ANNUAL CONFERENCE
AND J.T. VAUGHAN EQUINE CONFERENCE

Neurological examination – part 1: the head

Serena Ceriotti, DVM MS PhD DACVIM-LA

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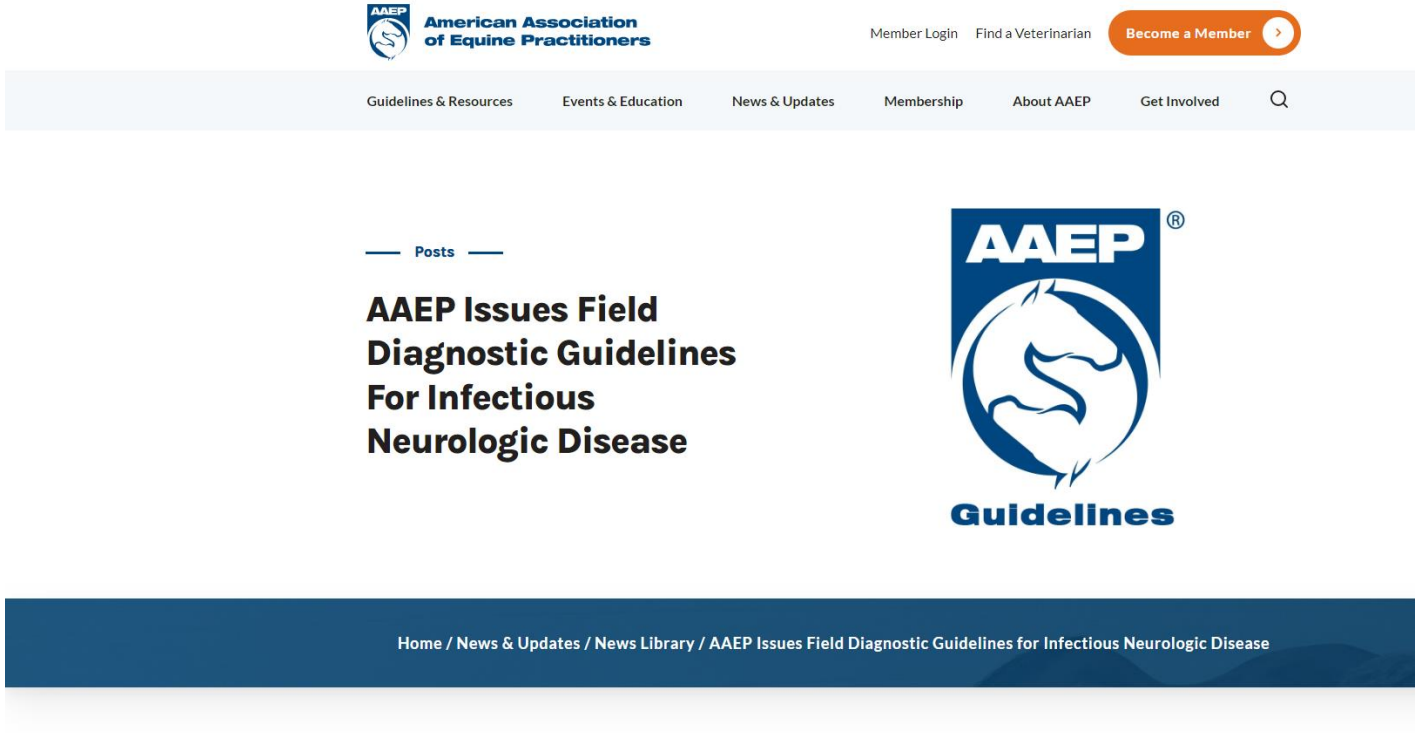
College of Veterinary Medicine

Breaking news…



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October 1, 2024

"Our goal was to provide field practitioners with readily accessible targeted guidance in the diagnosis of equine acute infectious neurologic disease in North America," said guidelines co-author Toby L. Pinn-Woodcock, DVM, DACVIM, chair of the AAEP Field Guidelines Subcommittee and assistant clinical professor, Department of Population Medicine and Diagnostic Sciences, at Cornell University College of Veterinary Medicine.

https://aaep.org/guidelines-resources/field-diagnostic-guidelines/.

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Credit and thanks to …

Dr
Tom Jukier

Dr
Sandy Taylor

Dr
Lana Dedecker

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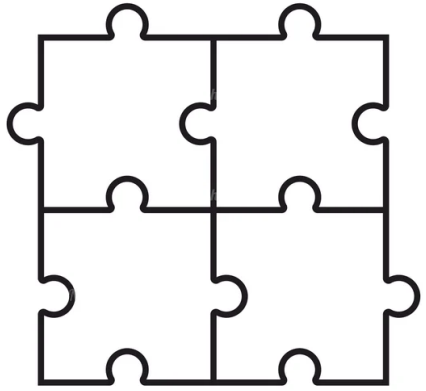
Outline



My (hopefully useful) approach to neurological exam interpretation

- Neurolocalizing the head: brain and cranial nerves
- Neurological approach to the vision function
- The Horner's signs and their interpretation
- Neurological approach to the vestibular system

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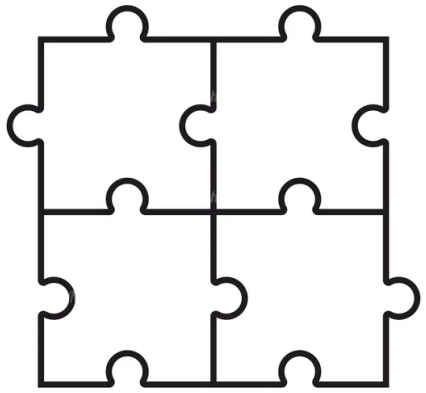

- Neurolocalizing the head: brain and cranial nerves
- Neurological approach to the vision function
- The Horner's signs and their interpretation
- Neurological approach to the vestibular system

- Is there a lesion in the brain?
- If so, in which part of the brain?
- Focal or multifocal?
- Unilateral (which side) or bilateral?

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Outline

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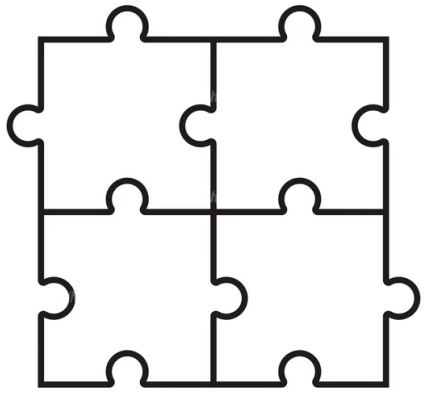

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Neurolocalizing the head: brain and cranial nerves

- Evaluation from the distance

- Cranial nerve examination

Pictures courtesy of Dr Sandy Taylor

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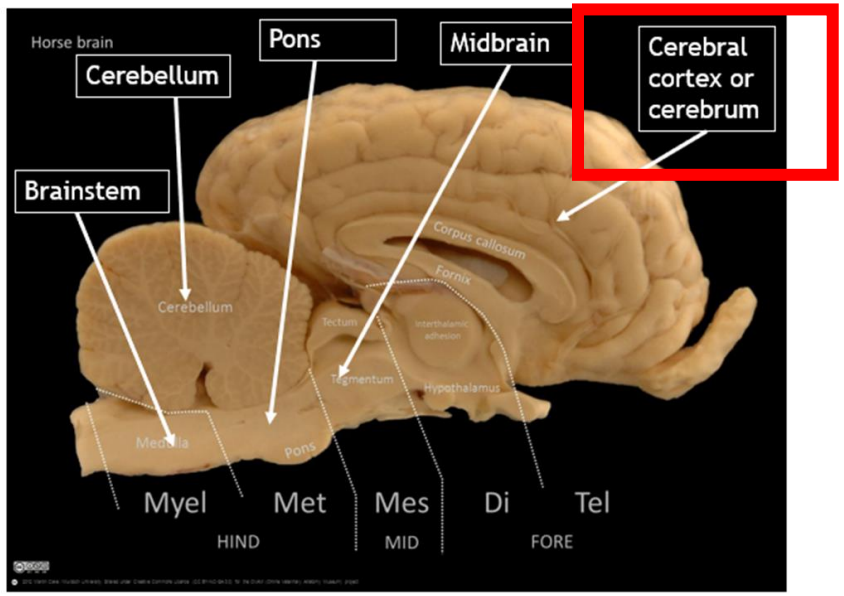
Neurolocalizing the head: brain and cranial nerves

- Evaluation from the distance
  - Behavioral changes
    - Aggressive behavior
    - Head pressing
  - Mental status
    - Obtundation
    - Mania
  - Posture



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Pictures courtesy of Dr Sandy Taylor / Dr Mariano Mora

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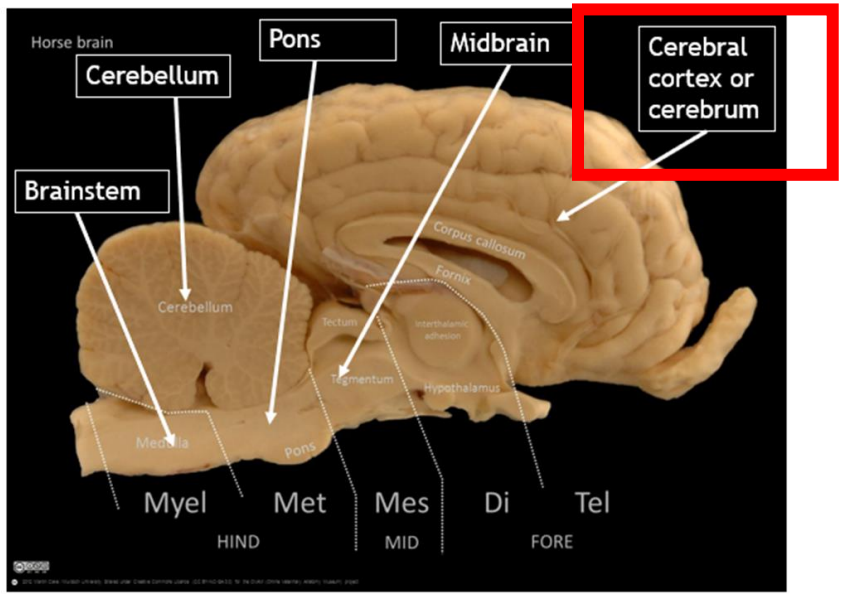
  - Posture
    - Head turn/compulsive walking in circle
      - Towards the side of the lesion
    - Proprioceptive deficits
      - On the side opposite to the lesion



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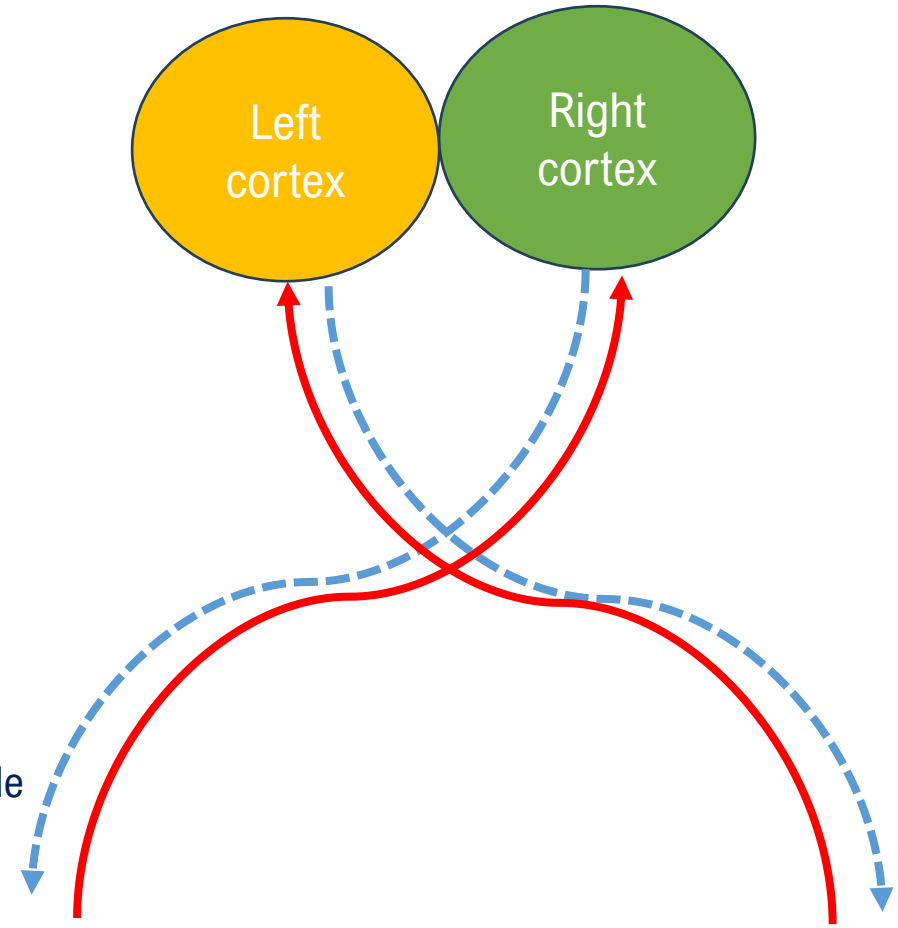

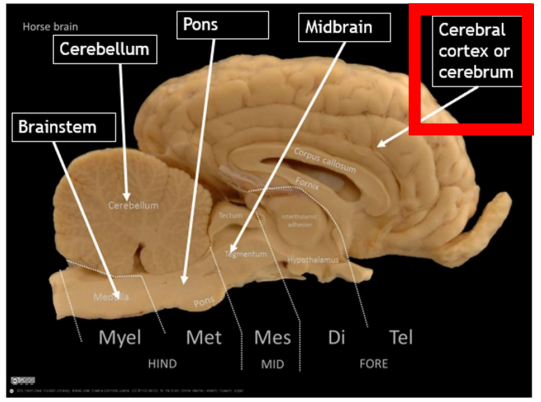

Blue dotted: descending motorneurons

Red full: ascending proprioceptive

Pictures courtesy of Dr Sandy Taylor

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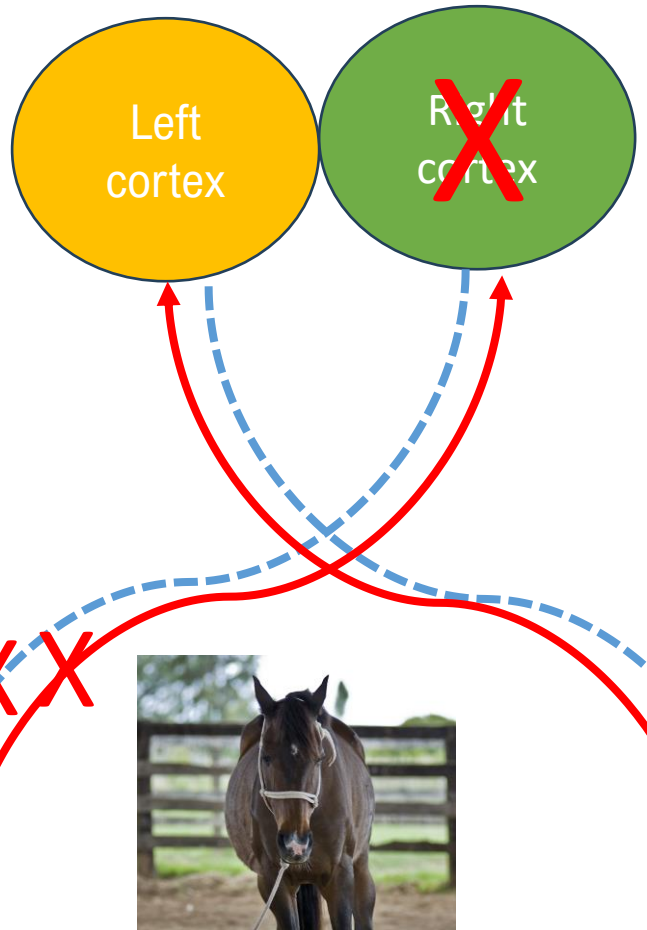
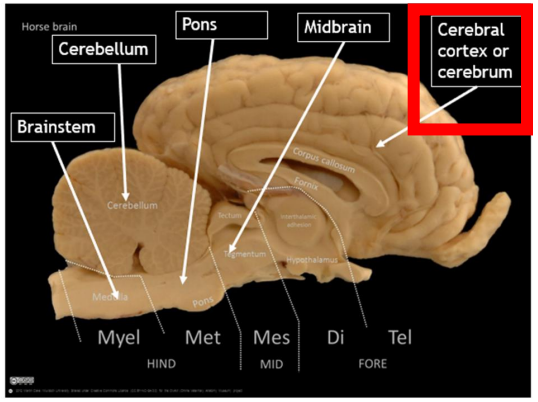
    - Aggressive behavior
    - Head pressing
  - Mental status
    - Obtundation
    - Mania
  - Posture
    - Compulsive walking in circle
      - Towards the side of the lesion
      - Specific for cerebrum
    - Proprioceptive deficits
      - On the side opposite to the lesion
      - Cerebrum/other brain areas





