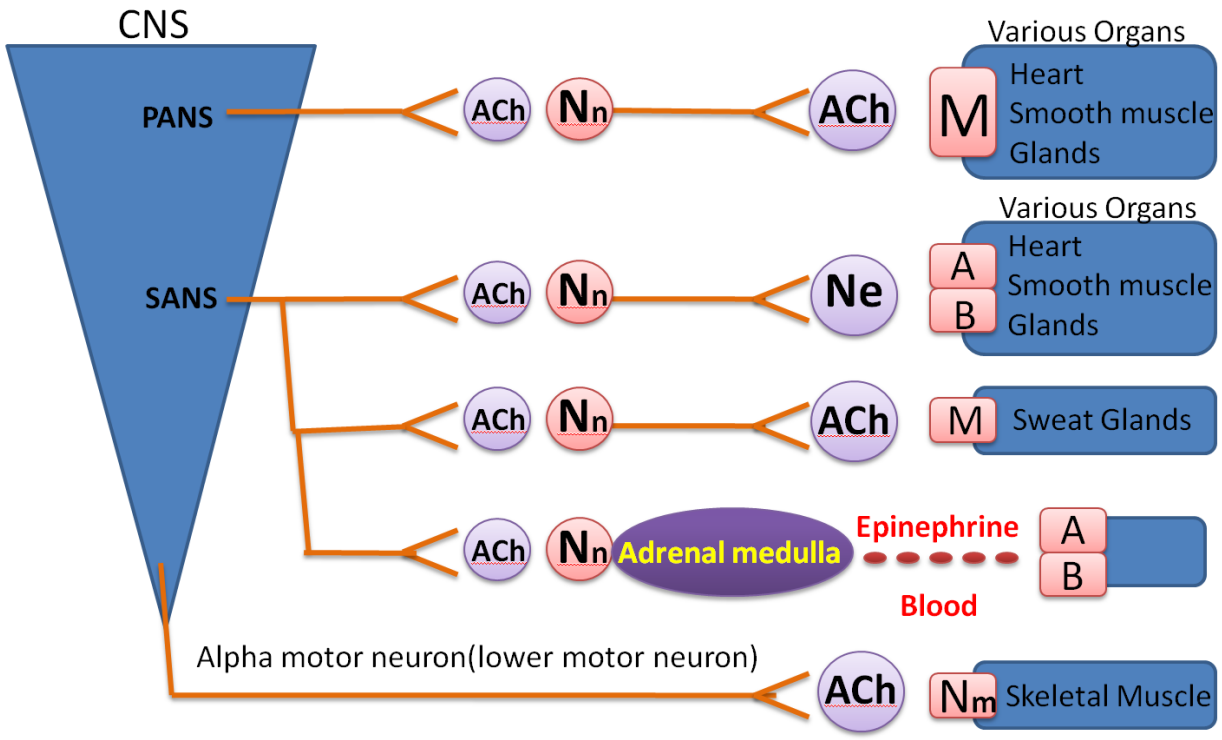
- Cholinergic Receptors
  - Muscarinic (M)
  - Nicotinic(N)
- Adrenergic Receptors
  - B(B1, B2), A(A1, A2)







Chemical synapses may be communication site between neuron-cell (gland, smooth muscle), neuron-skeletal muscle (Neuromuscular Junction), neuron-neruon (ganglion).



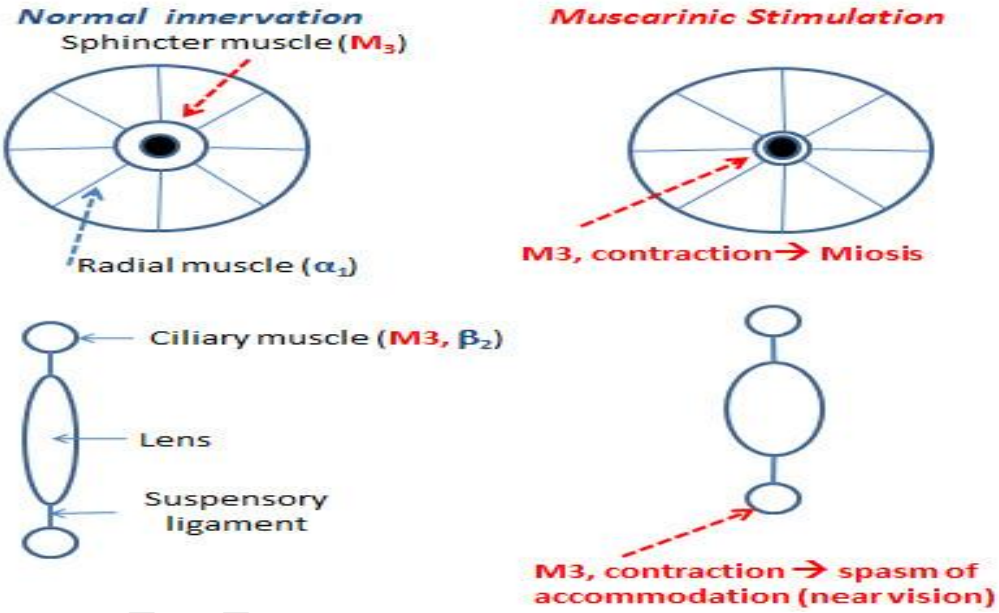
- Nicotinic receptors are located on skeletal muscles(Nm) and neurons (Nn).
- The synapse between the first neuron and second neuron is called: ganglion or preganglionic synapse. The synapse between the second neuron and the cell is called post-ganglionic synapse.
- The receptor in the ganglion (first synapse) is always Nicotinic (Nn).
- Therefore, the neurotransmitter released in the first synapse is always Acetylcholine.
- The receptor on skeletal muscles is always Nicotinic (Nm). Therefore, the neurotransmitter released in the neuromuscular junction by the alpha motor neuron is always Acetylcholine.
- The organs controlled by the Autonomic Nervous System (ANS) may have both cholinergic(muscarinic) and adrenergic receptors.
- Parasympathetic Autonomic Nervous Systemic activation will release Acetylcholine in the postganglionic synapse and stimulate muscarinic receptors. This will usually lead to a decrease in heart rate.
- Sympathetic Autonomic Nervous System activation will release Norepinephrine in the postganglionic synapse and stimulate adrenergic receptors. This will usually lead to increased heart rate.
- Stimulating muscarinic receptors will cause secretions in glands.
- Sweat glands have muscarinic receptors stimulated by the sympathetic system.

Adrenergic Receptors

- Norepinephrine: stimulates Alpha1, Alpha2, Beta1
- Epinephrine: stimulates Alpha1, Alpha2, Beta1, Beta2

A1: Arterioles >>> contraction >>> increase BP
B1: Heart >>> increase rate, contraction
B2: Lungs >>> bronchodilation
A2: inhibits Ne

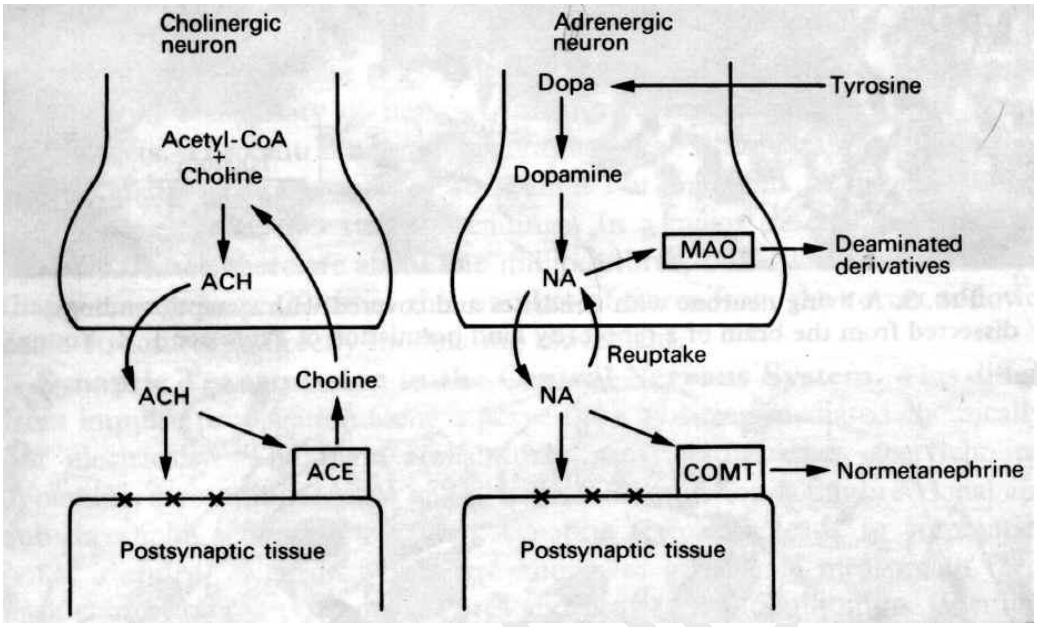
In a patient suffering from anaphylaxis with difficulty breathing, should we use epinephrine or norepinephrine or either??



Cholinergic Receptors

- Muscarinic stimulation will cause miosis.
- Muscarinic inhibition will cause mydriasis.
- Adrenergic stimulation will cause mydriasis.
- Adrenergic inhibition will cause miosis.
- Cholinergic drugs affect the ciliary muscle leading to blurry vision unlike adrenergic drugs.

<u>Conclusion:</u> cholinergic(muscarinic) drugs cause miosis and blurry vision



Notes

- Tyrosine (amino acid) enters cell to create dopa which turns into dopamine which turns into norepinephrine. Ne is released into synapse and may re-enter the cell (reuptake).
- Ne is metoblized by monoamine oxidase (MAO) inside the neuron, or by COMT within the synapse.
- Acetylcholine is metabolized in the synapse by Acetylcholinesterase which results in choline. Choline re-enters the neuron to create new Acetylcholine.
- If a drug stimulates the action of receptors it is referred to as an Agonist.
- If a drug inhibits the action of receptors it is referred to as an Antagonist.
- If a drug attaches to the receptor it is referred to as Direct.
- If a drug affects activity of a receptor without attaching, t is referred to as Indirect.

Nervous System

- Peripheral Nervous System
  - Autonomic Nervous System (sympathetic and parasympathetic)
  - Somatic Nervous System

- Central Nervous System

Central Nervous System

Neurotransmitters in the CNS include and not limited to:

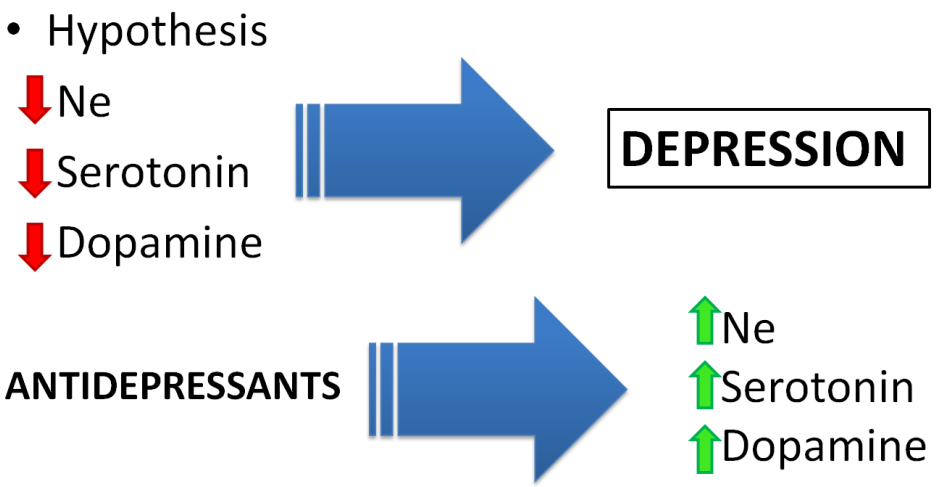
- Norepinephrine
- Acetylcholine
- Serotonin
- Dopamin
- GABA
- Glutamate

GABA type drugs: (Sedation, Anxiolytic, anticonvulsant)

- Benzodiazepines(Diazepine, Medazolam)
- Barbiturates (thiopental, phenobarbital)
- Alcohol

Antidepressants

A hypothesis was made that depression was due to a decrease in Norepinephrine, Serotonin and dopamine in the CNS. The treatment was directed towards increasing these neurotransmitters in the CNS.



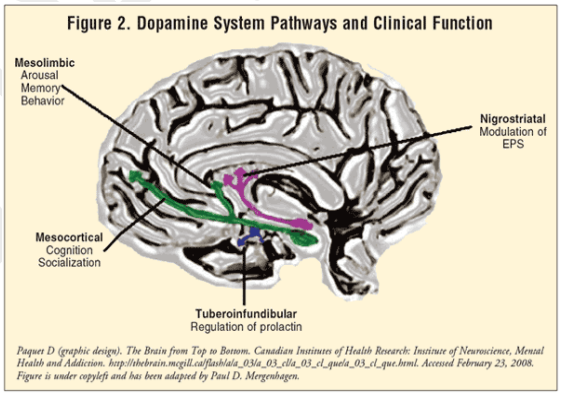
MAO inhibitors → ↑Ne, ↑Serotonin, ↑Dopamine

Tricylcic Antidepressants → ↑Ne, ↑Serotonin

Serotonin Selective Reuptake Inhibitors → ↑Serotonin

Antipsychotics

Nigrostriatal	Mesolimbic
Movement	Behavior
DA v.s. Ach	DA v.s. Serotonin



Nigrostriatal (Movement)

- Dopamine is critical to allow initiation of movement
- Increase DA >>> dyskinesia(hyperkinetic)(TD)
- Decrease DA >>> Parkinsons (pseudo-parkinsonism)

A decrease in dopamine and increase in Ach may lead to Parkinsons.
The treatment of Parkinsons is to increase Dopamine (Levodopa) and sometimes reduce the Ach with anticholinergics.

↓DA & ↑Ach >>>>>> Parkinsons

Parkinsons → Levodopa >>> ↑DA; Anticholinergic >>> ↓Ach

Mesolimbic tract(mood/behavior)

- Increase DA >>> positive reinforcement >>> drugs of abuse and may cause **psychosis**
- Decrease DA >>> don't feel good
- An increase in dopamine and decrease in serotonin may lead to Psychosis (schizophrenia for example)
- Treatment is directed towards decreasing dopamine.

↑DA & ↓5HT >>>> Psychosis(Schizophrenia)

Psychosis → Antipsychotics ↑5HT & ↓DA

Dopamine Summery

Movement >>>	↑DA	>>> Hyperkinesis(Diskinesis)
	↓DA	>>> Parkinson (Bradykinesis)
Behavior >>>	↑DA	>>> Euphoria >> Psychosis
	↓DA	>>> ↓cognitive function
Emesis >>>	↑DA	>>> Emetic
	↓DA	>>> Antiemetic

CNS pharmacology

- Antidepressants >> ↑Ne, ↑Serotonin, ↑Dopamine
- AntiPsychotics >> ↓Dopamine
- AntiParkinson >> ↑Dopamine

Histology

General Review

Epithelium

Connective Tissue

Oral Mucosa

Bone

Alveolar Process

Periodontium

Cementum

Blood

Hemostasis and Coagulation

Immune System

Enamel

Pulp-Dentin Complex

Tissue	Cells	Extracellular matrix	Main functions
Epithelium	Aggregated polyhedral cells	Small amount	Lining of surfaces or body cavities. Glandular secretion
Connective	Many types of fixed and wandering cells	Abundant amount	Support and protection
Nervous	intertwining elongated processes	None	Transmission of impulses
Muscular	Elongated contractile cells	Moderate amount	Movement

Organs can be divided into **parenchyma,** which is composed of the cells responsible for the main functions typical of the organ, and the **stroma**, which is the supporting tissue (connective tissue except in the brain and spinal cord)

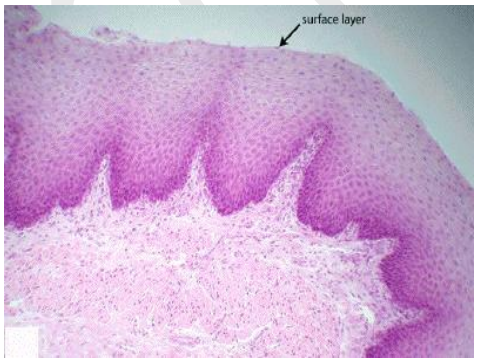
EPITHELIUM

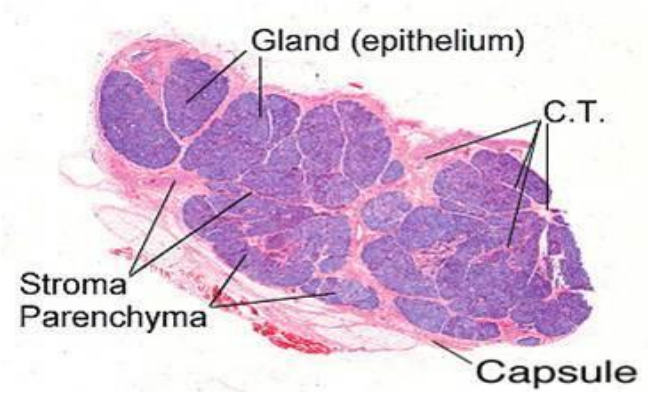
Functions

- Covering, lining and protecting surfaces.
- Absorption (Intestines)
- Secretion (epithelial cells of glands)
- Contractility (myoepithelial cells in glands)
- Sensation (temp. touch, pain, taste buds)

Two types

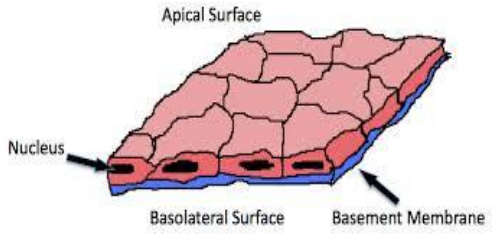
- Lining epithelium
- Glandular epithelium



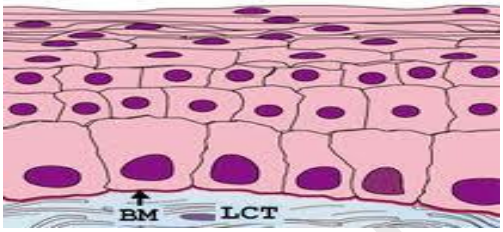


Lining Epithelium

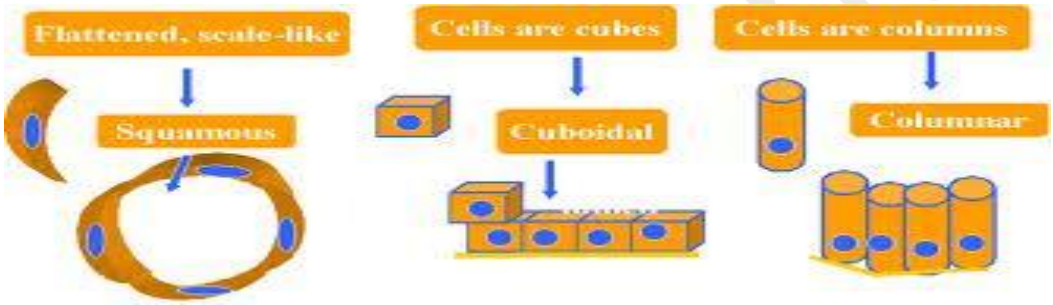
Simple Epithelia (one layer)



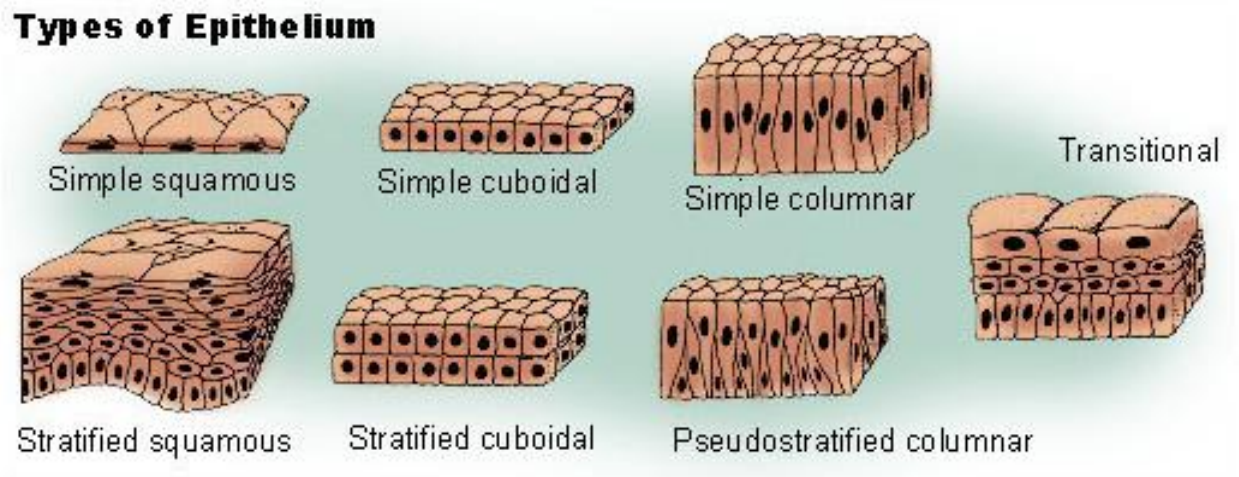
Stratified Epithelia (multiple layers)



Simple epithelium is classified based on the shape of the cell (squamous, cuboidal or columnar). Stratified epithelium is classified based on the shape of the surface cell layer.



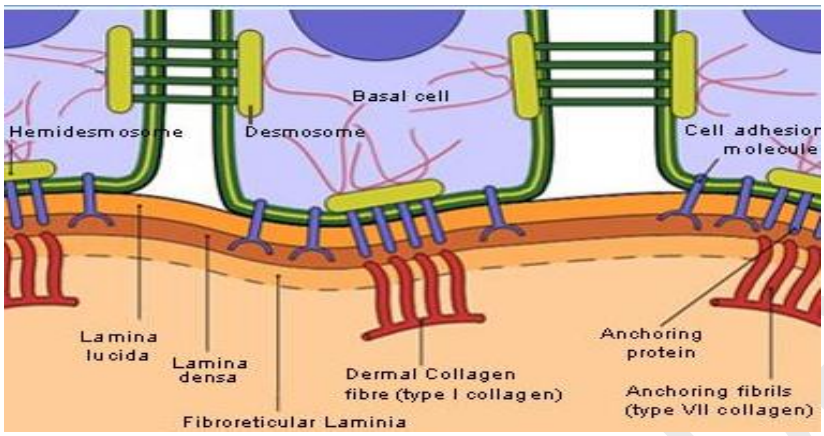
The different combinations will give multiple types of lining epithelium. The epithelium in the oral cavity is mainly *Stratified Squamous Epithelium*. The epithelium in the sinus and respiratory airways is *Pseudostratified Columnar Epithelium.*

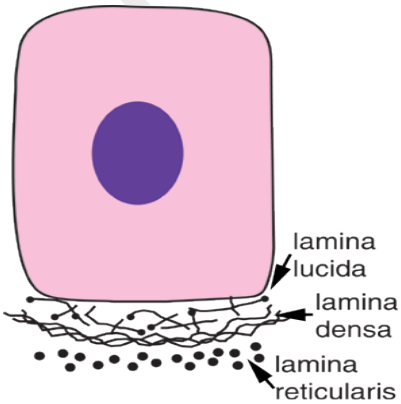


Adhesions and Junctions

In order to understand the function of epithelium and underlying connective tissue, we must understand how well all these components adhere to one another. We will study the junctions between the following components:

- Epithelium – Connective tissue junction (Basement Membrane)
- Cells - Cells junctions within epithelium (Intercellular Junctions)



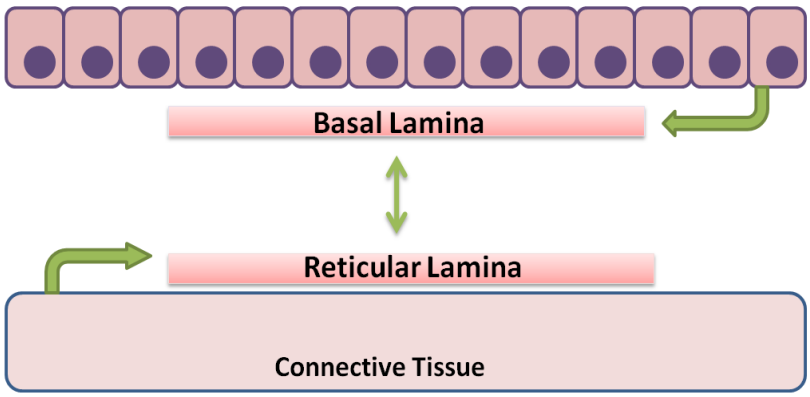


Basement Membrane

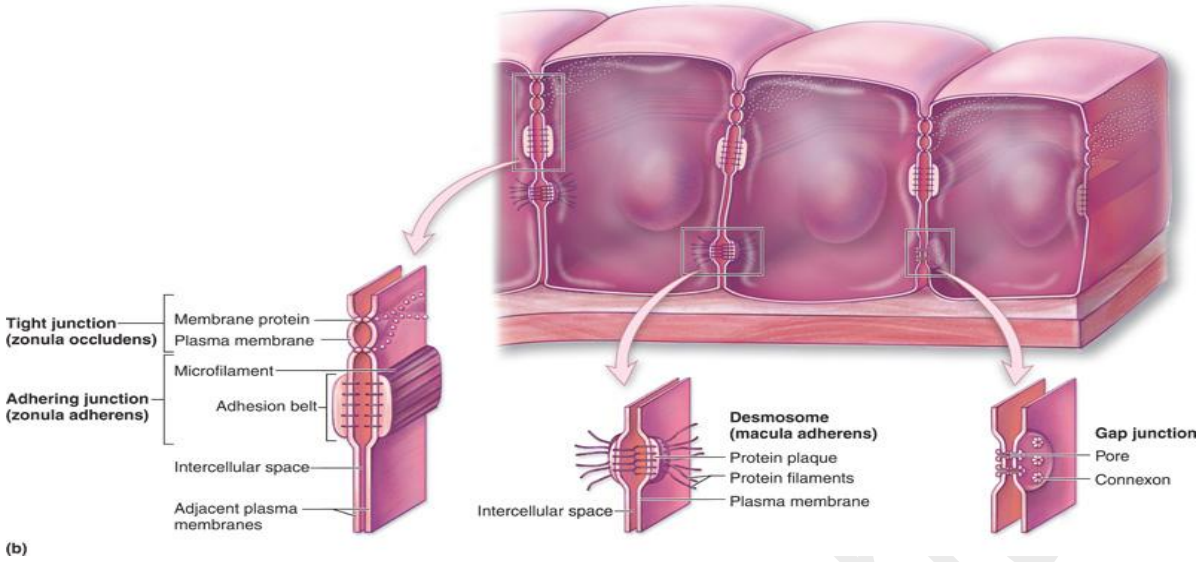
The basal cells of epithelium secrete the Basal Lamina.
The fibroblasts in the connective tissue secrete the reticular lamina.
The basal lamina and reticular lamina form the Basement membrane.
The basal cells attach to the basal lamina with hemidesmosomes.
The basal lamina consists of two layers: lamina lucida and lamina densa.

Basal Lamina
- Laminin
- Type 4 collagen
- Entactin

Reticular Lamina
- Type 3 collagen
- Type 7 collagen



Autoantibodies are directed against one or more components of the basement membrane (and hemidesmosome) in Pemphigoid >>> blisters.



Intercellular Junctions

Tight junctions, zonula occludens.

- Encircles the cell, main protein claudin.
- Principle function to form a seal that prevents the flow of materials between epithelial cells in either direction.
- Prevents the integral membrane proteins of the apical surface from being transferred to the basolateral surface and vice versa. This allows the two sides of the epithelium to maintain different receptors and function differently.

Adherent Junction

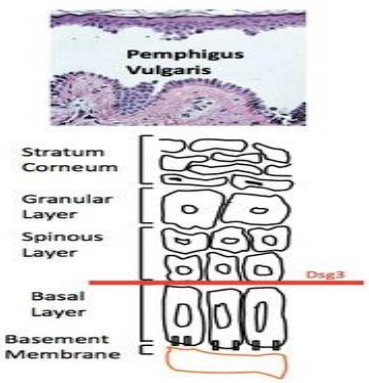
- Encircles the cell, glycoprotein cadherins
- Provides firm adhesion of one cell to its neighbors.

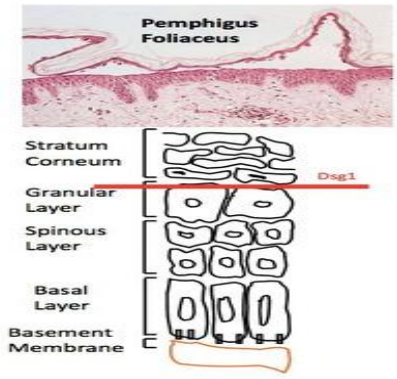
Desmosome

- Spot adherens , does not encircle the cell.
- Very strong, provides firm adhesion among the cells.
- Contain desmoglein 3, target of antibodies in pemphigus vulgaris.

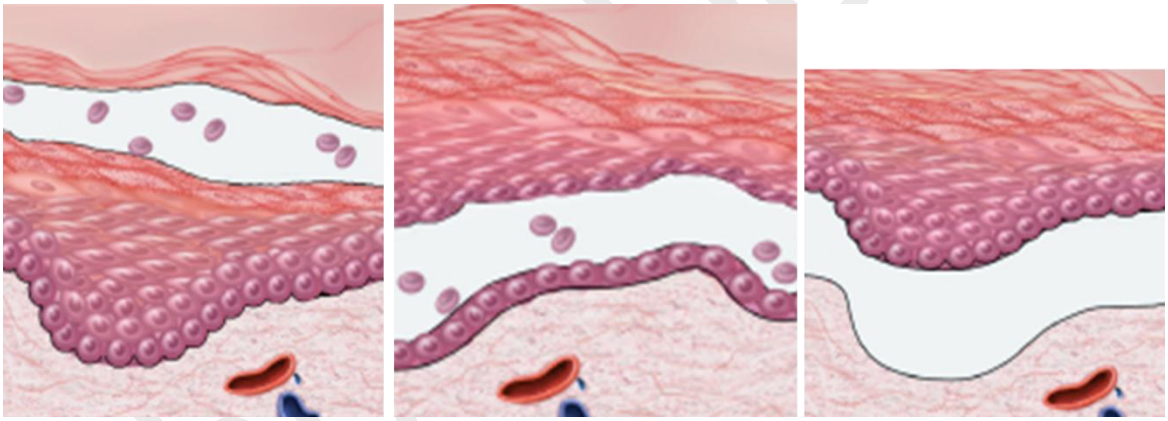
Gap Junctions (communicating junctions)

- Can occur almost anywhere along the lateral membranes of epithelial cells (don't encircle)
- Permit rapid exchange between cells of molecules with small diameters.
- Allows many tissues to act in a coordinated manner (example: heart muscle)





Blood vessels do not penetrate an epithelium and nutrients for the epithelial cells must diffuse from the lamina propria across the basal lamina and are taken up through the basolateral surfaces of the epithelial cell.
Some nerve endings penetrate the basal lamina.



Cells of Epithelium

Keratocytes

Stratified squamous epithelium:

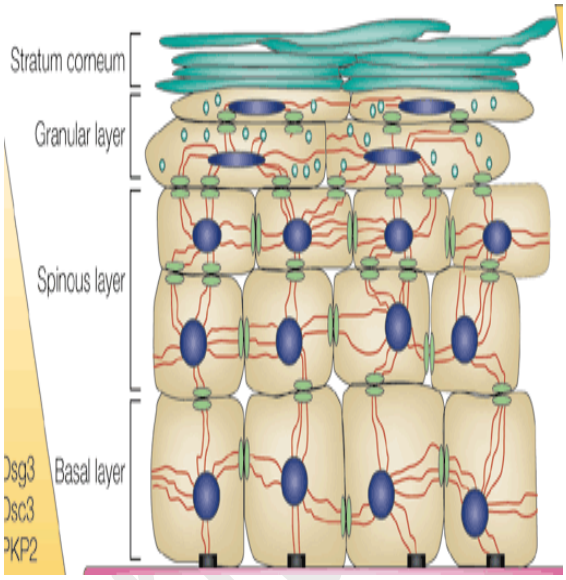
- Keratinized
- Non keratinized

In In stratified epithelial tissues, mitosis mostly occurs within the basal layers in contact with the basal lamina

Keratinized Stratified Epithelium

From basement membrane :

1. Basal layer(stratum basale)
    - Cuboidal or columnar cells, site of most cell divisions
2. Prickle layer (stratum spinosum)
3. Granular layer (stratum granulosum)
    - Contain keratohyaline granules
4. Keratinized (stratum corneum)

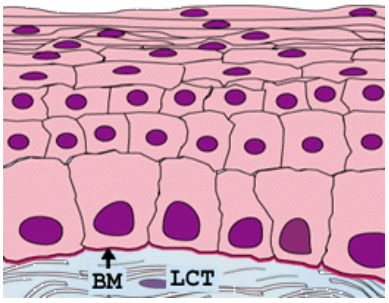


- **Prickle** = akanthe(greek)
- **Acanthosis**: increased thickness of prickle cell layer. Example: leukoplakia
- **Acantholysis**: separation of cells caused by loss of the intercellular bridges in prickle layer. Example : pemphigus

Non keratinzed Stratified Epithelium

From basement membrane :

1. Basal layer (stratum basale)
2. Prickle layer (stratum spinosum)
3. Intermediate layer
4. Superficial layer



Non keratinized epithelium could become keratinized in response to chronic irritation (frictional, heat) such as in Linea alba or keratosis.

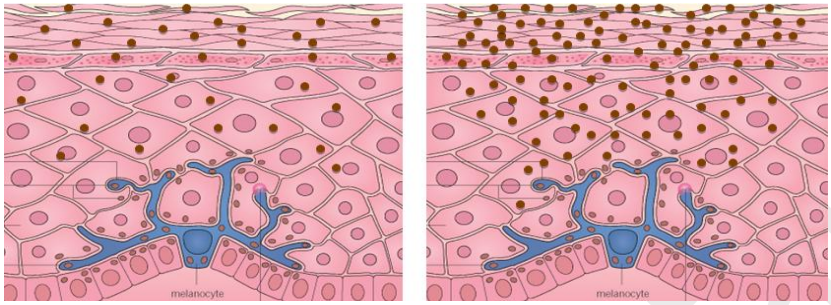
Hyperkeratosis of keratinized oral epithelium is a physiologic response to chronic irritation but can also be associated with abnormal cellular changes that eventually lead to cancer of the squamous epithelium.

Keratinized Stratified Squamous Epithelium	Non Keratinized Stratified Squamous Epithelium
Hard palate	Lips
Gingiva	Buccal mucosa
Dorsum of tongue	Alveolar mucosa
	Soft palate

Non Keratocytes

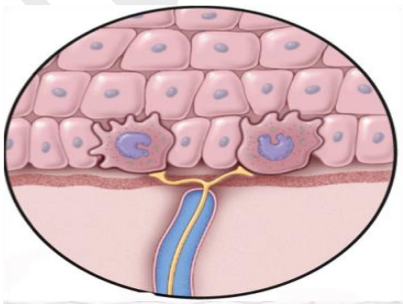
Melanocyte

- Dendritic cells that produce melanin >> pigmentation.



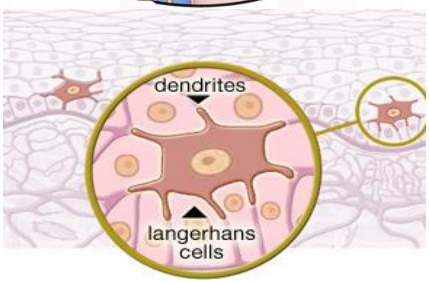
Merkel cells

- In the basal layer of epithelium
- Not dendritic, has desmosomes (cant move)
- Sensory and respond to touch.
- Contains vesicles, that could trigger an impulse within adjacent nerve fiber.



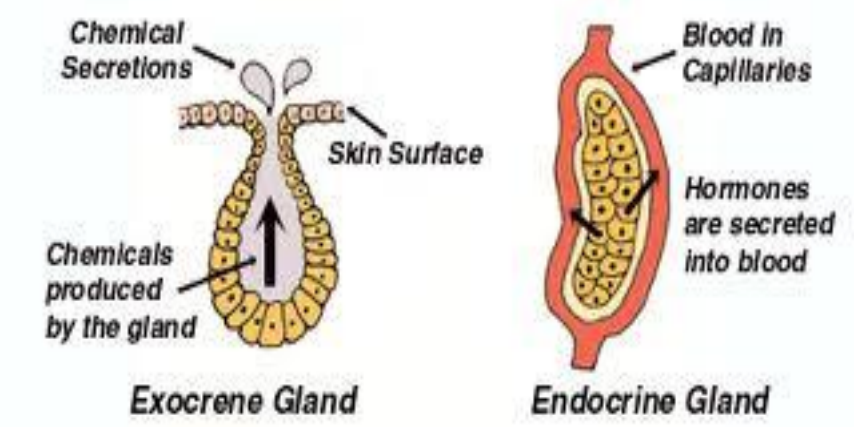
Langerhans Cells

- Dendritic cell, source is bone marrow
- Recognized antigenic material and presents them to T-lymphocyte (anitgen presenting)
- Moves within epithelium
- Origin is bone marrow (hematopoietic stem cell)



Inflammatory Cells

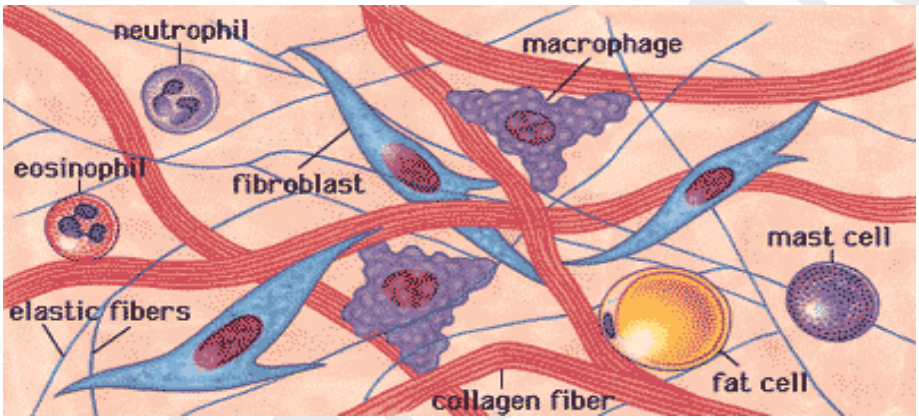
Glandular Epithelium



Carcinoma(Gr. Karkinos = cancer + oma = tumor): Malignant tumor of epithelial cell origin.
Adenocarcinoma(Gr. Adenos = gland + karkinos): Malignant tumors from glandular epithelial.
Undifferentiated carcinomas are difficult to diagnose, detect keratin by immunocytochemistry

- Keratinized squames >> Squamous cell carcinoma
- Basal cell layer >>> Basal cell carcinoma
- Melanocyte >>> Melanoma, Nevus, Macule
- Merkel cell >>> Merkel cell carcinoma
- Langerhans cell >>> Langerhan's Cell Histiocytosis

CONNECTIVE TISSUE



Connective tissue components

- Cells (Fibroblast)
- Fibers (Collagen, Elastin)
- Ground substance

The cells of connective tissue produce the extracellular matrix (fibers + ground substance)

Fibroblasts

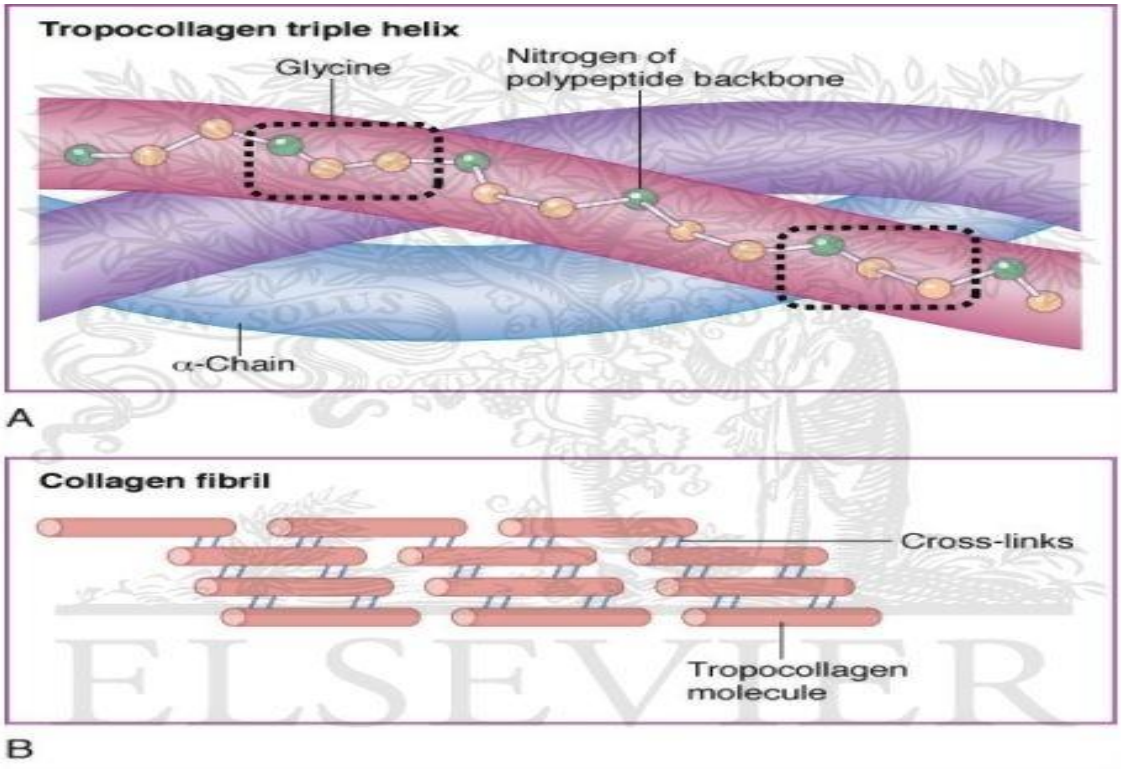
- Predominant cells of connective tissue. They are responsible for the formation and maintenance of the fibrous components and the ground substance of connective tissue.
- Fibroblasts originate from mesenchymal cells. Once differentiated they can replicate by mitosis.
- Exhibit motility and contractility, which are important during formation and remodeling, and during wound repair. In certain tissues, fibroblasts have significant contractile properties and are called *myofibroblasts.*

Fibrous Elements

Collagen

Elastin

Reticular Fibers



Collagen

- Mesenchymal cells and their derivatives (fibroblasts, chondroblast, osteoblasts, odontoblasts, and cementoblasts) are the major producers of collagen.
- Collagen are proteins, the most amino acids are glycine, hydroxyproline, hydroxylysine, proline.
- Degradation is initiated by specific enzymes called collagenases, members of matrix metalloproteinases or MMPs

- Vitamin-c is important for the hydroxylation of amino acids in collagen synthesis.
- In the periodontal ligament the collagen turnover rate is very high (8 times that of collagen in the skin and twice that of gingival collagen)
- In vitamin-c deficiency, tissues with high collagen content and turnover rate are affected severely >>> one of earliest symptoms of scurvy is loosening of the teeth.

Collagen Type 1

Most abundant collagen

- Skin, bone, dentin, cementum, tendons, ligaments, most connective tissue, pulp

Collagen Type 2

- Cartilage

Collagen Type 3

- Main collagen in reticular fibers
- Abundant in elastic tissues
- Pulp, skin, blood vessels

Collagen Type 4

- Basal lamina collagen, network forming collagen
- Major component of the basal lamina.
- Product of epithelial cells.

Collagen Type 7

- Anchoring fibril collagen
- Present in the anchoring fibrils that bind the basal lamina to reticular fibers in the underlying connective tissue.
- Fibroblasts produce both type 1 and type 3 in the pulp, odontoblasts produce only type 1 in dentin.

Dentin contains Type 1 collagen, Pulp contains collagen type 1 and type 3
Basement membrane contains collagen type 4 and type 7

Osteogenesis imperfecta : Mutation in genes >> bad collagen
Systemic sclerosis: Over accumulation of collagen (fibrosis)
Keloid: local swelling caused by abnormal amounts of collagen that form in scars of the skin.
Scurvy (VIT-C deficiency): PDL severely affected , high turnover rate

Elastin

- Secreted by fibroblasts in connective tissue and by smooth muscle cells in the walls of blood vessels.
- Forms fibers or sheet-like structures, both of which can be stretched by external forces.
- Elastin is resistant to digestion by most proteases, but is easily hydrolized by pancreatic elastase.

- Elastic properties of elastin result from numerous intermolecular cross-links between lysine groups.

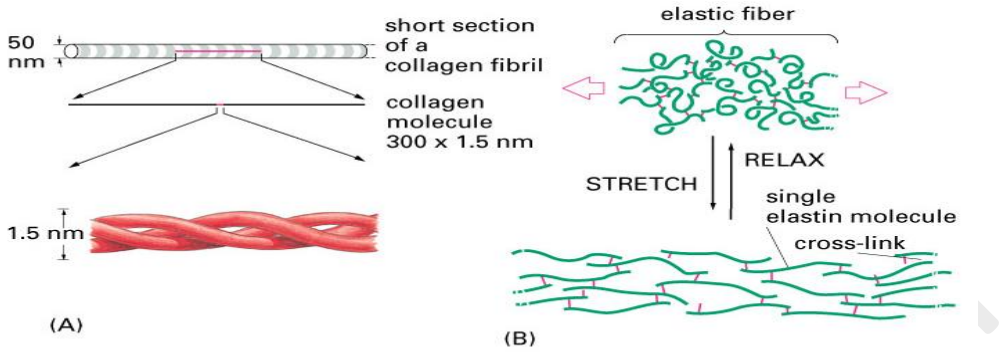


Figure 4-28 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Reticular Fibers

- Consist mainly of collagen type 3
- Reticular fibers constitute a network around the parenchymal cells of various organs (liver, endocrine)
- Abundant in the framework of hematopoietic organs (spleen, lymph nodes, red bone marrow)
- In the latter sites, reticular fibers are produced by fibroblast-like cells called reticular cells.

