Medical Neuroscience 4 - Trigeminal Pathways

Required Reading - Blumenfeld, Chapter 12, 508 - 512

READ - Key Clinical Concept in Blumenfeld Chapter 12, page 518

Learning Objectives

1. Indicate the location where trigeminal nerve attaches to the CNS and the general function of trigeminal nerve.
2. Name the brainstem nuclei associated with the trigeminal nerve, explain their location in the brainstem and their function.
3. Indicate the sensory modalities transmitted by the trigeminal lemniscal, trigeminothalamic, and proprioceptive mesencephalic pathways.
4. Describe the trigeminal lemniscal and trigeminothalamic tract pathways from stimulus reception to cortical perception.
5. Explain the pathway for conscious and unconscious proprioception from the face.
6. Describe the pathways of the jaw jerk and corneal reflexes: afferent and efferent arms, and integration centers.
7. Correlate the effects of a lesion at different brainstem levels with clinical exam findings.

Overview

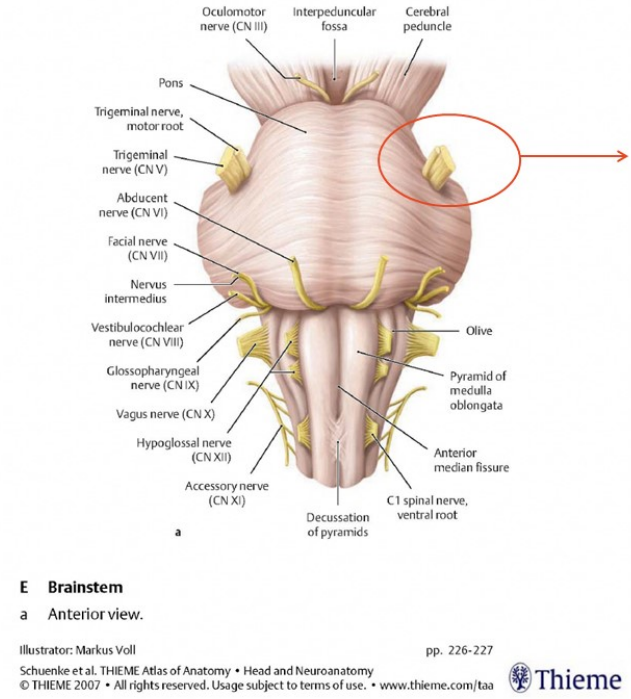
The trigeminal nerve is the cranial nerve that transmits information regarding somatic sensation from the face, gums, mucous membranes, anterior two thirds of the tongue, blood vessels, and supratentorial dura matter. Through its smaller motor root, the trigeminal nerve innervates the muscles of mastication.

Two important reflexes are associated with CN V: the jaw jerk and corneal reflexes.

Objective # 1

Slide 3:

Diagram showing the ventral surface of the brainstem and in particular the attachment of trigeminal nerve fibers to the lateral pons



OBJ. # 1

The trigeminal nerve attaches to the brainstem at the level of the mid pons. It has a large sensory root and a small motor root

Slide 4:

Description of the sensory and motor functions of trigeminal nerve

Trigeminal Nerve, CN V

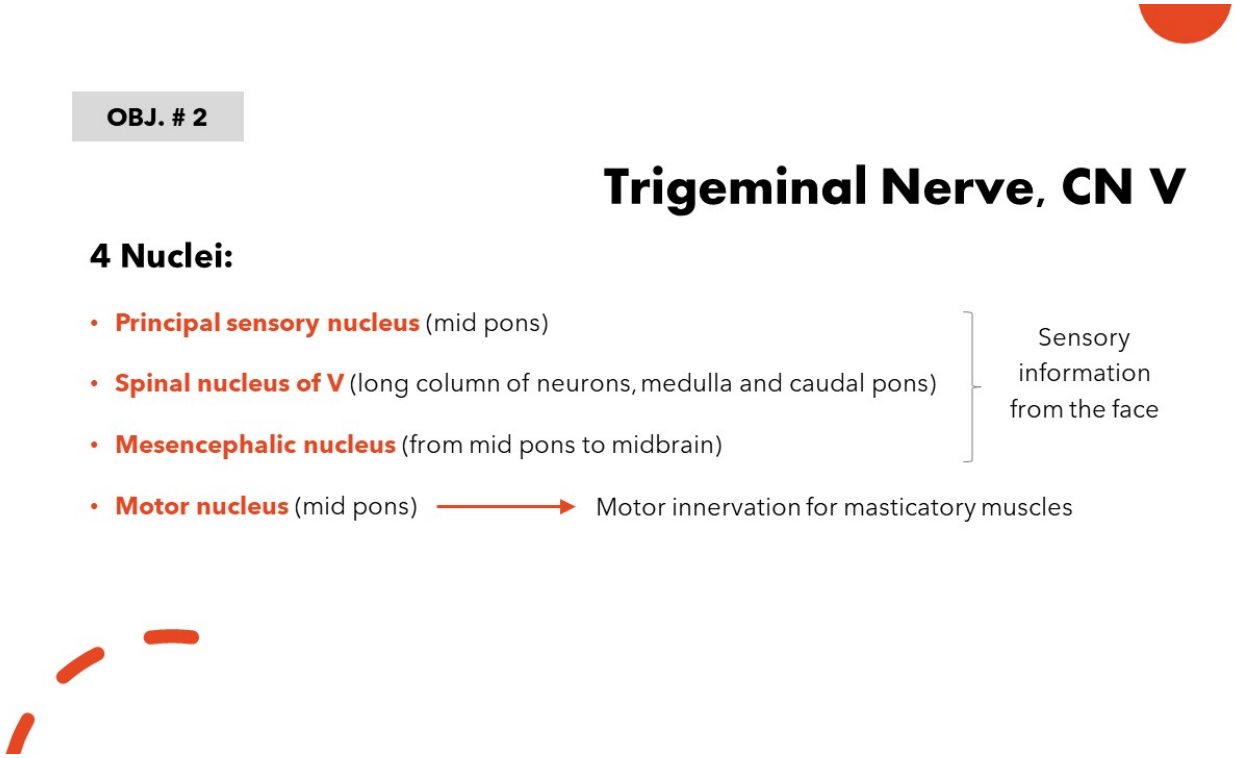
OBJ. # 1

Function	
Sensory innervation for the face, mucous membranes of the mouth, and nasal sinuses, joints, gums, supratentorial dura matter, blood vessels, ant. 2/3 of tongue	Motor innervation of the muscles of mastication

Objective # 2

Slide 5:

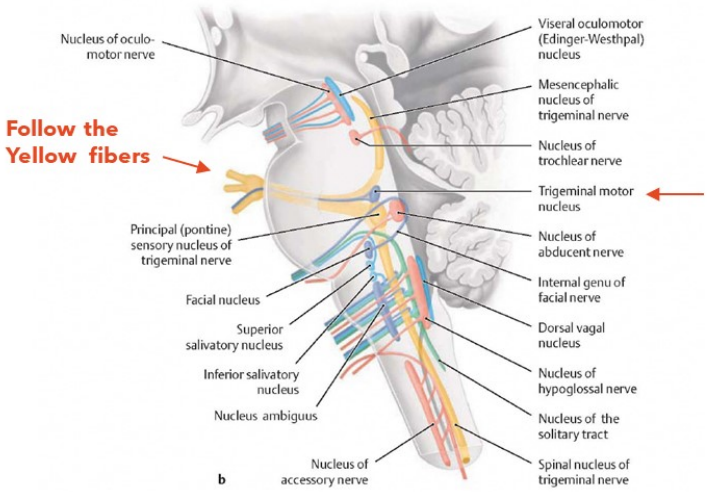
List of the 4 nuclei associated with the trigeminal nerve, their location in the brainstem and their general function. Think of the principal sensory nucleus as analogous to the nucleus gracilus/cuneatus and the spinal nucleus of V as analogous to the 2nd order neurons of the ALS pathway. The mesencephalic nucleus is an outlier, carrying important information about pressure on the teeth. **It is actually a sensory ganglion *inside* the cns.** This means that the first order neurons of it's pathway have their cell bodies in this 'nucleus,' unlike every other sensory ganglion in the body.



Slide 6:

Diagram of the brainstem (lateral view) with all the CN nuclei. Look for the yellow columnar nuclei and its associated ganglion (trigeminal ganglion) and a small blue nucleus, the motor nucleus in the mid pons. All the structures are labeled.

Location Of CN V Nuclei In The Brainstem



A Cranial nerve nuclei in the brainstem

b Midsagittal section of the right half of the brainstem viewed from the left side.

Illustrator: Markus Voll pp. 228-229

Schuenke et al. THIEME Atlas of Anatomy • Head and Neuroanatomy

Thieme

OBJ. # 2

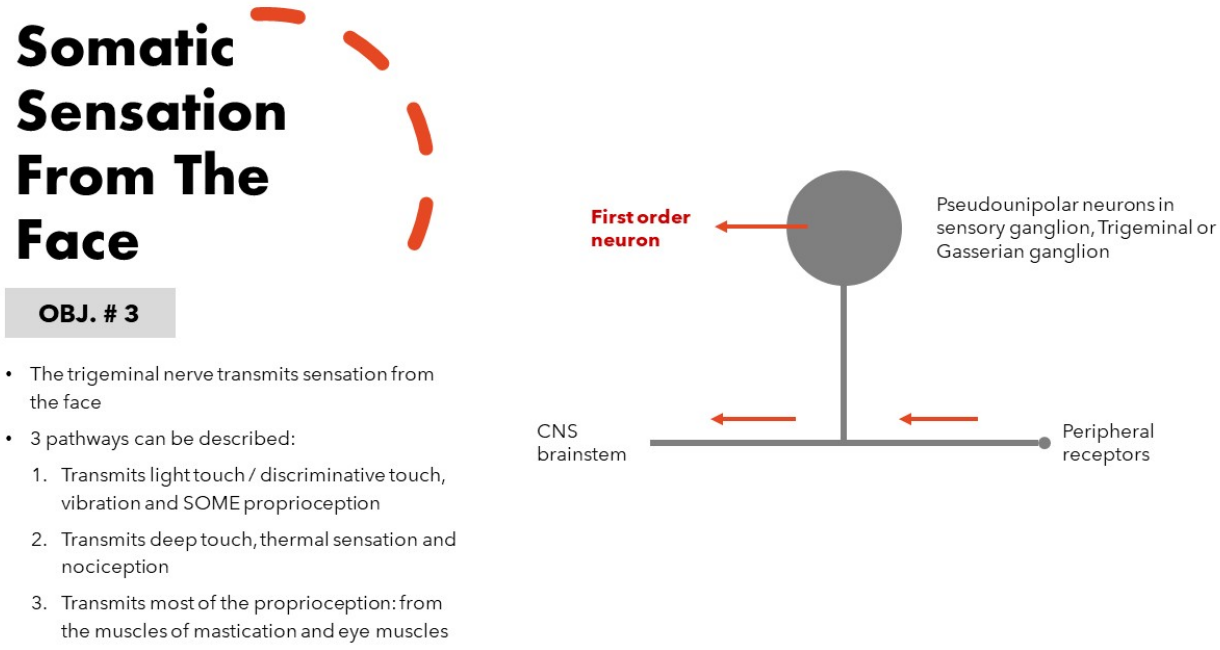
Objective # 3

Slide 7:

Summary of the 3 main pathways transmitting somatic sensation from the face and other head structures:

1. The trigeminal lemniscus
2. The trigemino-thalamic tract
3. The mesencephalic proprioceptive pathway

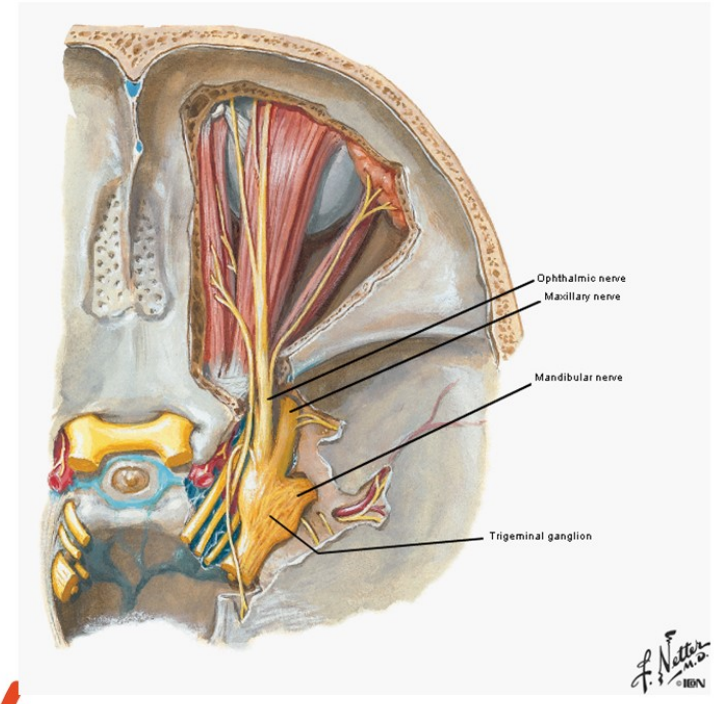
The trigeminal lemniscus and trigemino-thalamic pathways are often both referred to as the trigeminal lemniuscus. The lower part of the slide is a reminder that trigeminal sensory pathways originate from a pseudounipolar neuron (1st neuron of the pathway) in the trigeminal ganglion and enter the brainstem where they have their first synapse with the second neuron of the pathway located in one of the sensory nuclei associated with the trigeminal nerve. From there, the trigeminal fibers reach the thalamus following their analogous structures from the body: spinothalamic tract and medial lemniscus respectively. However, the trigeminal fibers project to the **ventral posteromedial nucleus (VPM)** of the thalamus.



Slide 8:

Diagram from Netter's atlas showing the location of the trigeminal ganglion and the 3 nerve branches that form the 3 facial dermatomes

OBJ. # 3

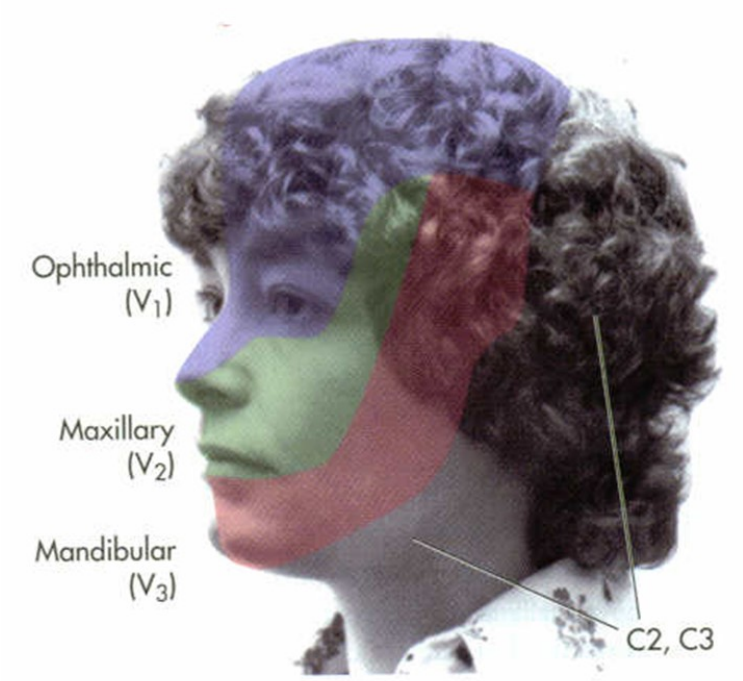


Nerves of the orbit and the ciliary ganglion: dorsal view and cross-section through the cavernous sinus

Slide 9:

Distribution of the trigeminal fiber to form the ophthalmic (V1), the maxillary (V2) and the mandibular (V3) dermatomes of the face.