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Neurolocalizing the head: brain and cranial nerves

- Evaluation from the distance
  - ~~Behavioral changes~~
  - Mental status
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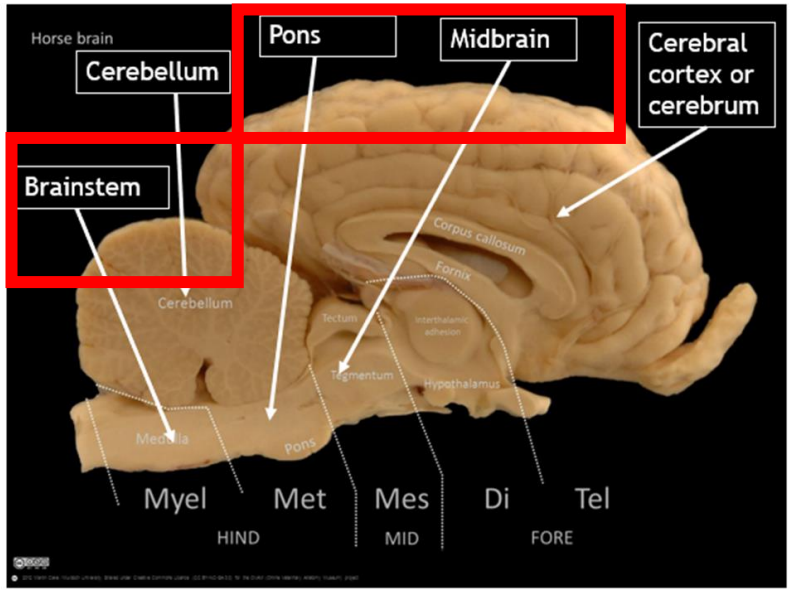
Ascending Reticular Activating System (ARAS)



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Neurolocalizing the head: brain and cranial nerves

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- ~~Behavioral changes~~
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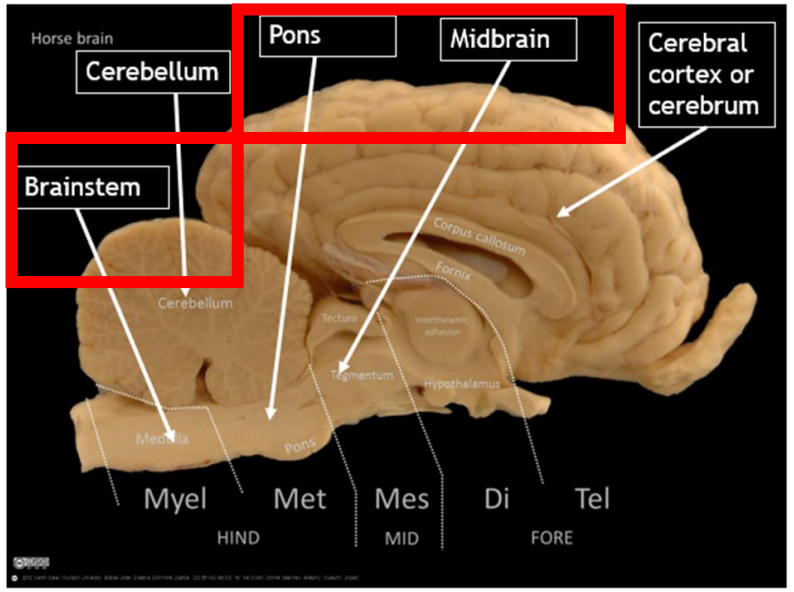
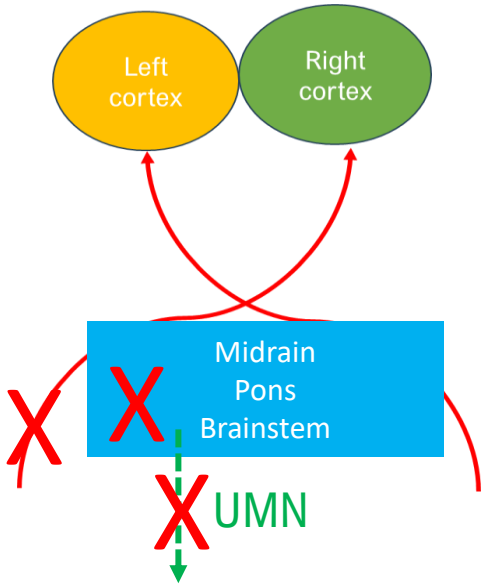
  } Ascending Reticular Activating System (ARAS)

- Posture
  - Spastic gait forelimbs and hindlimbs (Upper Motor Neuron)
    - Same side of the lesion
  - Proprioceptive deficits
    - Same side of the lesion





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Neurolocalizing the head: brain and cranial nerves

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Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – neuroanatomy “in brief”
    - Cranial nerves are bilateral

https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain

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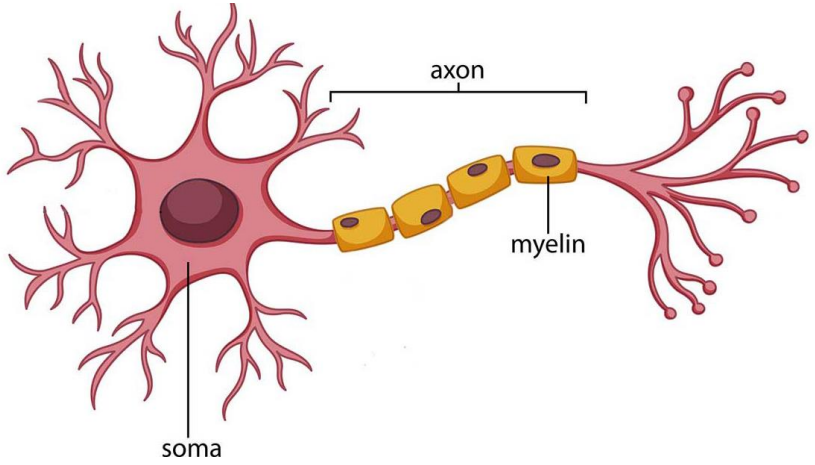

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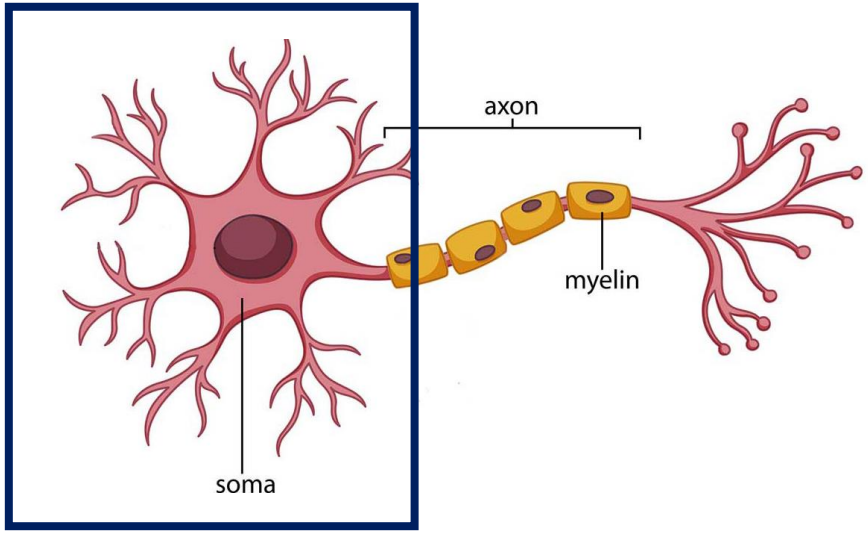

CN nuclei:
Located in the brain

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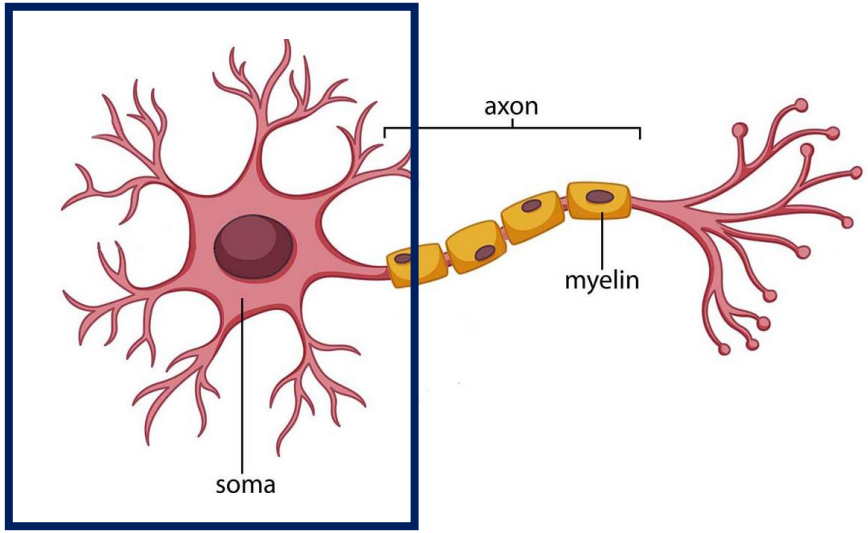

CN nuclei:
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Clinically….

A damaged CN means the lesion might be located:

- In the fibers = peripheral disease
- In the nuclei = central or brain disease

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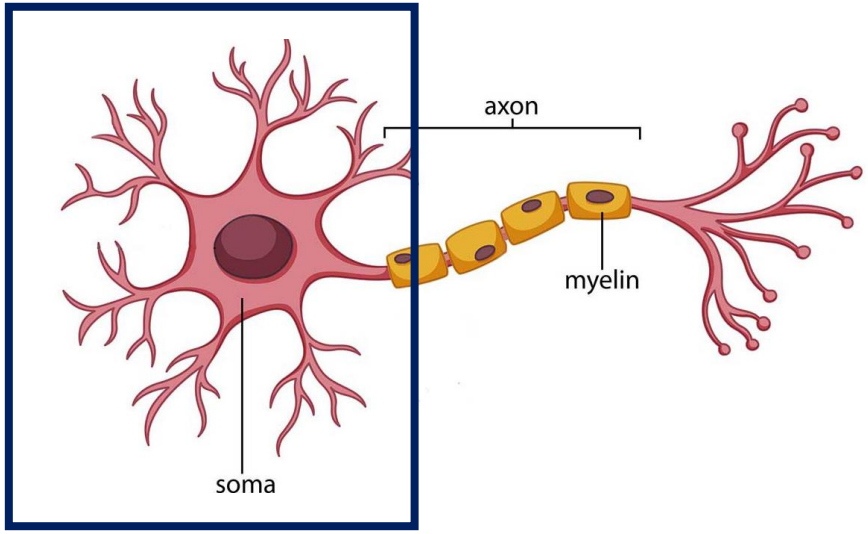

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Where are the nuclei of each CN located?

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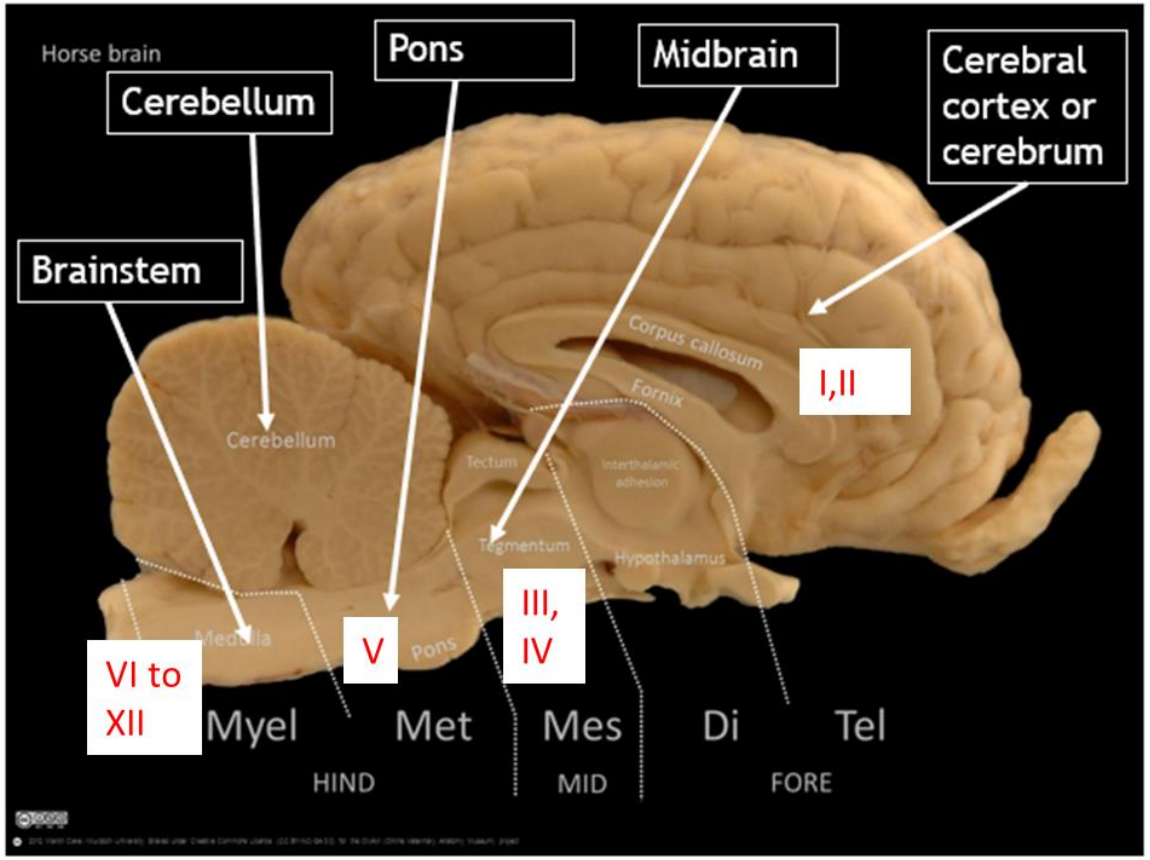

Where are the nuclei of each CN located?