Ground Substance

Glycosaminoglycans (GAGs)

- Hyaluronic acid

Proteoglycans

- Aggrecan (dominant in cartilage)
  - Chondroitin sulfate
  - Keratin sulfate

Multi-addhesive glycoproteins

- Fibronectin (binding sites for collagens, GAGs, and cell membranes)

Bacteria that produce hyaluronidase have greater invasive power because they reduce the viscosity of the connective tissue GS.
Hyaluronidase, an enzyme that hydrolyzes hyaluronic acid and other GAGs.

Edema: accumulation of water in the extracellular spaces. Water in the extracellular compartment of connective tissue comes from blood.

Edema may result from

- Venous or lymphatic obstruction.
- Decrease in venous blood flow(congestive heart failure).
- Obstruction of lymphatic vessels.
- Increased permeability of blood capillary endothelium resulting from mechanical or chemical injury or release of histamine (inflammation).

Matrix Metalloproteinase

A large Family of proteolytic enzymes that are responsible for extracellular matrix degradation. Degradation is important for connective tissue remodeling.
MMPs are synthesized and secreted by fibroblasts, inflammatory cells, and some epithelial and tumor cells.
Fibroblasts secrete the activators and the inhibitors of MMPs.

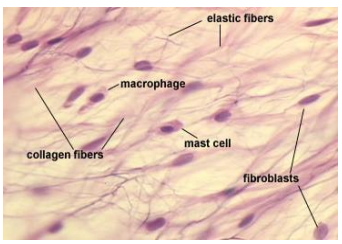
MMPs:

- Collagenases (MMP-1 , MMP-8, MMP-13)
- Gelatinases (MMP-2, MMP-9)
- Metalloelastase (MMP-12)
- Stromelysins (MMP-3, MMP-10)
- Matrilysins (MMP-7, MMP-26)

Connective Tissue proper

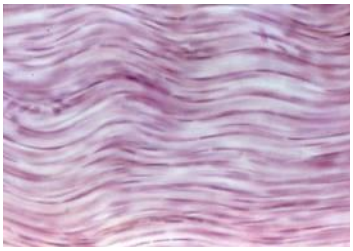
Loose Connective Tissue

- Has (cells, fibers, GS) in roughly equal parts.
- Supports structures normally under some pressure and low friction.
- Delicate consistency, flexible, well vascularized and not very resistant to stress.



Dense Connective Tissue

- Fewer cells and a clear predominance of collagen fibers over ground substance.
- Offers resistance and protection.
- Less vascularized, less flexible and far more resistant to stress than is loose connective tissue.



Oral Mucosa

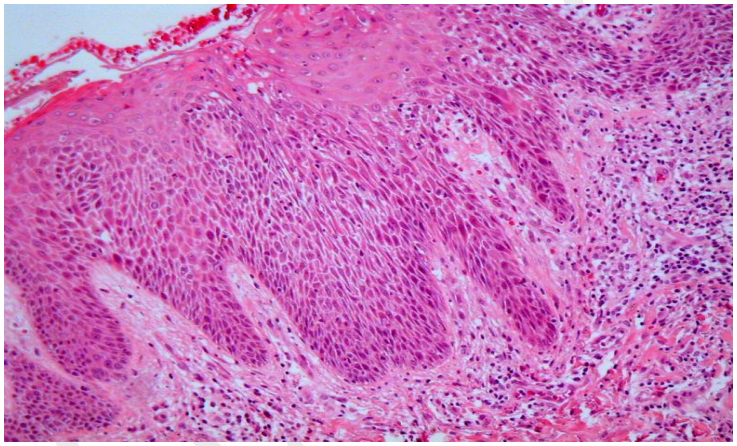
Mucous membrane : a term used to describe the moist lining of the GI tract, and other body cavities that communicate with the exterior. In the oral cavity this lining is called the *oral mucous membrane* or *oral mucosa*.

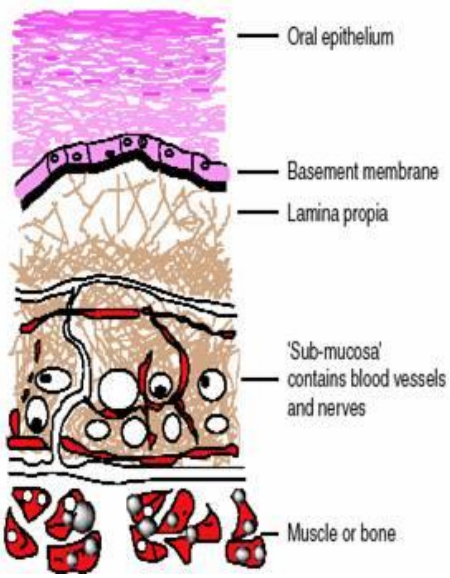
Oral mucosa:	Epithelium	Lamina propria
Skin:	Epidermis	Dermis

Most epithelia rest on connective tissue. In case of epithelia lining the oral cavity this layer of connective tissue is called the **Lamina propria**.

The **lamina propria** supports the epithelium provides nutrition, and binds it to the underlying structures.

The area of contact between epithelium and lamina propria is increased by irregularities in the connective tissue surface in the form of small evaginations called **papillae**. Papillae occur most frequently in the epithelial tissues subject to friction, such as the covering of the skin or tongue. Papillae interdigitate with epithelial ridges or pegs called **rete pegs.**





Color

- Concentration and dilation of blood vessels in the underlying connective tissue.
- Thickness of the epithelium.
- Degree of keratinization.
- Amount of melanin pigment in epithelium.

Submucosa

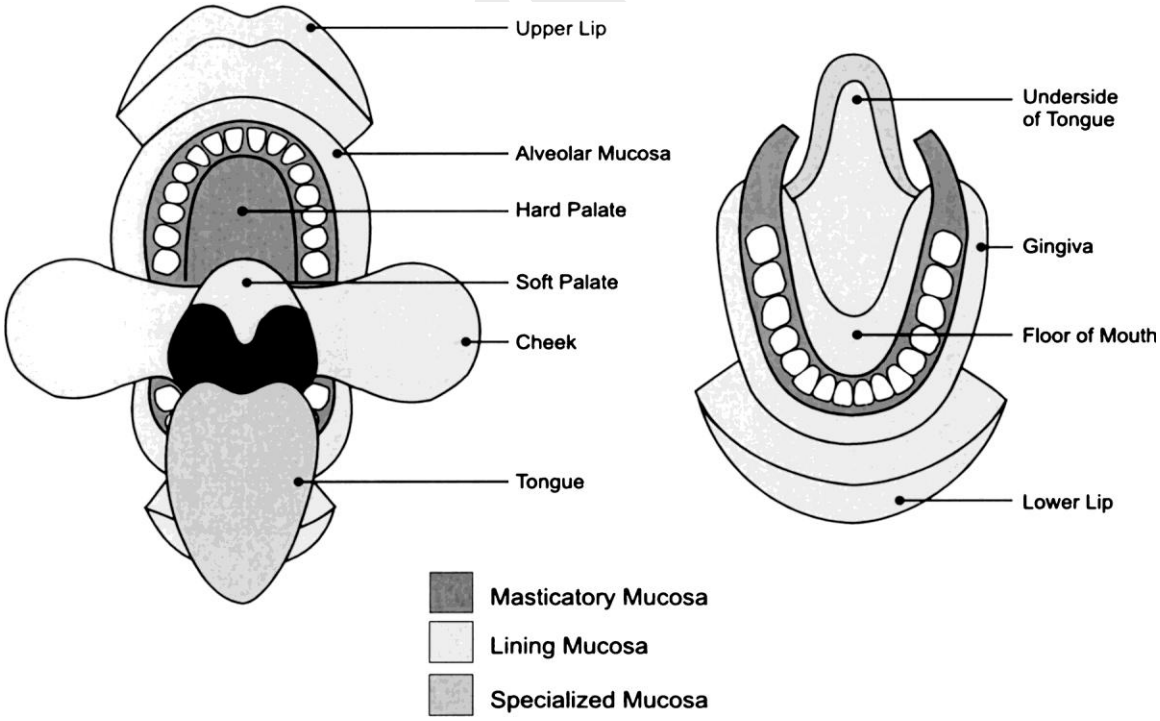
- A layer of loose fatty or glandular connective tissue containing the major blood vessels and nerves that supply the mucosa.
- Separates the oral mucosa from underlying bone or muscle.
- Its composition determines the flexibility of oral mucosa.
- In regions such as the gingiva and parts of the hard palate, oral mucosa is attached directly to the periosteum of underlying bone, with no intervening submucosa. This arrangement is called a ***mucoperiosteum*** and provides a firm inelastic attachment.

Oral Mucosa composed of two layers:

- Stratified squamous epithelium
- Supporting connective tissue (lamina propria)
- The epithelium may be keratinized or non-keratinized

Oral Mucosa is classified into 3 major functional types:

- Masticatory mucosa
- Lining mucosa
- Specialized mucosa



- **Masticatory Mucosa**

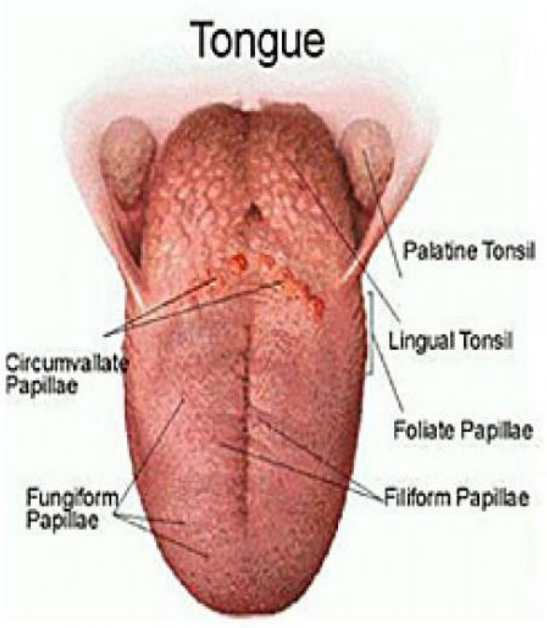
- Hard palate and gingiva, (dorsum of tongue?)
- Epithelium is keratinized.
- Lamina propria dense firm collagenous.
- Numerous elongated papillae probably provide good mechanical attachment between epithelium and lamina propria. (prevents epithelium from being stripped off under shear force)
- No distinct submucosa, except in lateral regions of the palate where there is fibrous submucosa contains fat and glandular tissue that protect nerves and blood vessels of the palate against mechanical loads.
- Inextensible and well adapted to withstand abrasion.

- **Lining Mucosa**

- Inside of lips, cheek, vestibule, lateral surfaces of alveolar process, floor of mouth, soft palate, ventral surface of tongue.
- Non-keratinized epithelium
- lamina propria contains fewer collagen
- Submucosa is loose connective tissue
- Interface with connective tissue is smooth.
- Movable tissue, flexible and withstands stretching.

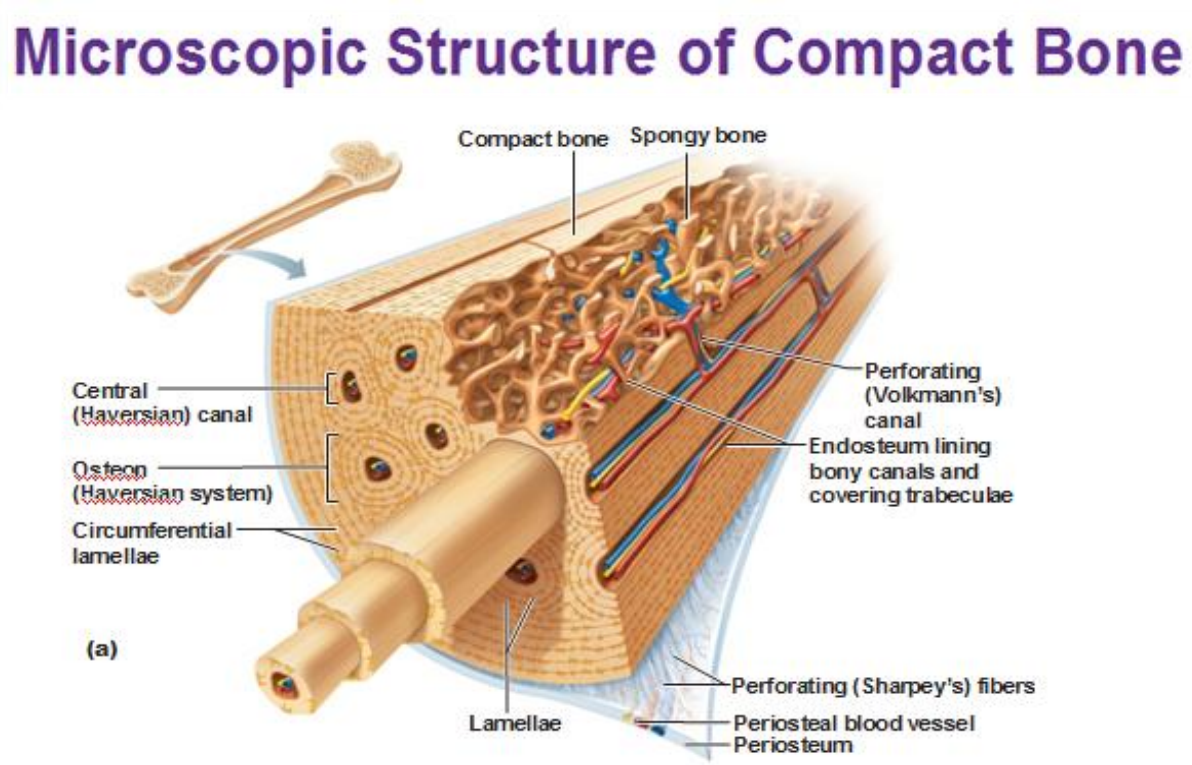
- **Specialized Mucosa**

- Dorsum of Tongue
- Functionally a masticatory mucosa, but because it has lingual papillae >> specialized.



- Filiform papillae (hair like)
- Fungiform papillae (fungus like)
- Foliate papillae (leaf like)
- Circumvallate papillae (walled)

BONE



Bone is specialized connective tissue composed of calcified intercellular material, the bone matrix, and three cell types.

Cells:

Osteoblasts, Osteocytes, Osteoclasts

- Osteoblasts:
- Synthesize the organic uncalcified matrix of bone called Osteoid(mainly collagen 1). Important role in calcification.
- Osteocytes:
- Found in cavities (lacunae) between layers (lamellae) of bone matrix.
- Osteoclasts:
- Multinucleated giant cells involved in resorption and remodeling of bone. Secrete collagenase, and forms acidic environment.

Bone matrix:

Inorganic , organic

The inorganic material is hydroxyapatite, and the organic material is primarily type 1 collagen, which is surrounded by a ground substance of glycoproteins and proteoglycans.

All bones are lined on both internal and external surfaces by layers of connective tissue containing osteogenic cells.

- Endosteum on the internal surface
- Periosteum on the external surface

Types of bone

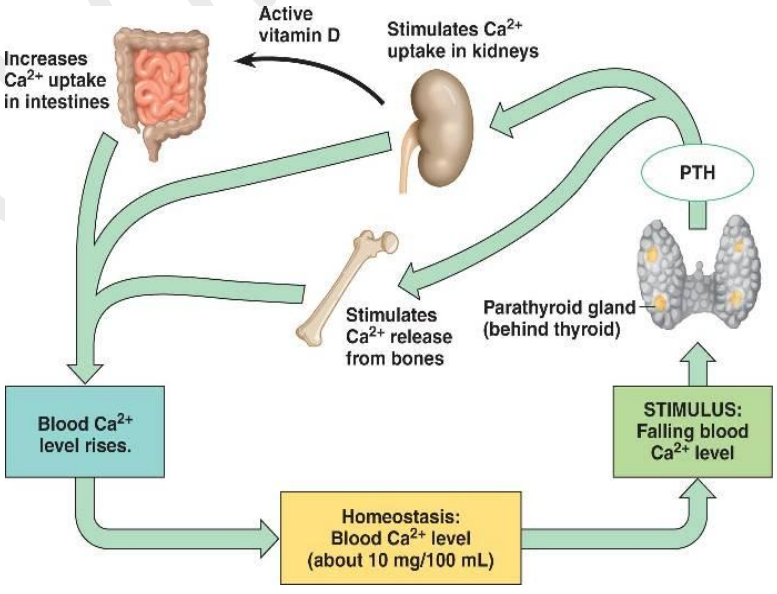
- All bones have a dense outer sheet of compact bone and a central cavity filled with bone marrow that is interrupted by a network of bone trabeculae (spongy bone).
- Compact bone: shows dense areas generally without cavities in cross section.
- Cancellous (spongy) bone: areas with numerous interconnecting cavities.
- These two types of bone behave differently and have different metabolic responses. However, under microscope, both types have the same basic histological structure.

Bone Physiology

- Hydroxyapatite = calcium and phosphate ions
- The skeleton serves as the calcium reservoir and contains 99% of the bodies total Ca.
- Absorption of Ca and PO4 from intestines needs Vitamin D.
- Mineralization needs the enzyme alkaline phosphotase (increase PO4 concentration locally)

Low serum calcium will stimulate PTH secretion from the parathyroid glands. PTH will increases free plasma calcium by several mechanisms:

- Dissolves bone
- Increase Kidney absorption of Ca
- Activates Vitamin D



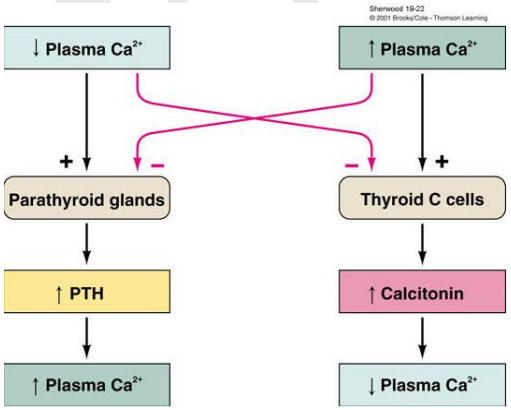
Calcium and Phosphate

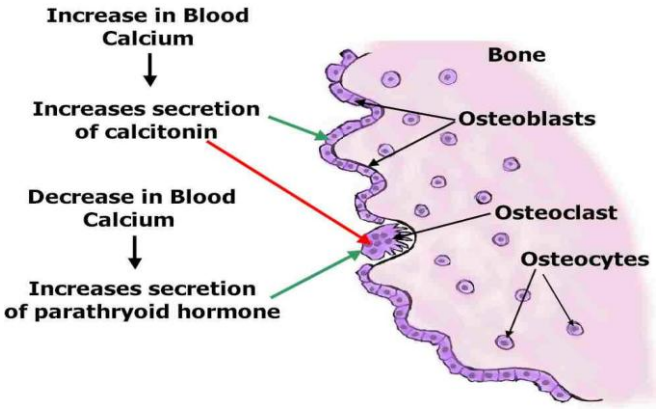
- 99% of calcium is in bone.
- 0.5% is protein bound, 0.5% is free in plasma.
- Only free calcium has biological effect/clinical effect.
- Phosphate is there to buffer up the calcium.
- Alkilosis >> cause decrease of free Calcium:
  - In alkilosis Hydrogen is removed from binding protein, Ca binds to the protein instead, >> decrease of free calcium.
- Acidosis >> Cause increase of free calcium.
- **Conclusion:** Acidosis >> hyperkalemia and hypercalcemia

- Ca vs PO4
- If Ca increases, PO4 normal >> bone is produced
- If Ca normal, PO4 increases >> bone is produced
- If Ca or PO4 decrease >> bone absorbed
- Example: decrease Ca and normal PO4 >> bone resorption >> release of Ca and PO4 >> PO4 excretion by kidney to keep it normal, Ca is retained to reach normal levels in plasma.

Calcitonin

- Peptide hormone, made in c cells/parafollicular cells of thyroid gland.
- Calcitonin is released only in pathologically elevated Ca levels.
- Calcitonin is not a major regulator of Ca levels, because in normal conditions it has unknown function.
- Calcitonin can be used therapeutically (inhibits osteoclasts)
  - Osteoporosis
  - Paget's disease of bone





- Indices of excess bone demineralization/remodeling
- Increase alkaline phosphate (associated with osteoblastic activity)
- Increase urinary excretion of hydroxyproline (breakdown product of collagen)
- Bone dissolving >> increase hydroxyproline in urine
- Bone making >> increase serum alkaline phosphate

Clinical

Excessive PTH >> (tumor, Kidney disease)
Osteopetrosis (genetic):
Osteomalacia
Rickets
Hypophosphatasia
Osteoporosis

Alveolar process

The bone of the jaws that contain the sockets for the teeth.
Consists of:
- Outer cortical plate (buccal and lingual compact bone)
- Central spongiosa (spongy bone)
- Alveolar bone: lining the alveolus

- The cortical plate and alveolar plate meet at the alveolar crest below the CEJ 1.5-2 mm
- Alveolar bone is perforated by many foramina thus it sometimes is referred to as the ***cribriform plate.***
- Radiographically, alveolar bone is referred to as the ***lamina dura***.
- The bone directly lining the socket (inner aspect of alveolar bone) specifically is referred to as ***bundle bone.***
- ***Bundle bone*** provides attachment for the PDL fiber bundles that insert into it.
- ***Sharpy's Fibers*** are portions of the principal collagenous fibers of PDL embedded in cementum and alveolar bone to attach the tooth to the alveolus .

- Cortical plate is supported by compact bone.
- The cortical plate is generally thinner in the maxilla, and thickest on the buccal aspect of the mandibular premolars and molars.
- The trabecular bone (spongy) occupies the central part of the alveolar process
- Trabecular bone is absent in the region of the anterior teeth >>> the cortical plate and alveolar bone are fused together.

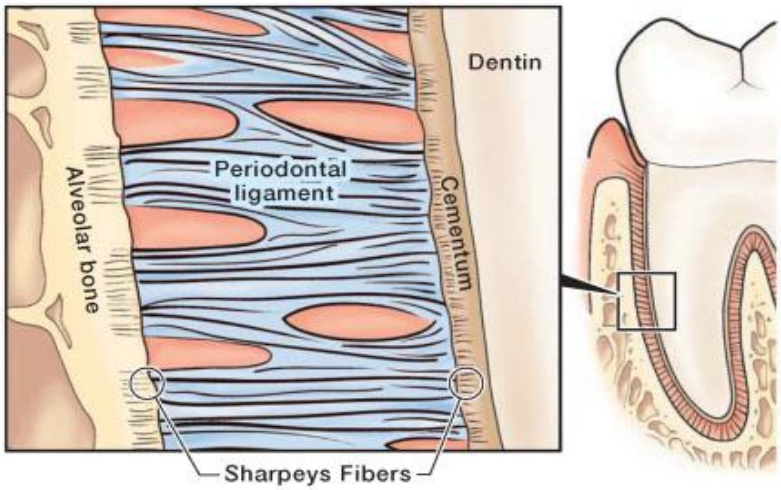


Figure 2.18. **Sharpey Fibers.** The ends of the periodontal ligament fibers that are embedded in the alveolar bone and the cementum are known as Sharpey Fibers.

Pg: 07 ***Ten Cate's Oral Histology Development, Structure, and Function***

"Although the histologic structure of the alveolar process is essentially the same as that of the basal bone, practically it is necessary to distinguish between the two"

Pg. 109 Ten Cate's Oral Histology Development, Structure, and Function

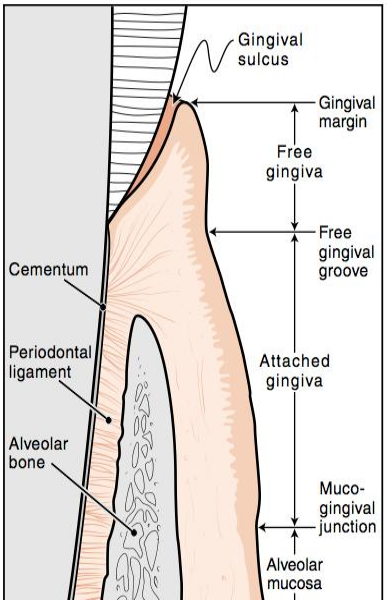
"These two types of bone behave differently and have different metabolic responses" referring to compact and cancellous bone

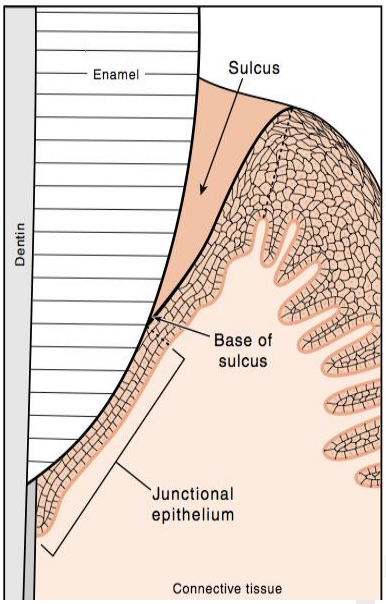
Card DD # 2 prostho, 2011-2012

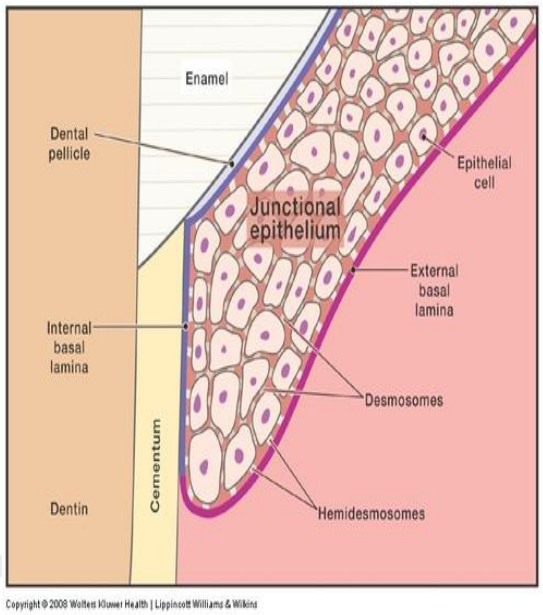
“The underlying basal bone (beneath the retromolarpad) is resistant to resorption. Coverage of this area will also provide some border seal. An overload of the mucosa will occur if the bases covering the area are too small in outline.”

Periodontium

Free Gingiva
Attached Gingiva
Keratinized Gingiva
Alveolar Mucosa
Mucogingival Junction
Free gingival groove
Junctional epithelium
Sulcular epithelium
Gingival Fibers
Periodontal Fibers







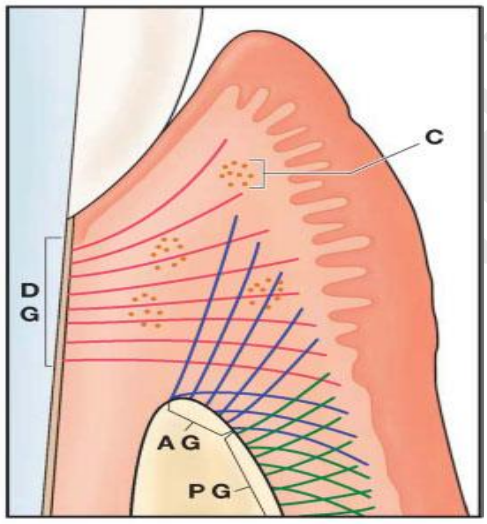
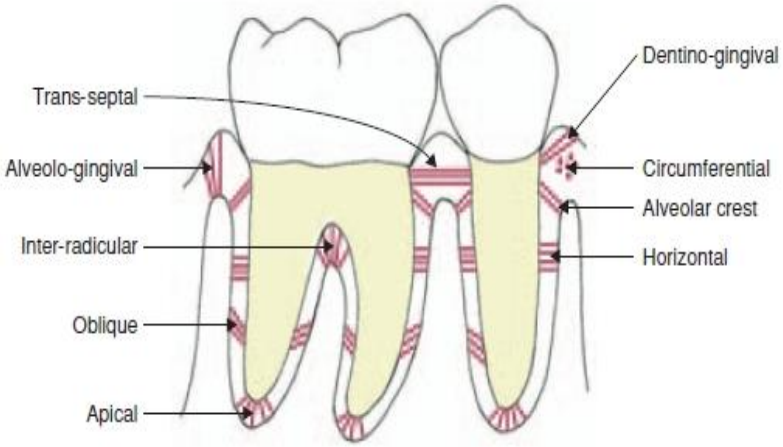


Figure 2.14. **Supragingival Fiber Groups.**

- C—circular
- AG—alveologingival
- DG—dentogingival
- PG—periostogingival



Cementum

Cementum is formed by cementoblasts which develop from undifferentiated mesenchymal cells in the connective tissue of the dental follicle (dental sac).

Consists of

- 45-50% inorganic material (hydroxyapatite)
- 50-55% organic matter and water
    - Organic portion is composed primarily of collagen(Sharpey's fibers) and protein polysachharides.
    - Cementum is avascular, and no nerve innervation.
    - Cementum is Formed continuously throughout life.

Two kinds of cementum are formed:

- Acellular (Primary)
- Cellular (secondary)
    - The acellular layer is living tissue that does not incorporate cells into its structure and usually predominates on the coronal half of the root.
    - The Cellular layer occurs more frequently on the apical half.

Acellular Cementum

- Primary, the first layers of cementum
- Formed at a slow rate
- No cementocytes embedded
- Coronal 2/3 of root

Cellular Cementum

- Secondary, the last layers of cementum deposited over the acellular layer
- Formed at a faster rate
- Contains embedded cementocytes
- Apical third

- Cellular cementum is usually the thickest to compensate for occlusal/incisal wear and passive eruption of the tooth.
- Cementum on the root end surrounds the apical foramen and may extend slightly onto the inner wall of the pulp canal.
- Cementum thickness can increase on the root end to compensate for attritional wear of the occlusal or incisal surface and passive eruption of the tooth.
- Cementum is capable of repairing itself to a limited degree.
- Cementum is similar to bone but harder and thus resists resorption during tooth movement >>> permits orthodontic movement.

BLOOD

Blood consists of plasma and cells.

- **Cells:**
- Erythrocyte
- Leukocyte
- Platelets

- **Composition of Plasma:**
- Proteins, nutrients, inorganic ions …..
- The major plasma proteins include:
- Albumin: the most abundant, made in the liver.
- Compliment proteins
- Immunoglobulins

Cells:

Erythrocytes (red blood cells)

- Lack nuclei, contain Hemoglobin (carry O2)
- Decrease RBC count results in anemia
- Increase RBC >> erythrocytosis/polycythemia
- Erythrocytes are normally quite flexible, permits them to adapt to small capillaries.
- Sickle cell disease >> inflexible and fragile RBC.

Leukocytes (white blood cells)

Divided into two groups:

- **Polymorphonuclear granulocytes.**
  - Neutrophils (60-70%)
  - Eosinophils (2-4%)
  - Basophils (0.5%)
- **Monoculear agranulocytes.**
  - Lymphocytes (28%)
  - Monocytes (5%)

Neutrophil (polymorphonuclear leukocyte)

- Most abundant leukocyte.
- Active phagocytes of bacteria and other small particles and are usually the first leukocytes to arrive at sites of infection, where they actively persue bacterial cells using chemotaxis.
- They are able to survive in an anaerobic environment.

- An increased number in neutrophils in blood is usually a response to a bacterial infection.
- Phagocytic leukocytes.
- Neutrophils are the predominant leukocyte in blood. Because neutrophils do not need to differentiate substantially to function, they are suited for rapid responses.
- They possess receptors for metabolites of the complement molecule C3.

Eosinophils

- Contains enzymes and proteins that have a cytotoxic effect on parasites.
- Eosinophils also phagocytose antigen-antibody complexes and modulate inflammatory responses in many ways.
- Eosinophils are an important source of the factors mediating allergic reactions (Type 1 allergy).
- An increase in eosinophils is associated with allergic reactions and parasitic infections.
- Found especially at sites of parasitic infection, or at allergic IgE- mediated sites.

Basophils

- Contains heparin and histamine.
- Contains other mediators of inflammation.
- Basophils may supplement the functions of mast cells in connective tissue.
- Both basophils and mast cells have heparin and histamine, have IgE bound to surface receptors, and secrete their granular components in response to certain antigens.
- In some individuals, a second exposure to a strong allergen >>> intense systemic response >>> basophils and mast cells rapidly degranulate >>> anaphylactic reaction.

Mast cells

- Activated when surface receptor-bound antigen-specific immunoglobulin E (lgE) encounters an antigen that the IgE recognizes.
- This triggers mast-cell degranulation, leading to the rapid release of inflammatory mediators, such as histamine, proteoglycans, and cytokines.
- Mast-cell activation also stimulates the arrival of other inflammatory cells - a critical step in local inflammation.
- Mast cells are not only necessary for allergic reactions, but recent findings indicate that they are also involved in a variety of neuroinflammatory diseases, especially those worsened by stress.
- In these cases, mast cells appear to be activated through their Fc receptors by immunoglobulins other than IgE, as well as by anaphylatoxins, neuropeptides and cytokines to secrete mediators selectively without overt degranulation.

Lymphocytes

- **T lymphocyte**
- **B lymohocyte**
- **Natural killer cells**

- Immune defense against invading microorganisms, foreign or abnormal antigens, and cancer cells.
- They are the only types of leukocytes that following diapedesis can return from the tissues back to the blood

- **B lymphocytes**

- Originate and mature in the bone marrow
- Covered with IgM surface receptors.
- B cells can re-differentiate into plasma cells if the B cell recognizes an antigen.
- Plasma cells can secrete antibodies.
- B cell activation requires T cell (helpers)
- Not all B cells become plasma cells, some remain as long lived B memory cells.
- Help control extracellular antigens such as bacteria, fungal, yeast, and virions.
- B cells recognize diverse antigens using the B-cell antigen receptor (BCR).
- After antigen exposure, some B cells differentiate to form plasma cells which secrete IgM. Others differentiate into memory B cells.
- They are important in antibody-mediated immunity.

- **T Lymphocytes**

- Recognize diverse antigens using a low-affinity transmembranous complex, the T-cell antigen receptor (TCR).
- T cells are subdivided based on whether they possess the co-receptors CD4 (T helper cells) or CD8 (T-cytotoxic cells).
- They are important in cell-mediated immunity Type 4 hypersensitivity reactions (contact dermatitis), and in the modulation of antibody-mediated immunity.
- Originate in bone marrow, mature in thymus.

- Three types
    - Helper T-cells
    - Cytotoxic T-cells
    - Regulatory T-cells

- Helper cells (CD4):
  - Produce cytokines that promote differentiation of B cells into plasma cells, activate macrophages to become phagocytic, activate cytotoxic T-lymphocytes, and induce many parts of an inflammatory reaction.
  - AIDS involves the killing of helper T-cells by infecting HIV.
- Cytotoxic T-cells (CD8)
  - Act directly against foreign cells or virus-infected cells by two main mechanism.
  - Attach to cell and release perforins.
  - Attach to cells and induce apoptosis.
- Regulatory T-cells (CD4 CD25)
  - Suppressing excessive immune responses.

- **Natural Killer Cells**

- NK-cells attack virus-infected cells, transplanted cells, and cancer cells without previous stimulations. For this reason they are involved in what is called innate immune system.
- Recognize and kill certain tumor and virally infected cells.

Monocytes/Macrophages

- Phagocytic leukocytes.
- Monocytes are referred to as macrophages when they leave the blood.
- They present antigen to T cells.
- Together, macrophages and lymphocytes orchestrate the chronic immune response.

Mononuclear Phagocyte System

Cell type	Location	Main Function
Monocyte	Blood	Precursor of macrophage
Macrophage	Connective tissue, lymphoid organs, lungs, bone marrow	Inflammation, phagocytosis antigen presentation cell
Kupffer cell	Liver	Same as macrophage
Microglia	Nerve tissue in CNS	Same as macrophage
Langerhans cell	Skin	Antigen presenting cell
Dendritic cell	Lymph nodes	Antigen presenting cell
Osteoclast	Bone (fusion of several macrophages)	Digestion of bone
Multinuclear giant cell	Connective tissue (fusion of several macrophages)	Digestion of foreign bodies

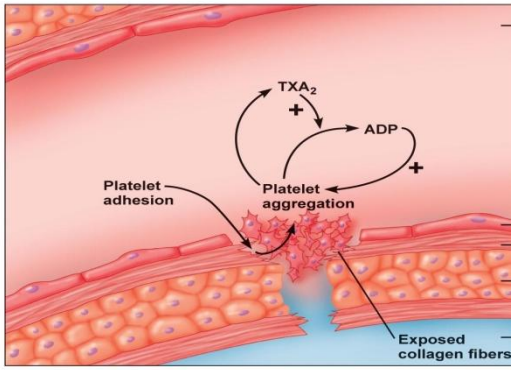
Platelets

- Promote blood clotting and help repair minor tears in the walls of blood vessels.
- Norm: 150,000 – 450,000 per microliter of bld
- Patients with less than 10,000 - 20,000 platelets have been known to bleed spontaneously.
- The minimal recommended platelet count before surgery is 75,000/mm3.

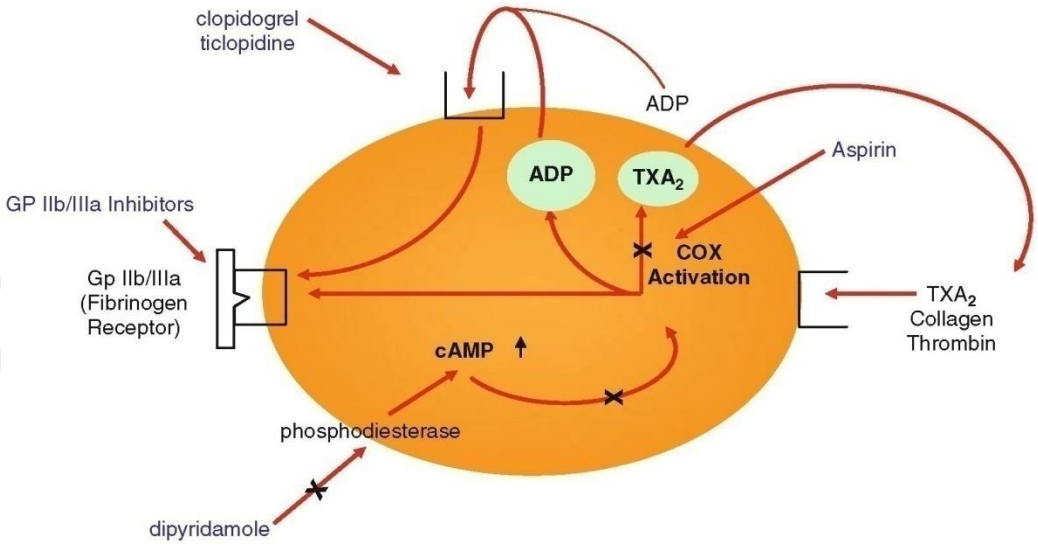
Hemostasis

Three phases of hemostasis:

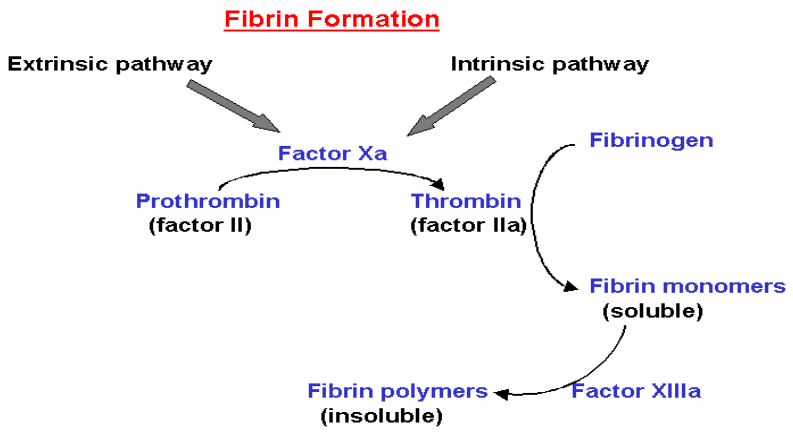
- Vascular phase
- Vasoconstriction, begins immediately after injury
- Platelet phase
- Platelet aggregation to collagen >> platelet plug.
- Coagulation phase
- Coagulation cascade >>> Fibrin >>> blood clot.
- Slower than other phases.

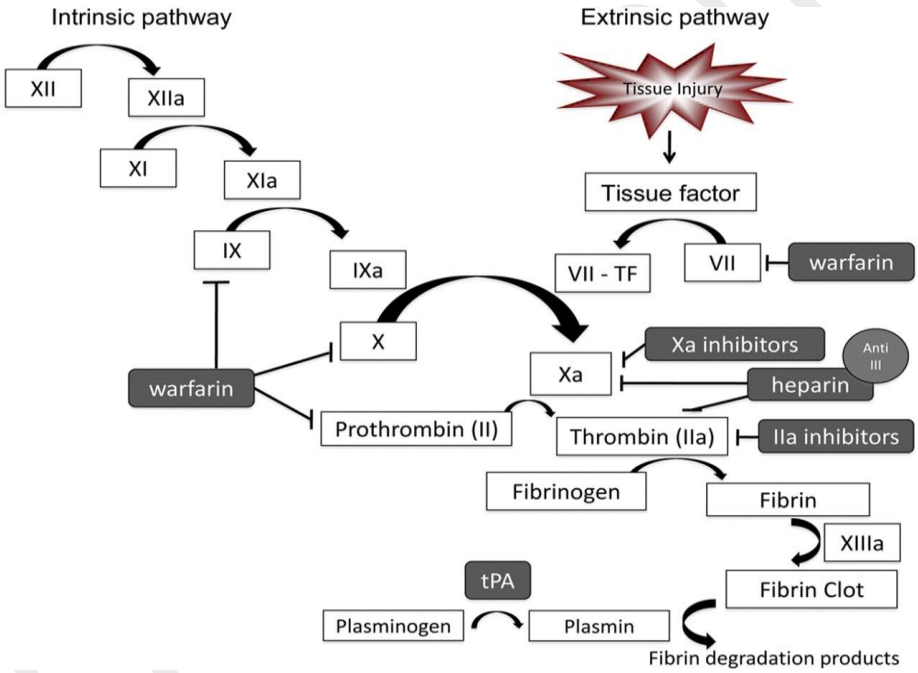


Antiplatelet Drugs



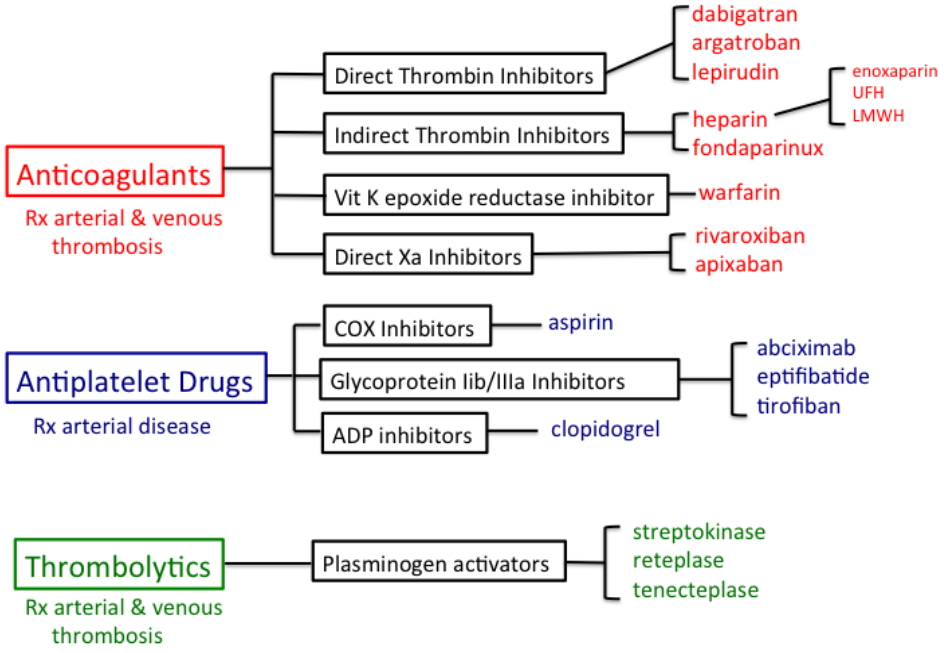
Coagulation

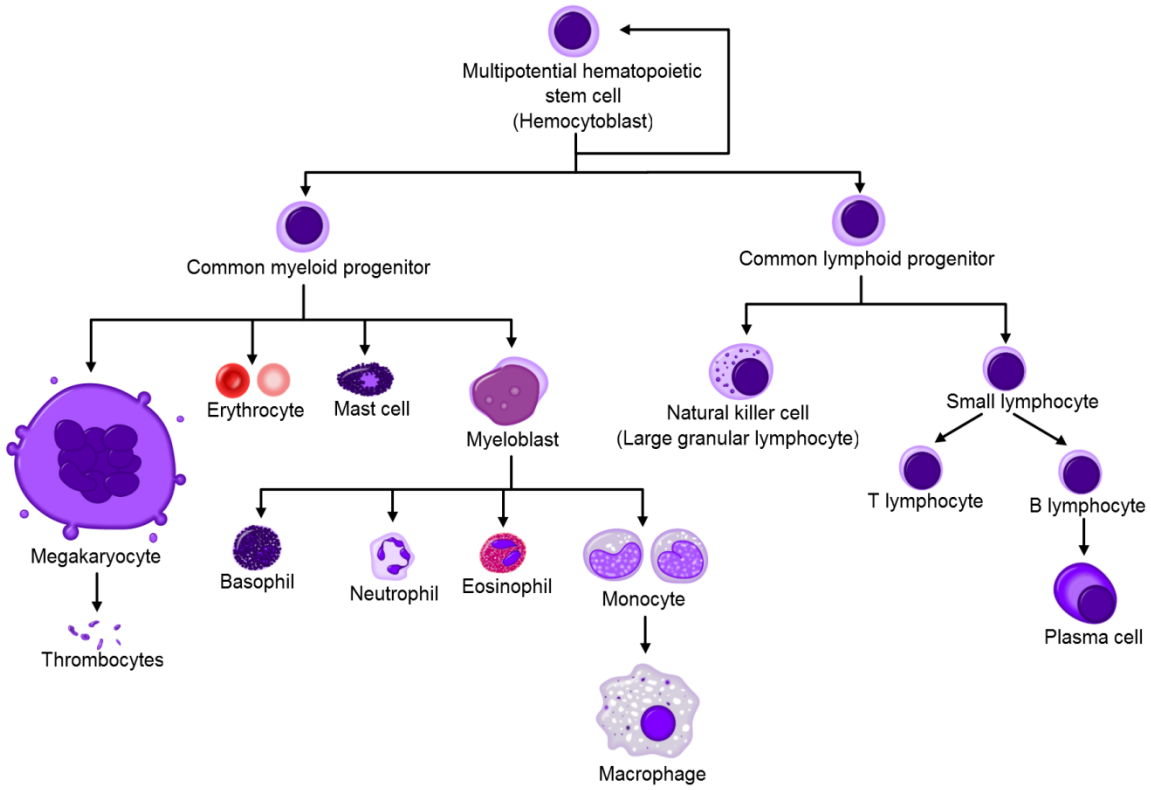




- The important factors (hemophilia)
- Vitamin K factors (2,7,9,10) affected by
  - Broad spectrum antibiotics
  - Warfarin
- Liver (hepatitis) may affect production of factors

Drugs Used to Treat Clotting Disorders





Immune System

Types of Immune Response

Innate response:

- Includes the action of the complement system, and cells such as neutrophils, macrophages, mast cells, and natural killer cells.
- Fast, nonspecific, does not produce memory cells.

