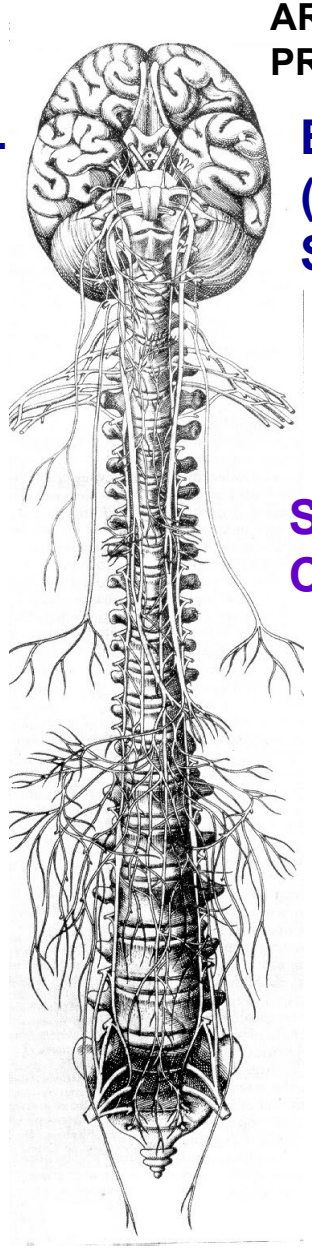
CRANIAL NERVES

ARISE FROM, PROJECT TO

CRANIAL NERVES

BRAIN (BRAIN-STEM)



SPINAL NERVES

SPINAL CORD

OVERVIEW: CRANIAL NERVES

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

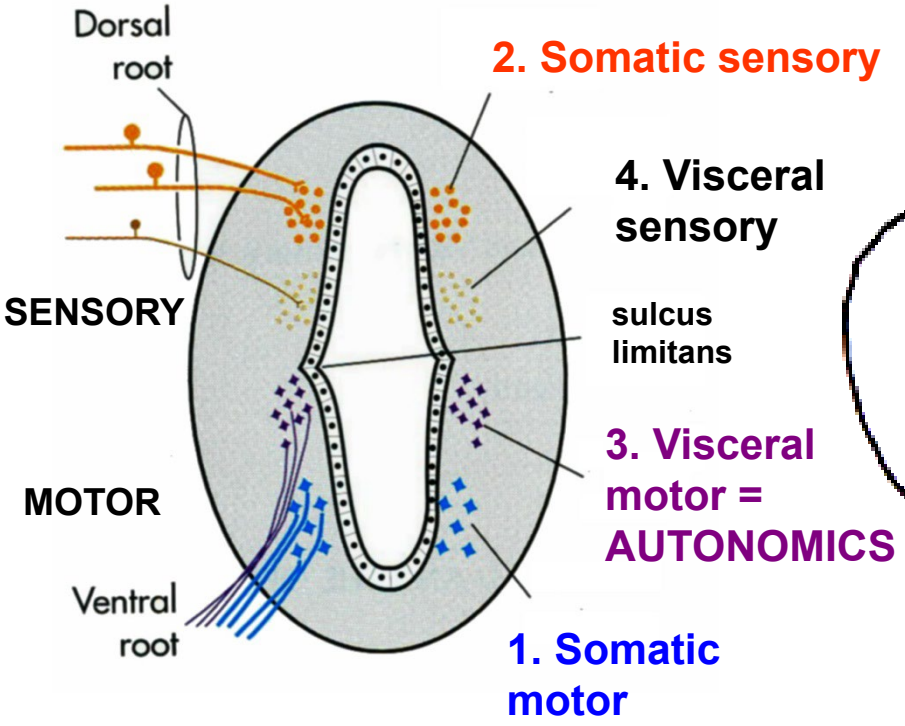
B. Contain types of similar to those found in spinal nerves; ex. sensory axons to skin.

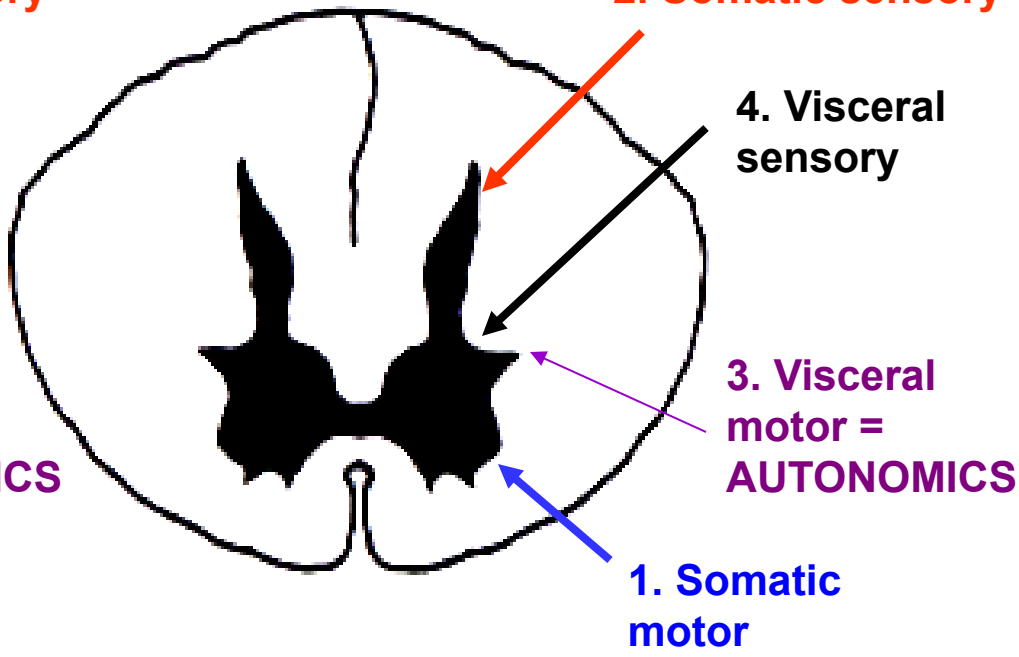
C. Contain types of neurons not found in spinal nerves; ex. taste fibers.

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

E. To analyze types of neurons in different cranial nerves, system of classification of types of neurons.

WHY DO YOU NEED TO KNOW THIS? CLASSIFICATION IS REFLECTED IN CENTRAL NERVOUS SYSTEM





Nervous system forms as a Neural Tube; cells form groups (columns); sensory dorsal, motor ventral; different types of neurons form columns that develop to adult locations

2) CLASSIFICATION OF INNERVATION

Seven types of neurons - some are the same types of neurons as are found in spinal nerves; others are only found in cranial nerves

A. Same types as spinal nerves

1. **Somatic motor** - Voluntary skeletal muscles (derived from somites)

2. **Somatic sensory -** Precise sensation to skin joints, muscle, tendon receptors (in head, also nasal and oral cavities)

3. **Visceral motor** (efferents) = AUTONOMICS - smooth muscles (including arrector pilae muscles of skin), blood vessels; secretomotor to glands.

4. **Visceral sensory** - Imprecise sensation from gut, blood vessels, glands, internal organs (in head, pharynx which is rostral end of gut)

2) CLASSIFICATION OF INNERVATION

B. Only in cranial nerves

5. **Special senses** - vision, hearing (auditory), balance (vestibular apparatus)

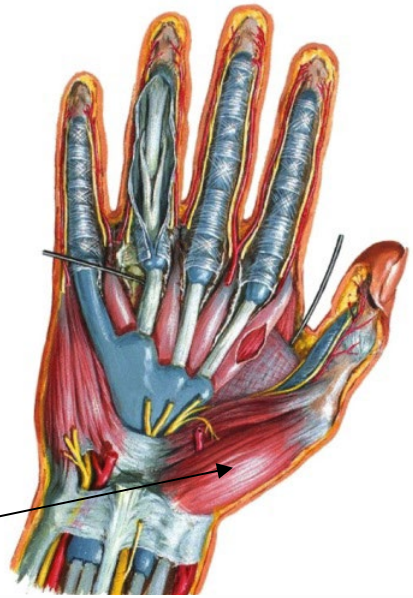
6. **Chemical senses** - taste and smell

7. **Branchiomotor** - Voluntary skeletal muscles from branchial arches

SOME TYPES OF NEURONS ARE SIMILAR TO THOSE FOUND IN THE SPINAL CORD

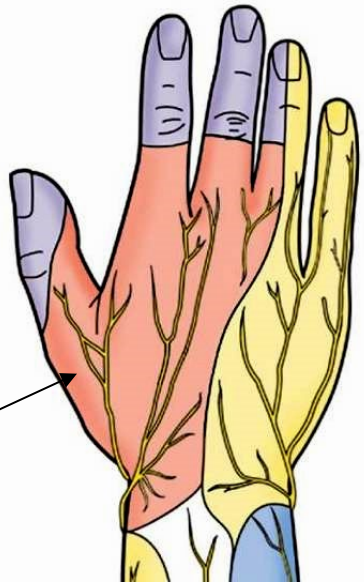
SOMATIC MOTOR - motor axons to skeletal muscles

ex. muscles of hand



SOMATIC SENSORY - sensory axons to skin ; also joints, body position

ex. skin of hand



SOMATIC NERVOUS SYSTEM

E. Major divisions of nervous system - terminology based upon function but very confusing

1. Somatic Nervous system - considered voluntary, conscious part of nervous system

a. Somatic Motor (Efferents) - control skeletal muscle; voluntary activities (ex. limb or eye movements, walking); conscious actions.

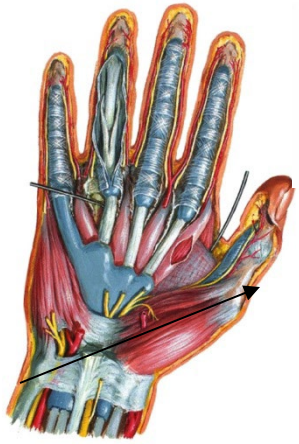
b. Somatic Sensory (Afferents) - sensory neurons that innervate skin, joints; provide precise conscious sensation of touch, pressure, pain etc to skin; also provide sense of body position (prioception).

THESE TYPES OF NEURONS ARE ALSO FOUND IN CRANIAL NERVES

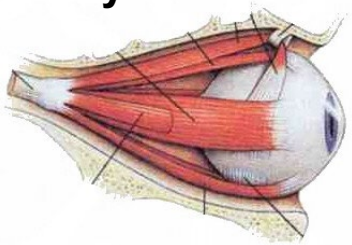
IN HEAD

SOMATIC MOTOR - motor axons to skeletal muscles

ex. muscles of hand



eye muscles



move eyes

muscles of tongue

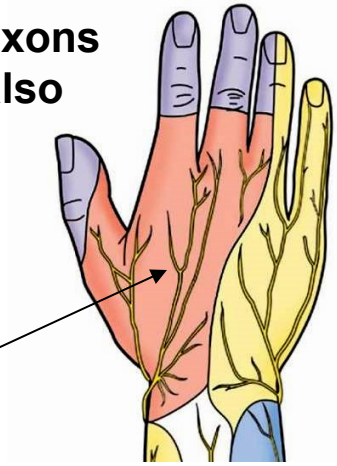
move tongue

SOMATIC MOTOR IN HEAD - limited to two groups

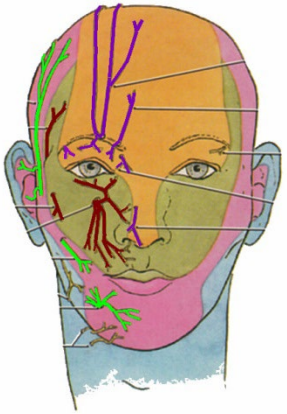
1. EYE MUSCLES - extraocular muscles that move eye (and lift upper eyelid)
2. MUSCLES OF TONGUE

SOMATIC SENSORY- sensory axons to skin ; also joints, body position

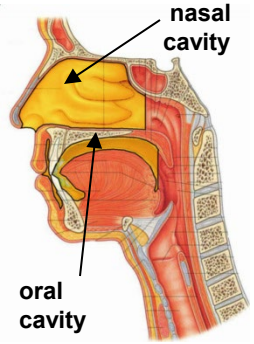
ex. skin of hand



skin of head

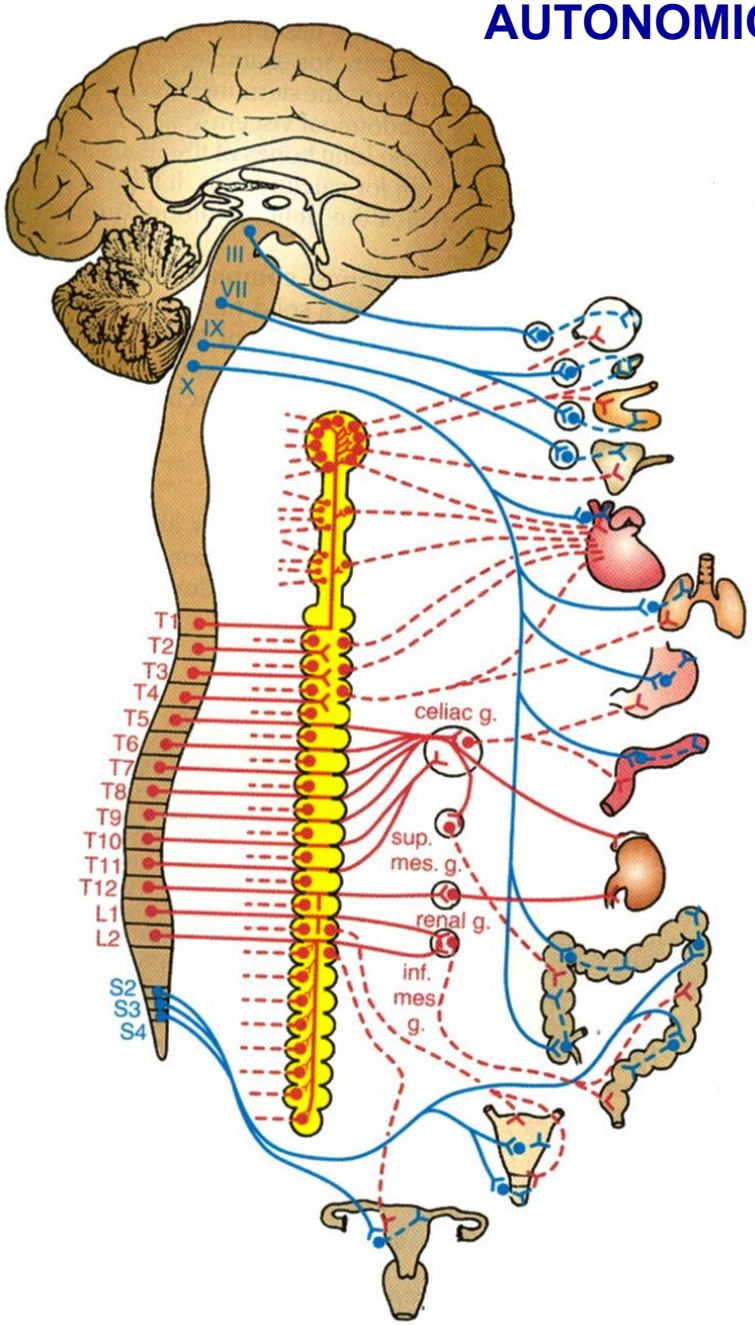


oral, nasal cavities



SOMATIC SENSORY IN HEAD - mostly in CN V - precise sensation sensory to skin ; also oral cavity (inside mouth), nasal cavity (inside nose)

