



Oliver  
OS1

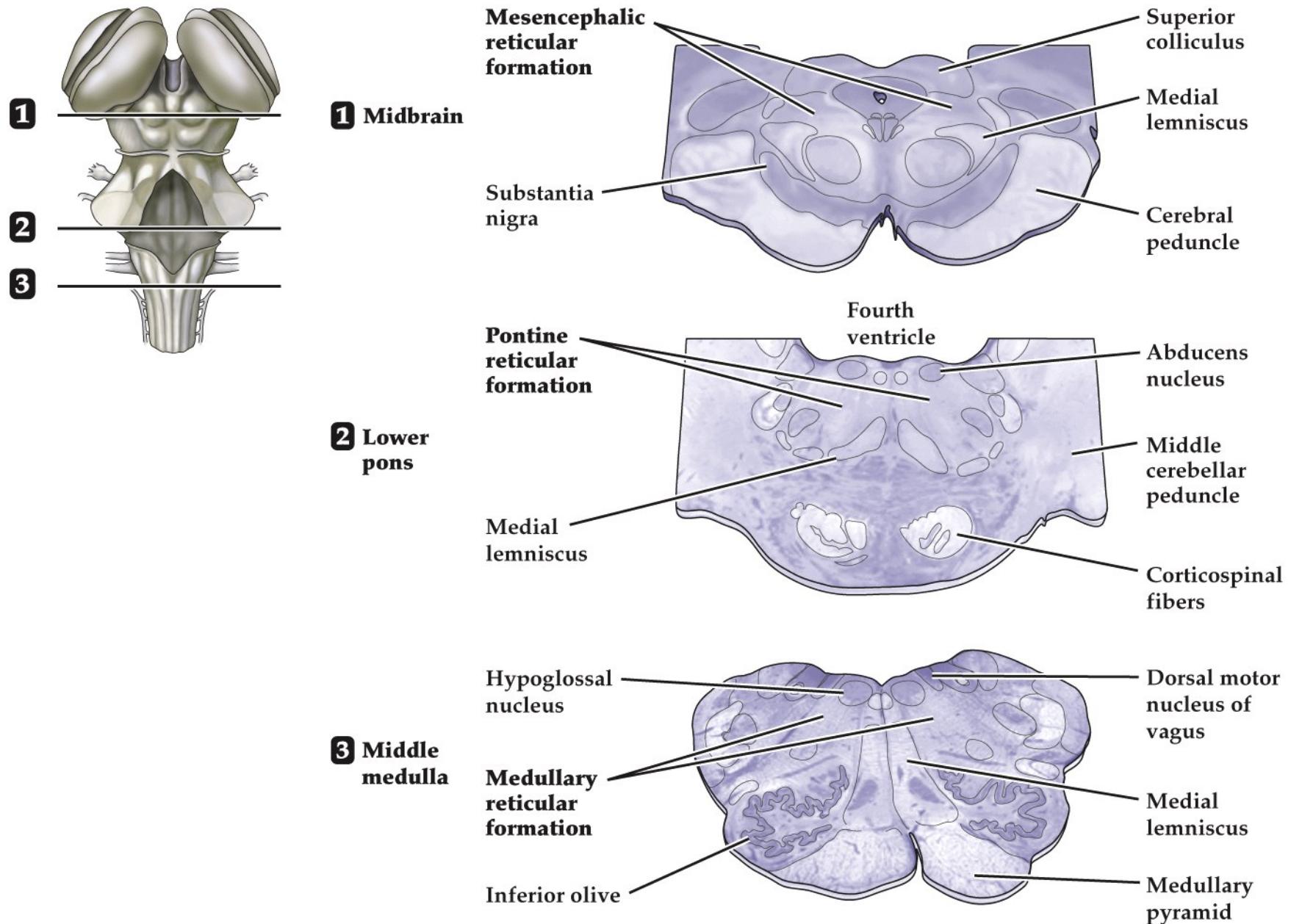


# RETICULAR FORMATION

# General anatomy of reticular formation

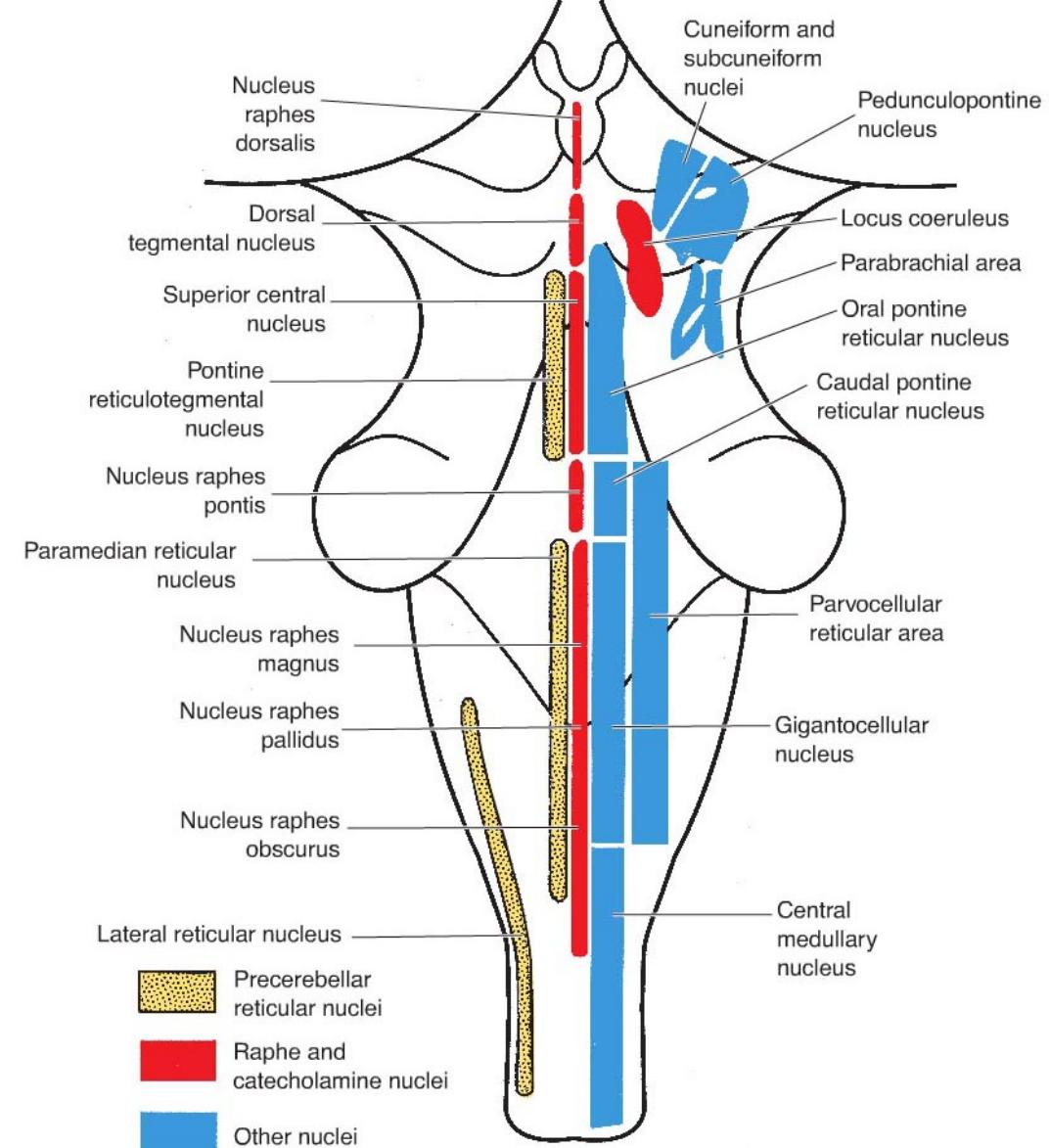
- Diffuse appearance – usually identified as the area between the brainstem nuclei
  - Neuron groups are indistinct
- Cells at raphe
- Very large neurons (gigantocellular) tend to be at paramedian location
- Smaller cells (parvocellular) tend to be lateral
- Medullary, Pontine, and Midbrain RF

