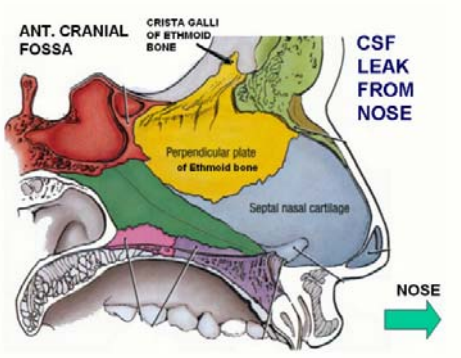
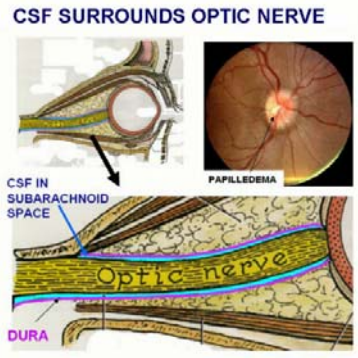
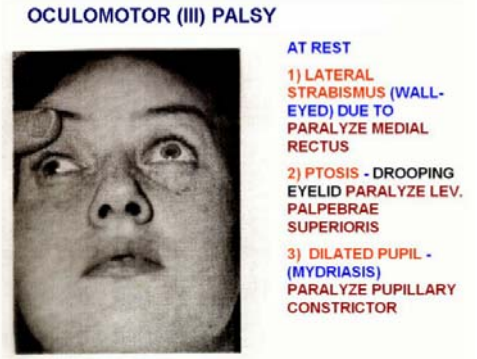
CLINICAL ANATOMY OF HEAD AND NECK PART 1

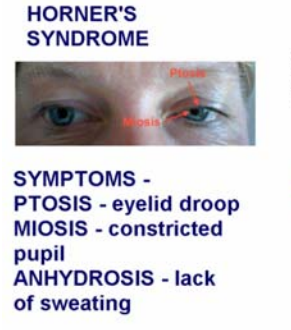
Clinical	Anatomy	Cause	Sign/Symptom
Anterior Cranial Fossa - Cranial nerve I, Nasal Cavity			
Fracture of cribriform plate of ethmoid bone	Nasal septum continuous with crista galli of ethmoid bone; Olfactory nerve passes through cribriform plate of ethmoid bone	Blow to nose; fracture produces **continuity between subarachnoid space and nasal cavity**	**Leakage of CSF from nose** ('runny nose'); **Decreased sense of smell** (hyposmia)
Middle Cranial Fossa - Cranial nerves II-VI Orbit, Eye Movements, Face			
Rapid loss of vision in one eye	Central artery of retina (branch of Ophthalmic artery from Int. Carotid) is an normally an end artery with no functional anastomoses (exception: Chorioretinal anatomoses)	**Occlusion of Central Artery of Retina**	Sudden onset blindness in one eye (one eye only, sign: artery occlusion visible through ophthalmoscope)
Slow loss of vision in one eye	Dura mater and subarachnoid continue over optic nerve; **Optic nerve function affected by CSF pressure**	**Communicating hydrocephalus** (many causes)	Decreased visual function both eyes; sign: **papilledema** in ophthalmoscope view; also other signs of increased intracranial pressure (headache, etc.)
Abducens nerve palsy	Abducens nerve innervates only Lateral Rectus muscle (action: abduction of eye)	Damage Abducens nerve VI (causes ex. increased intracranial pressure, Cavernous sinus thrombosis)	**Diplopia and Medial strabismus**
Trochlear nerve palsy	Trochlear nerve innervates only Superior Oblique muscle (action: abduct, depress and medially rotate eye)	Damage Trochlear nerve (ex. trauma)	**Inability to look down and out** (difficulty walking down stairs); **Head tilted toward side opposite lesion**
Oculomotor nerve palsy	Oculomotor nerve innervates Superior, Medial and Inferior Rectus and Inferior Oblique; part of Levator palpebrae superioris; also provides parasympathetics to pupillary constrictor, ciliary muscles	Damage Oculomotor nerve (frequently idiopathic)	**Lateral strabismus, dilated pupil, ptosis; also loss of accommodation (near vision) due to paralysis of ciliary muscles**

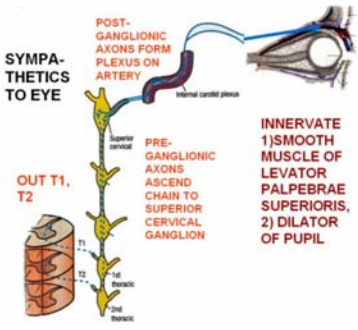


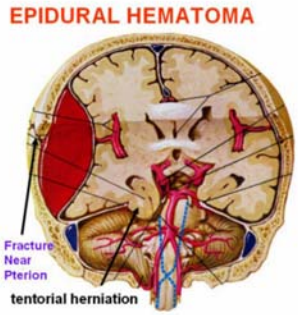


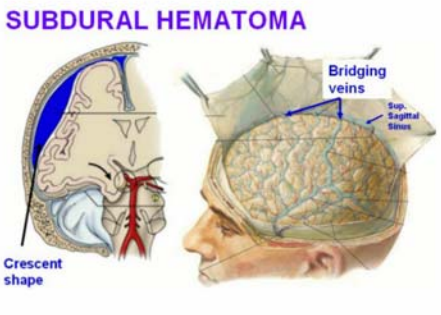


Clinical	Anatomy	Cause	Sign/Symptom
Horner's Syndrome	Sympathetics in head innervate smooth muscle part of Levator Palpebrae Superioris; Pupillary Dilator muscle; sweat glands of skin; **Pathway**: pre-ganglionic neurons out cord at T1,2; ascend in chain; post-ganglionics in Sup. Cerv. Ganglion; distributed with arteries (ex. Ophthalmic A.)	Block conduction in Sympathetics to head (tumors, etc)	**Ptosis (**drooping eyelid from smooth muscle part of Levator Palpebrae Superioris); **Constricted pupil** (miosis due to paralyze Dilator pupillae); **Anhydrosis** of forehead (denervate sweat glands)
Cavernous sinus thrombosis	Branches of cranial nerves (III, IV, V1, V2, VI) and Internal Carotid artery pass through wall of Cavernous sinus; Cavernous sinus drains ophthalmic veins which anastomose with branches of Facial Vein; veins have no valves	ex. **Infection in cav. sinus spread from infection of face (Facial Vein has no/few valves)** (angle of nose or upper lip particularly dangerous)	**Diplopia** (blurred vision) due to disruption of eye movements; increased venous pressure produces **engorgement in veins of retina (view in ophthalmoscope) +other symptoms**
Epidural Hematoma	**Middle Meningeal artery** (branch of Maxillary artery that passes through foramen spinosum) supplies bone of calvarium	**Blow to side of head (fracture skull in region of pterion)**	Patient conscious after accident; loses consciousness within hours; coma, death (Note: **hematoma is lens-shaped** on CT)
Subdural Hematoma	**Bridging veins** link Superficial cerebral veins on surface of brain and Superior Sagittal sinus (also other venous sinuses)	**Blow to head; in elderly can occur without distinct event**	**Slow onset** of neurological symptoms, headache (often hours to days) (Note: **hematoma is crescent-shaped** on CT)
Communicating Hydrocephalus due to decreased CSF reabsorption	CSF produce in choroid plexus; reabsorbed from subarachnoid space at arachnoid villi into venous sinuses	In elderly, **Calcification of arachnoid villi** (arachnoid granulations)	**Headache, papilledema**



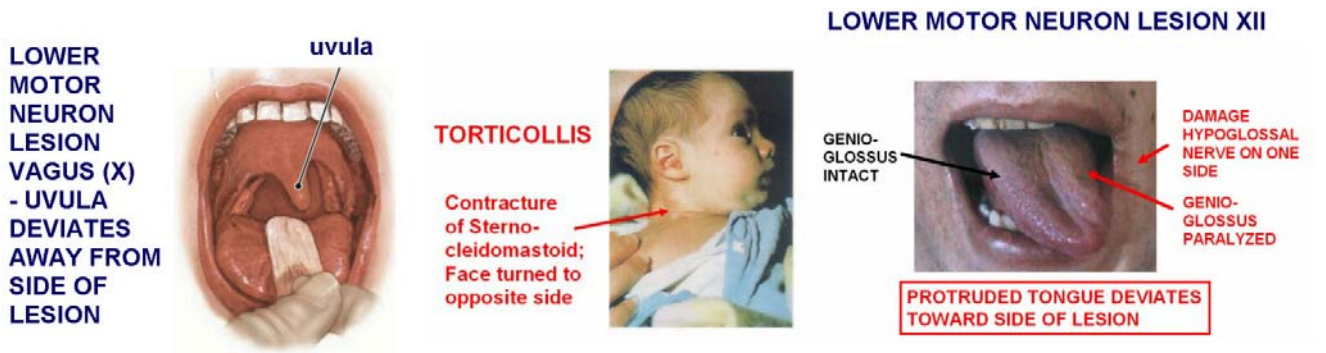




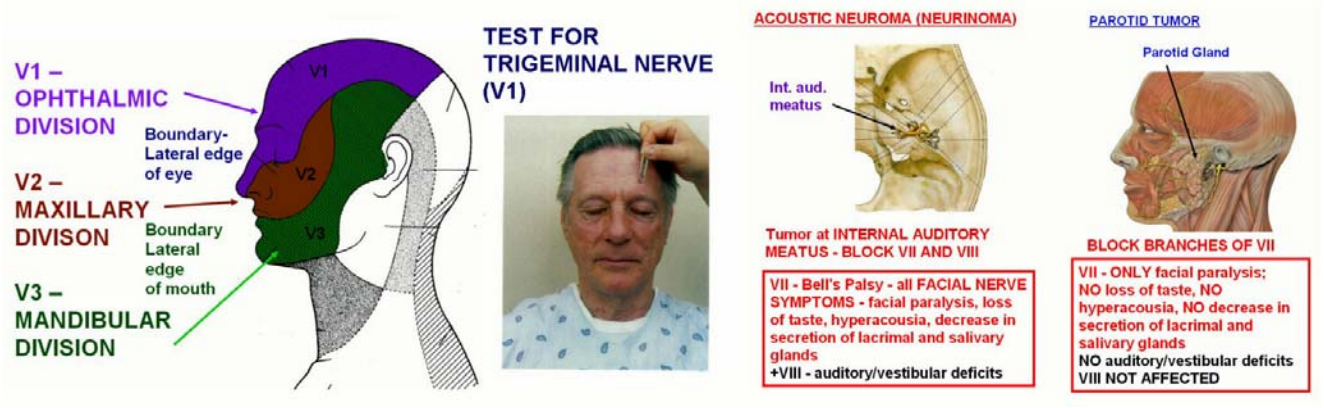


CLINICAL ANATOMY OF HEAD AND NECK

Clinical	Anatomy	Cause	Sign/Symptom
Posterior Cranial Fossa - Cranial Nerves VII-XII, face, ear, pharynx, tongue (cont.)			
Loss of function of IX and X	IX is major sensory nerve to pharynx (oropharynx); X is motor to all muscles of pharynx except Stylopharyngeus; all muscles of palate (except Tensor palati)	**Tumor at Jugular Foramen**	Difficulty in swallowing; **Absence of Gag Reflex**; (Gag reflex - IX sensory, X motor) **Uvula deviates away from side of lesion**
Hoarse voice after thyroid surgery	X is motor to all muscles of larynx; also sensory to larynx; Recurrent Laryngeal nerve passes posterior to Thyroid gland with Inf. Thyroid artery; motor to all laryngeal muscles except Cricothyroid	**Damage Recurrent Laryngeal nerve during Thyroid surgery**	Hoarse voice due to **unilateral paralysis of all laryngeal muscles (except Cricothyroid)**
Torticollis	XI innervates Sternocleidomastoid and Trapezius	Torticollis can be congenital or acquired	Contracture of Sternocleidomastoid - head is rotated with face directed to opposite side (Note: **Trapezius - clinical test for XI - shrug shoulders**)
Cleft Palate (palatoschisis)	**Anterior** - Fusion of medial nasal processes (Primary palate) and maxillary processes (Secondary Palate); **Posterior** - Secondary palate formed by fusion of Maxillary processes of two sides	**Failure of fusion**	**Anterior** - Cleft <u>anterior to Incisive foramen</u>; **Posterior** - Cleft <u>posterior to Incisive foramen</u> Treatment: Surgical repair
Paralysis of muscles of tongue	XII is motor to all muscles of tongue (no sensory component)	XII hypoglossal nerve palsy	Atrophy of muscles of tongue on one side; **protruded tongue deviates toward side of lesion due to Genioglossus) in Lower Motor Neuron Lesion**



Clinical	Anatomy	Cause	Sign/Symptom
Middle Cranial Fossa - Cranial nerves II-VI Orbit, Eye Movements, Face			
Numbness of regions of face	V is major sensory nerve of face and head; **Sensory neuron cell bodies** are in **Semilunar (Trigeminal) Ganglion**; V1 above lateral margin eyelids; V2 eyelids to upper lip; V3 below lateral margins of lips	Many; ex. Trigeminal Anesthesia	Numbness in specific region can be **correlated with specific division of V**
Pain in external auditory meatus following Facial paralysis	Skin of ear and external auditory meatus receive sensory innervation from V, VII, IX and X	**Bell's palsy**	Ear ache (following or accompanying Facial paralysis)
Weakness of muscles mastication	Muscles mastication innervated by V3; Lateral Pterygoid opens mouth; all other muscles Mastication close mouth	ex. **Tumor at foramen ovale**	When open mouth, **jaw deviates toward paralyzed side**
Facial paralysis (with effect on VIII)	CN VII and VIII exit post. cranial fossa via Internal auditory meatus; VIII ends in temporal bone; VII enters facial canal and gives off branches in temporal bone; 1) parasymp. to Lacrimal gland, mucous glands of nose, palate; 2) Nerve to Stapedius muscle; 3) Chorda tympani - taste to ant. 2/3 of tongue; parasymp. to Submandibular, Sublingual salivary glands	**Acoustic neuroma**	Loss or reduction of hearing in one ear; **Full Facial nerve palsy (Bell's palsy)** symptoms: 1) **Facial paralysis and loss of Corneal reflex** (V1 sensory, VII motor) 2) **Loss of taste to ant. 2/3 of tongue** 3) **Decreased secretion tears and saliva** 4) **Hyperacousia**
Facial paralysis (no effect on VIII)	Facial nerve exits skull via Stylomastoid foramen; only has motor branches after leaving skull	**Parotid tumor**	**Facial paralysis**; Loss of corneal reflex but **no loss of taste or decrease in tears or saliva; no hypercousia**



3) SPINAL REFLEXES AND DIAGNOSIS OF UPPER AND LOWER MOTOR NEURON LESIONS

REFLEX	STIMULUS/SENSE ORGAN(S) EXCITED	RESPONSE	CLINICAL/ABNORMAL RESPONSES
Stretch (Myotatic, Deep Tendon) Reflex	Rapid Stretch of muscle (test: tap on muscle tendon) Excites Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons (NOT Golgi Tendon Organ)	Stretched muscle contracts rapidly (monosynaptic connection); also excite synergist and Inhibit antagonist Note: Gamma motor neurons can enhance stretch reflexes (Gamma dynamic motor neurons specifically enhance Ia sensitivity; tell patient to relax before test)	Hyporeflexia - decrease in stretch reflexes occurs in Lower Motoneuron Diseases, Muscle atrophy etc. Hyperreflexia - (increase) - characteristic of Upper Motor Neuron lesions (ex. spinal cord injury, damage Corticospinal tract); note: Clonus = hyperreflexia with repetitive contractions to single stimulus
Autogenic Inhibition (Inverse Myotatic Reflex)	Large force on tendon excites Golgi Tendon Organ Ib (test: pull on muscle when resisted)	Muscle tension decreases; Also inhibit synergist muscles; excite antagonist muscles	Clasped Knife Reflex - occurs in Upper Motor Neuron lesions - forceful stretch of muscle is first resisted then collapses
Flexor Reflex	Sharp, painful stimulus, as in stepping on nail; Excites - Cutaneous and pain receptors	Limb is rapidly withdrawn from stimulus; protective reflex; also inhibit extensors of same limb and excite extensors of opposite limb (Crossed Extensor Reflex)	Babinski sign- toes extend (dorsiflex) to cutaneous stimulus of sole of foot (normally plantar flex); characteristic of Upper Motor Neuron lesion

LOWER AND UPPER MOTOR NEURON LESIONS

Lesion	Structure Affected	Symptoms	Examples
Lower Motor Neuron Lesion (Flaccid Paralysis)	Lower Motor Neurons = Alpha Motor neurons with axons that innervate skeletal muscles	Muscle is effectively denervated: 1) Decrease Stretch (Deep Tendon) Reflexes 2) Decreased Muscle Tone 3) Muscle atrophy; Fasciculations (twitches) precede atrophy 4) No Babinski sign	1) Compression of spinal nerve 2) Poliomyelitis - viral infections affecting motor neurons
Upper Motor Neuron Lesion (Spastic Paralysis)	Upper Motor Neurons = All descending neurons that affect Lower Motor Neurons (ex. Corticospinal Reticulospinal neurons)	Disrupt voluntary control and regulation of reflexes (remove inhibition): 1) Increase Stretch (Deep Tendon) Reflexes 2) Increased Muscle Tone 3) No Fasciculations 4) Babinski sign 5) Clasped Knife Reflex	1) Damage to Corticospinal (corticobulbar) tracts - can occur at all levels from cortex to spinal cord (including brainstem)

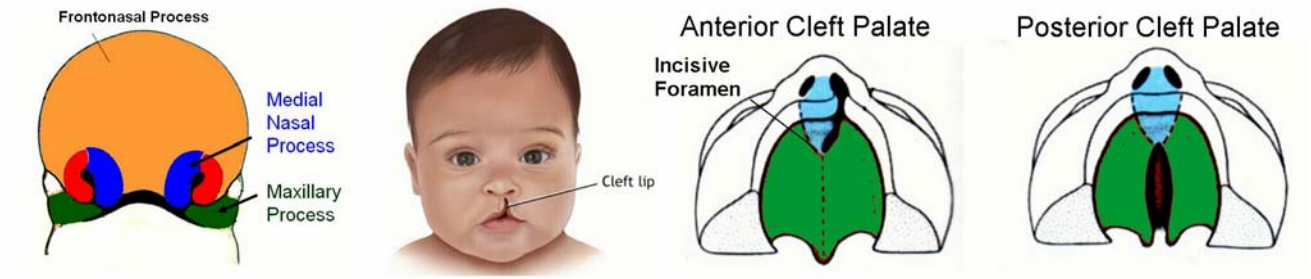
Note: Some diseases produce both Upper and Lower Motor Neuron Symptoms - (ex. ALS Amyotrophic Lateral Sclerosis)

REFLEXES OF CRANIAL NERVES

REFLEX	STIMULUS	SENSORY	RESPONSE	CLINICAL
Pupillary Light Reflex (II to III)	**Test: Shine light in eye**	**Light detected by Optic Nerve**	**Excite Constrictor of pupil of eye (III Short Ciliary nerves (Ciliary Ganglion, parasympathetic)**	**Extensively used to check CN II; Absence of Pupillary Light Reflex can indicate catastrophe (brain herniation)**
Corneal Reflex (V to VII)	**Touch cornea of eye with cotton**	**Touch detected by Long Ciliary nerves (V1), Somatic sensory**	**Close eye (VII to Orbicularis Oculi muscle) Branchiomotor**	**Absence of Corneal Reflex; Test for damage to V1 sensory, VII motor**
Gag Reflex (IX to X)	**Test: Touch posterior tongue, oropharynx;**	**Excites Visceral Sensory endings in Glossopharyngeal N. (IX)**	**Excite muscles of pharynx, palate; Vagus N. (X), Branchiomotor**	**Other symptoms of Vagus damage (X); Patient Say's Ahh: soft palate not elevated on ipsilateral side (paralyze Levator Palati); uvula deviated away from side of lesion**
Jaw Jerk Reflex Stretch (Deep Tendon) Reflex (V to V)	**Test: tap down on mandible; Stretch muscles of mastication (ex. Masseter)**	**Excites Muscle Spindle sensory neurons in Trigeminal nerve (V)**	**Contract muscles that elevate mandible Motor - V3**	**Hyporeflexia - indicates Trigeminal nerve damage**

CLINICAL EMBRYOLOGY OF HEAD AND NECK

Clinical Condition	Normal development	Abnormal	Signs/ Symptoms	Treatment
Cleft Lip (cheiloschisis)	Fusion of medial nasal and maxillary processes forms upper lip	**Failure of fusion of medial nasal and maxillary processes**	Cleft at philtrum of upper lip	Surgical repair
Malformation of nasolacrimal duct (dacryostenosis)	Duct forms as cord between maxillary and frontonasal processes; extends from lacrimal sac (at medial canthus of eye) to nasal cavity (inferior meatus)	**Cord fails to canalize**	Continuous flow of tears over lower lid onto face	Surgical repair
First Arch (Treacher Collins) Syndrome	First brachial arch forms skeletal elements: 1) malleus, incus 2) contributes to mandible (Meckel's cartilage)	**Neural crest cells do not migrate into Arch 1**	1) Mandibular hypoplasia 2) Conductive hearing loss 4) Facial malformation	Some surgical repair
Thyroglossal duct cysts	Thyroid forms as evagination at foramen cecum of tongue; tissue migrates ant. to Hyoid bone in midline of neck to location below Cricoid cartilage	**Glandular tissue or cysts develop anywhere along path of migration**	Mass in **midline** of neck	Surgical removal (remove tract to tongue)
Abnormal location/ Accidental Removal of parathyroid glands	Normally posterior to thyroid gland or embedded in it; develop from branchial pouches 3 and 4 Inferior parathyroid - pouch 3 Superior parathyroid - pouch 4	**Can be located within thyroid gland or ectopic**	Normally no symptoms; calcium imbalance If accidentally remove (during thyroid surgery)	Treat calcium imbalance pharmaco-logically, etc.