AUTONOMIC = VISCERAL NERVOUS SYSTEM

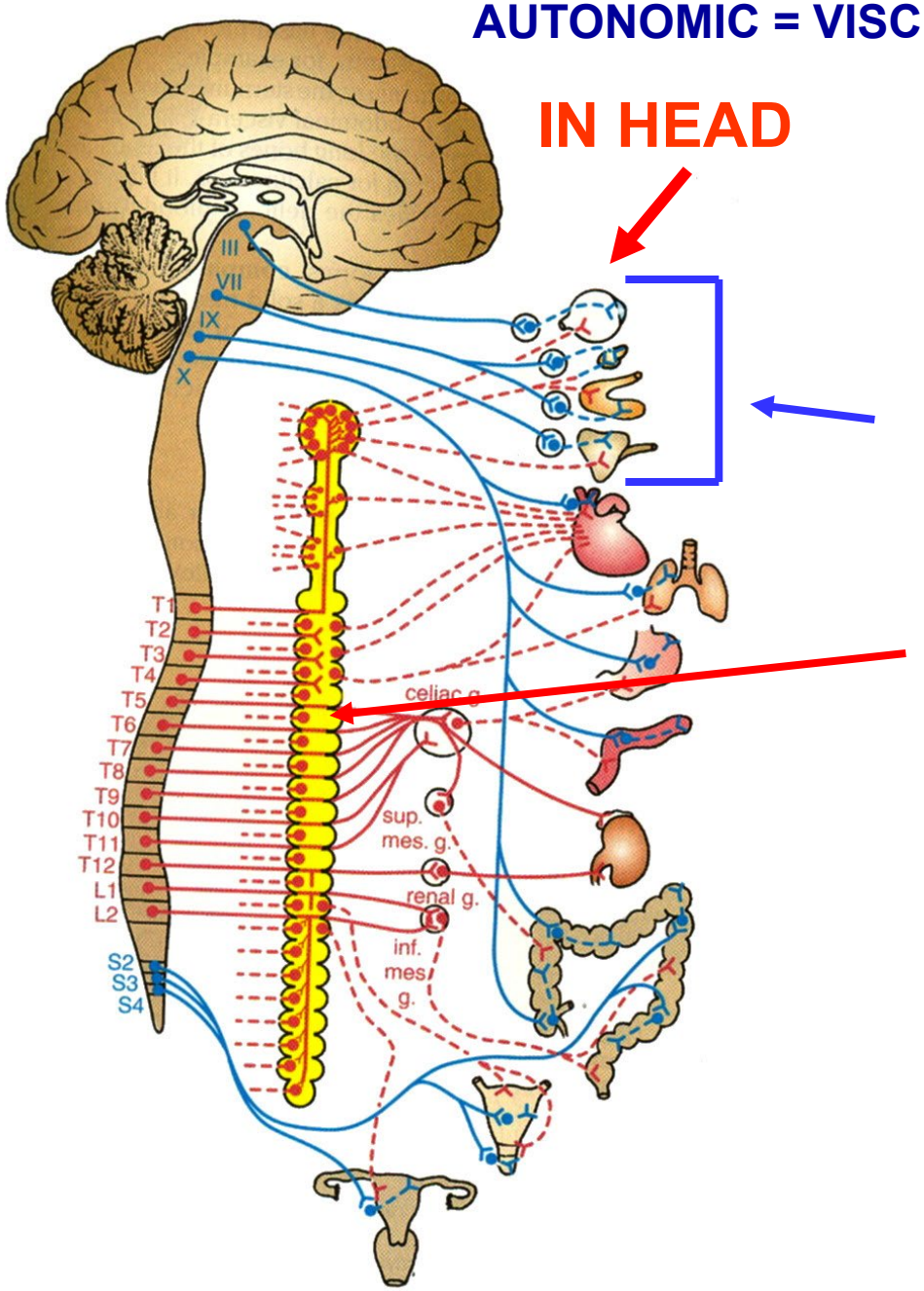


Autonomic Nervous system = Visceral nervous system - involuntary, unconscious part of nervous system

a. **Visceral Motor (parasympathetic and sympathetic efferents)** - control smooth and cardiac muscle, glands and internal organs; largely **unconscious actions (autonomic means self-regulating or automatic**).

b. **Visceral Sensory (afferents)** - sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation** and dull sense of pressure, pain, etc.

AUTONOMIC = VISCERAL NERVOUS SYSTEM IN HEAD



VISCERAL MOTOR Autonomic Nervous system = Visceral nervous system - involuntary, unconscious part of nervous system

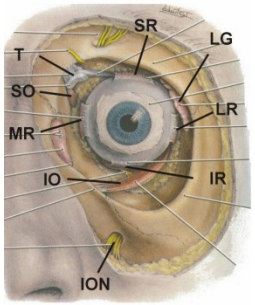
a. <u>Parasympathetic (CRANIO-SACRAL outflow - IN CRANIAL NERVES)</u> - <u>specific pathway in four cranial nerves</u>

b. <u>Sympathetics - not in cranial nerves</u> - come from spinal cord - **THORACO-LUMBAR outflow**

c. **<u>Visceral Afferents</u>** - (not shown in diagram); sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation and dull sense of pressure, pain, etc. - follow parasympathetic and sympathetic - <u>in HEAD, some specific</u>**.

SOME TYPES OF NEURONS ARE ONLY FOUND IN THE HEAD (IN CRANIAL NERVES)

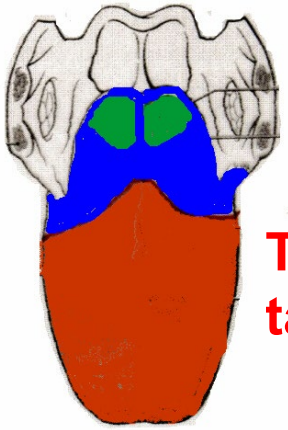
Special Senses - vision, audition, vestibular



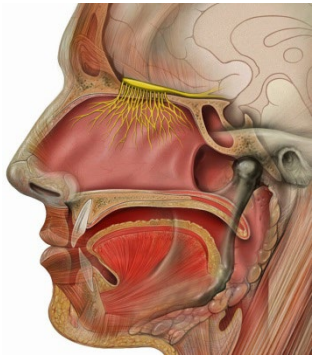
EYE

EAR

Chemical senses: taste and smell



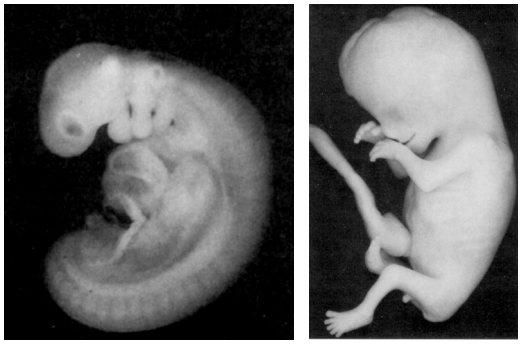
TONGUE - taste



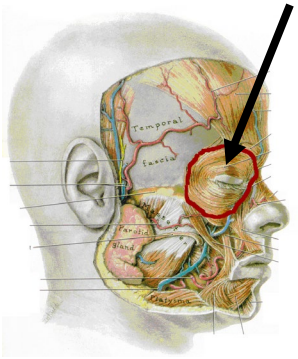
NOSE - smell

Branchiomotor - Skeletal muscles derived from branchial (gill) arches

FISH-LIKE → HUMAN

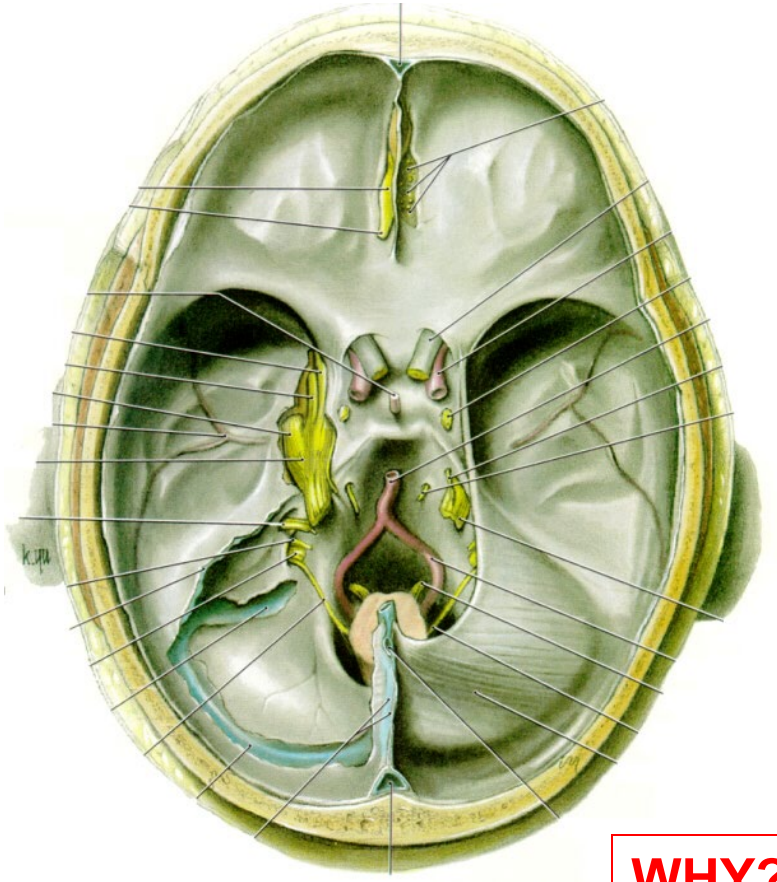


SKELETAL MUSCLES



HOW ARE THESE TYPES OF NEURONS DISTRIBUTED IN CRANIAL NERVES?

CRANIAL NERVES IN CRANIAL CAVITY



TYPES OF NEURONS

1. Somatic motor
2. Somatic sensory
3. Visceral motor
4. Visceral sensory
5. Special senses
6. Chemical senses
7. Branchiomotor

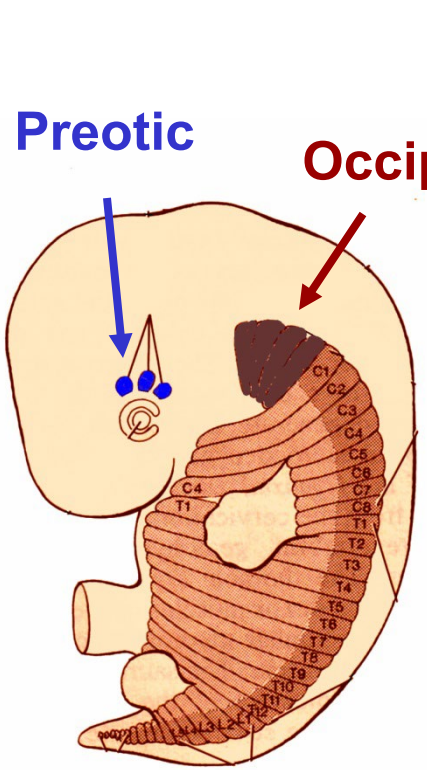
CRANIAL NERVES

I. Olfactory
II. Optic
III. Oculomotor
IV. Trochlear
V. Trigeminal
VI. Abducens
VII. Facial
VIII. Vestibulo-cochlear
IX. Glossopharyngeal
X. Vagus
XI. Accessory
XII. Hypoglossal

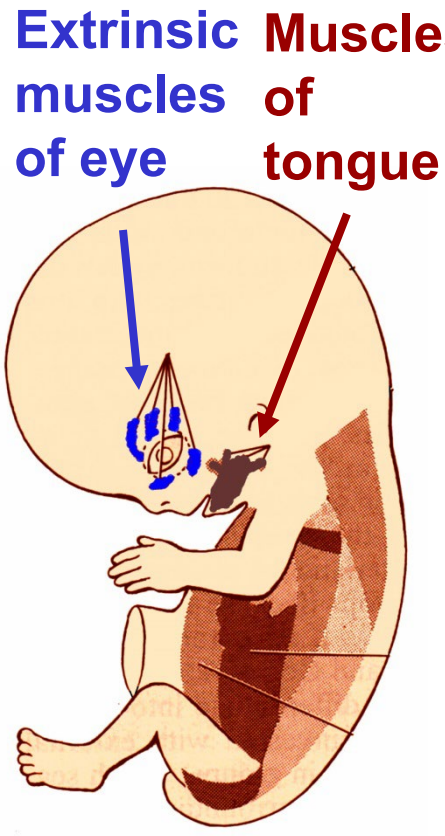
WHY? TYPES OF NEURONS CORRESPOND TO COLUMNS OF NUCLEI IN THE BRAINSTEM

SOMATIC MOTOR

motor to skeletal muscle derived from somites (myotomes) ; only two groups in head