Adaptive response:

- Depends on the initial recognition of antigens by B and T cells.
- Slower, specific, produces memory cells.

• **Humoral:**

- Accomplished by antibodies produced by plasma cells derived from clones of activated B-lymphocytes.

• **Cellular:**

- Mediated by T-cells.
- Secrete cytokines that act on B-cells, other T-cells, inflammatory cells such as macrophages and neutrophils.
- Attack virus infected cells and tumor cells.

Antigen-Presenting Cells

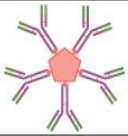
- These cells capture antigens(phagocytosis) in tissue, go to the lymph nodes through lymphatic vessels and present the antigen to T-helper cells triggering a complex immune response.
- Macrophages
- Dendritic cells (Langerhans cell in skin)

Antibodies

• IgG:

- Most abundant (75-80%)
- Blood, connective tissue, lymphoid organs.
- Crosses placental barrier and reaches fetal circulation in pregnant women.
- Activates phagocytosis

	IgG	IgM	IgA	IgD	IgE
Structure	Monomer	Pentamer	Dimer	Monomer	Monomer
percentage in serum	75-80% most	5-10%	10-15%	0.001%	0.002%
Presence in sites other than blood, connective, lymphoid organs	Fetal circulation in pregnant women	B lymphocyte (as surface monomer)	Secretions (saliva, milk, tears…)	Surface of B lymphocytes	Bound to the surface of mast cells and basophils
Known Functions	Activates phagocytosis, neutralizes antigens	First antibody produces in initial immune response, Activates complement	Protects mucosae	Antigen receptor triggering initial B cell activation	Destroys parasitic worms and participates in allergies

Name	Properties	Structure
IgA	Found in mucous, saliva, tears, and breast milk. Protects against pathogens.	
IgD	Part of the B cell receptor. Activates basophils and mast cells.	
IgE	Protects against parasitic worms. Responsible for allergic reactions.	
IgG	Secreted by plasma cells in the blood. Able to cross the placenta into the fetus.	
IgM	May be attached to the surface of a B cell or secreted into the blood. Responsible for early stages of immunity.	

Cytokines

- Greek cyto-, cell; and -kinos, movement
- The functions of cells in the immune system are regulated by a large number of molecules, mainly cytokines that act on many cells that have receptors for them (not only immune).
- Primarily produced by cells of the immune system but also produced by other cell types such as endothelial cells and fibroblasts.

Cytokine	**Main Function**
TNF, IL-1 , IL-6 ,	Inflammation and fever
IL-12	Simulation of innate and specific response
IL-2 , IL-4 , IL-3	Growth factors for T and B cells
IL-5	Eosinophil differentiation and activation
Interferon – g	Activation of macophages
IL-10 , tgf- beta	Regulation of the immune response
Interferon – a Interferon – b	Antiviral activity

Complement System

The complement system is a part of the immune system that enhances (complements) the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promotes inflammation, and attacks the pathogen's plasma membrane.

Functions

- Recruitment of inflammatory cells (chemotaxis), enhance vascular permeability
  - C5a, C3a
- Opsonization of pathogens and phagocyte activation.
  - C3b

Inflammation

Acute inflammation is rapid in onset and of short duration, lasting from a few minutes to as long as a few days, and is characterized by fluid and plasma protein exudation and a predominantly neutrophilic leukocyte accumulation.

Chronic inflammation may be more insidious, is of longer duration (days to years), and is typified by influx of lymphocytes and macrophages with associated vascular proliferation and fibrosis (scarring).

Cardinal signs of inflammation result from the vascular changes and cell recruitment:

- Heat.
- Redness.
- Swelling.
- Pain.
- loss of function.

Macrophages are the dominant cells of chronic inflammation.
Mast cells are sentinel cells widely distributed in connective tissues throughout the body, and they can participate in both acute and chronic inflammatory responses.

Inflammation Process

- Inflammatory process is an innate process.
- Extravasation of neutrophils
    - Neurtophils slow down but cannot bind tightly to endothelial cells.
    - Macrophages in the tissue produce IL-8 which helps neutrophils to bind tightly to endothelial cells.
    - IL-8 is most important chemotactic cytokine
- Chemotaxis:
    - Chemical attraction of neutrophils to bacteria.
    - Neutrophils release chemicals to attract more neutrophils.
- Phagocytosis
- Opsonization (IgG, C3b)
    - Enhances phagocytosis 4000 times.
    - Bonds to phagocyte after it has bonded to bacteria.

Side Notes
- IL-8, C5a >>> Chemotactic
- IL-1, IL-6 , TNFa >>> act systemically, fever.
- C5a, C3a >> degranulation of mast cells > vasodilate.

Hypersensitivity

Type 1 immediate: IgE , mast cells, basophils
Type 2 antibody mediated: IgM, IgG binds to cells, compliment involved.
Type 3 immune-complex mediated: IgM, IgG >> activates compliment.
Type 4 Delayed type: Mediated by T-cells

Type 1 Hypersensitivity

- Immediate, the only one that's IgE mediated.

1. First exposure (example : polin)

- Polin inhaled >> T-cells activate B-cells to secrete IgE antibody customized against polin, the IgE attaches to the surface of mast cells and basophils.

2. Second exposure

- Polin inhaled >> polin attach to IgE on mast cells and basophils which causes degranulation of these cells.

- Eosinophil reaction occurs later on because of a eosinophil chemotactic factor released >>> eosinophils also degranulate >> tissue destruction(eosinophil peroxidase)

Mast cell mediators "primary mediators"
Already made and stored in granules, hence the immediate response.
Has an immediate effect with short duration.

- Histamine: smooth muscle contraction and increases vascular permeability.
- Heparin : anticoagulant.
- Eosinophil chemotactic factor >> attracts eosinophils to the site.

Mast cell mediators "secondary mediators"
Not pre-made, made during degranulation
More potent and last longer
Made from arachidonic acid

- Prostoglandin, leukotreine
  - Chemotaxis, increase permeability, inflammatory response

Examples of Type 1 hypersensitivites:

- Allergic rhinits: (limited to nasal mucosa)
- Food allergies:
- Systemic anaphylaxis: (penicillins)
- Asthma

Type 4 Hypersensitivity

- Delayed type, the only one activated by T-cells
- Macrophages captures complex (antigen-skin protein), presents it to T-cell in lymph node, the T-cells activate macrophages, the activated macrophages returns to the tissue and causes inflammation/damage.
- Takes 2-3 days.

Examples

- Contact dermatitis
- Nickel, poison ivy,
- Patients with periodontitis often have T lymphocytes sensitized to plaque bacterial antigens.

ENAMEL

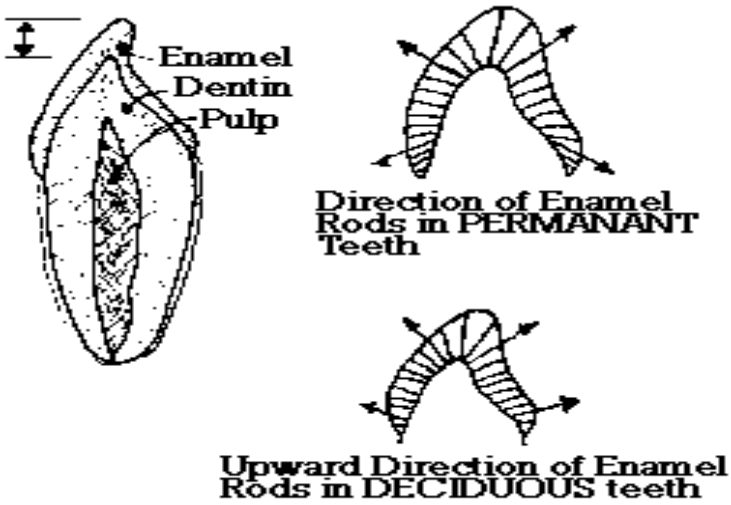
Properties

- Enamel is the hardest calcified tissue in the human body and the richest in caclium.
- Enamel is highly mineralized and totally acellular.
- 96% inorganic material, primarily calcium and phosphorus as hydroxyapatite.
- 1% organic material, 3% water.
- Enamel is of ectodermal origin.
- The organic matrix consists mainly of protein, which is rich in proline.
- Enamel rod diameter near the surface is double the diameter near the dentin.
- Hardness can vary over the external tooth surface according to location.
- Hardness decreases inwardly, with hardness lowest at the DEJ.
- The density of enamel also decreases from the surface to the DEJ.
- Enamel is a rigid structure that is both strong and brittle (high elastic modulus, high compressive strength, and low tensile strength) and requires dentin support to withstand masticatory forces.
- Dentin is more flexible which increases the fracture toughness of superficial enamel.

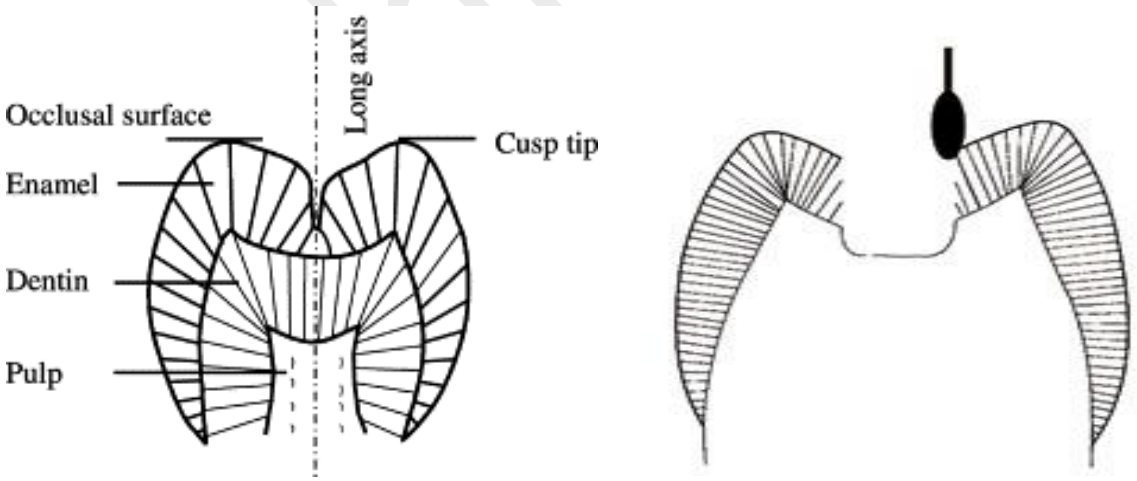
Structure

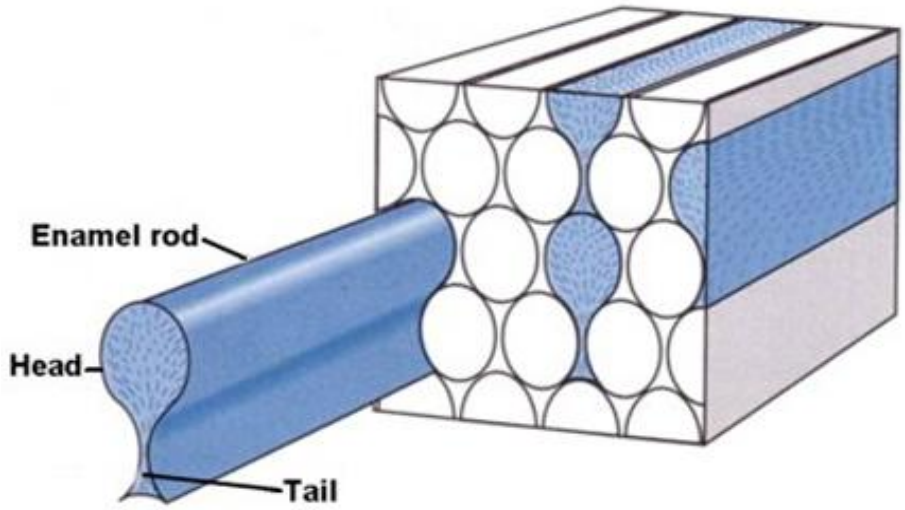
- The fundamental morphologic unit of enamel is the enamel rod or prism, bound together by an inter-prismatic substance (inter-rod substance)
- The rods are densely packed and intertwined in a wavy course, and each extends from the DEJ to the external surface of the tooth.

- In general, the rods are aligned perpendicularly to the DEJ and the tooth surface in the primary and permanent dentitions.

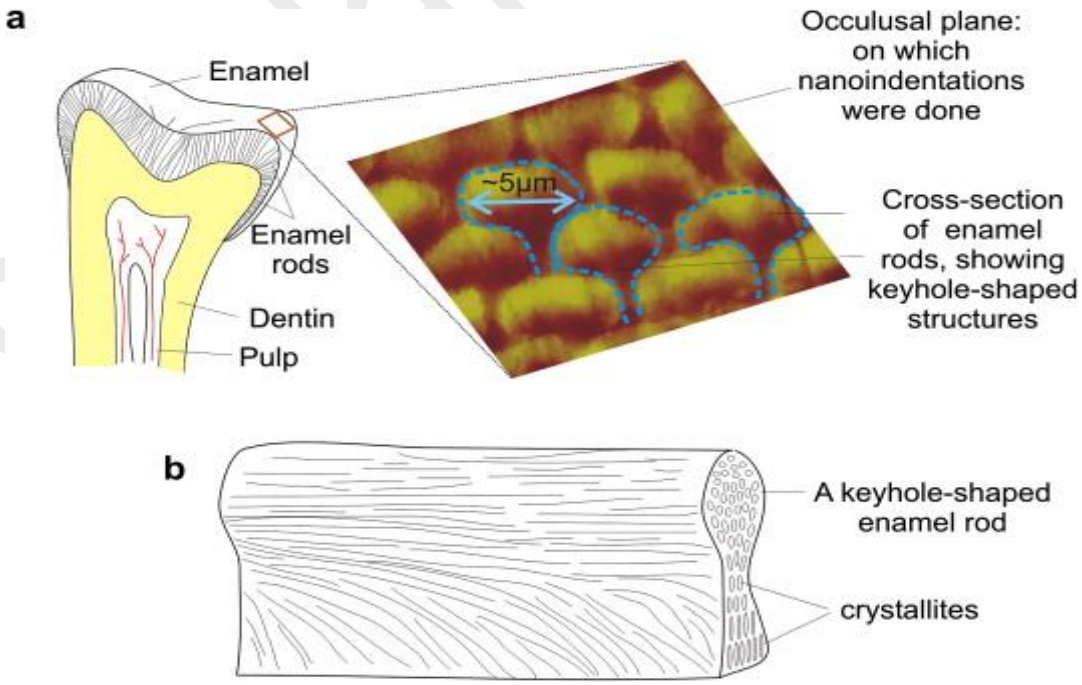


- In the cervical region of permanent teeth, they are oriented outward in a slightly apical position.
- The enamel rods (primary teeth) in the gingival third slope occlusally instead of cervically as in permanent teeth.



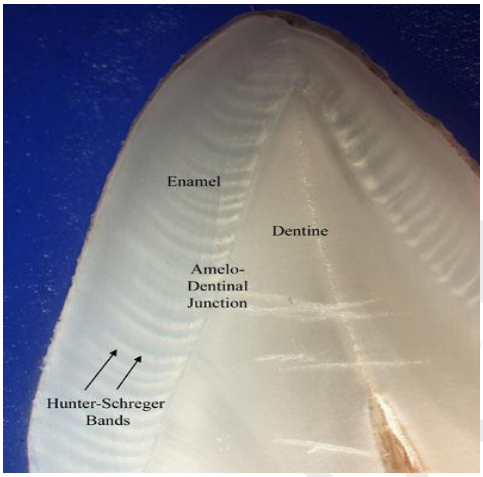


- The enamel rod has a body section and a tail section, forming a repetitive series of interlocking prisms.
- The structural component of the enamel prisms are millions of small, elongated apatite crystallites.
- The long axis of the apatite crystallites within the central region of the head (body) is aligned parallel to the rod long axis.
- The apatite in the tail region is at an angle to the long axis of the rod.
- The tail regions are relatively resistant to acid attack compared to the head region.



Other Features

- The enamel rods initially follow a curving path through one third of the enamel next to the DEJ. After that, the rods usually follow a more direct path through the remaining two thirds of the enamel to the enamel surface.
- The changes in direction of enamel prisms that minimize fracture in the axial direction produce an optical appearance called ***Hunter-Schreger bands***.



Enamel trufts:

Enamel trufts project from the DEJ for a short distance into the enamel. They appear to be branched and contain greater concentrations of enamel proteins than the rest of the enamel.

Enamel lamellae:

Consist of linear longitudinally oriented defects filled with organic material. Extend from the enamel surface toward the DEJ.

Enamel Cracks:

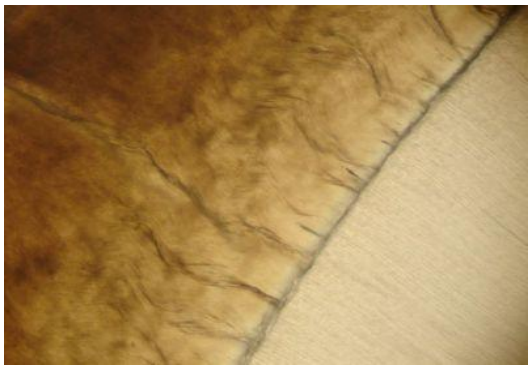
Sometimes can be mistaken for lamellae but can be distinguished from the latter because they generally do not contain organic material.

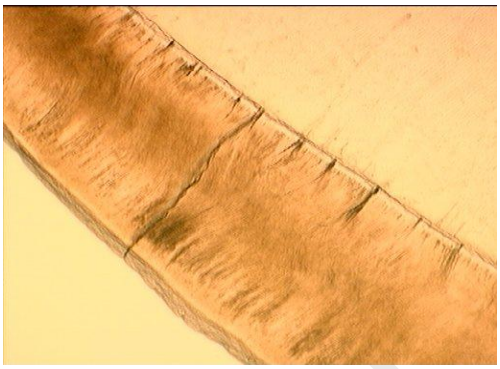
Enamel spindles:

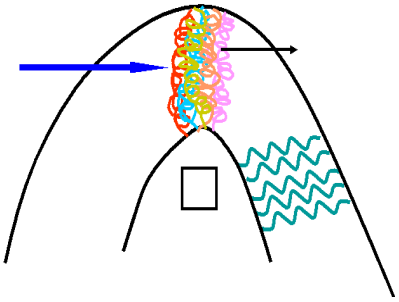
Before enamel forms, some developing odontoblast processes extend into the ameloblast layer and becomes trapped when enamel formation begins.

Gnarled enamel:

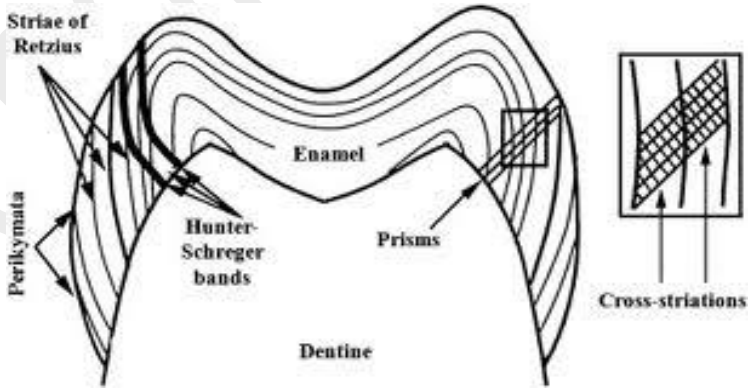
Over cusps of teeth the rods appear twisted around each other in a seemingly complex arrangement known as *gnarled enamel.*

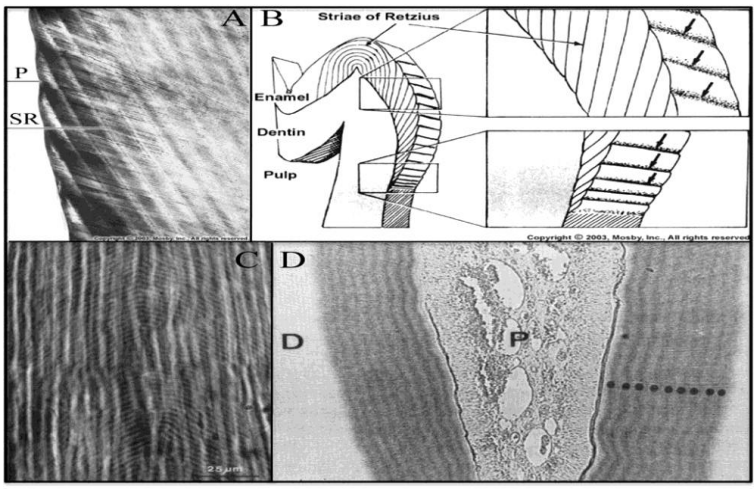






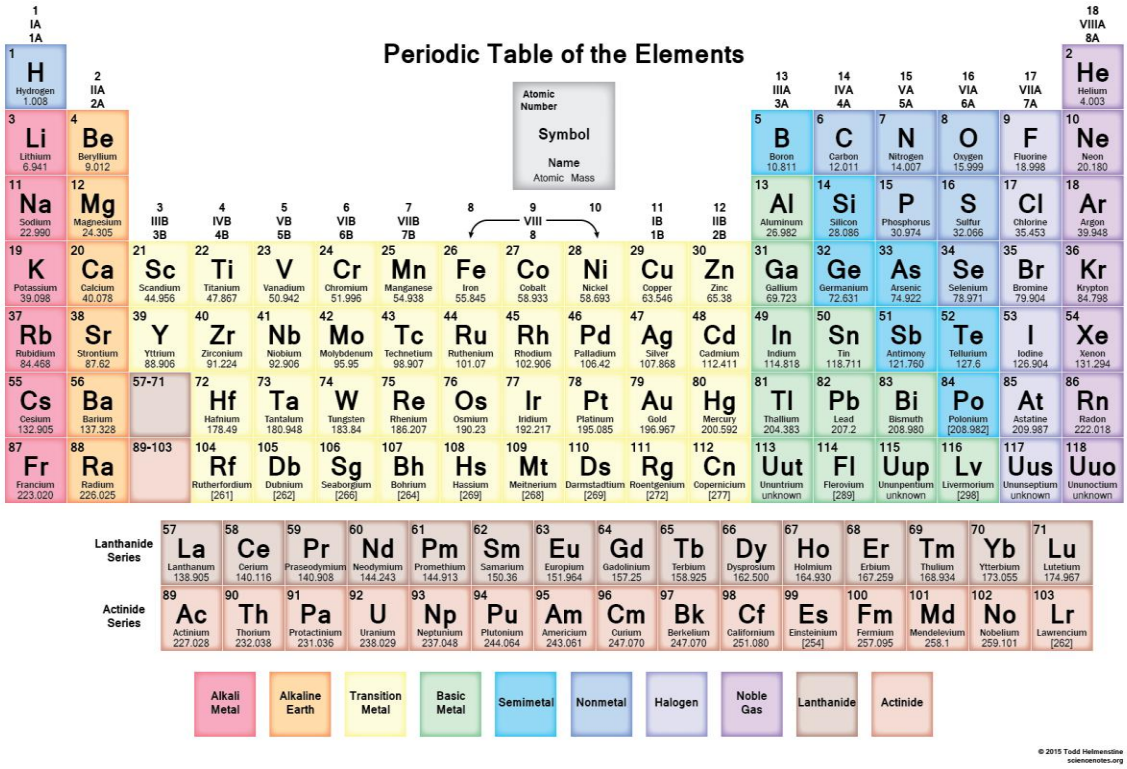
- Enamel rods are formed linearly by successive apposition of enamel in discrete increments. The resulting variations in structure and mineralization are call incremental ***Striae of Retzius.***
- These lines sometimes reach the surface >>> alternating grooves called *imbrication lines* of pickrill. The elevations between the grooves are called *perikymata*
- Perikymata run in circumferentially horizontal lines across the face of the crown

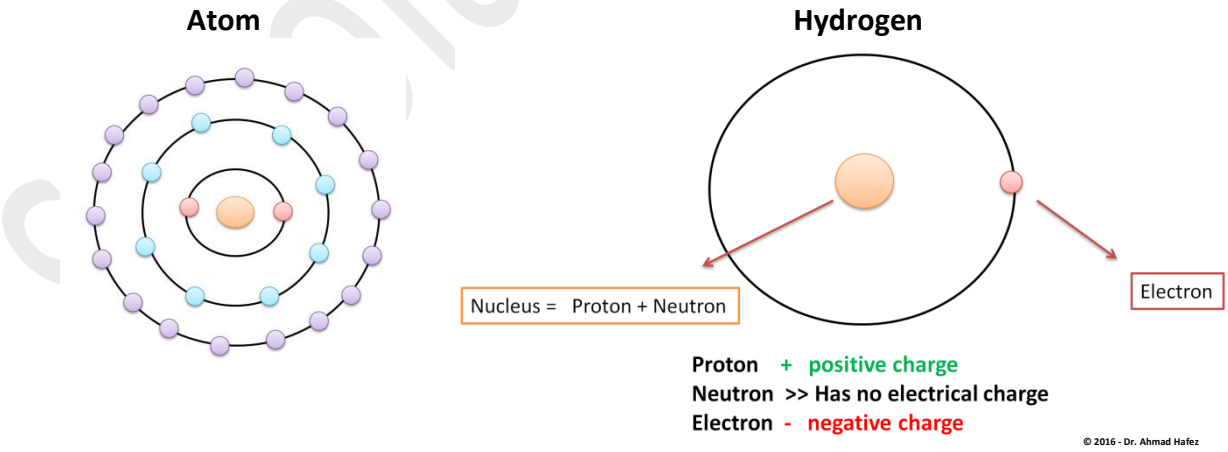


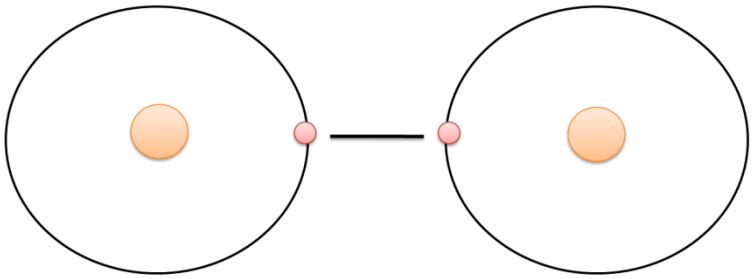


- Enamel is incapable of repairing itself because ameloblasts degenerate after formation of enamel rod.
- The final act of the ameloblast is secretion of a membrane covering the end of the enamel rod. This layer is referred to as ***Nasmyth's membrane*** or ***primary enamel cuticle***.
- This membrane covers the newly erupted tooth and is worn away by mastication and cleaning.
- The membrane is replaced by an organic deposit called the ***pellicle,*** which is salivary proteins.
- Enamel is permeable to certain ions and molecules. Permeability decreases with age because of changes in the enamel matrix, referred to as ***enamel maturation***.
- Enamel is soluble to acid, solubility increases from surface to DEJ. (DEJ more soluble)
- When fluoride ions are present during enamel formation or are topically applied to the enamel surface, the solubility of surface enamel is decreased.
- Fluoride concentration decreases toward the DEJ.

CHEMISTRY REVIEW

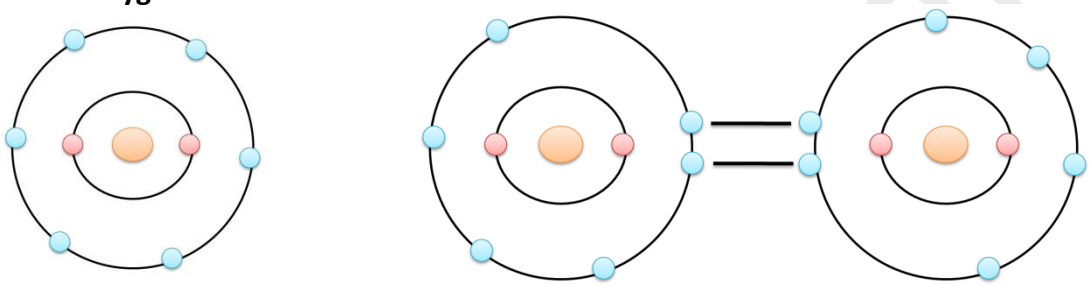






This is called a **Single Covalent Bond**: both atoms are sharing electrons

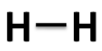
Oxygen



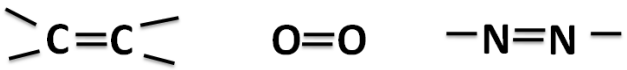
This is called a **Double Covalent Bond**: both atoms are sharing electrons

There are three types of covalent bond depending upon the number of shared electron pairs.

- **Single Covalent Bond**
  - A covalent bond formed by the mutual sharing of one electron pair between two atoms is called a "Single Covalent bond."



- **Double Covalent Bond**
  - A covalent bond formed between two atoms by the mutual sharing of two electron pairs is called a "double covalent bond"



- **Triple Covalent Bond**
  - A covalent bond formed by the mutual sharing of three electron pairs is called a "Triple covalent bond"

Primary Bonds

Covalent bond:

- Between nonmetal – nonmetal (example: H2O water)
- Two atoms share a pair of electrons, one electron from each atom.

Ionic bond:

- Between metal – nonmetal (example: NaCl table salt)
- One atom has tendency to give electrons (becomes positive charge).
- The other atom has a tendency to accept electrons (becomes negative charge).
- Attraction between positive and negative charge.

Metallic bond:

- Between metal – metal (Fe iron)
- Free floating electrons (sea of electrons) shared bind the metal atoms together.

Secondary Bonds

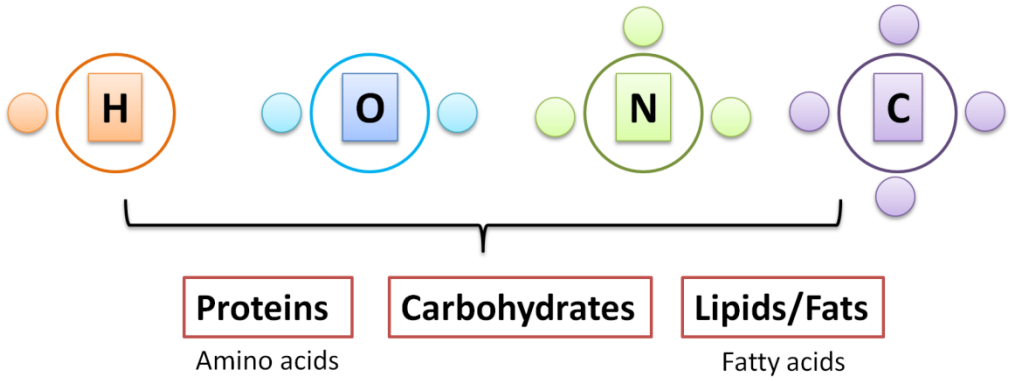
- Van der Waals
- Hydrogen bonds

Chemical components of the body

Chemical components in the body can be divided into organic and inorganic.

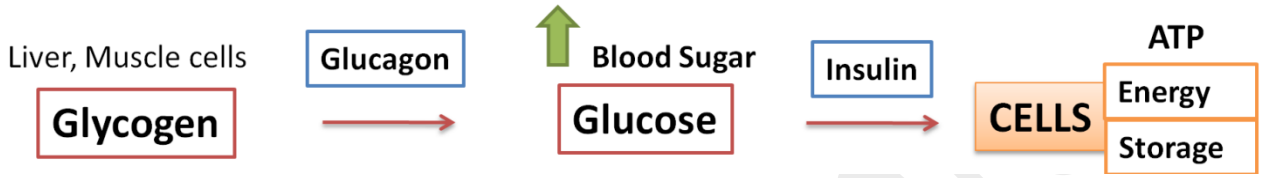
Organic Compounds

Four elements compose the organic compounds that form 99% of life.
These four elements are: Hydrogen, Nitrogen, Carbon, and Oxygen.
The organic compounds formed: Water, Proteins, Carbohydrates, and Fat.
Hydrogen and Oxygen (Water) form 60 -70% cell mass.

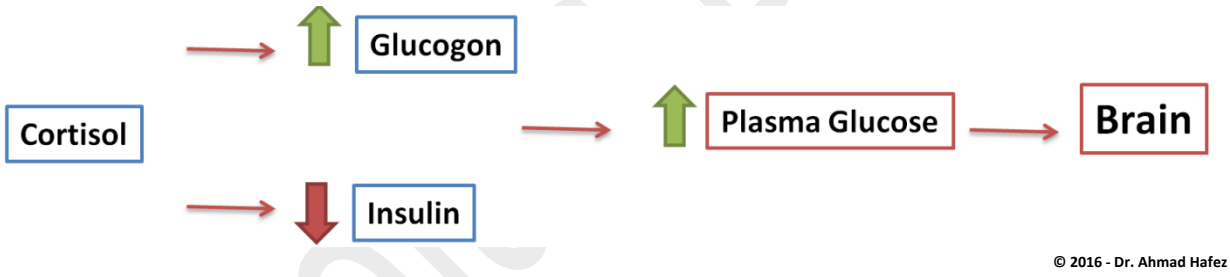


Carbohydrates

- In blood, they are in the form of glucose.
- In cells, they may be broken down for energy (glycolysis).
- In cells (liver, muscle), they may be stored as glycogen (glycogenesis).
- Form glycolipids, glycoproteins (GAGs).
- Glucagon will increase glucose level in blood.
- Most tissues require insulin for efficient glucose uptake.

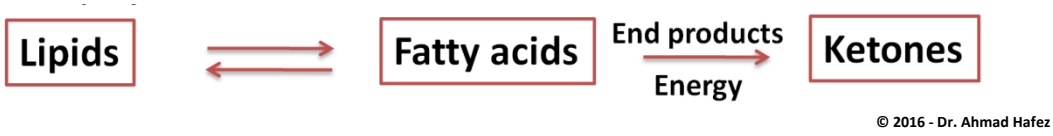


It should be noted here that there are some tissues that do not require insulin for efficient uptake of glucose: important examples are brain and the liver. This is because these cells don't use GLUT4 for importing glucose, but rather, another transporter that is not insulin-dependent.



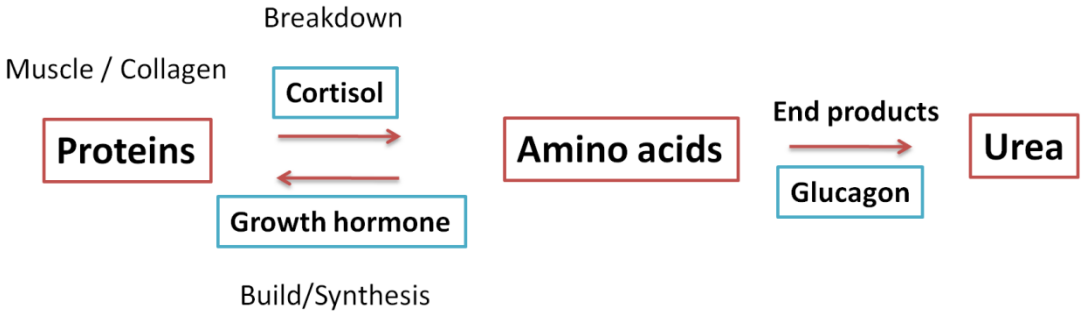
Lipids

- Soluble in organic solvents, not soluble in water.
- Energy reserve: stored in special cells (adipocytes).
- Structure: build cell membranes.
- Insulation: chemically and thermally.
- Hormones, mediators, vitamins (fat soluble).
- Fats are carried by proteins in blood until they reach target cells.



Proteins

- Structure: collagen, elastin, membrane (canals, carriers)
- Transport proteins: transport other compounds in the blood (albumin).
- Peptide hormones, transmitters, enzymes.
- Muscle: myosin, actin.



Inorganic Components

- 0.5% inorganic ions (Na, K, Mg, Ca, Cl)
- Trace elements (Fe, Zn, Cu, Mn, I, Se)

Thought

Imagine hormones as code messages from one group of cells to another in order to accomplish a goal for the body. Our body will assess the chemistry in the blood and will use hormones or other methods to return the blood its proper balance. There is a method to control almost every component in the body, most of the time it's through hormones.

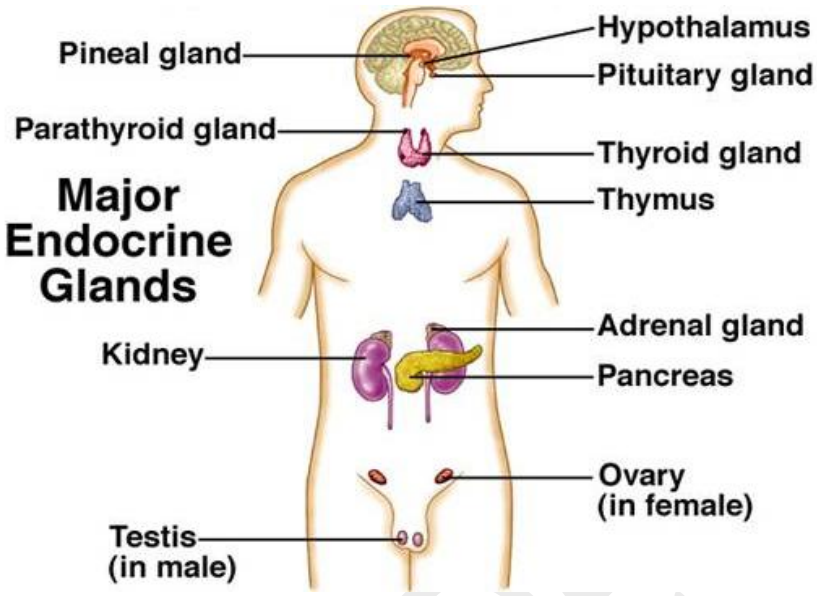
Components of body

- Water
- Proteins <> Amino Acids
- Lipids <> Fatty Acids
- Glycogen <> Glucose
- Minerals (Na, K, Ca)

Hormones

- Thyroxin
- Epinephrine
- Antidiuretic Hormone
- Calcitonin
- Erythropoietin
- Glucagon
- Growth Hormone
- Insulin
- Melanocyte Stimulating Hormone
- Oxytocin
- Parathyroid Hormone
- Aldosterone
- Prolactin
- Follicle-Stimulating Hormone
- Luteinizing Hormone
- Androstenedione (Estrogen)
- Estradiol
- Progesterone
- Testosterone

ENDOCRINE PHYSIOLOGY

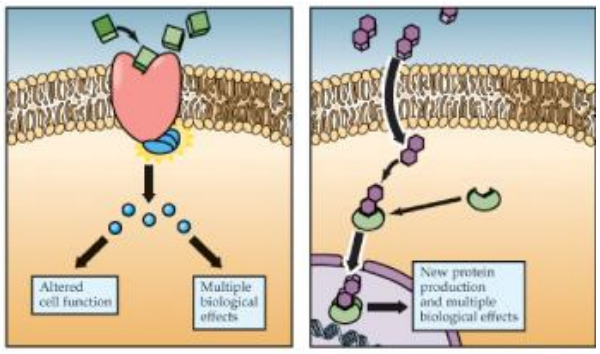


Peptide Hormones:

- The receptor is usually on the membrane.
- Water soluble and do not bind to protein in blood.
- Peptide hormones are pre-made and stored in vesicles.
- They can be released quickly, have short half-lives.
- Hypthalamus and pituitary gland make peptide hormones.

Steriod Hormones:

- The receptor is usually on the nucleus membrane within the cell.
- Lipid soluble and can cross the membrane, binds to protein.
- Steriod hormones are made when needed and cannot be stored.
- They require more time to be made and released (slow), longer half lives.

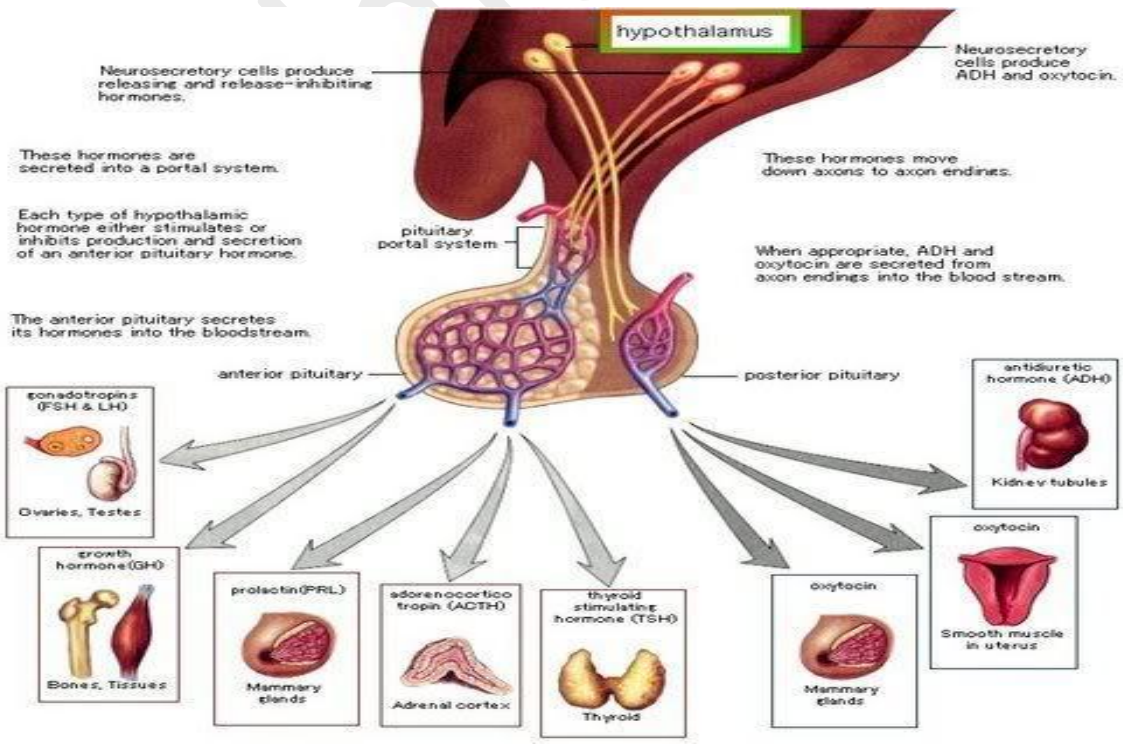


- Activity of a hormone depends on the amount of free hormone in plasma, and no the number of receptors.
- Receptors can develop a resistance to hormones such as in type II diabetes.
- Some hormones have a permissive action on other hormones. This means a hormone will be more effective in the presence of another hormone. For example:
    - Thyroid hormone for growth hormone
    - Catecholamines with cortisol
    - Cortisol with glucagon
- Hormones are released in a pulsatile nature (not continuous) which makes it difficult to measure hormone levels in plasma. The exception is thyroxin which is constantly released and can be measured using plasma levels.
- How can disease occur?
    - High or low function, benign tumor (adenoma), malignancies, atrophy, receptors.

Hypothalamus

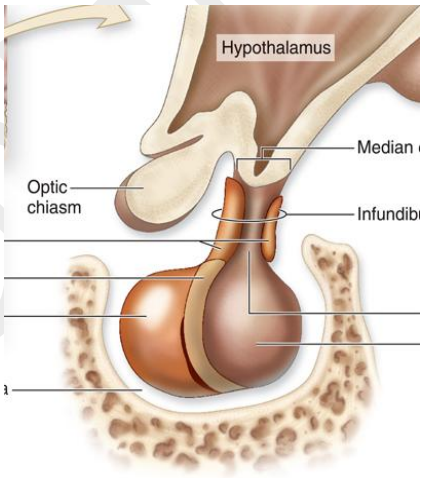
These hormones stimulate specific cells in the pituitary gland.

