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 (SUGGESTED: 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)