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

On the same side …
except for nerves that goes to the cortex (I, II) and nerve IV

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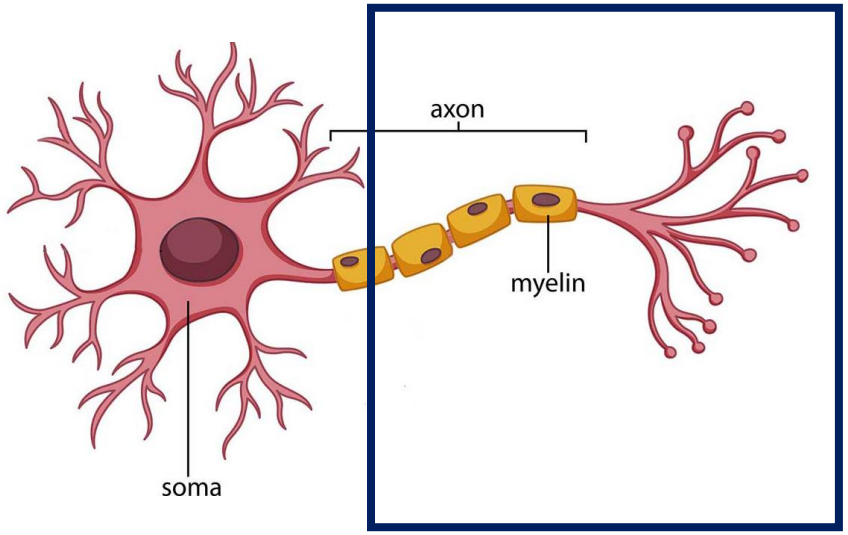

CN fibers:

✓ Somatic

Motor

Sensory

✓ Autonomous parasympathetic

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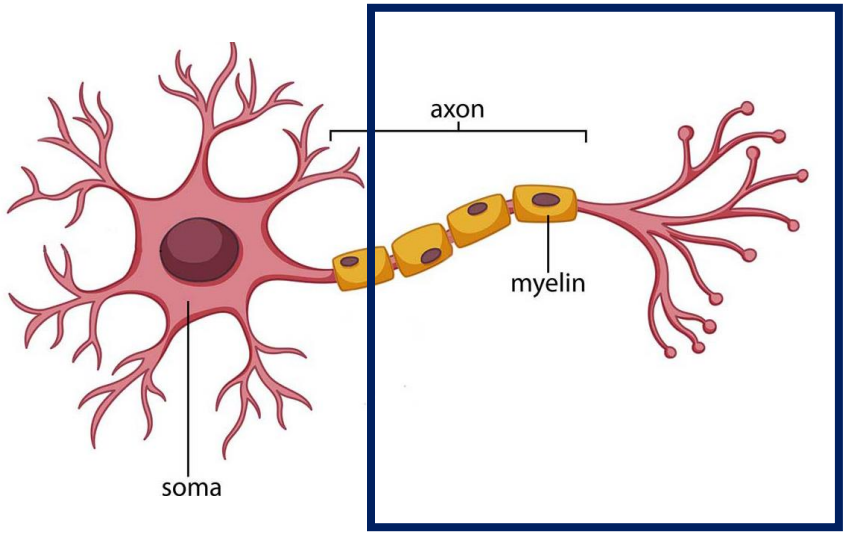

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Clinically….

A damaged CN results in alteration of specific functions:

- Abnormal motor function of specific muscles of the head
- Abnormal sensory function (tactile head/senses)
- Abnormal parasympathetic functions

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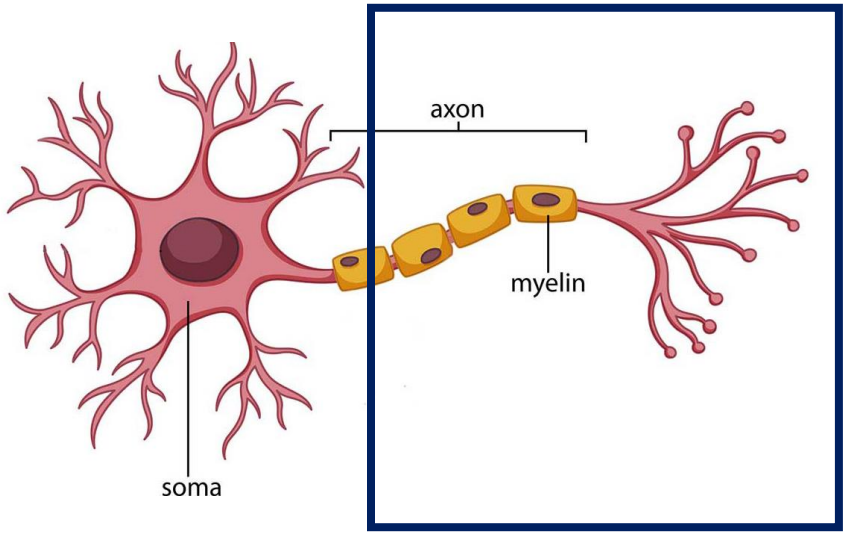

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Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – neuroanatomy "in brief"

Which are the specific functions of each CN?

NERVE	FUNCTION	TEST
Olfactory (I) Opposite cerebral cortex	Sensory: olfactory	-
Optic (II) Opposite cerebral cortex	Sensory: vision	PLR, dazzle, menace

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Oculomotor (III) Same side midbrain	Motor: eye muscles – eye globe position	Strabismus, lack of normal nystagmus
Trochlear (IV) Opposite side midbrain	Motor: eye muscles – eye globe position *(opposite side)*	Strabismus, lack of normal nystagmus
Abducens (VI) Same side brainstem	Motor: eye muscles – eye globe position	Strabismus, lack of normal nystagmus

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Trigeminus (V) Same side pons	Motor: mastication muscles Sensory: skin face tactile sensory	Mastication test/muscles palpation Facial tactile stimulation, palpebral reflex
Abducens (VI) Same side brainstem	Motor: eye muscles – eye globe position	Strabismus, lack of normal nystagmus

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Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – neuroanatomy "in brief"

Which are the specific functions of each CN?

NERVE	FUNCTION	TEST
Facial (VII) Same side brainstem	Motor: skin muscles of the face Parasympathetic: lacrimation, salivation	Facial symmetry, abnormal prehension, palpebral reflex, menace, twitching (facial stimulation) Schirmer test
Vestibulocochlear (VIII) Same side brainstem	Sensory: hearing, balance	Hearing tests (BAER), head tilt, pathological nystagmus, vestibular ataxia

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Vestibulocochlear (VIII) Same side brainstem	Sensory: hearing, balance	Hearing tests (BAER), head tilt, pathological nystagmus, vestibular ataxia
Glossopharyngeal (IX) Same side brainstem	Sensory: pharyngeal mucosa Motor: pharyngeal muscles Parasympathetic: salivation (parotid)	Swallowing, (taste)
Vagus (X) Same side brainstem	Sensory: pharyngeal, laryngeal mucosa Motor: pharyngeal, laryngeal muscles Parasympathetic: GI, cardiac, respiratory function, blood pressure	Swallowing, phonation, slap test Increased sympathetic tone
Accessory (XI) Same side brainstem	Motor: neck muscles	Cervicofacial reflex

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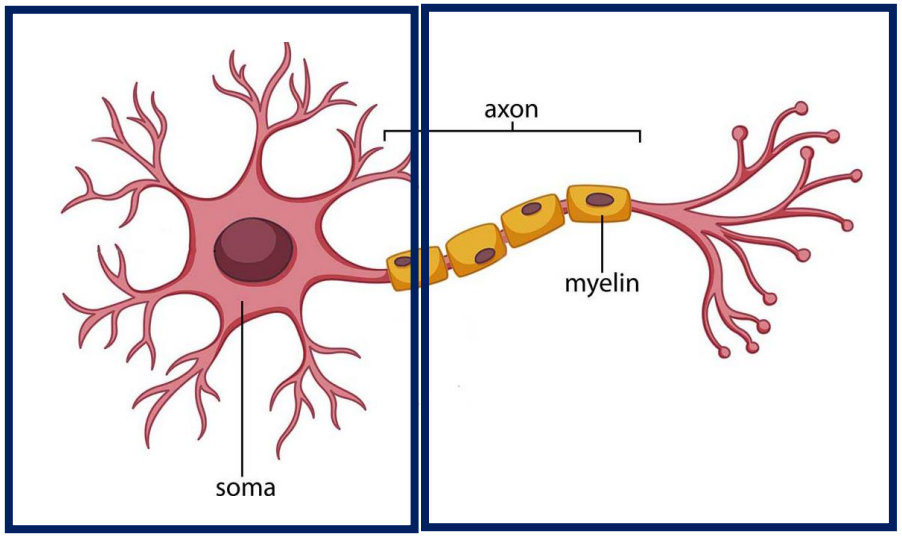
Accessory (XI) Same side brainstem	Motor: neck muscles	Cervicofacial reflex
Hypoglossal (XII) Same side brainstem	Motor: tongue muscles	Tongue tone testing

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – neurolocalization
  - Cranial nerves are bilateral
  - Cranial nerves are group of neuron fibers



CN nuclei:
Located in the brain

CN fibers:
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Clinically….

We aim to which identify cranial nerve function is abnormal and on which side to locate the lesion:

- <u>One nerve, unilateral</u>
  - Likely (not 100%) peripheral, same side
  - Possible central, focal, same side (except CN I, II, IV)

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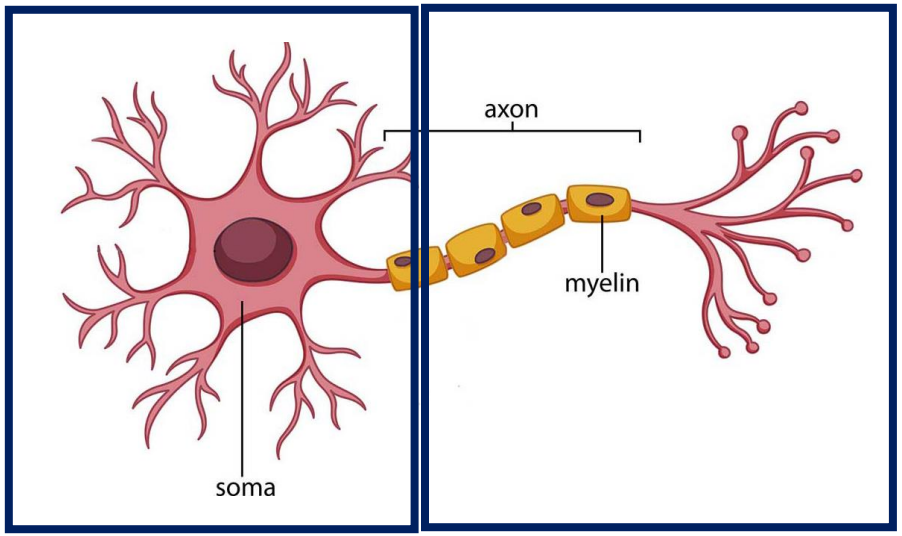

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  - Unlikely but possible central, focal, same side (except CN I, II, IV)
- <u>One nerve, bilateral</u>
  - Likely central, focal, bilateral
  - Unlikely (extremely rare) peripheral, bilateral

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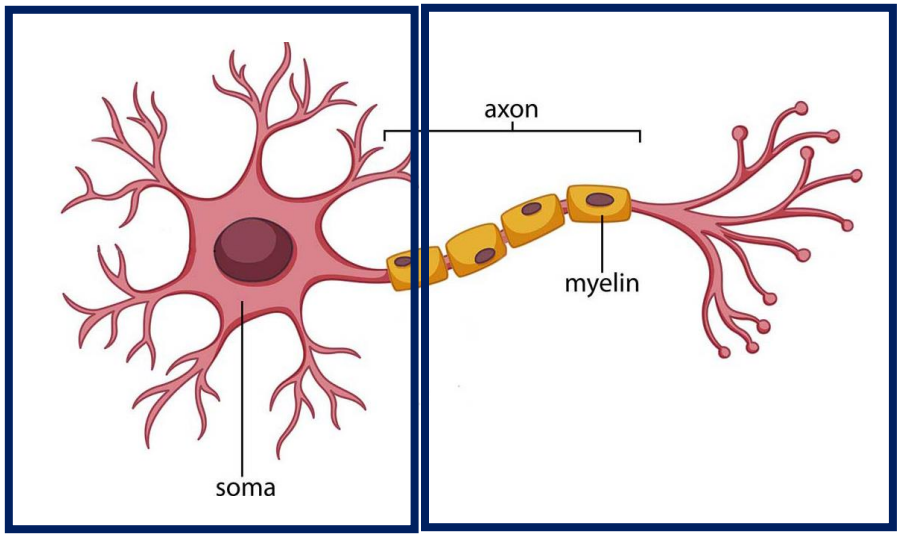

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  - Unlikely but possible central, focal, same side (except CN I, II, IV)
- <u>One nerve, bilateral</u>
  - Likely central, focal, bilateral
  - Unlikely (extremely rare) peripheral, bilateral
- <u>Multiple nerves</u>
  - On the same side: likely central, unilateral focal/multifocal, possible peripheral for nerves that run close one to each other (i.e. CN VII, VIII)
  - On different sides: likely central, bilateral, focal/multifocal

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Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization
  - Menace response
  - Obstacle testing
  - Pupillary light reflex
  - Palpebral reflex

Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization

  - Menace response
  - Obstacle testing
  - Pupillary light reflex
  - Palpebral reflex

.... Always perform ophthalmologic evaluation:
Loss of vision due to ophthalmologic disease are more common than loss of vision due to neurological disease

Neurological approach to the vision function

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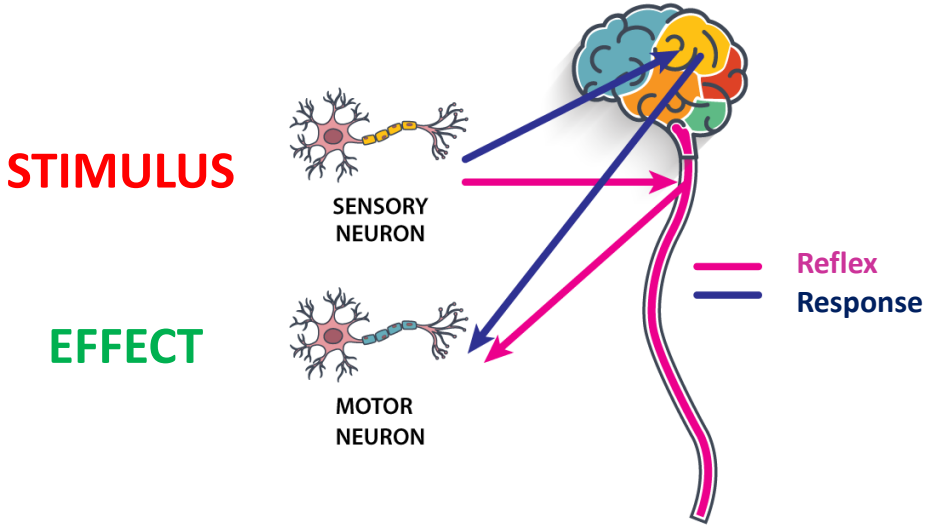
REMIND DIFFERENCE BETWEEN:

- **Reflex:** does involve CNS (spinal cord, brainstem, midbrain, pons) but NOT cerebral cortex
  (NO voluntary component)
- **Response**: does involve CNS all the way up to the cerebral cortex (YES voluntary/learning component)