Figure 17.12 Location of the reticular formation



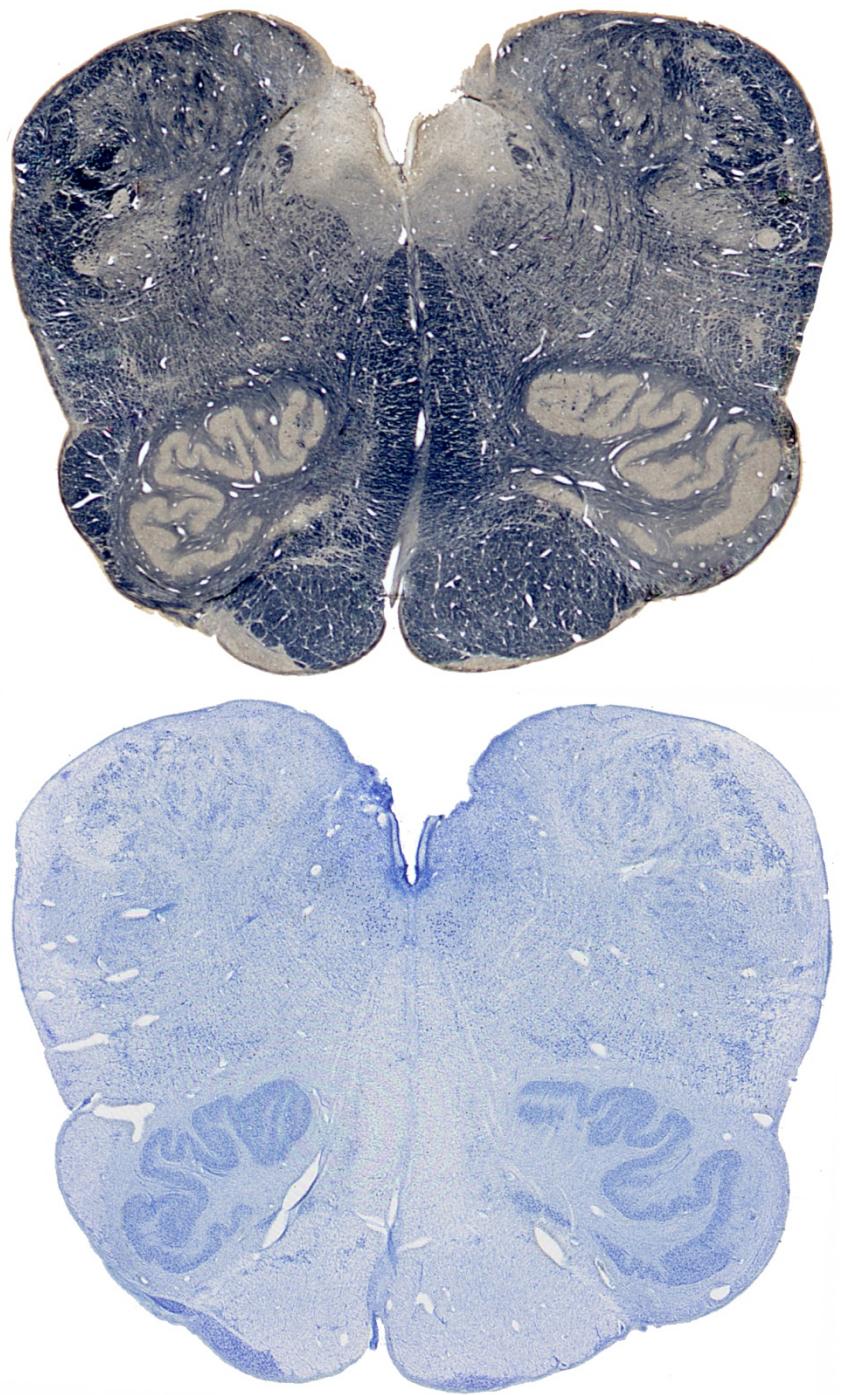
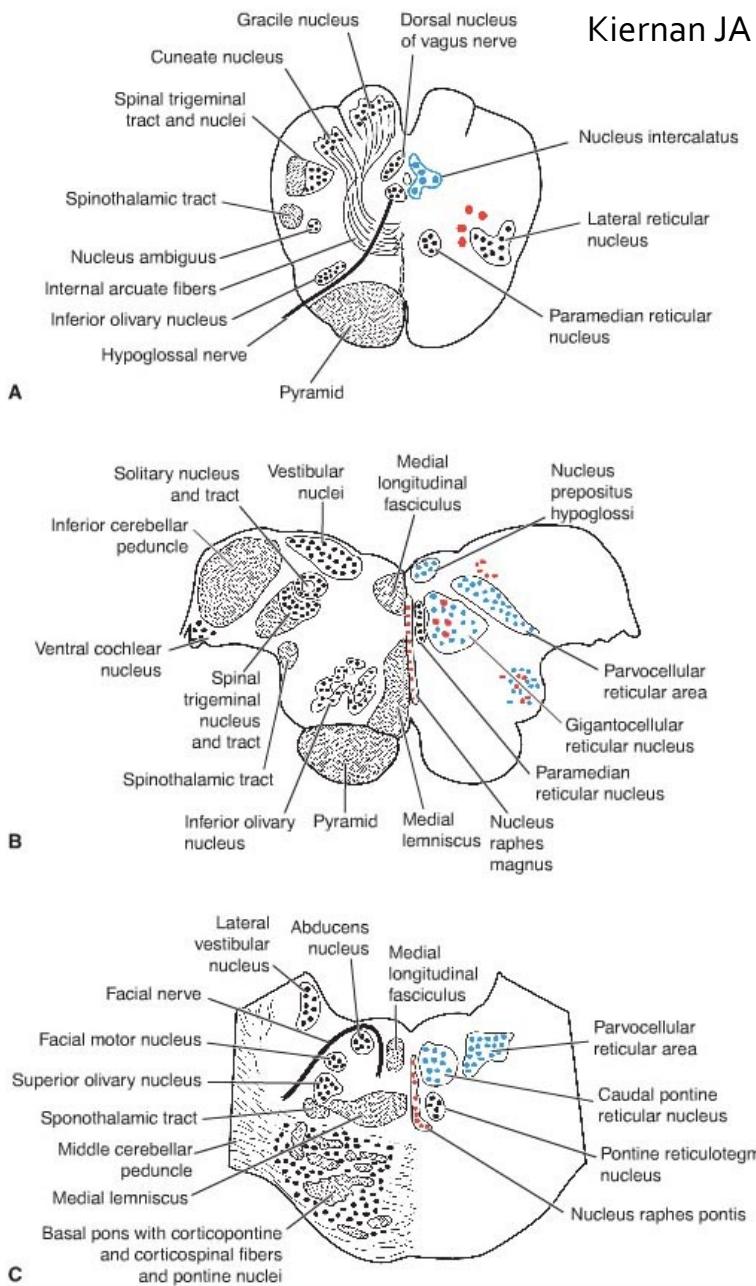
# Nuclei of the reticular formation