6 weeks



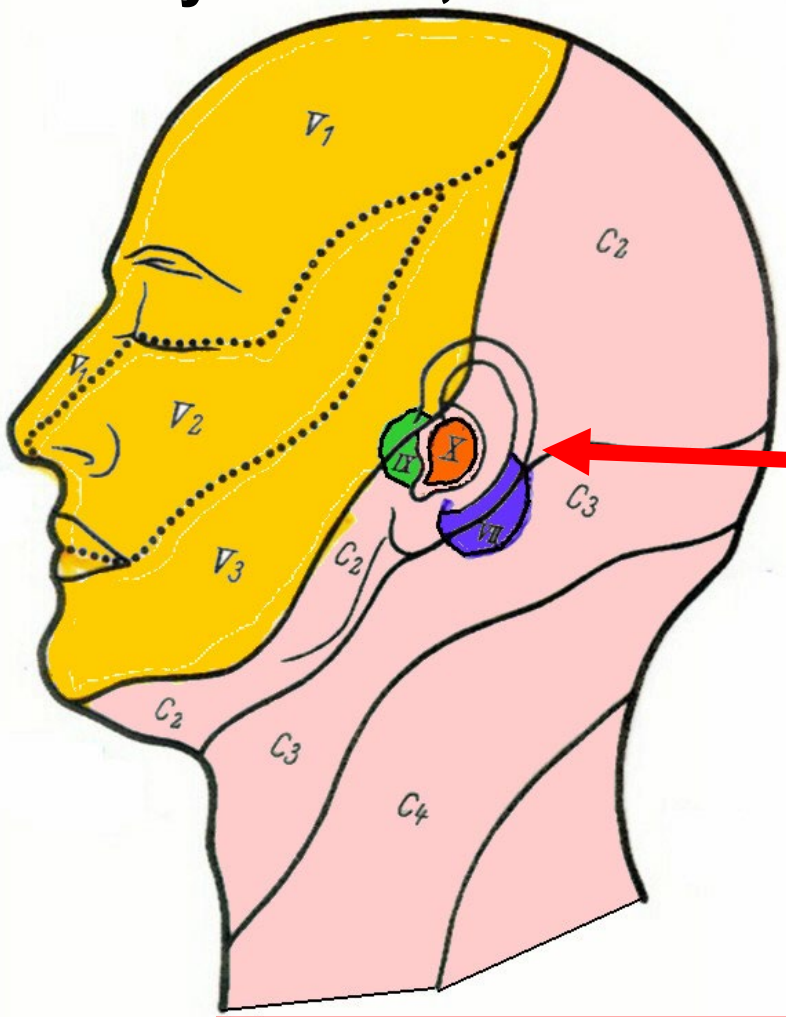
8 weeks

1) Preotic somites (somitomeres) form extrinsic muscles of <u>EYE</u>: in CN
III - Oculomotor,
IV - Trochlear,
VI - Abducens.

2) <u>Occipital somites</u> form muscles of <u>TONGUE</u> - in CN XII Hypoglossal N.

SOMATIC SENSORY

sensory to skin, ORAL cavity, NASAL cavity, joints, muscles

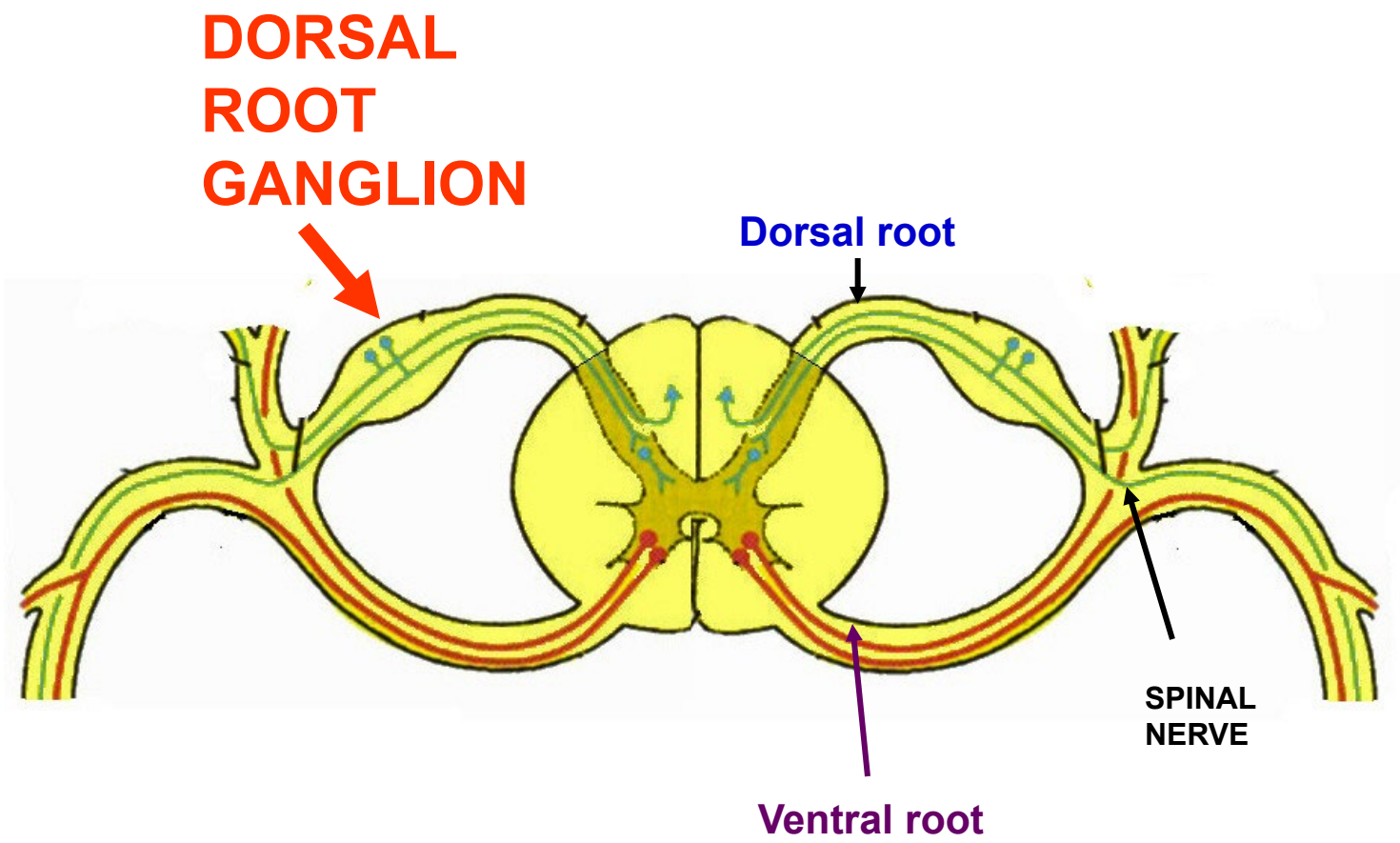


ALMOST ALL TRIGEMINAL V
EXCEPTION:
SKIN OF OUTER EAR – <u>FOUR CRANIAL NERVES</u>
1) V - TRIGEMINAL
2) VII- FACIAL
3) IX - GLOSSO-PHARYNGEAL
4) X - VAGUS

**

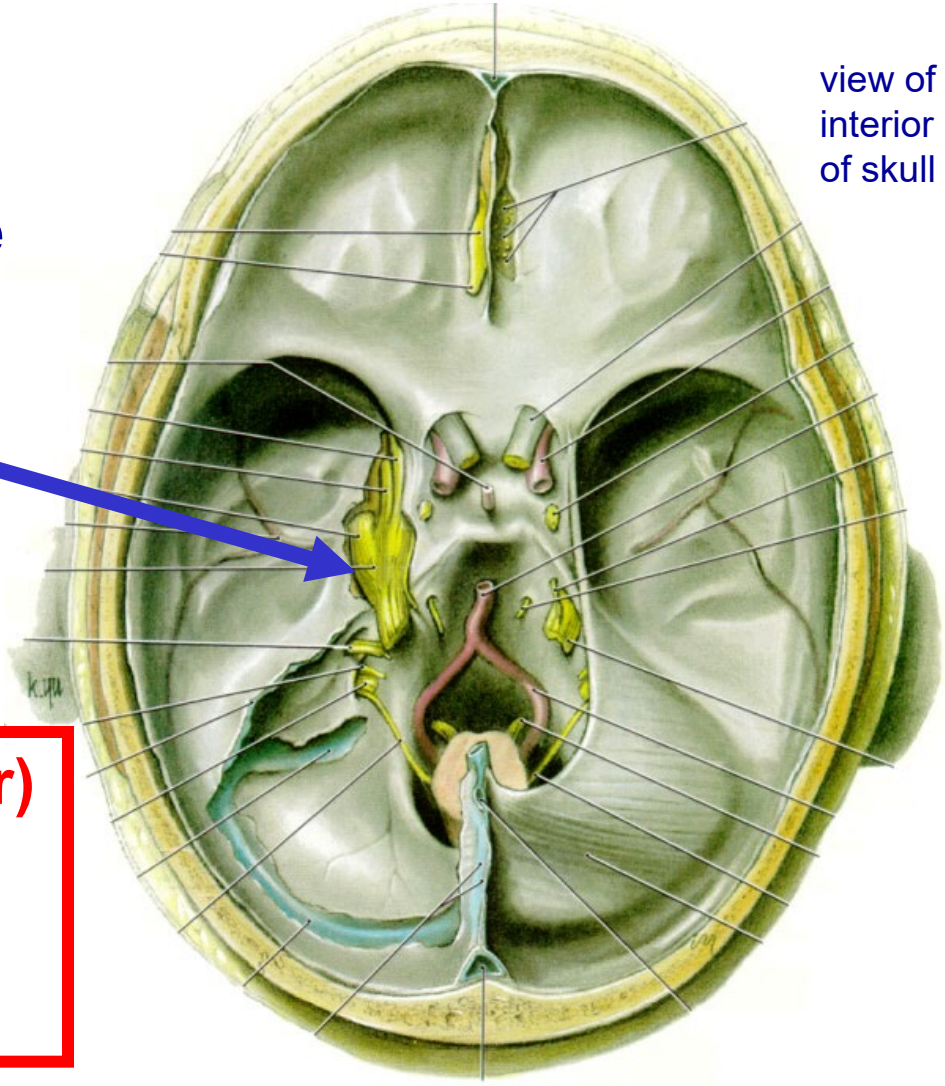
BELL'S PALSY (VII) - PARALYSIS OF FACIAL MUSCLES; IN RECOVERY, PATIENTS COMPLAIN OF EARACHES

SENSORY CELL BODIES IN DORSAL ROOT GANGLIA IN SPINAL CORD



SENSORY GANGLIA ARE ATTACHED TO CRANIAL NERVES

- cell bodies of sensory neurons in Trigeminal Nerve are in Trigeminal (Semilunar) Ganglion



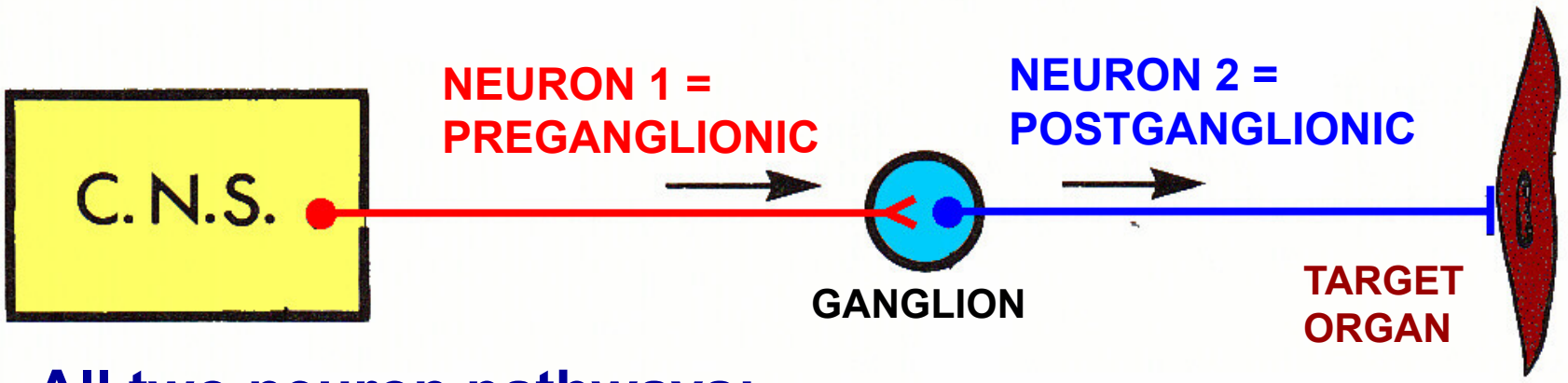
view of interior of skull

Clinical - Mass (ex. tumor) pressing on Trigeminal Ganglion can produce numbness, intense pain