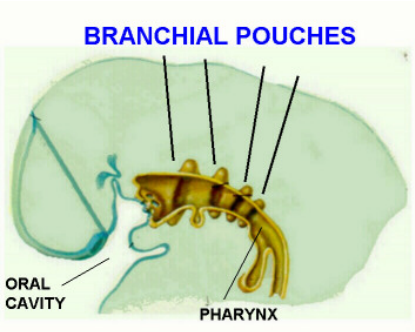
BRANCHIAL ARCHES AND DERIVATIVES

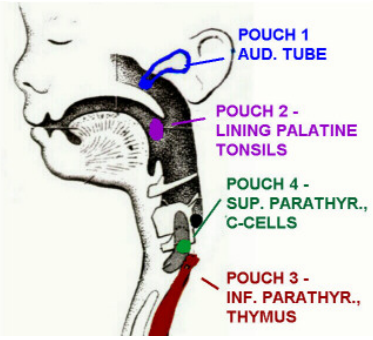
ARCH (NERVE)	SKELETAL	LIGAMENTS	MUSCLES
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Spheno-mandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VII)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
Third (IX)	Hyoid bone - greater horn, lower half of body	----------	Stylopharyngeus
Fourth (X)	Cartilages of Larynx	----------	1) All muscles of Larynx 2) All muscles of Pharynx (except Stylopharyngeus) 3) All muscles of Soft Palate (except Tensor palati)
Sixth (XI)	----------	----------	1) Sternocleidomastoid 2) Trapezius

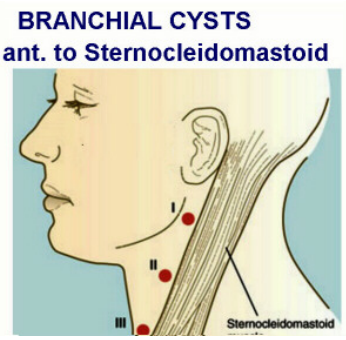
STRUCTURES DERIVED FROM BRANCHIAL POUCHES, CLEFT AND MEMBRANE: BRANCHIAL 'CLEFT' CYSTS (FISTULI = channels from pharynx to skin)

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract to external auditory meatus or auditory tube
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract to tonsillar fossa (palatine tonsils) - **MOST COMMON CYST**
Third	1) Inferior parathyroid gland 2) Thymus	Third Branchial 'Cleft' cyst - tract to thyrohyoid membrane or piriform recess
Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	Rare

Note: Pouch 3 structures migrate below (caudal) to Pouch 4 structures.
Note: **Location of Cysts and Fistuli - <u>in lateral neck, anterior to Sternocleidomastoid muscle</u>**
Note: **First Branchial Cleft forms Ext. Auditory Meatus; First Branch. Membrane = Tympanic Membrane**







FACE

I. OVERVIEW: FACE IS UNIQUE - Skin on face is thin and moveable; has many sebaceous glands and sweat glands. Superficial fascia of face is loose, except at nose; facial muscles (i.e. muscles of facial expression) are embedded in superficial fascia; there is NO deep fascia over face.

A. Facial muscles (embedded in superficial fascia) take origin from underlying bones (mostly) and insert onto skin.

Note: **Facial transplant** - In severe damage to face, facial transplants are required because muscles of facial expression insert onto skin rather than tendons (therefore, cannot use grafts of other body muscles); transplants contain muscles and skin.

B. Neural control of Facial muscles - Facial muscles are under both voluntary and involuntary (emotional) control.

C. Detecting action of Facial muscles - Muscles of face have no (or very few) muscle spindles; muscle contractions are thought to be detected by stretching of skin.

D. Facial paralysis - is a defining symptom in Bell's Palsy

Bell's palsy - paralysis of facial muscles; **lower motor neuron syndrome of facial nerve (CN VII)**; thought to be associated with **viral infection** (herpes simplex); **Symptoms unilateral**: sudden onset **paralysis or paresis of all facial muscles on one side**; drooling; inability to close eye; also hyperacousis (sounds seem too loud), loss of taste to anterior tongue; pain in or behind ear.

Note: **Upper motor neuron lesions affecting facial nerve** (ex. **cortical stroke** = vascular insufficiency) - **'Sparing' of upper face** - Often **only muscle of lower face are paralyzed on one side**, **muscles of upper face not affected** (ex. brow, orbicularis oculi); cortical projections bilateral to upper face; unilateral (contralateral) to lower face.

II. ARTERIAL SUPPLY

A. Overview of Arterial supply to Head (see Diagrams of Arterial Supply attached); Common Carotid arteries ascend in neck and divided into External and Internal Carotid Arteries (at upper border of thyroid cartilage); Arterial supply to Face derived from branches of - extensive; vessels have many anastomoses.

1. branches to face of External Carotid artery (major blood supply to head).

a. Facial artery - course: extremely winding and tortuous; artery arises from anterior side of External Carotid, first courses medial to mandible, then appears on face anterior to the mandible (site of pulse of Facial artery); artery ascends lateral to lips and ends medial and inferior to orbit. Branches on face:

i) Superior and Inferior Labial arteries - upper and lower lips.
ii) Angular artery = main part of facial artery adjacent to nose and to angle (corner) of eye.

b. Superficial Temporal artery - one of two terminal branches of External Carotid; course - arises anterior to external auditory meatus (opening to ear), deep to parotid salivary gland; has many branches to scalp; named small branch on face Transverse Facial artery.

2. branches to face of Internal Carotid artery (major blood supply to brain, orbit)

a. Ophthalmic artery - many branches to orbit but also has a number of named branches to face, forehead and nose:

i) Supraorbital artery (above orbit)
ii) Supratrochlear artery (on medial and superior side of orbit)

Note: Orbit (= eye socket) contains the eye and muscles that move the eye; orbit is also **a major route for nerves/blood vessels to get to other places**, (ex. to face, nasal cavity).

III. VENOUS DRAINAGE OF FACE - veins of face generally follow arteries; **have no valves**; veins drain both into the skull and down face to the neck; have **extensive anastomoses**.

Clinical Note: **Prolonged infections on face** (pimples or acne) are dangerous because veins of face anastomose, have no valves and drain both to the brain and down to the neck; **infections can spread via anastomoses from face into venous sinuses inside of skull** (ex. through orbit) and involve cranial nerves to muscles of eye (**clinical sign is 'blurred vision' = diplopia**); infections on face lateral to nose are particularly dangerous.

IV. SENSORY INNERVATION OF FACE - Sensory supply - via branches of Trigeminal nerve (cranial nerve V); Trigeminal nerve has three divisions: Ophthalmic division (V1), Maxillary division (V2) and Mandibular division (V3).

1. branches of Ophthalmic division - to skin above orbit; Supraorbital, Supratrochlear, Infratrochlear, Lacrimal and External Nasal nerves.

2. branches of Maxillary division - to skin of cheek below orbit; Infraorbital, Zygomaticofacial and Zygomaticotemporal nerves.

3. branches of Mandibular division - to skin of jaw and face below angle of mouth; Mental nerve, Auriculotemporal nerve and Buccal branch of Trigeminal nerve.

V. MUSCLES OF FACIAL EXPRESSION - move skin of face, close eyes and close and open mouth; allow you to convey emotions by facial gestures (ex. sneering and contempt); most are attached to bones and insert upon skin; many named for their actions or Latin or Greek words; movements elicited in test for Facial Nerve function

1. Orbicularis oculi - has palpebral (eyelid) and orbital part (edge of orbit); action - close eyelids (note: orbital part 'buries' eyelids, as closing eyes in a sandstorm).
2. Orbicularis oris - surrounds and closes mouth.
3. Muscles of nose - a. Compressor naris - acts to compress nasal cartilages; b. Dilator naris - dilates nostrils; c. Procerus - wrinkles skin of nose.
4. Muscles of upper lip - a. Levator labii superioris - lifts upper lip; b. Zygomaticus major and minor - raise and pull upper lip laterally.
5. Muscles at angle of mouth - a. Levator anguli oris - raises corner of mouth; b. Risorius - smiling muscle; b. Depressor anguli oris - tragedy muscle.
6. Muscle of lower lip and chin - a. Depressor labii inferioris - depresses lower lip; b. Mentalis - wrinkles skin of chin.
7. Buccinator - muscle in cheek; compresses mouth and keeps food between teeth when chewing; buccinator is latin for trumpeter.

Clinical: **Facial nerve damage – can produce difficulty eating** (chewing) because food not kept between teeth after **paralyze Buccinator** (this was board question)

8. Frontalis and Occipitalis – muscles in scalp attached to Epicranial Aponeurosis, skin; Frontalis raises eyebrows.

Clinical: **Test Facial nerve - raise eyebrows with Frontalis**.

9. Platysma - extends in neck from mandible to fascia over Pectoralis Major muscle; moves skin of neck.

VI. MOTOR INNERVATION TO MUSCLES OF FACIAL EXPRESSION - via Facial nerve (cranial nerve VII); nerve leaves skull via stylomastoid foramen; enters parotid gland; divides into 5 terminal branches: superior to inferior

1. Temporal
2. Zygomatic
3. Buccal - (not to be confused with Buccal branch of V)
4. Mandibular
5. Cervical

VII. DEVELOPMENT OF FACE

A. Five facial primordia - form in fourth week in development and surround developing stomodeum (= primitive mouth) (Note: the term process is the same thing as prominence)

1. Frontonasal process - formed by mesenchyme below brain; unpaired
2. Maxillary processes - from first branchial arch; paired.
3. Mandibular processes - from first branchial arch, inferior to maxillary processes.

B. Sequence of Development

1. Thickenings (Nasal placodes) form on each side of Frontonasal process.
2. Medial and Lateral Nasal processes form at margins of Nasal placodes.
3. Upper parts of Medial and Lateral Nasal processes fuse to form upper part of nostril.
4. Inferior part of Medial Nasal processes fuse with Maxillary process on each side to form upper lip.

Note: **Cleft Lip (Cheiloschisis (Gk. Cheilos, lip)** - results from **failure of fusion of Medial Nasal processes with Maxillary process** on that side; can be unilateral or bilateral; occurs in 1 in 1000 births.

5. Nasolacrimal duct - connects anterior eye to nasal cavity; drains tears; forms in development as a solid epithelial cord that extends from medial angle of eye to nasal cavity; cord becomes canalized to form duct.

Note: **Obstructed Nasolacrimal duct** - results from failure of duct to canalize; must be opened for tears to drain to nasal cavity.

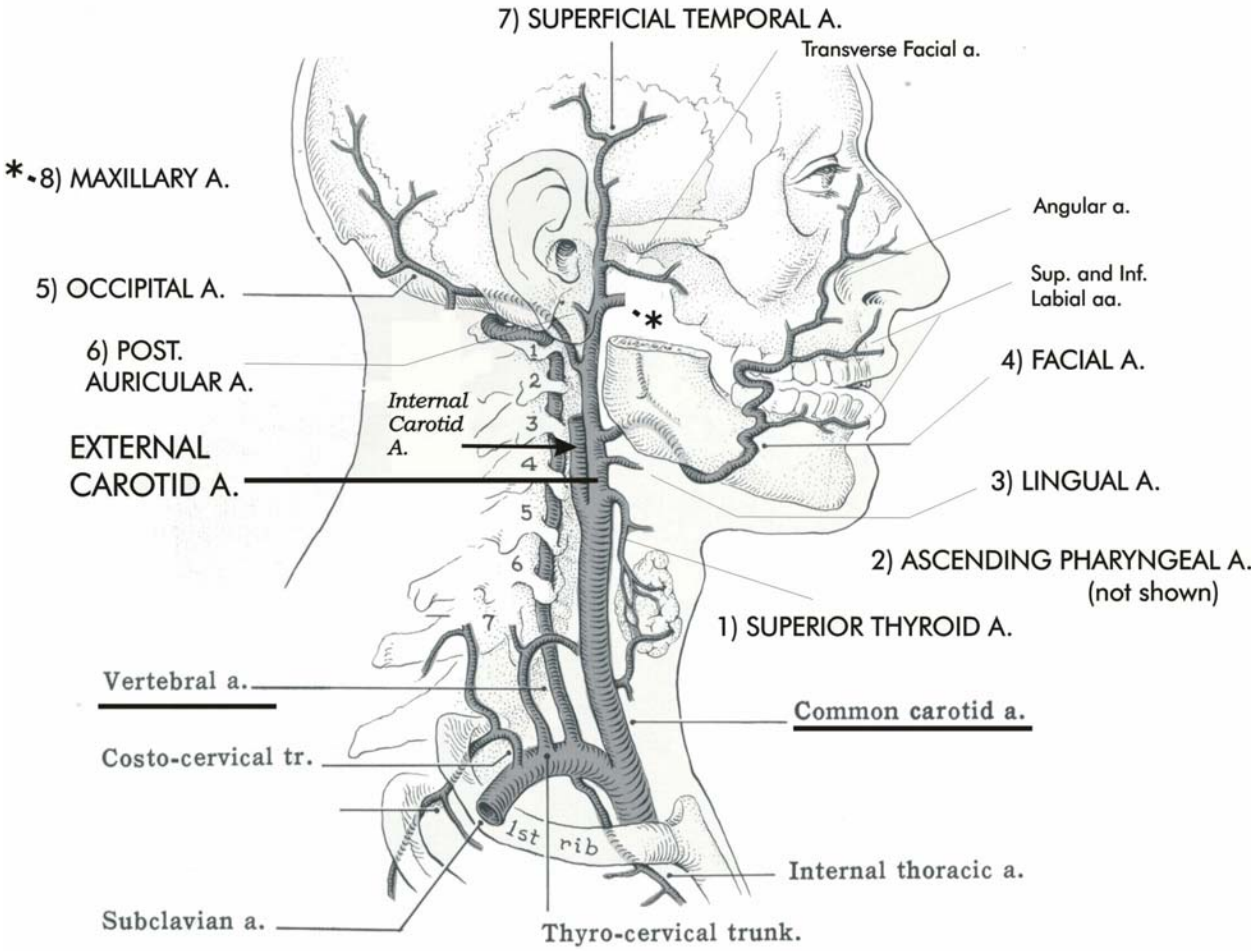
TABLE OF MUSCLES OF FACIAL EXPRESSION

Muscle	Action	Clinical Note
Eye		
Orbicularis oculi	Orbital part (surrounds eyelids) – 'buries' eyelids (as in sandstorm) Palpebral part (within eyelids) – closes eyelid	**Closing eyelid is essential to prevent damage to cornea** - cover, sew eyelids shut (neonates) in Facial paralysis
Nose		
Compressor naris	compress nasal cartilages	
Dilator naris	dilates nostrils	
Procerus	wrinkles skin of nose.	
Mouth		
Orbicularis Oris	closes mouth (surrounds lips)	
Levator labii superioris	lifts upper lip	
Zygomaticus major and minor -.	raise and pull upper lip laterally	
Levator anguli oris -	raises corner of mouth	drooping of corner of mouth in Bell's palsy
Risorius (Latin for smiling)	smiling muscle	
Depressor anguli oris	tragedy muscle	
Depressor labii inferioris	depresses lower lip	
Other		
Mentalis	wrinkles skin of chin	
Buccinator (latin for trumpeter)	compresses mouth and keeps food between teeth when chewing	**patients with Bell's palsy have difficulty 'eating food', drooling**
Frontalis and Occipitalis	move scalp (attach to Epicranial Aponeurosis); frontalis raises eyebrows	drooping of eye brow in Bell's palsy (Clinical test - raise eyebrows)
Platysma	stretches skin of neck	

SEE VIDEO: FACIAL MUSCLES FOR ILLUSTRATION OF LOCATION

OVERVIEW OF BLOOD SUPPLY TO HEAD

(EXCLUDING BRANCHES OF INTERNAL CAROTID A.)