Kiernan JA  
(2009) *Barr's the Human Nervous System: an Anatomical Viewpoint*, 9th ed., ISBN: 978-0-7817-8256-2.



**FIGURE 9-1** Diagram showing the positions of the larger nuclei of the reticular formation of the brain stem.

Kiernan JA (2009)



**FIGURE 9-2** Transverse sections of the brain stem. The left side of each figure shows nuclei and tracts that are major anatomical landmarks. The right side shows the positions of reticular and other nuclei discussed in this chapter. Black dots indicate precerebellar nuclei; red dots indicate groups of serotonin- and catecholamine-containing neurons, and blue dots indicate other nuclei.

(continued)

Acetylcholine  
Norepinephrine  
Serotonin



Hypoglossal nucleus

Gigantocellular  
reticular nucleus

Nuc  
Ambiguus

Lateral reticular  
nucleus -  
precerebellar

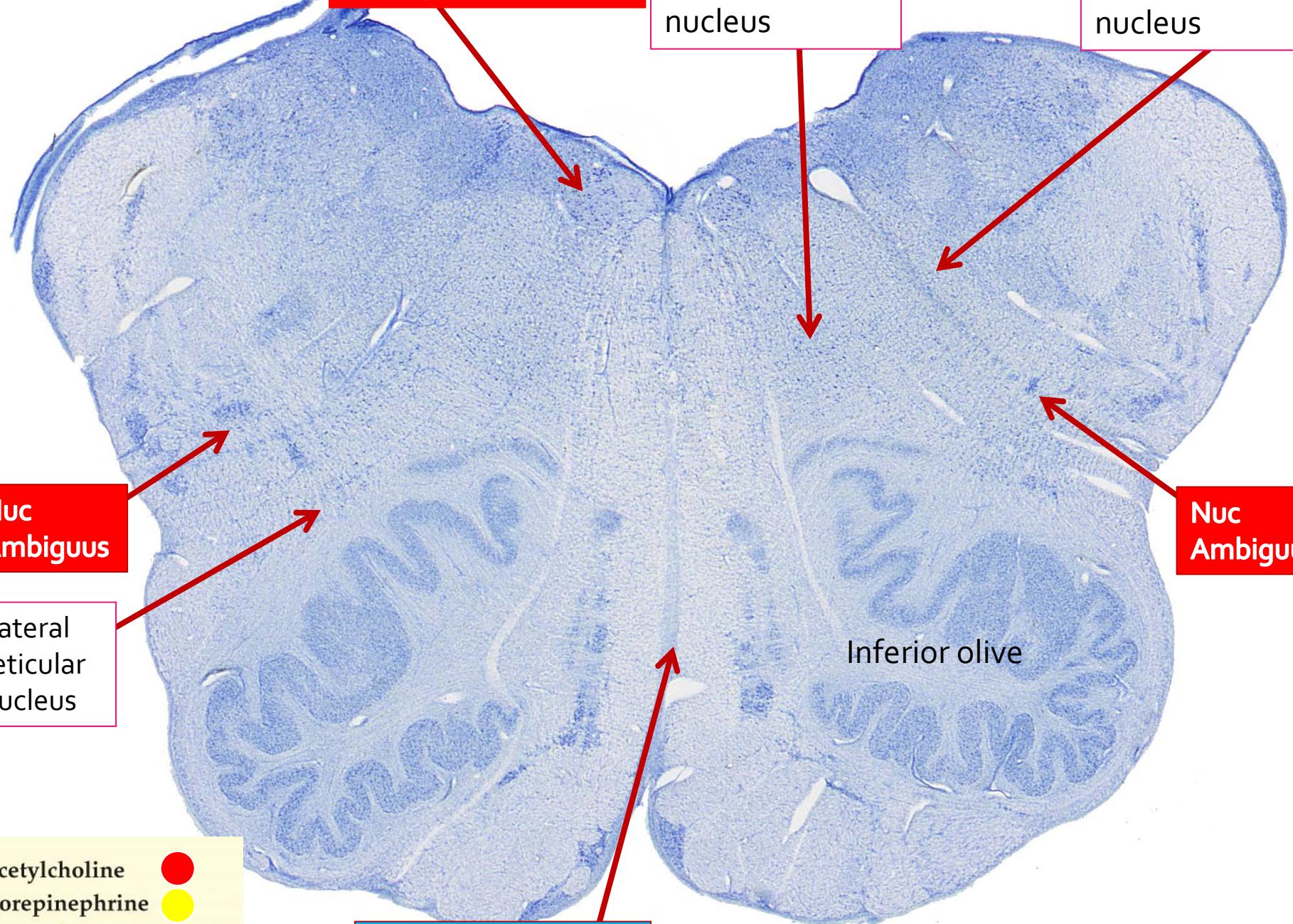
ML

Inferior olive

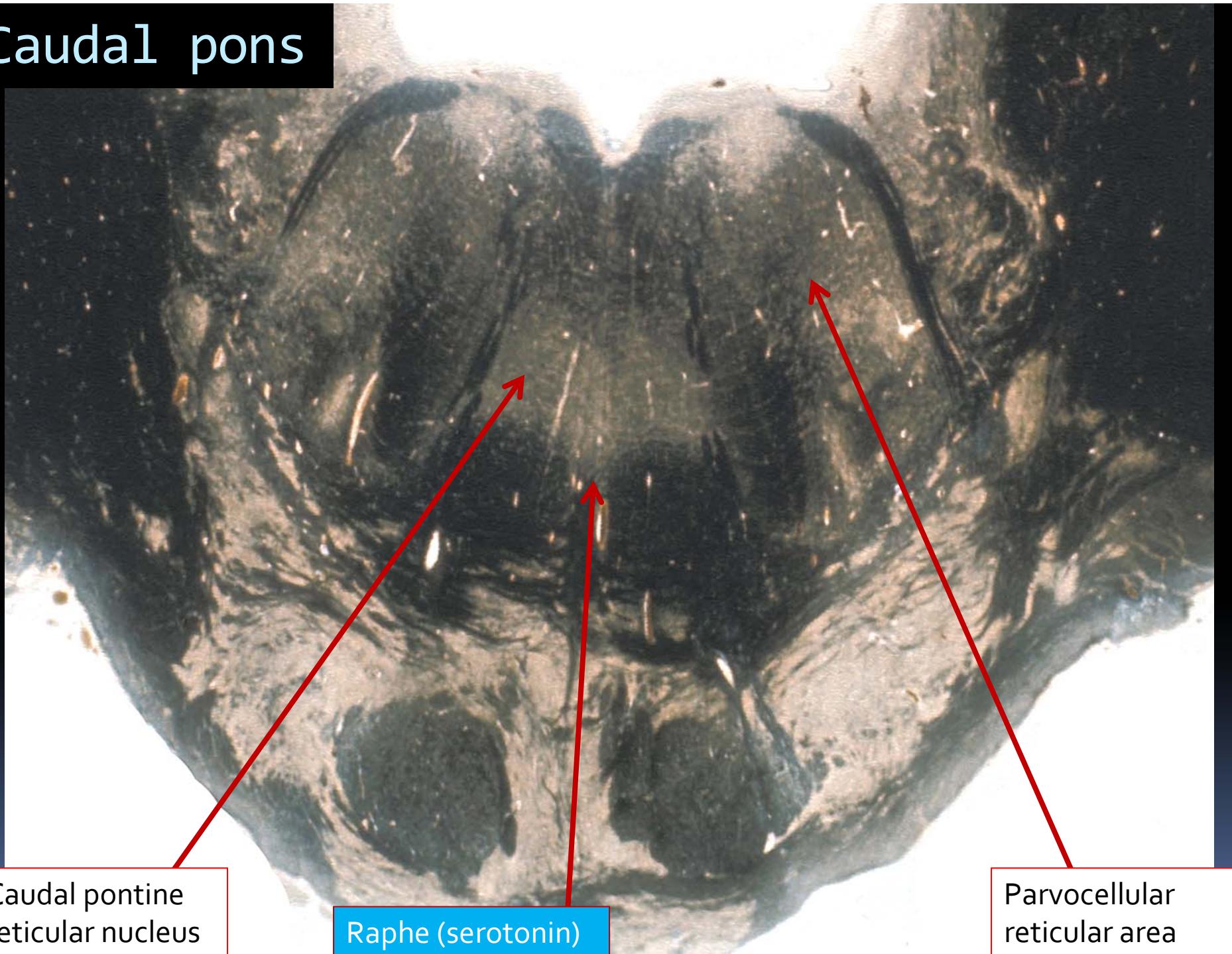
CST

Raphe (serotonin)