**

Cell bodies of sensory neurons in VII (Facial Nerve) in Geniculate Ganglion

VISCERAL MOTOR = AUTONOMIC NERVOUS SYSTEM



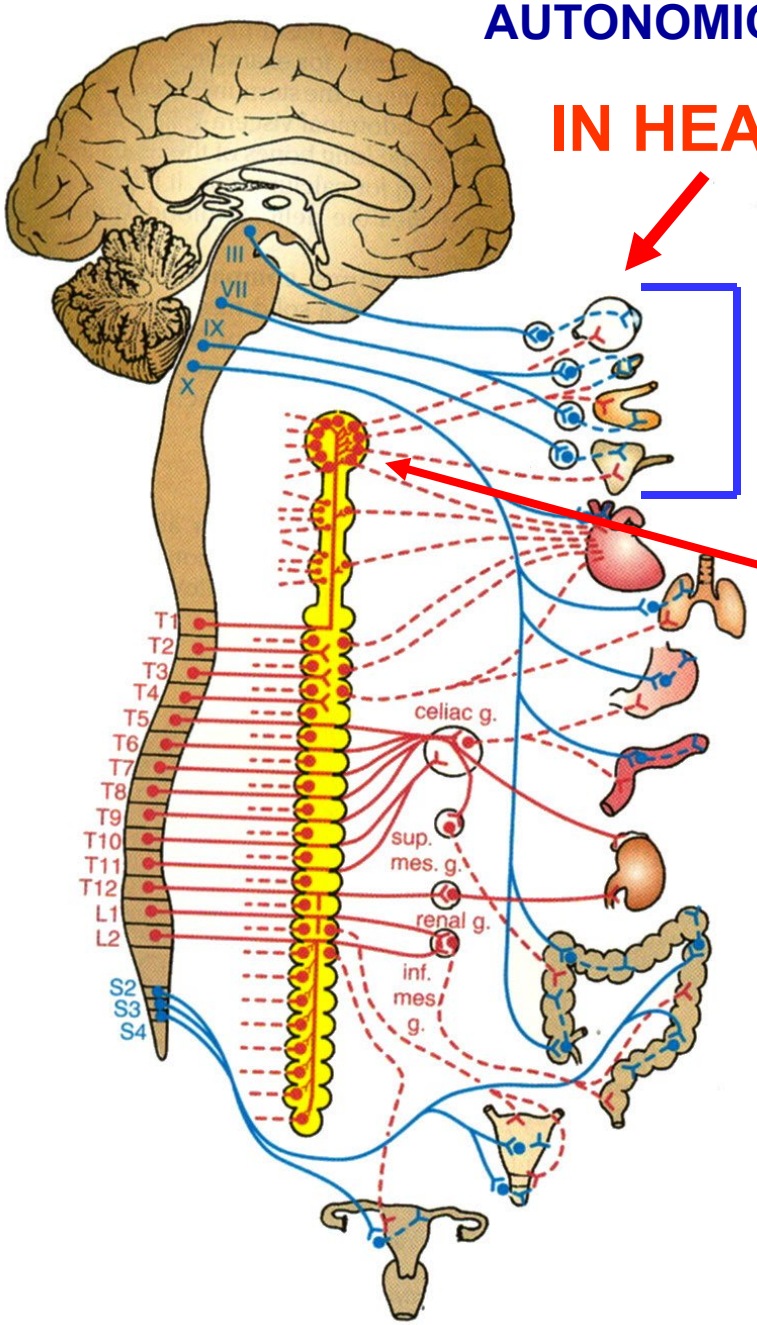
All two neuron pathways:

1) Neuron 1 = Preganglionic neuron - cell body in CNS; axon leaves CNS and synapses in autonomic ganglion

2) Neuron 2 = Post ganglionic neuron - cell body in autonomic ganglion; axon goes to target organ

note: Sympathetic - ganglia close to vertebrae
Parasympathetic - ganglia close to target organ

AUTONOMIC = VISCERAL NERVOUS SYSTEM IN HEAD



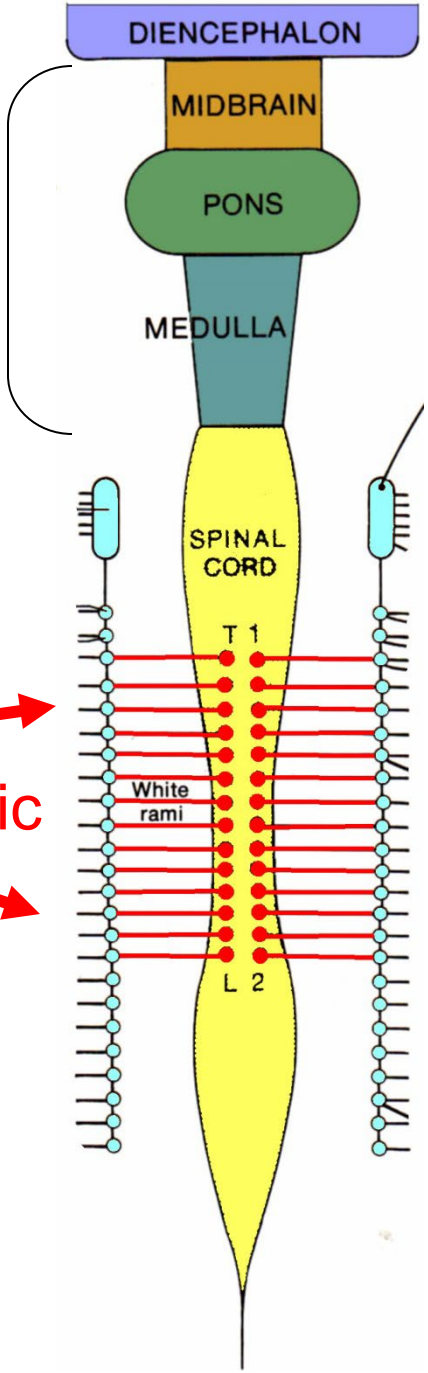
VISCERAL MOTOR Autonomic Nervous system = Visceral nervous system - involuntary, unconscious part of nervous system

a. <u>Parasympathetic (Cranio-sacral outflow)</u> - <u>in four cranial nerves</u>

b. Sympathetics - not in cranial nerves - come from spinal cord - Thoraco-lumbar outflow

c. **<u>Visceral Afferents</u>** - (not shown in diagram); sensory neurons that innervate internal organs, blood vessels; only provide imprecise localization of sensation and dull sense of pressure, pain, etc. - **follow parasympathetic and sympathetic** - in HEAD, some specific (see below).

BRAIN - parts of brainstem



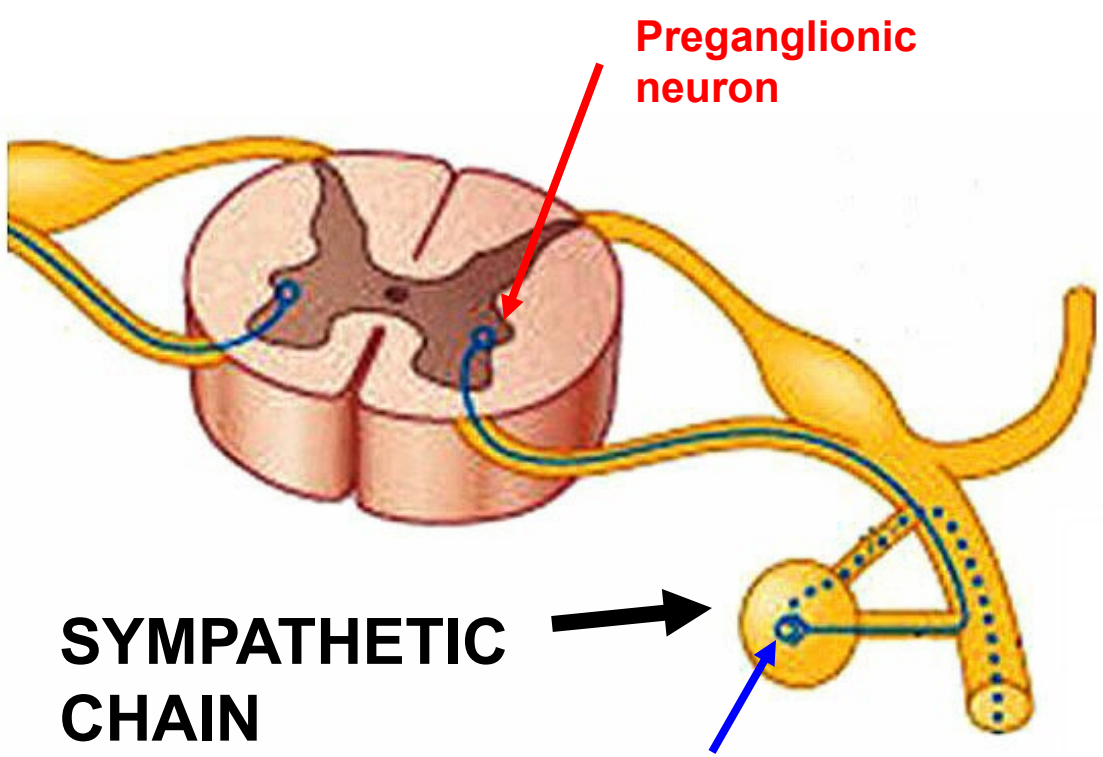
Sympathetic outflow (preganglionic neurons)

SYMPATHETIC AUTONOMICS

Sympathetics - not in cranial nerves - come from spinal cord - All preganglionic sympathetics come out spinal cord at **Thoracic and Lumbar levels**

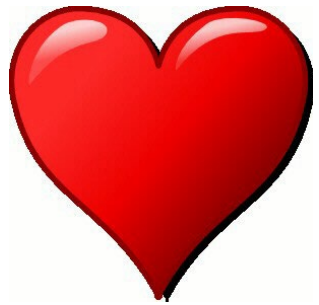
To supply rest of body - some preganglionic **fibers ascend or descend in sympathetic chain**

SYMPATHETICS IN THORAX, ABDOMEN

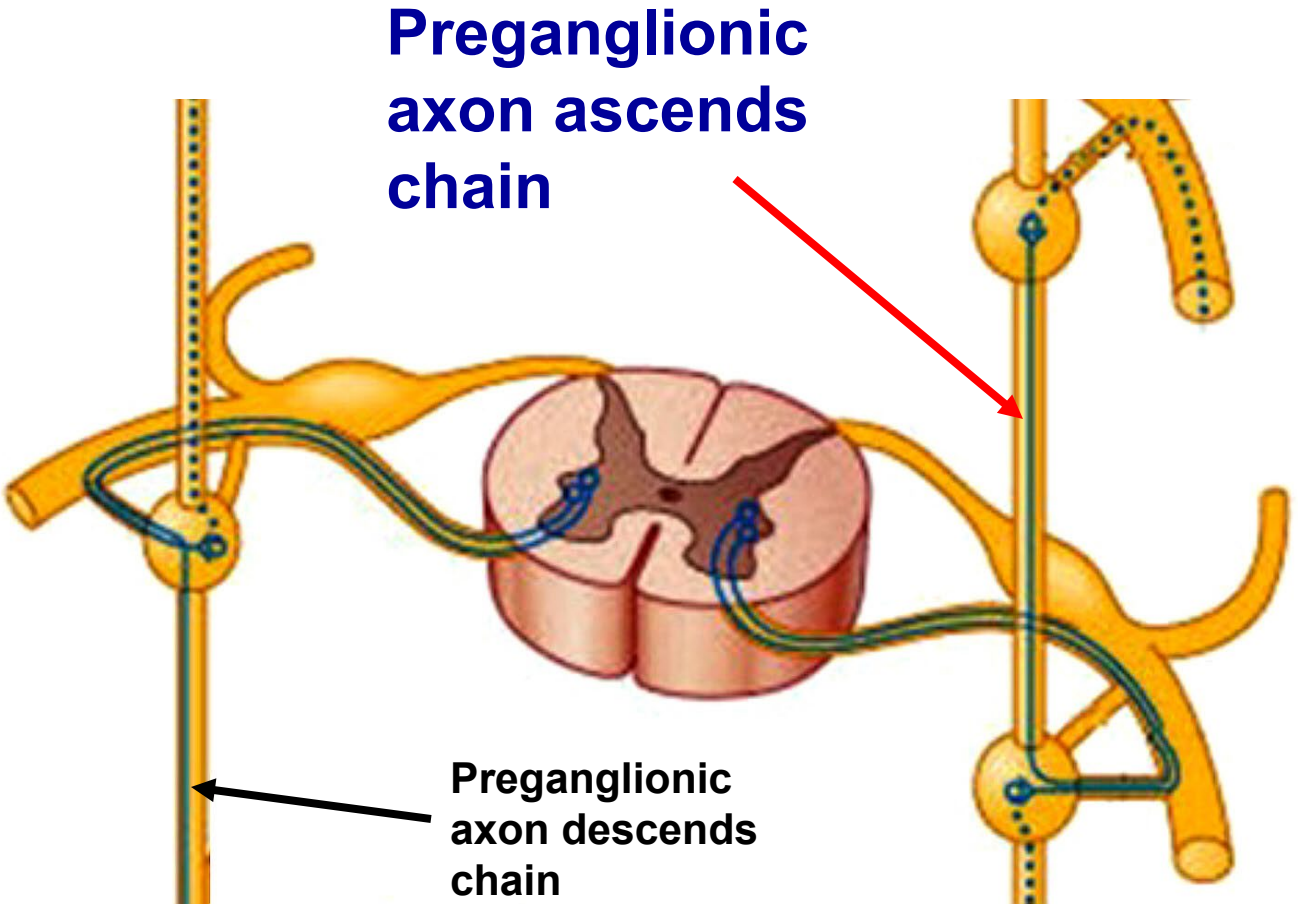


Thoraco-Lumbar T1-T12, L1, L2

Heart



SYMPATHETICS TO HEAD



PATHWAY TO HEAD -
Preganglionic neuron in spinal cord at T1, T2
- leaves and ascends sympathetic chain