EXTERNAL CAROTID ARTERY

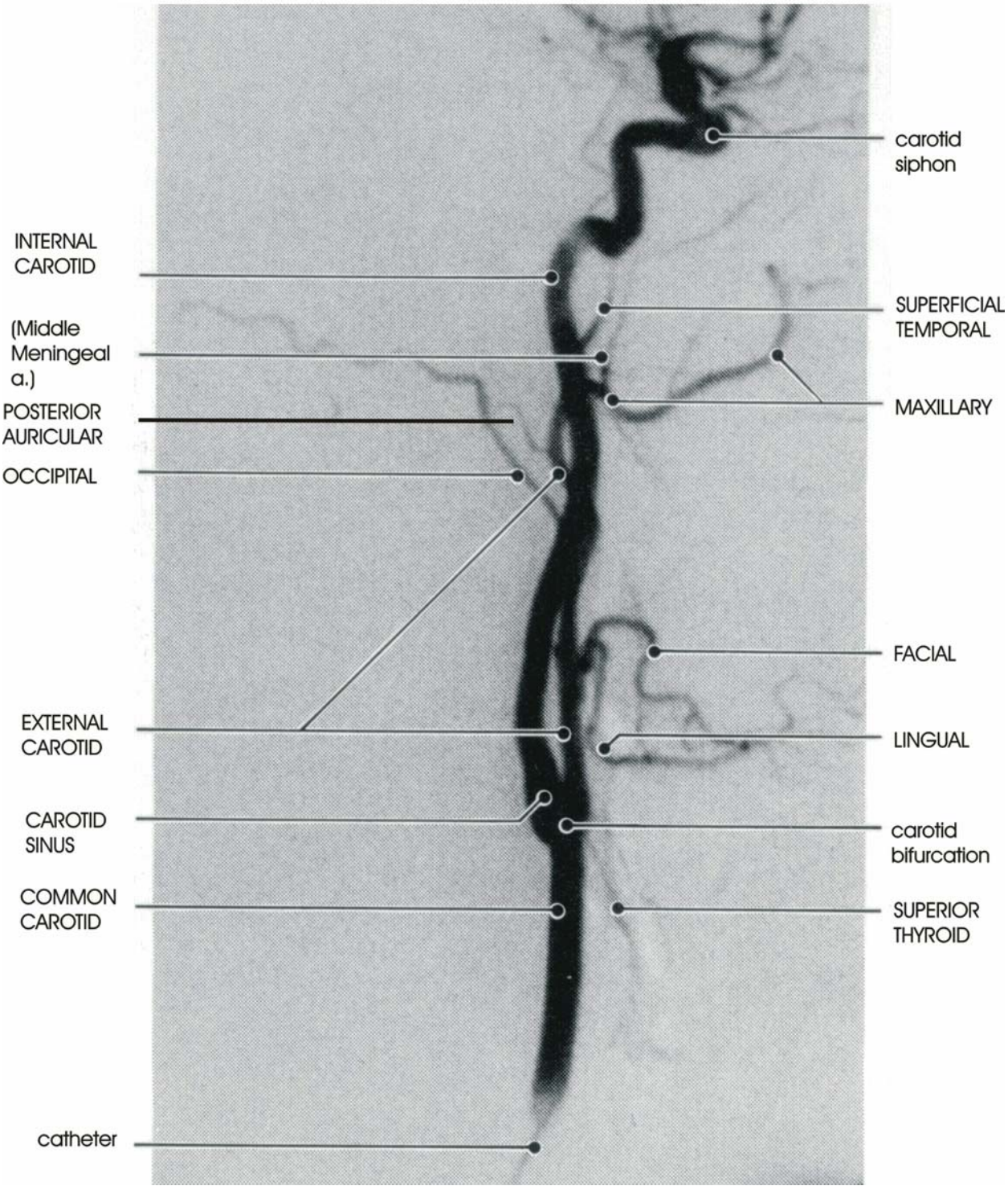
1) Superior Thyroid a.
2) Ascending Pharyngeal a.
3) Lingual a.
4) Facial a.
5) Occipital a.
6) Post. Auricular a.
7) Superficial Temporal a.
8) Maxillary a.

SUBCLAVIAN ARTERY

Vertebral a.
Internal Thoracic a.
Thyrocervical trunk
Costocervical trunk

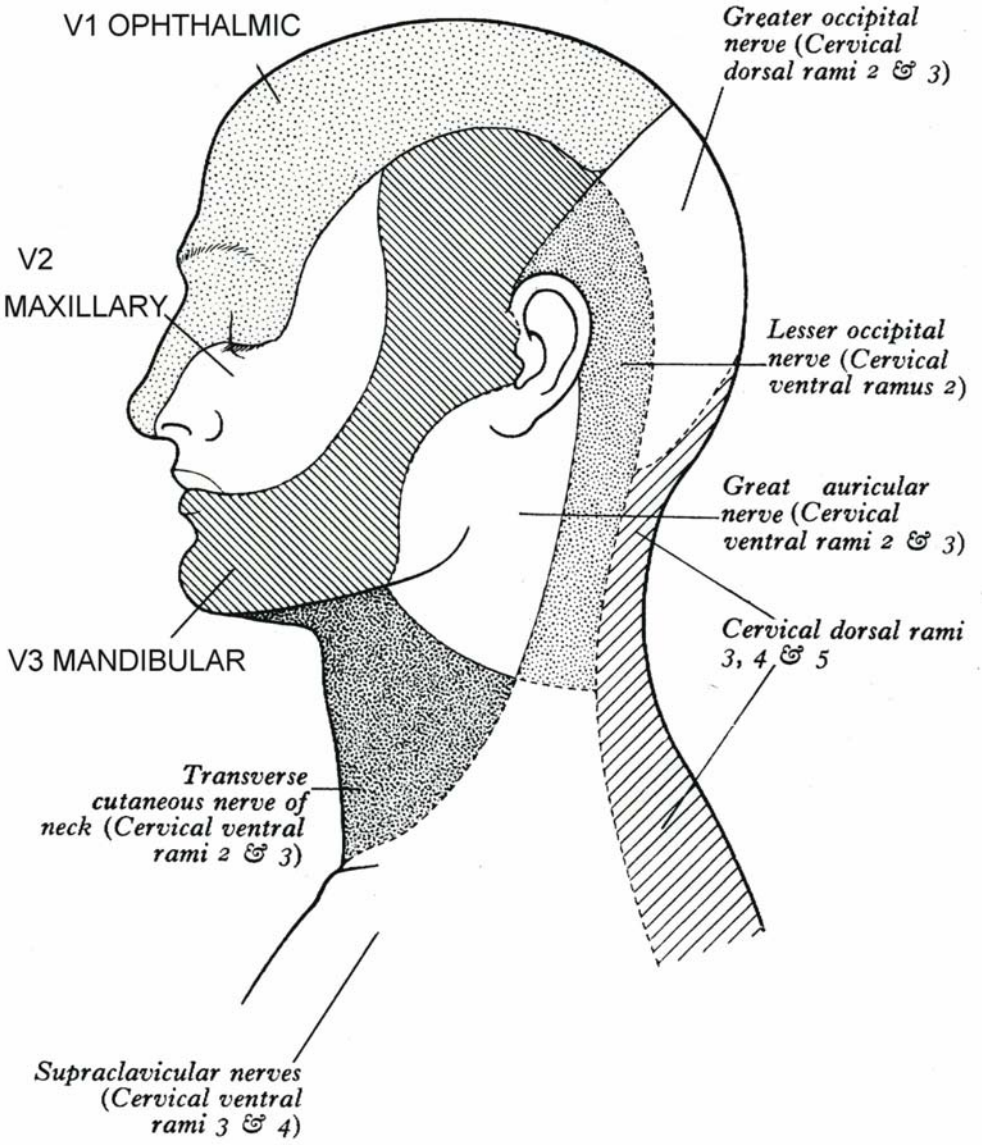
ORIENTATION: NOSE---->

CAROTID ARTERIOGRAM



CUTANEOUS INNERVATION OF HEAD AND NECK

TRIGEMINAL NERVE (V) - three divisions - V1 Ophthalmic, V2 Maxillary, V3 Mandibular



REFERENCE HANDOUT (DO NOT MEMORIZE): TRIGEMINAL NERVE BRANCHES

zill@musom.2021

V1 Ophthalmic - Somatic Sensory only (GSA) - through Superior Orbital Fissure to Orbit

Nerve	Branches	Innervates
1. Frontal Nerve	a. Supraorbital Nerve	Scalp forehead, upper eyelid
	b. Supratrochlear Nerve	Scalp forehead, upper eyelid
2. Lacrimal Nerve		Upper eyelid
3. Nasociliary Nerve	a. Long Ciliary Nerve	Cornea of eye
	b. Ant. and Post. Ethmoidal Nerves	Nasal cavity, ethmoid sinus, tip of nose
	c. Infratrochlear Nerve	Upper eyelid, nose

V2 Maxillary - Somatic Sensory (GSA) only - through Foramen Rotundum to Pterygopalatine Fossa

Nerve	Branches	Innervates
1. Meningeal branches		Dura of mid. Cranial fossa
2. Ganglionic branches	a. Greater Palatine Nerve	Hard Palate
	b. Lesser Palatine Nerve	Soft Palate
	c. Nasopalatine Nerve	Nasal Cavity, Hard Palate
	d. Nasal branches	Nasal Cavity
3. Post. Sup. Alveolar Nerve		Maxillary teeth
4. Infraorbital nerve		Lower eyelid, nose, upper lip
	a. Ant. Sup. Alveolar Nerve	Maxillary teeth
	b. Mid. Sup. Alveolar Nerve	Maxillary teeth
5. Zygomatic nerve	a. Zygomaticofacial Nerve	Skin of cheek
	b. Zygomaticotemporal Nerve	Skin of temporal region

V3 Mandibular - Somatic Sensory (GSA) and Branchiomotor (SVE) - Foramen Ovale to Infratemporal Fossa

Nerve	Branches	Innervates
1. Nervous spinosus		Sensory to Dura of mid Cranial fossa
2. Motor branches		Motor to Med. Pterygoid, Tens. Tympani, Tensor Palati
3. Anterior division	a. Nerve to Lateral Pterygoid	Motor to Lateral Pterygoid
	b. Masseteric Nerve	Motor to Masseter
	c. Deep Temporal Nerve	Motor to Temporalis
	d. Buccal Nerve	Sensory to Cheek
4. Posterior Division	a. Auriculotemporal Nerve	Sensory to external auditory meatus, tympanic membrane, TMJ, lateral scalp
	b. Lingual Nerve	Sensory (touch) ant. 2/3 tongue
	c. Inferior Alveolar Nerve i. Nerve to Mylohyoid ii. Mental Nerve	Sensory to Mandibular teeth Motor to Mylohyoid, ant. Digastric Sensory to Chin, Lower lip

CRANIAL NERVES

1) OVERVIEW - Cranial nerves vs. Spinal nerves.

A. Cranial nerves contain inflow/outflow of brain; spinal nerves contain inflow/outflow of spinal cord.

B. Cranial nerves often contain types of neurons that are similar to types of neurons found in spinal nerves; ex. sensory axons to skin.

C. Cranial nerves can contain types of neurons not found in spinal nerves; ex. taste fibers.

D. Many cranial nerves contain more than one type of neuron.

E. In order to analyze and remember the types of neurons found in different cranial nerves we have a system of classification of types of neurons - WHY? Neurons of same type will form columns of nuclei in brainstem.

2) CLASSIFICATION OF INNERVATION - Seven types of neurons - some are the same types as found in spinal nerves; others are only found in cranial nerves

A. Same types of neurons as are found in spinal nerves

1. **Somatic motor** - Voluntary skeletal muscles (derived from somites)
2. **Somatic sensory** - Precise sensation - sensory to skin, joints, muscle and tendon receptor endings, in head, also nasal and oral cavity
3. **Visceral motor** (efferents) - AUTONOMICS - smooth muscles (including arrector pilae muscles of skin,) blood vessels; secretomotor to glands
4. **Visceral sensory** - Imprecise sensation sensory from gut, blood vessels, glands, internal organs; in head, pharynx which rostral end of gut.

B. Types of neurons only found in cranial nerves

5. **Special senses** - vision, hearing (audtiory) and balance (vestibular apparatus)
6. **Chemical senses** - taste and smell
7. **Branchiomotor** - Voluntary skeletal muscles from branchial arches.

3) NAMES OF CRANIAL NERVES - nerves often referred to by name or number

I. Olfactory - smell
II. Optic - vision
III. Oculomotor - eye movements; also parasympathetics to eye smooth muscles
IV. Trochlear - eye movements
V. Trigeminal - sensory nerve to skin, oral and nasal cavities, outer ear
VI. Abducens - eye movements

VII. Facial - muscles of facial expression; also taste, parasympathetics, etc.
VIII. Vestibulo-cochlear (Stato-acoustic) - hearing and balance
IX. Glossopharyngeal - sensory to pharynx, back of tongue (Gag reflex), etc.
X. Vagus - motor to pharynx (most), larynx (voice box); soft palate; many others
XI. Accessory (Spinal Accessory) - motor to sternocleidomastoid, trapezius
XII. Hypoglossal - motor to muscles of tongue

4) SOMATIC MOTOR AXONS IN CRANIAL NERVES - like spinal nerves; innervate voluntary skeletal muscles derived from somites; two groups of muscles.

1. Eye (Extraocular) muscles - derived from pre-otic somites; innervated by

a. III (Oculomotor) - to Superior, Inferior and Medial Rectus, Inferior Oblique and Levator Palpebrae Superioris (skeletal part).
b. IV (Trochlear) - to Superior Oblique muscle.
c. VI (Abducens) - to Lateral Rectus muscle.

2. Intrinsic and Extrinsic Muscles of Tongue - derived from occipital somites - all innervated by XII (Hypoglossal).

5) SOMATIC SENSORY NEURONS - Precise sensation - innervate skin, oral cavity, nasal cavity, joints, muscles; sensory cell bodies in sensory ganglia attached to cranial nerves as they enter central nervous system, similar to dorsal root ganglia.

1. All of face, forehead, temporal region, oral cavity, temporo-mandibular joint innervated by V (Trigeminal); Note: cell bodies in Trigeminal ganglion (similar to dorsal root ganglia of spinal nerves).

2. Exception: skin of outer ear, external auditory meatus is innervated by V (Trigeminal), plus branches of VII (Facial), IX (Glossopharyngeal) and X (Vagus).
(note: sensory cell bodies of VII in sensory ganglion called Geniculate ganglion)

Note: In Bell's Palsy (paralysis of VII) patients can complain of ear ache due to precise sensory innervation of outer ear by Facial nerve.

6) VISCERAL MOTOR = **AUTONOMIC INNERVATION OF HEAD** - two neuron arcs.

1. Sympathetic innervation (thoracolumbar outflow) - NOT in cranial nerves

a. **First neuron arises from spinal cord levels T1, T2**; axon exits via ventral roots and white communicating rami, ascends in paravertebral sympathetic chain to synapse in Superior Cervical Ganglion.

b. **Second neuron in Superior Cervical Ganglion**; axon joins plexuses associated with branches of Internal and External Carotid arteries; these give off branches in two ways: i) small unnamed branches close to target; ii) small named

branches that come off arterial plexuses and join other nerves (ex. deep petrosal nerve).

2. Parasympathetic innervation (craniosacral) - in cranial nerves - first neuron in brainstem; axon goes out with cranial nerve to synapse in named ganglion located close to target; second neuron innervates target.

Nerve	Ganglion	Innervates
III (Oculomotor)	Ciliary ganglion	Pupillary sphincter muscle, ciliary muscle
VII (Facial) and	Pterygopalatine ganglion	Lacrimal gland, mucus glands of nose palate
	Submandibular ganglion	Submandibular and sublingual salivary glands
IX (Glossopharyngeal)	Otic Ganglion	Parotid gland
X (Vagus)	(Many ganglia in thorax, abdomen)	Provides parasympathetic innervation to many organs in thorax and abdomen.

7) VISCERAL SENSORY - distributed with both parasympathetic and sympathetic innervation; imprecise sensation, poorly localized

1. Sensory axons with Sympathetics - sensory to blood vessels, pharynx and its derivatives; cell bodies in dorsal root ganglia of spinal cord; axons travel with sympathetic efferents.

2. Sensory axons with Parasympathetic - more localized, specific

Nerve	Innervates
VII (Facial)	Nasopharynx
IX (Glossopharyngeal)	Sensation (touch, pressure) to posterior third of tongue, oropharynx, tympanic cavity and auditory tube, carotid sinus.
X (Vagus)	Sensation to laryngopharynx, larynx in head (also innervates many organs in thorax and abdomen).

8) SPECIAL SENSES - Vision, hearing, balance

1. II (Optic nerve) - vision (actually a brain tract); primary receptors (rods and cones) in retina; axons of ganglion cells of retina form optic nerve; half of axons cross over to opposite side at optic chiasm.

2. VIII (Vestibulocochlear nerve) - auditory and vestibular sensation; cell bodies in cochlear and vestibular apparatus.

9) CHEMICAL SENSES - Smell and taste.

1. Smell - I (Olfactory nerve) - cell bodies in olfactory epithelium; axons project through fila olfactoria to olfactory bulb.

2. Taste - more complex - distributed over several cranial nerves.

Nerve	Taste sensation from
VII (Facial)	Anterior two thirds of tongue
IX (Glossopharyngeal)	Posterior third of tongue
X (Vagus)	Posterior tongue, immediately anterior to epiglottis

10) BRANCHIOMOTOR - voluntary motor to skeletal muscles of face, ear, pharynx and neck that are derived from branchial arches.

Nerve	Innervates
V (Trigeminal) (all in V3)	muscles of mastication mylohyoid tensor tympani tensor palati anterior belly of digastric
VII (Facial)	muscles of facial expression stylohyoid posterior belly of digastric stapedius
IX (Glossopharyngeal)	stylopharyngeus
X (Vagus)	all muscles of pharynx (except stylopharyngeus) muscles of larynx all muscles of palate (except tensor palati)
XI (Accessory)	sternocleidomastoid trapezius

VII. SUMMARY OF TYPES OF NEURONS IN CRANIAL NERVES (parenthesis - OLD 3 Letter system)

TYPES OF NEURONS	INNERVATE	ASSOCIATED CRANIAL NERVES	CLINICAL
SOMATIC MOTOR (GSE)	Motor to voluntary skeletal muscles (derived from somites)	CN III, IV, VI - 1) Extraocular muscles (pre-otic somites) CN XII - muscles of tongue (occipital somites)	see ORBIT, TONGUE lectures
SOMATIC SENSORY (GSA)	<u>Precise sensation</u> Sensory to skin, joints (oral cavity, nasal cavity)	CN V - mostly V1 - Ophthalmic (above angle of eye) V2 - Maxillary (angle of eye to angle of mouth) V3 - Mandibular (below angle of mouth) also Skin of External (Outer) Ear - V, VII, IX, X	1) Trigeminal Neuralgia - pain in region of affected division 2) Bell's palsy (VII)- pain in outer ear
VISCERAL MOTOR (GVE) (Parasympathethics in Cranial Nerves)	Smooth muscles, Glands, etc. (ganglia close to target organ)	III - Ciliary ganglion - Pupillary constrictor, CIliary muscle VII - Pterygopalatine ganglion - Lacrimal gland, mucous glands of nose and palate VII - Submandibular ganglion - Submandibular, Sublingual salivary glands IX - Otic ganglion - Parotid	see Associated lectures (Orbit; Nasal, Oral Cavities; Ear)
VISCERAL SENSORY (GVA)	<u>Imprecise sensation</u>: Innervation of Gut, Blood Vessels, etc. Specific for Innervation of Pharynx, Middle Ear	Pharynx VII - Nasopharynx IX - Oropharynx X - Laryngopharynx also Middle Ear - IX	Imprecise localization in Choking on food; Middle ear infections
SPECIAL SENSES (SSA)	Vision, Audition, Balance	II - Vision VIII- Audition (hearing), Balance (vestibular apparatus)	many; see associated lectures
CHEMICAL SENSE (SVA)	Taste, Smell	Taste is distributed: VII - anterior 2/3 of tongue IX - posterior 1/3 of tongue X - taste buds anterior to epiglottis Smell - I - olfaction	Damage produces loss of taste in region of innervation
BRANCHIO-MOTOR (SVE)	Voluntary skeletal muscles derived from Branchial Arches	V - muscles of First Branchial Arch VII - muscles of Second Branchial Arch IX - muscles of Third Branchai Arch X - muscles of Fourth and Sixth Branchial Arches XI - muscles of caudal Sixth Branchial arch (disagreement among authors)	see Branchial artch chart (above); also Branchial Arch Lecture, etc.