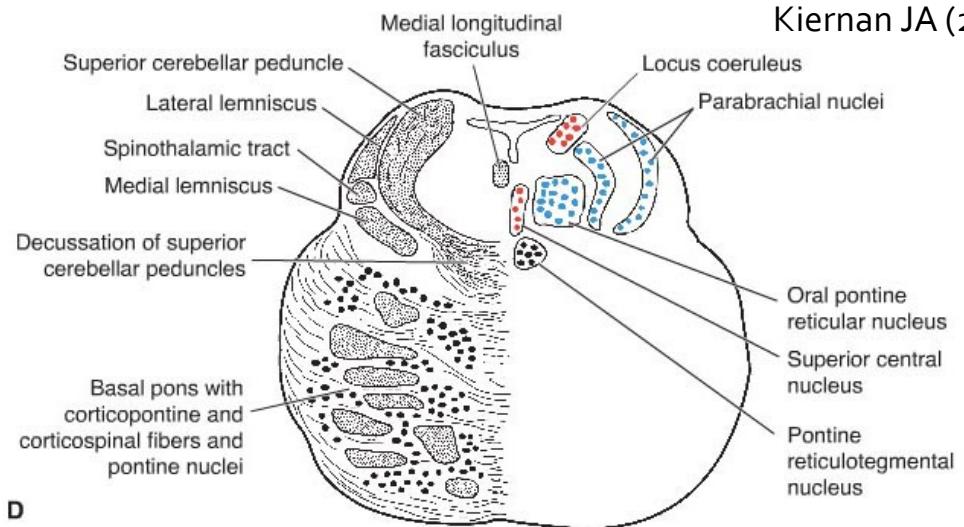
Caudal Medulla



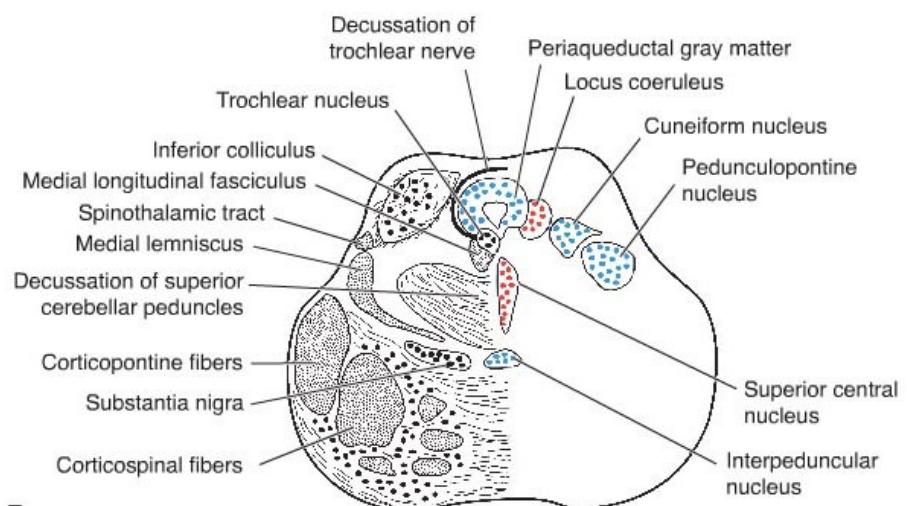
# Caudal pons



Kiernan JA (2009)



