Nerve Components and the Autonomic Nervous System of the Head & Neck Regions

Mikel H. Snow, Ph.D.
Integrative Anatomical Sciences
Dental Head & Neck Anatomy
mikelhes@usc.edu
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What’s inside each peripheral nerve?

Five nerves are labelled. Can you ID them?

A cross-section thru any of them look like this:

Hundreds of axons are packed within each nerve, with most nerves having more than one type of axon.

Example: #4 (vagus) has parasympathetic pre-ganglionic axons, somatomotor axons, and viscerosensory axons.

Example: #5 (phrenic) has somatomotor axons, somatosensory axons and sympathetic post-ganglionic axons.
These different types of axons are called NERVE COMPONENTS. For the head and neck regions there are a total of 9 different types of axons:

1. Somatomotor (SM)
2. Somatosensory (SS)
3. Visceromotor (VM)
   3a. Sympathetic (pre- & post-ganglionics)
   3b. Parasympathetic (pre- & post-ganglionics)
4. Viscerosensory (VS)
5. Taste
6. Smell (olfaction)
7. Hearing
8. Balance (vestibular apparatus)
9. Vision

The following slides define these nerve components in the order presented here…
1. **SOMATOMOTOR** (SM) axons are found in all nerves that innervate a skeletal muscle, causing the muscle fibers to contract.

Examples in photo on slide 2 include 1 (XI), 2 (XII), 4 (X) & 5 (phrenic). Can you list other nerves that contain SM axons?
2. **SOMATOSENSORY** (SS) axons convey sensations (pain or pain, touch temperature) from the body’s peripheral tissues to the CNS. Such peripheral tissues are ECTODERMALLY derived.

None of the five nerves in photo on slide 2 innervate ectodermally derived structures.
3. **VISCEROMOTOR** (VM) axons are in nerves innervating CARDIAC MUSCLE, SMOOTH MUSCLE or GLANDS. Since these axons function autonomously, they collectively represent the AUTONOMIC NERVE SYSTEM (ANS).

3a. Some VM axons are active when the body is facing an emergency, and these are called **SYMPATHETIC AXONS**.

**Response to Emergencies**

“Fight or Flight”

3b. Some VM axons are active between emergencies, and these are called **PARASYMPATHETIC AXONS**.

**Replenish Bodily Reserves**

“Rest & Digest”

Because these two involuntary functions are so different, they are regulated by two anatomically distinct pathways:

**Sympathetic Subdivision**

**Parasympathetic Subdivision**

**ANS Pathways begin on slide 13.**
4. **VISCERSENSORY (VS)** axons convey pain or reflex sensations from some of the body’s internal tissues to the CNS. Such internal tissues are **ENDODERMALLY derived**.

- **Endodermally derived tissues in head & neck**
  - Baroreceptors (carotid sinus)
  - Chemoreceptors (carotid body)
  - Tongue epithelium (posterior 1/3)
  - Mucosa (Pharynx, larynx, trachea)

Nerve #3 (internal br. superior laryngeal nerve) in photo on slide 2 mediates VS pain (e.g., sore throat) and reflex (e.g., cough) from mucosa of upper region of larynx.
6. **TASTE** axons are sensory fibers that found within nerves that convey taste sensations from taste buds to the CNS.

Taste buds are located on the entire surface of the tongue epithelium (anterior 2/3 and posterior 1/3), as well as the epiglottis of the larynx.

Taste axons are within the facial, glossopharyngeal and vagus nerves as they arise from the brainstem. Facial taste fibers go with the chorda tympani nerve to the lingual nerve to reach the anterior 2/3 of tongue.
6. **Olfactory** axons are sensory fibers within the olfactory epithelium at the roof of the nasal cavity. They pass thru the cribriform plate to synapse in the olfactory bulb. These secondary axons travel thru the olfactory tract to reach the CNS.

Olfactory axons are only found in the olfactory nerve.
7. **Cochlear** axons are sensory axons for hearing that travel from the cochlea to CNS. They pass thru the vestibulocochlear nerve to reach the CNS.
8. **Vestibular** axons are sensory axons for balance that travel from the vestibular apparatus to the CNS. They pass thru the vestibulocochlear nerve to reach the CNS.
9. **Visual** axons are sensory axons for sight that travel from the retina to the CNS. They pass thru the optic nerve to reach the CNS.
ANS (visceromotor) Pathways

Two important principles regarding ANS...

Sympathetics go Everywhere!

Parasympathetics only go to viscera!
Why is it necessary to distribute sympathetic axons to all areas of the body? Two reasons:

1. In emergencies, survival depends on a quick, total body response, shunting blood from skin to limb muscles, increasing heart rate, inhibiting digestion, etc.

2. Arteries are ubiquitous (everywhere in the body), and arteries are lined by smooth muscle.

Thus, smooth muscle is everywhere.
So, why don’t parasympathetic axons go everywhere?

Because parasympathetic functions (“rest & “digest”) are limited only to organs or structures that restore and maintain bodily reserves & eliminate bodily wastes.

Body wall structures, such as sweat glands, arrector pili, and arteries are only innervated by sympathetics.

Parasympathetic axons do not go to body wall structures!!!
If sympathetics need to go everywhere, why don’t they arise from every spinal cord segment?

All sympathetic pathways start from spinal cord segments T1 to L2.

All parasympathetic pathways start from the brainstem or sacral segments S2-S4.

Thoracolumbar Outflow

Craniosacral Outflow

Lumbar enlargement

Brain stem

Cervical enlargement
Let’s focus on sympathetics…
Since sympathetics arise from such a limited region of the spinal cord, how do they eventually get to all areas of the body? **2 solutions.**

One solution is a **two-neuron system** allowing for amplification of the sympathetic axons stemming from T1 to L2 by having each axon synapse with ~30 secondary neurons outside the CNS.

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**Diagram:**
- **Preganglionic** cell body
- **Preganglionic axon**
- **Postganglionic cell bodies**
- **Postganglionic axons**
- **Intermediate or lateral horn**
- **T7 Spinal cord segment**
- **ganglion:** collection of nerve cell bodies
- **“Cholinergic”** (Ach)
- **“adrenergic”** epinephrine & norepinephrine
The second solution for getting sympathetics everywhere is by having paired secondary conduits, called sympathetic trunks.

1. Each sympathetic trunk has several ganglia where amplification occurs as symp/pre axons synapse with several symp/post cell bodies.

2. The trunks also serve as conduits for distributing sympathetics upward (to head & neck) & downward to all 31 pairs of spinal nerves.
Let’s Focus on Sympathetics to the Head

How do sympathetics get from spinal cord to the head?

Cervical sympathetic trunk
All start from lateral horns of T1 to T4.

Once inside the thoracic trunk, sympathetic pre-ganglionic axons ascend up the cervical trunk.

These symp/pre axons synapse in superior cervical sympathetic ganglion with post-ganglionic sympathetic axons that continue on internal carotid artery.
Superior cervical sympathetic ganglion

Cervical sympathetic trunk

T1 level
From internal carotid artery, the symp/post axons enter the orbit to innervate dilator pupillae muscle and superior tarsal muscle.
Parasympathetic pathways are more straightforward:

Parasympathetic pre-ganglionic axons are also amplified by a two-neuron system, but to a much lesser extent.

**Cell body**

Very short postganglionic axons

Very long preganglionic axons

Ganglia visible in head region

**Cranial nerve**

**Acetylcholine “cholinergic”**

Cranial nerves that convey parasympathetic axons:

- Oculomotor
- Facial
- Glossopharyngeal
- Vagus
The End

Wonder Lake and Denali