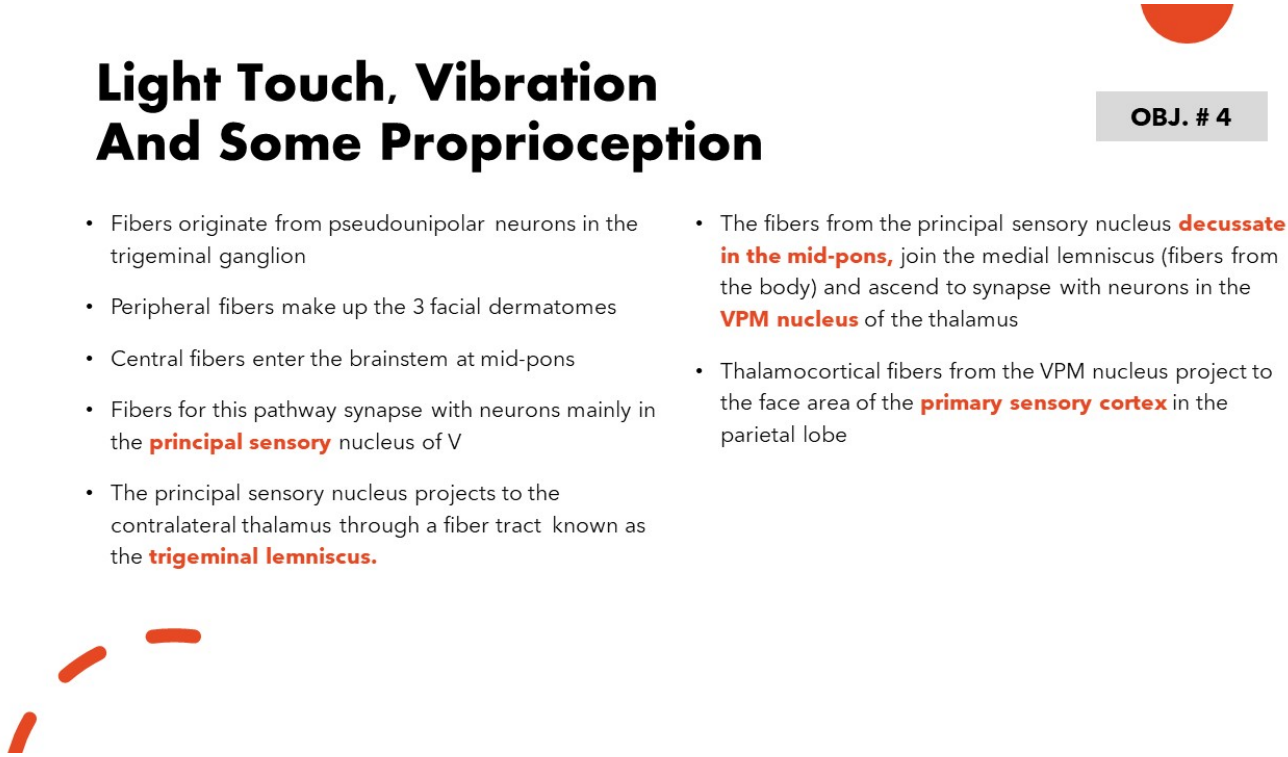
OBJ. # 3



Trigeminal Dermatomes

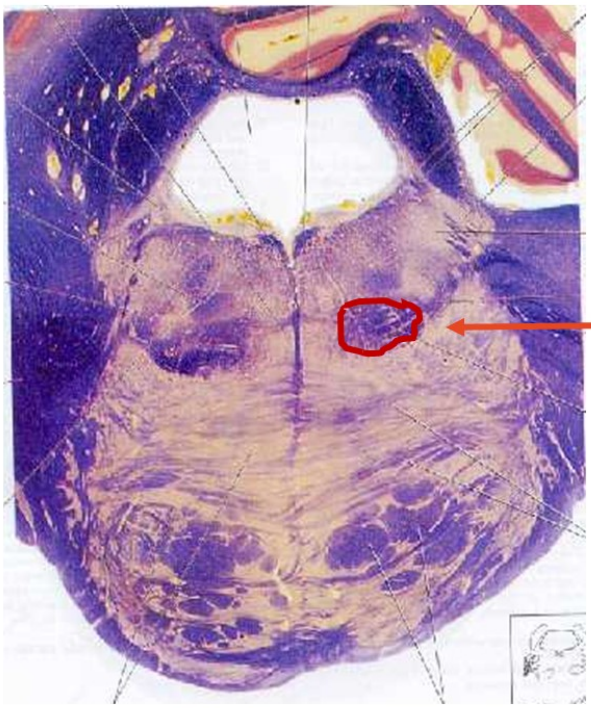
Objective # 4

Slide 11: Pathway for the trigeminal lemniscus from the origin of the fibers in the trigeminal ganglion to their termination with the thalamocortical fibers reaching the primary sensory cortex.



Slide 12:

Cross section through the mid pons showing the location of the medial lemniscus (fibers from the body). The fibers transmitting light touch, vibration and some proprioception from the face, the trigeminal lemniscus, cross the pons to join the medial lemniscus contralaterally at this level; the TL fibers ascends to the VPM nucleus of the thalamus.



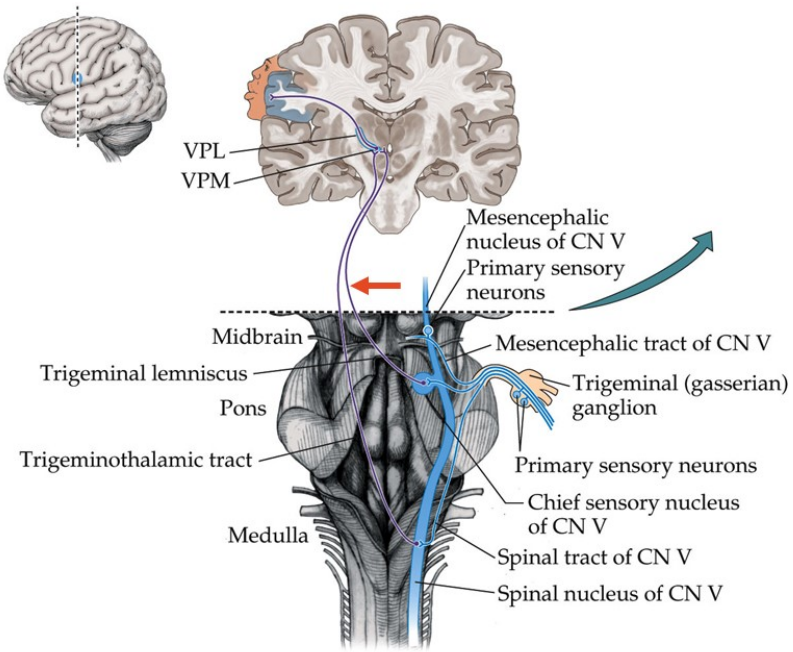
OBJ. #4

The medial lemniscus Trigeminal fibers start to join this pathway as they cross from the contralateral side