CHART OF DISTRIBUTION OF COMPONENTS IN CRANIAL NERVES (LEARN TO DRAW THIS OR EQUIVALENT)

Nerve	SOMATIC MOTOR (GSE)	BRANCHIO-MOTOR (SVE)	VISCERAL MOTOR (GVE)	SOMATIC SENSORY (GSA)	VISCERAL SENSORY (GVA)	CHEMICAL SENSE (SVA)	SPECIAL SENSES (SSA)
III.	+		+				
IV.	+						
VI.	+						
XII.	+						
V.		+		+			
VII.		+	+	+	+	+	
IX.		+	+	+	+	+	
X.		+	+	+	+	+	
XI.		+					
I.						+	
II.							+
VIII.							+

APPENDIX - OLD CLASSIFICIATION - TYPES OF NEURONS ARE CALLED FUNCTIONAL COMPONENTS

I. **BASIS OF CLASSIFICATION** - three letter system.

A. First letter

G = General = types of neurons found both in spinal nerves and cranial nerves.

S = Special = types of neurons only found in cranial nerves not spinal nerves.

B. Second letter

S = Somatic = types of neurons innervating structures derived from somites.

V = Visceral = types of neurons innervating gut, structures derived from or associated with gut and branchial arches; also vascular system, smooth muscle, internal organs and glands.

C. Third letter

A = Afferent = sensory neurons.

E = Efferent = motor neurons to skeletal and smooth muscle; also secretomotor neurons to glands.

II. **TRANSLATING TYPES OF NEURONS TO FUNCTIONAL COMPONENTS (ALPHABET SOUP)**

Like spinal nerves -
1. SOMATIC MOTOR = GSE
2. SOMATIC SENSORY = GSA
3. VISCERAL MOTOR = GVE
4. VISCERAL SENSORY = GVA

Only in cranial nerves -
5. SPECIAL SENSES = SSA
6. CHEMICAL SENSES = SVA
7. BRANCHIOMOTOR = SVE skeletal muscles from branchial arches)

SKULL

I. **CALVARIUM** - skull cap.

A. Bones - Calvarium consists single Frontal, Sphenoid and Occipital bones and paired Parietal and Temporal bones (lobes of Cerebral Cortex are named for bones of skull).

B. Sutures - named fibrous joints that connect bones of calvarium:

1. **Coronal suture** - between Frontal and Parietal bones
2. **Sagittal suture** - between Parietal bones
3. **Lambdoidal suture** - between Parietal and Occipital bones

C. Landmarks:

1. **Bregma** - midpoint of Coronal Suture
2. **Lambda** - midpoint of Lambdoidal suture
3. **Pterion** - area of junction of Sphenoid, Temporal, Parietal and Frontal bones **(Note: Skull fractures in region of Pterion are clinical important, ex. Epidural Hematoma)**

D. Fontanelles - in infants, bones are further apart and joined by fontanelles; fontanelles permit cranial compression at birth, later cranial growth:

1. **Anterior Fontanelle** - at Bregma
2. **Posterior Fontanelle**- at Lambda
3. **Lateral Fontanelle**- at Pterion

Clinical: **Anterior Fontanelle** can be used to **access Superior Sagittal venous sinus in neonates.**

Forensic note: Sutures progressively fuse with age; extent of fusion can be used to estimate age of skull.

E. Internal structure of calvarium

1. Calvarium consists of **hard inner and outer tables** of cortical bone surrounding layer of **spongy bone (Diploe = double**).

2. **Diploic veins** - course within diploe, connect both to cranial cavity and surface of skull via **Emissary veins** (**can transmit infection through emissary veins, see below**).

F. Blood supply to calvarium - outer surface receives branches from arteries to scalp (see below); inner surface receives branches from Meningeal arteries (coursing immediately below bone).

II. **SCALP** - layers of skin and connective tissue overlying calvarium.

A. Layers - superficial to deep

1. **S**kin - with associated hair follicles, sweat glands and sebaceous glands.

2. **C**onnective tissue layer - dense fibrous connective tissue surrounding arteries and nerves.

3. Epicranial **A**poneurosis - thin tendinous sheet, tightly attached to skin and connective tissue above; moveable anteriorly and posteriorly; laterally attached to temporal fascia; attached to Frontalis and Occipitalis muscles.

4. **L**oose Areolar tissue - loosely connects epicranial aponeurosis to periosteum of skull; crossed by emissary veins (see below).

5. **P**ericranium - periosteum (connective tissue layer) of outer side of calvarium.

Clinical note: Infections can readily spread through loose areolar layer deep to epicranial aponeurosis.

Primitive note: When tribesmen scalp someone, they merely cut along the periphery of the scalp. It is then readily **removed between the layers of the epicranial aponeurosis and the loose areolar tissue**. Civilized people (including medical students) do not keep scalps as souvenirs.

B. Innervation

1. branches of Trigeminal nerve innervate anterior and lateral scalp: 1) Supratrochlear and 2) Supraorbital nerves (anterior scalp), 3) Zygomaticotemporal and 4) Auriculotemporal nerves (lateral scalp).

2. Cervical spinal nerves innervate lateral and posterior scalp: 1) Lesser Occipital nerves (from ventral ramus of C2) and 2) Greater Occipital nerves (from dorsal ramus of C2).

C. Arterial Supply - very rich

1. branches of Ophthalmic artery: Supratrochlear and Supraorbital arteries (anterior scalp)

2. branches of External Carotid artery - 1) Superficial Temporal artery (to lateral scalp); 2) Posterior Auricular artery (scalp above and posterior to external ear); 3) Occipital artery (posterior scalp).

Clinical note: There are extensive anastomoses between arteries to scalp; scalp wounds can bleed profusely from both sides of cut.

D. Venous drainage - by veins with same names as arteries; **also drain via emissary veins (passing into diploe) into interior of skull**.

Clinical note: Infections can spread from scalp to brain via Emissary veins.

III. **CRANIAL NERVES** - brain is bilaterally symmetrical; cortex is connected to spinal cord by brainstem; outflow/inflow of brain is via cranial nerves; cranial nerves are numbered using Roman numerals:

I. Olfactory - sense of smell
II. Optic - vision
III. Oculomotor - eye muscles
IV. Trochlear - eye muscles
V. Trigeminal - sensory to skin; motor to muscles of mastication (chewing), etc.
VI. Abducens - eye muscles
VII. Facial - motor to muscles of facial expression, etc.; taste to ant. tongue
VIII. Vestibulo-Cochlear - hearing and balance (vestibular apparatus)
IX. Glossopharyngeal - sensory to pharynx
X. Vagus - sensory and motor to larynx (voice box), etc.
XI. Accessory - motor to Trapezius and Sternocleidomastoid
XII. Hypoglossal - motor to muscles of tongue (no sensory)

IV. **LANDMARKS AND BONES OF SKULL**

A. Views of skull

1. Front of skull

a. Frontal bone – forms forehead, upper margin and roof of orbit
b. Orbit - bones covered in orbit lecture.
c. Zygomatic bones - form cheeks.
d. Maxilla - has sockets for upper teeth (alveolar processes); infraorbital foramen (below orbit).

e. Nasal apertures (Choanae) - covered superiorly by nasal bones.

f. Mandible - separate bone; alveolar processes for lower teeth; mental foramen (below second pre-molar tooth).

2. Lateral view

a. Zygomatic arch - consists of zygomatic bones and zygomatic processes of maxillary and temporal bones.

b. Temporomandibular joint - joint between head of mandible (upper end of ramus) and temporal bone.

c. Temporal bone - has parts: 1) mastoid process (inferiorly), 2) squamous (flat) part laterally; 3) tympanic part forms anterior side of external auditory meatus (opening of ear); 4) petrous part is inside skull.

d. Parietal, Temporal, Frontal and Sphenoid bones form lateral side of cranial cavity.

3. Posterior view of skull

a. Occipital bone - has Superior and Inferior Nuchal lines; External Occipital protuberance (inion) is raised bump in middle of Superior Nuchal line.

4. Base of skull

a. Temporal bone - has Styloid process for muscle attachment.

b. Occipital bone - has Foramen Magnum for spinal cord and vertebral arteries; occipital condyles articulate with vertebra C1 (Atlas).

c. Palatine bones and palatine process of maxillary bones form hard palate.

B. Individual bones of skull

1. Sphenoid bone - "core" of skull - forms part of orbit, lateral side of skull, base of skull, parts of all three cranial fossae.

a. Medial and Lateral Pterygoid plates - processes for muscle attachments.

b. Spine of Sphenoid - on inferior side of sphenoid for ligament attachment.

c. Lesser wing of Sphenoid - in interior of skull, above Superior Orbital fissure.

d. Greater wing of sphenoid - extends below Superior Orbital fissure, extends out laterally.

e. Sella Turcica (Turkish saddle) - depression above body of sphenoid (central part) between Anterior and Posterior Clinoid processes; pituitary gland is located in

Sella Turcica.

f. Clivus - central part of sphenoid that extends down to Posterior Cranial Fossa.

Clinical Note: **Parts of Sphenoid bone are important landmarks in Neurology**.

V. **CRANIAL CAVITY** - divided into depressions or fossae that are functionally related to parts of brain and facial skeleton.

A. Anterior cranial fossa - related to roof of nasal cavity (also forms roof of orbit).

1. Bones - Frontal, Ethmoid and Sphenoid bones.

2. contains Olfactory bulbs and Frontal lobes of cortex.

3. Foramina - in cribriform plate of ethmoid bone conduct branches (fila olfactoria) of olfactory nerve (CNI).

B. Middle cranial fossa - related to orbit, nasal cavity and face.

1. Bones - Sphenoid, Temporal and Parietal bones.

2. contains - Pituitary gland, Temporal lobes of cortex and cranial nerves from rostral brainstem.

3. Foramina - for nerves to orbit (Optic nerve and nerves to eye muscles), nasal cavity and face (CNII-CNVI).

C. Posterior cranial fossa - related to face oral cavity, neck.

1. Bones - Sphenoid, Temporal, Parietal and Occipital bones.

3. contains - lower brainstem and cerebellum; Petrous part of Temporal bone contains cochlea (hearing) and semicircular canals (gravity).

4. Foramina - for nerves to face, oral cavity (also taste), muscles of tongue and neck (CNVII-CNXII); Foramen Magnum transmits Spinal Cord and Vertebral arteries.

CHECKLIST OF FEATURES AND BONES OF SKULL TO IDENTIFY

Coronal suture - between Frontal and Parietal bones
Sagittal suture - between Parietal bones
Lambdoidal suture - between Parietal and Occipital bones
Bregma - midpoint of Coronal Suture
Lambda - midpoint of Lambdoidal suture
Pterion - junction of Sphenoid, Temporal, Parietal and Frontal bones (fracture - **Epidural Hematoma**)
Anterior Fontanelle - located at Bregma
Posterior Fontanelle - located at Lambda
Lateral Fontanelle - located at Pterion
Diploe - spongy bone in calvarium between hard inner and outer tables
Zygomatic arch - zygomatic bones and zygomatic processes of maxillary and temporal bones
Temporomandibular joint - joint between head of mandible and mandibular fossa of temporal bone
Mastoid process - inferior part of temporal bone posterior to external auditory meatus
Squamous part of Temporal bone - lateral part, contributes to calvarium
Tympanic part of Temporal bone - anterior to external auditory meatus
Petrous part of Temporal bone - hard, inside cranial cavity (contains cochlea, semicircular canals)
Superior and Inferior nuchal lines - raised ridges on posterior surface of Occipital bone
External Occipital protuberance - raised midline bump in Superior Nuchal line
Bony palate - palatine bones, palatine process of maxillary bones
Medial Pterygoid plates- inferior projection of Sphenoid bone for muscle attachment (has hamulus (hook) for Tensor Palati muscle)
Lateral Pterygoid plates - inferior projection of Sphenoid bone for muscle attachment (Pterygoid muscles)
Spine of Sphenoid - inferior projection for ligament attachment
Lesser wing of Sphenoid - smaller part of Sphenoid Superior to Superior orbital fissure
Greater wing of Sphenoid - larger part of Sphenoid, extends laterally
Sella Turcica - depression above body of sphenoid (contains pituitary gland)
Anterior and Posterior Clinoid processes - anterior and posterior projections around sella turcica
Clivus - central part of sphenoid extending into Posterior Cranial Fossa

FORAMINA OF SKULL: SKULL SESSION

The skull is rigidly structured to protect the brain but has many foramina (openings) for passage of nerves (nn.), arteries (aa.) and veins (vv.); knowledge of the foramina of the skull is ESSENTIAL to understanding head and neck anatomy. The foramina are listed below according to how one can view them on a skull. Each entry indicates the bone the foramen is in, the areas it connects and structures that pass through it; many foramina are doubly listed as they can be seen from the inside or outside of the skull.

I. **FACE**

1. Supraorbital notch or foramen - in frontal bone; connects orbit and forehead; contains Supraorbital n., a. and v.

2. Infraorbital foramen - in maxillary bone; connects orbit and face; contains Infraorbital n., a. and v.

3. Mental foramen - in mandible; connects mandibular canal to face; contains Mental n., a. and v.

II. **CALVARIUM AND CRANIAL VAULT**

1. Parietal foramen - in parietal bone on either side of sagittal suture; connects; diploe in bone to scalp; contains Emissary veins.

III. **INTERIOR OF SKULL**

1. Olfactory foramen - located in cribriform plate of ethmoid bone in anterior cranial fossa; connects anterior cranial fossa and nasal cavity; contains branches of Olfactory nerve (fila olfactoria) (I).

2. Optic foramen and canal - located at base of Lesser wing of sphenoid bone in middle cranial fossa; connects middle cranial fossa to orbit; contains Optic nerve (II) and Ophthalmic artery.

3. Superior Orbital fissure - located between Greater and Lesser wings of Sphenoid bone in Middle Cranial fossa; connects middle cranial fossa and orbit; contains Oculomotor (III), Trochlear (IV), Abducens (VI) nerves and Ophthalmic division of Trigeminal nerve (V1) and Ophthalmic veins.

4. Carotid canal - located in temporal bone; connects base of skull to middle cranial fossa (opening of Carotid canal in middle cranial fossa called Foramen Lacerum); contains Internal carotid artery and Sympathetic Plexus surrounding artery.

5. Foramen rotundum - located in Greater wing of Sphenoid bone; connects middle cranial fossa and Pterygopalatine fossa; contains Maxillary division of Trigeminal nerve (V2).

6. Foramen ovale - located in sphenoid bone; connects middle cranial fossa and infratemporal fossa; contains Mandibular division of V (V3) and Accessory Meningeal artery (when present).

7. Foramen spinosum - located in sphenoid bone; connects middle cranial fossa and infratemporal fossa; contains Middle meningeal artery and Nervus spinosus (from V3).

8. Internal auditory meatus - located in temporal bone; connects posterior cranial fossa to Inner ear and (via facial canal) Stylomastoid foramen; contains Facial (VII) and Vestibulocochlear (VIII) nerves.

9. Jugular foramen - located in temporal and occipital bones; connects posterior cranial fossa and base of skull; contains Internal Jugular vein, Glossopharyngeal (IX), Vagus (X) and Accessory (XI) nerves.

10. Hypoglossal canal - located in occipital bone; connects posterior cranial fossa and base of skull; contains Hypoglossal nerve (XII).

11. Foramen magnum - located in occipital bone; connects posterior cranial fossa and vertebral canal; contains Spinal Cord (with meninges) and Vertebral arteries and veins.

IV. **ORBIT**

1. Optic foramen and canal - located at base of Lesser wing of sphenoid bone in middle cranial fossa; connects middle cranial fossa to orbit; contains Optic nerve (II) and Ophthalmic artery.

2. Superior Orbital fissure - located between Greater and Lesser wings of Sphenoid bone in Middle Cranial fossa; connects middle cranial fossa and orbit; contains Oculomotor (III), Trochlear (IV), Abducens (VI) nerves and Ophthalmic division of Trigeminal nerve (V1) and Ophthalmic veins.

3. Inferior Orbital fissure - located between sphenoid and maxillary bones; connects pterygopalatine fossa and infratemporal fossa to orbit; contains Infraorbital and Zygomatic nn., aa. and vv. (nerves are branches of V2).

4. Anterior and Posterior Ethmoidal Foramina - located between ethmoid and frontal bones; connect orbit and nasal cavity; contain (respectively) Anterior and Posterior Ethmoidal nerves (branches of V1), arteries (branches of Ophthalmic artery), and veins.

5. Supraorbital notch or foramen - located in frontal bone; connect orbit and forehead; contain Supraorbital n., a. and v.

6. Infraorbital foramen - in maxillary bone; connects orbit and face; contains Infraorbital n., a. and v.

7. Nasolacrimal duct - located in maxillary, lacrimal bones and Inferior nasal concha; connects orbit and nasal cavity; contains Membranous Nasolacrimal duct and tears.

CHART OF FORAMINA FOR SKULL SESSION

Foramen	**Contains**
Supraorbital Foramen	Supraorbital nerve V1, artery (from Ophthalmic artery), vein
Infraorbital Foramen	Infraorbital nerve V2, artery (rom Maxillary artery), vein
Mental Foramen	Mental nerve V3, artery (from Maxillary artery), vein
Parietal Emissary Foramina	Emissary veins (connect scalp to diploe, venous sinuses in cranial cavity
Olfactory Foramina	Olfactory nerves (I)
Optic Foramen (canal)	Optic nerve (II), Ophthalmic artery (from Internal Carotid artery)
Superior Orbital Fissure	III, IV, V1 (Ophthalmic division of Trigeminal nerve), VI; Ophthalmic veins
Foramen Rotundum	Maxillary division of Trigeminal nerve (V2).
Foramen Ovale	Mandibular division of V (V3) and Accessory Meningeal artery (when present
Foramen Spinosum	Middle Meningeal artery and Nervus Spinosus
Carotid canal	Internal carotid artery and Sympathetic plexus surrounding artery
Internal Auditory Meatus	Facial nerve (VII and Vestibulocochlear nerve (VIII)
Stylomastoid foramen	Facial nerve (VII)
Jugular foramen	Glossopharyngeal (IX), Vagus (X) and Accessory (XI) nerves.
Hypoglossal canal	Hypoglossal nerve (XII)
Foramen Magnum	Spinal cord and Vertebral arteries and veins
Inferior Orbital Fissure	Infraorbital Nerve V2, artery, vein
Anterior and Posterior Ethmoidal Foramina	Anterior and Posterior Ethmoidal nerves (V1), artery, vein
Nasolacrimal Duct	Membranous lacrimal duct (to Inferior Meatus of Nasal Cavity)

MENINGES AND VENOUS SINUSES OF BRAIN

I. **ARTERIAL SUPPLY OF BRAIN** - derived from two sources

A. Internal Carotid Artery – Common Carotid Artery arises from Brachiocephalic Artery on right, Arch of Aorta on left; bifurcates at level of upper border of thyroid cartilage (Adam's apple) into Internal and External Carotid Arteries; Internal Carotid ascends to enter skull via Carotid Canal to Middle Cranial Fossa.