- Thyrotropin Releasing Hormone (TRH):
- Corticotropin Releasing Hormone (CRH):
- Gonadothropin Releasing Hormone (GnRH)
- Growth Hormone Releasing Hormone (GHRH)



Hypothalamus	Pituitary	Target
TRH	Thyroid Stimulating Hromone (TSH)	Thyroid Gland
CRH	Adrenocorticotropic Hormone (ACTH)	Adrenal Gland
GnRH	Luteinizing Hormone (LH) Follicle Stimulating Hormone (FSH)	Reproductive system, growth, various functions
GHRH	Growth Hormone (GH)	Cells of the body

Pituitary Gland



- **Anterior Pituitary**
  - GH (Growth Hormone)
  - ACTH (Adrenocorticotropic Hormone)
  - TSH (Thyroid Stimulating Hormone)
  - LH, FSH (Luteinizing, follicle stimulating Hormone)
  - Prolactin >> (promotes lactation/ milk production)
  - MSH (Melanocytic Stimulating Hormone)

- **Posterior Pituitary**
  - Oxytocin (contraction of uterus during birth)
  - Anti-diuretic hormone (ADH)

Growth Hormone (somatotropin)

- Made by somatotrophs in anterior pituitary.
- Early hypothyroidism leads to GH failure and eventually cretinism.
  - Growth hormone needs thyroxin (permissive action)
- GH, Insulin, thyroid hormones are anabolic hormones.
- Increases protein synthesis and growth.
- Increases muscle mass through hypertrophy.
- Promotes lipolysis.
- Promotes gluconeogenesis in liver the (increase glucose).
- Reduces liver uptake of glucose.

- **Gigantism:** GH over-production before puberty
- **Acromegaly :** GH over-production after puberty
- **Pituitary Dwarfism :** GH under-production before puberty
- GH deficiency after puberty is not a problem (stress hormone only)

Antidiuretic Hormone (ADH) (Vasopressin)

- A peptide hormone, made in the hypothalamus, stored and released in the posterior pituitary gland.
- Regulates the body's retention of water by increasing water reasbsorption in the kidneys.
- Also increases peripheral vascular resistance, which in turn increases arterial blood pressure.
- ADH deficiency can lead to a condition known as diabetes Insipidus.

Thyroid Gland

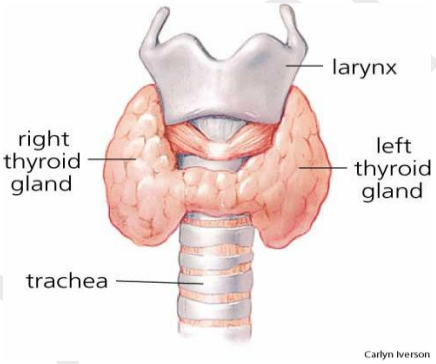
Triiodothyronin (T3)

- More potent than T4

Tetraiodothyronin (T4) or thyroxin

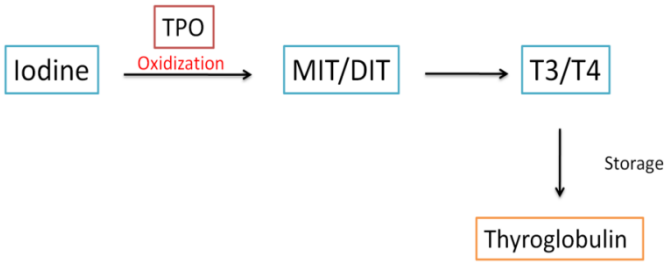
- 90% of thyroid hormone

Calcitonin



T4/T3 are made in thyroid gland after several steps of oxidization of Iodine molecules by Thyroperoxidase (TPO). The oxidation leads to Monoiodotyrosine (MIT) or Dioiodotyrosin (DIT).

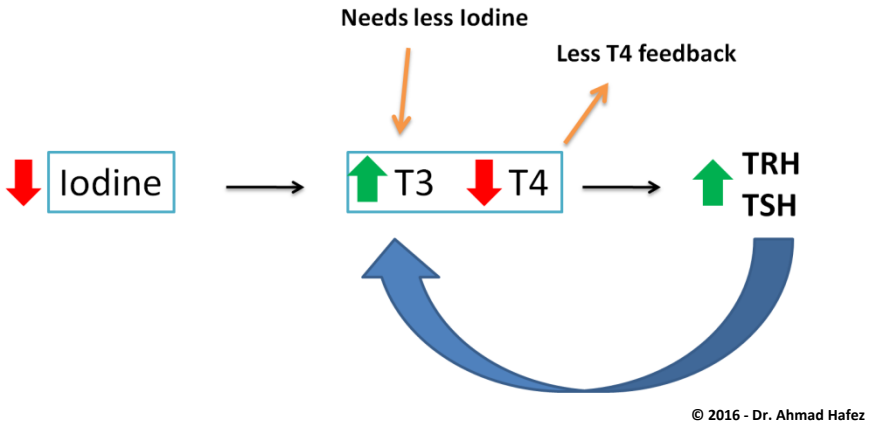
- If MIT combines with DIT the result will be triiodothyronin (T3)
- If DIT combines with DIT the result will be tetraiodothyronin (T4)



- Thyroid hormones control metabolic rate (heat, O2 consumption)
- Neural tissue metabolic rate is not controlled by thyroid hormone. It is not understood why thyroid diseases are associated with mental symptoms.
- Thyroid hormones are important for development of neural tissue (permissive effect)
- Thyroid hormones increase B-receptors >> increase sympathetic stimulation.

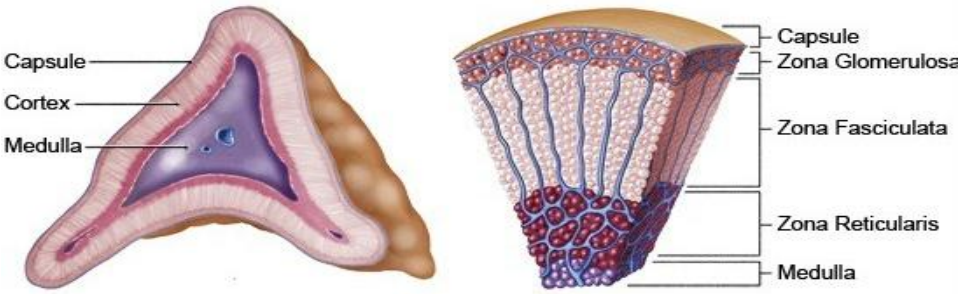
	T4	TSH	TRH
Primary hypothyroidism/ Hashimoto's	↓	↑	↑
Pituitary hypothyroidism	↓	↓	↑
Hypothalamic hypothyroidism	↓	↓	↓
Pituitary hyperthyroidism	↑	↑	↓
Primary hyperthyroidism/ Graves disease	↑	↓	↓

- Thyroid hormones have a negative feedback inhibition on hypothalamus and pituitary gland. The negative feedback is more related to the effect of T4 (thyroxin)
- Hypothyroidism can be primary, secondary, or tertiary.
- Inflammation diseases can effect thyroid function:
  - Hashimoto's thyroiditis >> hypothyroidism
  - Graves disease >> hyperthyroidism
- Low intake of Iodine leads to goiter.



Adrenal Gland

Aldosterone
Cortisol
Androgens
Catecholamines



Cortisol

- Cortisol is a steroid hormone made in the zona fasciculata of the adrenal cortex.
- Cortisol is the only endogenous true glucocorticoid.
- Glucocorticoid : glucose + cortex + steroid
- Cortisol is stimulated by the release of ACTH.
- Cortisol helps in emotional and physical stress (exercise, infection, fear)
- Cortisol mobilizes energy storage: fatty acids/glucose
- Cortisol has a permissive effect on glucagon.
- Increase glucose
- Increase free acids and promote lypolysis.
- Decrease lypogenesis
- Cortisol dissolves proteins >> amino acids
- Cortisol dissolves lipids >> free fatty acids, glycerol
- Cortisol raises blood glucose through:
    - Inhibits glucose uptake by peripheral tissues
    - Gluconeogenesis of amino acids in liver (Gluconeogensis occurs only in the liver.)

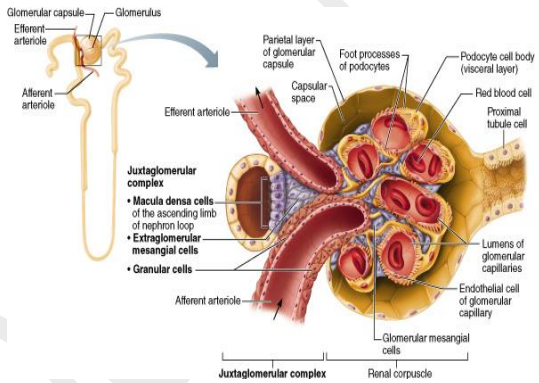
- **Stress Hormones**
- **Cortisol >> Dissolves proteins**
- **Growth Hormone >> Increases protein formation**
- **Glucagon >> Gluconeogenesis of amino acids**
- **Catecholamines >> No effect on proteins**

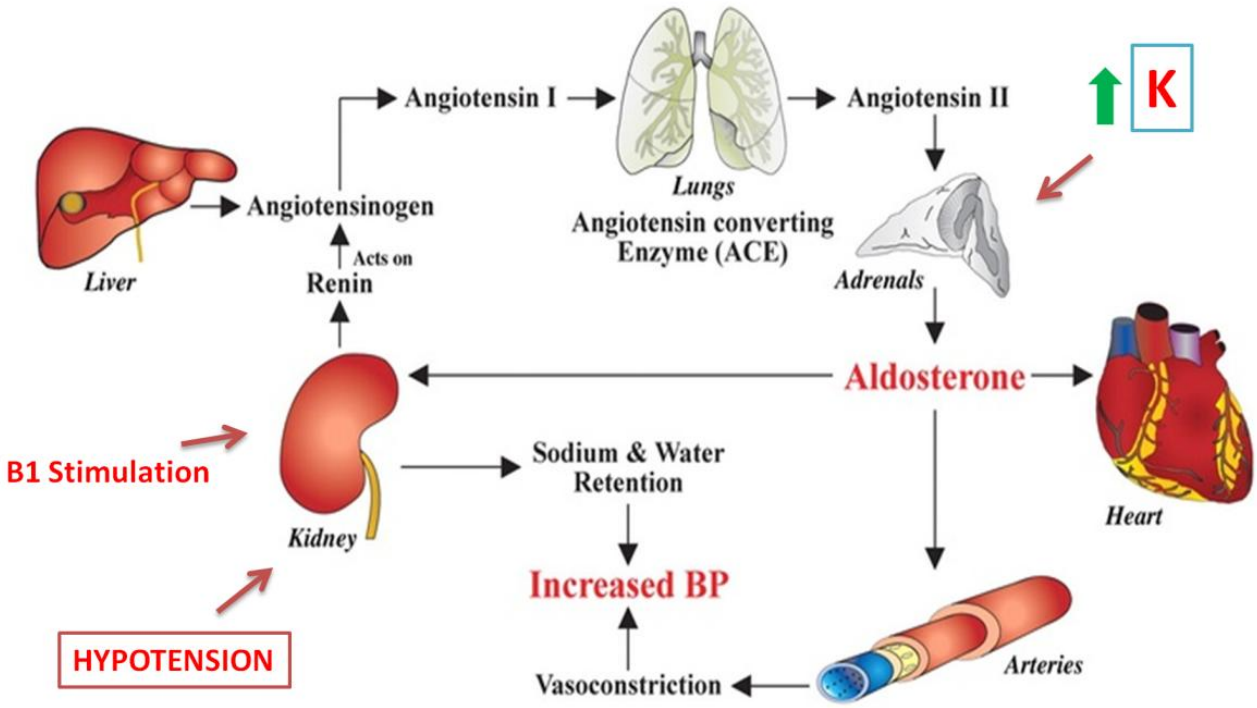
- All of the above will increase glucose, increase free acids, promote lypolysis and decrease lypogenesis.
- The difference between them is their effect on proteins.
- Glucagon doesn't dissolve proteins like cortisol, but it takes amino acids before they form proteins and uses them in gluconeogenesis in the liver (makes glucose from AA)

Aldosterone

- A corticosteroid hormone released from the zona glomerulosa of the adreanal cortex.
- Aldosterone is a mineralocorticoid (regulates salt and water)
- Retains salt (Na) and excretes K or H in kidney.
- Retention of salt is associated with retention of water.
- Aldosterone affects kidney, colon, sweat glands, and salivary glands.
- Aldosterone is not controlled by the pituitary gland.

- What stimulates aldosterone?
- Renin: Released from the juxtaglomerular cells in the kidneys during hypotension.
- Low Na at macula densa (kidney) >> Renin.
- B1 stimulation
- Increased K levels >> Aldosterone





- **Congestive Heart Failure medication**
- B blockers
- ACE inhibitors
- ARBs
- Spironolactone
    - Week diuretic, K sparring diuretic
    - Blocks aldosterone (aldosterone antagonist)
    - This means more water excretion without lowering potassium in blood.
- Digoxin: to improve heart contraction

Conditions of the adrenal cortex:

- Cushings syndrome : hypercortisolism regardless of the cause.
- Cushings disease : hypercortisolism due to adenoma of anterior pituitary.
- Primary hypercortisolism: problem in the adrenal gland.
- Secondary hypercortisolism : problem not in the adrenal gland (example: pituitary).
- Addisons disease : low cortisol.
- Conn's syndrome = hyperaldosteronism.

- **Hypercortisolism (cushings)**
- Obesity (unknown exactly why)
- Fat redistribution lipolysis and fat build in areas (buffalo hump)
- Protein depletion (bone dissolution, osteopororsis)
- Inihibits neutrophils/inflammatory cells
- Hyperglycemia (diabetes, polyurea, polydipsia)
- Hypertension
- Hyperlipidemia
- If secondary due to pituitary cause >> increase androgens >>additional symptoms such as acne and hirsutism(hair).

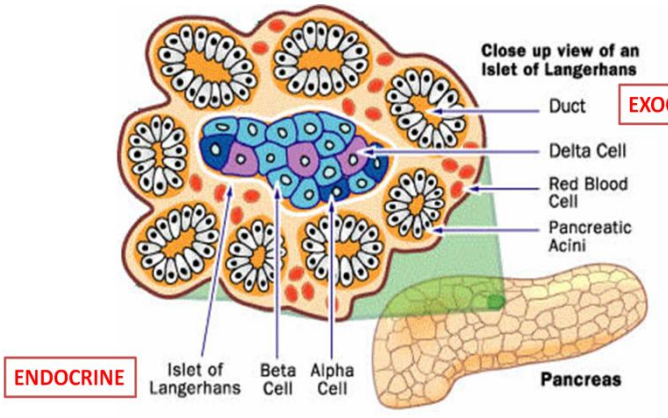
- **Hypocortisolism (Addisons)**
- Hypotension
- Increase ACTH: leads to hyperpigmentation due to increase of MSH
- Dehydration due to sodium waste

- **Hyperaldosteronism (Conn's syndrome)**
- Hypertension (retention of water and salt)
- Hypokalemia (excretion of potassium)
- Alkilosis: excretion of H

Epinephrine

- Released from the adrenal medulla
- Stimulates B1, B2, A1, A2 receptors
- Sympathetic Autonomic nervous system
- Pheochromocytoma: benign tumor in adrenal medulla >> episodic hypertension

Pancreas



A cells >> glucagon >> brings sugar into blood

B cells >> insulin >> brings sugar into cells

D cells >> somatostatin >> can inhibit either hormone

Insulin

- Peptide hormone released from B cells of islets of Langerhans of the pancreas.
- Insulin is controlled by glucose, amino acids(specific), glucagon.
- Insulin receptors are called tyrosine kinase.
- Tissues that do not require insulin:
    - Nervous tissue (Brain), liver.
    - Kidney tubules, RBCS, intestinal mucosa, B-cells of pancreas
- Insulin is an anabolic hormone (stores fat for example)
- Insulin brings glucose into cells to use for energy or for storage.
- Without insulin, proteins may break down for energy.
- Growth hormone and IGF >> induce protein synthesis and AA uptake into cells.
- Andorgens (estrogen, testosterone) form protein (lean muscle).
- Glucagon stimulates secretion of insulin.
- Insulin inhibits glucagon secretion.
- Somatostatin >> decrease insulin.
- Sympathetic innervation (norepinephrine) >> decrease insulin

Glucagon

- Glucagon targets the liver
- Increases liver glycogenolysis, gluconeogensis
- Increase liver ketogenesis and decreases lipogenesis
- Increases liver lipolysis
- Increase ureagenesis from AA (doesn't break down protein)
- Increases insulin secretion
- Insulin inhibits glucagon
- An Increase in amino acids stimulates glucagon secretion >> gluconeogenesis

Calcium Hormones

Parathyroid Hormone

- Released by the parathyroid glands.
- The only feedback inhibition on PTH is free Calcium.
- High free Ca inhibits PTH.
- Low free Ca stimulates PTH.
- Low Ca causes PTH stimulation, PTH increases free calcium using 3 methods:
    - Dissolves bone
    - Increase kidney absorption of Ca
    - Activated vit-D
        - Increases calcium absorption in GI

Calcitonin

- Peptide hormone, made in c cells/parafollicular cells of thyroid gland.
- Calcitonin is released only in pathologically elevated Ca levels.
- Calcitonin is not a major regulator of Ca levels, because in normal conditions it has unknown function.
- Calcitonin can be used therapeutically (inhibits osteoclasts)
    - Osteoporosis
    - Paget's disease of bone

- **Hypercalcemia**

- Most common cause is hyperparathyroidism.
- Hyperparathyroidism could be asymptomatic.
- Hypercalcemia may be caused by: sarcoidosis, malignancy, immobility, hyper Vit-D3.
- Stones, bones, moans and groans (primary hyperparathyroidism)

- **Hypocalcemia**
- Most common cause is surgical removal of parathyroid glands.
- Low Ca and increased PO4
- Tetany:
    - Chvostek's sign (face),
    - Trouseau's sign (arm)

Condition	Ca	PO4
Primary Hyperparathyroidism	↑	↓
Primary hypoparathyroidism	↓	↑
Kidney Failure	↓	↑
Vitamin D deficiency	↓	↓
Hypervitaminosis D	↑	↑

Estrogen

- The ovaries are the prime location for estrogen production
- Promote formation of female secondary sex characteristics
- Increase fat store
- Maintenance of vessel and skin
- Reduce bone resorption, increase bone formation
- Increase hepatic production of binding proteins
- Coagulation
    - Increase circulating level of factors 2, 7, 9, 10, plasminogen
    - Decrease antithrombin III\
    - Increase platelet adhesiveness

Respiration Plasma PH

$$H_2O + CO_2 \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

ANATOMY

Cranial Nerves

Skull

Muscles (facial, mastication, hyoid)

Trigeminal nerve

Facial nerve

Arteries

Veins

Lymph nodes

Palate, Tongue, Salivary glands

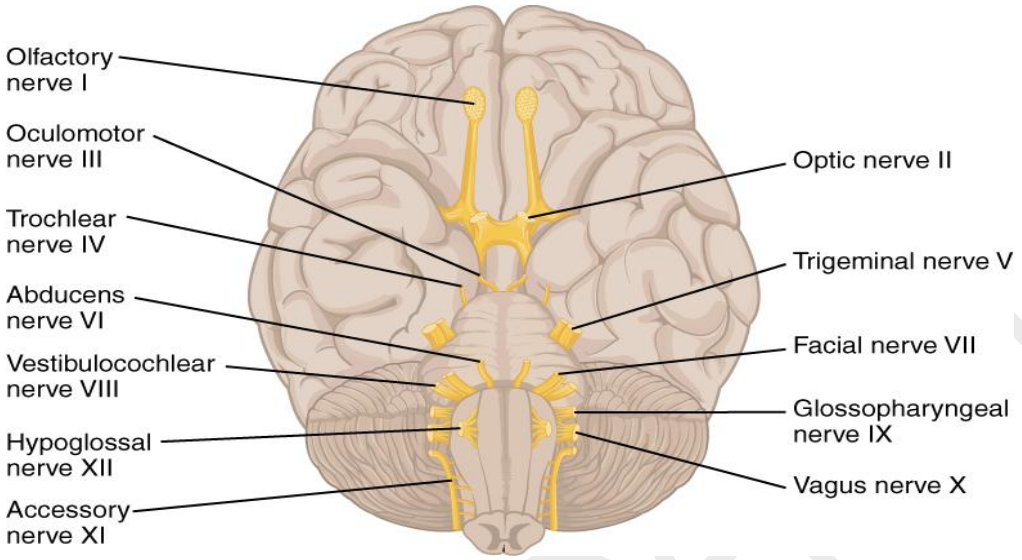
TMJ

Occlusion

Terminology

- Afferent = sensory (from periphery to CNS)
- Efferent = motor (from CNS to periphery)
- Somatic efferent = volunteer motor (skeletal muscle)
- Visceral efferent = autonomic motor (ANS)
- Special sensory = special afferent
- General sensory = general somatic afferent
- Somatic motor = general somatic efferent
- Visceral motor = general visceral efferent
- Branchial motor = special visceral efferent

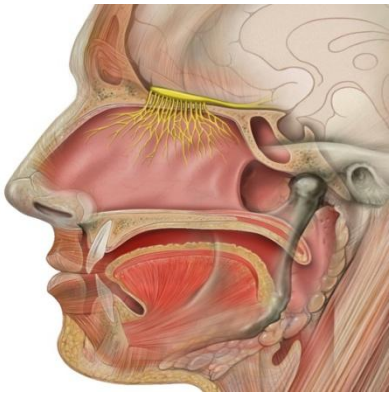
Cranial Nerves

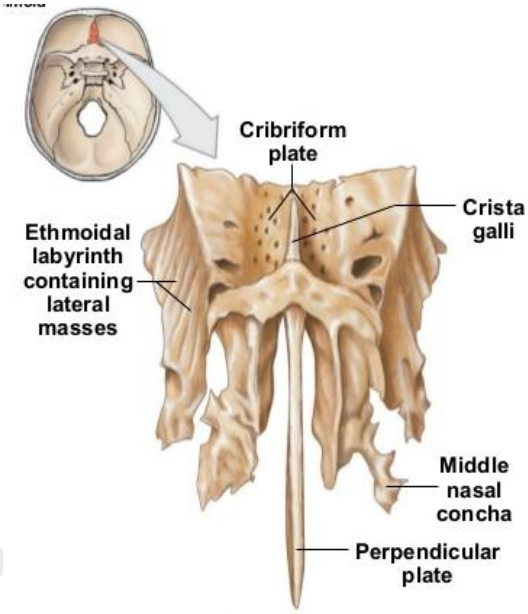


Nerve	Site of Exit from Skull
Olfactory (CN I)	Cribriform plate of ethmoid bone
Optic (CN II)	Optic foramen
Oculomotor (CN III)	Superior orbital fissure
Trochlear (CN IV)	Superior orbital fissure
Trigeminal (CN V)	
Abducens (CN VI)	Superior orbital fissure
Facial (CN VII)	Stylomastoid foramen
Vestibulocochlear (CN VIII)	Internal acoustic meatus
Glossopharyngeal (CN IX)	Jagular foramen
Accessory (CN XI)	Jugular foramen
Hypoglossal (CN XII)	Hypoglossal canal

Olfactory Nerve (CN I)

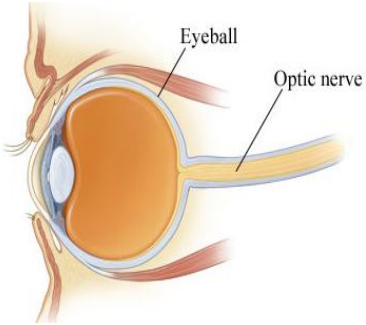
- Special sensory
- Sense of smell

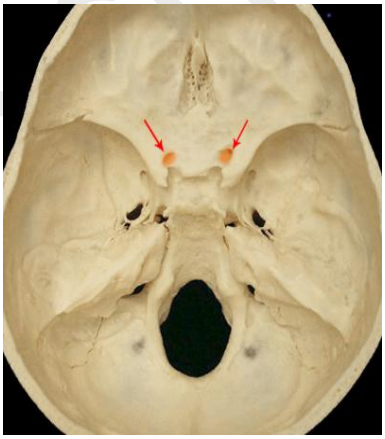


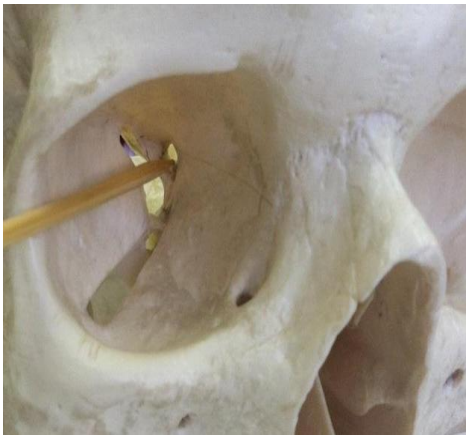


Optic Nerve (CN II)

- Special sensory
- Conveys information from the retina





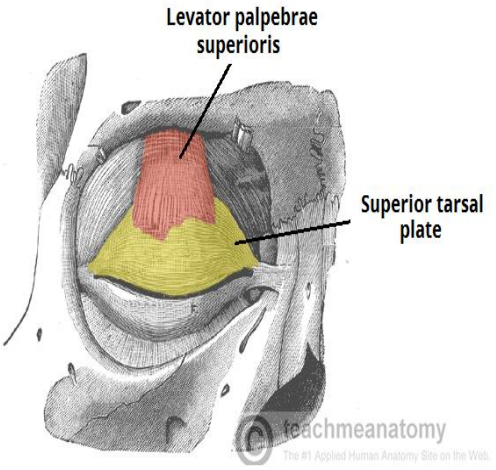


Oculomotor Nerve (CN III)

- Superior orbital fissure

- **Somatic motor**
- Supplies four of the six extraocular muscles of the eye and the **levator palpebrae superioris** muscle of the upper eyelid.

- **Visceral motor**
- Parasympathetic innervation of the constrictor pupillae and ciliary muscles.

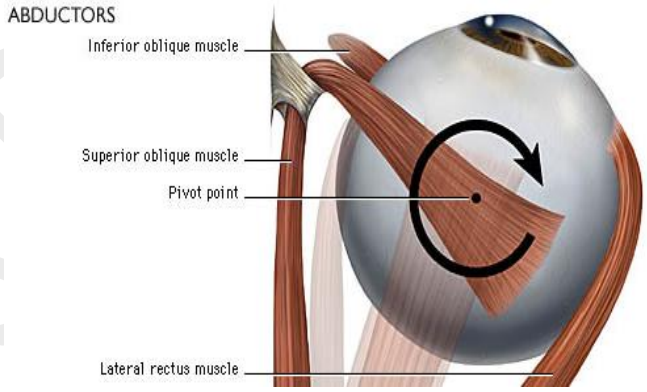


Trochlear Nerve (CN IV)

- Superior orbital fissure
- Somatic motor
- Innervates the superior oblique muscle

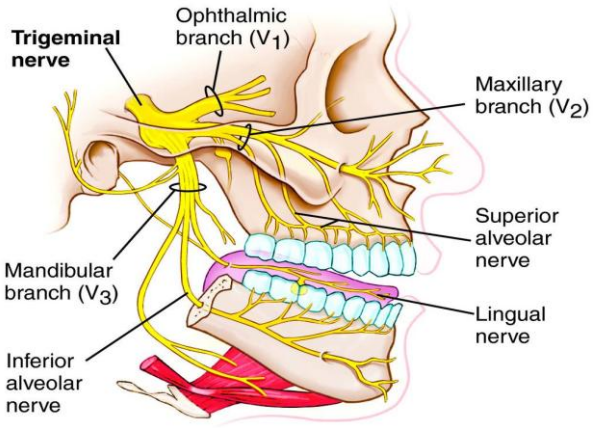
Abducens Nerve (CN VI)

- Superior orbital fissure
- Somatic motor
- Innervates the lateral rectus muscle



Trigeminal Nerve (CN V)

- **Ophthalmic branch**
  - Superior orbital fissure
- **Maxillary branch**
  - Foramen rotundum
- **Mandibular branch**
  - Formane ovale



Facial Nerve (CN VI)

- Stylomastoid foramen

- **Branchial motor**

- Supplies the muscles of facial expression; posterior belly of digastric muscle; stylohyoid muscle and stapedius muscles

- **Visceral motor**

- Parasympathetic innervation of lacrimal, submandibular and sublingual glands, as well as mucous membranes of the nasopharynx and the hard and soft palate

- **General sensory**

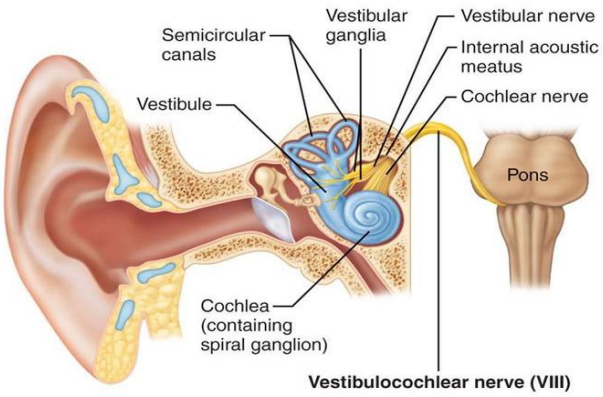
- General sensation from the skin of the concha of the auricle and from a small area behind the ear.

- **Special sensory**

- Provides taste sensation from the anterior two thirds of the tongue; hard and soft palates.

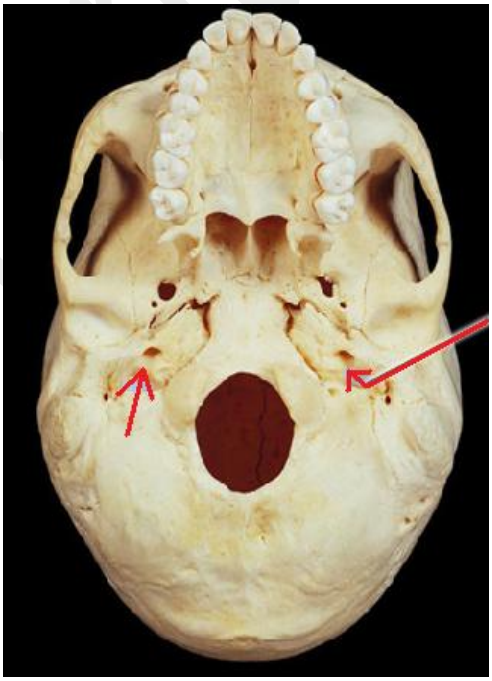
Vestibulocochlear Nerve (CN VIII)

- Internal acoustic meatus
- To the organ of corti for **hearing**
- To the semicircular canals for **balance**



Glossopharyngeal Nerve (CN IX)

- Jugular foramen



- **Branchial motor**
- Supplies the stylopharyngeus muscle

- **Visceral motor**
- Parasympathetic innervation of the smooth muscle and glands of the pharynx, larynx and viscera of the thorax and abdomen

- **Visceral sensory**
- Caries visceral sensory information from the carotid sinus and body

- **General sensory**
- Provides general sensation information from the skin of the external ear, internal surface of the tympanic membrane, upper pharynx and posterior one-third of the tongue.

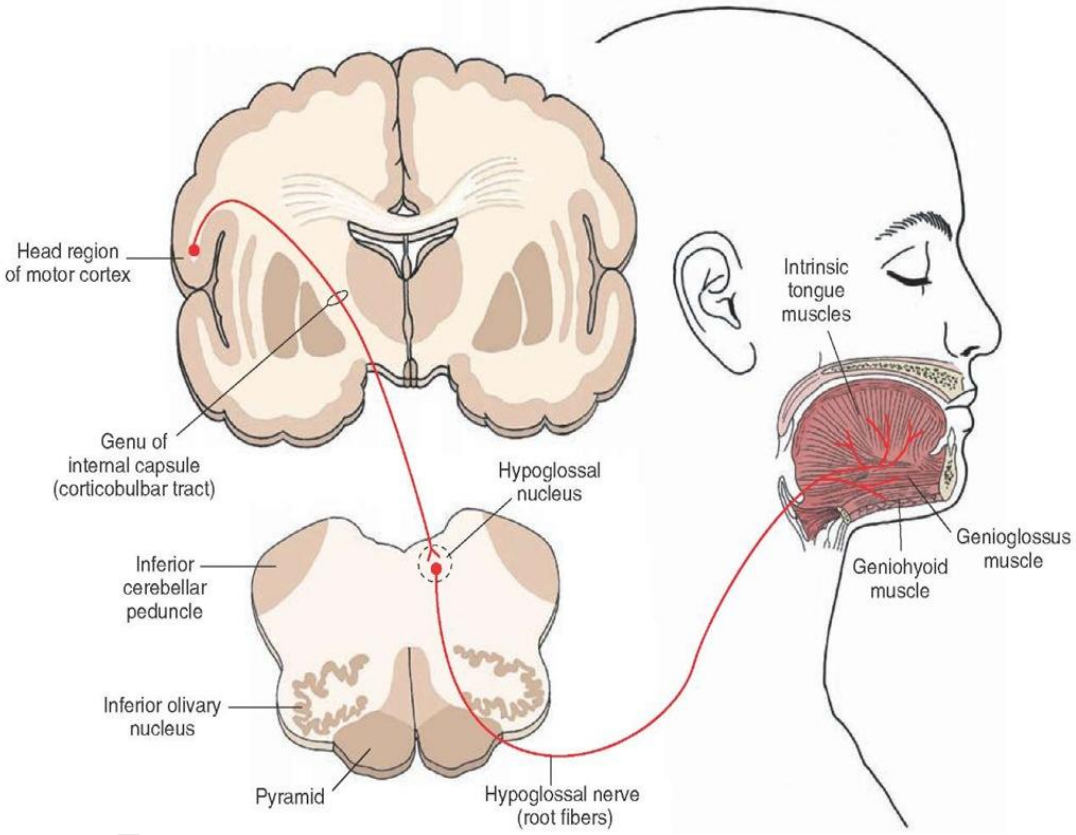
- **Special sensory**
- Provides taste sensation from posterior one-third of the tongue

Accessory Nerve (CN XI)

- Jugular foramen
- Innervates muscles of the larynx and pharynx
- Innervates the trapezius and sternocleidomastoid muscles

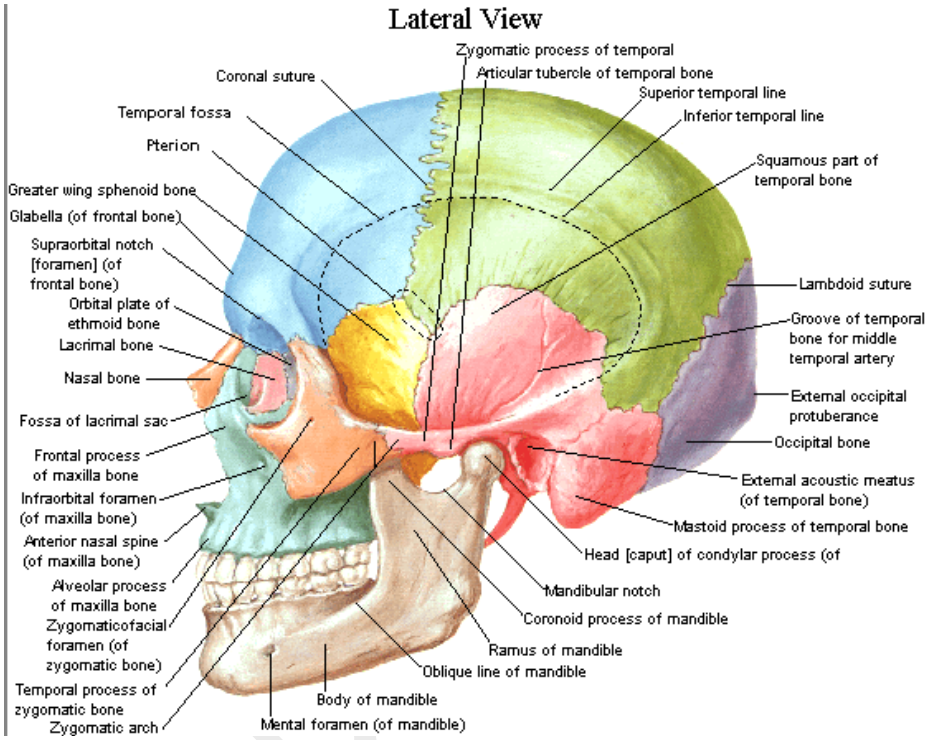
Hypoglossal Nerve (CN XII)

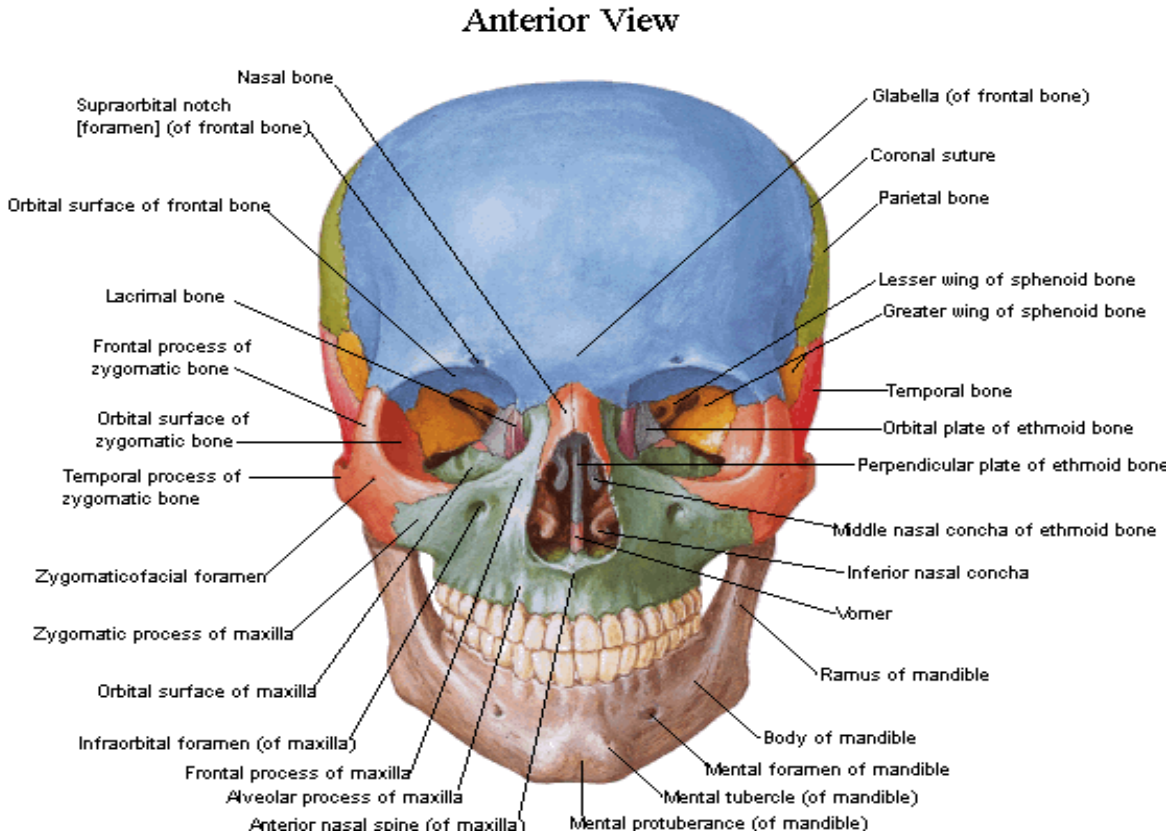
- Hypoglossal canal
- Somatic motor
- Innervates all of the intrinsic and most of the extrinsic muscles of the tongue (genioglossus, styloglossus and hyoglossus muscles)

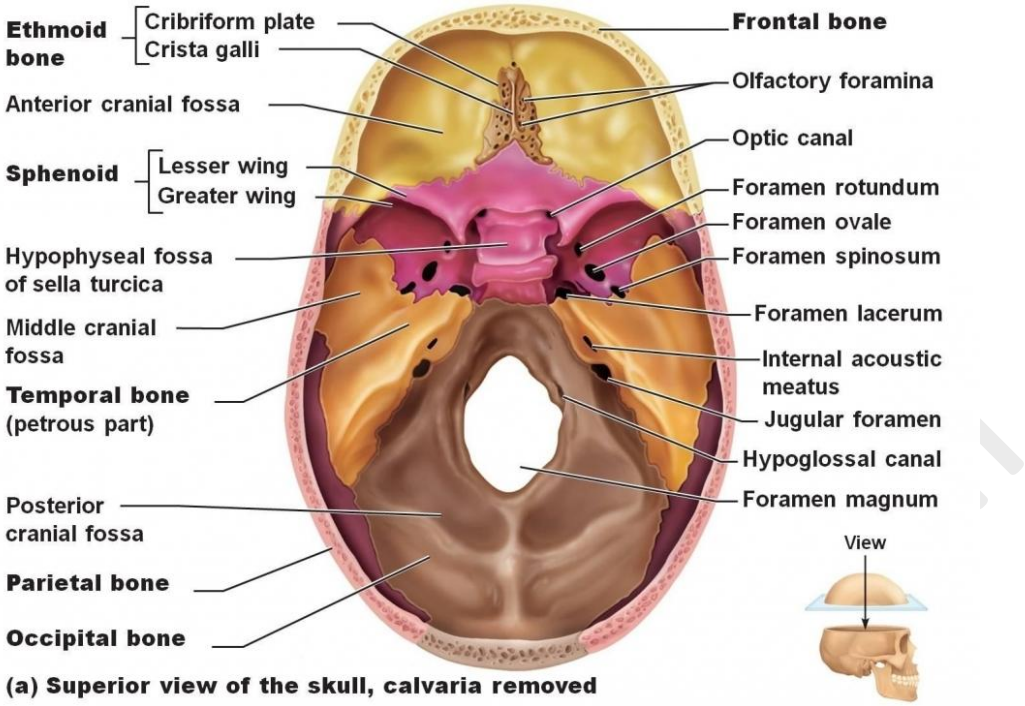


Bones of the Skull

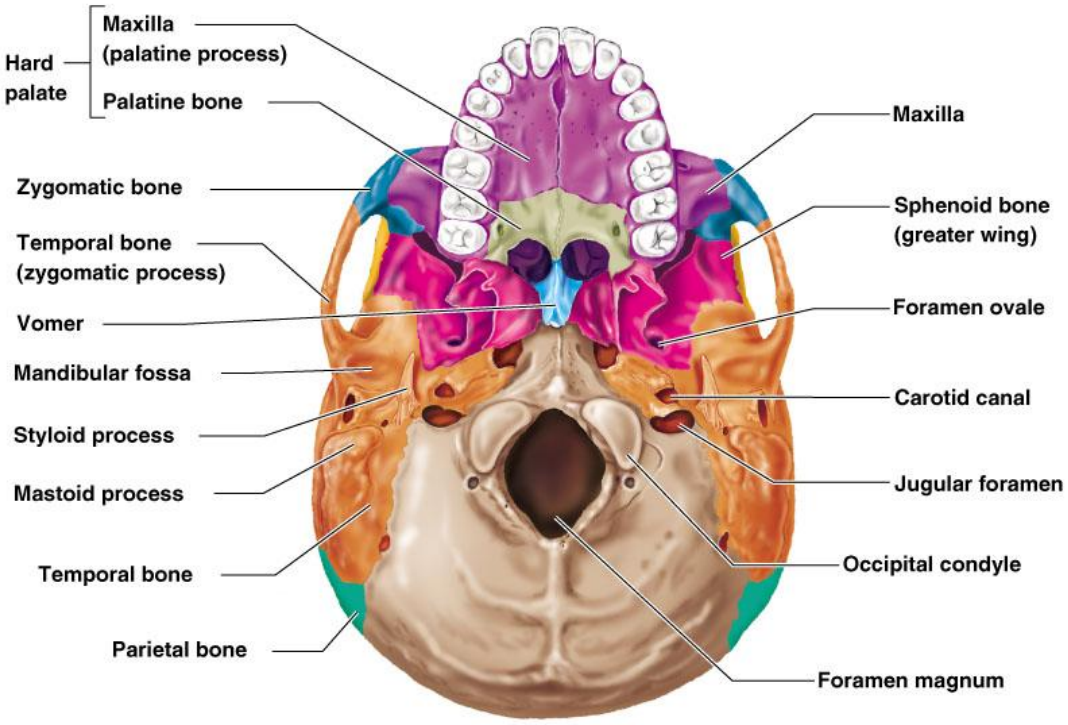
- Frontal bone
- Parietal bone
- Occipital bone
- Temporal bone
- Sphenoid bone
- Ethmoid bone
- Zygomatic bone
- Maxilla
- Mandible
- Lacrimal bone
- Nasal bone
- Vomer bone
- Palatine bone
- Inferior nasal conchae