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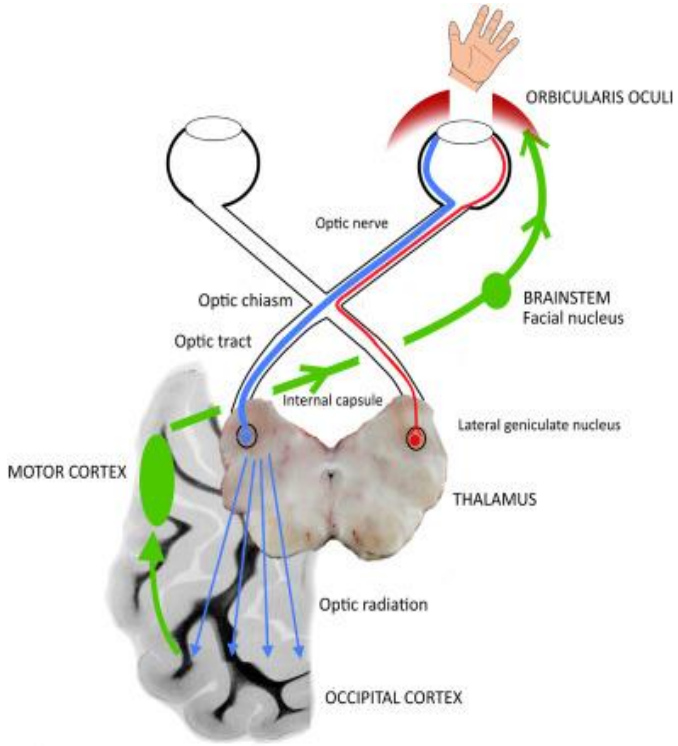
Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization
  - Menace response
    - Retina
    - Optic nerve (II), chiasm, tract
    - Cerebral cortex

    → Absent menace, **horse is blind**
    - Cerebellum
    - Brainstem
    - Facial nerve (VII)

    → Absent menace, **horse is visual**



- Obstacle testing
- Pupillary light reflex
- Palpebral reflex

→ Helps to localize the lesion especially in case of absent menace!

https://www.vetequine.theclinics.com/article/S0749-0739(22)00021-9/fulltext#fig3

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    - Cerebellum
    - Brainstem
    - Facial nerve (VII)

    → Absent menace, **horse is visual**
  - Obstacle testing → In case of absent menace, is the horse visual or blind?
  - Pupillary light reflex
  - Palpebral reflex

Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization

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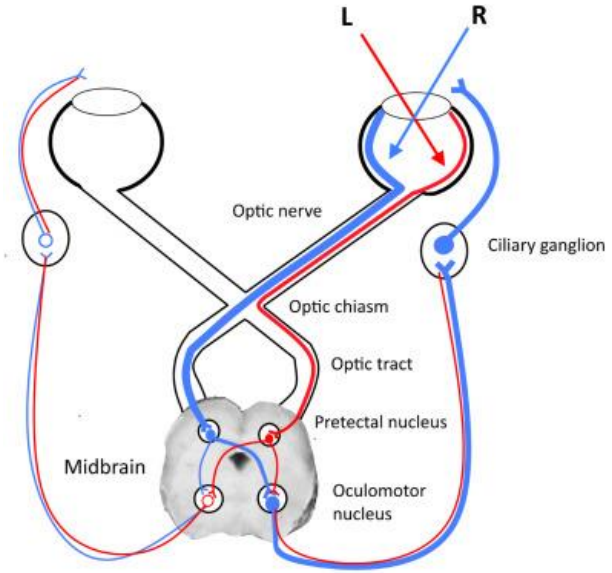

- Obstacle testing
- **Pupillary light reflex** → In case of absent menace, blind horse, is it peripheral (nerve II) or central (cortex) blindess?
  - Retina
  - Optic nerve (II), (chiasm)
  - Midbrain
  - Oculomotor – parasympathetic (III)
  - Pupil
- Palpebral reflex

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    - Brainstem
    - Facial nerve (VII)

    → Absent menace, **horse is visual**
  - Obstacle testing
  - Pupillary light reflex
  - **Palpebral reflex** → In case of absent menace, visual horse, is it cerebellum or brainstem/cranial nerve VII?
    - Nerve V sensory
    - Brainstem
    - Nerve VII

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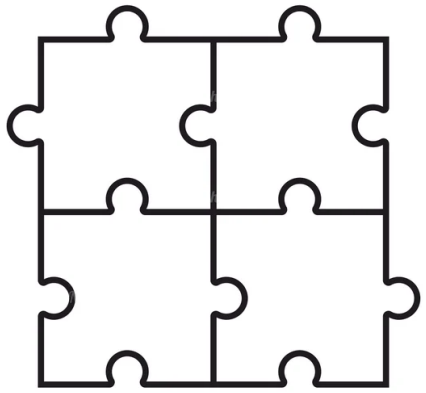
Outline

My (hopefully useful) approach to neurological exam interpretation



- Neurolocalizing the head: brain and cranial nerves
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- The Horner's signs and their interpretation
- Neurological approach to the vestibular system

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- Focal or multifocal?
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Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization

PLR	Menace	Obstacles	Palpebral	Lesion
-	-	-	+	Eye, nerve II peripheral
-	+	+	+	Nerve III peripheral, midbrain (parasympathetic)
+	-	-	+	Cerebral cortex (central blindness)
+	-	+	+	Cerebellum (likely other concurrent cerebellar signs)
+	-	+	-	Brainstem, nerve VII peripheral

Neurological approach to the vision function

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Video courtesy of Dr Lana Dedecker

Neurological approach to the vision function

- Pathways of vision testing … to help neurolocalization

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Two possibilities:

- Cortex
- Cerebellum

Video courtesy of Dr Lana Dedecker

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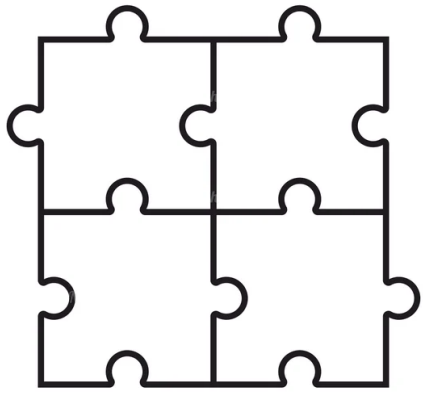

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The Horner's signs and their interpretation

- Pathways of Horner's: physiology "in brief"
  - Autonomous pathways that regulate sympathetic functions of the head and neck

https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain

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    - Sweating glands – b2 adrenoceptors
      *** not completely understood in the horse****
      - *Sympathetic stimulation: sweating*
      - *Over-stimulation: receptor downregulation and anhidrosis*
      - *Lack of sympathetic tone: persistent sweating*

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The Horner's signs and their interpretation

- Pathways of Horner's: Horner's syndrome
  - Horner's syndrome/ signs of Horner's
    - Pupil dilator muscle ~~X~~ mydriasis → persistent miosis/anisocoria (unilateral)
    - Tarsal muscle ~~X~~ eyelid elevation → palpebral ptosis, enophthalmos, third eyelid prolapse
    - Sweating glands – b2 adrenoceptors
      *** not completely understood in the horse****
      - *Sympathetic stimulation: sweating*
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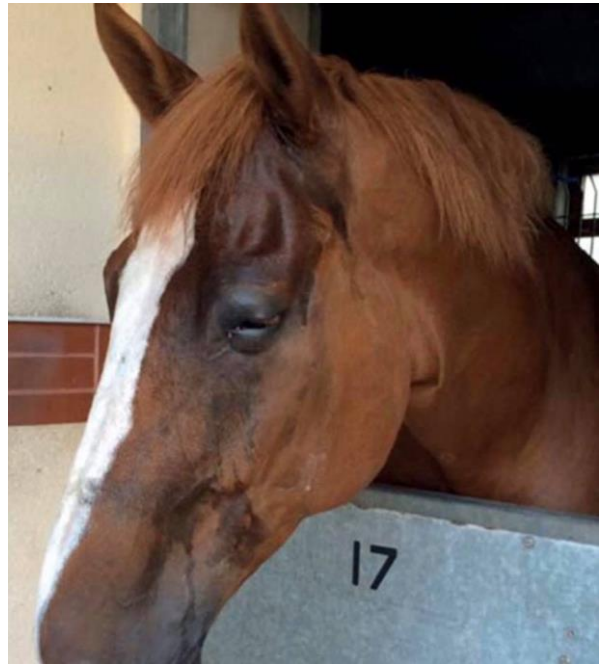
      - *Lack of sympathetic tone: persistent sweating → localized head and/or neck*



https://www.centrallakesequine.co.nz/new-blog-1/2020/4/28/1aivbzmsp339zkb3ss6unvszqq3l9p

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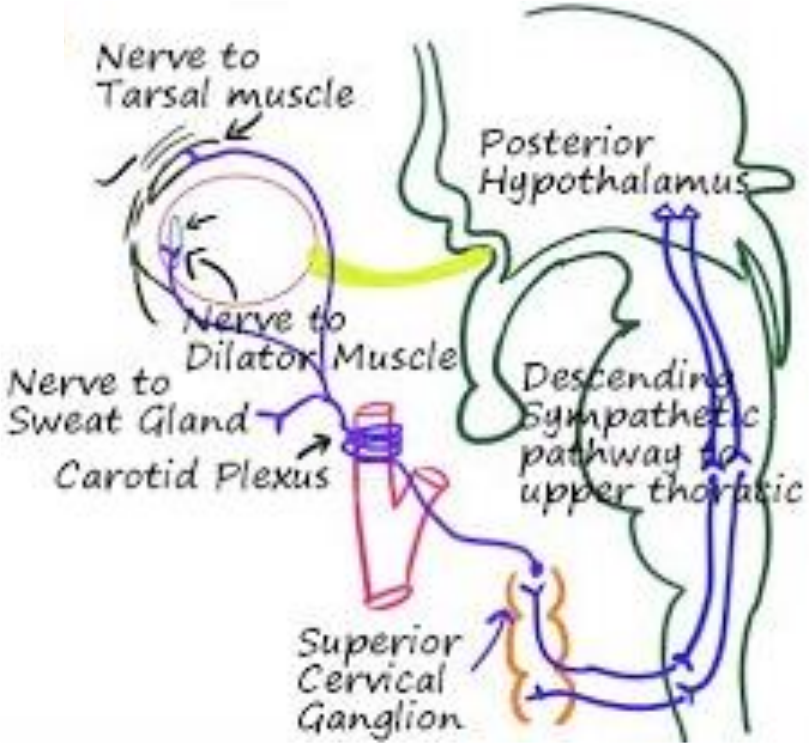

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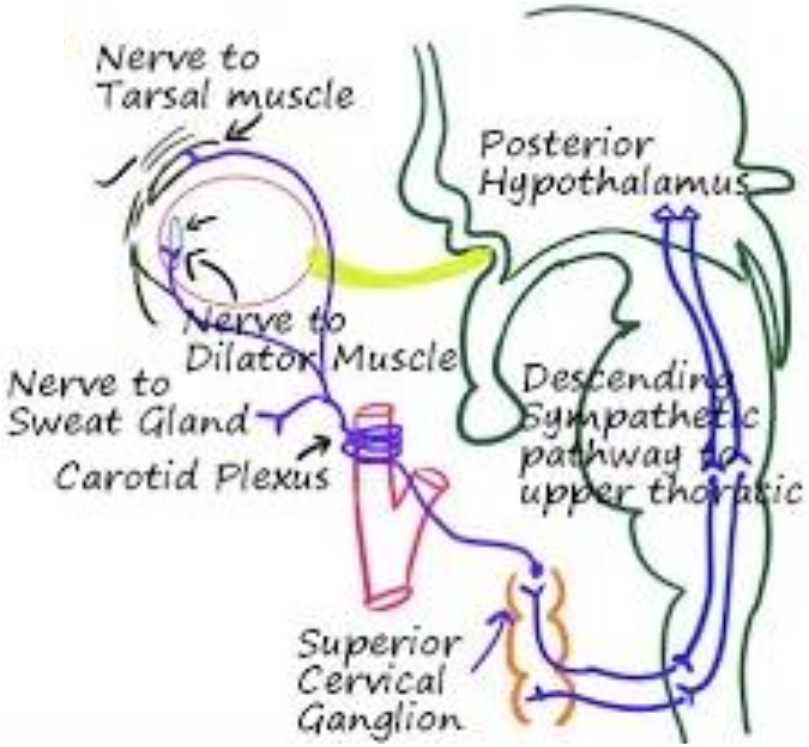

- Descending pathways (1st order neurons)
  - Hypothalamus
  - Midbrain
  - Pons
  - Brainstem
  - Spinal cord cervical

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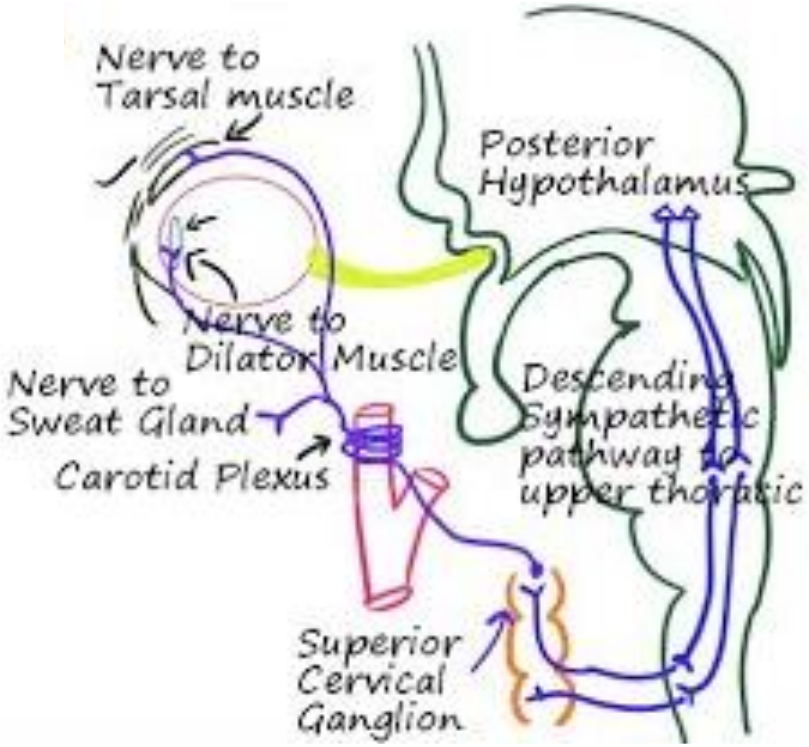

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- Ascending pathways (2nd order neurons)
  - Thoracolumbar spinal cord