B. Vertebral Artery – arises from Subclavian Artery; ascends through Foramina Transversaria of vertebrae C1-C6; enters skull via Foramen Magnum.

II. **MENINGES OF BRAIN** - 3 layers, as in spinal cord; however, **dura mater is tightly attached to inner side of cranial cavity** and **has extensions (= reflections) into the cranial cavity. <u>There is no epidural space in the cranial cavity</u>.**

A. **<u>Dura mater</u>** (tough mother) - tough connective tissue layer said to be composed of two layers: inner meningeal (true dura) and outer endosteal (periosteum of inner side of calvarium); the two layers are fused in most places and tightly attached to inner surface of calvarium and cranial cavity (there is normally no epidural space) however, layers of dura separate to form inward folds called dural reflections. Dural reflections support and stabilize the brain and contain venous sinuses (see below):

1. **Falx cerebri** - sickle shaped fold between cerebral hemispheres; attached anteriorly to crista galli of ethmoid bone; posteriorly blends into tentorium cerebelli.

2. **Falx cerebelli** - small sickle-shaped fold that projects anteriorly from posterior wall of posterior cranial fossa between cerebellar hemispheres.

3. **Tentorium cerebelli** - crescent-shaped fold, forms roof over posterior cranial fossa; anteriorly has gap called tentorial notch for passage of brainstem.

4. **Diaphragma sella** - small circular fold of dura mater over sella turcica (has opening for stalk of pituitary).

B. <u>Arachnoid</u> (spider like) – similar to spinal cord; layer attached to inner surface of dura (separated from dura by potential space, subdural space); separated from pia mater by subarachnoid space which contains cerebrospinal fluid.

C. <u>Pia mater</u> (tender mother) - thin layer closely adherent to brain, surrounds arteries and veins that course on surface of brain.

III. **VENOUS SINUSES OF BRAIN** - course between two layers of dura; receive blood from brain, orbit and emissary veins.

A. Named sinuses

1. **Superior Sagittal sinus** - courses in upper fixed border of Falx Cerebri; begins anteriorly at foramen cecum and ends posteriorly by becoming continuous with transverse sinus; communicates laterally with outpocketings called venous lacunae; receives blood from Superior Cerebral veins which course on surface of hemispheres (via branches called **bridging veins**).

2. **Inferior Sagittal sinus** - courses in lower free border of Falx Cerebri; joins Great Cerebral vein to form Straight Sinus.

3. **Straight sinus** - courses between dural layers at junction of Falx Cerebri and Tentorium Cerebelli; posteriorly can join with Superior Sagittal sinus at Confluens of Sinuses or just turn left and be continuous with Transverse sinus.

4. **Transverse sinuses** - course posteriorly in fixed part of Tentorium Cerebelli; arise either at Confluens of Sinuses or as continuations of Superior Sagittal and Straight Sinuses.

5. **Sigmoid sinuses** - S-shaped continuations of Transverse sinuses; end at jugular foramen to drain into Internal Jugular veins.

6. **Occipital sinus** - courses in attached part of Falx Cerebelli; drains to confluens of sinuses.

7. **Cavernous sinuses** - situated in the middle cranial fossa on each side of the body of the sphenoid bone surrounding Pituitary gland (both Cavernous sinuses are connected by Intercavernous sinus); receive venous blood from Superior and Inferior Ophthalmic veins, cerebral veins; drains to Superior and Inferior Petrosal sinuses.

Note: Cavernous sinus also has anastomoses with Pterygoid venous plexus; provides a pathway by which infection can spread from face to brain.

Note: Cavernous Sinus Thrombosis - Internal Carotid artery and a number of cranial nerves (III, IV, V1, V2, VI) pass through wall of the cavernous sinus; disease processes in sinus can produce neurological symptoms; (Carotid siphon = U shaped turn of Int. Carotid as it passes through Cav. Sinus)

8. **Superior and Inferior Petrosal Sinuses** - situated on superior and inferior parts of petrous part of temporal bone; receive blood from cavernous sinus anteriorly; Superior Petrosal drains to Transverse sinus, Inferior Petrosal to Internal Jugular Vein.

IV. **CEREBROSPINAL FLUID** - made inside brain in choroid plexuses; flows out of brain into subarachnoid space; is re-absorb into venous sinuses at inpockets of subarachnoid

space called **arachnoid** villi (arachnoid granulations containing arachnoid villi are particularly prominent in walls of Superior Sagittal sinus); calcification of arachnoid villi common in elderly.

Note: **Communicating Hydrocephalus** - **Reduced re-absorption** of cerebrospinal fluid can result in **communicating hydrocephalus**; can damage brain by increased pressure.

V. **HEMATOMAS** - internal bleeds; in cranium can occur at a number of places; can damage brain by increasing intracranial pressure and by physically pressing brain.

A. **Epidural hematomas** - bleeding between dura mater and bone; often results from tearing of a **meningeal artery** (caused by skull fracture near pterion); bleeding can be quite profuse and **rapid** (arterial); lens shaped (biconvex) mass on CT; can displace brain and cause herniation (Uncal herniation = displacement of temporal lobe (uncus) through Tentorial Notch; Tonsillar herniation = displacement of cerebellum (tonsil) through Foramen magnum; patient often lucid at first (ex., following car accident) but bleeding can be fatal within hours.

B. **Subdural hematomas** - bleeding into potential space between dura and arachnoid; often results from tearing of branches of Superior Cerebral veins **(bridging veins)** or **venous sinus**; bleeding is often **slow** (venous blood) and chronic subdural hematomas can remain undetected; crescent shaped mass on CT; can cause herniation if untreated.

C. **Subarachnoid hematomas** - bleeding into subarachnoid space; can result from rupture of aneurysm (swelling on vessel wall) or physical tearing of **cerebral artery or vein**; bleeding **can be rapid (if arterial** blood) and fatal.

SUMMARY: INTRACRANIAL HEMATOMAS

Clinical	**Anatomy**	**Cause**	**Sign/Symptom**
Epidural Hematoma	**Middle Meningeal artery (**90% of Epidural hematomas; branch of Maxillary artery that passes through foramen spinosum; supplies bone of calvarium;	**Blow to side of head (fracture skull in region of pterion)**	Patient conscious after accident; loses consciousness within hours; coma, death (Note: **hematoma is lens-shaped** on CT)
Subdural Hematoma	**Bridging veins** link Superficial cerebral veins on surface of brain and Superior Sagittal sinus (also other venous sinuses)	**Blow to head; in elderly can occur without distinct event**	**Slow onset** of neurological symptoms, headache (often hours to days) (Note: **hematoma is crescent-shaped** on CT)
Subarachnoid hematoma	Rupture of artery (ex. **'berry aneurism'**) or vein into subarachnoid space	**Many, Hypertension, Trauma, etc.**	**Berry Aneurysm: Headache (sudden onset); rapid loss of consciousness, 25-50 % die**

ORBIT, EYE STRUCTURES AND EYE MUSCLES

I. **BONES OF ORBIT** - bones are rigidly linked together to form a stable socket to permit precise movements of eye.

A. Boundaries

1. Roof - Frontal bone (anterior cranial fossa is superior to roof)
2. Floor - Maxillary bone (Maxillary sinus is inferior to floor).
3. Medial wall - Maxillary, Lacrimal, Ethmoid, Frontal and Sphenoid bones (nasal cavity is medial to medial wall of orbit).
4. Lateral wall - Zygomatic bone and sphenoid bone (greater wing).

B. Foramina - openings which transmit nerves and vessels to structures in orbit (eye, extraocular muscles and lacrimal gland (tears); also IMPORTANTLY, orbit serves as passageway for nerves that are sensory to face, scalp and nasal cavity - see Foramina handout

C. Lining of orbit - periosteum of bones of orbit is called Periorbita.

II. **EYELIDS** - layered, moveable structures which protect eye, keep cornea (outermost layer) of eye moist.

A. Layers

1. Skin - contains eyelashes (cilia), openings of sebaceous and sweat glands.
2. Subcutaneous layer - connective tissue containing sebaceous glands;

Clinical: **Obstruction of sebaceous glands in subcutaneous layer of eyelid** called a **stye (hordeolum)**.

3. Orbicularis oculi muscle - skeletal muscle which surrounds eyelid; closes eyelids; innervated by Facial nerve (VII); damage to facial nerve paralyzes muscle; patient unable to close eyelids and spread tears over cornea; can result in corneal damage.
4. Orbital septum, tarsal plate and Levator Palpebrae Superioris muscle.

a. Orbital septum - fascial layer inside eyelid, is continuous with connective tissue lining orbit (periorbita).
b. Tarsal plate - dense fibrous connective tissue, located deep to orbital septum; forms 'skeleton' of eyelid; contains **tarsal glands.**

Clinical: Obstruction of **tarsal glands in eyelid called a chalazion**.

c. Levator palpebrae superioris muscle - muscle composed of both smooth and skeletal muscle components; origin - Tendinous ring (see below); insertion - skin and tarsal plate of upper lid; action - opens eyelids; **innervation - skeletal part by Oculomotor nerve (III), smooth part by Sympathetics.**

Clinical – Ptosis = eyelid droop, important clinical sign; can result from damage to Oculomotor Nerve (III) or sympathetics.

5. Conjunctiva - membrane covering inner side of eyelid; conjunctiva continues as a layer over sclera of eye and fuses to cornea; reflection of conjunctiva from eyelid to eye called Superior and Inferior fornices of conjunctiva; very sensitive.

III. **LACRIMAL APPARATUS** - tears are constantly produced in lacrimal gland, drain to nasal cavity via lacrimal duct.

A. Lacrimal gland - located in superolateral orbit; have numerous ducts (about 12) which open through conjunctiva; produce tears;

Flow of tears: circulate over conjunctiva and wash out dirt; drain through **lacrimal puncta** (openings) in medial part of upper and lower eyelids (you can see these on yourself in a mirror); puncta drain to **lacrimal sac** which drains via **Nasolacrimal duct** to **Inferior Meatus of nasal cavity** (this is why you blow your nose when you are crying)

B. Innervation of lacrimal gland - **Parasympathetics from Facial nerve** (VII) via a complicated pathway in which fibers hitch-hike with branches of the Trigeminal nerve (V) (more in future Cranial nerve lecture).

Clinical: **Obstructed Nasolacrimal Duct** - Nasolacrimal duct develops embryologically as a solid cord between maxillary and nasal processes; cord then becomes canalized; failure of canalization is Obstructed Nasolacrimal duct; tears flow onto face of neonate.

IV. **FASCIAL SHEATH OF EYEBALL** - thin fascial membrane surrounding eye (also called Tenon's capsule); thickenings of sheath attach to bones and form Medial and Lateral Check ligaments which prevent excess movement of eye.

V. **LAYERS OF EYE**

A. Structure of eyeball - described as three layers

1. Fibrous layer

a. Sclera - tough, smooth fibroelastic layer surrounding eye (continuous anteriorly with cornea); functions to protect eye and maintain shape; provides attachment of extraocular muscles; pierced by nerves and vessels of eye.

b. Cornea - avascular, transparent layer covering anterior eye; important in focusing light; **Clinical: irregularities in cornea responsible for astigmatism**.

2. Vascular layer

Note: Blood supply to eye is derived from branches of **Ophthalmic artery** (from Internal Carotid Artery); major branches to eye: 1. Choroidal arteries (Anterior and Posterior) - to choroid; 2) Central Artery of Retina - to retina.

a. Choroid - highly vascular (Choroidal arteries and veins), pigmented membrane; provides nutrients and oxygen to other layers of eye.

b. Ciliary body - attaches to suspensory ligament of lens; hold lens taut; contains ciliary muscles.

i. Ciliary muscles - smooth muscles attached to suspensory ligaments of lens; **contraction of muscles produces relaxation of suspensory ligaments**; **causes lens to thicken** for **near vision (accommodation)**; innervation - **Parasympathetics from Ciliary ganglion (nerve III)** cause contraction of ciliary muscles (parasympathetics travel in **Short Ciliary nerves**).

c. Iris - pigmented, contractile layer surround pupil (opening); controls amount of light entering eye; contains two muscles

i. Constrictor pupillae - circular smooth muscle which constricts iris, pupil; innervated by Parasympathetics (from Ciliary ganglion of III).

ii. Dilator pupillae - radial smooth muscle which dilates pupil; innervated by sympathetics.

3. Retina - contains photosensitive rods and cones and many neurons which process visual information; artery - **Central Artery of Retina** (branch of Ophthalmic artery), classically thought to have no anastomoses (occlusion results in blindness).

New Anatomy: imaging has shown that branches of Ciliary Arteries (**Cilioretinal arteries**) are present in about 20% of people; can provide partial sparing of retina in cases of **Central Retinal Artery Occlusion (CRAO).**

Note: **Subarachnoid space** extends around optic nerve up to its junction with sclera in back of eyeball; optic nerve can be viewed in ophthalmoscope as optic disc; changes in

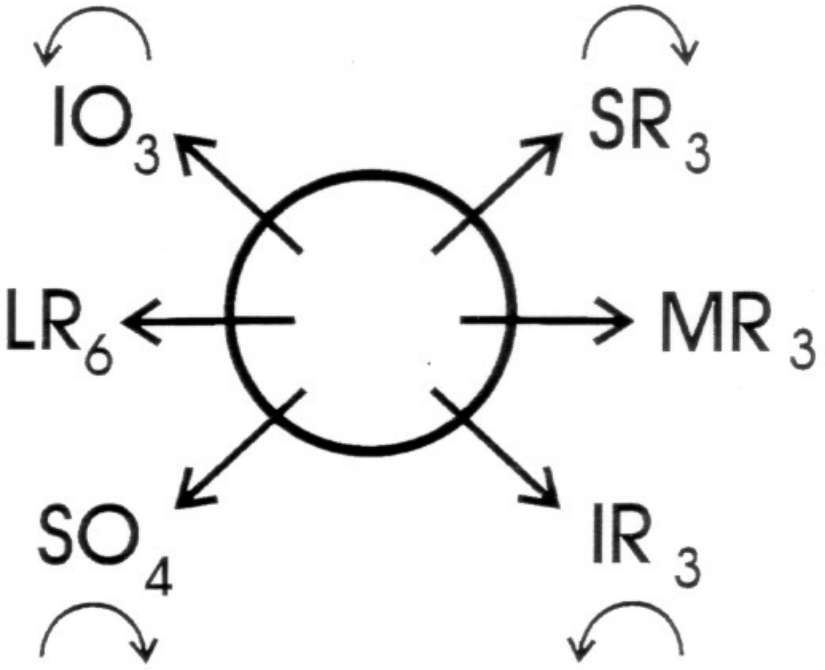
intracranial pressure (ex. hydrocephalus) can be diagnosed by viewing optic disc.

VI. **EXTRAOCULAR MUSCLES**

A. Origins - all take origin from Tendinous ring (except Inferior Oblique which has origin on floor of orbit); Tendinous ring is ring of connective tissue surrounding opening of Optic canal and Superior Orbital Fissure.

B. Actions and Innervation

Muscle	Nerve	Action
Medial rectus	III	Adduct eye
Lateral rectus	VI	Abduct eye
Inferior rectus	III	Adduct, lower and laterally rotate eye
Superior rectus	III	Adduct, raise and medially rotate eye
Superior oblique	IV	Abduct, lower and medially rotate eye
Inferior oblique	III	Abduct, raise and laterally rotate eye.



VII. **NERVE DAMAGE**

A. **Abducens** nerve (VI) - damage causes **Medial Strabismus** (cross-eyed).

B. **Trochlear** nerve (IV) - damage results in **inability to turn eye down and out**; ALSO **Head Tilt**: at rest, **patient tilts head to opposite side (compensate for unilateral eye rotation)**

C. **Oculomotor** nerve (III) - damage causes **ptosis** (**drooping eyelid** from paralysis of skeletal component of Levator palpebrae superioris), **Lateral Strabismus** (wall-eyed, from damage to Medial rectus), **dilated pupil** (from paralysis of Constrictor pupillae) and **diplopia** (double vision)

VIII. **CILIARY GANGLION** - parasympathetic ganglion of Oculomotor nerve (III)

A. Contains - parasympathetics for Ciliary muscles and Sphincter Pupillae; parasympathetics travel in Short Ciliary nerves.

B. Nerves passing to back of eye (in addition to Optic Nerve)

1. Short Ciliary nerves - parasympathetics from III to Ciliary muscles and constrictor pupillae

2. Long ciliary nerves - sensory branches of Ophthalmic division (V1) of Trigeminal nerve which innervate cornea.

Clinical: 'Blown' Pupil = Pupil Dilated (Mydriasis) - pupil unable to constrict in response to light; indicates catastrophe (stroke, herniation, etc.); Anisocoria – pupils of unequal size (can be normal or abnormal)

DEVELOPMENT OF BRANCHIAL ARCHES

I. **DEVELOPMENT OF BRANCHIAL ARCHES** - structures which develop in an embryo that are comparable to gills of fish; reflect fact that ontogeny (development of individual) resembles phylogeny (evolution of species); are important in understanding the final structure and innervation of head and neck.

A. Week 4 - Neural crest cells invade future head and neck region of embryo; cells form ridges on side of head and neck located lateral to rostral part of the foregut; will form branchial arch components. Terminology is confusing. (Note: Branchial Arch = Pharyngeal Arch, Branchial Arch Artery = Aortic Arch, Cleft = Groove)

B. Branchial apparatus - Composed of 4 elements (including branchial arches):

1. **Branchial arch** - components - arches are covered by ectoderm externally; lined internally by endoderm; core of arch formed by mesenchyme; mesenchyme will form muscles, arteries, connective tissue, cartilage and parts of skeleton; each arch has a specific nerve that innervates the muscles that develop from that arch; some arteries will form adult vessels (considered as Aortic Arches).

2. **Branchial groove** (Pharyngeal cleft) - ectodermal (external) cleft between adjacent arches

3. **Branchial pouch** - endodermal outpocketing of rostral part of foregut; pouches are located between adjacent branchial arches.

4. **Branchial membrane** - site of contact of ectoderm of branchial groove with endoderm of pharyngeal pouch.

D. Branchial apparatus of embryo is reshaped into new structures; structures can disappear or form vestigial remnants by the end of the embryonic period.

II. **FATE OF BRANCHIAL ARCHES** - contribute to formation of face, neck, mouth, larynx, and pharynx – see chart

A. Branchial Arch Cartilages – form skeletal elements (bones, cartilages and ligaments)

B. Branchial Arch Nerves are cranial nerves (**Branchiomotor, SVE component**) - **First** arch = **Trigeminal** (V), **Second** arch = **Facial** N. (VII); **Third** arch = **Glossopharyngeal** N. (IX); **Fourth** arch = **Vagus** (X); **Sixth** arch (caudal) = **Accessory** N. (XI)

Note: Fifth arch forms no adult structures in humans; Sixth arch is small; descriptions of Fourth and Sixth Arches vary among authors.

C. Branchial arch muscles – many (see chart); each muscle migrates but continues to be innervated by the cranial nerve to the arch from which the muscle is derived.