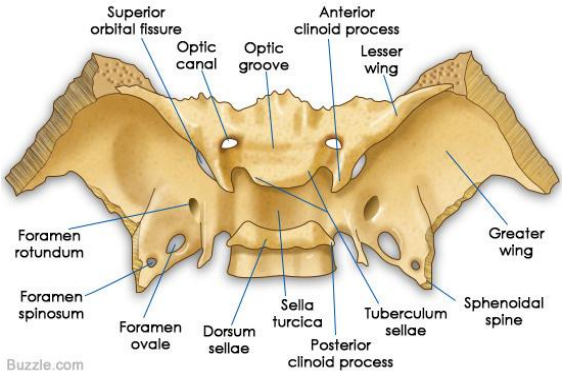


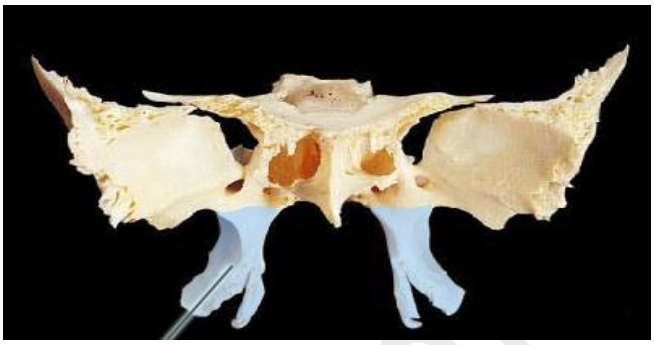


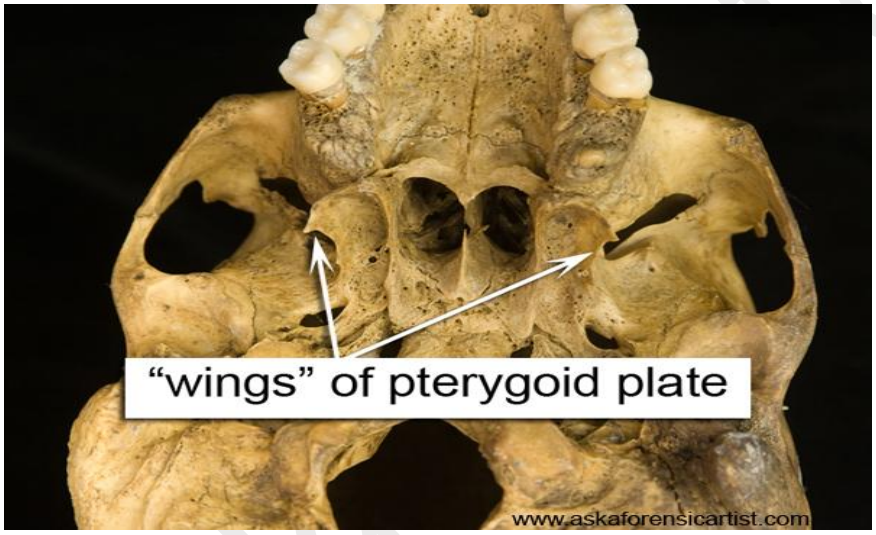
(a) Superior view of the skull, calvaria removed



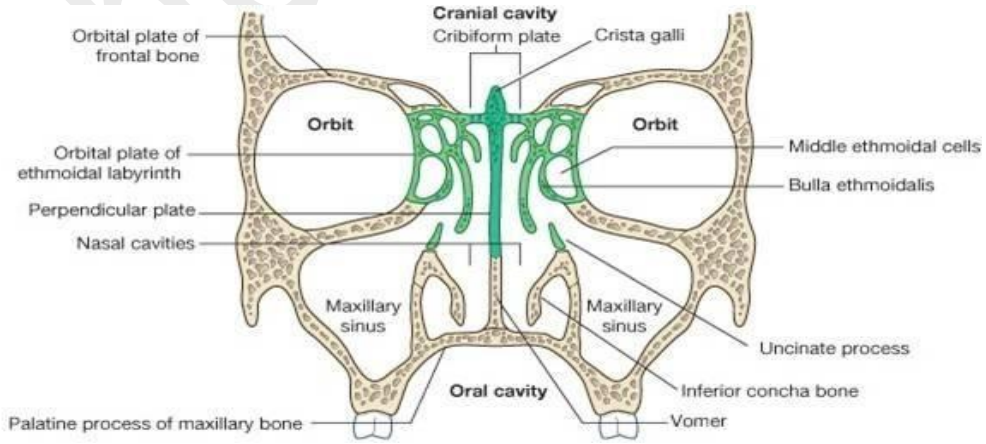
Sphenoid Bone



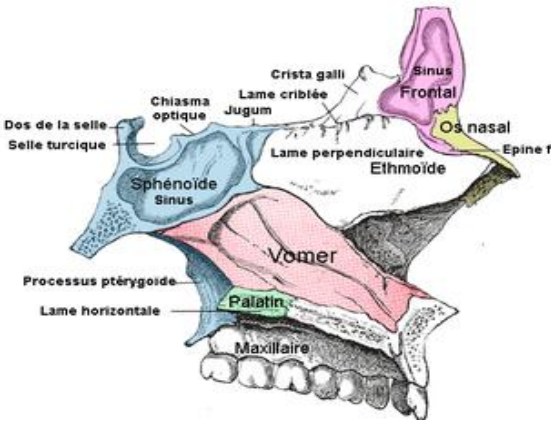


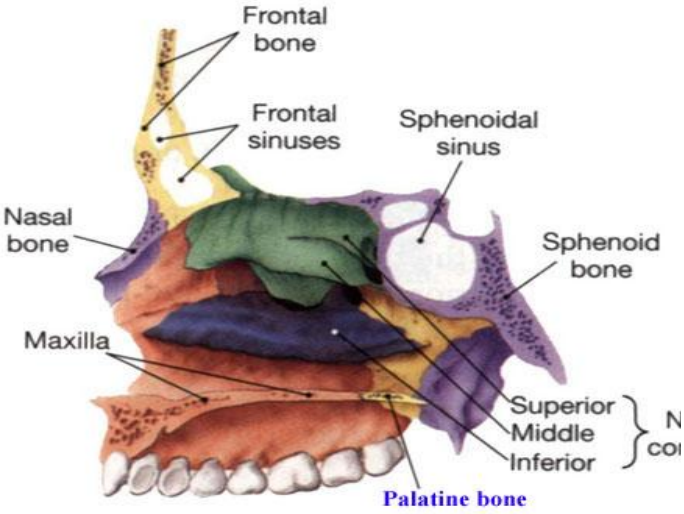


Ethmoid Bone

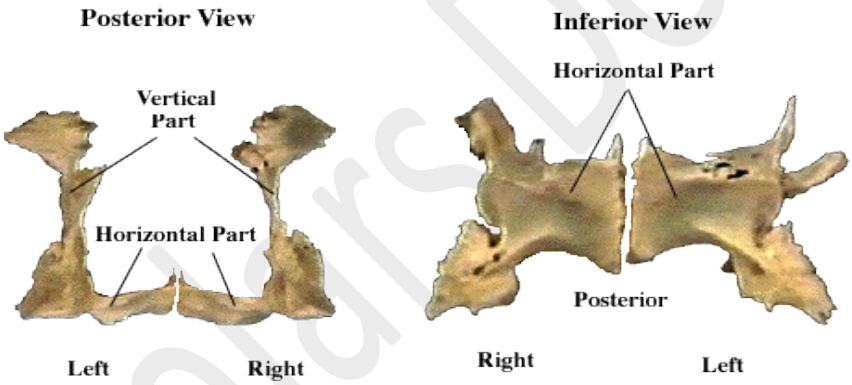


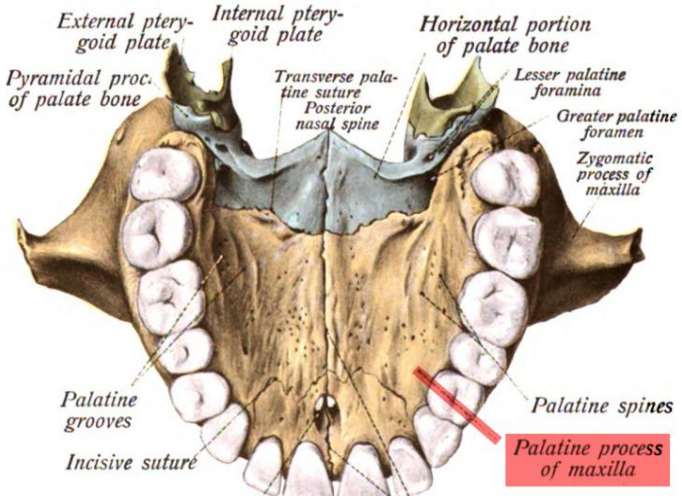
Vomer Bone



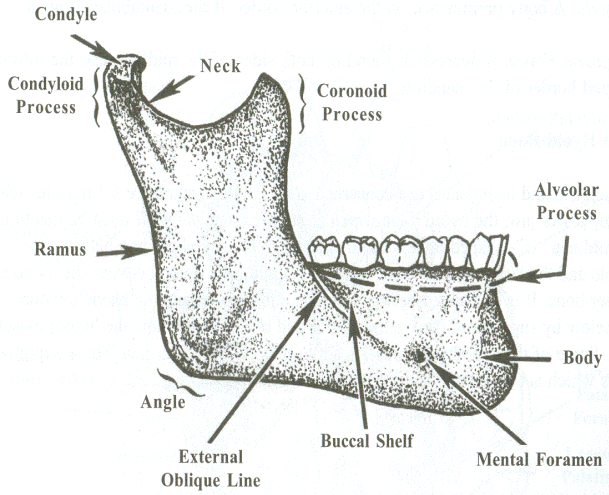


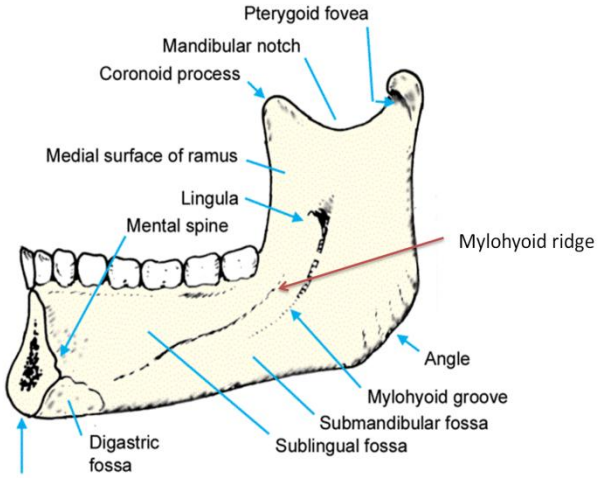
Palatine Bone

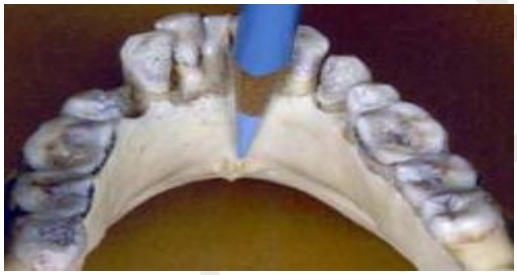




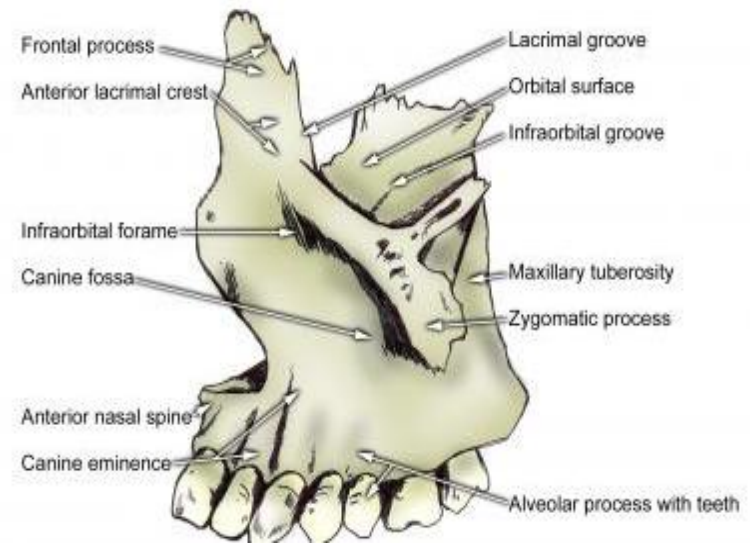
Mandible



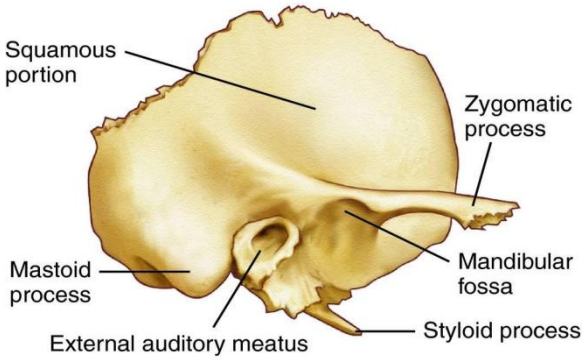




Maxilla



Temporalis



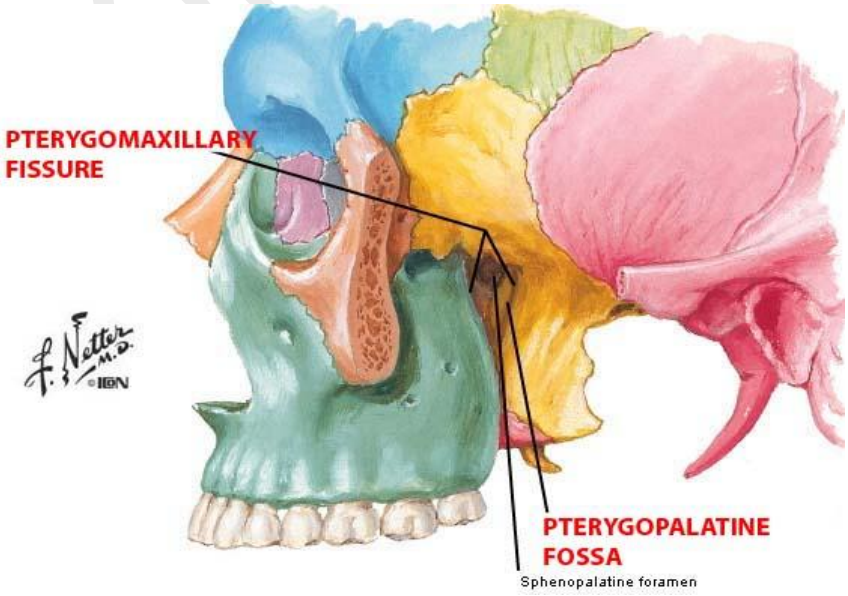
Regions of the Skull

- Temporal fossa
- Infra-temporal fossa
- Pterygomaxillary fissure
- Pterygopalatine fossa
- Oribital cavity
- Nasal cavity
- Oral cavity
- Cranium (anterior, posterior, middle)

Infratemporal Fossa

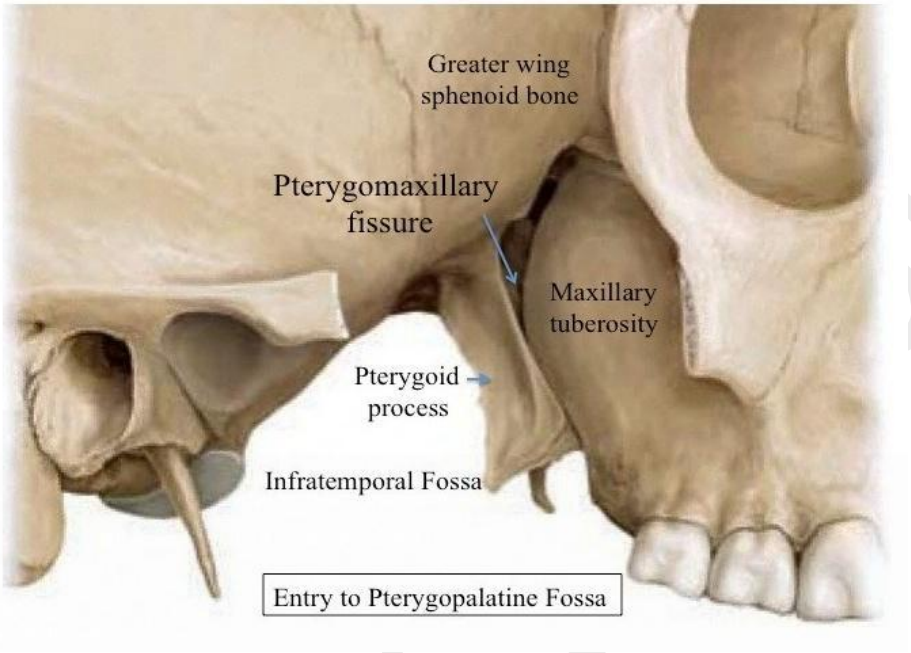
- The infratemporal fossa is an irregular space behind the maxilla. Its roof is formed by the greater wing of the sphenoid. The lateral pterygoid plate of the sphenoid is medial. Laterally, it is limited by the coronoid process and ramus of the mandible.
- The infratemporal fossa communicates with the pterygopalatine fossa through the pterygomaxillary fissure which is a cleft between the lateral pterygoid plate and the maxilla.
- It communicates with the orbit through the inferior orbital fissure which is between the maxilla and the greater wing of the sphenoid.
- Structures

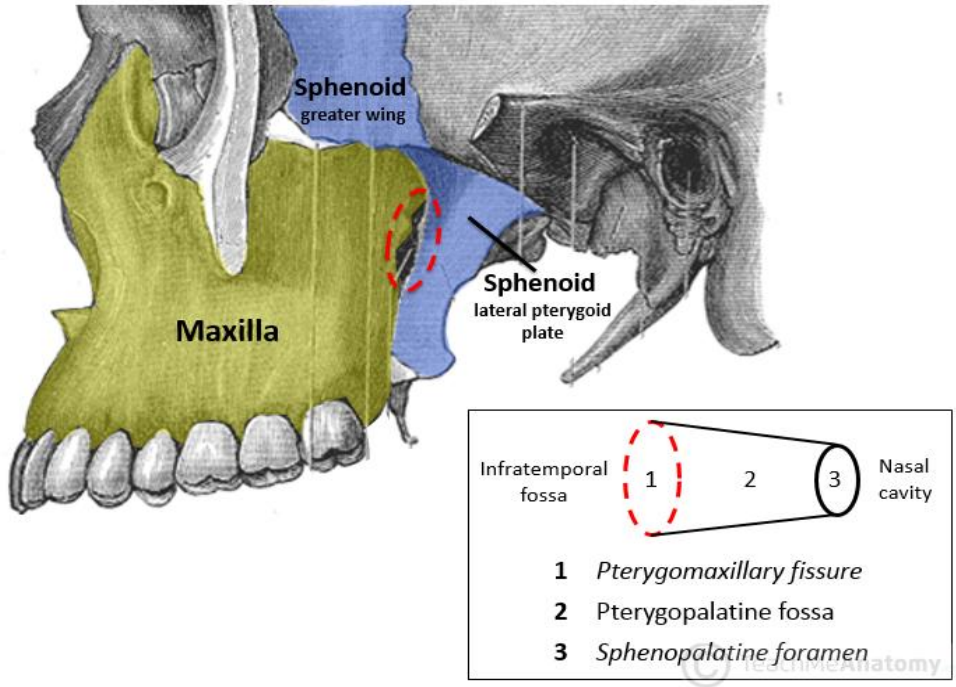
- Lateral and medial pterygoid muscles
- Maxillary artery
- Pterygoid venous plexus
- Mandibular nerve



Pterygopalatine Fossa

The pterygopalatine fossa is a small space behind and below the orbital cavity. It lies between the pterygoid plates of the sphenoid and palatine bone below the apex of the orbit.

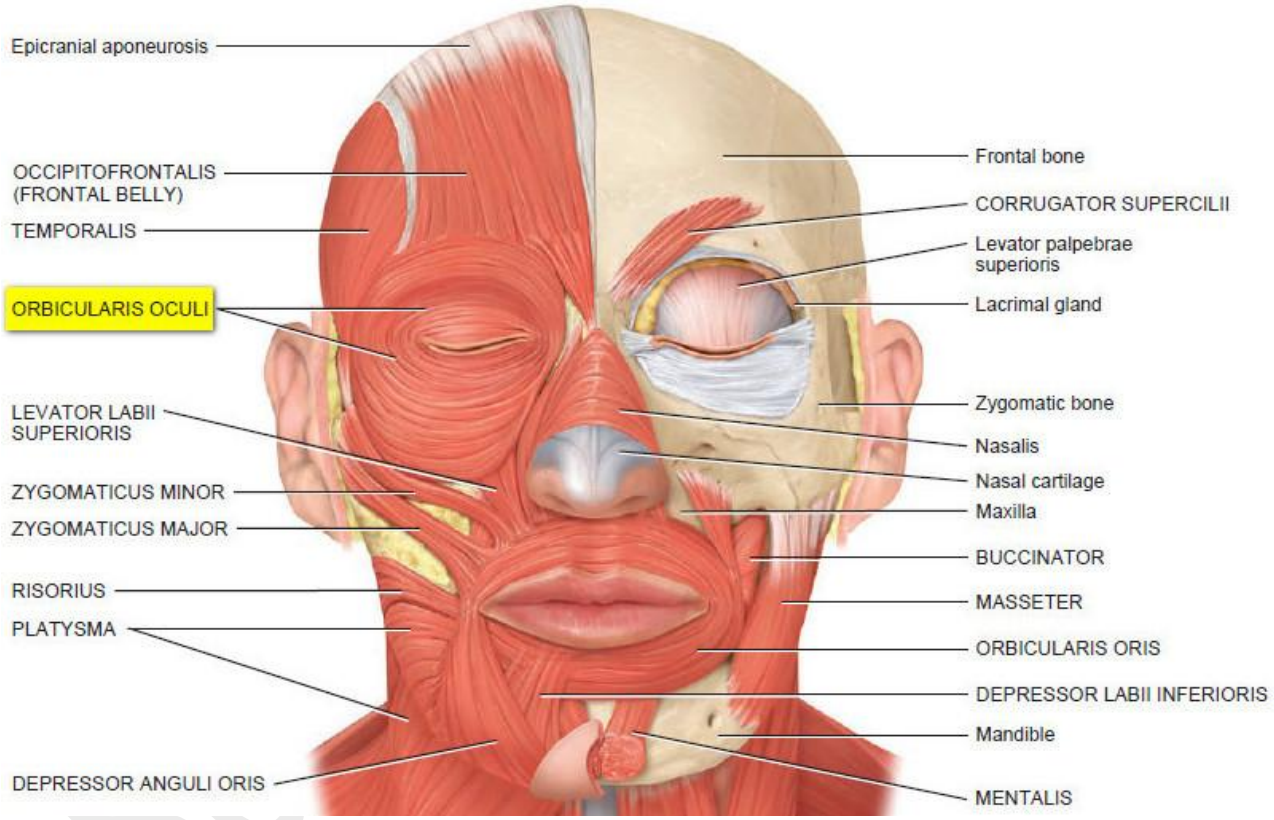




Muscles

Muscles of Facial Expression

- Orbicularis oris
- Depressor labii inferioris
- Depressor anguli oris (triangularis)
- Mentalis
- Levator labii superioris
- Levator angular oris (caninus): pulls up corner of lip
- Buccinator: innervated by facial nerve (motor) and by trigeminal (sensory)
- Levator palpebrae superioris.



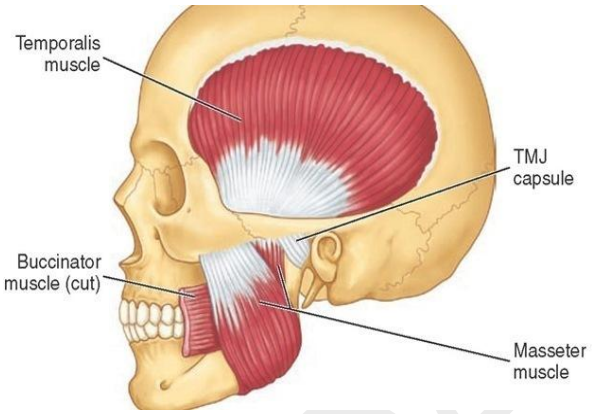
Muscles of Mastication

Motor innervation of muscles of mastication via trigeminal nerve (CN V – mandibular branch)

- Masseter muscle
- Temporalis muscle
- Medial pterygoid muscle
- Lateral pterygoid muscle

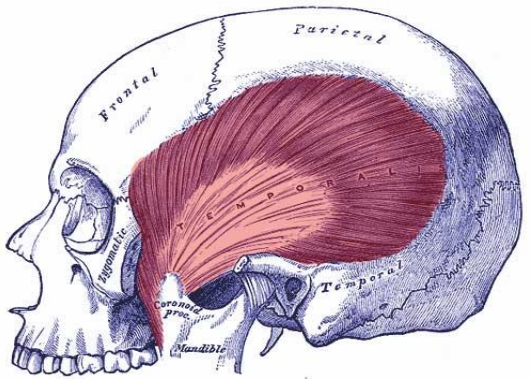
Masseter Muscle

- **Origin:** zygomatic arch, inferior and medial surfaces of the zygomatic bone and the temporal process of zygomatic bone. From here it extends downward and posteriorly.
- **Insertion:** Lateral surface of the ramus, angle and lower border of mandible.
- **Action:** Elevator closes jaw and applies great power in crushing food.



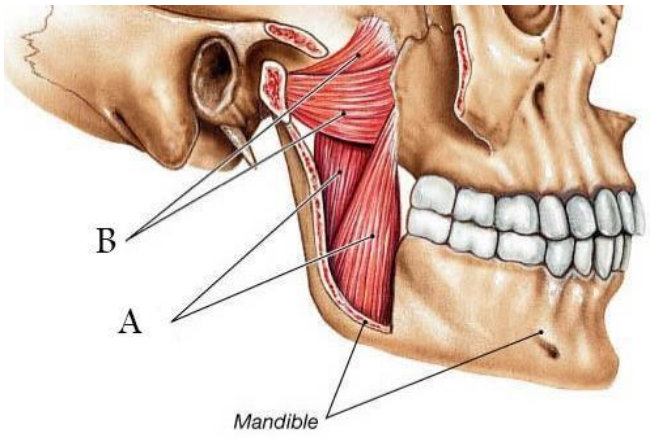
Temporalis Muscle

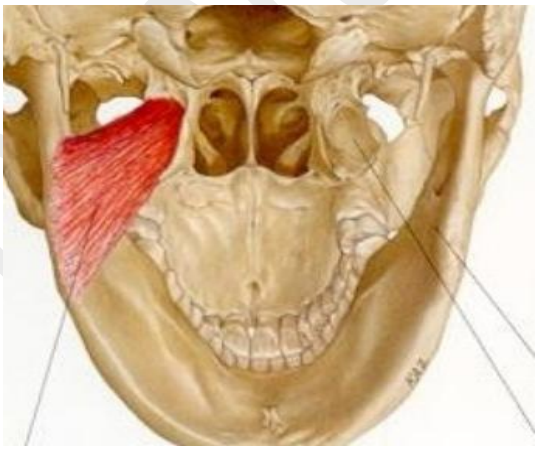
- **Origin:** entire temporalis fossa (part of the frontal and parietal bones, squamous part of temporal, and greater wing of the sphenoid bones, its fibers are directed downward (anterior part) and downward and anteriorly (posterior part), passing medial to the zygomatic arch.
- **Insertion:** coronoid process of the mandible, the anterior border of the ramus, and the temporal crest of the mandible via one common tendon.
- **Action:** anterior vertical muscle fibers contract to act as an elevator to close the jaw especially when great power is not required and the posterior more horizontal fibers retract or pull the jaw backward.

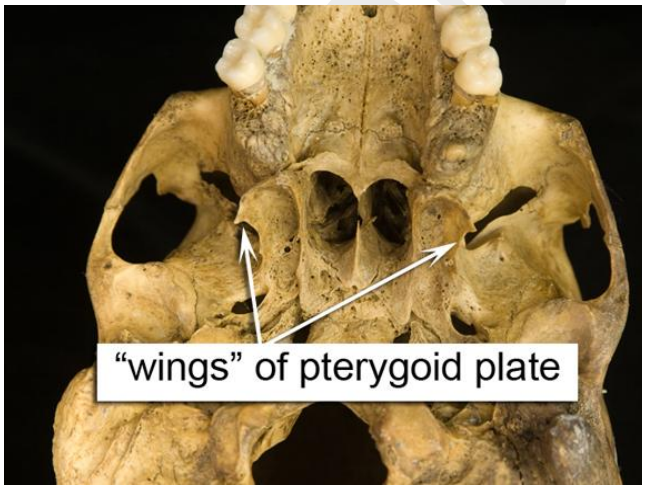


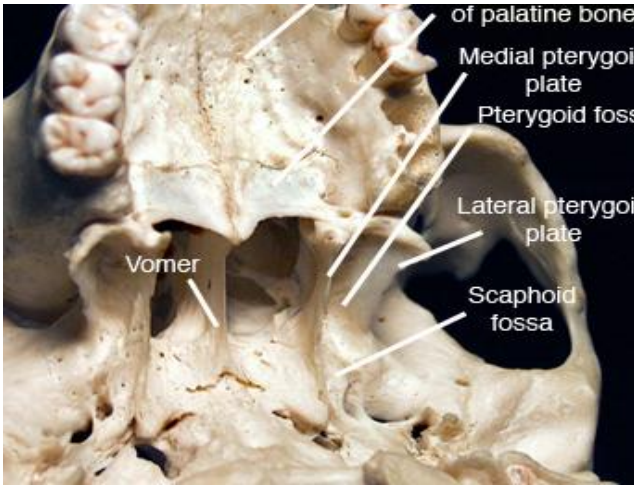
Medial Pterygoid Muscle

- **Origin:** mainly from the medial surface of the lateral pterygoid plate and the pterygoid fossa between the medial and lateral plates of the sphenoid bone. Also from the pyramidal process of the palatine bone, with a few fibers to the maxillary tuberosity. The fibers pass downward and laterally toward the angle of the mandible.
- **Insertion:** medial surface of the mandible in a triangular region just above the angle and to the angle.
- **Action:** elevator (like temporalis and masseter muscles). Although not as large or powerful it is a synergist of the masseter muscle in helping apply the power or great force on closures with the larger masseter muscle. Acting together, these two muscles form a sling on each side of the mandible.



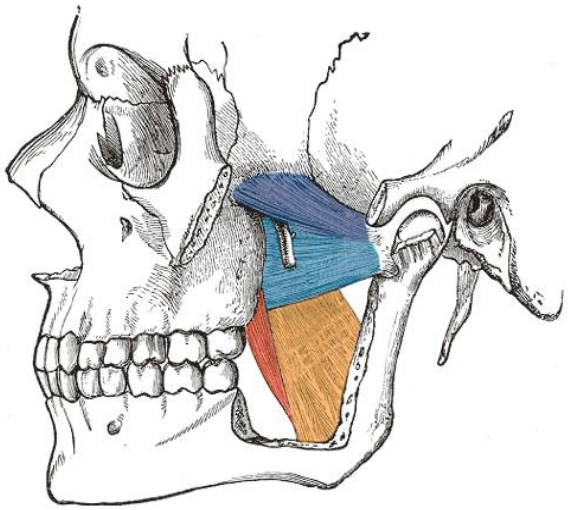


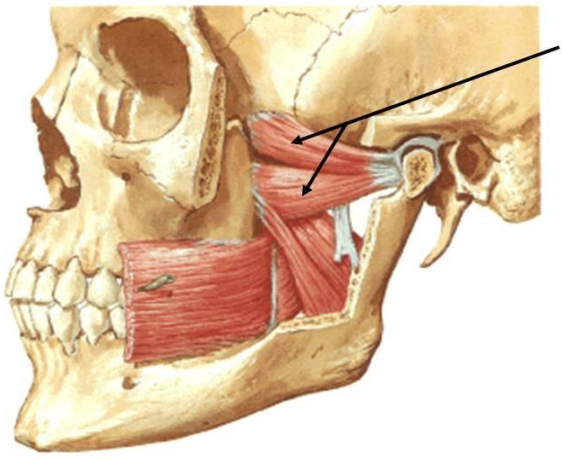




Lateral Pterygoid Muscle

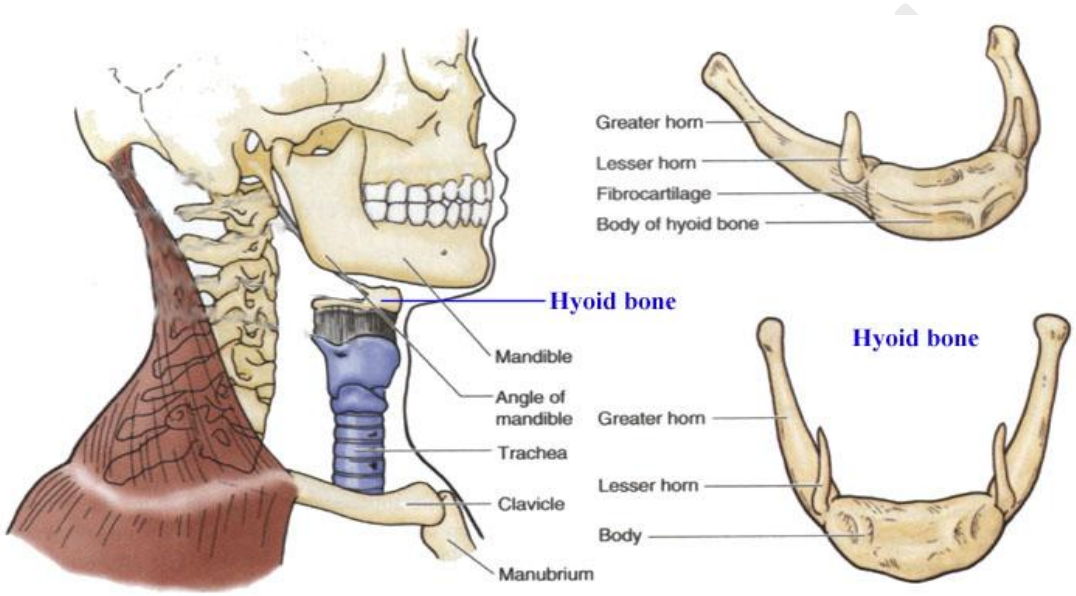
- **Origin:** it has two heads.
- The smaller upper head is attached to the infratemporal surface on the great wing of the sphenoid bone.
- The large lower head is attached to the lateral side of the lateral pterygoid plate on the sphenoid bone.
- **Insertion:**
- Upper head: front of the neck of the condyloid process and to the anteromedial surface of the capsular ligament penetrating the capsule and inserting into the disc.
- Lower head: roughened pterygoid fovea on the anterior surface of the neck of the condyle.
- Minor forward contractions of the upper head work in concert with the stretching of the elastic band of retrodiscal tissues to prevent the disk from becoming displaced posteriorly.
- **Action:**
- With both contracting simultaneously >> opening the jaw. The lateral pterygoids are assisted somewhat by the hyoid muscles.
- With both contracting simultaneously >> protruding the jaw. No other muscles are capable of doing this but can only assist in this action as stabilizers or by controlling the degree of jaw opening during the protrusion.
- Unilateral contraction >> Lateral movement of the mandible. No other muscle is capable of moving the mandible sideways, although synergestic unilateral contraction of the posterior fibers of the temporalis muscle occurs on the side toward which the jaw moves.

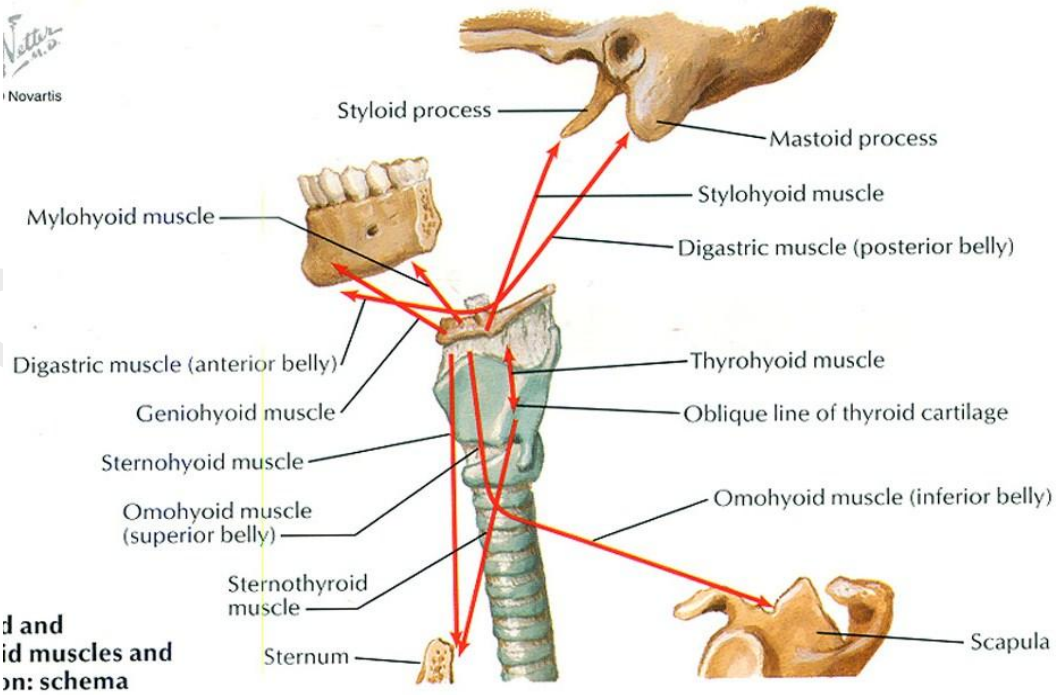




Hyoid Muscles (7 muscles)

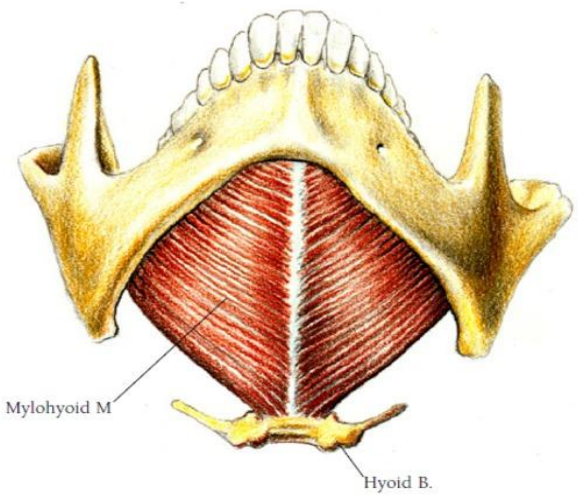
- **Suprahyoid Muscles**
  - Mylohyoid muscle
  - Geniohyoid muscle
  - Stylohyoid muscle
  - Diagastric muscle
- **Infrahyoid Muscles**
  - Omohyoid muscle
  - Sternohyoid muscle
  - Thyrohyoid muscle

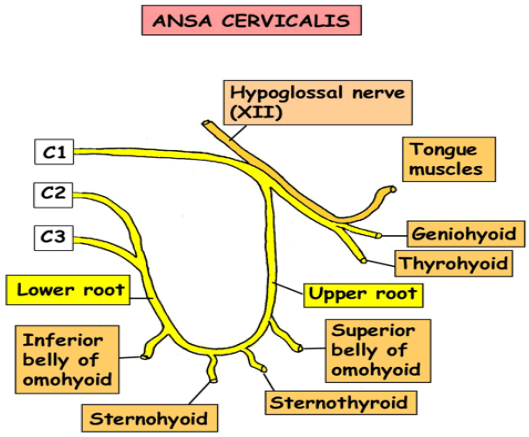




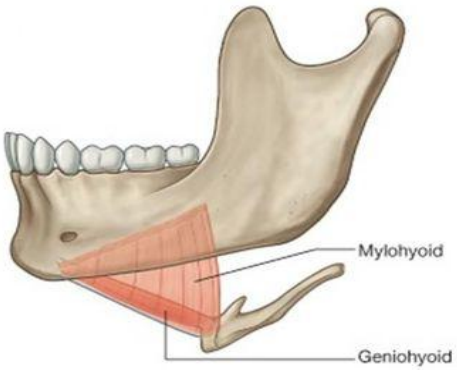
Suprahyoid muscles

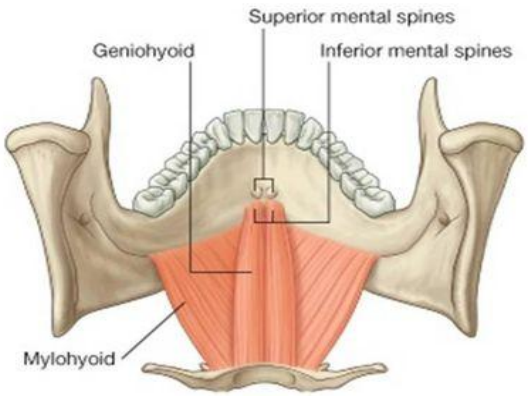
- **Mylohyoid muscle**
  - Origin: mylohyoid line (ridge) of the mandible
  - Insertion: body of hyoid bone
  - Action: pull hyoid bone up and forward
  - Innervation:
  - CN V trigeminal nerve
  - V-3 mandibular branch (Mylohyoid nerve)



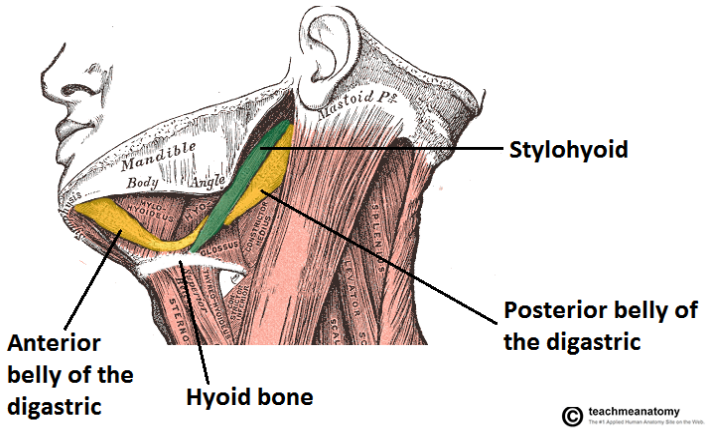


- **Geniohyoid muscle**
  - Origin: lower genial spine (tubercles)
  - Insertion: body of hyoid bone
  - Action: pull hyoid bone up and forward
  - Innervation: C1 via the hypoglossal nerve (XII)

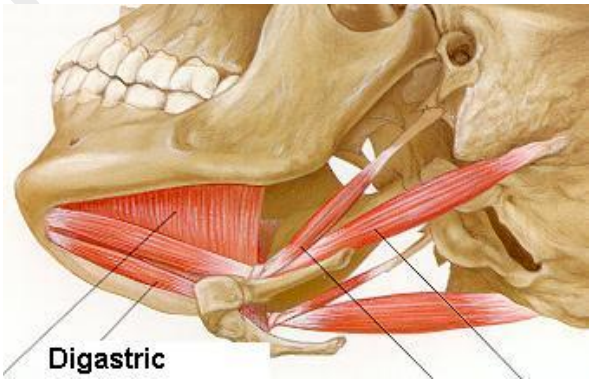




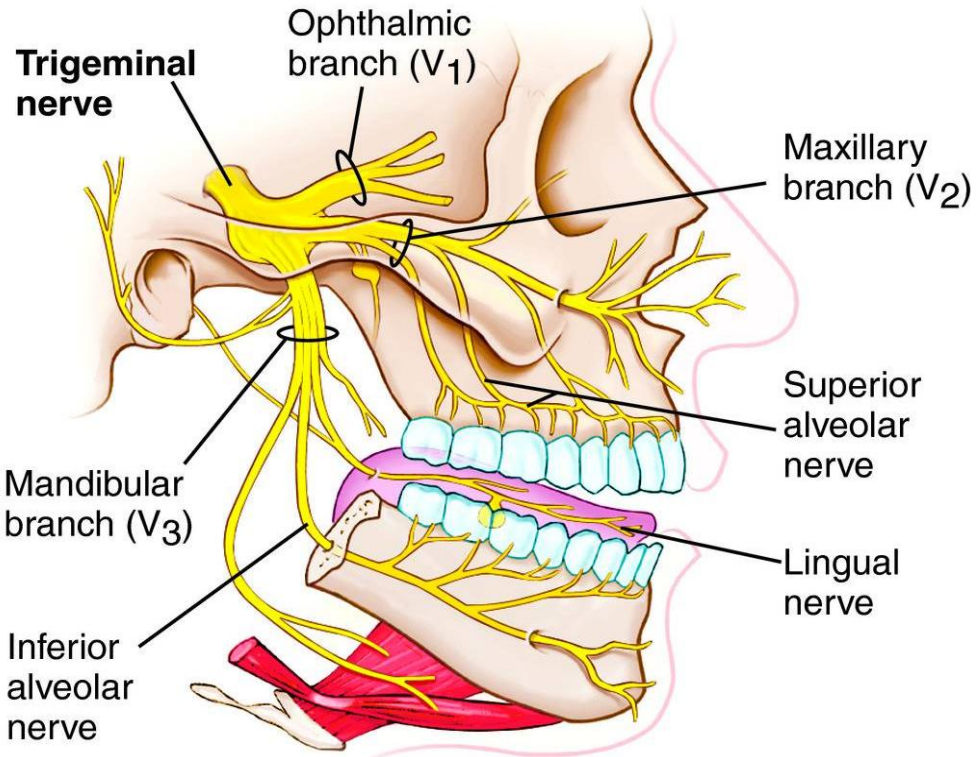
- **Stylohyoid muscle**
  - Origin: styloid process
  - Insertion: greater horn of hyoid bone
  - Action: pull hyoid bone backward
  - Innervation: Facial nerve (CN-VII)

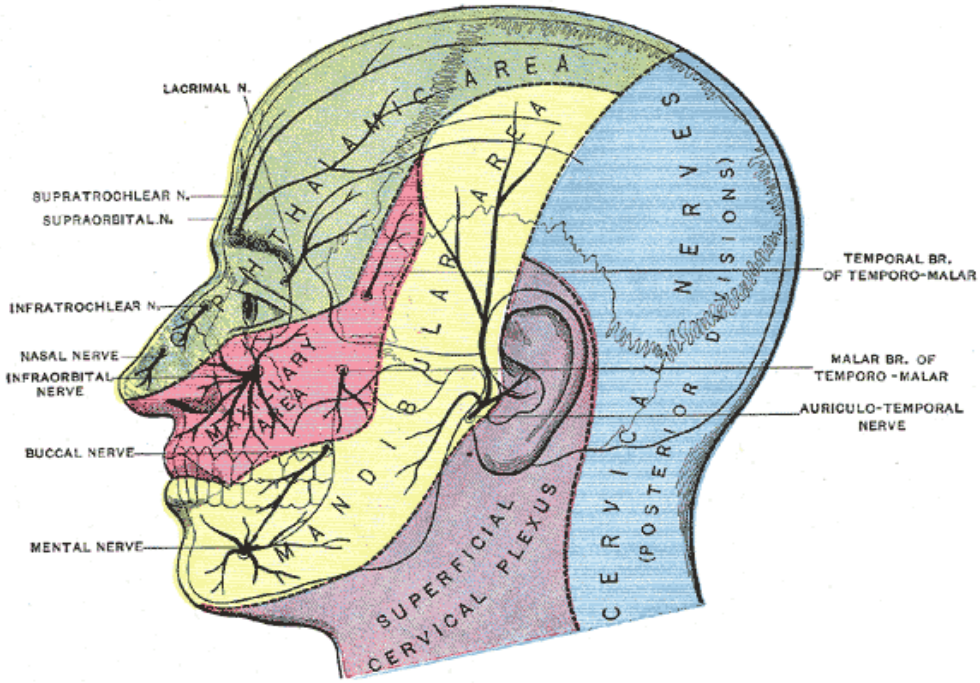


- **Diagastric muscle**
  - Action: Pulls hyoid bone up
  - Posterior belly
    - Origin: digastric notch + mastoid bone
    - Insert: tendon enters opening of stylohyoid muscle and to body of hyoid
    - Innervation: facial nerve (CN-VII)
  - Anterior belly
    - Origin: lower aspect of the mandible just lateral to midline (digastric fossa of mandible)
    - Insertion: back to tendon and hyoid bone
    - Innervation: Trigeminal nerve (CN-V)



Trigeminal Nerve





Division I, Ophthalmic nerve:

- Afferent (sensory) only.
- Exits from the skull via superior orbital fissure.