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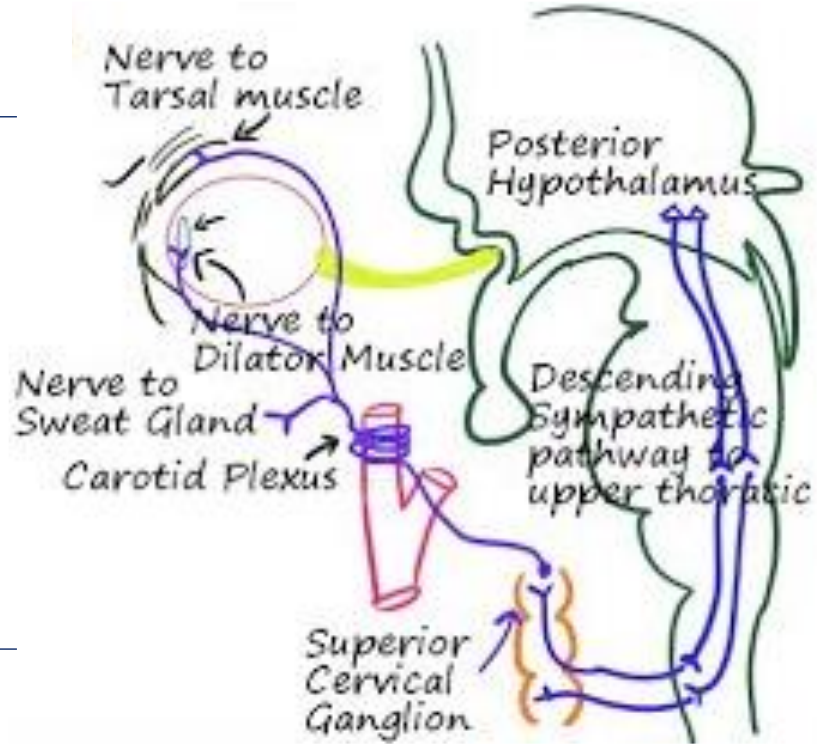
  - Superior cervical ganglion
  - Sympathetic trunk
  - Nerve to
    - Sweating glands head & neck
    - Pupil dilator muscle
    - Tarsal muscle



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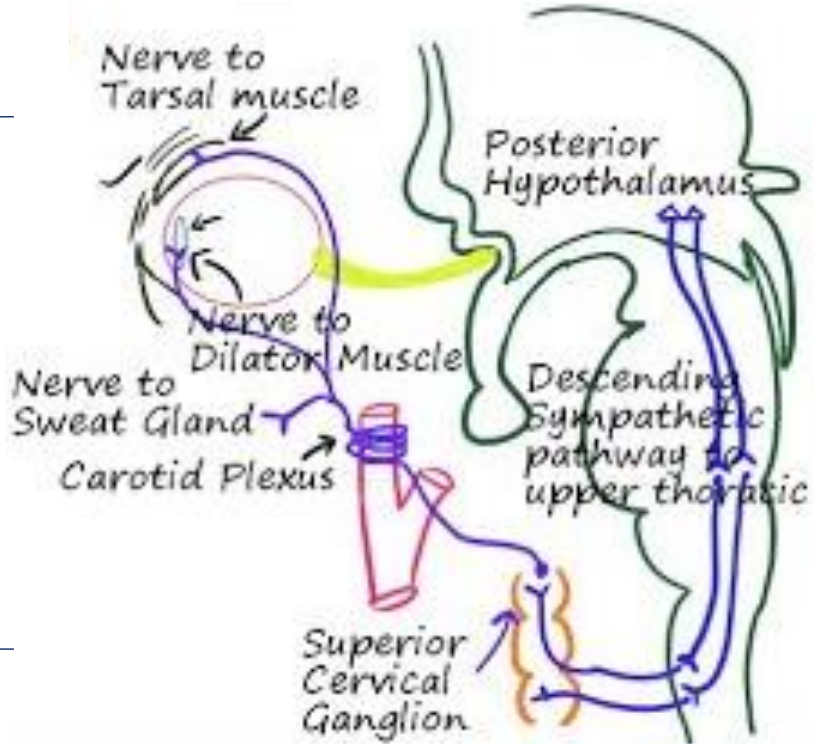
Sympathetic trunk passes in the medial wall of guttural pouches (close to IX, X, XI, XII CNs)

Sympathetic trunk passes close to temporal pars petrosa next to CNs VII and VIII



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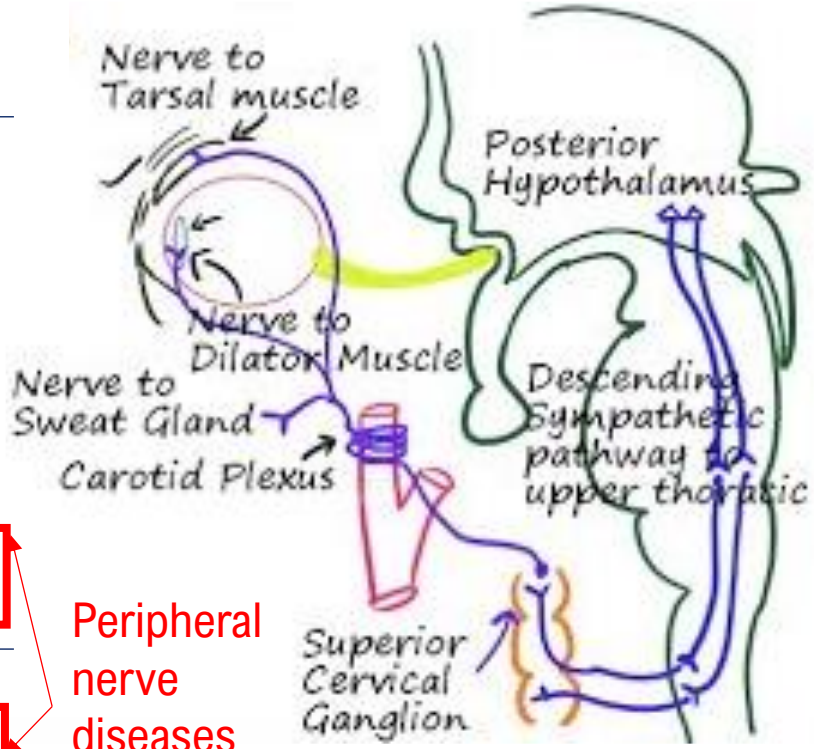

Peripheral nerve diseases (unilateral)

- Descending pathways (1st order neurons)
  - Hypothalamus
  - Midbrain
  - Pons
  - Brainstem
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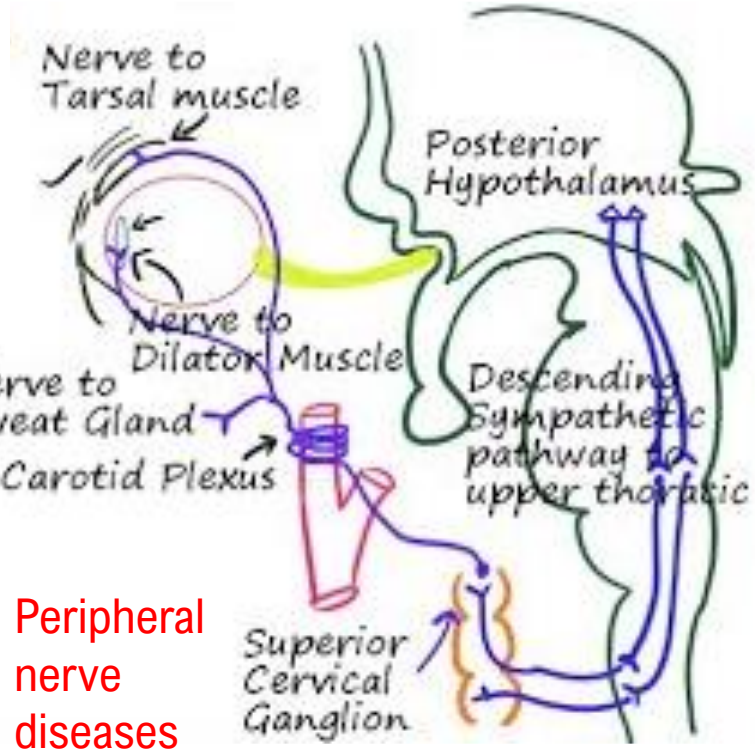

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Central NS diseases – brain/spinal cord (unilateral ++/bilateral)

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Outline

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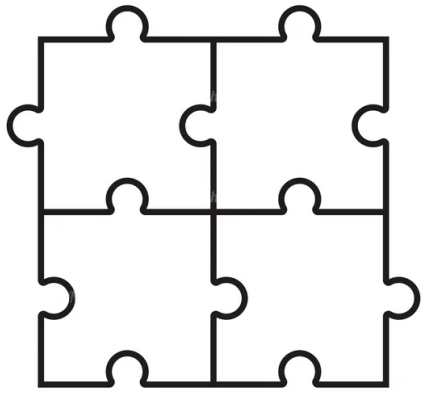

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Neurological approach to the vestibular system

- The vestibular system – physiology “in brief”

  Bilateral neurological pathways responsible for balance while standing/during movement:

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  - Input information:

    - Body, head, eye position in the space (from one side)

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  Bilateral neurological pathways responsible for balance while standing/during movement:

  - Input information:
    - Body, head, eye position in the space (from one side)
  - Output information:
    - Increase extensor muscle tone on the same side = prevents head/body falling on same side
    - Physiological nystagmus while moving = fast phase towards the direction of movement

Neurological approach to the vestibular system

- The vestibular system – vestibular syndrome

  Damage to vestibular system results in:

  - Head falling towards lesion side = **head tilt**
  - Body falling towards one side = **vestibular ataxia**
  - Pathological nystagmus = horizontal (**fast phase away from lesion side**), rotatory, changy, vertical

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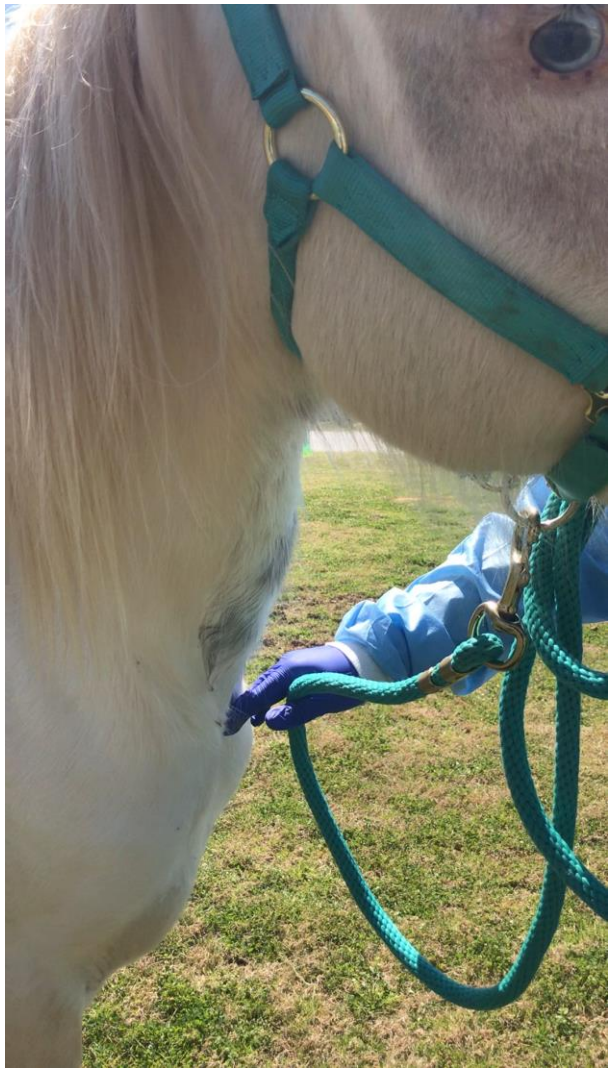

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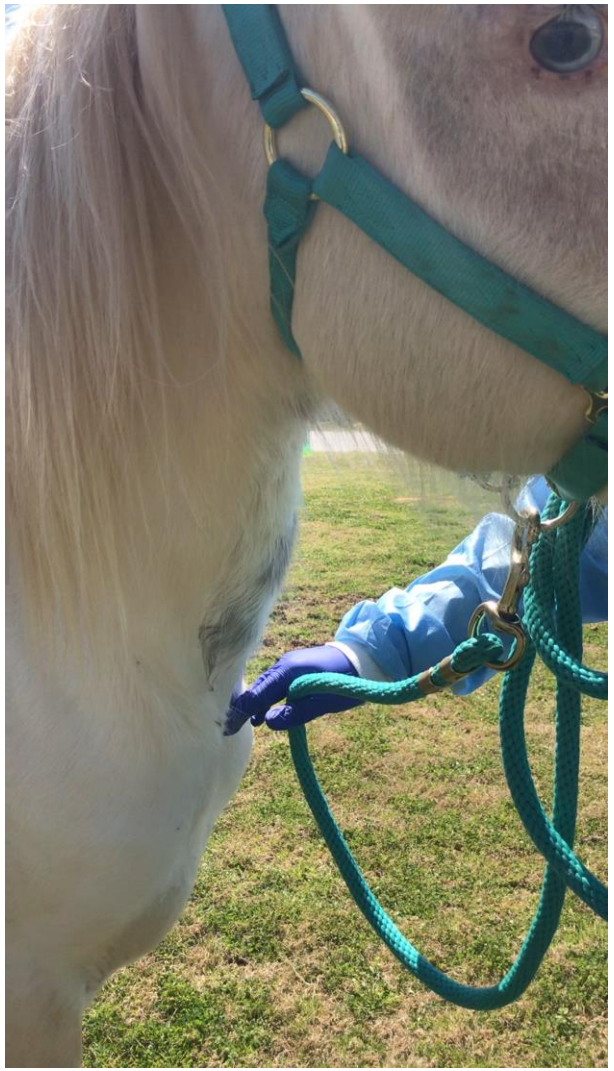

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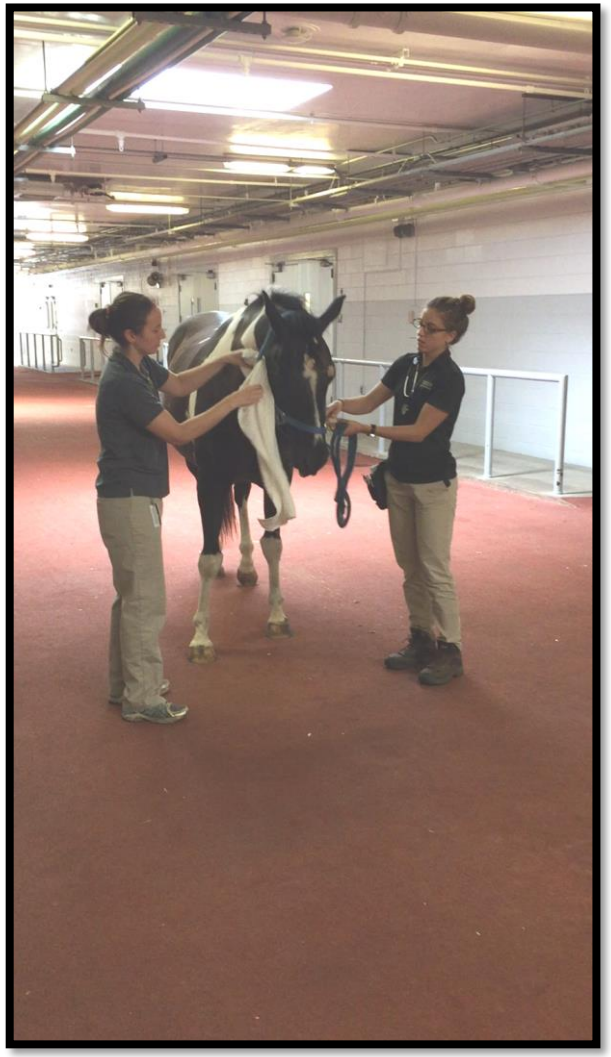

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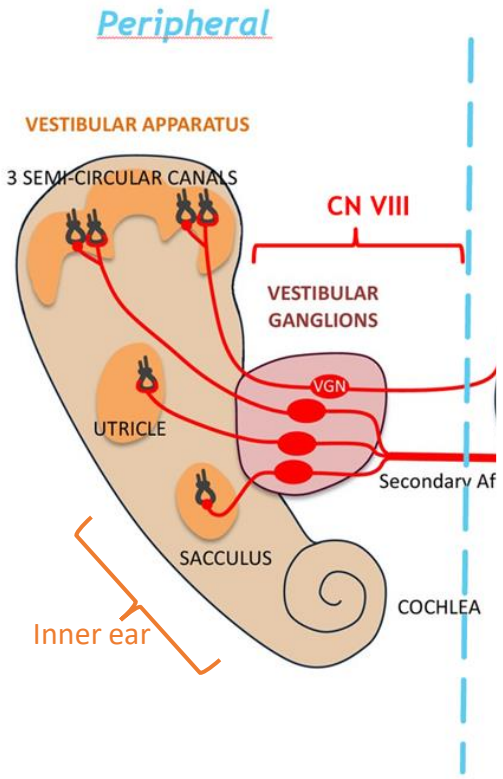
THESE NEUROLOGICAL SIGNS ARE SEEN ONLY WITH LESIONS INVOLVING THE VESTIBULAR SYSTEM!!!!