STRUCTURES DERIVED FROM BRANCHIAL ARCHES

ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Sphenomandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VII)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
Third (IX)	Hyoid bone - greater horn, lower half of body	----------	Stylopharyngeus
Fourth (X)	Cartilages of Larynx	----------	1) All muscles of Larynx 2) All muscles of Pharynx (except Stylopharyngeus) 3) All muscles of Soft Palate (except Tensor palati)
Sixth (XI)	----------	----------	1) Sternocleidomastoid 2) Trapezius

Note: First Branchial Groove (Cleft) becomes External Auditory Meatus
First Branchial Membrane becomes Tympanic Membrane

PLANE OF SECTION

III. **FATE OF BRANCHIAL POUCHES**

A. **Pouch 1** - elongates into tubotympanic recess; forms **Auditory tube** and **Tympanic cavity (middle ear cavity)**.

B. **Pouch 2** - forms epithelial lining of **Crypts** (spaces) **of the Palatine tonsils**.

C. **Pouch 3** - Upper part forms **Inferior Parathyroid gland**; lower part forms **Thymus** gland

D. **Pouch 4 -** forms **Superior Parathyroid gland** and **C cells of Thyroid gland** (produce hormone calcitonin).

NOTE: Superior parathyroid gland develops from Pouch 4 and Inferior parathyroid gland from Pouch 3; final position occurs because **elements from Pouch 3 migrate caudal to Pouch 4**.

IV. **FATE OF BRANCHIAL GROOVES AND MEMBRANES, ANOMALIES**

A. Four branchial grooves separate the branchial arches externally on each side; only one pair of branchial grooves forms a structure in the adult; the **First Branchial Groove** forms the **External Auditory meatus** (outer ear canal), the **First Branchial Membrane** forms the **Tympanic Membrane**.

B. The other **branchial grooves** develop to lie in a larger depression called the **Cervical Sinus**; this sinus is **normally obliterated** during development

Note: **Cervical sinus can persist as a Branchial sinus** (blind pouch off pharynx) or a **Branchial Cyst Fistula** (channel connecting pharynx to skin); when present are found **anterior to Sternocleidomastoid**.

Note: **Branchial fistula (channel)** - when present often extends from 2nd pharyngeal pouch and passes between Internal and External Carotid arteries and exits to skin Anterior to the sternocleidomastoid muscle; can become infected.

STRUCTURES DERIVED FROM BRANCHIAL POUCHES, CLEFT AND MEMBRANES

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract linked to tonsillar fossa (palatine tonsils)
Third	1) Inferior parathyroid gland 2) Thymus	Third Branchial 'Cleft' cyst - tract at thyrohyoid membrane or piriform recess
Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	does not form
Sixth (XI)	----------	----------

Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**
Note: **Branchial Pouch structures are NOT innervated by the same nerves as the Branchial arches** (see lectures on Pharynx).

CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

V. **DEVELOPMENT OF THYROID GLAND**

A. Initial stage - a median endodermal thickening forms in floor of primitive pharynx at site of **junction of future anterior 2/3's and posterior 1/3 of tongue**.

B. Later - thickening elongates into floor of pharynx as the **Thyroid diverticulum**; opening of diverticulum on surface of developing tongue called the Foramen Cecum.

C. Developing Thyroid diverticulum descends in the neck anterior to the hyoid bone and larynx; as diverticulum (developing gland) elongates into neck, a Thyroglossal duct connects diverticulum with foramen cecum.

D. Developing thyroid gland reaches final site in neck (anterior to upper rings of trachea); thyroglossal duct disintegrates; foramen cecum remains as a vestigial pit on the

tongue.

E. Congenital malformations

1. **Persistent thyroglossal duct remnants** - part of duct can remain and form thyroglossal cysts anywhere from foramen cecum of tongue to thyroid gland in neck; cysts found in midline of neck and can be located anterior to hyoid bone or larynx.

Clinical note: **Lingual Thyroid** – Developing Thyroid Gland can fail to migrate and remain in tongue as Lingual Thyroid; can produce difficulty in swallowing (but should not be inadvertently removed).

2. **Pyramidal lobe** - present in 50 percent of people; represents persistent part of thyroglossal duct, which can contain some thyroid tissue; lobe can be attached to hyoid bone by fibrous strand; usually no associated clinical problems.

NECK Part I

I. **OVERVIEW OF NECK**

A. Neck is compartmentalized:

1. Posterior compartment - contains

a. Vertebrae of neck = cervical vertebrae

b. Muscles which surround and move cervical vertebrae and neck: i. posterior to vertebrae, muscles are continuations of Muscles of Back and Suboccipital region; ii. laterally, muscles are called Scalenes; iii. anteriorly, muscles located directly anterior to vertebrae are called Prevertebral muscles

2. Anterior compartment contains

a. Viscera - in lower part of neck: Trachea, Thyroid gland and Esophagus.

b. Pharynx - in upper part of neck: Pharynx. Pharynx is a tube composed of muscles and fascia that is continuous anteriorly with the Oral and Nasal cavities; the Esophagus and the Larynx open into the pharynx.

3. Lateral compartment (lateral and posterior to pharynx) - Carotid Sheath contains blood vessels (Carotid arteries and Internal Jugular veins) and Vagus nerve; Sympathetic Chain is posterior to Carotid Sheath.

II. **MUSCLES OF NECK** - **see Table of Muscles of Neck** for actions and innervation.

A. Muscles not attached to hyoid bone

1. Sternocleidomastoid muscle

Note: **Torticollis** (L. torti, twisted; collum, neck) - Rotational torticollis can be congenital or acquired; associated with contracture of Sternocleidomastoid; **head is rotated so face is directed to opposite side (contralateral to lesion)** (BOARD QUESTION).

Note: Sternocleidomastoid is important landmark in diagnosis and procedures in neck. **Internal Jugular vein** can be accessed and catheterized between Sternal and Clavicular heads of Sternocleidomastoid; Thyroid gland and Jugular chain of Lymphatics are located anterior to Sternocleidomastoid; Branchial cleft cysts are lateral masses anterior to Sternocleidomastoid.

2. Scalenus anterior and medius

Note: Scalene muscles are important landmarks; Brachial plexus and Subclavian artery pass between Scalenus Anterior and Scalenus Medius; **Phrenic nerve (nerve to Diaphragm) passes anterior to Scalenus Anterior, posterior to Sternocleldomastoid** (BOARD QUESTION)**.**

B. Hyoid bone - located in anterior part of neck; 'free-floating', attached to skull and skeleton only by muscles and ligaments; Stylohyoid ligament links hyoid to styloid process of temporal bone; Thyrohyoid membrane link hyoid to Thyroid cartilage; Hyoid bone has parts: body (central part),

Greater and Lesser horns (cornu); all Infrahyoid and Suprahyoid muscles (except Sternothyroid) attach to body of hyoid; Greater horns can be palpated in neck above thyroid cartilage and used as landmarks to locate surrounding structures.

Functional Note: **Hyoid bone anchors tongue and floor of mouth; also supports larynx**; muscles which move hyoid bone produce movements of larynx and tongue (as occur during swallowing and talking)

C. Infrahyoid muscles - all muscles act to depress hyoid bone: Omohyoid, Sternohyoid, Sternothyroid, Thyrohyoid.

D. Suprahyoid muscles - all act to elevate the hyoid bone: Digastric - also opens mouth; Stylohyoid - note: splits to surround digastric tendon; Mylohyoid - forms muscular floor of mouth; Geniohyoid - pulls hyoid forward.

III. **NERVES OF NECK**

A. Cervical plexus - formed from ventral primary rami of spinal nerves C2-C4, which emerge from posterior border of Sternocleidomastoid (near its mid-point); most branches are cutaneous:

1. Lesser Occipital nerve - innervates skin behind ear and skin of upper lateral neck
2. Great Auricular nerve - innervates skin over parotid gland and skin located inferior to ear.
3. Transverse Cervical nerve - innervates skin of anterior neck.
4. Supraclavicular nerves - innervate skin of lower lateral neck and shoulder
5. **Phrenic nerve** - (C3,4,5) provides motor innervation to the diaphragm, crosses anterior to Scalenus Anterior muscle, posterior to Sternocleidomastoid.

B. Ansa cervicalis – loop of fibers from **cervical spinal nerves that innervate neck muscles**; loop is attached to the Hypoglossal nerve; fibers from C1 travel with Hypoglossal nerve then leave and join fibers from C2 and C3 forming a loop; loop is located anterior to Carotid sheath and is attached to Hypoglossal nerve; however, **no fibers from the Hypoglossal nerve innervate neck muscles**.

IV. **ARTERIES OF HEAD AND NECK**

A. Subclavian artery - at root of neck; artery passes laterally toward arm, posterior to Scalenus Anterior muscle; Scalenus Anterior muscle is used as a landmark to divide the artery into three parts:

1. Part I (medial to Scalenus Anterior) - **three branches**: (1) **Vertebral artery**, which ascends into neck and enters foramina transversaria of vertebra C1-C6; (2) **Internal Thoracic artery** which descends into thorax posterior to sternum; (3) **Thyrocervical trunk** - branches into **Inferior Thyroid**, **Transverse (or Superficial) Cervical,** and **Suprascapular arteries**.

2. Part II (post. to Scalenus Ant.) - one branch: **Costocervical trunk** - which

branches into a. Superior Intercostal artery to supply first two intercostal spaces with Posterior Intercostal arteries and b. Deep Cervical Artery to deep neck muscles.

3. Part III (lat. to Scalenus Ant.) - no branches.

B. Carotid arteries - Common carotid artery arises from aorta on left, brachiocephalic artery on right; it ascends into neck and divides at level of upper border of thyroid cartilage (vertebral level C4) into Internal and External Carotid arteries; Internal Carotid artery ascends to skull without branching; **External Carotid branches** supply face and scalp; branches are (from inferior to superior):

Branches from Anterior side of External Carotid

1. Superior Thyroid artery - descends to thyroid gland - gives off Superior Laryngeal artery which courses to larynx.
2. Ascending Pharyngeal artery - small branch which ascends to pharynx.
3. Lingual artery - ascends to supply tongue.
4. Facial artery - arises below mandible; first courses medial to mandible to supply tonsils and salivary glands; hen crosses over surface of mandible to supply face, lips and nose.

Branches from Posterior side of External Carotid

5. Occipital artery - small branch which arises on posterior side of ext. carotid (opposite Facial artery) and supplies posterior scalp.
6. Posterior Auricular artery - small branch from posterior side of External Carotid which supplies posterior ear and adjacent scalp.

Terminal branches of External Carotid - Ext. Carotid ends when it divides into:

7. Superficial Temporal artery - large terminal branch of External Carotid; arises opposite External Auditory meatus; ascends to supply scalp and Temporalis muscle.
8. Maxillary artery - second large terminal branch of External Carotid; many branches (considered in lecture on Infratemporal region).

Clinical Note: **Carotid Artery Stenosis is a major cause of ischemic stroke of the brain**. MRI and CT angiography are the principal diagnostic tools for diagnoses and surgical intervention (Carotid Endarterectomy).

V. **VEINS OF HEAD AND NECK**

A. Overview - most arterial branches have accompanying veins (venae comitantes); branching pattern is variable; normally:

1. Superficial Temporal and Maxillary veins unite to form Retromandibular vein.
2. Retromandibular vein divides at angle of mandible into Anterior and Posterior divisions.
3. Anterior division joins Facial Vein to form Common Facial vein which drains into Internal Jugular vein.

4. Posterior division joins Posterior Auricular vein to form External Jugular vein.

5. External Jugular vein descends across Sternocleidomastoid muscle to drain into Subclavian vein.

6. Anterior Jugular vein forms from small veins below mandible; descends to join Ext. Jugular vein above clavicle.

VI. **FASCIA OF NECK**

A. Superficial fascia - loose connective tissue below dermis; in neck generally thin and hard to demonstrate; contains platysma muscle and superficial veins.

B. Deep cervical fascia - layers of connective tissue; one layer completely surrounds neck; other layers form tubes contained within that layer; names of some layers are confusing

1. Investing layer of Deep cervical fascia - completely surrounds neck; splits into 2 layers to enclose Trapezius , Sternocleidomastoid, Suprahyoid and Infrahyoid muscles.

2. "Prevertebral" layer of deep cervical fascia - forms a tube which completely surrounds vertebral column, muscles of back of neck, prevertebral, lateral vertebral and suboccipital muscles (not Trapezius).

3. "Pretracheal" (visceral) layer of deep cervical fascia - actually completely surrounds cervical viscera, including thyroid gland, trachea, and esophagus; inferiorly it enters mediastinum.

Clinical Note: Retropharyngeal space - potential space between "prevertebral" and "pretracheal" layers; **infection (Retropharyngeal abscess)** can spread from head (as in tonsillitis) and neck via retropharyngeal space into mediastinum; George Washington may have died from this.

4. Carotid sheath - paired; on each side surrounds Common and Internal Carotid arteries, Internal Jugular vein, Vagus nerve, and Deep Cervical lymph nodes (sympathetic chain is posterior to carotid sheath); **infections tend to remain localized within the sheath.**

Clinical Note: Infections within Carotid sheath and Opioid drug use - Heroin (and fentanyl) addicts can cause infections within the Carotid sheath by attempting to inject drugs intravenously into the Internal Jugular vein.

Anatomical Note: The Internal Jugular Vein courses inside the Carotid Sheath. The External Jugular vein is NOT in the sheath but typically courses on the surface of the Sternocleidomastoid muscle.

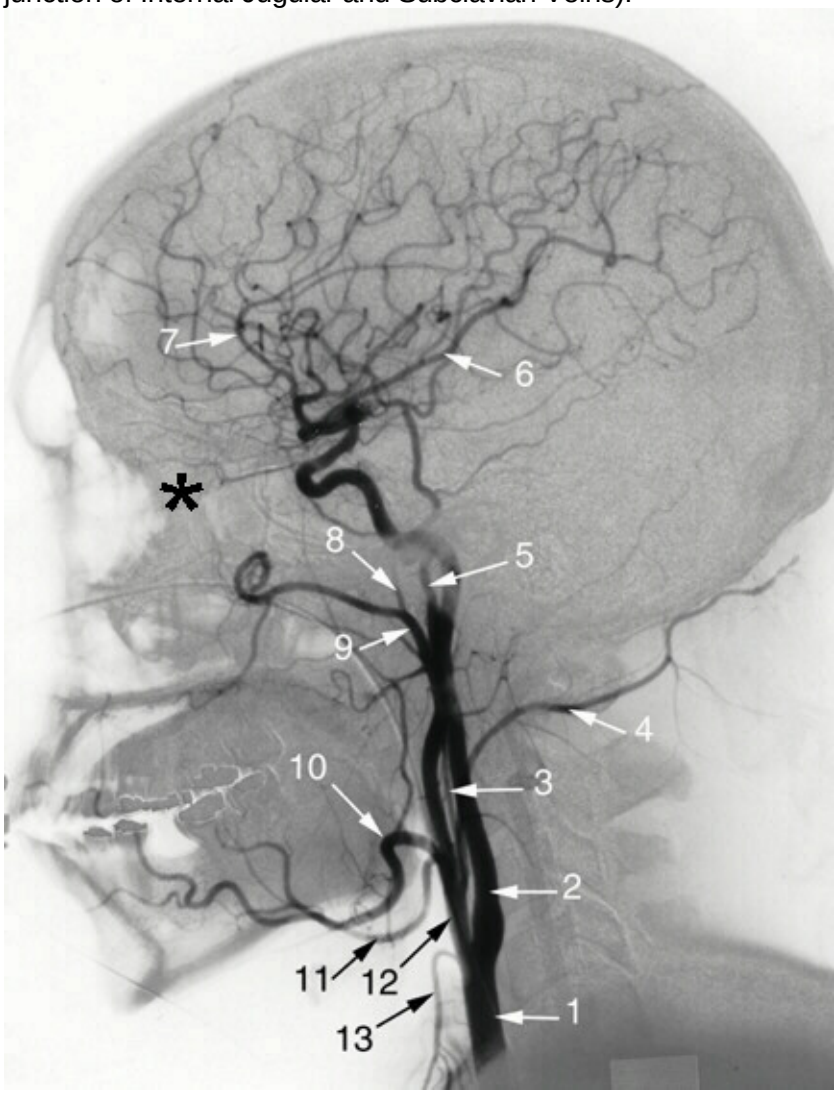
VII. **LYMPHATICS OF HEAD AND NECK** - described as three groups of lymphatics and nodes: Superficial and Deep Rings of nodes and Deep Cervical chain

A. Superficial Ring of nodes - drain areas adjacent to their location: consist of Submental, Submandibular, Buccal, Parotid, Retroauricular and Occipital nodes.

B. Deep Ring of nodes - consist of Retropharyngeal and Pretracheal nodes.

C. Deep Cervical Chain of lymph nodes - chain of nodes along Internal Jugular vein; receive lymph vessels from all nodes of head and neck.

D. Jugular lymph trunk - efferent lymph vessels from deep cervical nodes drain into Thoracic Duct (on left), Right Lymphatic Duct (on right); these drain into Brachiocephalic veins (at junction of Internal Jugular and Subclavian Veins).



1. COMMON CAROTID
2. INTERNAL CAROTID
3. ASCENDING PHARYNGEAL
4. OCCIPITAL
5. SUPERFICIAL TEMPORAL
6. MIDDLE CEREBRAL
7. ANTERIOR CEREBRAL
8. MIDDLE MENINGEAL
9. MAXILLARY
10. FACIAL
11. LINGUAL
12. EXTERNAL CAROTID
13. SUPERIOR THYROID

*- OPHTHALMIC ARTERY ARISING FROM CAROTID SIPHON

NECK Part II

I. **TRIANGLES OF NECK** - for purposes of description and location of structures, neck is divided by Sternocleidomastoid muscle into an **Anterior triangle** (anterior to muscle) containing structures related to Carotid arteries and a **Posterior triangle** (posterior to muscle), containing structures related to Subclavian artery, Cervical and Brachial Plexuses.

A. Posterior triangle

1. Boundaries: Anterior: Sternocleidomastoid; Posterior: Trapezius; Inferior: Clavicle; Superficial cover: Superficial fascia, Platysma and Investing layer; Floor: covered by Prevertebral layer of deep fascia.

2. Contents - Arteries: Subclavian artery, Superficial (Transverse) Cervical and Suprascapular arteries (from Thyrocervical trunk), Occipital artery; Veins: External Jugular vein; Nerves: Roots and Trunks of Brachial plexus, Phrenic nerve, Accessory nerve (CN XI), branches of cervical plexus.

Clinical Note: **Accessory nerve is considered to divide the posterior triangle into a clinically 'careful' zone (inferior) and 'carefree' zone (superior); brachial plexus is in 'careful' zone.** (On the other hand, would a patient want to be operated on by a surgeon who thinks part of the neck is 'carefree'?)

Note: Subclavian vein is not within posterior triangle

B. Anterior triangle of neck

1. Boundaries: anterior by midline of neck, posterior by Sternomastoid muscle, superiorly by lower margin of Mandible.

2. Contents - Arteries: Carotid sheath with Common Carotid dividing into Internal and External Carotid arteries, numerous branches of External Carotid; Veins: Internal Jugular vein; Nerves: Hypoglossal nerve and descending branch of Ansa Cervicalis, Accessory and Vagus nerves; Lymphatics: Deep Cervical chain of lymph nodes.