Slide 13:

Diagram showing the entire trigeminal lemniscus pathway. Look for the red arrow.

OBJ. # 4



NEUROANATOMY 2e, Figure 12.8 (Part 1)

Slide 14:

Description of the pathway for the trigeminothalamic tract from the origin of the fibers in the

trigeminal ganglion to their termination with the thalamocortical fibers reaching the primary sensory cortex.

Deep Touch, Thermal Sensation And Nociception

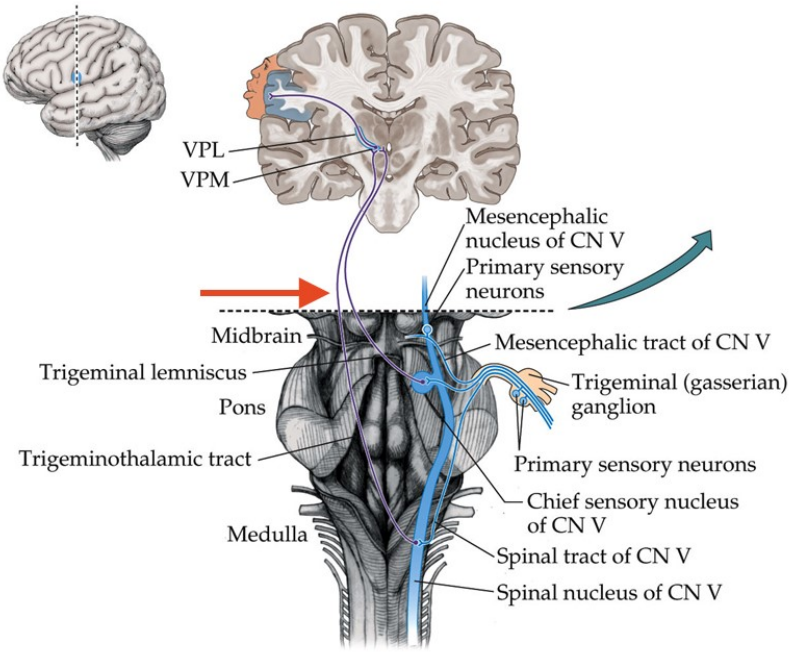
OBJ. # 4

- Fibers originate from pseudounipolar neurons in the trigeminal ganglion
- Peripheral fibers make up the 3 facial dermatomes
- Central fibers enter the brainstem at mid-pons and **descend along the pons and medulla - Spinal tract of V**
- Fibers for this pathway synapse with neurons in the **spinal nucleus of V**
- Neurons in the spinal nucleus project to the contralateral thalamus through a fiber tract known as the **trigeminothalamic tract**
- Spinal trigeminal fibers decussate at all medullary levels, join the other sensory pathways and ascend to the **VPM nucleus** of the thalamus
- Thalamocortical fibers from the VPM terminate in the face area of the **primary sensory cortex** in the parietal lobe

Slide 15:

Diagram of the entire trigemino-thalamic pathway. Look for the red arrow.