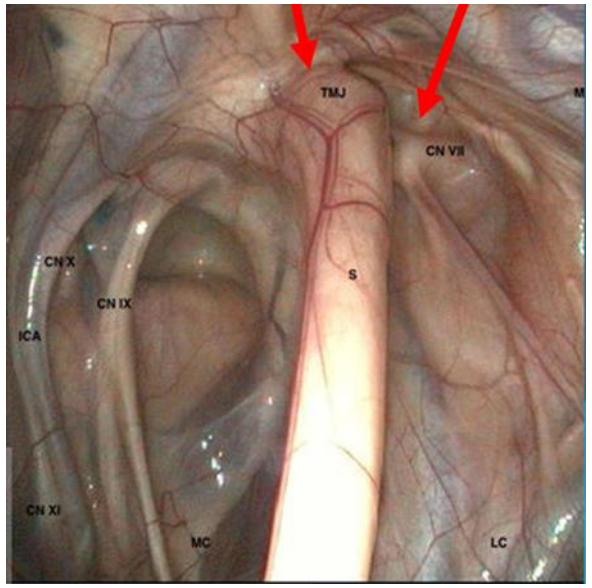
Which are the neurological structures that form the vestibular system (VS)?

- Outside the brain = PERIPHERAL VS
- Inside the brain = CENTRAL VS

Neurological approach to the vestibular system

- The vestibular system – neuroanatomy & neurolocalization





Cranial nerve VIII runs very close to CN VII (facial) and in part to sympathetic trunk

Cranial nerve VII and VIII runs next to the temporohyoid and dorsolateral wall of the guttural pouch

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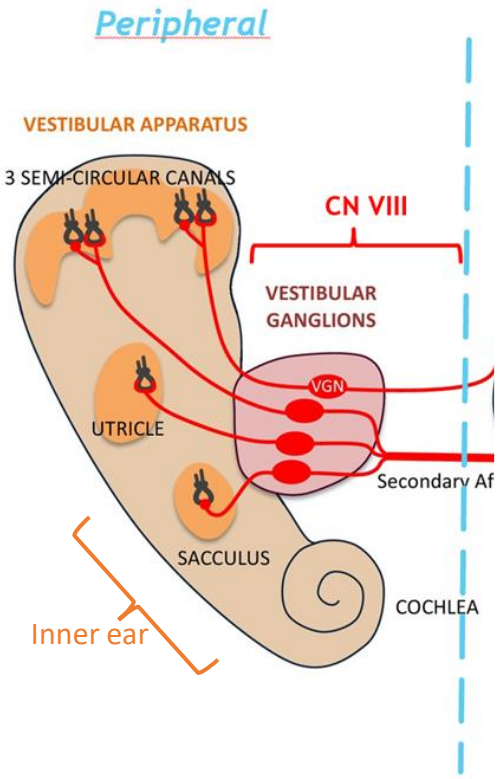

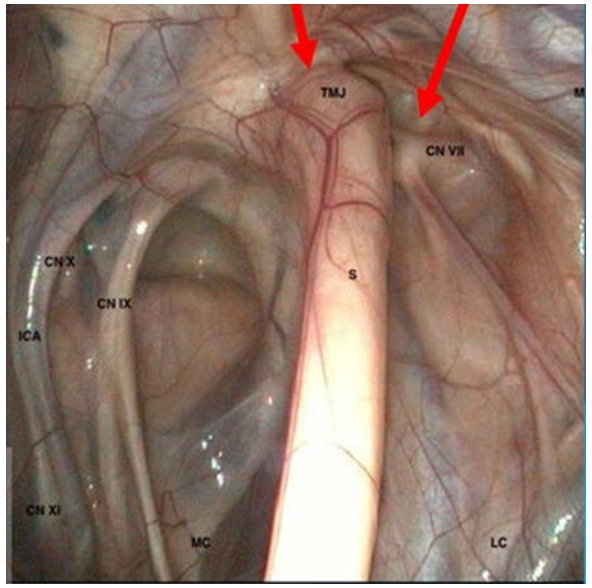

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Peripheral vestibular disease

- Damage to inner ear
- Damage to cranial nerve VIII fibers
  - Often associated to peripheral CN VII disease due to proximity/sometimes associated with Horner's signs

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Neurological approach to the vestibular system

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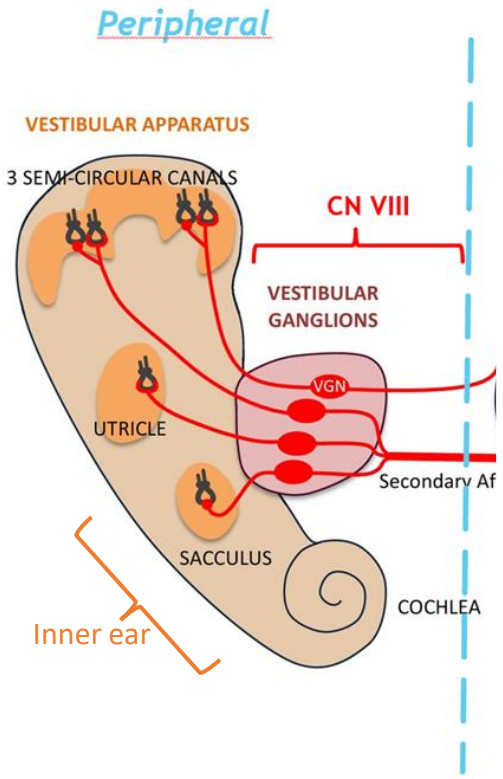

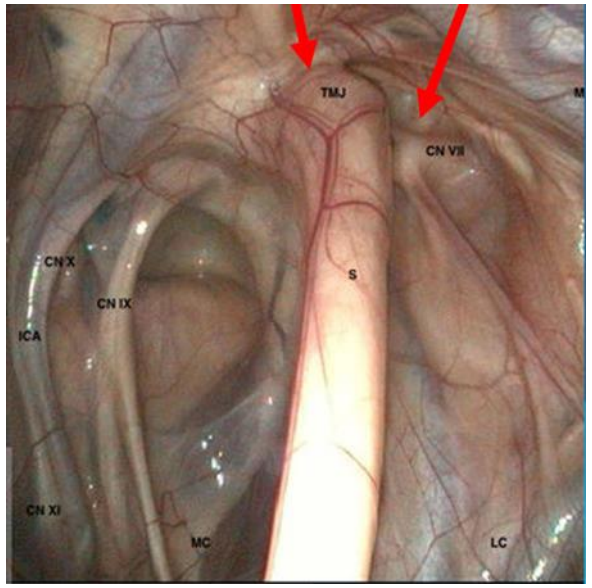

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Lack of vestibular information input on one side = reduced output to extensor muscles on the same side

- Head tilt towards same side
- Falling towards the same side
- Nystagmus fast phase away from the affected side

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Neurological approach to the vestibular system

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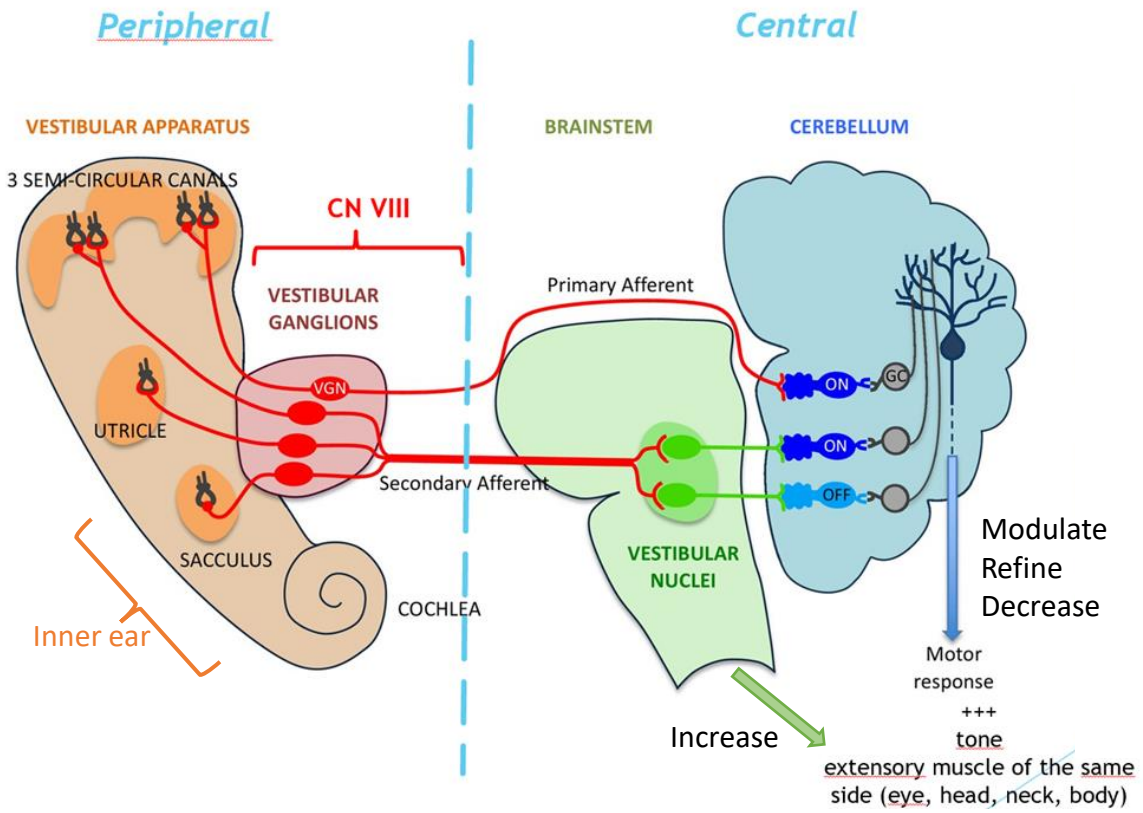

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Neurological approach to the vestibular system

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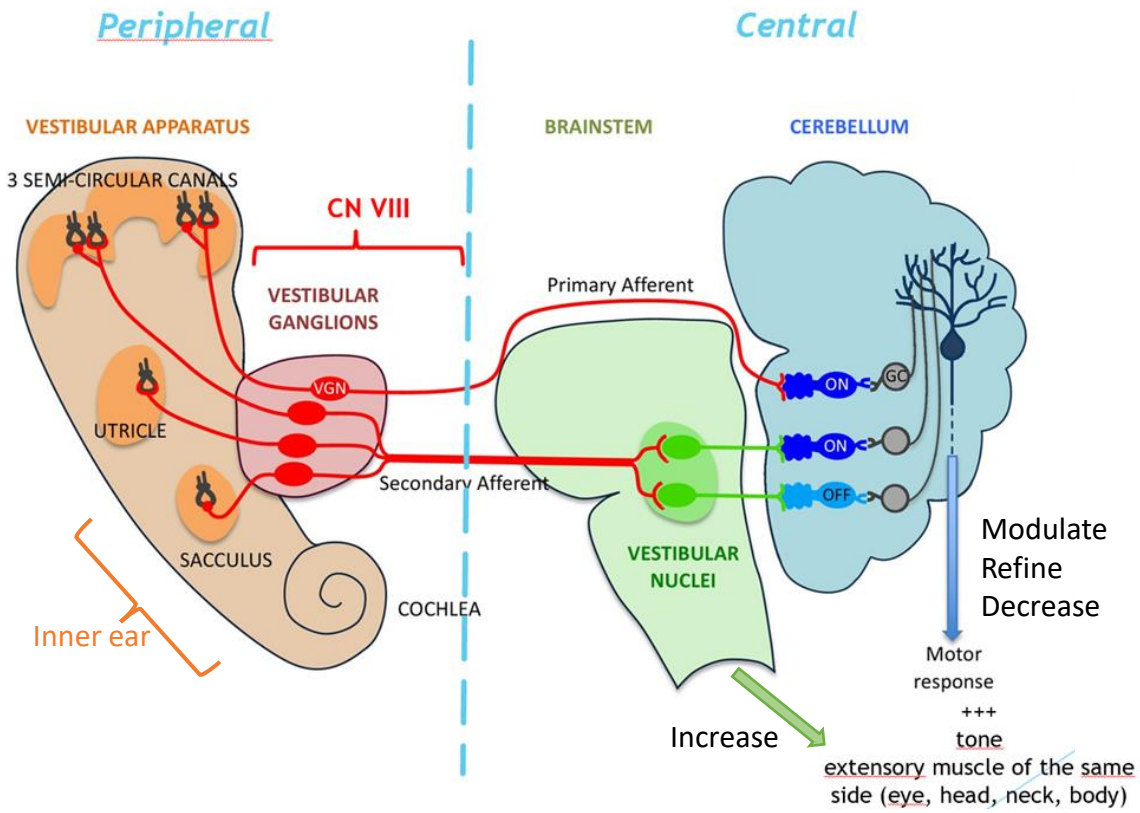

Central vestibular disease

- Damage to brainstem
  - Nuclei CN VIII and VII are located very close in the brainstem (but also CN VI, IX, X, XI, XII, descending Horner's pathways, ascending proprioceptive pathways)

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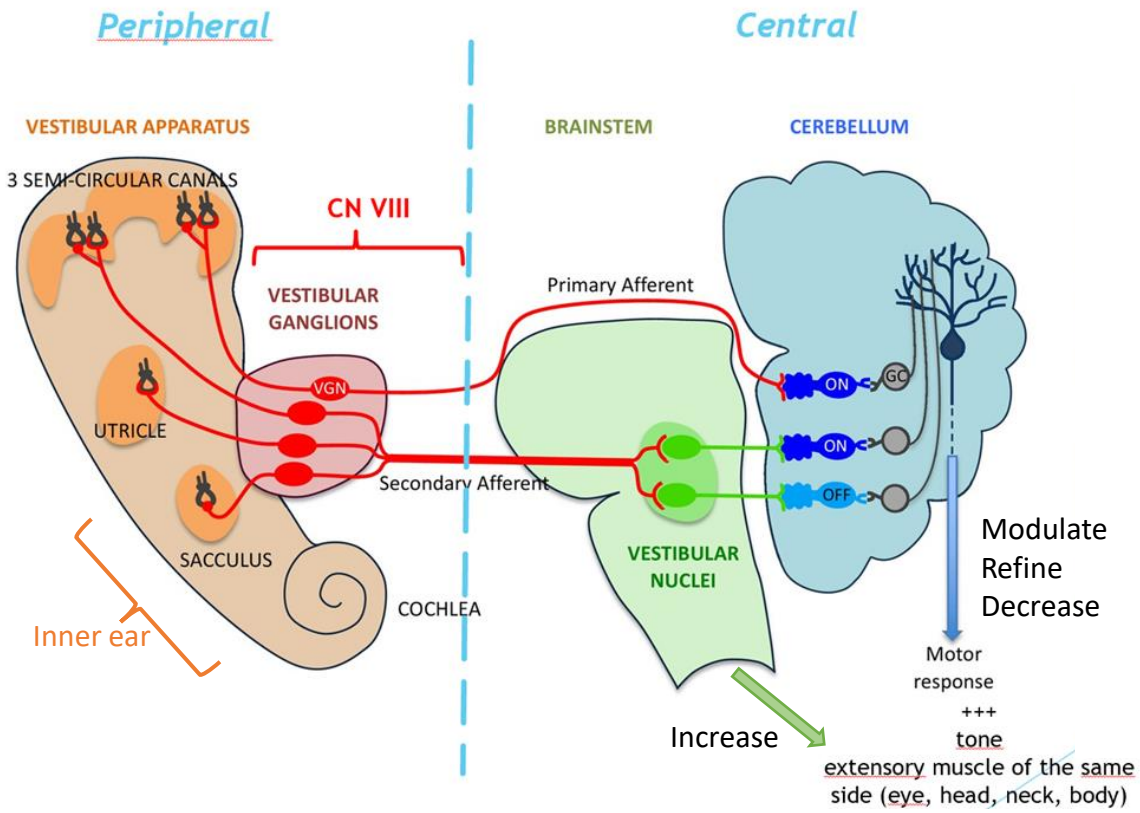