II. **DEEP STRUCTURES OF NECK**

A. Thyroid gland: Composed of two lateral lobes and a central isthmus, which is located below cricoid cartilage; Lateral lobes cover Common Carotid artery; Pyramidal lobe sometimes present above isthmus; when present, it is connected to the hyoid bone via a fibrous strand (no clinical consequences).

Pyramidal lobe – is normal variant; recall that thyroid forms **embryologically as a mass in tongue** that migrates to neck; thyroid tissue can be found along the path of migration.

1. Arterial supply: Gland is very vascular.

a. Superior Thyroid artery (from External Carotid Artery) - accompanied by Superior Laryngeal nerve.

b. Inferior Thyroid artery (branch of Thyrocervical trunk); Inferior Thyroid artery courses near Recurrent Laryngeal nerves (located in groove between trachea and esophagus).

Clinical Note: **Care must be taken during thyroid surgery not to damage Recurrent Laryngeal nerves when ligating Inferior Thyroid artery**; can paralyze all muscles of larynx on one side (except Cricothyroid muscle); patient has only hoarse voice or whisper.

2. Veins: Superior Thyroid veins follows arteries; Middle Thyroid vein; both veins drain into Internal Jugular vein; Inferior Thyroid vein - Left and right veins can join together and enter Left Brachiocephalic vein.

Clinical Note: **Inferior Thyroid veins course anterior to trachea; if large, can cause extensive bleeding in Tracheotomy** (emergency access to trachea; this is avoided by Cricothyrotomy: see Larynx lecture).

3. Parathyroid glands - 4 very small bodies located posterior to thyroid gland or within gland; position very variable.

B. Sympathetic trunk - there are three cervical ganglia (Superior, Middle, Inferior); all 3 ganglia send gray rami to cervical spinal nerves. Most of head and neck is supplied by Superior Cervical ganglion; Superior Cervical ganglion sends postganglionic fibers via unnamed branches (e.g., joy to medical students) to form a plexus on Carotid arteries and their arterial branches.

C. Thoracic duct at root of neck - follows left margin of esophagus, enters Left Brachiocephalic vein (at junction of Internal Jugular and Subclavian veins)

D. Recurrent laryngeal nerve - Right recurrent laryngeal nerve courses under Subclavian artery; Left recurrent laryngeal under Aorta; both ascend in groove between trachea and esophagus.

SPINAL AND CRANIAL NERVE REFLEXES

I. DEFINITION AND OVERVIEW OF REFLEXES

A. **Definition of a reflex** = **stereotyped motor response to a specific sensory stimulus.**

B. **A reflex usually consists of sensory receptors, interneurons and motor neurons:**

1. **sensory receptor** - detects stimulus (termed: **afferent arm** of reflex arc)
2. **interneurons** - receive inputs from sensory receptors and synapse on motor neurons; effects on motor neurons can be excitatory or inhibitory; not present in monosynaptic reflexes.
3. **motor neurons** - (termed **efferent arm** of reflex arc) produce muscle contraction, motor response.

C. Reflexes are **valuable tools for clinical evaluation of nervous system function**. For reflex to occur, all elements must be functional and pathways must be intact. If reflexes are absent, a physician can diagnose where the pathway is interrupted; if reflexes are abnormal, can diagnose where function is compromised.

D. **Reflexes are evaluated according to**
1) **amount (size, magnitude) of motor response**
2) **latency (time to elicit motor response)**

Note: Changes in reflexes are clinical signs - In some disease processes, damage can enhance motor responses (hyper-reflexia = abnormally large reflex responses); responses can also occur with abnormal muscle contractions (ex. Clonus - rapid alternating contraction and relaxation following a single stimulus)

RATING STRETCH (DEEP TENDON) REFLEXES – Decreased = 0,1, Normal = 2, Increased = 3,4

Rating	Characteristics
0	Absent
1	Diminished
2	Normal
3	Brisk, Hyper-reflexic
4	Hyper-reflexic, Pathologic

E. **Some reflexes are protective and relatively constant**; ex. **Pupillary light reflex**

F. **Other reflexes are constant under the same controlled circumstances**; ex. **Stretch reflex (deep tendon reflex)** - **Reflexes can be modulated by the central nervous system**: GET PATIENT TO RELAX.

G. **Other 'reflexes' actually represent triggering of more complex behaviors by sensory signals (ex. 'stepping reflexes' in neonates, infants). Some behaviors (ex. walking) are produced by pattern generators (see below).** Pattern generators are groups of interneurons in the CNS that produce activities in motor neurons and generate rhythmic behaviors. Stepping 'reflexes' in infants may represent triggering of activity in the walking pattern generator.

II. THREE CLASSIC SPINAL REFLEXES - Each reflex has a specific sensory stimulus and motor response

Note: **Terminology** - In describing a reflex:

Homonymous muscle - the muscle that contains or is associated directly with the sense organ producing the reflex
Synergist muscle - muscle that produces a similar motor action (movement)
Antagonist muscle - muscle that produces the opposite motor action (movement)
Contralateral muscle - muscle of opposite limb (leg or arm).

A. **Stretch reflex** (also termed: Monosynaptic Stretch Reflex, Myotatic Reflex, Deep Tendon Reflex)

1. **Stimulus** - fast stretch of muscle; clinically, produced by a brief sharp tap to a muscle tendon. This produces a sudden small lengthening of muscle (not stimulation of tendon receptors).
2. **Sense organ excited** - **Muscle spindle Primary (Group Ia) afferents**; can also produce much weaker discharges of muscle spindle Secondary (Group II) afferents.
3. **Primary response** - **MONOSYNAPTIC** and polysynaptic activation of alpha motor neurons in **muscle that is stretched contracts rapidly**. Monosynaptic reflex is the fastest reflex known, with a central delay of about 1 msec at the synapse.
4. **Effects on synergist and antagonist muscles -** a. **Excite synergist muscles** - Activate muscles with similar action (ex. in arm - biceps spindle sensory neurons excite motor neurons to brachialis muscle). b. **Inhibit antagonist muscles (RECIPROCAL INHIBITION)** - Decrease activity in muscles with opposing action (ex. biceps spindle neurons produce inhibition of triceps motor neurons); these connections are polysynaptic.
5. **Muscle Tonus** - Because the reflex connection is monosynaptic, the ongoing activity in muscle spindles is important determining the level of activity of motor neurons to muscles at rest. Decreases in sensory activity can cause a decrease in muscle tonus (measured by resistance to slow stretch of the muscle). Increased sensory activity can increase muscle tonus.

Note: **Spasticity/Rigidity** – **Increased tonus** (rigidity) occurs after **Upper Motor Neuron lesions** (ex. cortical strokes) due, in part, to **loss of modulation of stretch reflexes** (see below).

6. **Reflexes must be modified during voluntary movements**. Reflexes can be altered by mechanisms of 1) **gamma motor neurons** (reset muscle spindles) 2) **descending inputs from brain** - pre-synaptic inhibition (decrease effectiveness of spindle sensory discharges) and 3) **modulation of motor neuron activities (excitability)**. Some of these changes are produced by activities in neurons of descending motor tracts. 4) **Renshaw cells** - Alpha motor neurons have recurrent processes (axon collaterals); some of these branches make excitatory synapses upon interneurons (Renshaw cells). Renshaw cells can **limit motor neuron firing** and change reflexes (see Dr. Grover's lecture in January).

Note: Changes in stretch reflexes are also symptomatic: **In general, <u>Decrease stretch reflexes can indicate Lower Motor Neuron Disorders</u>, <u>Increase Stretch reflexes can indicate Upper Motor Neuron Syndromes.</u>**

B. **Autogenic Inhibition** (also termed: Inverse Myotatic Reflex, Tendon Organ Reflex or Clasped-

Knife Reflex)

1. **Stimulus** - large force exerted by pulling on muscle tendon (ex. isometric contraction)
2. **Sense organ excited** - Golgi tendon organ (Ib afferent)
3. **Primary response** – motor neurons to muscle are inhibited (hyperpolarized) and muscle attached to tendon **relaxes; effect is polysynaptic.**
4. **Effect on synergist (similar action) and antagonist (opposing action) muscles – all effects polysynaptic -** a. Inhibit synergist muscles - b. Excites antagonist muscles
5. **Function of Autogenic inhibition** - **Regulating muscle tensions.**

Note: **Clasped knife reflex**: In Upper Motor neuron lesions, tonus may increase and resistance of muscle to stretch increases; if sufficient force is applied, **limb resistance suddenly decreases** (like a pocket knife snapping shut); this is thought to be mediated by reflexes of Golgi tendon organs.

Note: The connections for autogenic inhibition are inactivated during walking; Effects of Golgi tendon organs then become excitatory (through other interneurons).

C. **Flexor reflex** - reflex withdrawal from a painful or noxious stimulus; can produce excitation of flexor motor neurons; can also take other forms (exciting muscles with other actions, ex. abductor muscles that pull limb away from midline)

1. **Stimulus** - noxious or painful stimulus to skin
2. **Sense organs excited** - Cutaneous touch receptors, pain (nociceptors)
3. **Primary response** - polysynaptic excitation of motor neurons to flexor muscles.
4. **Other effects - a. Same side – excite flexors, inhibit extensors. b. Opposite side – excite extensors, inhibit flexors.**
5. **Function of Flexor Reflex** - Protective (example: stepping on a nail). The net effect of these connections is that very rapid adjustments are made so that one leg is lifted rapidly and the other supports the weight of the body.
6. **Clinical Changes in Flexor Reflexes** - Flexor Reflexes can change after lesions, disease processes;

ex. **Babinski Sign** - seen after **Upper Motor neuron lesion**; normal response - stroking sole of foot **normally** results in **flexion (plantar flexion) of toes** (not strictly a withdrawal reflex); Babinski sign - direction of movement **changes to extending (dorsiflexing) toes**.

III. REFLEXES OF CRANIAL NERVES

A. Pupillary light reflex (Optic Nerve CNII in; Oculomotor CN III out) - Light shone in the eye causes the pupil to constrict; Stimulus - light; detected by sensory neurons (photoreceptors) in retina; sensory signals in Optic Nerve (Cranial Nerve II); Response - motor signals in Oculomotor Nerve (Cranial Nerve III, innervates pupillary constrictor muscle); Function - limit amount of light; protects photoreceptors in retina; connection present at all times.

B. Corneal reflex (Trigeminal nerve CNV in; Facial nerve CN VII out) - Touching corning of eye causes closing of eyelids. Stimulus - touch detected by sensory neurons (Somatic Sensory) in Trigeminal nerve V (Long Ciliary Nerves V1); Response – Motor signals in Facial Nerve (CN VII) innervate Orbicularis Oculi muscle (muscle of Facial Expression) which closes eyes; Function –

protective of Cornea.

C. Gag Reflex (Glossopharyngeal nerve CNIX in; Vagus nerve CNX out) - Touching pharynx induces gagging. Stimulus - Touch detected by Visceral Sensory neurons in Oropharynx innervated by Glossopharyngeal nerve CNIX; Response - motor signals in Vagus nerve (CNX) cause contraction of pharyngeal constrictor muscles.

D. Jaw Jerk Reflex (Stretch Reflex of Muscles of Mastication (ex. Masseter) (Trigeminal nerve V in; Trigeminal nerve V out) - Tap down on mandible induces contraction of muscles that elevate mandible (close mouth). Stimulus – detected by Muscle spindles in muscles of mastication (ex. jaw closer, Masseter) contained in Trigeminal nerve (CNV); Response - motor neurons also contained in Trigeminal nerve cause. contraction of jaw closer muscle

IV. PATTERN GENERATORS IN SPINAL CORD AND BRAINSTEM

A. Spinal cord contains networks of interneurons that generate patterned motor activities (networks are called Pattern Generators; see Dr. Grover's lecture, Neuronal Integration, next block).

B. ex. Walking - Walking is thought to be produced by pattern generators. In addition, after spinal cord lesion, rear limbs of animals and legs of humans can walk on treadmills (if body weight is supported). This has led to new therapies for patients with spinal cord injuries (ex. Christopher Reeve, actor who played 'Superman')

Note: Stepping reflexes in infants probably represent activation of the pattern generator for walking. Infants don't learn to walk; they learn to maintain balance while walking.

SPINAL REFLEXES AND DISORDERS

REFLEX	STIMULUS/SENSE ORGAN(S) EXCITED	NORMAL RESPONSE	UPPER MOTOR NEURON DISORDERS
Stretch (Myotatic, Deep Tendon) Reflex – Compensatory maintain position (ex. riding on moving bus)	Rapid Stretch of muscle (test: tap on muscle tendon) Excites Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons (NOT Golgi Tendon Organ)	Stretched muscle contracts rapidly (monosynaptic connection); also Excite synergist and Inhibit antagonist Note: Gamma motor neurons can enhance stretch reflexes, tell patient to relax before test	Hyperreflexia - (increase) - characteristic of Upper Motor Neuron lesions (ex. spinal cord injury, damage Corticospinal tract); note: Clonus = hyperreflexia with repetitive or sustained contractions to single stimulus
Autogenic Inhibition - Limits Muscle Tension	Large force on tendon excites Golgi Tendon Organ Ib (test: pull on muscle when resisted)	Muscle tension decreases; Also inhibit synergist muscles; excite antagonist muscles	Clasped Knife Reflex - occurs in Upper Motor Neuron lesions - forceful stretch of muscle is first resisted then collapses
Flexor Reflex - Protective avoidance reflex	Sharp, painful stimulus, as in stepping on nail; Excites - Cutaneous and pain receptors (test: stroke foot with pointed object)	Limb is rapidly withdrawn from stimulus; protective reflex; also inhibit extensors of same limb and excite extensors of opposite limb (Crossed Extensor Reflex)	Babinski sign- toes extend (dorsiflex) to cutaneous stimulus of sole of foot (normally plantar flex); characteristic of Upper Motor Neuron lesion

REFLEXES OF CRANIAL NERVES

REFLEX	STIMULUS	SENSORY	RESPONSE	CLINICAL
Pupillary Light Reflex (II to III)	Test: Shine light in eye	Light detected by Optic Nerve	Excite Constrictor of pupil of eye (III Short Ciliary nerves (Ciliary Ganglion, parasympathetic)	Extensively used to check CN II; Absence of Pupillary Light Reflex can indicate catastrophe (brain herniation)
Corneal Reflex (V to VII)	Touch cornea of eye with cotton	Touch detected by Long Ciliary nerves (V1), Somatic sensory	Close eye (VII to Orbicularis Oculi muscle) Branchiomotor	Absence of Corneal Reflex; Test for damage to V1 sensory, VII motor
Gag Reflex (IX to X)	Test: Touch posterior tongue, oropharynx;	Excites Visceral Sensory endings in Glossopharyngeal N. (IX)	Excite muscles of pharynx, palate; Vagus N. (X), Branchiomotor	Other symptoms of Vagus damage (X); Patient Say's Ahh: soft palate not elevated on ipsilateral side (paralyze Levator Palati); uvula deviated away from side of lesion
Jaw Jerk Reflex Stretch (Deep Tendon) Reflex (V to V)	Test: tap down on mandible; Stretch muscles of mastication (ex. Masseter)	Excites Muscle Spindle sensory neurons in Trigeminal nerve (V)	Contract muscles that elevate mandible Motor - V3	Hyporeflexia - indicates Trigeminal nerve damage

ANATOMY AND DIAGNOSTIC USE OF AUTONOMIC NERVOUS SYSTEM PATHWAYS

I. GENERAL REVIEW OF AUTONOMIC NERVOUS SYSTEM - Autonomic nervous system (= Visceral nervous system) is considered part of peripheral nervous that is not under voluntary control (Autonomic means automatic or self-regulating)

A. **OVERVIEW** -

1. Autonomic nervous system innervates visceral structures: smooth and cardiac muscles, blood vessels, glands (sweat glands, salivary glands, etc) and internal organs (ex. GI tract, heart, etc.).

2. The autonomic nervous system is **often thought of as reactive** to stimuli (ex. fight or flight). However, many autonomics provide pathways for the CNS to **continuously regulate and control body functions**:

examples 1) Thermoregulation - regulate body temperature; 2) Cardiovascular function in heart and blood vessels - monitor and regulate heart rate, blood pressure, etc.;3) GI function - secretion, motility.

B. Basic pathway - 2 neuron arc; **pre-ganglionic neuron is in CNS**; axon leaves CNS; synapses in autonomic ganglion - post-gangliionic cell in autonomic ganglion innervates smooth muscle, glands, etc.

C. Divergence - Why have a two neuron arc? Autonomics can activate many targets at the same time. A single pre-ganglionic neuron synapses on many post-ganglionic neurons (ratio 1 pre/15 post up to 1 pre/200 post). This divergence can allow for widespread effects (ex. in thermoregulation, many sweat glands are activated simultaneously).

D. Parts Autonomic Nervous System - Sympathetic and Parasympathetic: Review:

1. **Sympathetics: 'FIGHT OR FLIGHT'** - Out CNS at **Thoraco-Lumbar levels**; **ganglia close to CNS** (paravertebral); pre-ganglionics short, post-ganglionics long; Actions - ex. Increase heart rate, decrease gastric movements and secretions, decrease secretion of salivary glands.

2. **Parasympathetics: 'REST AND DIGEST'** - Out CNS at **Cranio-Sacral levels** (Cranial nerves and Sacral Spinal nerves); **ganglia close to target**; pre-ganglionics long, post-ganglionics short; Actions - ex. decrease heart rate, increase gastric movements and secretions; increase secretion of salivary glands.

E. **Asymmetry - Some body structures receive only Sympathetics NOT Parasympathetics - Classic description: 'Parasympathetics do not go to body wall'; examples:**

1. **Skin** - **sweat glands and arrector pilae** muscles **are only innervate by Sympathetics** not Parasympathetics.

2. **Peripheral blood vessels** - Blood vessels are innervated by Sympathetics not parasympathetics.

Consequence of Asymmetry: **Sympathetics are much more widely distributed than Parasympathetics** - pathways are more complex.

F. **Thermoregulation by sweating** - sweating decreases body temperature by evaporation; mediated by Sympathetics to skin.

G. **CNS Regulation** - Centers in the CNS regulate autonomic function (ex. brainstem reticular formation). The **Hypothalamus** (part of CNS) is a major center for regulation of autonomic function.

II. ANATOMICAL ORGANIZATION OF SYMPATHETIC PATHWAYS

A. **Pathways** - Sympathetics (pre-ganglionic neurons) come out Spinal cord (at Thoracic and Upper Lumbar Levels); can do three things.

1. **Synapse in ganglion at level of outflow** - Pre-ganglionics course in Communicating rami (connect to Sympathetic ganglion); Post-ganglionics join spinal nerve of that segment. (ex. Skin of thorax - innervated by Intercostal nerves).

2. **Ascend or descending chain and synapse in other ganglia of chain**; Post-ganglionics then course in Communicating rami to join spinal nerves at those segments (ex. cervical spinal nerves of Brachial plexus).

3. **Not synapse in chain; pre-ganglionics continue to ganglia nearer to target organ**; ex. Splanchnic nerves to gut (covered in Spring semester)

III. SYMPATHETICS TO HEAD AND HORNER'S SYNDROME

A. Sympathetic pathway - Sympathetics to head come **out T1 and T2**; **ascend sympathetic chain; Synapse in Superior Cervical Ganglion**; Post-ganglionics **distributed with plexus on Carotid arteries**.