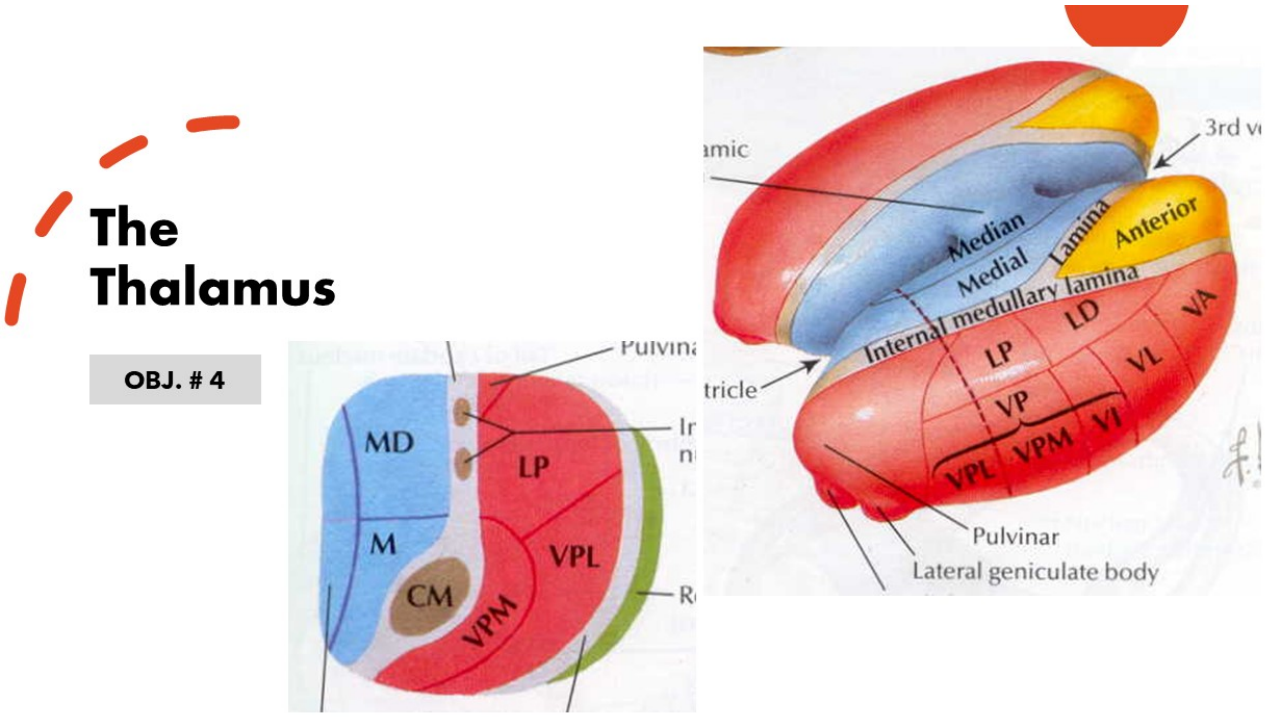
OBJ. # 4



NEUROANATOMY 2e, Figure 12.8 (Part 1)

Slide 16:

This is a diagram of the thalamus and the thalamic nuclei showing the location of the VPM and VPL nuclei. On the left the thalamus is viewed in cross section. On the right, both thalamai are shown attached by the massa intermedia.

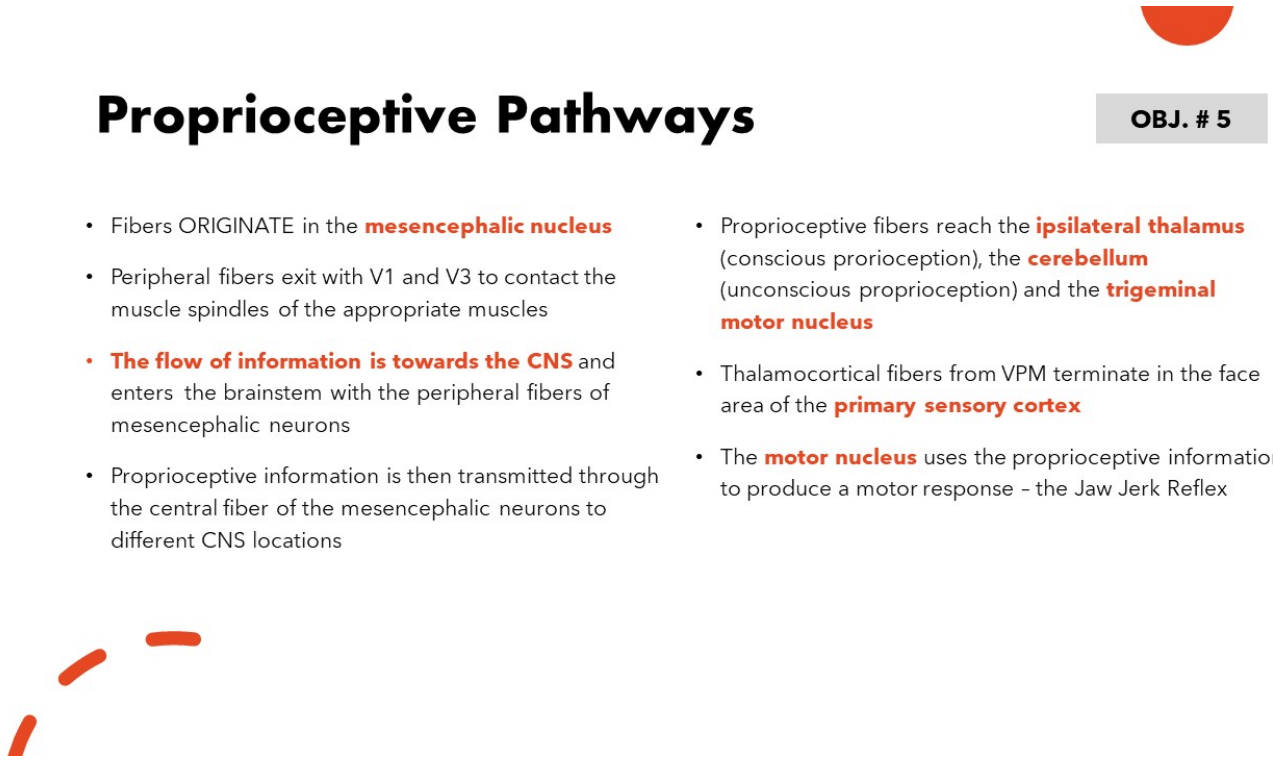


Objective # 5

Slide 17:

Description of the pathway transmitting conscious and unconscious proprioception from the periodontium and muscles of mastication. A unique feature of this pathway is it's origin. It doesn't start in the trigeminal ganglion but in the mesencephalic nucleus. In fact, this nucleus is not a real nucleus but a misplaced ganglion that contains pseudounipolar neurons. These neurons send out a peripheral fiber to capture the proprioceptive information. The information enters the brainstem and will be distributed to different CNS locations.