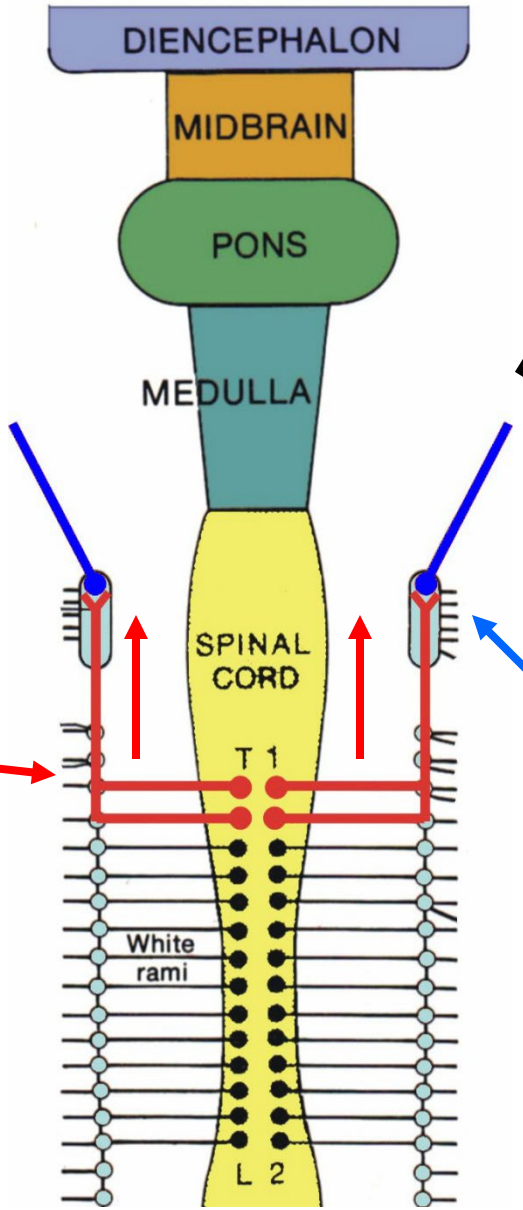
SYMPATHETICS CAN ALSO COME OUT AND ASCEND OR DESCEND SYMPATHETIC CHAIN TO TERMINATE IN OTHER GANGLIA

SYMPATHETICS TO HEAD

PATHWAY TO HEAD -

1) <u>Neuron 1 (Preganglionic neuron)</u> in spinal cord at T1, T2

- leaves and ascends sympathetic chain



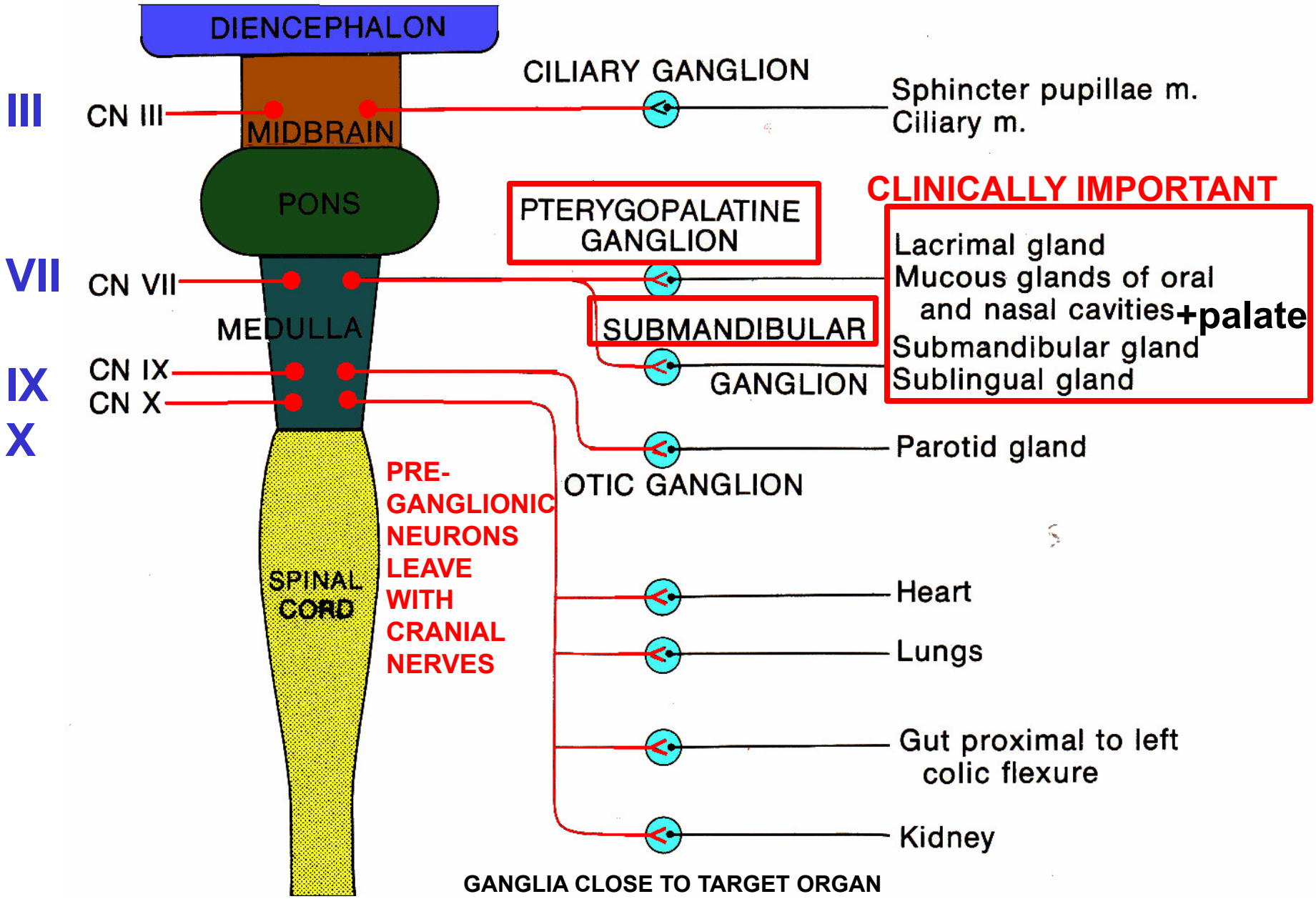
to Target Organ

Joins Plexus on Internal and External Carotid Arteries

in mostly Unnamed branches

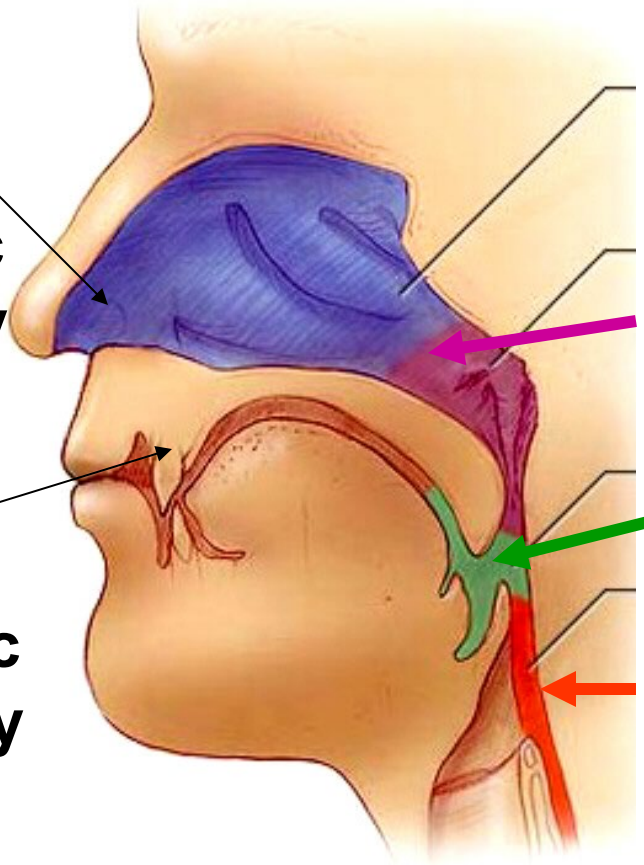
2) <u>Neuron 2 (Postganglionic neuron)</u> In <u>Superior Cervical Ganglia</u>

PARASYMPATHETICS - IN CRANIAL NERVES



VISCERAL SENSORY

Sensory to Pharynx and derivatives



All Pharynx is
Visceral Sensory
In 3 Cranial Nerves

NASOPHARYNX - VII

OROPHARYNX - IX

LARYNGOPHARYNX - X

PHARYNX IS UPPER PART OF GI TRACT = VISCERAL

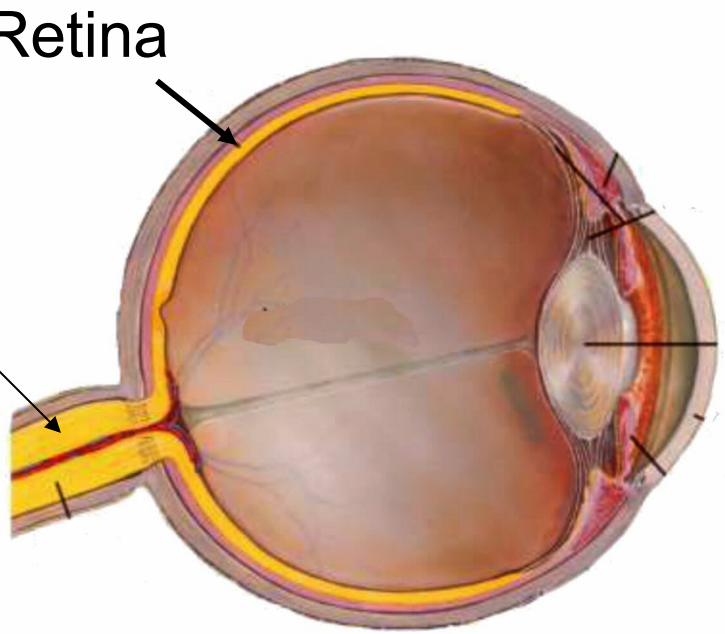
Note: Authors disagree on innervation of nasopharynx