Division II, Maxillary nerve:

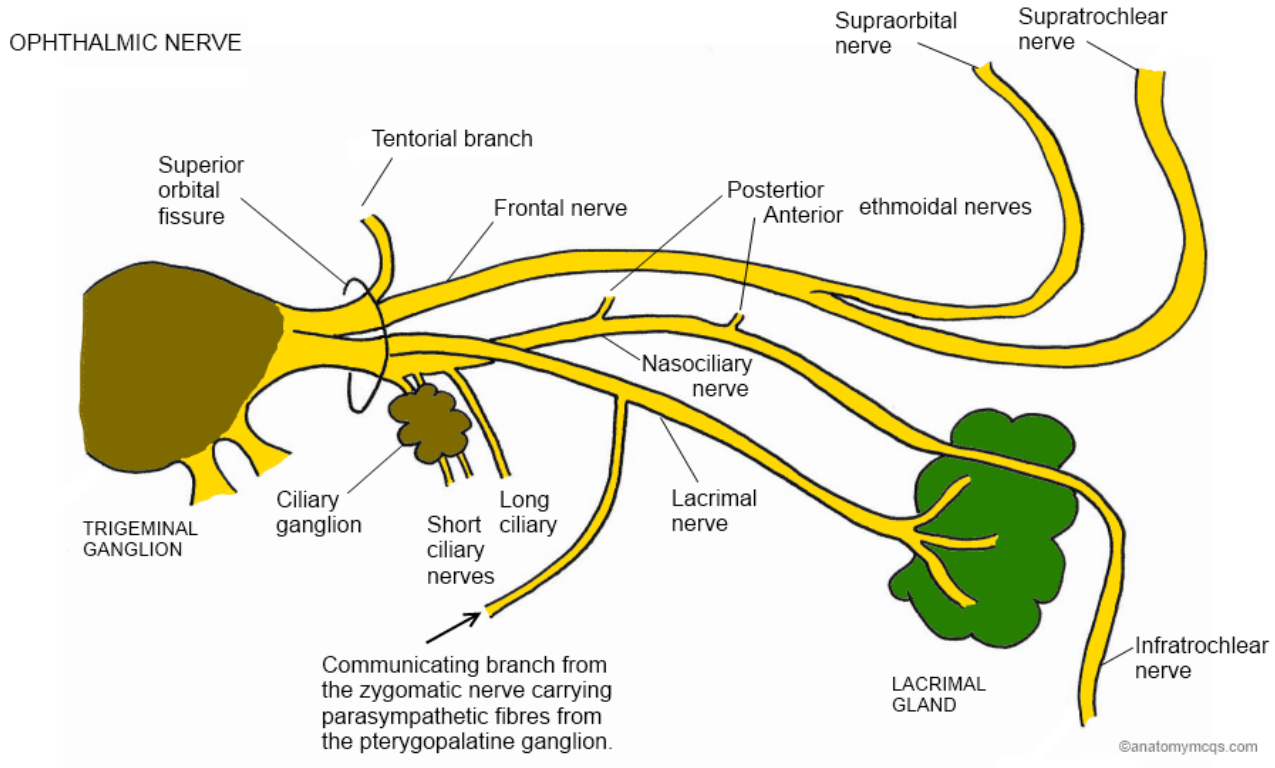
- Afferent (sensory) only.
- Exits from the skull via foramen rotundum

Division III, Mandibular nerve:

- Afferent (sensory) and efferent (motor).
- Exits from the skull via foramen ovale.

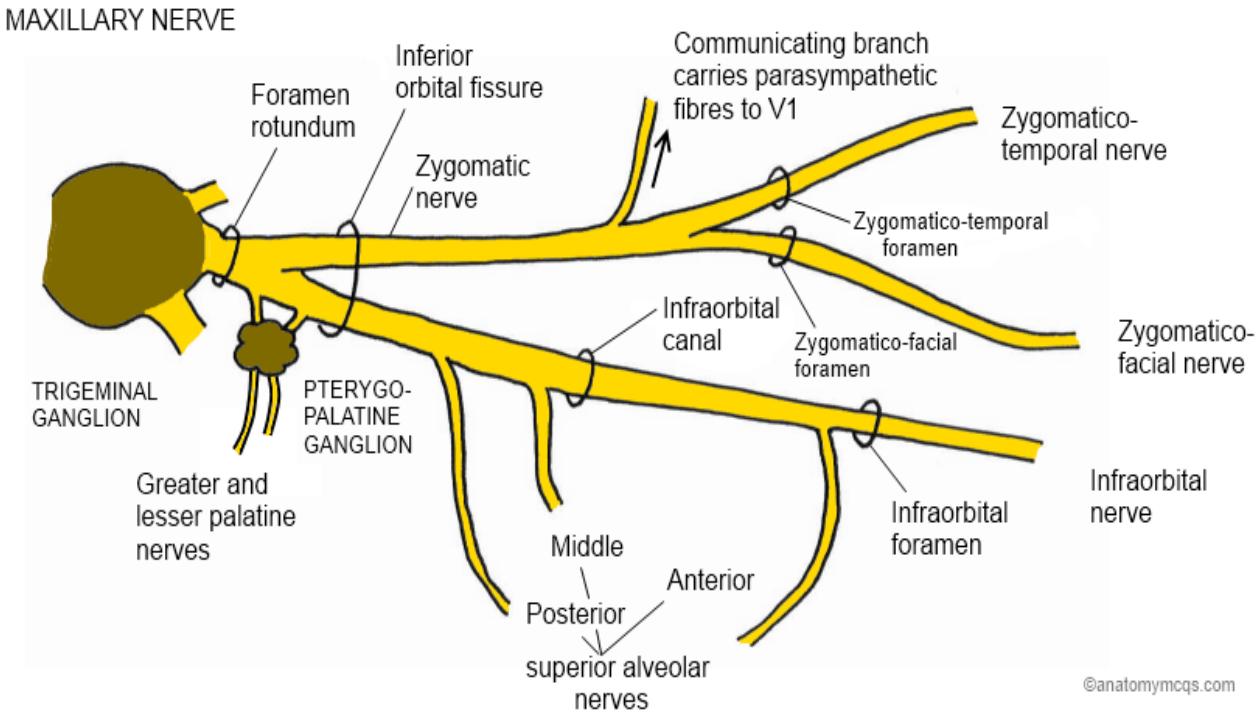
The maxillary and mandibular divisions of the trigeminal nerve supply afferent or sensory neurons that provide the brain with information about the position of the teeth and jaws. The interpretation of the postural information by the brain is called proprioception. Proprioception (sense of position) is supplied to the PDL of teeth, capsule and disc of TMJ, muscles and ligaments.

Ophthalmic Nerve



Maxillary Nerve

- **Pterygopalatine nerve**
  - Nasopalatine nerve
  - Palatine nerves
- **Posterior superior alveolar nerve**
- **Infraorbital nerve**
  - Middle superior alveolar nerve
  - Anterior superior alveolar nerve
  - Terminating branches : labial, nasal, palpebral
- **Zygomatic nerve**
  - Zygomaticotemporal
  - Zygomaticofacial

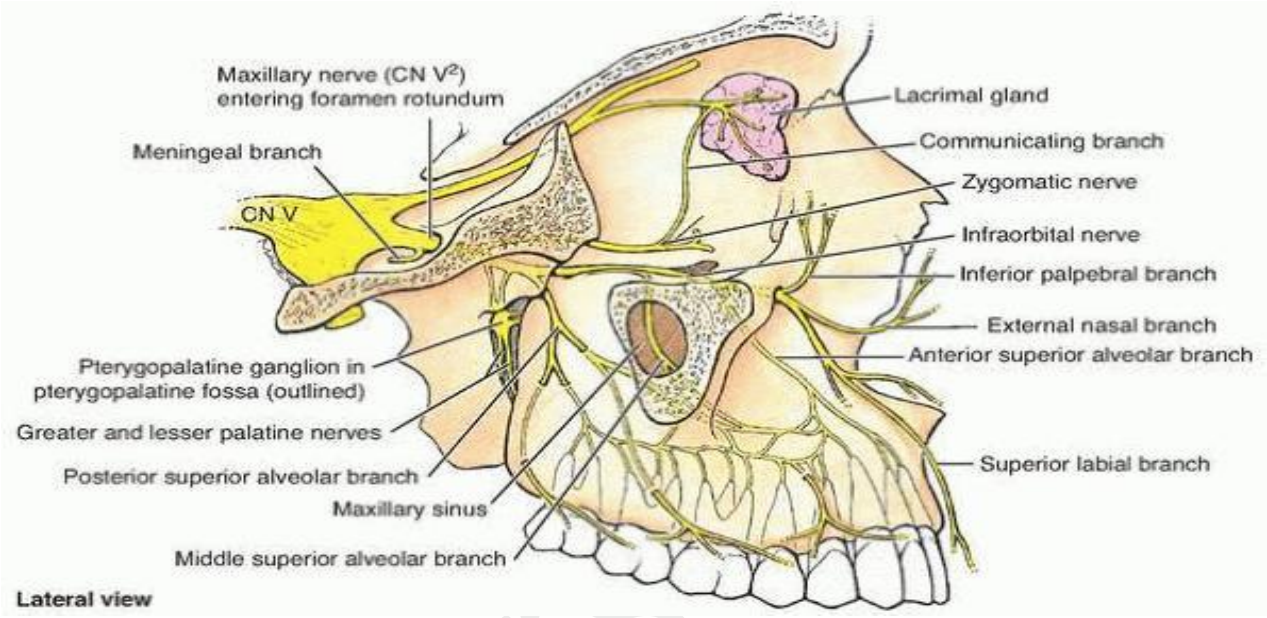


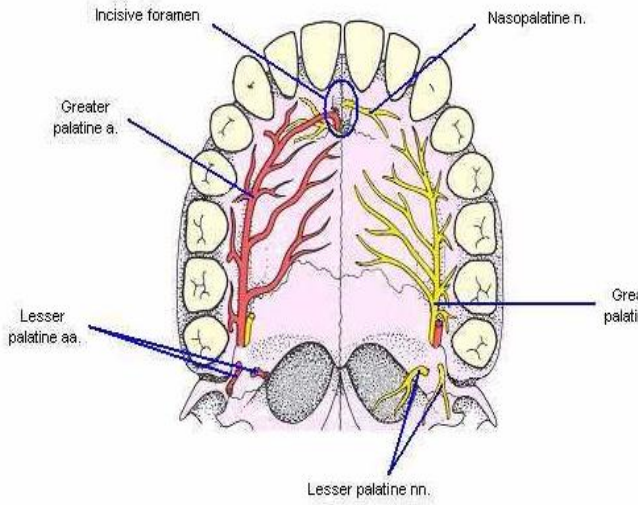
Pterygopalatine Nerve

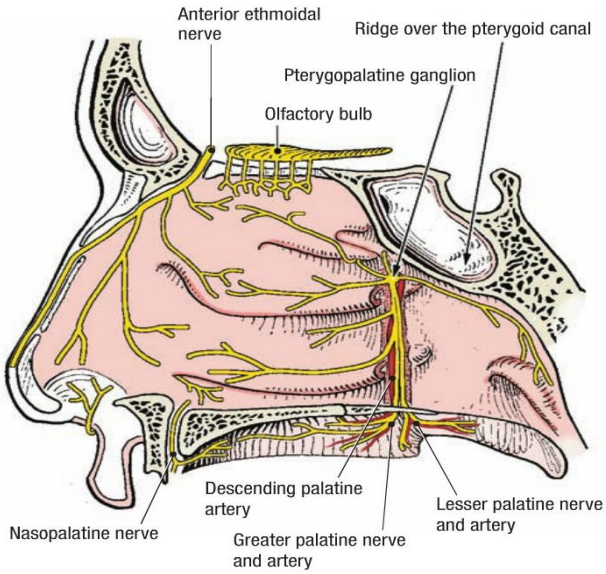
Given off in the pterygopalatine fossa and is attached to the pterygopalatine ganglion. The fibers of the pterygopalatine nerve pass through the ganglion and its two main branches:

- **Nasopalatine nerve**
  - Anterior palatal mucosa, mucosa of the nasal septum, palatal gingiva from the maxillary incisors to the canines

- **Palatine nerves**
  - Greater palatine nerve (anterior palatine nerve)
    - Mucosa/gingival of hard palate of premolars and molars
  - Lesser palatine nerve (middle and posterior palatine nerves)
    - Soft palate (middle) and tonsils (posterior)

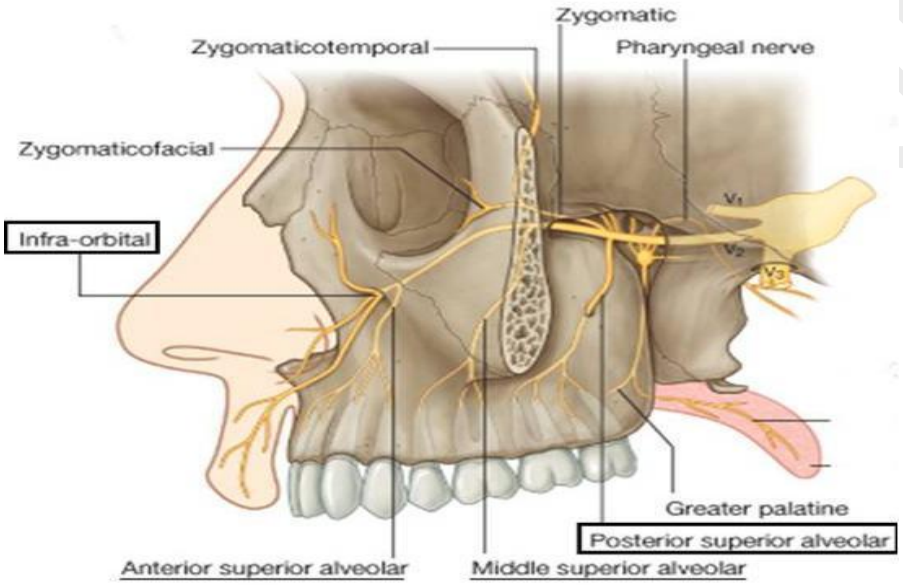






Posterior superior alveolar nerve

- Branches off within the pterygopalatine fossa and enters the body of the maxilla on the infratemporal surface via alveolar canals.
- Branches of the posterior superior alveolar nerve pass down through the wall of the maxillary sinus and supply:
    - Pulp of max. molars except the MB root of max. First molar
    - Buccal gingiva, PDL , alveolar process of the max. molars
    - Mucosa of max. Sinus



Infraorbital nerve

- **Middle superior alveolar nerve**
    - Pulps, buccal gingiva, PDL, alveolar process, mucosa of sinus >> premolar area
- **Anterior superior alveolar nerve**
    - Pulps, labial gingiva, PDL, alveolar process, mucosa of sinus >> anterior region
- **Terminating branches**
    - Labial >> skin /mucosa of upper lip
    - Nasal >> skin /mucosa of side of nose
    - Palpebral >> skin/mucosa of lower eyelid

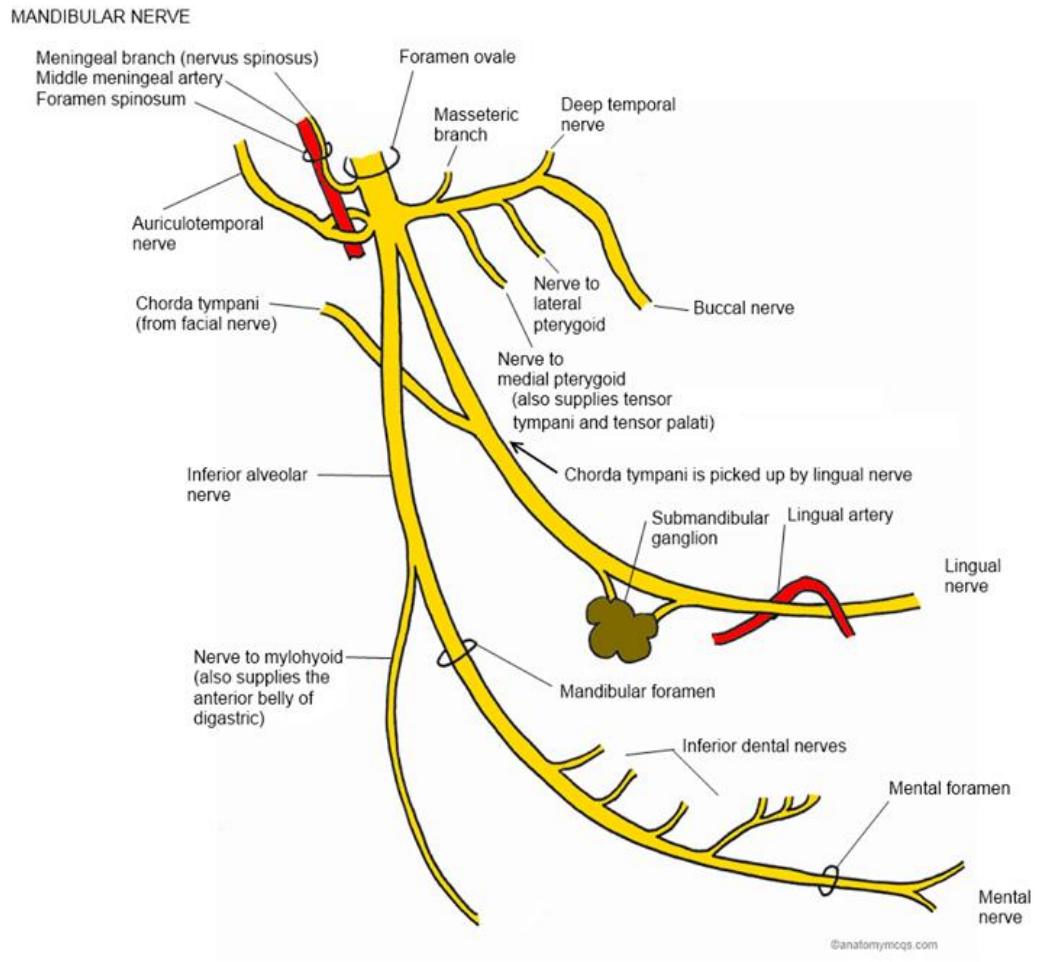
Zygomatic nerve

- This nerve areises in the pterygopalatine fossa.
- Enters the orbit via the inferior orbital fissure, and then divides into:
    - **Zygomaticotemporal (upper branches)**
    - **Zygomaticofacial (lower branches)**
    - Supplies the bone and temporal region and the orbit.

Mandibular Nerve

Motor branches

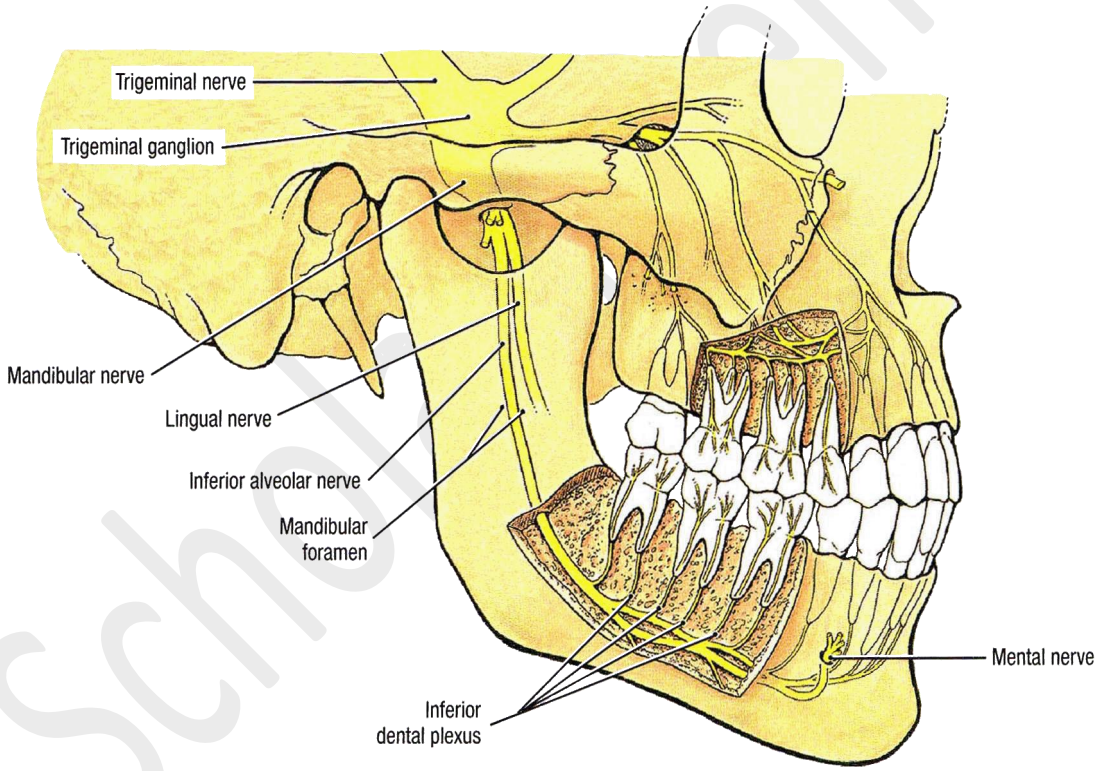
- **Masseteric nerve:** masseter, TMJ
- **Posterior/anterior temporal nerve:** temporalis
- **Medial pterygoid nerve:** MP muscle
- **Lateral pterygoid nerve:** LP muscle
- **Mylohyoid nerve:** mylohyoid muscle, anterior belly of digastric muscle
- **Tensor veli palatine:** soft palate
- **Tensor tympani:** middle ear



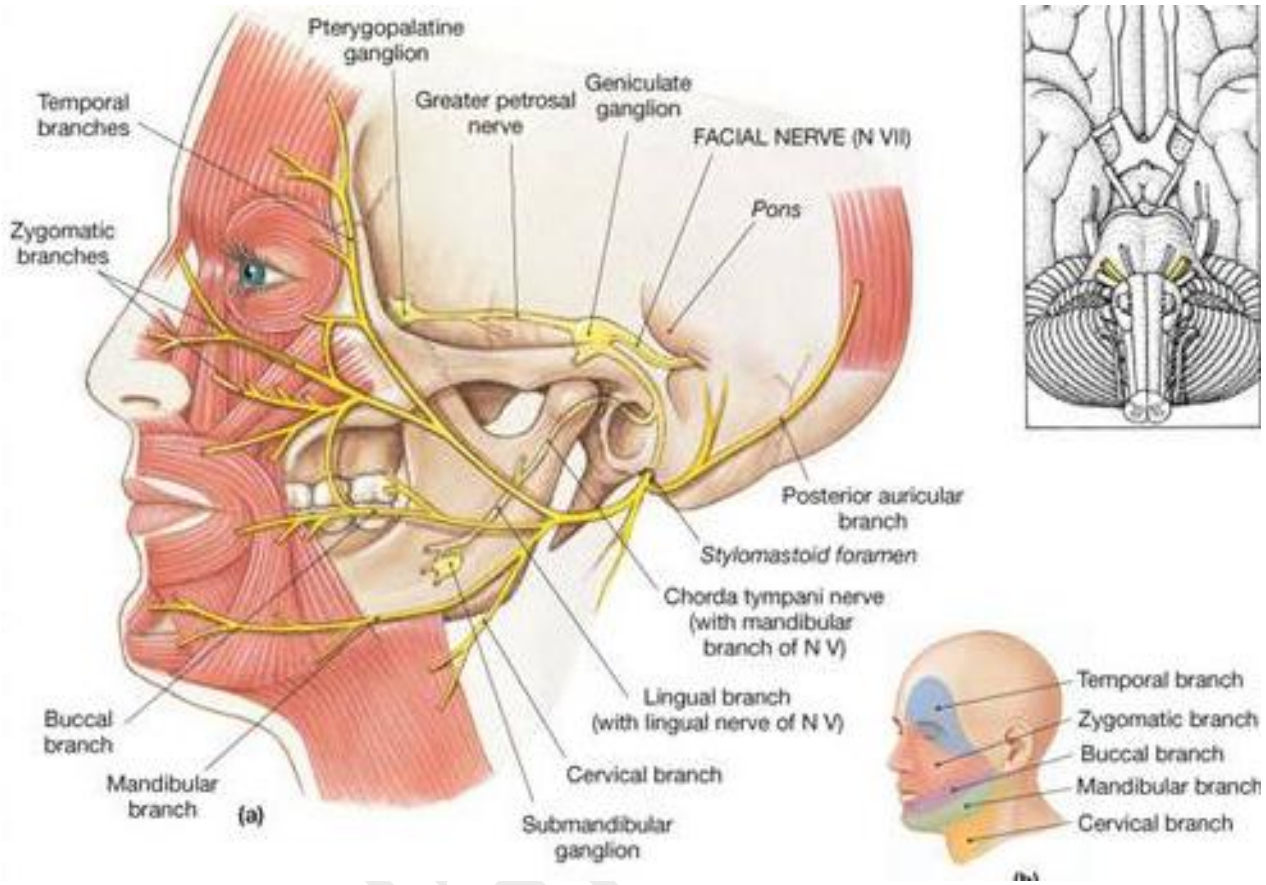
Sensory branches

- **Buccinator nerves:**
  - Buccal gingiva of lower molars, may, mucosa/skin of cheek, corner of mouth.
- **Auriculotemporal:**
  - TMJ (pain, proprioception), parotid gland, skin of outer ear, cheek, lateral skull.

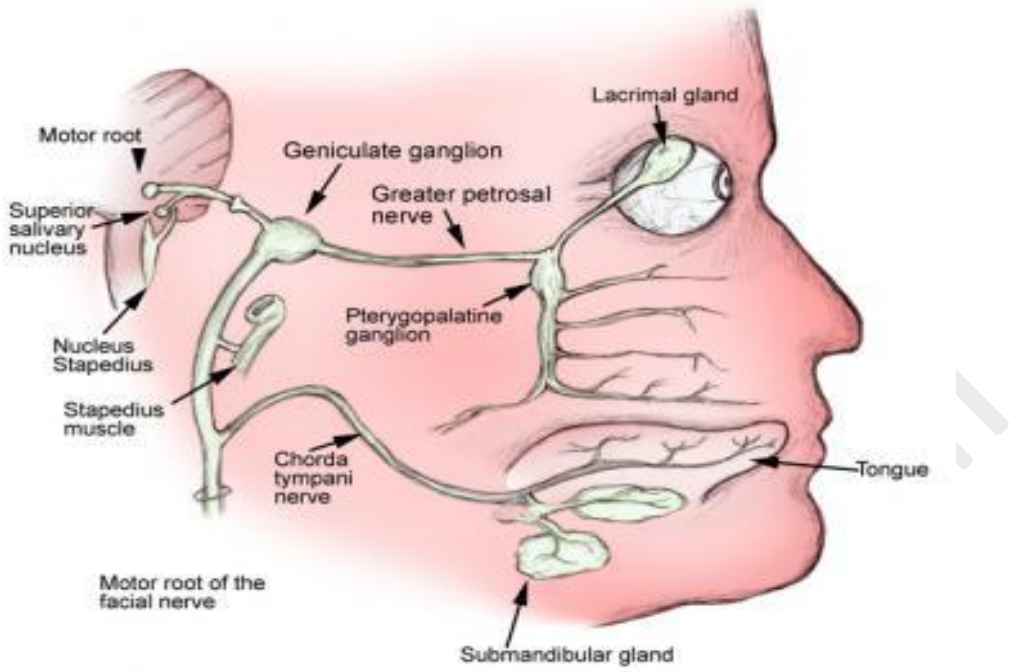
- **Lingual nerve:**
  - Lingual gingiva of lower arch, floor of mouth, anterior 2/3 of tongue (not taste).
  - Carries chorda tympani (taste of anterior 2/3 of tongue).
- **Inferior alveolar nerve**
  - Pulp, PDL, alveolar process, buccal gingiva (molar/premolar area)
  - Gives mylohyoid branch (motor)
- **Mental nerve**
  - Facial gingiva of anterior teeth and premolars.
  - Mucosa and skin of lower lip.
- **Incisive nerve**
  - Pulp, PDL, alveolar process of anterior teeth.



Facial Nerve

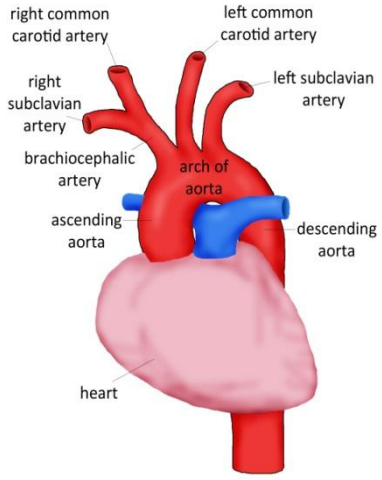


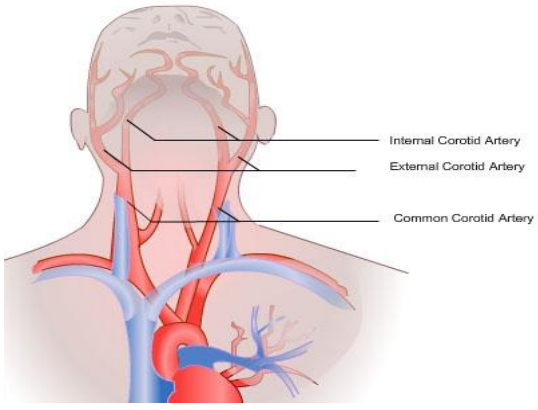
- Exits skull from stylomastoid foramen
- Branchial motor (Efferent)
  - Muscles of facial expressions
  - Stylohyoid muscle
  - Posterior belly of digastric
- Parasympathetic preganglionic (Efferent)
  - Lacrimal gland (by pterygopalatine ganglion)
  - Sublingual, submandibular glands (by submandibular ganglion)
- Sensory (afferent)
  - Special >> chorda tympani >> taste for anterior 2/3 tongue
  - General >> behind ear

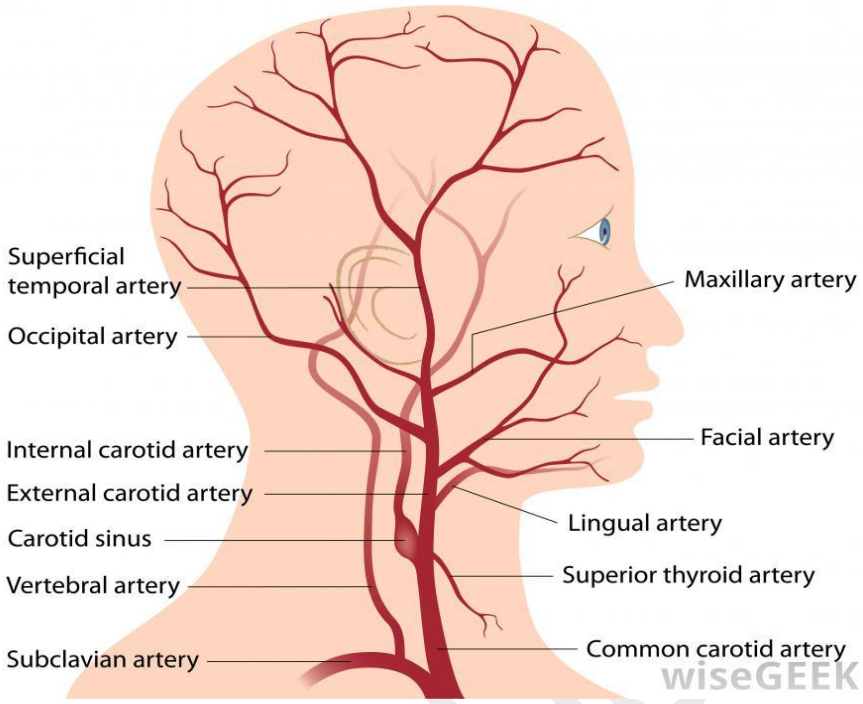


ARTERIES

- Left ventricle >> Aorta >> common carotid >> external carotid and internal carotid.
- Internal carotid supply the cranium and brain.
- External carotid supply maxillofacial region and give two terminal branches:
  - Maxillary artery
  - Superficial temporal artery

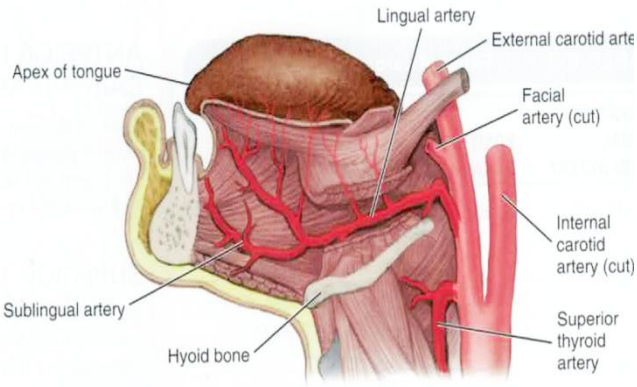


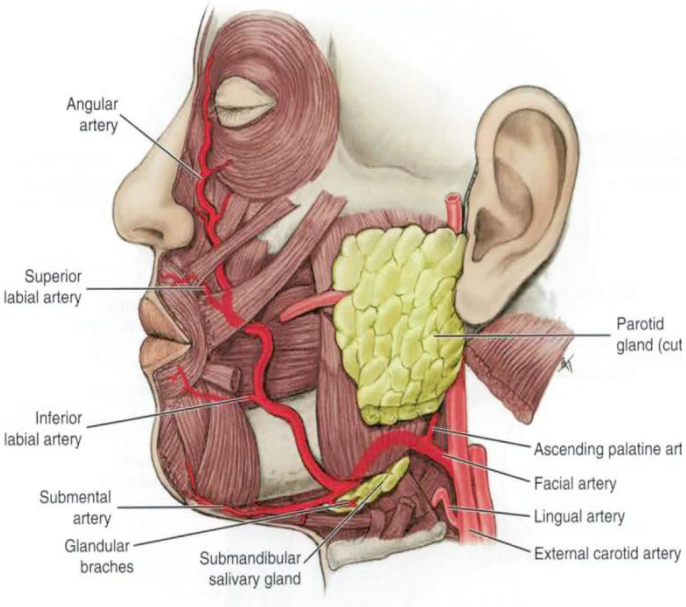




External Carotid Artery

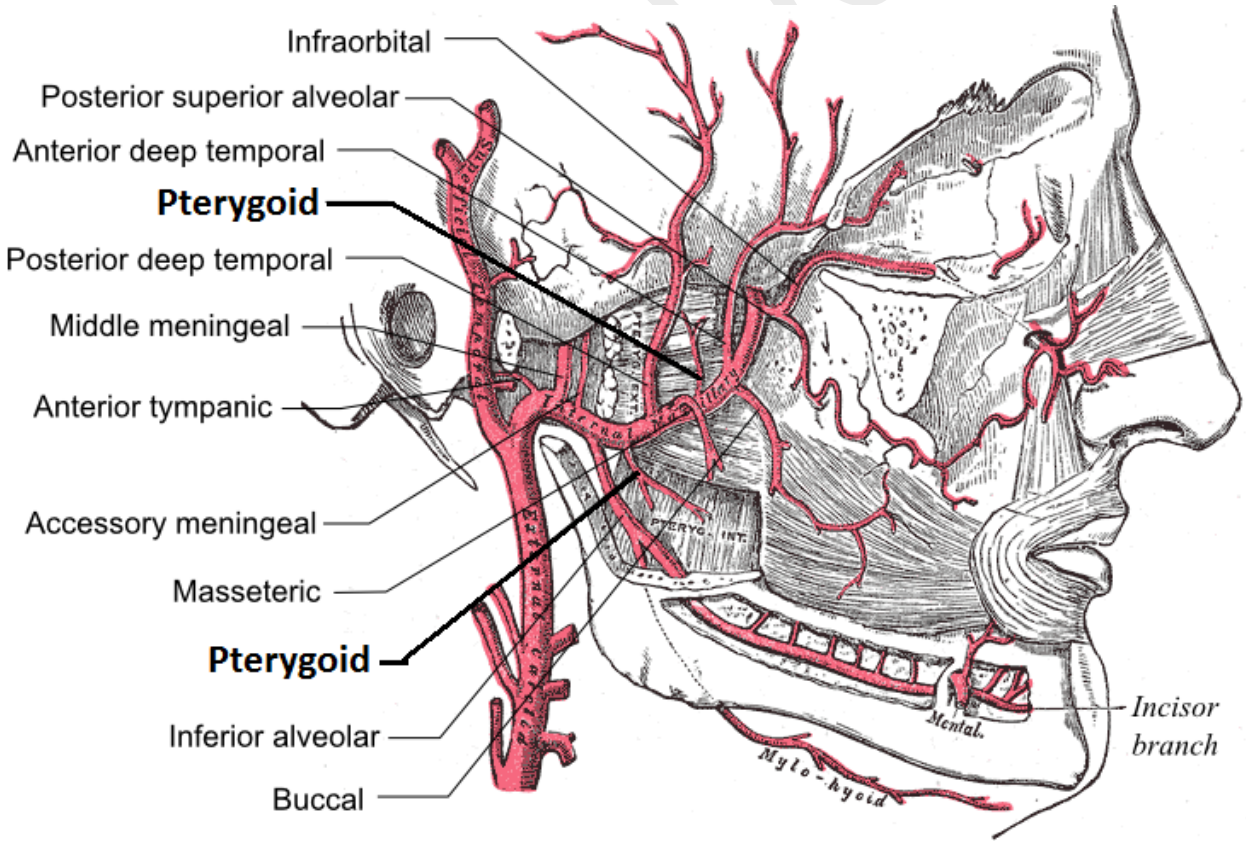
- Lingual artery
- Facial artery
- Maxillary artery
- Superficial temporal artery
- Ascending pharyngeal



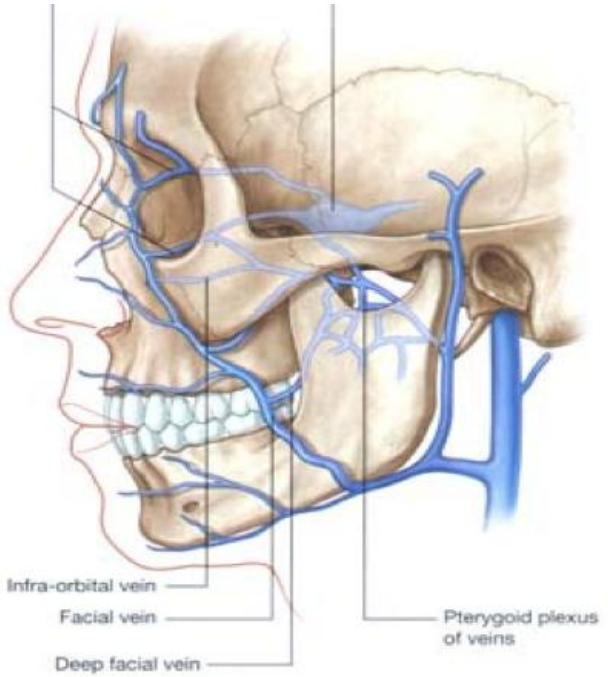


Maxillary artery

- Mandibular part
    - Anterior tympanic >> TMJ
    - Middle meningeal >> TMJ
    - Inferior alveolar artery
        - Mental artery
        - Incisive artery
- Pterygoid part: not involved directly with teeth
- Pterygopalatine part
    - Posterior superior alveolar artery > follows the nerve
    - Infraorbital artery >> follows nerve\
        - Middle superior alveolar artery
        - Anterior superior alveolar artery
    - Descending palatine (greater palatine artery) > nasal cavity > pterygopalatine canal > greater palatine foramen > incisive canal > nasal cavity



Veins



- The facial vein unites with the retromandibular vein below the border of the mandible and empties into the main venous structure of the neck, the internal jugular vein.
- The internal jugular vein descends through the neck within the carotid sheath and unites behind the sternoclavicular joint with the subclavian vein to form the brachiocephalic vein.
- The brachiocephalic veins (right and left) unite in the superior mediastinum to form the superior vena cava, which returns blood to the right atrium of the heart.
- Carotid sheath contains: vagus nerve, carotid arteries, jugular vein.

Pterygoid plexus >> Maxillary veins >> Retromandibular vein << Superficial temporal vein

↓

Common facial vein

↓

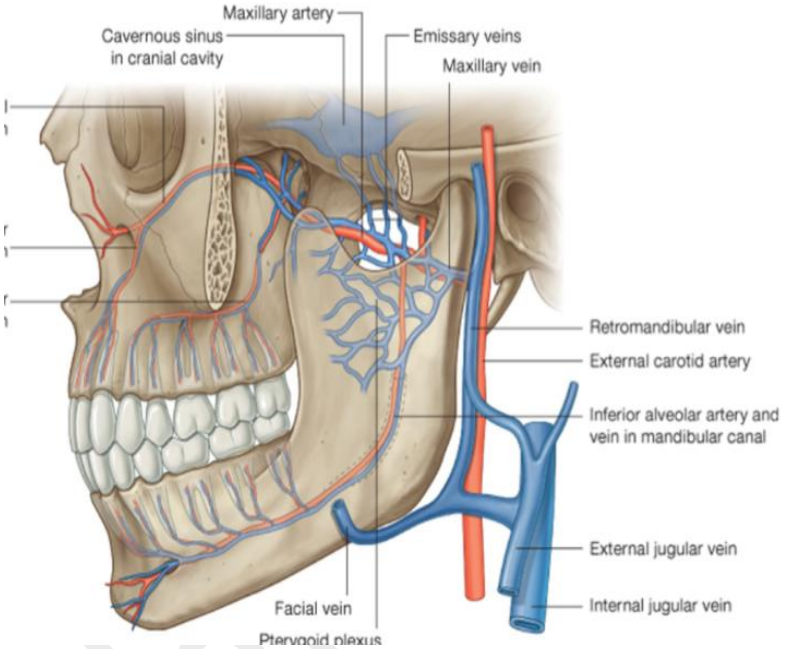
Internal jugular

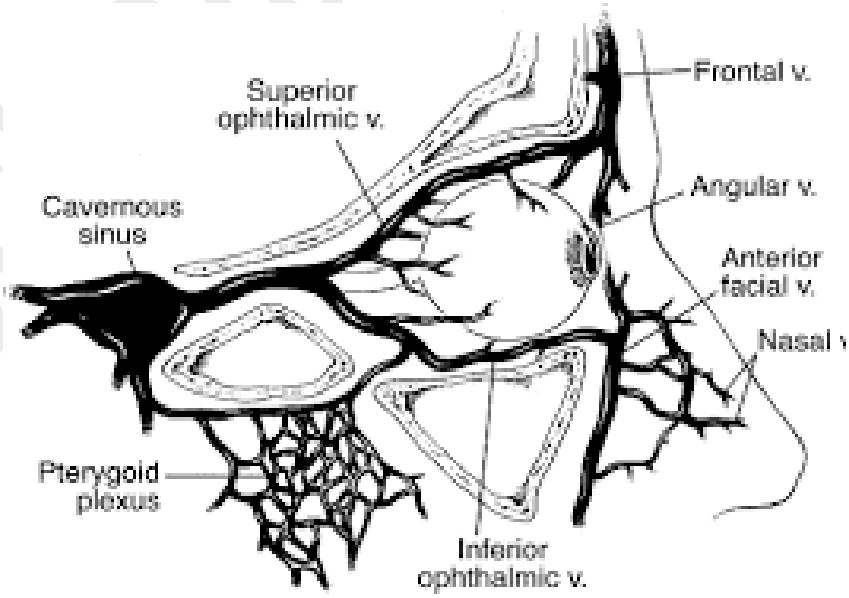
↓

Joins subclavian vein

Heart ← Superior vena cava ← Brachiocephalic vein

- Small emissary veins often connect the pterygoid plexus in the infratemporal fossa to the Cavernous Sinus in the cranial cavity.
- The pterygoid plexus connects posteriorly, via a short maxillary vein, to the retromandibular vein in the neck.
- The pterygoid plexus connects anteriorly, via a deep facial vein.