B. **Horner's Syndrome** - **interruption/damage to Sympathetic pathway**

Symptom	**Structure innervated**	**Damage**
Anhydrosis (lack of sweating)	**Sweat glands in skin**	**lack of sweating in skin (ex. forehead)**
Ptosis (eyelid droop)	**Levator Palpebrae Superioris - sympathetics to Smooth muscle part**	**Levator lifts upper eyelid; damage produces eyelid droop**
Miosis (constricted pupil)	**Pupillary Dilator muscle**	**Damage paralyzes Dilator muscle; pupil is constricted (Constrictor Pupillae muscle is intact - innervation CN III)**

3. Differential Diagnosis of Ptosis = EYELID DROOP; cause - damage to innervation of **Levator Palpebrae Superioris** - Levator Palpebrae Superioris is **innervated by both Sympathetics and Somatic Motor Neurons (CN III, Oculomotor)**; **however, differential effects on Pupil of Eye, Sweat glands.**

Structure	**Horner's Syndrome**	**Oculomotor Palsy (nerve damage)**
Upper eyelid	**Ptosis (eyelid droop) - paralyze Smooth muscle part of Levator Palpebrae Superioris**	**Ptosis (eyelid droop) - paralyze Skeletal muscle part of Levator Palpebrae Superioris**
Pupil of eye	**Pupil constricted (Miosis) - Pupillary Dilator muscle paralyzed;** Pupillary constrictor muscle intact	**Pupil dilated (Mydriasis) - Pupillary constrictor muscle paralyzed;** Dilator muscle is intact
Sweat glands in skin	**Anhydrosis - lack of sweating in skin** (ex. forehead)	**No effect (**parasympathetics do not innervate skin)

Also: Eye Movements - Oculomotor nerve innervates Extraocular muscles; damage effects eye movements; no deficit in eye movements in Horner's syndrome.

Note: Others causes of Ptosis - Myasthenia Gravis; Aponeurotic ptosis (levator palpebrae loses insertion to tarsal plate); Orbital Fracture; etc.

NASAL CAVITY

I. **NASAL CAVITY** - openings - anteriorly opens to Anterior Nares, posteriorly at Choanae (Posterior Nares); cavity lined by mucoperiosteum.

A. Nasal Cartilages - Septal Cartilage with fused Lateral Nasal Cartilages; Alar Cartilages - surround medial side of nostrils; function - direct inhalation toward mouth (smell what you eat).

B. Nasal Cavity Boundaries; Floor = palate - Maxillary bone (palatine process) and Palatine (horizontal plate) bones; Roof - Nasal, Frontal, Ethmoid and Sphenoid bones; Medial wall = nasal septum: Septal cartilage, Ethmoid bone and Vomer; Lateral Wall - Nasal, Maxillary, Ethmoid, Palatine and Sphenoid bones and Inferior Nasal Concha.

Clinical Note: **Fractures of nose are common**; **fractures of cribriform plate** of Ethmoid (which forms roof of nasal cavity and floor of anterior cranial fossa) can lead to meningitis or **cerebrospinal fluid leakage** into nasal cavity if the dura is torn.

C. Nasal Conchae (L. shell) - also called Turbinates - projections from lateral wall increase surface area of mucosa to warm, humidify, and clean air; Superior and Middle conchae are part of Ethmoid bone; Inferior concha is a separate bone.

Note: Opening of auditory tube is in nasopharynx, posterior to inferior concha.

1. Four Spaces of Nasal Cavity associated with conchae, each space (Meatus, L. passage) has its own openings for nerves, air sinuses or nasolacrimal duct.

Space	**Location**	**Openings/Sinuses**
Sphenoethmoidal Recess	**Above Superior Concha**	1) Olfactory foramina of cribriform plate and 2) Sphenoidal air sinus (opening)
Superior Meatus	**Below Superior Concha**	1) Posterior Ethmoidal Air sinus (opening)
Middle Meatus	**Below Middle Concha - parts** **Ethmoidal Bulla -** rounded elevation in wall **Hiatus Semilunaris -** slit below Ethmoid Bulla **Infundibulum -** anterior part of Hiatus	1) Middle Ethmoidal sinuses open onto Ethmoidal bulla 2) Anterior Ethmoidal sinus - open to Hiatus 3) Maxillary sinus opens to Hiatus Semilunaris; 4) Frontal sinus drains to Infundibulum
Inferior Meatus	**Below Inferior Concha**	1) Nasolacrimal duct (opening)

Clinical Note: **Opening of Maxillary sinus is high up (superior)** on wall of sinus, can lead to **poor drainage** of sinus when infected.

C. Divisions - Respiratory area - lower part of mucosa, lined with respiratory epithelium; Olfactory area - upper part of mucosa, lined with olfactory epithelium

D. Nerves

1. **Olfactory** area - Olfactory nerve (CN I, sense of smell)
2. **General sensation** (touch, temperature, etc.) **Somatic Sensory branches from V1 and V2** - Anterior Ethmoidal nerve (from V1) and Nasopalatine nerve and Nasal branches (from V2)
3. **Parasympathetic Innervation to nasal mucous glands** - **Facial nerve (CN VII)** - Visceral Motor (Parasympathetic) from Pterygopalatine ganglion; branches of Facial nerve (VII) travel with Trigeminal nerve (V)

E. Blood supply

1. Arteries - Mostly from Sphenopalatine artery (branch of Maxillary artery); also from Anterior and Posterior Ethmoidal arteries (branches of Ophthalmic artery) and branches of Facial artery (anteriorly).

2. Veins - Ethmoidal veins drain to Ophthalmic vein; other branches to Pterygoid venous plexus and Facial vein.

Clinical Note: **Epistaxis (Nosebleed)** - Rich anastomoses in nose results in epistaxis (nosebleed) often due to tearing of veins; spurting of blood occurs from tears of arteries.

F. Lymphatics - drain to Retropharyngeal nodes.

II. **PARANASAL AIR SINUSES** - air filled extensions of nasal cavities; all are paired; develop after birth; lined by mucous membrane; serve to lighten growing bones; possibly a mistake of evolution as could have filled growing bones with spongy (cancellous) bone and would not get infected.

A. Frontal sinus - two sinuses separated by a median septum; variable in size.
B. Sphenoid sinus - paired sinuses located in body of sphenoid bone
C. Ethmoidal sinus (also call air cells) - Anterior, Middle, and Posterior groups
D. Maxillary sinus - largest, occupies entire body of maxilla; Roof - floor of orbit; Medial wall - related to lower part nasal cavity.

Clinical Note: **Blocked Ethmoidal sinuses** may cause **infection** to pass laterally through thin medial wall of **Orbit** to infect eye.

Clinical Note: **Tooth Extraction Fractures Maxillary Bone** - Roots of teeth closely related to floor of sinus; Extraction of molar teeth can result in fracture of floor of sinus.

Clinical Note: **Maxillary Sinus Infections are sensed as Toothache** - Anterior and Posterior Superior alveolar branches of CN V2 supplies mucous membrane of maxillary sinus and teeth; infected sinus can result in sensation of **tooth ache**.

III. **PALATE DEVELOPMENT**

A. Development - occurs during 5-12th week

1. Two parts form palate: primary and secondary palates.

a. Primary palate (Median palatine process) - formed by union of Medial Nasal Processes, become part of palate anterior to incisive foramen, bearing incisor teeth

b. Secondary palate (posterior to incisive foramen) - formed of Maxillary processes of Arch I; Maxillary processes fuse with the Median Palatine processes anteriorly; posteriorly, Maxillary processes fuse with each other at midline; fusion proceeds anteriorly to posteriorly.

2. Malformations

a. **Anterior Cleft palate** - improper fusion of primary and secondary palates (**Medial Nasal processes and Maxillary processes fail to fuse**); cleft is anterior to incisive foramen; 1:1000 births

b. **Posterior Cleft palate** - improper fusion of parts of secondary palate (**Maxillary processes from each side fail to fuse with each other**); cleft is posterior to incisive foramen; 1:2500 births

IV. **PALATINE TONSILS** - located between palatoglossal and palatopharyngeal folds on lateral side of oropharynx; tonsils are a collection of lymphoid tissue covered by mucous membrane; lateral to tonsil is the tonsillar bed (lateral wall of pharynx)

A. Arteries - mainly from Tonsillar branch of Facial artery.

B. Veins - join pharyngeal plexus of veins which drain to Facial, Lingual or Internal Jugular veins.

Clinical Note: Bleeding after tonsillectomy - Tonsillar branch of Facial artery can bleed extensively after tonsillectomy.

Clinical Note: Damage Glossopharyngeal nerve in tonsillectomy - Glossopharyngeal n. - passes forward with Tonsillar artery in lateral wall of pharynx; only mucosa and fascia cover nerve; can be damaged in removal of tonsil.

C. Lymphatics - Drain to Jugulodigastric node (one of the Deep Cervical nodes, becomes enlarged during tonsillitis); located near angle of mandible and inferior to posterior belly of Digastric muscle.

LARYNX

I. **CARTILAGES** - larynx consists of cartilages which are connected by membranes and ligaments and moved by muscles; larynx sits above trachea; produces sound, prevents objects from entering respiratory system.

A. Thyroid cartilage - shield shaped cartilage; has horns (cornua) projecting from upper and lower edges; have synovial hinge joints with cricoid cartilage.

B. Cricoid cartilage - complete ring of cartilage resting on first tracheal cartilage; has narrow arch (anterior part) and broad lamina (posterior part).

C. Arytenoid cartilages- two pyramidal shaped cartilages that rest above lamina of cricoid; have synovial joints with cricoid cartilage that allow for swivel and sliding movements.

D. Corniculate cartilages - two small nodule shaped cartilages that articulate with apices of the arytenoid cartilages, give attachment to aryepiglottic folds (see below).

E. Cuneiform cartilages - two small rod shaped cartilages in aryepiglottic folds.

F. Epiglottic cartilage - leaf-shaped cartilage posterior to root of tongue; connected to body of hyoid bone and back of thyroid cartilage.

II. **LIGAMENTS OF LARYNX**

A. Structural ligaments - hold larynx, hyoid and trachea together

1. Thyrohyoid membrane - links thyroid cartilage to hyoid bone; thickened medial part called median thyrohyoid ligament.

2. Cricothyroid membrane - links cricoid to thyroid cartilage; thickened medial and anterior part called Median cricothyroid ligament.

3. Cricotracheal ligament - links cricoid to first tracheal cartilage.

4. Quadrangular membrane - links arytenoid to epiglottis; lower free edge is called vestibular ligament.

5. Thyroepiglottic ligament - links epiglottis to thyroid cartilage.

B. Functional Ligaments

1. Conus elasticus - elastic membrane forming vibrating lips; arises from entire upper edge of arch of cricoid; attaches anteriorly to thyroid cartilage, posteriorly to vocal processes of arytenoid cartilages; upper free edges are thickened to form vocal ligaments; opening between vocal ligaments is called rima glottidis.

C. Functions of conus elasticus

1. Sound production - When the vocal ligaments are brought close together, air forced through rima glottidis causes ligaments to vibrate producing sound.

2. Closing rima glottidis - When vocal ligaments are pressed tightly together the rima glottidis is closed; this prevents upward movement of the diaphragm when the abdominal muscles contract; contraction of the abdominal muscles therefore increases pressure in the abdomino-pelvic cavity; this is useful in childbirth, micturition, defecation, etc.

III. **MUSCLES OF THE LARYNX**

A. Extrinsic muscles of larynx - move entire larynx, active during swallowing; suprahyoid muscles elevate larynx, infrahyoid muscles depress larynx.

B. Intrinsic muscles of larynx - mostly well named for their origins and insertions.

MUSCLE	**ACTION**	**NERVE**
Cricothyroid	Tenses vocal fold, raises pitch of sound	External Laryngeal n. (X)
Thyroarytenoid	Relaxes vocal fold, decreases pitch of sound	Recurrent Laryngeal n. (X)
Posterior cricoarytenoid	Abducts vocal folds, opens rima glottidis	Recurrent Laryngeal n. (X)
Lateral cricoarytenoid	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Arytenoid (Transverse arytenoid)	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Aryepiglottic muscle	Pulls down epiglottis during swallowing	Recurrent Laryngeal n. (X)

Note: the branch of the Recurrent Laryngeal n. (X) innervating the laryngeal muscles is specifically called the Inferior Laryngeal n. (this was a picky question on the board exams)

IV. **TERMS ASSOCIATED WITH LARYNX**

A. Folds

1. Vocal (True Vocal) folds - overlie vocal ligaments.
2. Vestibular (False Vocal) folds - overlie vestibular ligaments.
3. Aryepiglottic folds - overlie upper edge of quadrangular membrane.

B. Areas

1. Vestibule - inlet above false vocal folds.
2. Ventricle - between false and true vocal folds; laryngeal sinus is lateral extension of ventricle.

V. **INNERVATION** - from Vagus

A. Superior Laryngeal nerve

1. Internal Laryngeal nerve - Visceral sensory to larynx above vocal folds.

2. External Laryngeal nerve - Branchiomotor to cricothyroid muscle.

B. Recurrent Laryngeal nerve - Visceral sensory to larynx below vocal folds; Branchiomotor to all other muscles of larynx.

VI. **BLOOD SUPPLY** - Superior Laryngeal Artery - from Superior Thyroid a.; Inferior Laryngeal Artery - from Inferior Thyroid a.

VII. **LYMPHATICS** - Superior deep cervical nodes - drain larynx above vocal folds; Inferior deep cervical nodes - drain larynx below vocal folds.

Clinical Note: **Anaphylactic Shock** - Mucosa is tightly attached to vocal folds; in Anaphylactic Shock (acute allergic reaction) swelling of Vestibular folds can constrict airway and lead to asphyxiation)

VIII. **OBSTRUCTION OF LARYNX** - asphyxiation may also result if food or foreign object becomes lodged in larynx; in emergency a cut may be made through the cricothyroid membrane to open air passage (**Cricothyrotomy)**; this is preferable to cutting into the trachea (Tracheotomy) because the Thyroid veins overlie the trachea.

EAR

I. Overview - specialized for sound detection

A. Outer ear - funnel shaped structure of cartilage and skin that leads to Tympanic membrane; directs sound toward Tympanic membrane; helps detect source of sound.

B. Middle ear - air filled chamber that contains bones (ossicles) that link Tympanic membrane to cochlea; also contains muscles that dampen sounds; middle ear is linked to Nasopharynx by auditory tube which allows for equilibration of air pressure on inner side of Tympanic membrane.

C. Inner ear - fluid filled chamber in petrous part of temporal bone; inner ear contains Cochlea (hearing) and Vestibular apparatus for gravity detection (both innervated by CN VIII).

Clinical Note: Functioning of inner ear can be tested independently by vibrations transmitted directly through bone (Weber test: tuning fork on calvarium is perceived as sound); **CONDUCTIVE HEARING LOSS** - damage to middle ear (tympanic membrane, auditory ossicles); **SENSORINEURAL HEARING LOSS** - damage to inner ear (cochlea, CN VIII).

II. Outer Ear - composed of two parts:

A. Auricle (pinna) - elastic cartilage covered with skin; functions to reflect sound waves. Parts: helix, antihelix, tragus and lobule.

Decorative Note: Cartilage does not extend into Lobule; Lobule can be readily pierced to provide support for decorative metal objects.

B. **External auditory meatus** - tube from auricle to the Tympanic membrane; posterior to Parotid gland and TMJ (Temporomandibular joint); located anterior to mastoid process. Outer third consists of elastic cartilage; contains hairs, sebaceous glands and ceruminous glands (produce cerumen = ear wax); serves to protect Tympanic membrane; Inner two thirds is composed of bone lined with skin.

Clinical note: External auditory meatus is curved **anteriorly in adults**, is **straight in children**; in **adults, auricle is pulled up and back to insert otoscope**.

Clinical note: sensory innervation of Outer Ear is complex and derived from CN V, VII, IX and X; patient's with Bell's palsy can have sensation of ear ache.

III. Middle Ear (**Tympanic cavity**) - cavity in the petrous portion of the temporal bone that is hard to visualize; lies below middle cranial fossa

A. Boundaries

1. Roof - tegmen tympani (thin plate of petrous part of temporal bone) separates Tympanic cavity from middle cranial fossa.

2. Floor - Jugular foramen lies below cavity; rupture of the internal jugular vein can result in hemorrhaging into the Tympanic cavity.

3. Anterior wall - has opening of Auditory tube (posterior 1/3 of tube is in bony canal, anterior 2/3 is cartilage); Auditory tube links middle ear with nasopharynx for equilibration of pressure; anterior wall also has bony canal containing tensor tympani muscle.

4. Posterior wall - leads to mastoid air cells in mastoid process (opening is call aditus); canal for Facial nerve (CN VII) courses in posterior wall (after passing from medial wall).

5. Medial wall - is lateral wall of inner ear; landmarks - **Oval window** (fenestra vestibuli) is **attachment for stapes**; Round window (fenestra cochlea) is other end of coiled cochlea; landmarks - promontory is bulge in wall from first turn of cochlea; prominence of facial nerve canal - horizontal ridge from underlying facial nerve.

6. Lateral wall - Tympanic membrane.

Clinical Note: **Otitis media** (middle ear infection) is common in children. Middle ear is functionally a dead end cavity that opens to nasopharynx. Infection can spread from upper respiratory system. Damage to auditory ossicles can cause hearing loss. **Prolonged infection in Tympanic cavity can spread through tegmen tympani to brain**.

Clinical Note: **Incidence of Otitis media declines rapidly after age of 5**; growth is associated with a change in orientation of the auditory tube (from horizontal to angled inferiorly) and an increase in the size of its lumen; both factors may contribute to decreased incidence of Otitis media.

B. **Auditory ossicles** - from lateral to medial: **malleus** (hammer), **incus** (anvil) and **stapes** (stirrup); ossicles amplify effect of vibration; in addition, Tympanic membrane has 15-20 times greater area than footplate of stapes; this increases force per unit area and helps transmit sound vibrations from air to fluid in inner ear (impedance matching).

Otoscope view: Handle malleus is attached to upper half of Tympanic membrane; malleus is supported by ligaments linking it to wall of Tympanic cavity; part of Tympanic membrane surrounding handle is tense (pars tensa); upper end is less tense (pars flaccida)

C. Muscles

1. **Tensor tympani muscle** - origin - canal in anterior wall; insertion - handle of malleus; innervation - V3

2. **Stapedius muscle** - origin - posterior wall (landmark is pyramid); insertion - neck of stapes; innervation - VII

Actions - Both muscles act to dampen movements of ossicles (decrease intensity of sound); tensor also makes Tympanic membrane tighter; prevents damage to inner ear; **paralysis of muscles produces hyperacousia (sounds seem too loud, Bell's palsy)**.

D. Innervation - **Tympanic nerve** - **Visceral Sensory** (GVA, imprecise sensation) branch of **IX** that enters Tympanic cavity). Nerve forms Tympanic plexus that also innervates mastoid air sinus and auditory tube; can give rise to Lesser Petrosal nerve (to Parotid Gland).

Clinical Note: Damage Chorda tympani (branch of VII) - Chorda tympani has no function in middle ear; it provides taste to anterior 2/3 of tongue, Parasympathetics to Submandibular ganglion; however, it leaves facial canal and passes through Tympanic cavity and crosses over upper end of handle of malleus before exiting via petrotympanic fissure; <u>if Tympanic membrane is pierced, can damage Chorda tympani and lose taste to anterior tongue</u> on that side; this fact may have baffled early physicians and patients.