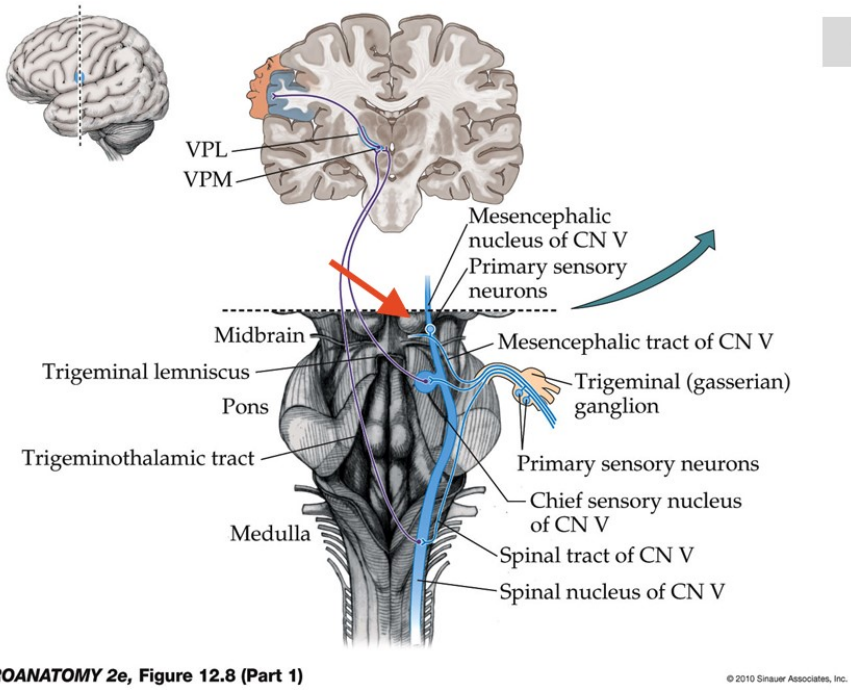
Information about unconscious proprioception related to the position of the jaw in space serves is sent to various structures: cerebellum, thalamus, and the trigeminal motor nucleus. This information provides the **afferent limb of the jaw jerk reflex.**



Slide 18:

Diagram of the entire proprioceptive pathways. Look for the red arrow.

OBJ. # 5



NEUROANATOMY 2e, Figure 12.8 (Part 1)

Slide 19:

Review of the nuclei and ganglia associated with CN V

Nuclei Associated With CN V

- Spinal nucleus of V
- Principal sensory nucleus
- Motor nucleus
- Mesencephalic nucleus

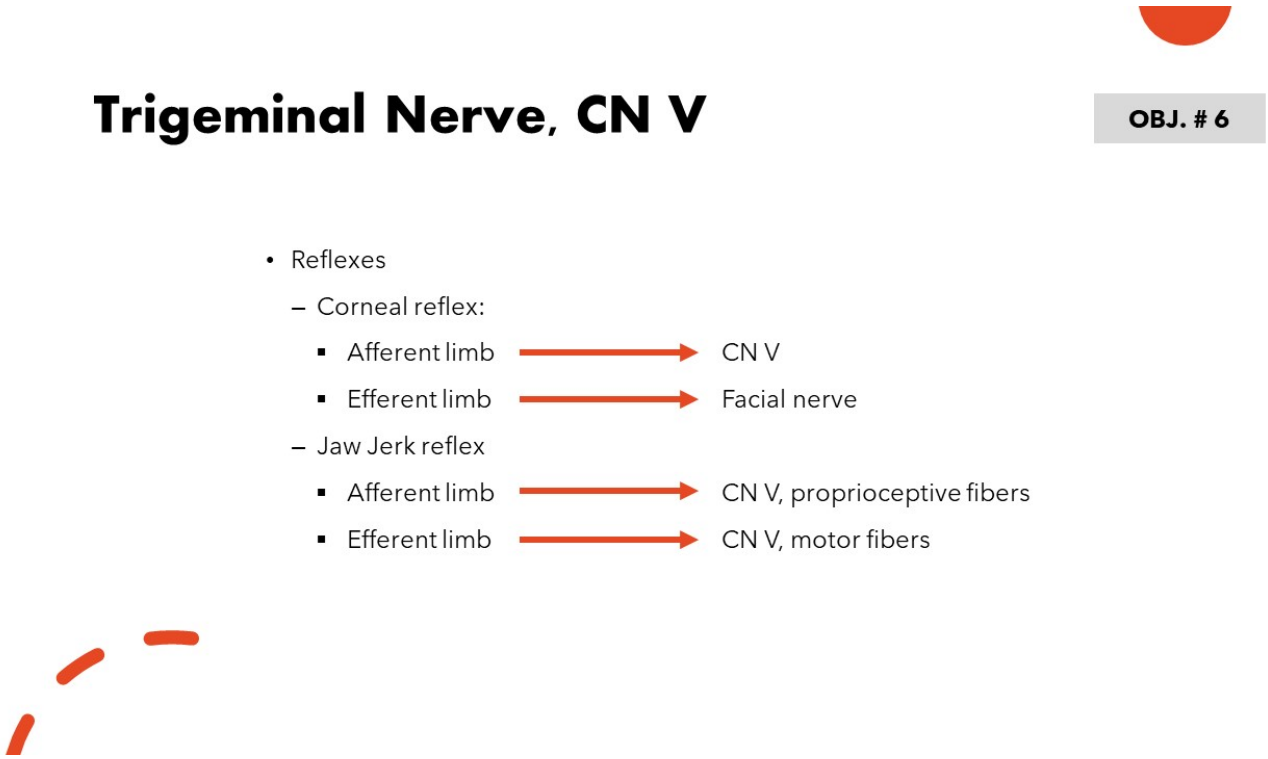
Ganglia Associated With CN V

- Trigeminal ganglion
- Mesencephalic nucleus

Objective # 6 - Reflexes involving the trigeminal nerve

Slide 20:

Description of the afferent and efferent limbs of 2 important reflexes used clinically to assess the function of trigeminal sensory and motor fibers: the corneal or blink reflex and the jaw jerk reflex.