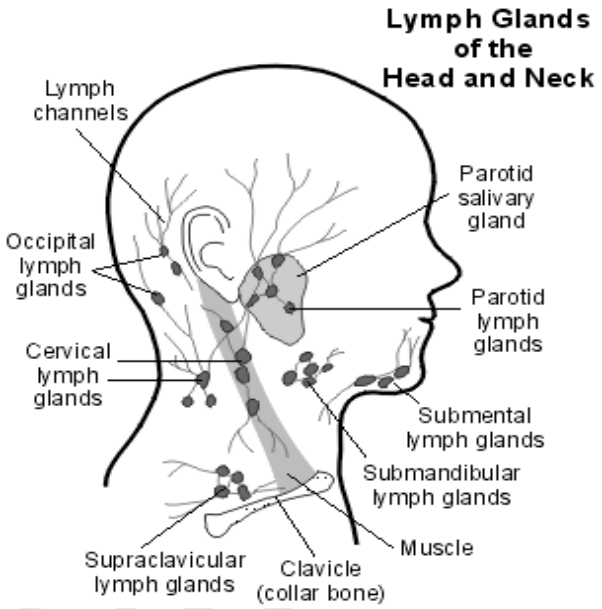




Lymph Nodes

Submental nodes

- Chin
- Tip of tongue
- Anterior floor of mouth
- Lower lip and mandibular incisors



Submandibular nodes

- Submental nodes
- Posterior floor of mouth
- Tongue
- Cheek, nose, upper lip
- Vestibular gingiva of both jaws
- Mucosa and gingiva of palate
- All maxillary teeth, maxillary sinus, and mandibular teeth, except lower incisors

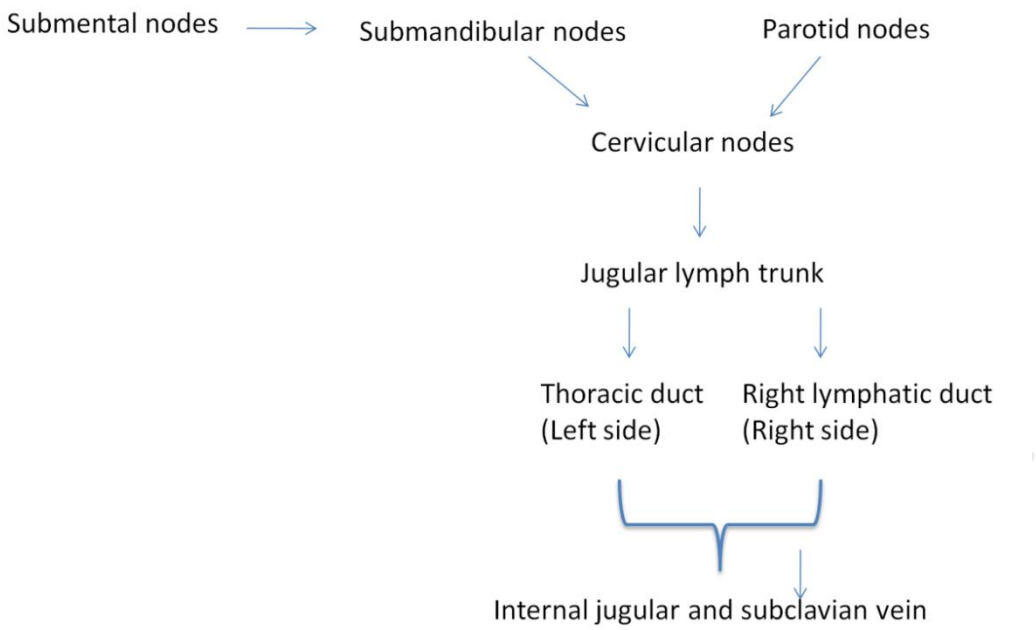
Parotid nodes

- Ear, eyelid, scalp
- Prominence of cheek

Deep cervical nodes

- Submandibular nodes
- Parotid nodes
- Lingual gingiva

	Submental nodes	Submandibular nodes
Tongue	- Tip of tongue only	- Anterior 2/3 of tongue
Floor	- Anterior floor of mouth	- Posterior part
Teeth	- Lower incisors	- All other teeth
Gingiva	- Gingiva of lower incisors	- buccal gingiva of both jaws
Lips	- Center of lower lip	- Upper and lower lip except __
Nodes	- ----------	- Submental
Skin	- Chin	- Cheek, nose
Other	- ----------	- Max. Sinus
		- Mucosa and gingiva of palate



Notes

- Mylohyoid nerve pierces the sphenomandibular ligament
- Mylohyoid nerve may act as afferent nerve for mandibular first molar
- Trigeminal ganglion = semilunar ganglion
- Trigeminal cave = meckel's cave
- Before anterior and posterior devisions, the mandibular nerve gives a meningeal branch
- Trigeminal nerve has no parasympathetic fibers
- Trigeminal ganglia is located at apex of petrous part of the temporal bone in middle cranial fossa

Palate

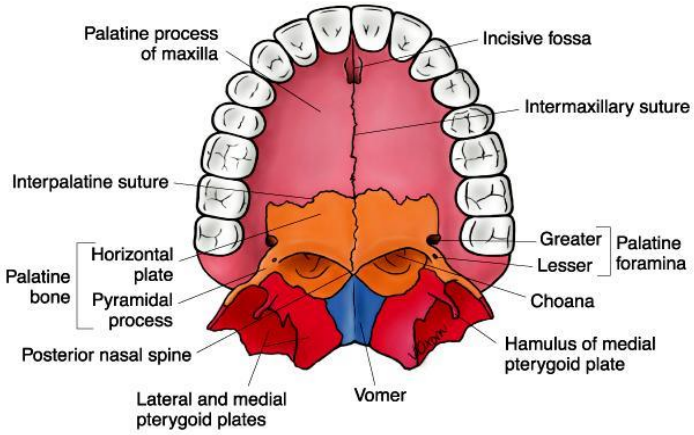


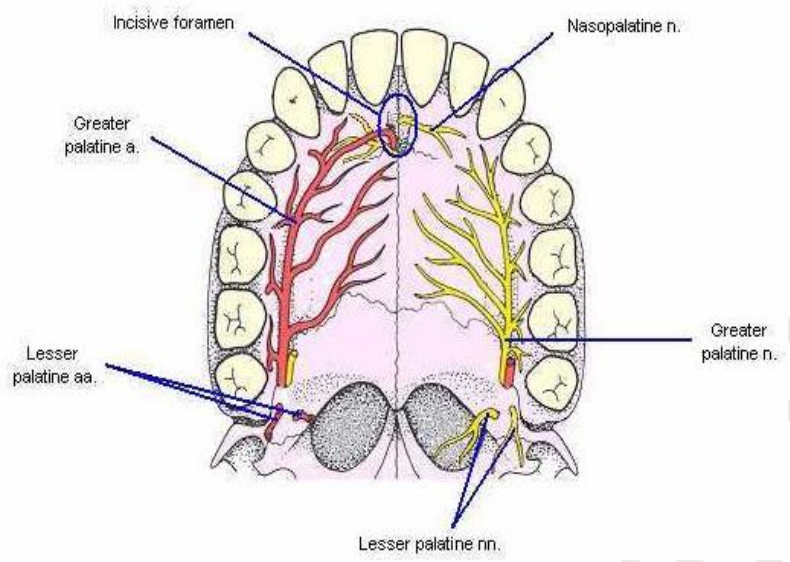
FIGURE 8.34 Teeth and hard palate. Inferior view of the bones forming the hard palate.

The hard palate is perforated by the following foramina:

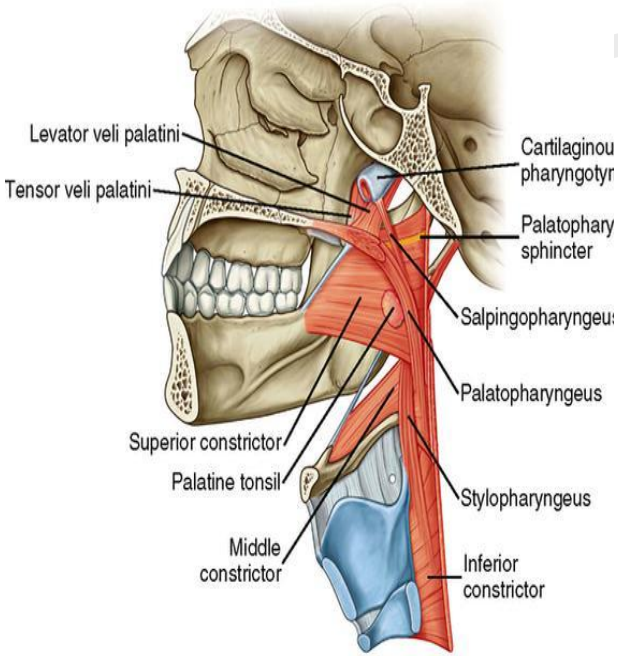
- **The incisive foramen:**
  - Posterior to the maxillary incisors, which transmits the nasopalatine nerves and the terminal branches of the sphenopalatine artery.
- **The greater palatine foramen**:
  - Most frequently located distal to the maxillary second molar, which transmits the greater palatine vessels and nerve.
  - The greater palatine foramen is generally located halfway between the gingival margin and midline of the palate, approximately 5 mm anterior to the junction of the hard and soft palate (vibrating line) distal to the apex of the maxillary second.
- **The lesser palatine foramen:**
  - Just posterior to the greater palatine foramen, which transmits the lesser palatine vessels and nerve.

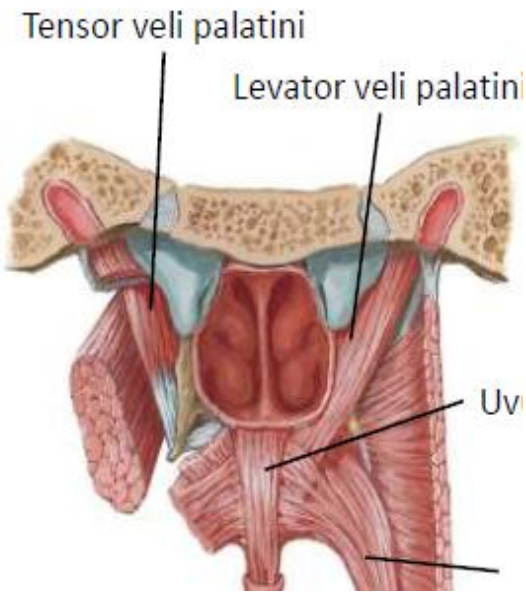
Nerves of the palate:

- **Sensory Innervation to the palate:** is supplied by the maxillary nerve.
  - The anterior part of the hard palate is supplied by the nasopalatine nerve which passes through the incisive foramen.
  - The posterior part of the hard palate is supplied by the greater palatine nerve which passes through the greater palatine foramen.
  - The soft palate is supplied by the lesser palatine nerve which passes though the lesser palatine foramen.

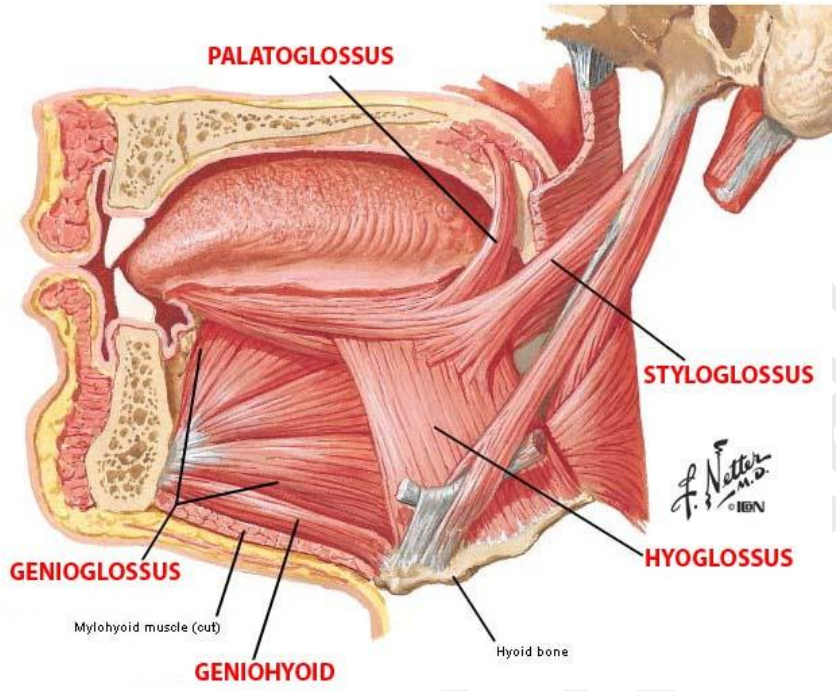


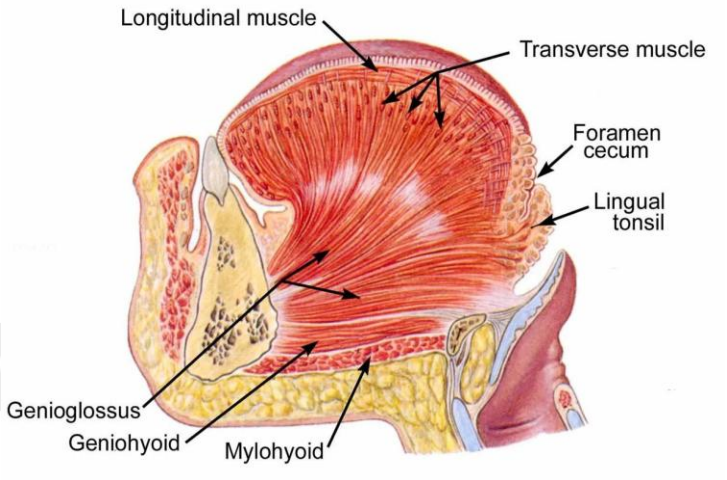
- **Motor Innervation:**
  - The tensor veli palatini is innervated by a muscular branch from the mandibular division of the trigeminal nerve CN V.
  - All other muscles are innervated by the pharyngeal plexus (motor portion from the vagus nerve and cranial part of the accessory nerve





Tongue





Motor innervation:

All glossal muscles intrinsic and extrinsic are innervated by hypoglossal nerve (CN XII) EXCEPT the palatoglossal muscle (innervated by the vagus nerve)

Blood supply

- Lingual artery (main one)
- Tonsillar branch of the facial artery
- Ascending pharyngeal artery

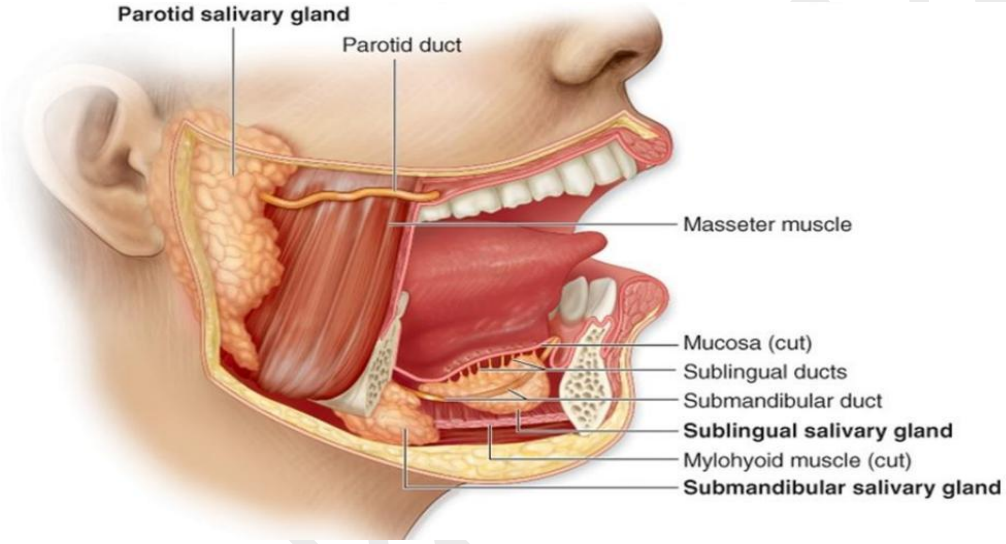
Sensory Innervation

- Anterior 2/3 >> lingual nerve (CN V, V-3)
- Posterior 1/3 >> Glossopharyngeal nerve (CN IX)

Taste

- Anterior 2/3 >> chorda tympani (CN VII) via lingual nerve
- Posterior 1/3 >> Glossopharyngeal nerve (CN IX)

Salivary Glands



Parotid Gland

- Serous
- More secretions during eating
- Contains the facial nerve, but not innervated by the facial nerve.
- Stenson's duct

Innervation

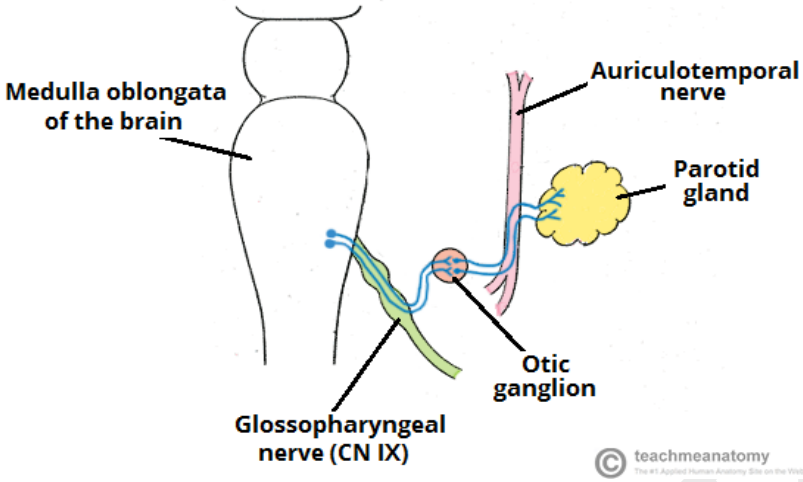
- Glossopharyngeal nerve (parasympathetic)
- Tympanic > lesser petrosal nerve > otic ganglion > auriculotemporal nerve > parotid

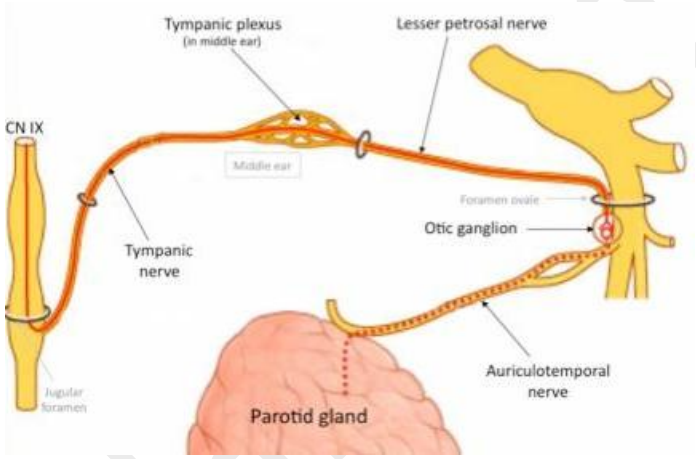
Blood supply

- Superficial temporal, maxillary arteries (external carotid)

Lymph drainage

- Parotid lymph nodes >> deep cervical nodes





Submandibular

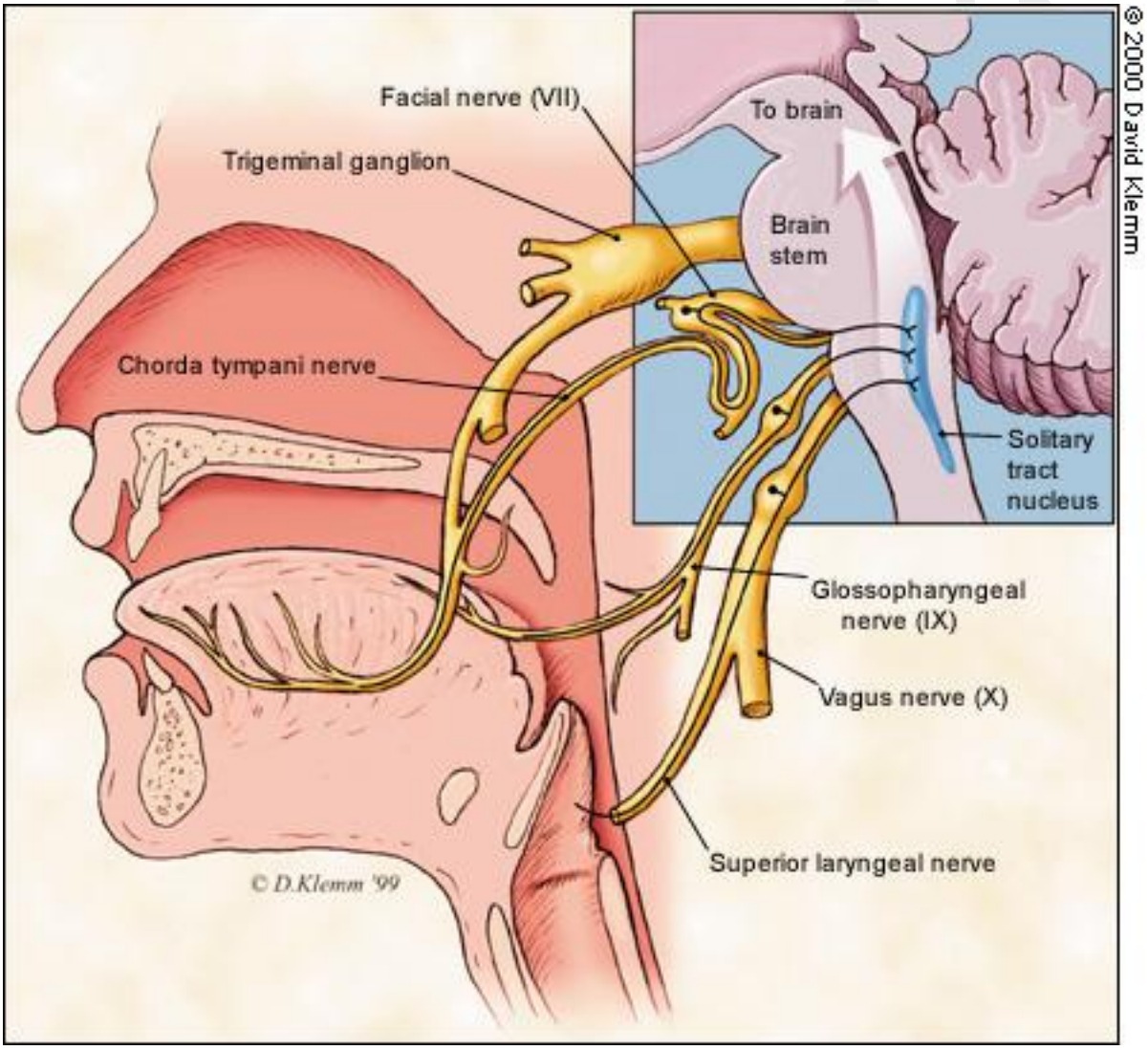
- Mixed serous/mucous secretions, predominantly serous
- Gland under mylohyoid muscle
- Wharton's duct
- Sublingual caruncle: a small papilla near the midline of the mouth floor on each side of the lingual frenum marks the opening of wharton's duct.

Sublingual gland

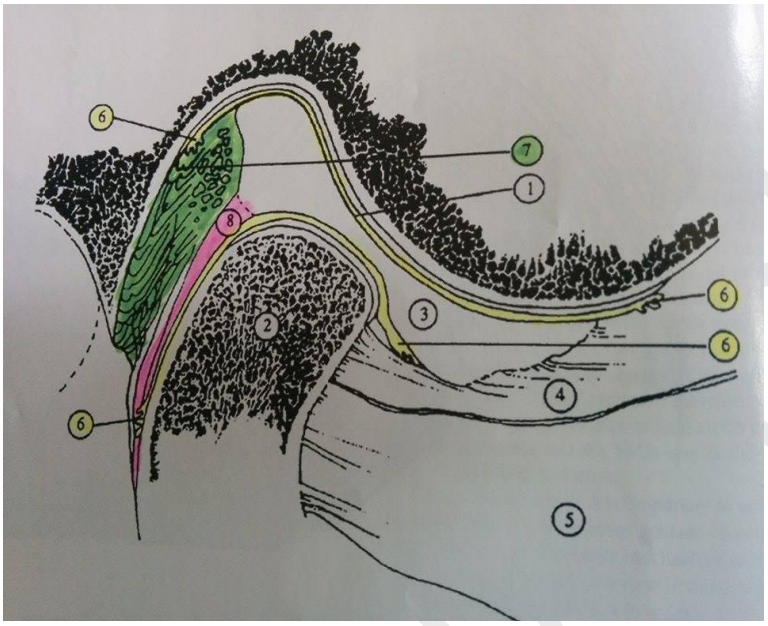
- Mixed serous/mucous secretions, predominantly mucous
- Above mylohyoid muscle
- The sublingual gland drains via approximately 12-20 small ducts (Rivian's ducts),the majority open into the mouth on the summit of the sublingual fold, but a few open into the submandibular duct.
- Bartolin's duct, a common duct that drains the anterior part of the sublingual gland in the region of the sublingual papilla may be present.

Innervation for Submandibular and Sublingual glands:

- Parasympathetic innervation
  - The chroda tympani brancehes from the facial nerve and joins fibers of the lingual nerve. The chorda tympani innervates theses glands through the lingual nerve.
- Blood supply >> Facial, lingual arteries
- Veins >> facial/lingual veins
- Lymph >> submandibular > deep cervical nodes
- Lingual nerve, wharton's duct, sublingual gland are near structures under mucosa of floor of the mouth.



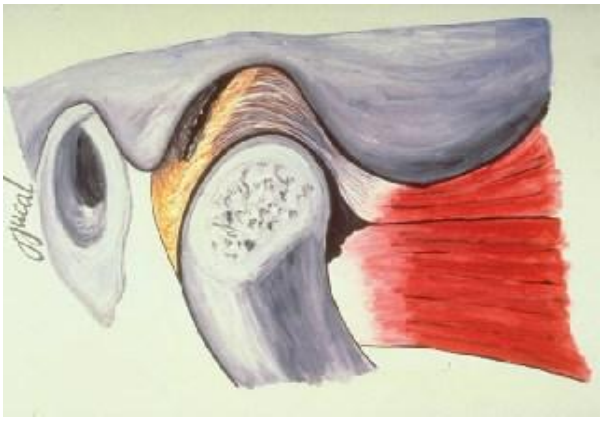
TMJ



The Temporomandibular Joint

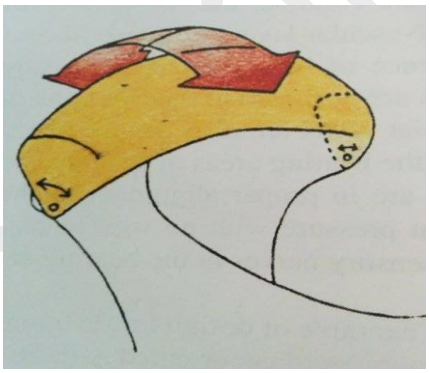
- 1. Posterior slope of the eminentia
- 2. Condyle
- 3. Disk
- 4. Superior lateral pterygoid muscles
- 5. Inferior lateral pterygoid muscle
- 6. Synovial tissue
- 7. Retrodiskal tissue including posterior attachment of disk to temporal bone
- 8. Posterior ligamentous attachment of disk to the condyle

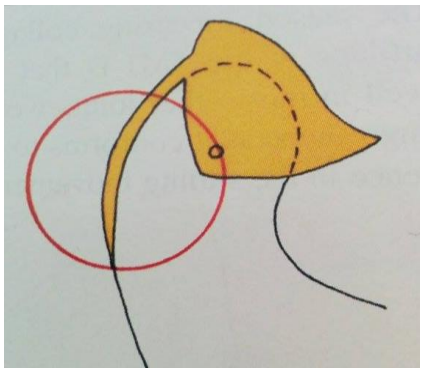
- All of the articular surfaces of the condyle, the fossa, and the eminence are covered with avascular layers of dense fibrous connective tissue (also non innervated).
- The absence of blood vessels is a sure sign that those specific areas are designed to receive considerable pressure.
- The avascular areas are also devoid of innervation, and this includes the bearing areas of the disk; so if the condyle and the disk are in proper alignment in the fossa, they can receive great pressure with no sign of discomfort.



- The bearing area is avascular, and so it is nourished by synovial fluids that also lubricate the joint for smooth gliding function.
- The disk is composed of layers of collagen fibers oriented in different directions to resist the shearing effect that might occur in a sliding joint.
- The reason for using collagen fibers instead of hylaine cartilage in the TMJ is that the stiffer cartilage that works well in most other joints would not be pliable enough to change shape as it conforms to the contours of the convex eminance in the sliding movements.

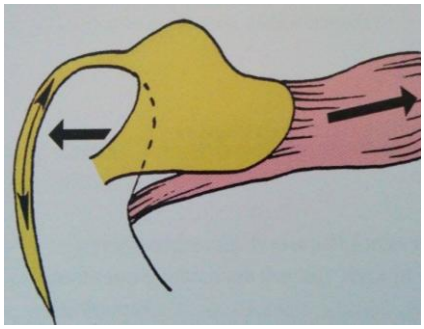
- The disk is firmly attached to the medial and lateral poles of the condyle, and such attachment is the reason it moves in unison with the condyle.
- The disk is designed to rotate on the condyle like a bucket handle that attaches to the medial and lateral poles of the condyle (collateral ligaments).

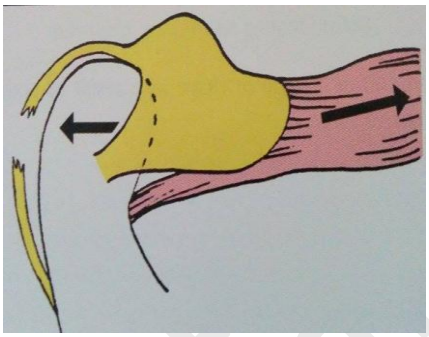




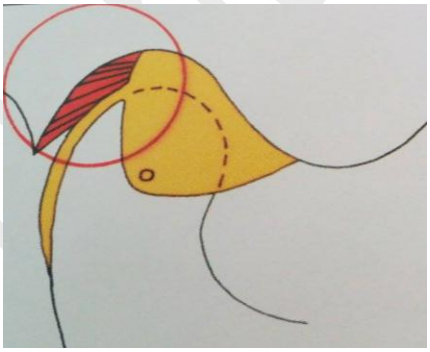
- The disk is tethered to the back of the condyle by an inelastic band of collagen fibers. This prevents the disk from rotating too far forward. It also prevents the disk from being displaced anteriorly.

- The disk cannot displace anteriorly if the posterior ligament is intact. It must be stretched or torn to permit any forward displacement.

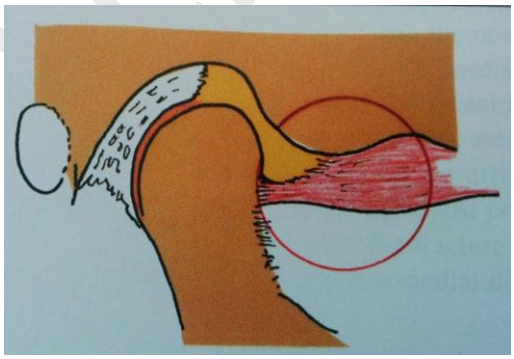


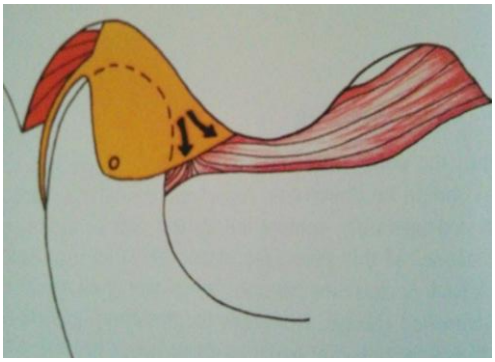


- Superior elastic stratum
- Elastic fibers bind to the disk to the temporal bone behind it, and maintain constant tension on the disk toward the distal.

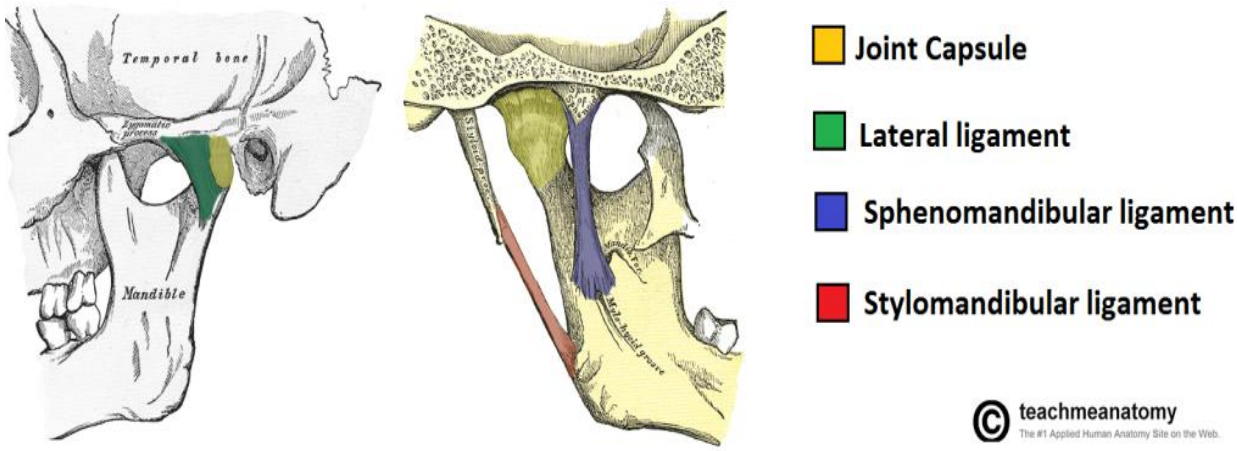


- The only forward pulling force that could anteriorly displace the disk is the superior lateral pterygoid muscle.
- It is the muscle that in combination with the elastic fibers behind the disk controls the position of the disk on the condyle.





TMJ ligaments



- **Capsular ligament (fibrous capsule)**
- Its basically the anterior portion of the capsule.
- Restricts posterior movement of condyle on wide openings.

- **Temporomandibular ligament (lateral ligament)**
- Lateral portion of the fibrous capsule
- From: zygomatic arch, drops obliquely down and backward (in decks it says from articular eminence)
- To: side and back of neck of condyle
- Function: main stabilizing ligament, prevents lateral and posterior displacement, keeps condyle near fossa if fracture occurs

- **Stylomandibular ligament**
- from: styloid process
- To: posterior border and angle of mandible and fascia of medial pterygoid muscle
- Function: for extreme protrusion limitation

- **Sphenomandibular ligament**
- From: angular spine of sphenoid bone
- To: linguala and lower border of mylohyoid groove

TMJ blood supply

- Mainly the superficial temporal and maxillary arteries.
- Venous drainage >> a diffuse plexus around capsule.

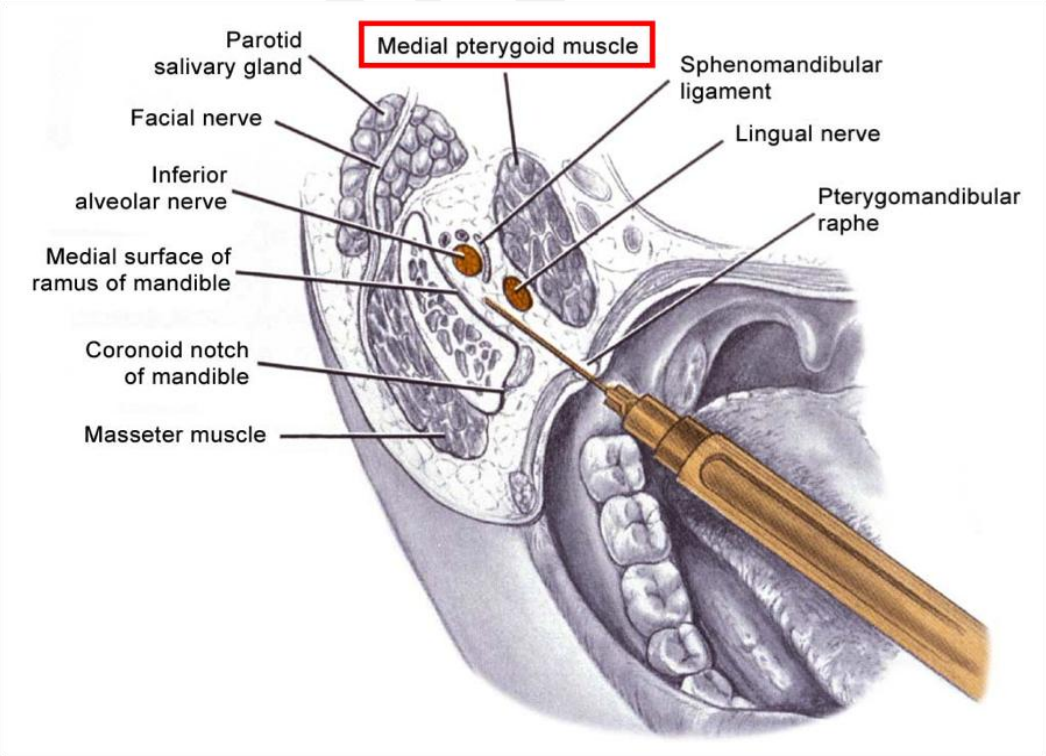
TMJ innervation

The TMJ is innervation by the Mandibular branch of the trigeminal nerve CN - V

- Fibrous capsule: auriculotemporal nerve (CN V, V 3)
- Anterior region: masseteric nerve and posterior deep temporal nerve (CN V, V 3)
- Sensory innervation >> trigeminal nerve (CN V, V3)

Notes

- TMJ have fibrocartilage articular surfaces, not hyaline cartilage like other joints.
- TMJ is ginglymoarthrodial joint (hinge joint + glide joint)
- Mandibular fossa = glenoid fossa
- Meniscus = articular disc , it is a fibrocartilage disc (DD)
- Posterior band of disc is thicker than anterior
- Anterior band is diffused with capsule, condyle, muscle (slpm)
- Sphenomandibular ligament usually pierced/damaged with inferior alveolar nerve block.
- The buccinator muscle is pierced by the needle when performing an IANB.
- Colateral ligaments (medial and lateral) are discal ligaments from disc sides to medal/lateral poles of condyle, they stabalize disc one condyle, they are collagenous connective tissue (don't stretch)
- Treat unilateral condyle fracture with intermaxillary fixation
- Pterygomandibular raphe has nothing to do with TMJ ligaments

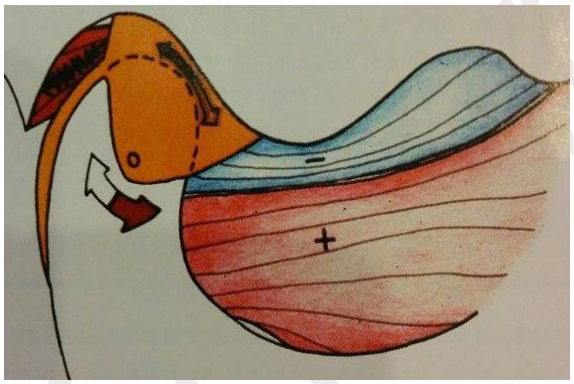


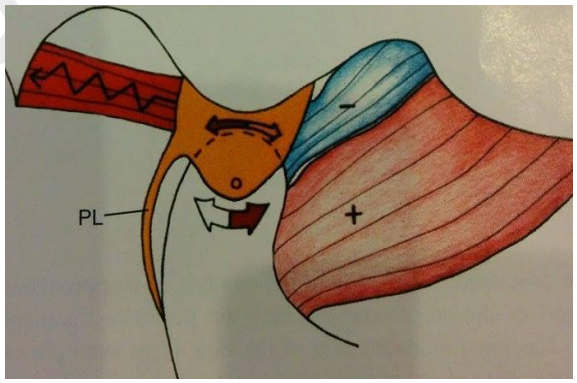
- The pterygomandibular raphe extends from the hamulus and passes inferiorly to attach to the posterior end of the mandible's mylohyoid line. It is formed by the union of the tendinous ends of the superior constrictor of the pharynx and the buccinator muscle.
- As the mandible moves relative to the hamulus, the length of the raphe is passively increased.
- The deep tendon of the temporalis muscle and the superior pharyngeal constrictor muscle form a V-shaped landmark for an inferior alveolar nerve block.
- When draining purulent exudate from an abscess of the pterygomandibular space from an intraoral appraoch, the buccinator muscle is most likely to be incised.

TMJ Function

Opening

- If the condyle disk assembly is fully seated in centric relation, the disk is positioned at he most forward position (on top of the condyle) that the posterior ligament allows.
- As the inferior lateral pterygoid muscle (+) starts to pull the condyle forward, the superior lateral pterygoid muscle (-) releases contraction to allow the elastic fibers to start pulling the disk more to the top of the condyle.



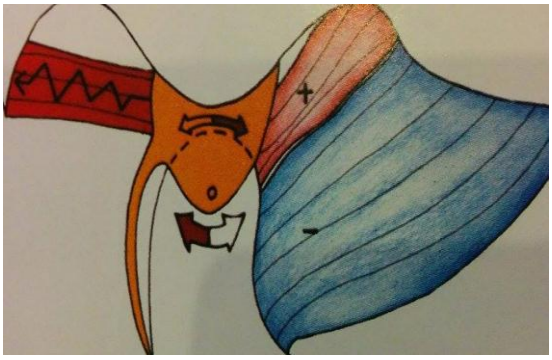


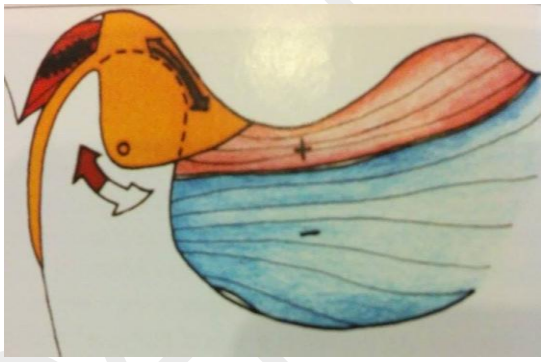
Maximum opening

- When the condyle reaches the crest of the eminence, the disk should be directly on top of the condyle as forces are directed upwardly against the flattest part of the articular eminence.
- At this point, the elastic fibers have rotated the disk back because the superior lateral pterygoid muscle is in a controlled release.

Closing

- As the jaw closes, the condyle starts to move back and up the steeper slope of the articular eminence, so the disk must be pulled back to the front of the condyle.
- To accomplish this, the superior lateral pterygoid muscle (+) starts its contraction as the inferior lateral pterygoid muscle (-) releases the condyle to the elevator muscles that pull it back.

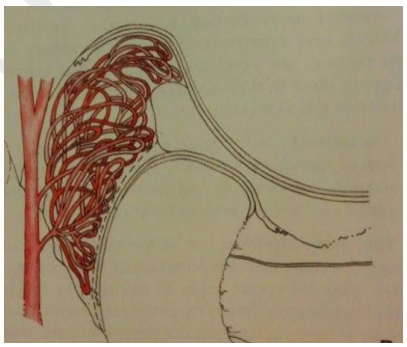


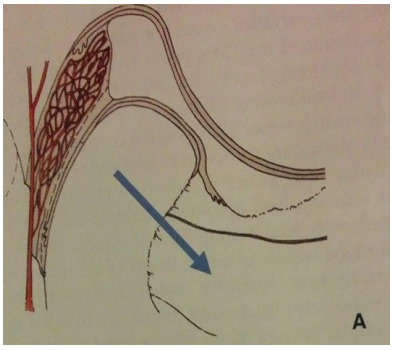


Closed

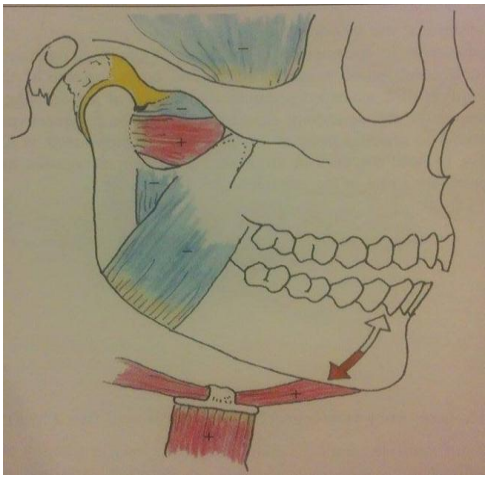
- When the condyle reaches centric relation, the disk has been pulled as far forward as the posterior ligament will allow.
- If the ligament is intact and has not been stretched or torn, the disk is stopped in perfect alignment with the direction of loading through the condyle.
- In the absence of occlusal interferences to centric relation, the inferior lateral pterygoid muscle will stay passive, even if the patient clenches. The superior belly holds its contraction to maintain the disk in its correct alignment.

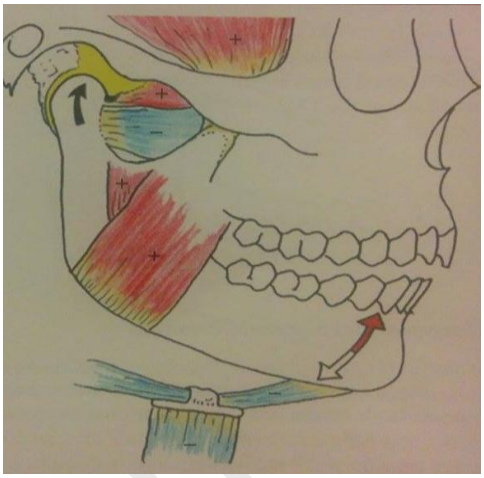
The space behind the condyle changes rapidly as the condyle moves forward and back. A network of blood vessels with elastic walls allows blood to rush in to fill the space with the expanded vessels as the condyle moves forward. As the condyle moves back, the blood is shunted out the vessels. This shunting system is called the vascular knee.





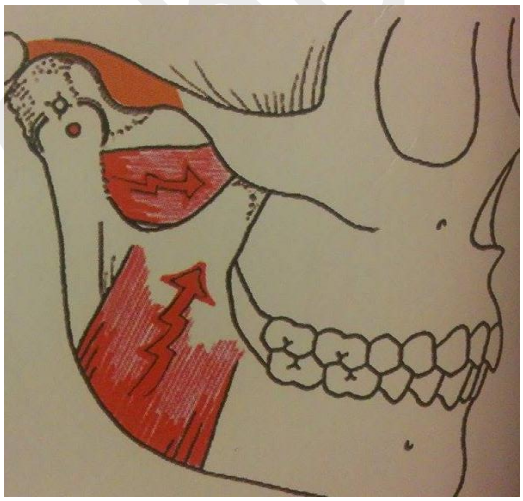
- As the jaw opens, the depressor muscles contract while the elevator muscles release their contraction. The inferior lateral pterygoid muscle contracts during opening.