Central vestibular disease

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Lack of vestibular output to extensor muscles on the same side

- Head tilt towards same side
- Falling towards the same side
- Nystagmus fast phase away from the affected side

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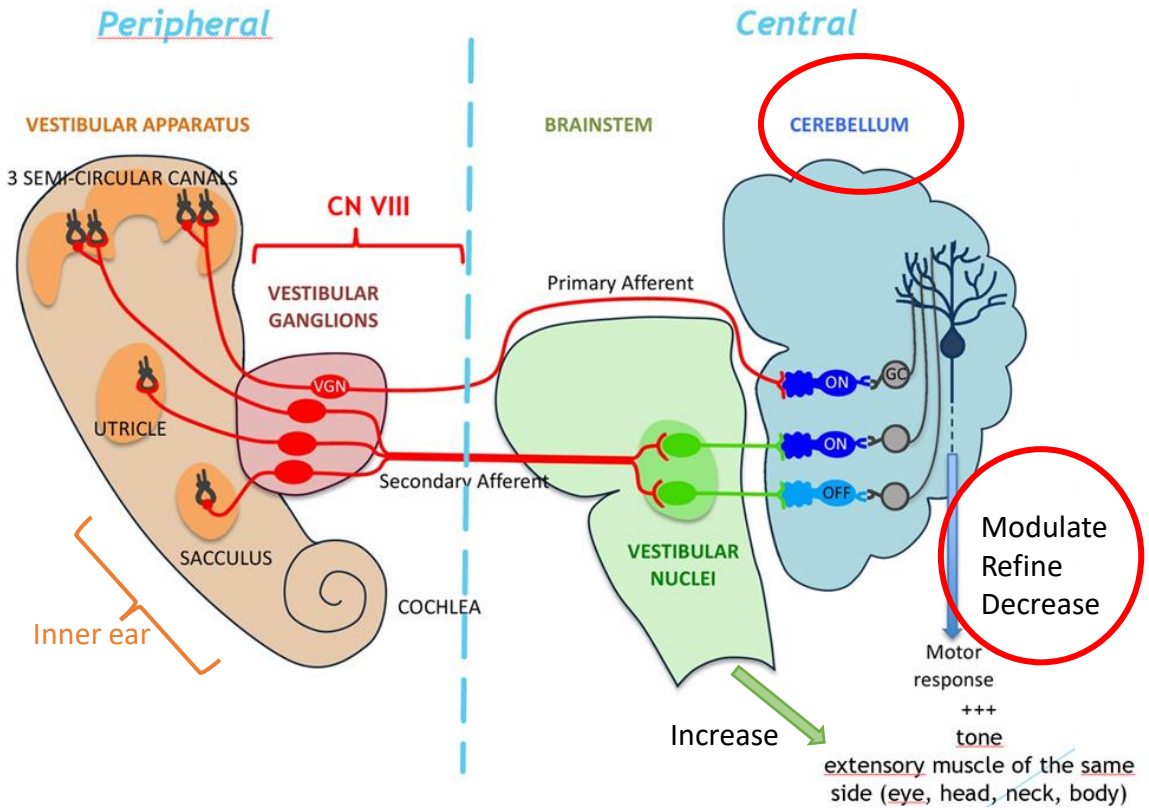

Central vestibular disease

- Damage to cerebellum
  - Often associated with other cerebellar signs (hypermetria, intentional tremors)

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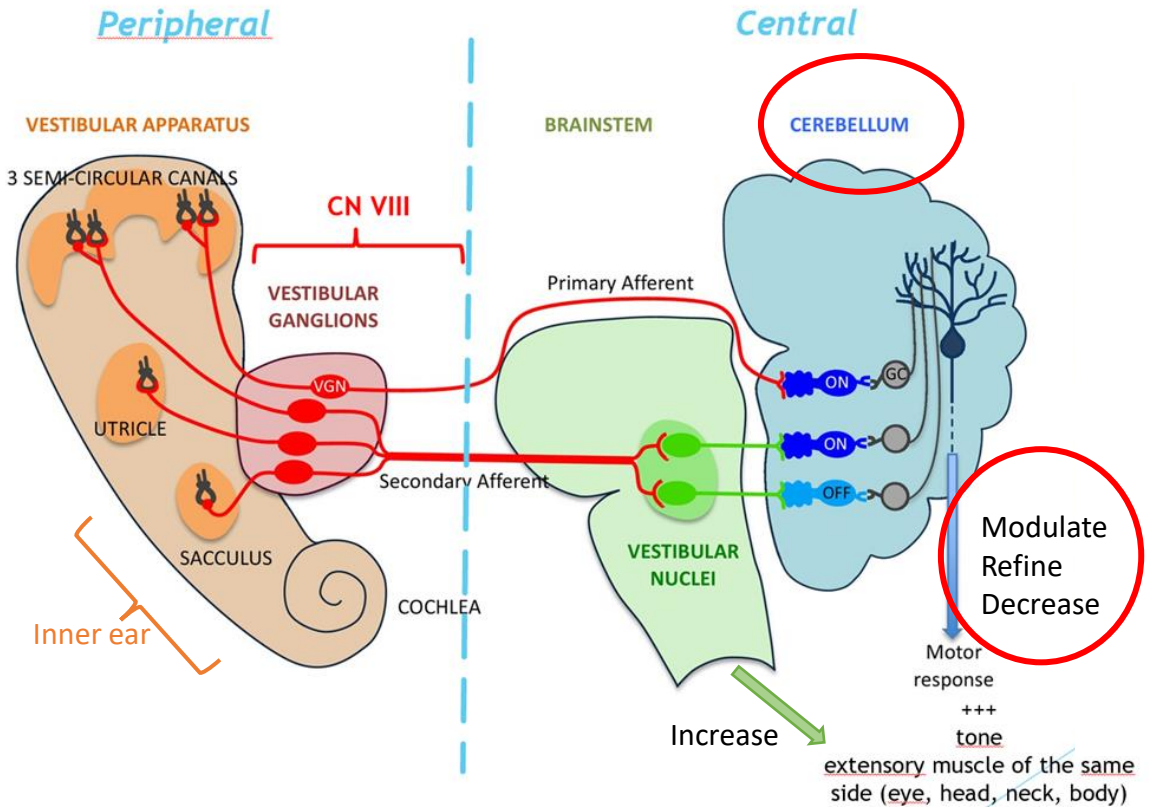

Central vestibular disease

- Damage to cerebellum
  - Often associated with other cerebellar signs (hypermetria, intentional tremors)

Lack of modulation vestibular output to extensor muscles on the same side = excessive tone on the same side

- Head tilt towards opposite side
- Falling towards the opposite side
- Nystagmus fast phase towards the affected side

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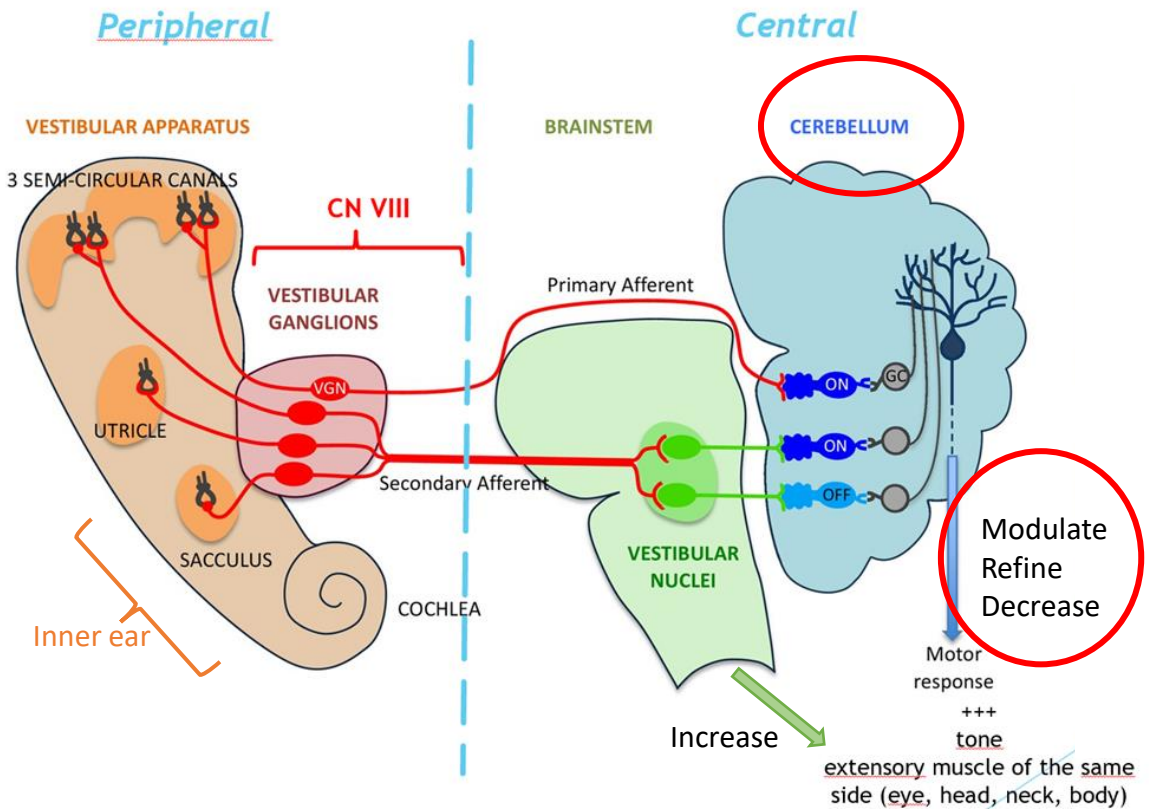

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PARADOXICAL VESTIBULAR SYNDROME

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Peripheral or central?

CLINICAL SIGN	CENTRAL	PERIPHERAL
Head tilt	YES	YES
Nystagmus (horizontal/rotatory)	YES	YES
Vestibular ataxia/loss of extensory tone	YES	YES
Horner's syndrome	YES	YES
Deficits CN VII (facial nerve)	YES	YES
Deficits CNs other than VII	YES	NO
Cerebellar ataxia/proprioceptive ataxia or deficits	YES	NO
Nystagmus (vertical/changy)	YES	NO
Behavioral/mental changes	YES	NO

One can never say that a vestibular syndrome is "for sure" peripheral

One can sometimes say that a vestibular syndrome is "for sure" central

Neurological approach to the vestibular system

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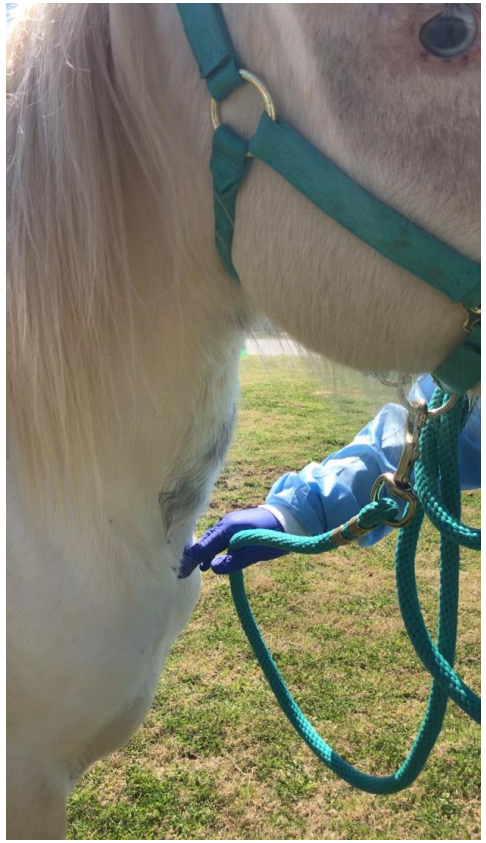
Peripheral or central?



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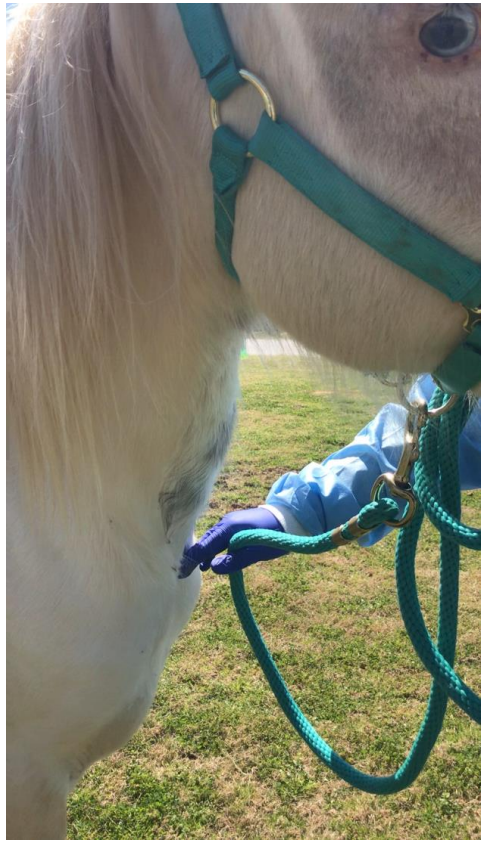
Peripheral
(Idiopathic vestibular syndrome)



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Peripheral or central?