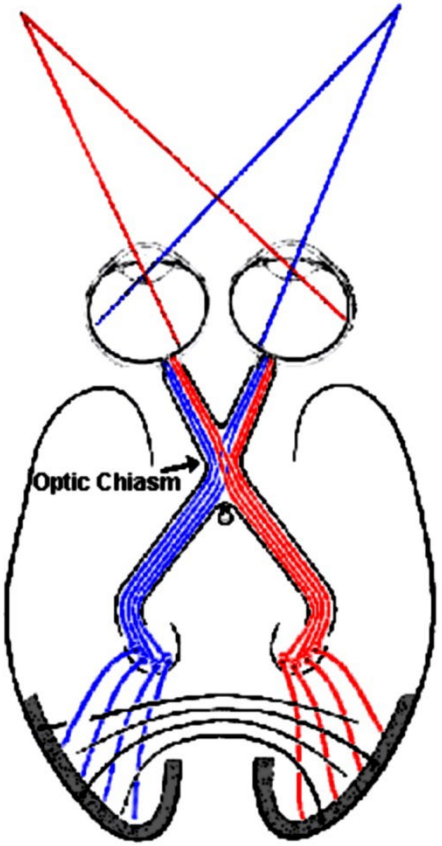
SPECIAL SENSES

Special senses only found in head - vision II, hearing and balance VIII

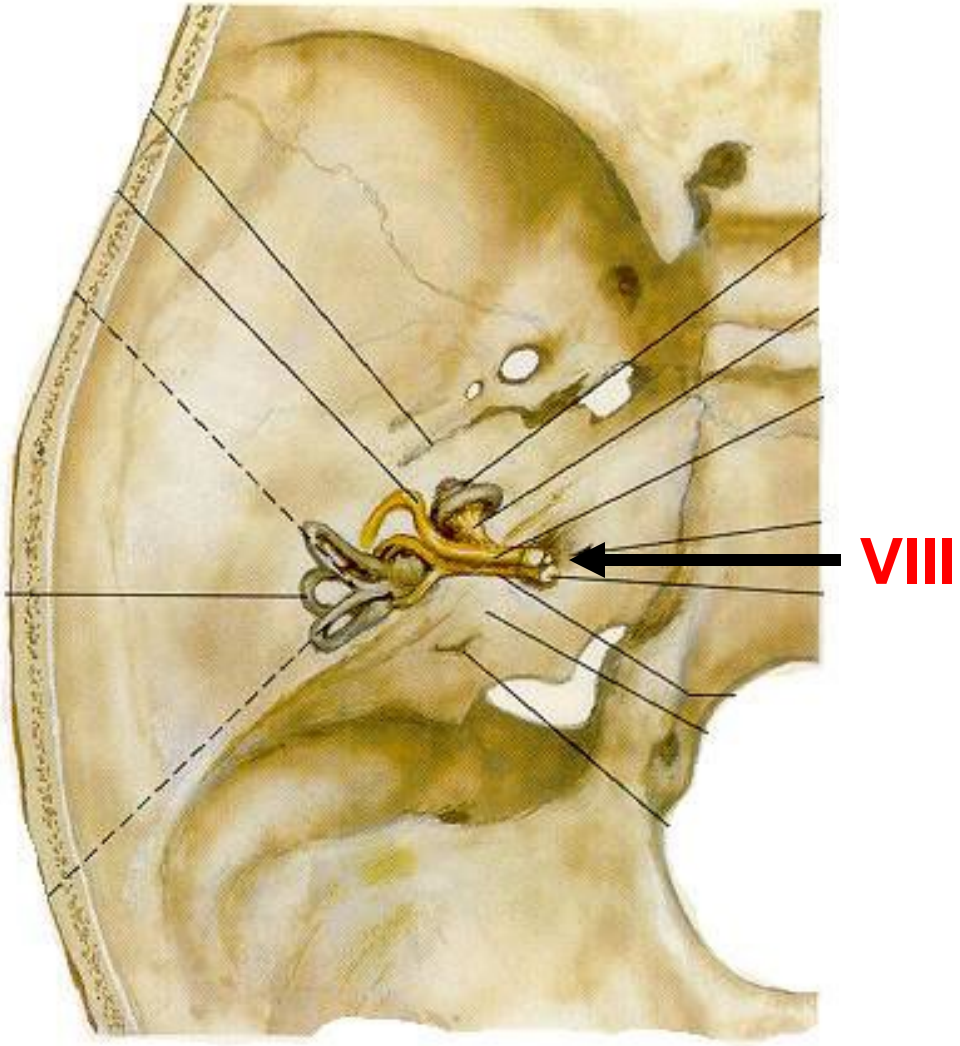
CN II- OPTIC NERVE

fibers cross at optic chiasm





SPECIAL SENSES



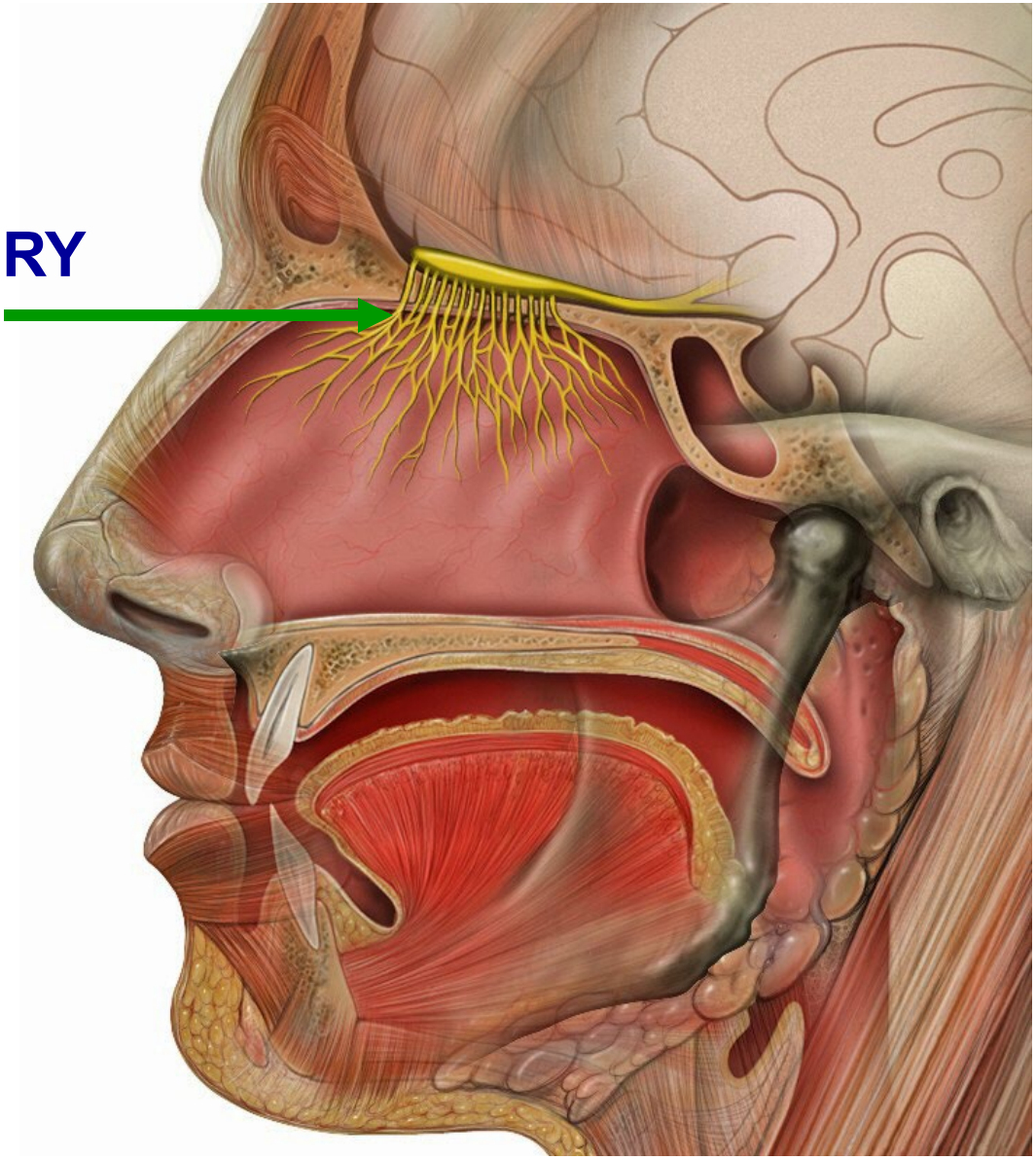
VIII - VESTIBULO-COCHLEAR

to 1) cochlea - <u>hearing</u>
2) semicircular canals - (vestibular apparatus) - <u>balance</u>

in petrous part of temporal bone

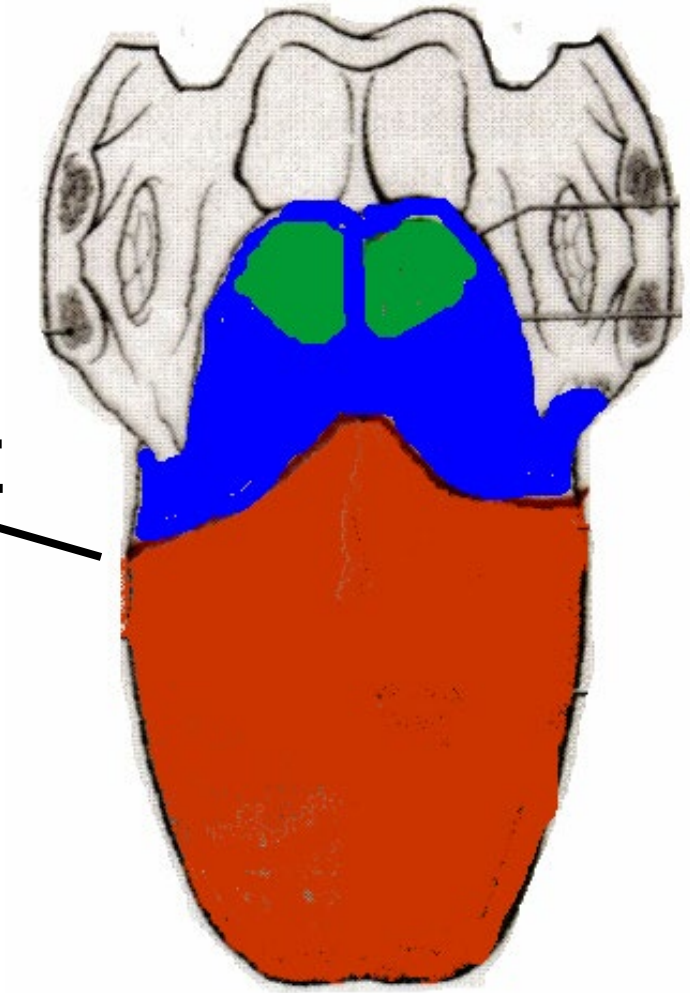
CHEMICAL SENSES - TASTE AND SMELL

I - OLFACTORY NERVE - SMELL



CHEMICAL SENSES - TASTE - in three cranial nerves

TONGUE



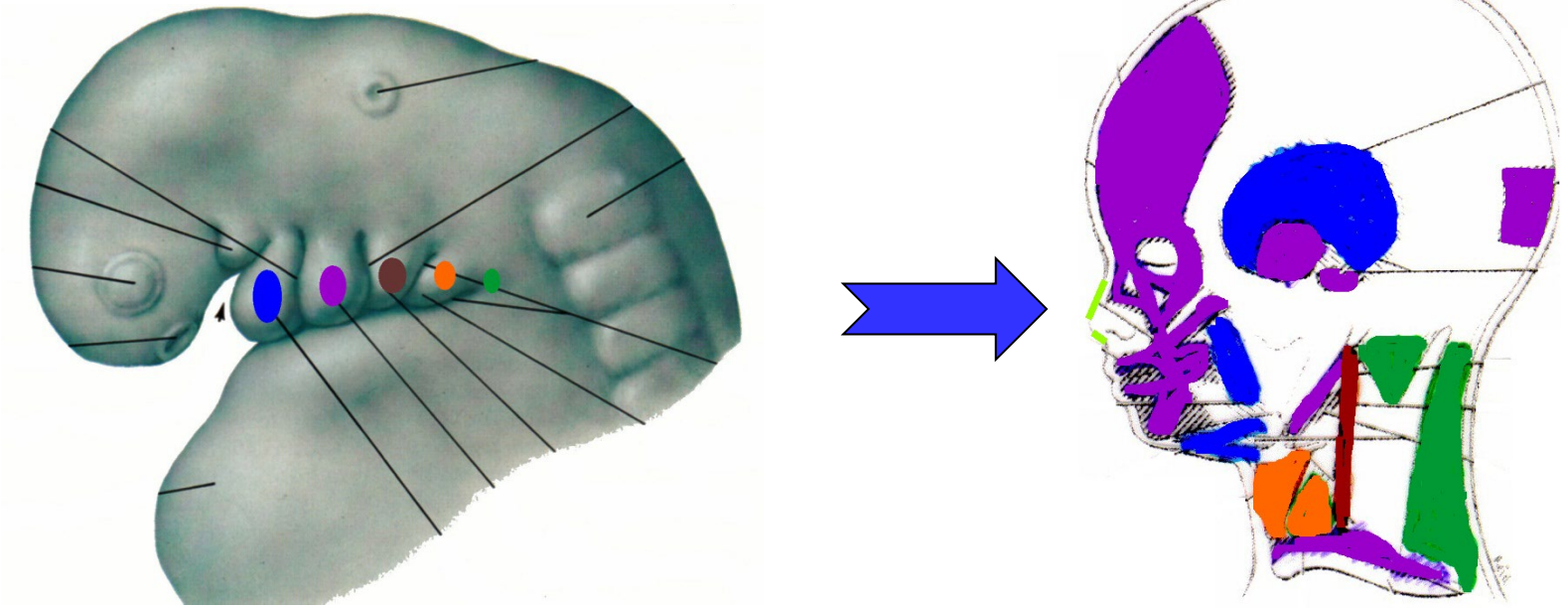
X - VAGUS -
ant. to epiglottis

IX - GLOSSO-PHARYNGEAL
post. 1/3 of tongue

VII - FACIAL -
ant. 2/3 of tongue

BRANCHIOMOTOR

- motor to <u>voluntary skeletal muscles derived from branchial arches</u>
- 'visceral' because develop in pharynx then migrate



First - Trigeminal V

Second - Facial VII

Third Glosso-pharyngeal IX

Fourth Vagus X

Sixth Accessory XI

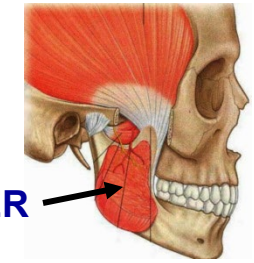
10) BRANCHIOMOTOR - voluntary motor to skeletal muscles of face, ear, pharynx and neck that are derived from branchial arches.

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

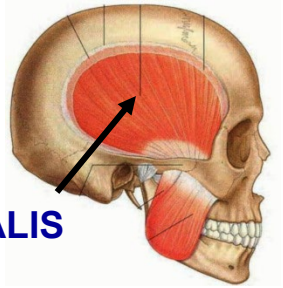
KNOW THIS FOR EXAMS (ALSO STEP 1)

V - TRIGEMINAL - BRANCHIOMOTOR

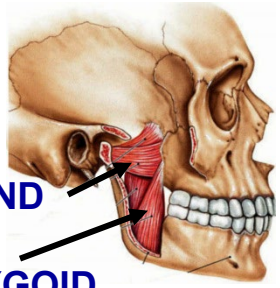
MUSCLES OF MASTICATION



MASSETER

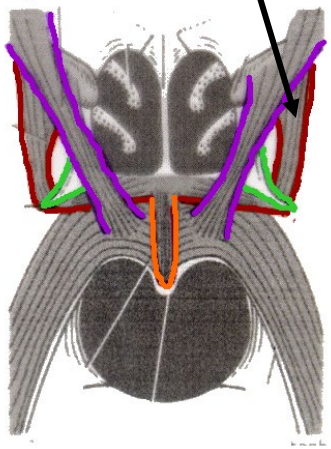


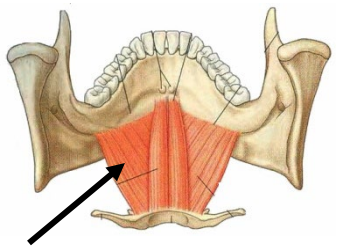
TEMPORALIS



LAT. AND MED. PTERYGOID

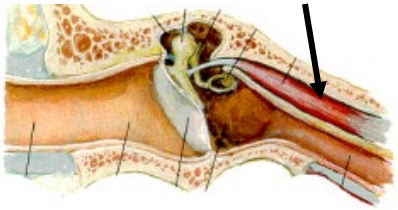
TENSOR PALATI - tenses palate in swallowing

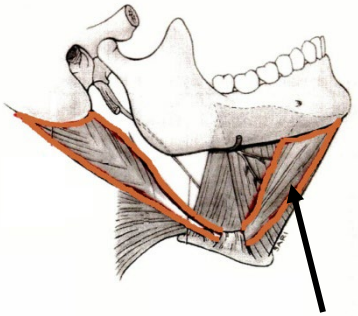




MYLOHYOID - raise floor of mouth in swallowing

TENSOR TYMPANI - dampen sound



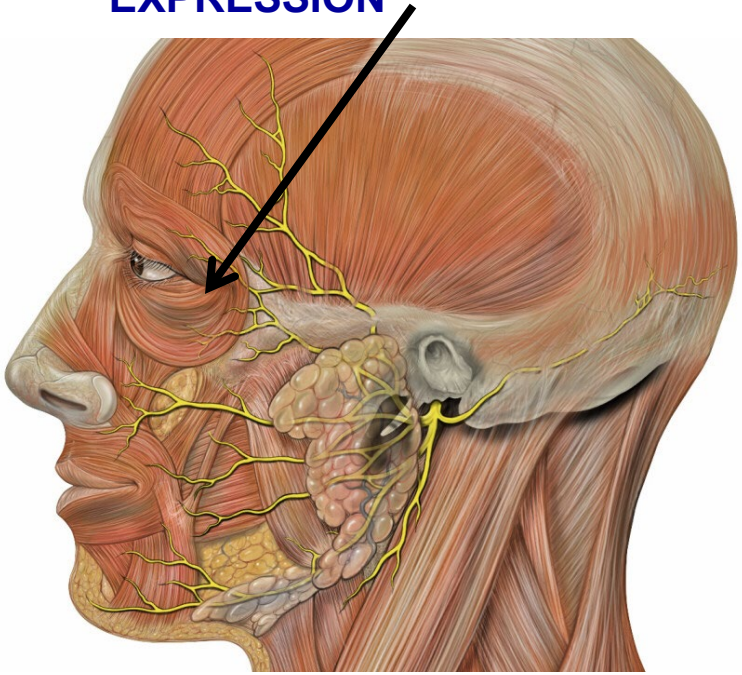


ANT. BELLY OF DIGASTRIC - opens mouth

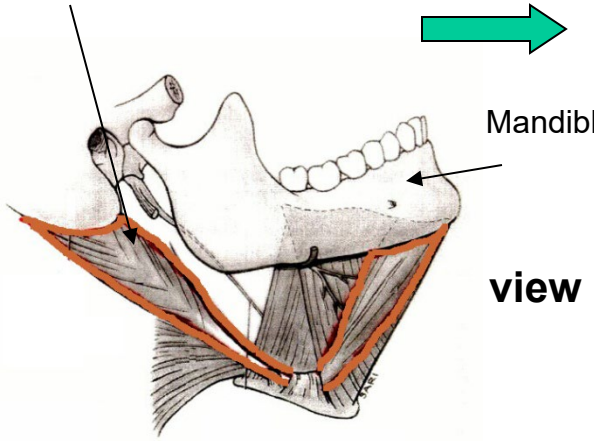
ACTIONS - MOST CLOSE MOUTH - MASSETER, TEMPORALIS, MED. PTERYGOID
OPEN MOUTH - LAT. PTERYGOID