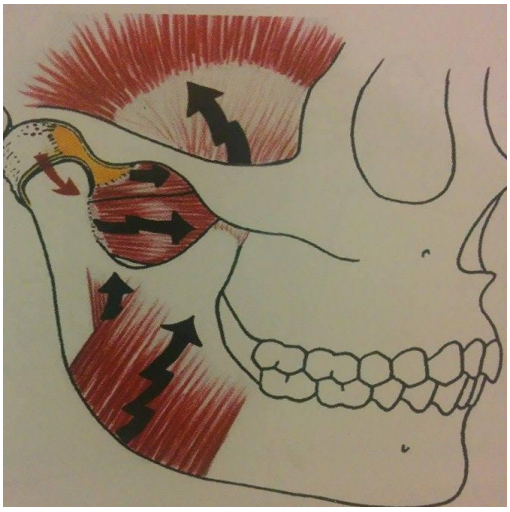




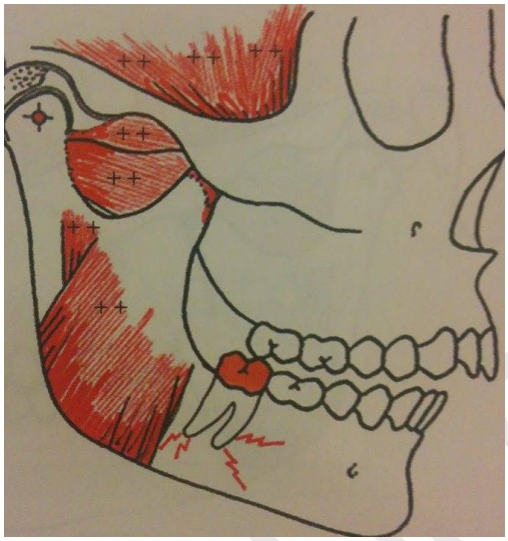
- As the jaw closes, the elevator muscles contract while the depressor muscles release contraction.
- Note that during jaw closure the inferior lateral pterygoid muscle releases its contraction and is passive. In the absence of deflective occlusal interferences, it stays passive even during firm clenching.

- If the TMJs must displace to achieve maximum intercuspation, the inferior lateral pterygoid muscles must actively contract to hold the condyles down on a slippery incline in direct opposition to contraction of all the elevator muscles every time the teeth are brought into maximum contact.

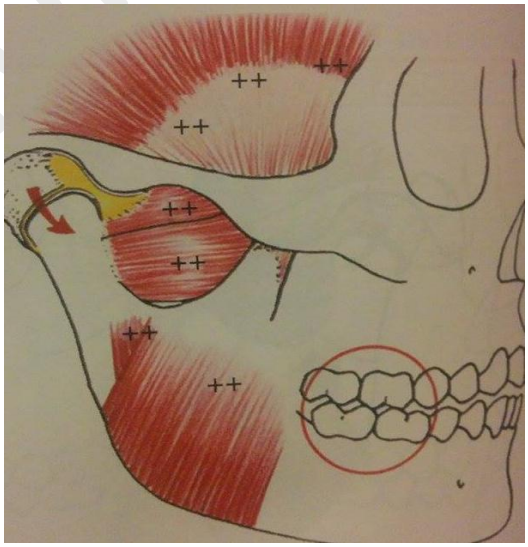




- An occlusal interference such as a high crown or deflective incline activates muscle hyperactivity. Pain is often focused in the masticatory muscles to give impression of a TMJ disorder.



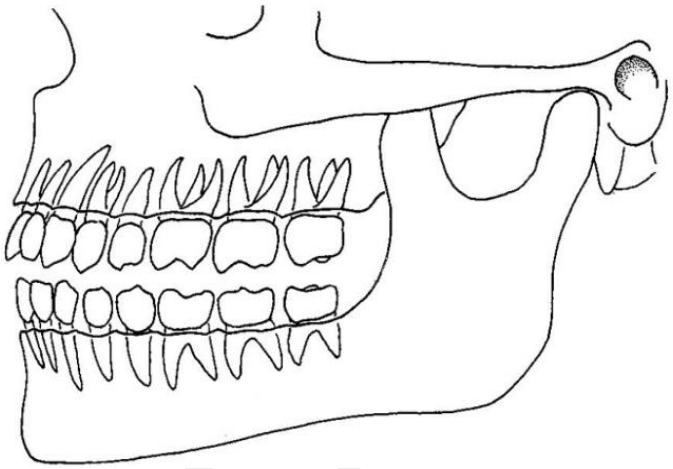
- When any posterior tooth interferes with the anterior guidance in eccentric movement, the lateral pterygoid muscles are activated and the elevator muscles are hyperactivated.
- This results in incoordinated muscle hyperfunction. It also puts the posterior teeth in jeopardy of horizontal overload, and subjects them to excessive attritional wear, fractures, and hypermobility.



OCCLUSION

Physiologic Position

- Also called “rest position” or “postural positions”
- Determined mainly by the musculature (**muscle-guided**)
- Free way space/ interocclusal distance = 2-6 mm
- This position results when the mandible and all of its supporting muscles are in their resting posture (there is a relative muscular equilibrium)
- Considered to be the beginning and end point of most mandibular movements.

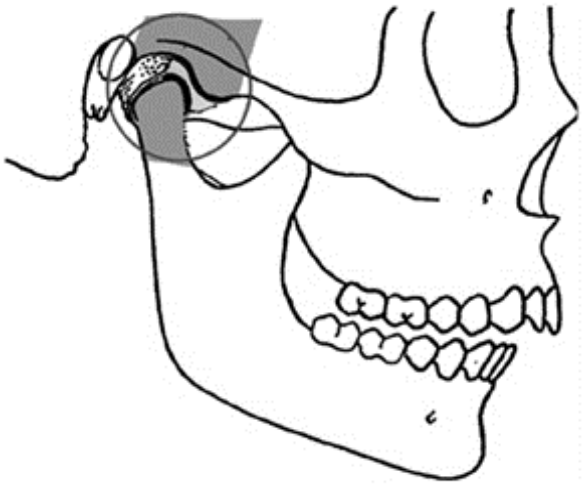


Maximum Intercuspation

- The relationship between maxillary and mandibular occlusal surfaces that provides the maximum contact and or intercuspation independent of condylar position.
- It is a **“tooth-guided”** position.
- The mandible is braced in this position during typical empty mouth swallowing.

Centric Relation

- A terminal hinge position defined as the maxillomandibular relation in which the condyles articulate with the thinnest avascular portion of their respective discs with the complex in the anterior-superior position against the shapes of the articular eminences.
- This position is independent of tooth contact.
- This position is clinically discernable when the mandible is directed superiorly and anteriorly.
- It is restricted to a purely rotary movement about the transverse horizontal axis.



- This is a relationship of the bones of the upper and lower jaws without tooth contact.
- This is a “ligament-guided” position.
- It is the closing end point of the retruded border movement (the terminal hinge movement).
- The current concept about centric relation: it occurs when the condyles are in their most superoanterior position, resting on the posterior slopes of the articular eminences with the discs properly interposed.
- This is a repeatable reference position to mount the casts on the articulator.
- **Old Definition:** The most unstrained, retruded anatomic and functional position of the heads of the condyles of the mandible in the mandibular (glenoid) fossae of the TMJ. (bone -bone)
- This is a relationship of the bones of the upper and lower jaws without tooth contact. The presence or absence of teeth, or the type of occlusion or malocclusion, are not factors.
- In most people (90%), CR and CO do not coincide.
- In fixed and removable prosthodontics, centric relation should be established prior to designing the frameworks.
- If sufficient natural posterior occlusion exists, the mandibular cast may be mounted in centric occlusion (MIC).
- Whether the record will be in centric occlusion or centric relation will depend upon the individual case and is dictated by the presence or absence of any natural posterior occlusion in the patient.
- The mandible cannot be forced into centric relation from the rest position because the patient’s reflex neuromuscular defense would resist the applied force. The mandible should be relaxed and gently guided into centric occlusion.

Bite Reigistartion in Centric Relation

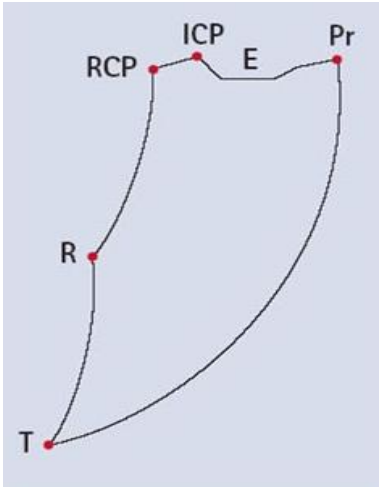
- When a centric relation record is taken in the natural dentition, imprints of the teeth should be confined to cusp tips and the registration material should not be perforated.
- Primary requirements for making a centric relation record when fabricating a removable denture:
    - To record the correct horizontal relation of the mandible to the maxilla.
    - To stabilize the lower record base with equalized vertical pressure.
    - To retain the record in an undistorted condition until the casts have been accurately mounted on the articulator or until a previous record can be verified.

- Bite registration material used to make an accurate interocclusal record should:
    - Offer a minimum resistance to the patient's jaw closure and have low flow at mixing.
    - Be easy to handle, uniformly soft while the record is being made, rapid setting, and totally rigid but not brittle when set.

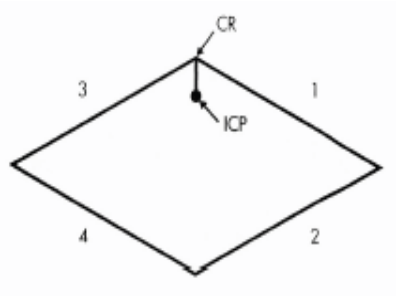
- Rapid setting plaster, zinc oxide and eugenol pastes, and modeling plastic all approach the ideal.
- Avoid soft waxes as a recording material (least satisfactory). They never become rigid and are likely to be distorted during the cast mounting procedure.
- The recording material of choice is polyether, next is zinc oxide eugenol paste.
- The most common material used for interocclusal records are was (Aluwax) and fast setting elastomeric materials such as polyvinyl siloxane and polyether.
- The jaw relationship most frequently used in the actual design of restorations is the acquired centric occlusion.

Posselt's envelope (sagital)

- ICP = Intercuspal position
- RCP = Retruded position
- PR = Maximum protrusion
- E = Edge to edge
- T = Maximum opening
- PR-T = Anterior border
- RCP-R = Rotational movement
- R-T = Transitional movement
- RCP-R-T = Posterior border



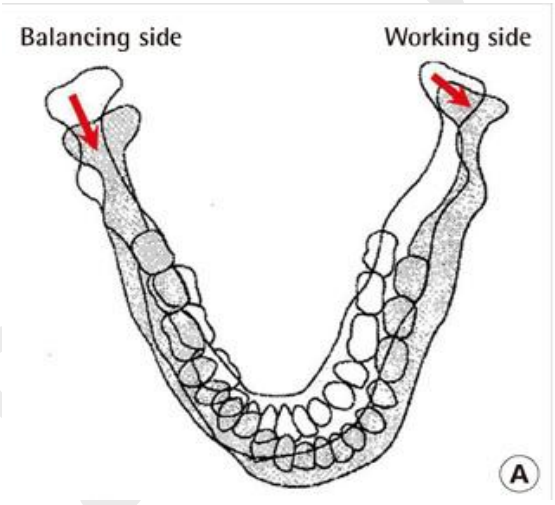
Posselt's envelope (frontal and horizontal)

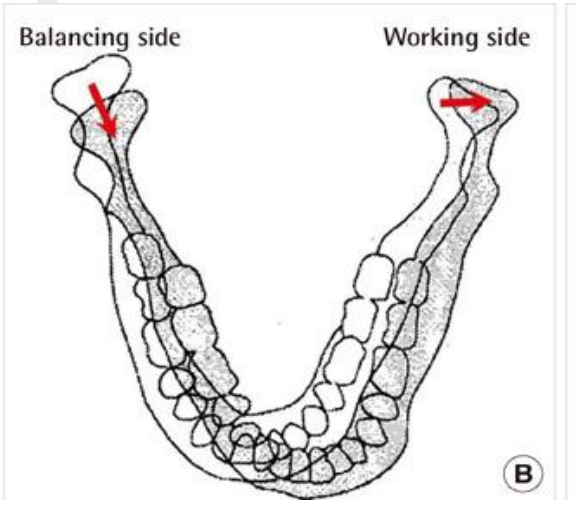


Jaw movements

- A protrusive movement requires the condyles to move downward and forward.
- In lateral movements, the working condyle moves down, forward and laterally.
- In lateral movements, the non-working condyle moves down, forward, and medially.

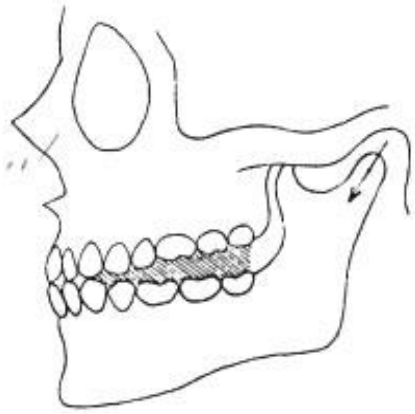
- Approximately 9-10 mm anteriorly (protrusive movement)
- Approximately 50-60 mm inferiorly (opening)
- Approximately 10 mm laterally
- Approximately 1 mm posteriorly (retrusive movement)



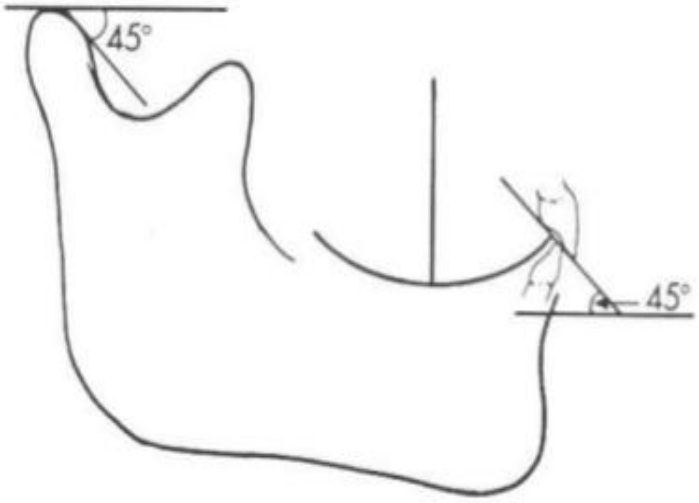


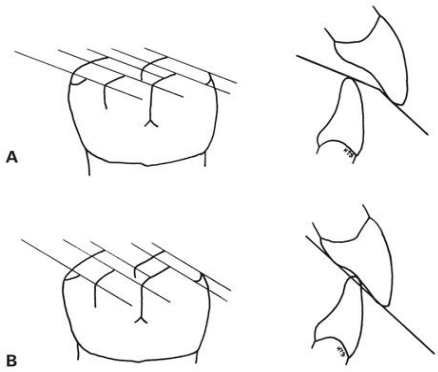
Protrusive movement

- Accomplished when the mandible is moved straight forward until the maxillary and mandibular incisors contact edge-to-edge.
- This movement is bilaterally symmetrical in that both sides of the mandible move in the same direction.



- The inclination of the condylar path during protrusive movement can vary from steep to shallow in different patients.
- It forms an average angle of about 30 with the horizontal reference plane.
- If the inclination is steep, posterior teeth have higher cusps
- If the inclination is shallow, posterior teeth have short cusps





Posterior guidance and Anterior guidance

- This factor is the most important aspect of condylar guidance that affects the selection of posterior teeth with appropriate cusp height.
- Anterior guidance also affects surface morphology of posterior teeth. The greater the overlap, the longer the cusp height.
- Anterior guidance must be preserved, especially when restorative procedures change the surfaces of anterior or posterior teeth that guide the mandible in excursive (lateral, protrusive) movements.

Anterior guidance/Incisal guidance

- The influence of the contacting surfaces of anterior teeth on tooth limiting mandibular movements.
- The influence of the contacting surfaces of the guide pin and anterior guide table on articular movements.
- The fabrication of a relationship of the anterior teeth preventing posterior tooth contact in all eccentric mandibular movements.
- A measure of the amount of movement and the angle at which the lower incisors and mandible must move from the overlapping position of centric occlusion to an edge-to-edge relationship with the maxillary incisors.
- It is to some degree, under the control of the dentist.
- Influencing factors include: esthetics, phonetics, ridge relations, arch space, inter-ridge space.
- Esthetics and phonetics are the primary factors limiting the dentists control of incisal guidance.
- The incisal guidance on the articulator is the mechanical equivalent of horizontal and vertical overlap.
- Anterior teeth have a mechanical advantage over posterior teeth, due to the fact that they are farther away from the fulcrum (condyles), giving them better leverage to offset the closing musculature.

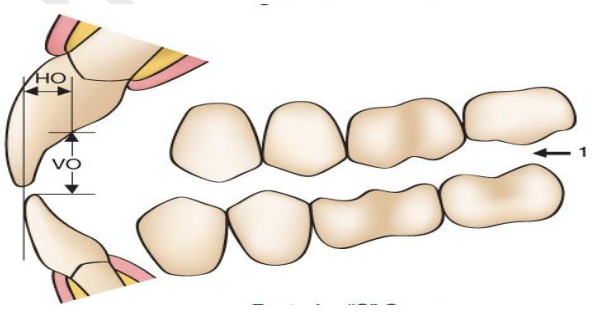
Posterior guidance/Condylar guidance

- The mechanical device on an articulator which is intended to produce similar guidances in articulator movement that are produced by the paths of the condyles in mandibular movements.
- Condylar guidance is a factor which is totally dictated by the patient. It cannot be adjusted by the dentist.
- The incline or angulation of the condylar element on the articulator is anatomically related to the slope of the condylar articular eminences (condyle inclination).

- The inclination of condylar guidance depends on:
  - The shape and size of the bony contour of the TMJ
  - The action of the muscles attached to the mandible
  - The limiting effects of the ligaments
  - Method used for registration

Notes

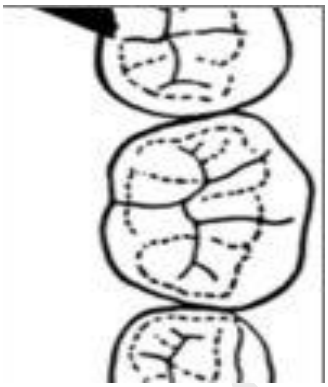
- The space that opens between the posterior teeth during anterior movement of the mandible is called **Christensen's Phenomenon**. This posterior separation is increased if the incisal guidance is increased.
- The amount of posterior separation is affected by both the incisal guidance and the horizontal condylar guidance.
- The separation is increased as both IG and HCG increase -the effect of IC is greater anteriorly and the effect of HCG is greater posteriorly.
- In complete dentures, the path of condyle during free mandibular movements is governed primarily by the shape of the fossa and meniscus (articular disc) as well as the muscular influence.
- The protrusive record is probably the least reproducible maxillomandibular record.
- When adjusting the condylar guidance for protrusive relationship, the incisal guide pin on the articular should be raised out of contact with the incisal guide table.
- When restoring the entire mouth with crowns, the protrusive condylar path inclination influences the mesial inclines of the mandibular cusps and the distal inclines of the maxillary cusps.

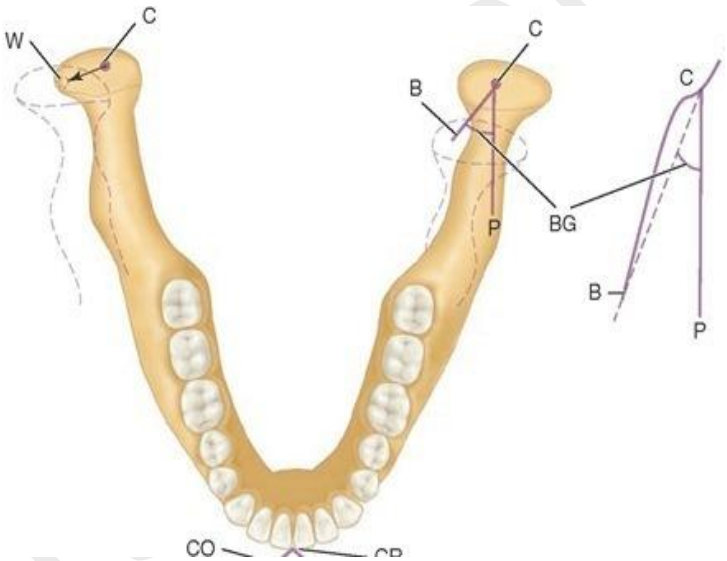


Bennett angle/Lateral shift/Immediate side shift

- The angle formed by the sagittal plane and the path of the non-working condyle during lateral movement of the mandible, as viewed in the horizontal plane.

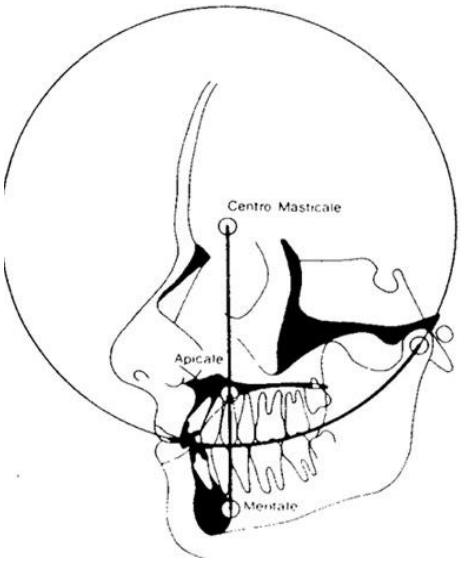
- This movement influences the lingual concavity of the maxillary anterior teeth and directional placement of the ridges and grooves on the mandibular posterior teeth as well as the mesiodistal position of the cusps of posterior teeth.
- In a lateral movement, the non-working side condyle moves downward, forward, and medially.
- The working side condyle moves laterally.
- The amount that the non-working condyle moves medially determines how far the working side condyle moves laterally.

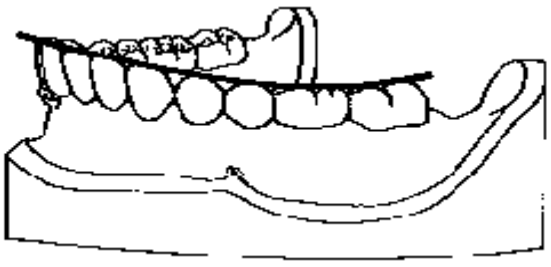




Orientation of the occlusal plane:

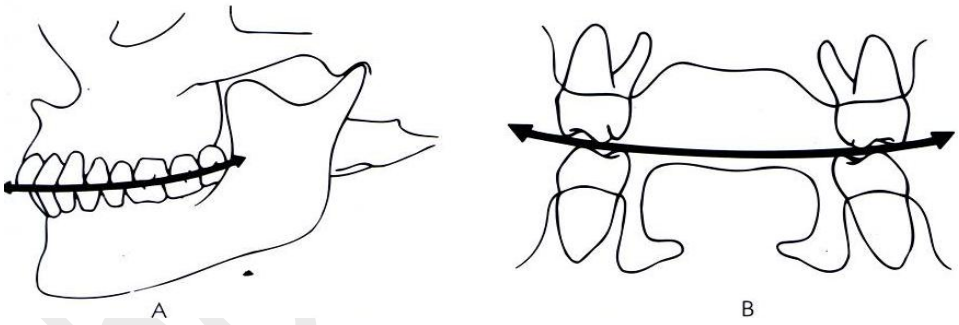
- The occlusal plane is an imaginary surface which is related anatomically to the cranium.
- The occlusal plane theoretically touches the incisal edges of the incisors and the tips of the occluding surfaces of the posterior teeth.





- The anterior point of the occlusal plane is determined by the position of the anterior teeth.
- The posterior determinants are anatomical landmarks (Two-thirds the height of the retromolar pads).
- Therefore, it is debatable as to the extent of control the dentist may exercise over the orientation of the occlusal plane.

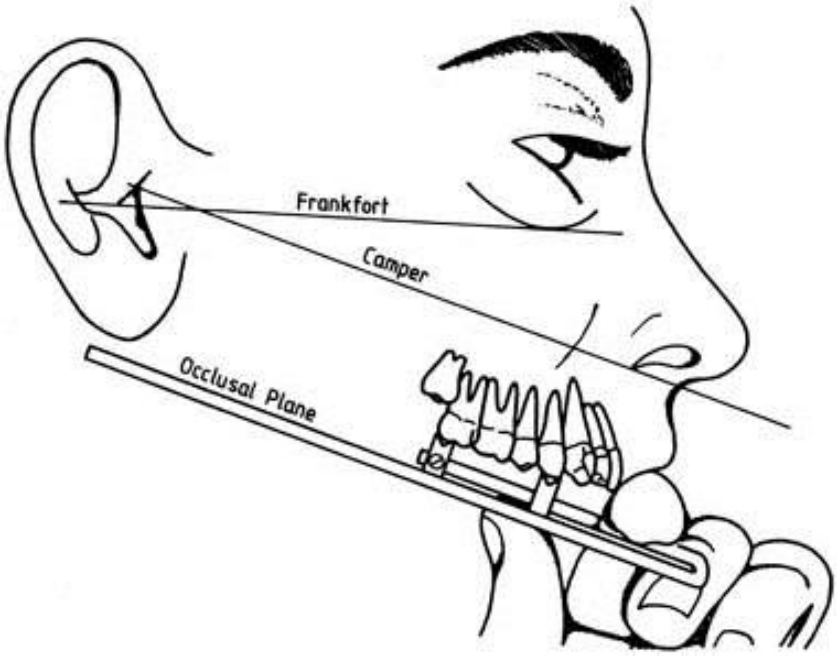
- Represents the mean curvature of the surface.
- Curve of spee
- Curve of wilson



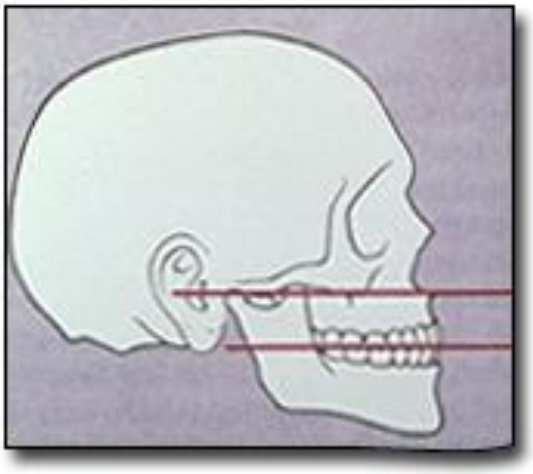
Campers line: Line running from the inferior border of the ala of the nose to the superior border of the tragus of the ear.

Interpupillary line: An imaginary line drawn between the eye pupils.

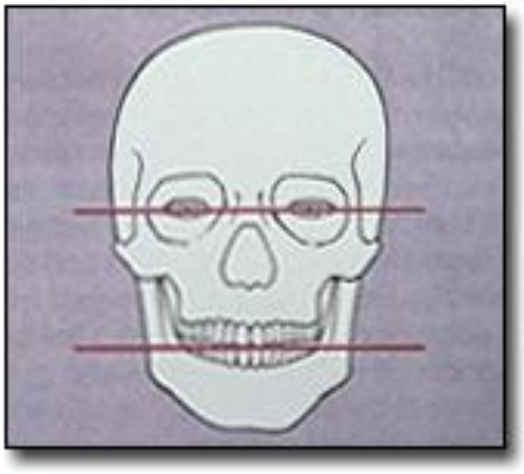
Frankfort horizontal plane: Extends from the outer canthus of the eye to the tragus of the ear. It is commonly used in orthodontics for cephalometric analysis.



Ala-tragal plane

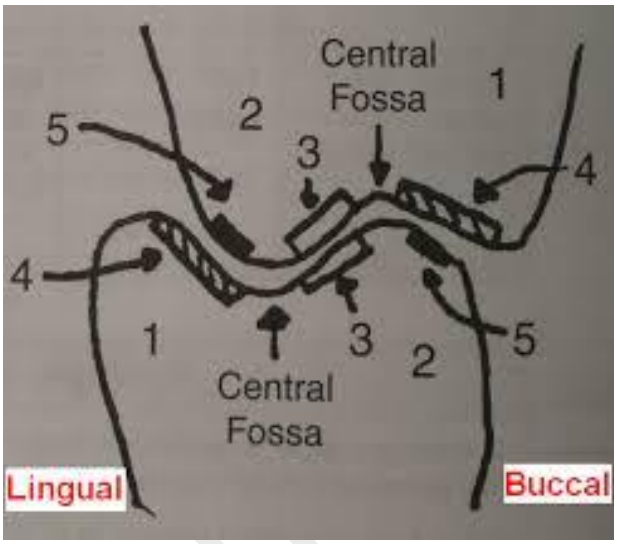


Interpupillary line



Cusps

Supporting cusps



- Working, Centric, Grinding, Stamp cusps.
- Maxillary lingual and mandibular buccal.
- Centric stops are areas of contact that a supporting cusp makes with opposing teeth. (contact marginal ridge or a fossa)
- They contact the opposing tooth in the intercuspal position.
- They support the vertical dimension of the face.
- They are nearer the faciolingual center of the tooth than the non-supporting cusps.
- Their outer incline has a potential for contact.
- They have broader, more rounded cusp ridges than guiding cusps.

Guiding cusps

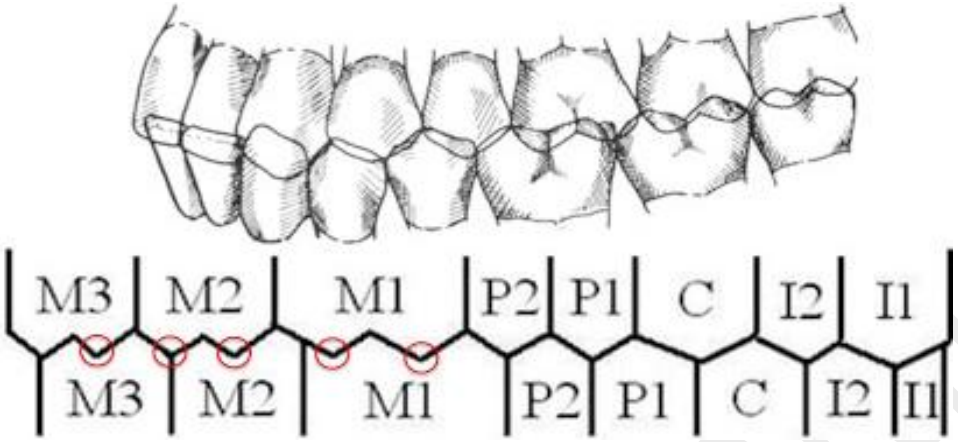
- Guiding, Balancing, Non-supporting, Non-centric, Shearing cusps.
- Maxillary buccal and mandibular lingual cusps.
- These cusps do not occlude or fit into fossae or marginal ridge areas on the opposite arch. They overlap the opposing tooth without contacting the tooth.
- They allow the dentition to move apart, out of occlusion. They allow the teeth to "unlock" and move back and forth and side to side.
- These cusps have sharper cusp ridges that serve to shear food as they pass close to the supporting cusp ridges during chewing strokes.

- **Guiding inclines**

  The inner occlusal inclines of the guiding cusps are called guiding inclines because in contact movements they guide the supporting cusps away from the midline.
  - bucco-occlusal inclines (lingual inclines of the buccal cusps) of the maxillary posterior teeth.
  - linguo-occlusal inclines (buccal inclines of the lingual cusps) of the mandibular posterior teeth.

Note: In posterior cross-bite situations, the supporting and guiding cusps are opposite. The maxillary buccal and the mandibular lingual would be supporting and the maxillary lingual and the mandibular buccal would be guiding.

Intercuspations

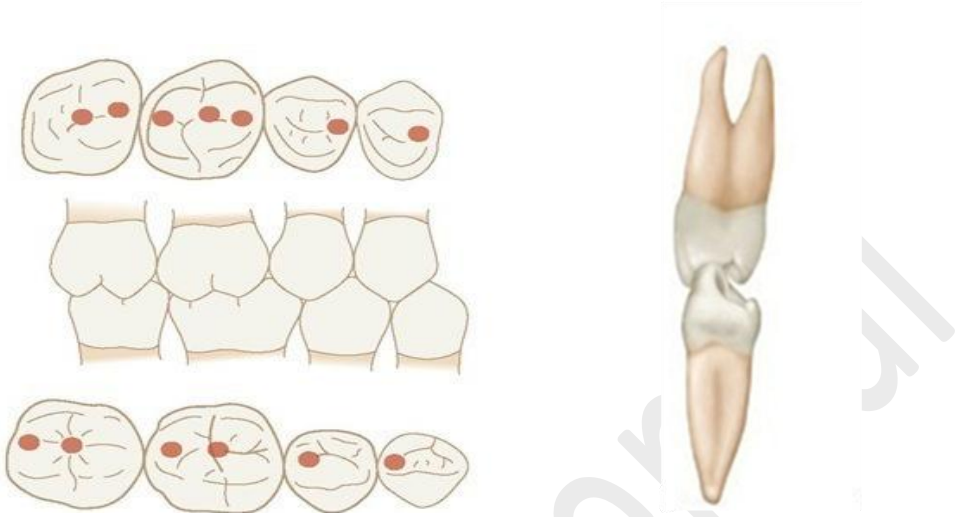


Maxillary Lingual cusps	Occludes into Area of Mandibular Teeth
First premolar	• Distal triangular fossa of first premolar
Second premolar	• Distal triangular fossa of second premolar
First molar mesiolingual cusp First molar distolingual cusp	• Central fossa of first molar • Distal marginal ridge of first molar and mesial marginal ridge of second molar
Second molar mesiolingual cusp Second molar distolingual cusp	• Central fossa of second molar • Distal marginal ridge of second molar and mesial marginal ridge of third molar

Mandibular Buccal cusps	Occludes into Area of Maxillary Teeth
First premolar	• Mesial triangular fossa of first premolar and distal marginal ridge of canine
Second premolar	• Mesial triangular fossa of second premolar
First molar Mesiobuccal cusp First molar Distobuccal cusp First molar Distal cusp	• Mesial marginal ridge of frist molar and distal marginal ridge of second premolar • Central fossa of frist molar • Distal fossa of first molar
Second molar mesiobuccal cusp Second molar distobuccal cusp	• Mesial marginal ridge of second molar and distal marginal ridge of first molar • Central fossa of second molar

Intercuspation of Premolars

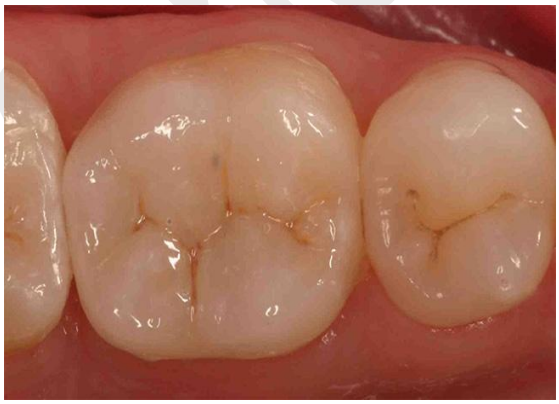
- In an ideal intercuspal position, the facial cusp tips of permanent maxillary premolars oppose the facial embrasure between their class counterpart and the tooth distal to it.

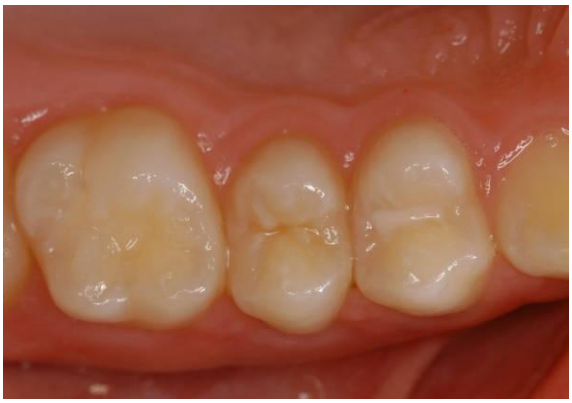


- The facial cusp tip of a maxillary first premolar opposes the facial embrasure between the mandibular first and second premolars.
- The facial cusp tip of a maxillary second premolar opposes the facial embrasure between the mandibular second premolar and mandibular first molar.
- The lingual cusp of permanent mandibular first premolars does not occlude with anything.

Intercuspation of Mandibular Molars

- The mesiolingual cusp of the mandibular first molar opposes the lingual embrasure between the maxillary first molar and second premolar.

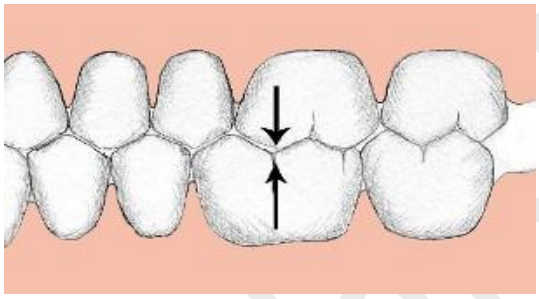


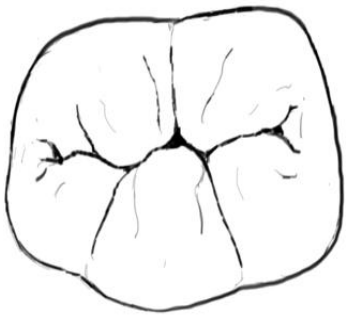


- The distolingual cusp of the mandibular first molar fits into (opposes) the lingual groove of the maxillary first molar.

- The mesiolingual cusp of the mandibular second molar opposes the lingual embrasure between the maxillary second molar and first molar.

- The mesiobuccal cusp of the maxillary first molar opposes the mesiobuccal groove of the mandibular first molar. This relationship is a key factor in the definition of Class I occlusion.





- The distobuccal cusp of the maxillary first molar opposes the distobuccal groove of the mandibular first molar.
- The oblique ridge of the maxillary first molar opposes the developmental groove between the distobuccal and distal cusps of the mandibular first molar.
- The distobuccal groove also serves as an escape way for the ML cusp of the maxillary first molar during non-working excursive movements.

Lateral Excursion

- The facial cusp ridge of the maxillary first premolar on the working side opposes the distal cusp ridge of the first premolar and the mesial cusp ridge of the second premolar.
- During mandibular movements (working, non-working, etc) the outer aspects of the lingual cusps of the mandibular molars will not contact their maxillary antagonists.
- All other areas of buccal and lingual cusps may contact during mandibular movements (this is assuming that all occlusal relationships are normal).

Articulation

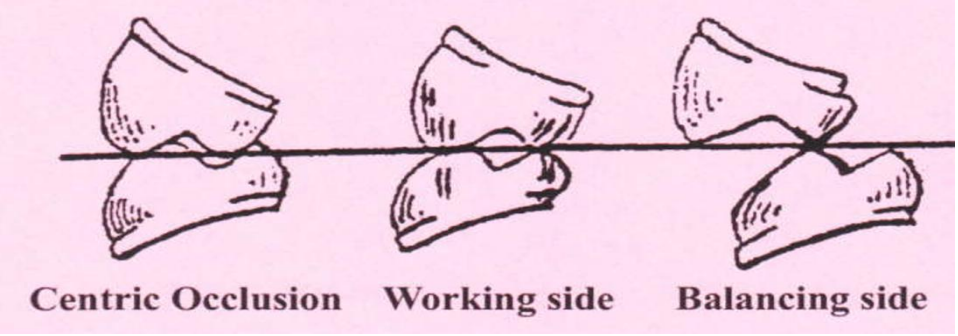
- Bilaterally balanced articulation
- Unilateral balanced articulation
- Mutually protected articulation

Current emphasis in teaching fixed prosthodontics and restorative dentistry has been on the concept of mutual protection.

Bilaterally balanced articulation

- This requires having a maximum number of teeth in contact in maximum intercuspation and all excursive positions.
- In complete denture fabrication, this tooth arrangement helps maintain denture stability because the nonworking contact prevents the denture from being dislodged.
- However, as the principles of bilateral balance were applied to the natural dentition and in fixed prosthodontics, it proved to be extremely difficult to accomplish, even with great attention to detail and with the use of sophisticated articulators. In addition, high rates of failure resulted.
- An increased rate of occlusal wear, increased or accelerated periodontal breakdown, and neuromuscular disturbances were commonly observed.
- The last were often relieved when posterior contacts on the mediotrusive(non-working) side were eliminated in an attempt to eliminate unfavourable loading. Thus, the concept of a unilaterally balanced occlusion (group function) evolved.

- Working side: contact of opposing cusps
- Balancing side (non-working): contact of maxillary lingual cusps (lingual inclines) and mandibular facial cusps (lingual inclines)



Unilaterally Balanced Articualtion (Group function)

- Excursive contact occurs between all opposing posterior teeth on the laterotrusive (working) side only. On the mediotrusive (non-working) side, no contact occurs.
- Thus, in this occlusal arrangement, the load is distributed among the periodontal support of all posterior teeth on the working side.
- This can be advantages if, for instance, the periodontal support of the canine is compromised.
- In the protrusive movement, no posterior tooth contact occurs.
- The group function of the teeth on the working side distributes the occlusal load. The absence of contact on the non-working side prevents those teeth from being subjected to the destructive, obliquely directed forces found in non-working interferences.
- Some relationships are not amenable to group function such as Class II, deep vertical overlap.

Mutually Protected Articulation

- In this arrangement, centric relation coincides with the maximum intercuspation position. The six anterior maxillary teeth, together with the six anterior mandibular teeth, guide excursive movements of the mandible, and no posterior occlusal contacts occur during any lateral or protrusive excursions.
- Investigations of the neuromuscular physiology of the masticatory apparatus indicate advantages associated with a mutually protected occlusal scheme. However, in studies involving unrestored dentitions, relatively few occlusions can be classified as mutually protected.

- **Canine protected occlusion (Mutually protected)**

- It is an occlusal relationship in which the vertical overlap of the maxillary and mandibular canines produces a disclusion (separation) of all of the posterior teeth when the mandible moves to either side.
- When placing a crown on a maxillary canine, if you change a canine protected occlusion to group function you increase the potential for a “non-working side” interference.
- Some relationships are not conducive to cuspid protected occlusion such as Class II or end-to-end relationship.

Regardless of what lateral concept is used, we do not want contact on the non-working side:

- They are damaging
- They are difficult to control due to mandibular flexure
- They deliver more force to the teeth than other contacts.
- Horizontal forces on teeth are the most destructive to he periodontium.

Notes

- There are four features of the human dentition which directly affect the health of the PDL and its hard tissue anchorage in terms of resisting occlusal force:
- Anterior teeth have slight or no contact in the intercuspal position.
- The occlusal table is less than sixty percent of the overall faciolingual width of the tooth.
- The occlusal table of the tooth is generally at right angles to the long axis of the tooth.
- Crowns of mandibular molars are inclined about 15-20 degrees toward the lingual.
- **If you plan on changing a patient's vertical dimension through crowns, it is critical to mount a patient's casts on the true hinge axis (use a face bow)**

Protrusive movement

- Anteriorly the facial surface of the lower incisors will contact the guiding inclines (lingual) of the upper incisors and canines.
- In any restorative case involving all teeth in the mouth, the protrusive condylar path inclination will have its primary influence on the same inclines (distal of maxillary and mesial of mandibular).

Selective Grinding

The purpose of selective grinding is to remove all interferences without destroying cusp height.

Selective Grinding in Centrix Relation

- Do not grind the upper lingual or lower buccal cusps.
- A forward slide from centric can be corrected by grinding the mesial inclines of maxillary teeth and distal inclines of mandibular teeth.
- Primary centric holding cups are the maxillary lingual cusps. Never grind these cusps.
- Secondary centric holding cusps are the mandibular buccal cusps. Grind these cusps only if there is a balancing side interference.

Selective grinding in working side relation

- The rule of **B-U-L-L**
- **B**uccal cusps inner inclines of **U**pper teeth.
- **L**ingual cusps inner inclines of **L**ower teeth.

Selective grinding in balancing side relation

- Grind the inner incline of the mandibular buccal cusps (secondary holding cusps).
- Never grind the maxillary lingual cusps (primary centric holding cusps)

- Reducing occlusal interferences (selective grinding) should usually be done before constructing a fixed bridge/RPD. This is done to prevent duplicating the deflective occlusal contacts in the final restoration.
- One common case in which it would be preferable for selective grinding to be completed after the fixed bridge or partial denture is in place, is when a fixed or removable partial denture is to be constructed for a space over which the opposing tooth has extruded slightly. The bridge or partial is frequently constructed to the ideal plane of occlusion and the opposing tooth is adjusted after insertion.

Interferences

- Non working side interferences generally occur on the inner aspect of the facial cusps of mandibular molars.
- Working side interferences generally occur on the inner aspects of the buccal cusps of maxillary molars.
- Protrusive interferences generally occur between the distal inclines of maxillary posterior teeth and mesial inclines of mandibular posterior teeth.
- A centric interference (forward slide) can be corrected by grinding the mesial inclines of maxillary teeth and distal inclines of mandibular teeth.

Compensating Curve

- The form of the compensating curve is entirely under the control of the dentist. The function of this curve is to help provide a balanced occlusion.
- The value of the compensating curve is that it allows the dentist to alter the effective cusp angulation without changing the form of the manufactured denture teeth.
- As the condylar inclination increases, the compensating curve must increase to keep a balanced occlusion.
- A prominent compensating curve is required when there is a steep condylar path associated with a low degree of incisal guidance.