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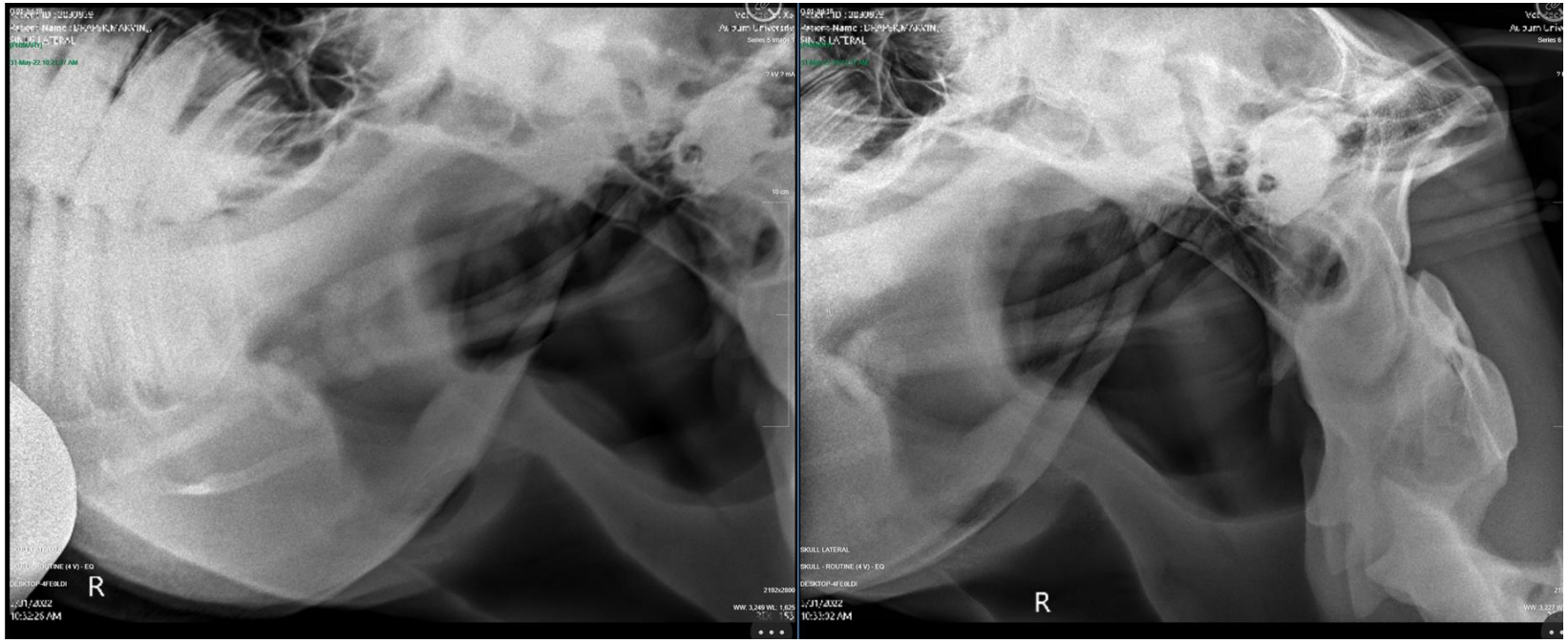
Central
(Brainstem-basisphenoid fracture)



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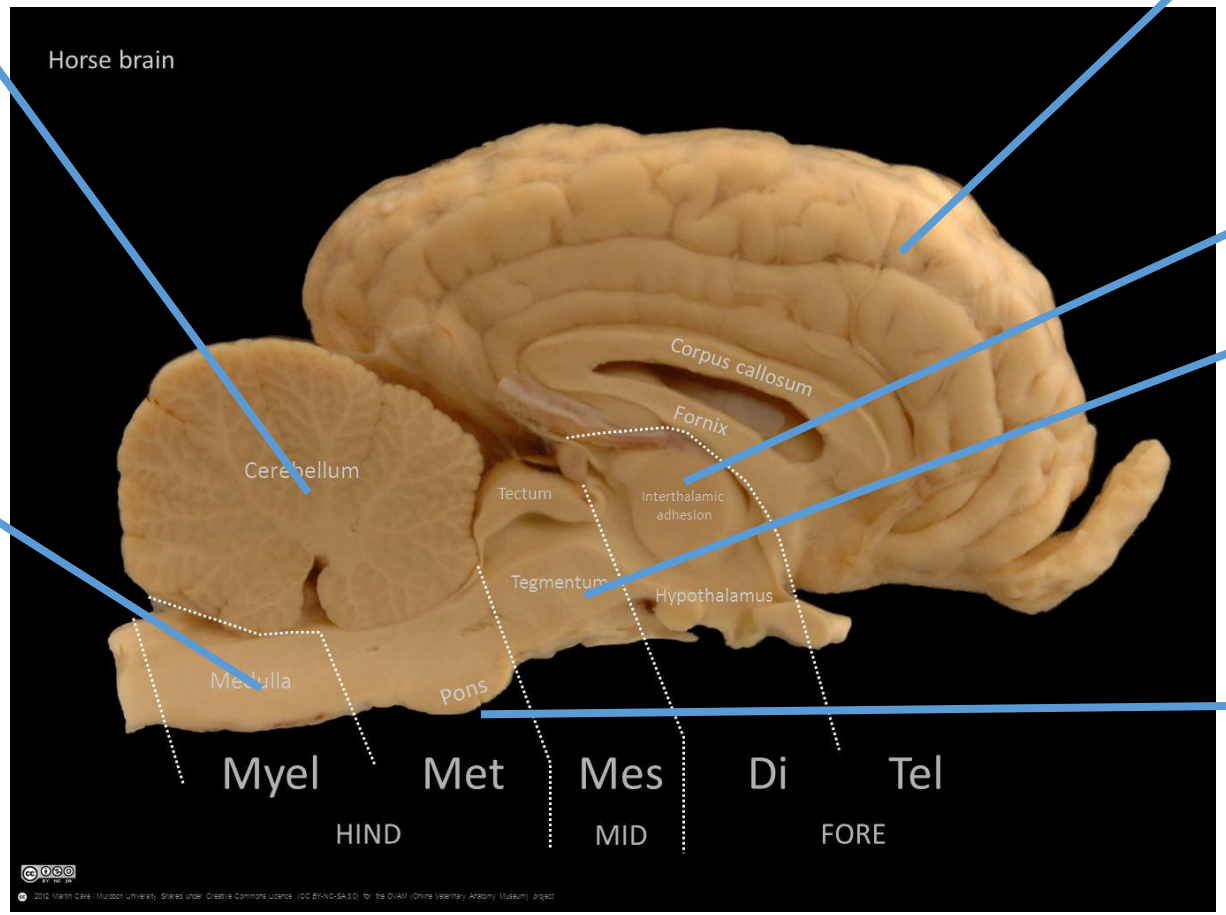
Neurolocalizing the head – in summary …

Cerebellum *(**part of central vestibular system**)*

- Hypermetria flexoria
- Intentional tremors
- Absence of menace
- Vestibular signs (paradoxical)
  - Paradoxical head tilt
  - Nystagmus
  - Vestibular ataxia

Brainstem *(**part of central vestibular system**)*

- Abnormalities cranial nerves VI-XII (same side)
- Obtundation
- Proprioceptive ataxia/deficits (opposite side)
- Upper Motor Neuron fore & hindlimbs
- Horner's



Cerebral cortex disease

- Abnormal behavior
- Abnormal mental status
- Central blindness (opposite side)
- Head turn/compulsive walking towards side of the lesion
- Proprioceptive ataxia/deficits (opposite side)

Hypothalamus

- Altered endocrine functions
- Horner's

Midbrain

- Abnormalities cranial nerve III (same side)
- Abnormalities cranial nerve IV (opposite side)
- Obtundation
- Proprioceptive ataxia/deficits (opposite side)
- Upper Motor Neuron fore & hindlimbs
- Horner's

Pons

- Abnormalities cranial nerve V (same side)
- Obtundation
- Proprioceptive ataxia/deficits (opposite side)
- Upper Motor Neuron fore & hindlimbs
- Horner's

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https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain


WHY'D YOU SPOOK?
I DON'T KNOW, WHY'D YOU SPOOK?
I DON'T REMEMBER
ME NEITHER
WHAT WERE WE EVEN DOING?
HEY, WHY ARE WE WEARING SADDLES?
© 2019 J.L. WERNER / MISFIT DESIGNS for EQUINED
"SPOOK BRAIN"

Questions?

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
  - Head and eye resting evaluation
  - Head (and eye) passive movements
  - Functional evaluation eating
  - Additional tests (if necessary)

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
  - Head and eye resting evaluation
    - Head position, symmetry, sensation
      - Head tilt (CN VIII)
      - Facial paresis (CN VII)
      - Facial sensation (CN V, VII)
      - (Hearing test (CN VIII))

Picture and video courtesy of Dr Sandy Taylor

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
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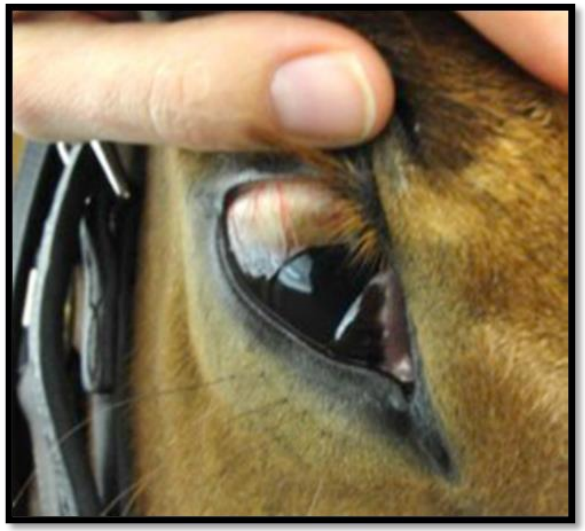
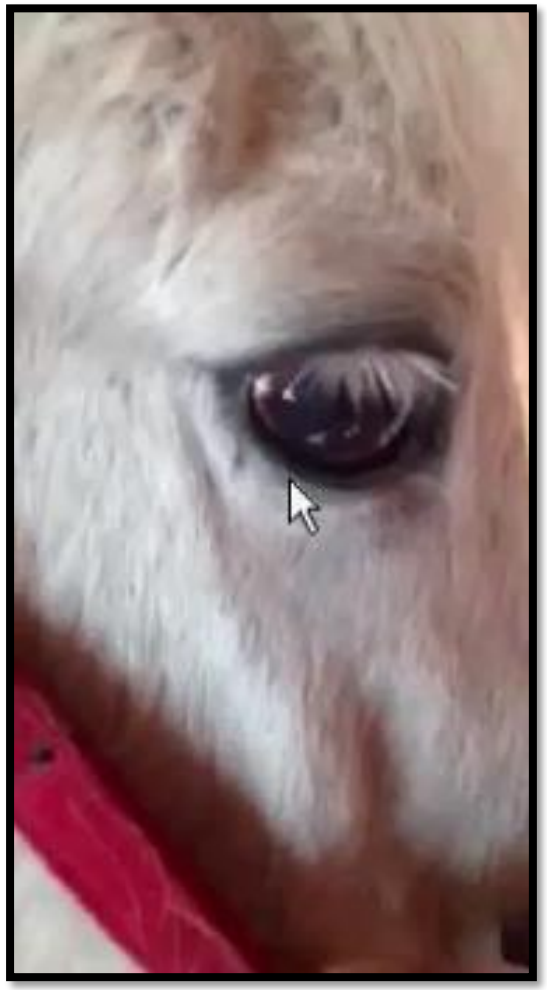
    - Head position, symmetry, sensation
      - Head tilt (CN VIII)
      - Facial paresis (CN VII)
      - Facial sensation (CN V, VII)
      - (Hearing test (CN VIII))
    - Eye position and symmetry
      - Strabismus/exophthalmos (CN III, IV, VI)
      - Anisocoria (pupil symmetry, CN III)
      - Resting pathological nystagmus (CN VIII)
      - Presence of corneal ulcers (CN VII)





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Picture and video courtesy of Dr Sandy Taylor

Neurolocalizing the head: brain and cranial nerves

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    - Head position, symmetry, sensation
      - Head tilt (CN VIII)
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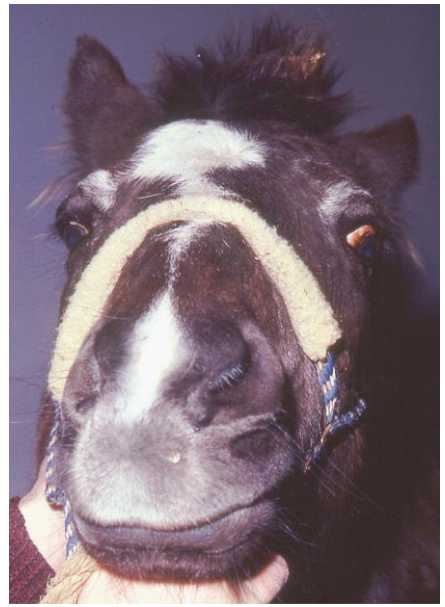
      - Facial sensation (CN V, VII)
      - (Hearing test (CN VIII))
    - Eye position and symmetry
      - Strabismus/exophthalmos (CN III, IV, VI)
      - Anisocoria (pupil symmetry, CN III)
      - Resting pathological nystagmus (CN VIII)
      - Presence of corneal ulcers (CN VII)
    - Eye reflexes/responses
      - Pupillary light reflex (CN II, III), dazzle reflex (CN II, VII)
      - Menace response (CN II, cerebral cortex, cerebellum, CN VII)
      - Palpebral reflex (CN V, VII)

Picture and video courtesy of Dr Sandy Taylor and Dr Lana Dedecker

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
  - Head (and eye) passive movements
    - Up/down passive movements
      - Onset of strabismus (CN III, IV, VI)
    - Lateral passive movements
      - Physiological nystagmus absence (CN III, IV, VI)
      - Pathological nystagmus (wrong direction) (CN VIII)



https://www.vetequine.theclinics.com/article/S0749-0739%2822%2900021-9/fulltext
https://absorbine.com/blogs/blog/equine-movement-issues-solved

Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
  - Functional evaluation eating
    - Offer food
      - Prehension (CN VII), mastication (CN V), swallowing (CN IX, X)
    - Mastication muscle trophism/symmetry
      - Masseter/temporalis palpation (CN V)
    - Tongue tone
      - Tongue palpation (CN XII)

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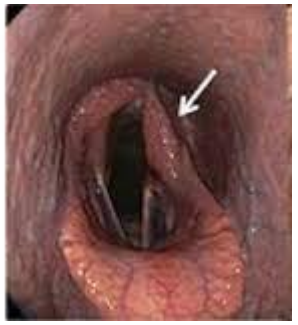
Picture and video courtesy of Dr Sandy Taylor and Dr Lana Dedecker

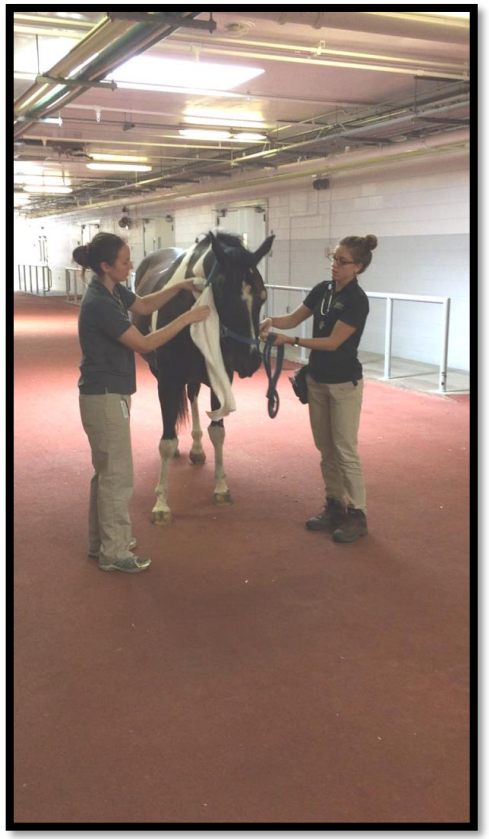
Neurolocalizing the head: brain and cranial nerves

- Cranial nerve (CN) examination – steps
  - Additional testing
    - Slap test (endoscopy)
      - CN X

      Blindfolding
      - Challenge CN VIII

    - Obstacle test
      - Vision testing (++ lack of menace with normal PLR)





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Video courtesy of Dr Sandy Taylor