VII BRANCHIOMOTOR

MUSCLES OF FACIAL EXPRESSION



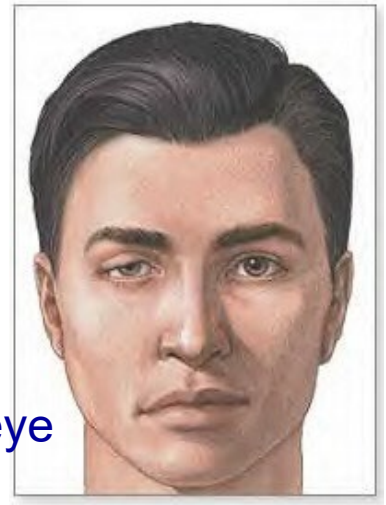
STYLOHYOID, POST. BELLY DIGASTRIC



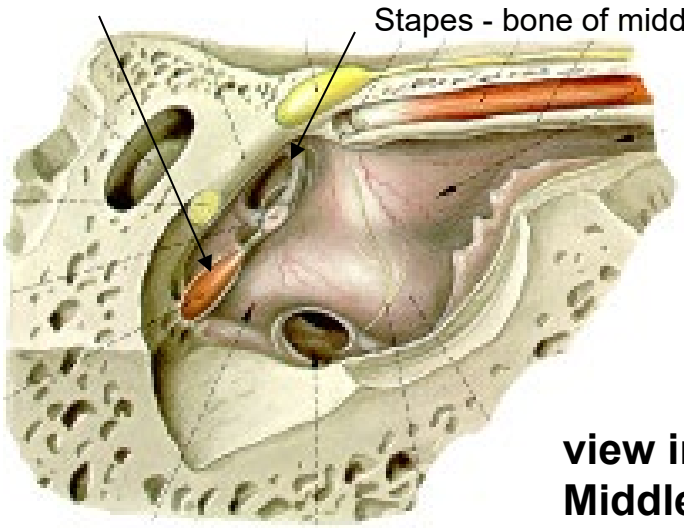
view of Neck

FACIAL PARALYSIS

sagging face
loss of naso-labial fold
inability to close eye

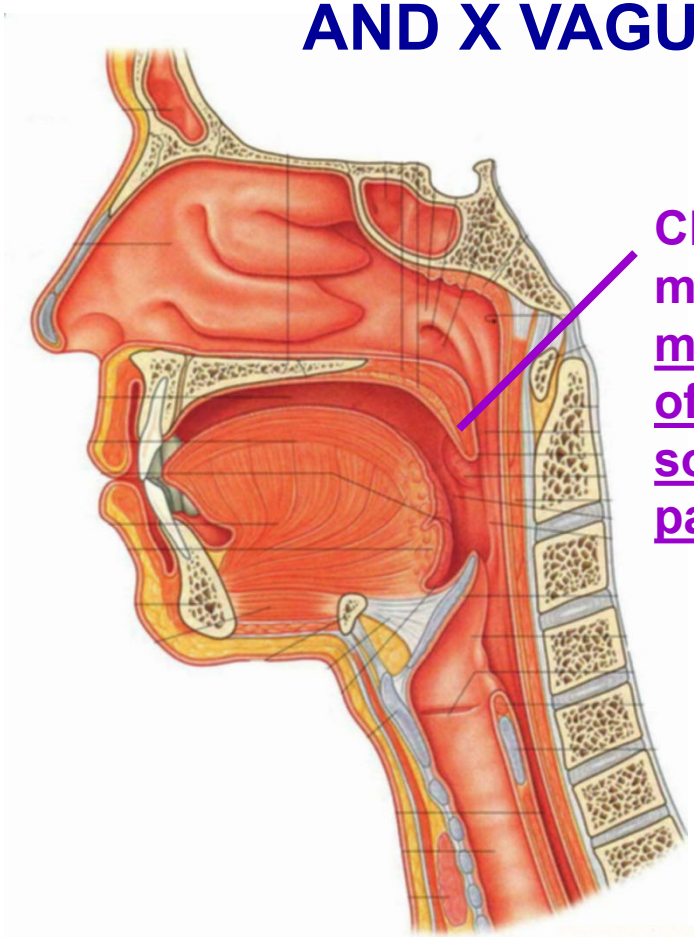


STAPEDIUS - dampens sound - DAMAGE HYPERCOUSIA - sounds seem too loud

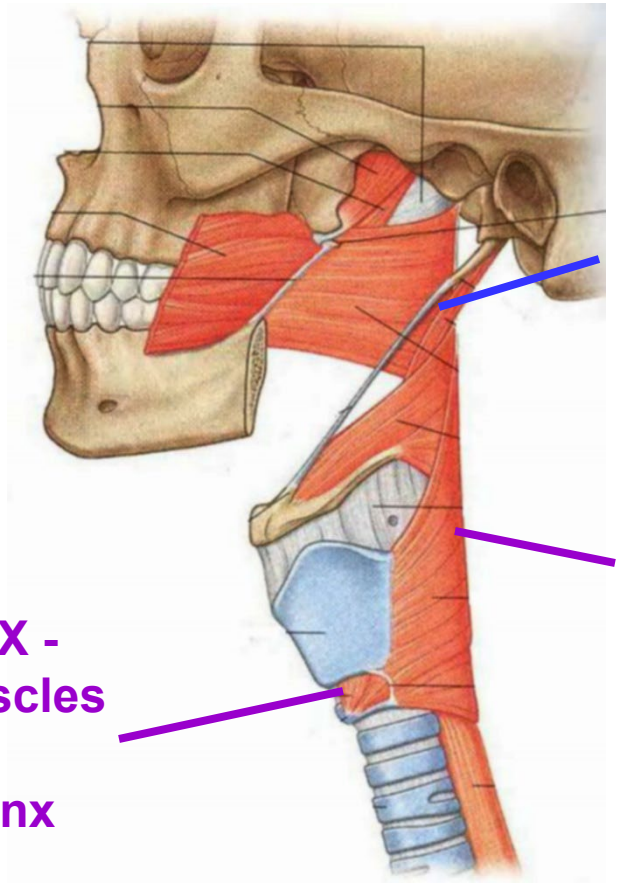


view inside Middle ear

BRANCHIOMOTOR - IX GLOSSOPHARYNGEAL AND X VAGUS



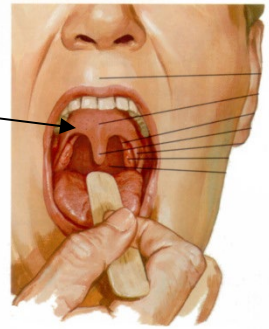
CN X - most muscles of soft palate



CN IX - stylo-pharyngeus

CN X - muscles of pharynx

CN X - muscles of larynx



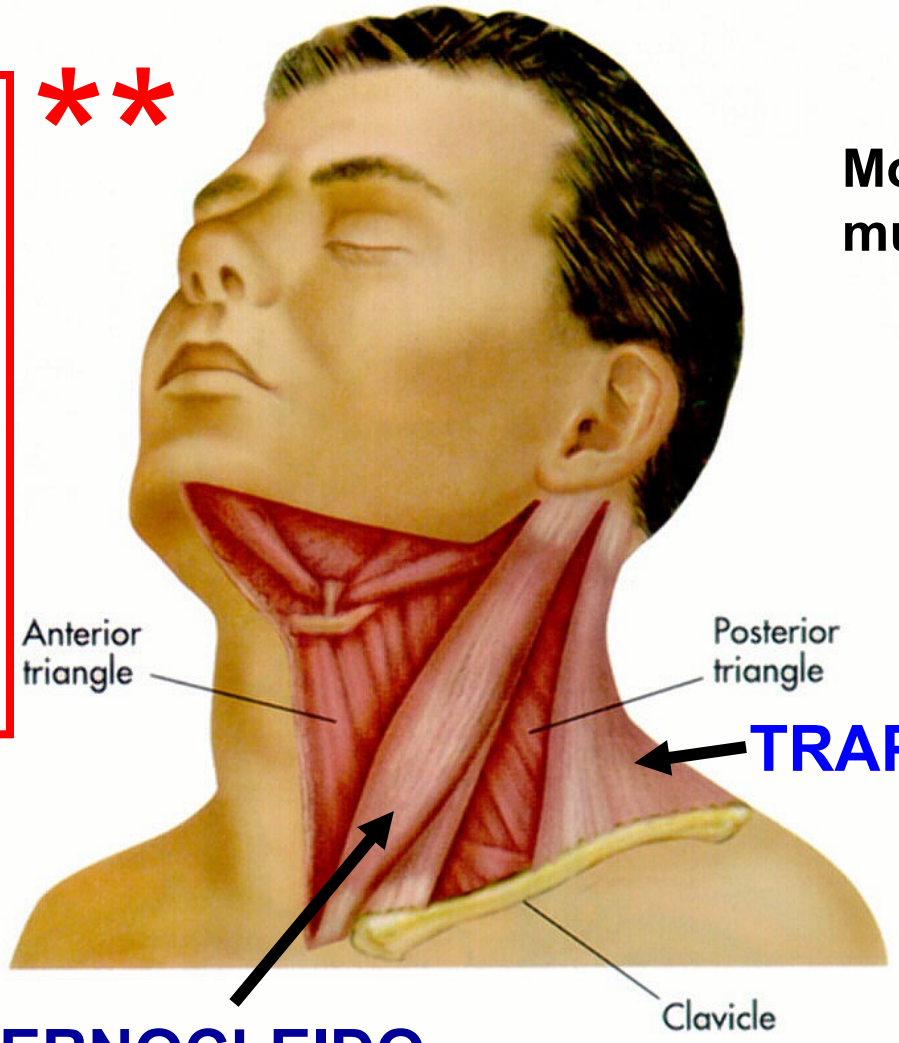
soft palate

TEST BY HAVING PATIENT SAY AAHH!

XI - ACCESSORY NERVE - BRANCHIOMOTOR

Clinical Test for XI (Accessory N.) -
1) Shrug shoulders
2) Rotate head against resistance

**



Motor to two muscles

**

TRAPEZIUS

Shrug shoulders

STERNOCLEIDO-MASTOID

Turn head

SUMMARY TYPES OF NEURONS IN CRANIAL NERVES

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)	Precise sensation 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)	Imprecise sensation: 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. 'INCANTATION)

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

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.							+

2) CLASSIFICATION OF INNERVATION - 7 types of neurons - some are the same as found in spinal nerves; others are only found in cranial nerves