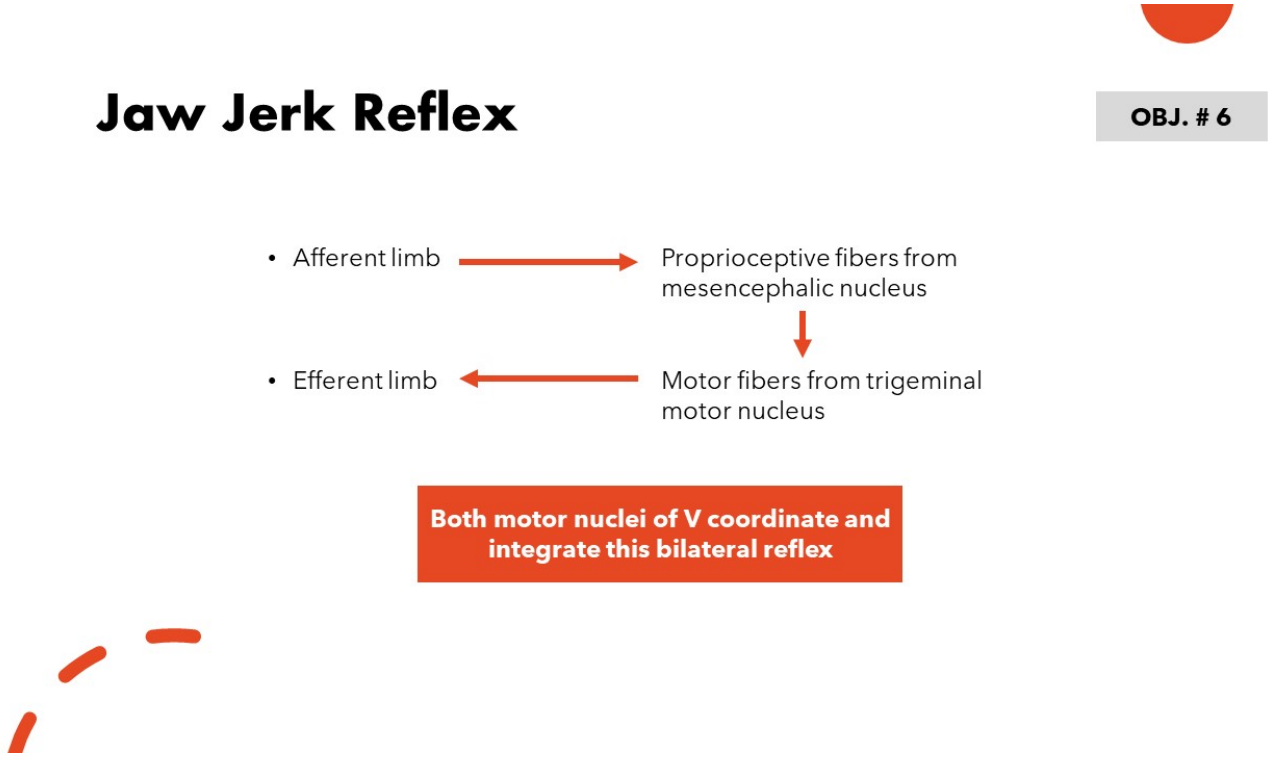


Slide 21: The jaw jerk reflex

This reflex is elicited when you place your finger on the patient's chin, jaw open slightly, and tap lightly with your reflex hammer. The response is a contraction of the masticatory muscles which bring the jaw upwards. Normally the reflex is minimal or absent. The presence of a brisk reflex is abnormal.

The afferent limb of the reflex consists of the proprioceptive fibers from the jaw that enter the mesencephalic nucleus of the trigeminal nerve. Information about jaw position in the space is transmitted from the mesencephalic nucleus to the motor nucleus of V. The trigeminal motor fibers that exit the brainstem at the mid pons level form the efferent limb of the reflex. The reflex is a bilateral reflex and both motor nuclei of V coordinate the pathways from each side.

This reflex is helpful clinically when examining a patient that is noted to be briskly reflexic in all four extremities. By checking for an exaggerated jaw jerk, you can localize the abnormality above the level of CNV. A patient with a cervical lesion may have brisk reflexes throughout their limbs, but the jaw jerk should remain absent or minimally present. In contrast a patient with a more diffuse injury of the upper motor neurons such as in primary lateral sclerosis or advanced neurodegenerative disease may have brisk reflexes throughout with a positive jaw jerk.



Slide 22: The corneal reflex

The corneal reflex or blink reflex is elicited when the cornea of the eye is touched with a cotton swab. The afferent limb of the reflex is the sensory fibers from free nerve ending receptors in the cornea. The stimulus is transmitted to the brainstem through the ophthalmic branch or VI. These fibers terminate in both the rostral end of the spinal nucleus of V and the principal sensory nucleus from where the information is transmitted to neurons in the reticular formation of the pontomedullary junction - caudal pontine area. Reticular formation neurons, in turn, project bilaterally to the facial motor nuclei that provide the efferent limb of the reflex. The pontine reticular formation is the integration center for this reflex.

Blink Reflex / Corneal Reflex

OBJ. # 6

- Afferent limb → Pain receptor on the cornea
  - ↓ Trigeminal nerve
  - Spinal nucleus of V & Principal sensory
  - ↓ Bilaterally
  - Neurons in the reticular formation
- Efferent limb → Motor fibers from both facial motor nuclei (blink bilaterally)

The pontine reticular formation is the reflex integration center