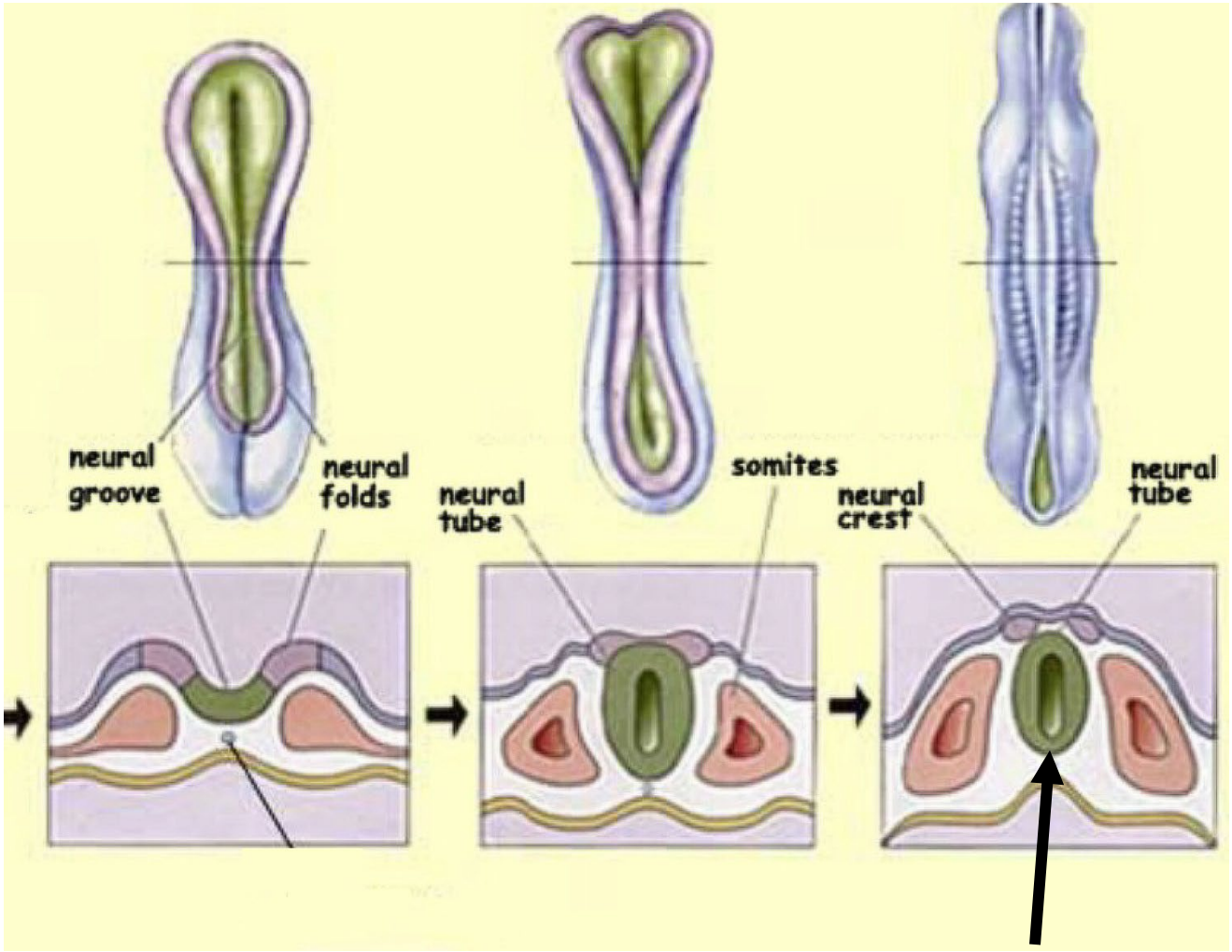
A. Same as spinal nerves

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

B. Only in cranial nerves

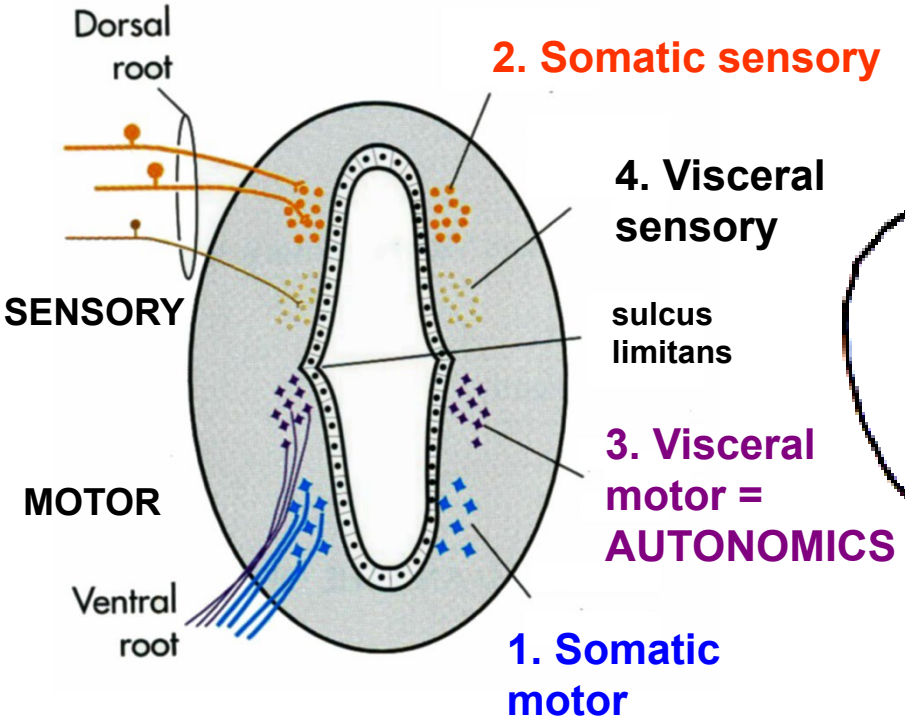
5. **Special senses** - vision, hearing (auditory) and balance (vestibular apparatus)
6. **Chemical senses** - taste and smell
7. **Branchiomotor** - Voluntary skeletal muscles from branchial arches.

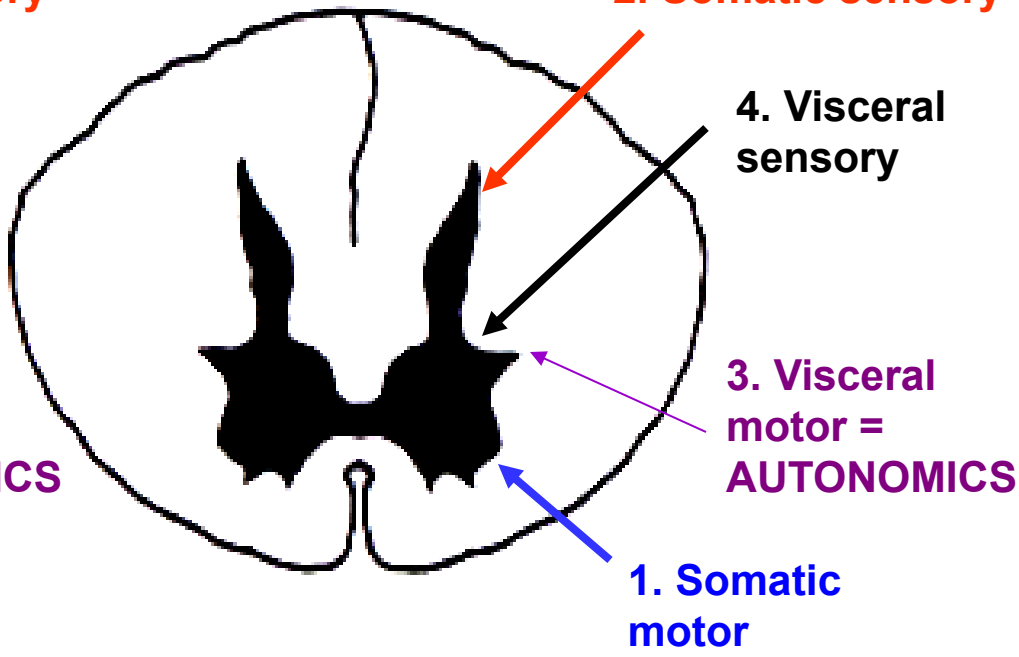
WHY DO YOU NEED TO KNOW THIS? CLASSIFICATION IS REFLECTED IN CENTRAL NERVOUS SYSTEM



Nervous system forms as a Neural Tube

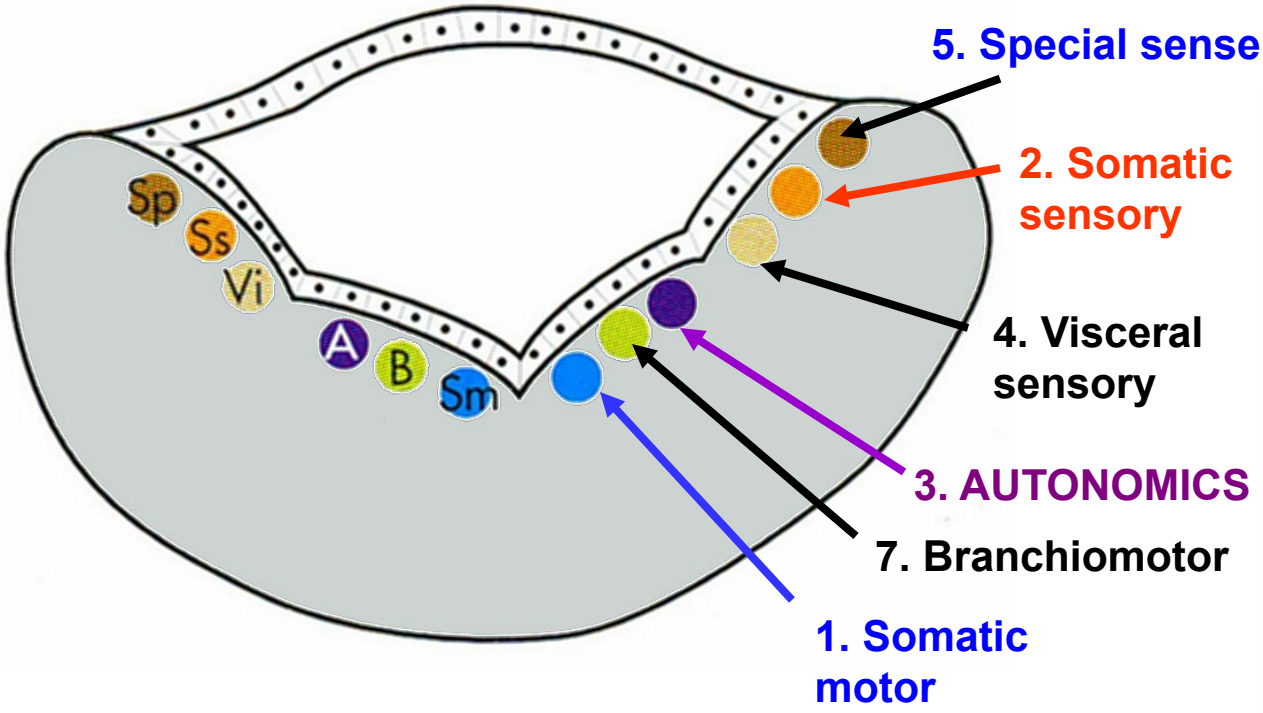
WHY DO YOU NEED TO KNOW THIS? CLASSIFICATION IS REFLECTED IN CENTRAL NERVOUS SYSTEM





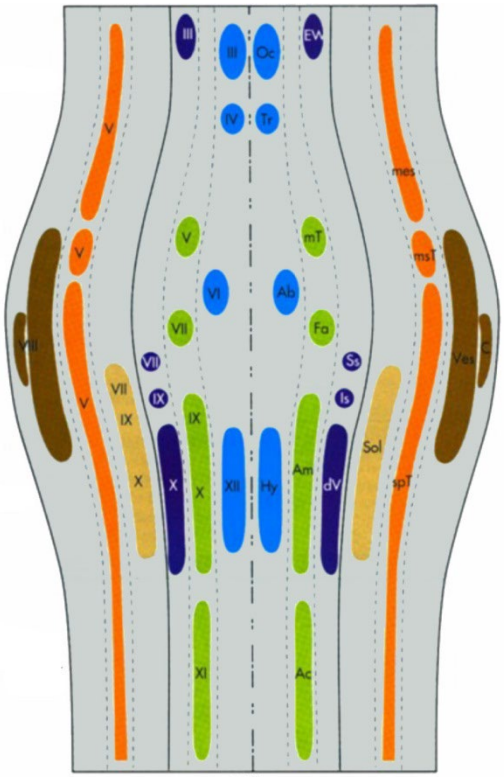
Nervous system forms as a Neural Tube; cells form groups (columns); sensory dorsal, motor ventral; different types of neurons form columns that develop to adult locations

WHY DO YOU NEED TO KNOW THIS? CLASSIFICATION IS REFLECTED IN CENTRAL NERVOUS SYSTEM



LONGITUDINAL VIEW

BRAINSTEM



SPINAL CORD

In brainstem, add more types of neurons; axons from cranial nerves arise from/project to columns of nuclei according to type of neuron

CRANIAL NERVE: CAPSULE SUMMARY

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, also pain, temperature touch to oral and nasal cavities, (outer ear)
VI. Abducens - eye movements
VII. Facial - muscles of facial expression; also taste, parasympathetics
VIII. Vestibulo-cochlear (Stato-acoustic) - hearing and balance
IX. Glossopharyngeal - sensory to pharynx, back of tongue (Gag reflex)
X. Vagus - motor to pharynx (most), larynx (voice box); soft palate; parasympathetics to thorax, abdomen
XI. Accessory (Spinal Accessory) - motor to sternocleidomastoid, trapezius
XII. Hypoglossal - motor to muscles of tongue

APPENDIX: OLDER SYSTEM: **CLASSIFICATION OF INNERVATION AS FUNCTIONAL COMPONENTS**

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.

CLASSIFICATION OF INNERVATION AS FUNCTIONAL COMPONENTS

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

Like spinal nerves -

1. **SOMATIC MOTOR = GSE - General Somatic Efferent**
2. **SOMATIC SENSORY = GSA - General Somatic Afferent**
3. **VISCERAL MOTOR = GVE - General Visceral Efferent**
4. **VISCERAL SENSORY = GVA - General Visceral Afferent**

Only in cranial nerves -

5. **SPECIAL SENSES = SSA - Special Somatic Afferent**
6. **CHEMICAL SENSES = SVA - Special Visceral Afferent**
7. **BRANCHIOMOTOR = SVE - Special Visceral Efferent**

Table 9.1. Functional Components of the Cranial Nerves

No.	*Name*	*SSA*	*GSA*	*GVA*	*SVA*	*GSE*	*SVE*	*GVE*
I	Olfactory				•			
II	Optic	•						
III	Oculomotor					•		•
IV	Trochlear					•		
V	Trigeminal		•				•	
VI	Abducent					•		
VII	Facial		•	•	•		•	•
VIII	Vestibulocochlear	•						
IX	Glossopharyngeal		•	•	•		•	•
X	Vagus		•	•	•		•	•
XI	Accessory						•	
XII	Hypoglossal					•		

CAPSULE SUMMARY OF CRANIAL NERVES: TYPES OF NEURONS

GSE = SOMATIC MOTOR - voluntary skeletal muscle from somites; two groups: eye (III, IV and VI) and tongue (XII)

GSA = SOMATIC SENSORY precise sensory – touch, pain etc. – skin, also nasal cavity and oral cavity; also joint position, muscles; almost all V; also Bell's palsy ear ache – VII, IX, and X to skin of outer ear

GVE = VISCERAL MOTOR autonomics - parasympathetics – see chart – III, VII, IX, X

(note: sympathetics to head – out T1, T2; up chain; synapse Sup. Cerv. Ganglion; post-ganglionics with arteries, unnamed branches)

GVA = VISCERAL SENSORY - imprecise sensory (blood vessels, etc); also pharynx is VII, IX, X (popcorn); also middle ear (IX)

SSA = SPECIAL SENSES - means special senses vision (II) and hearing and balance (VIII)

SVA = CHEMICAL SENSES - means smell (I) and taste (VII, IX, X)

SVE = BRANCHIOMOTOR - voluntary skeletal muscle from branchial arches – V, VII, IX, X, XI – memorize incantation