D



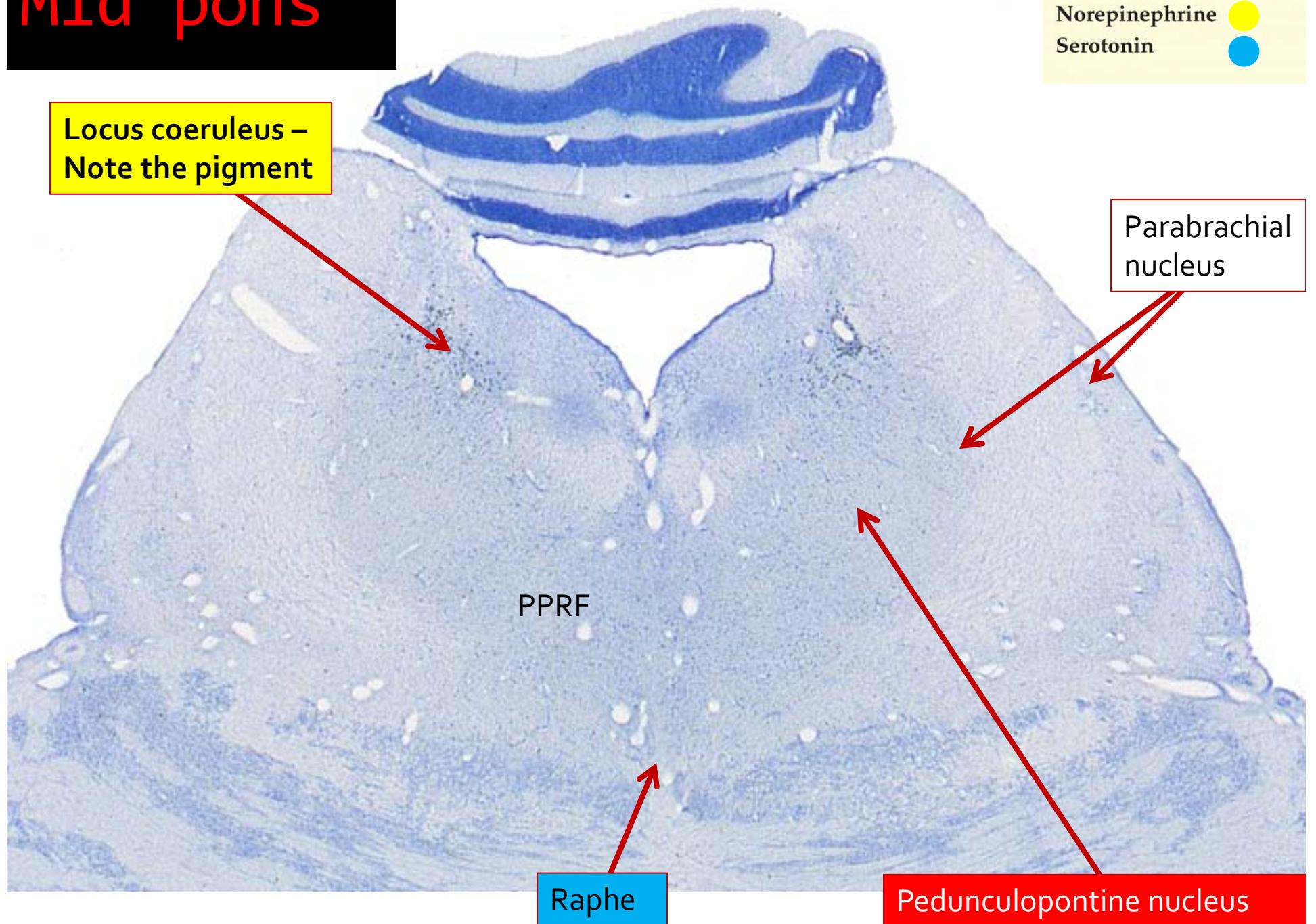
E

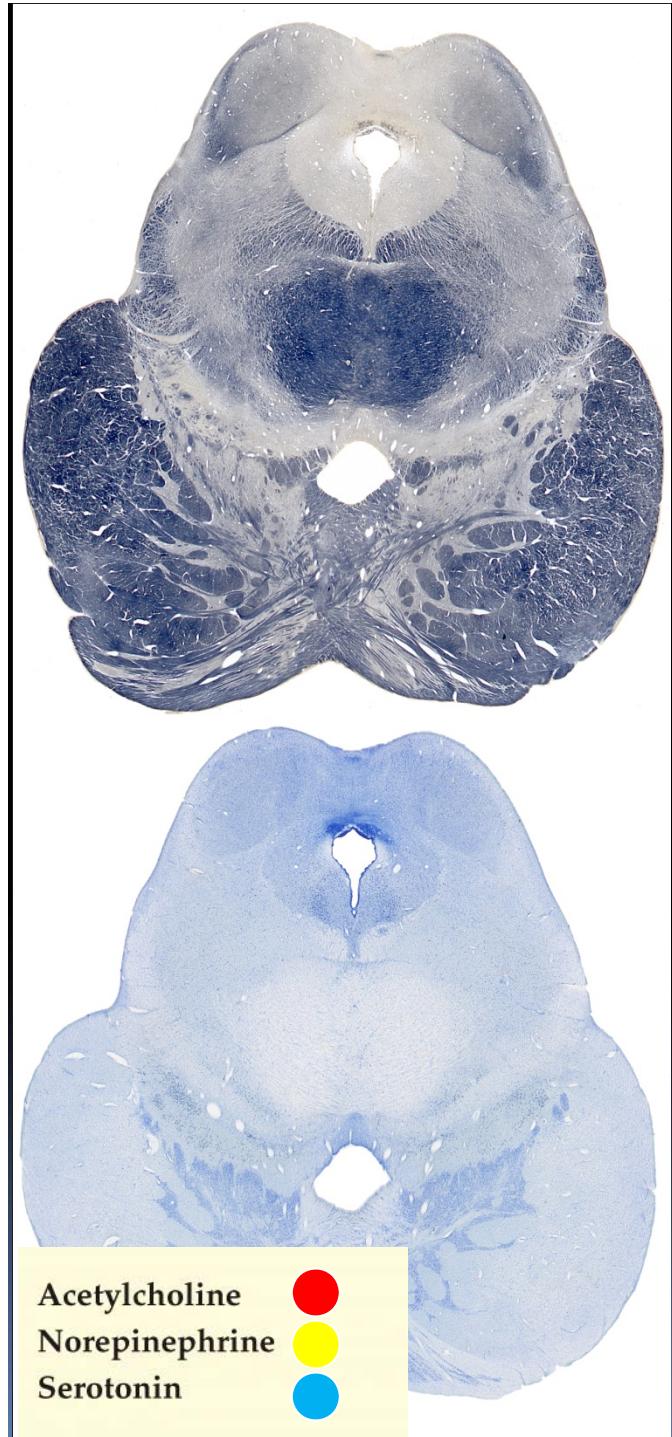
**FIGURE 9-2** (continued) Transverse sections of the brain stem. The left side of each figure shows nuclei and tracts that are major anatomical landmarks. The right side shows the positions of reticular and other nuclei discussed in this chapter. Black dots indicate precerebellar nuclei, red dots indicate groups of serotonin- and catecholamine-containing neurons, and blue dots indicate other nuclei. **(A)** Nuclei at the level of the caudal pole of the inferior olive nucleus, in the closed part of the medulla. (The unlabeled red dots indicate scattered adrenergic neurons.) **(B)** Nuclei at the level of the rostral pole of the inferior olive nucleus, in the open part of the medulla. (The unlabeled red dots indicate groups of noradrenergic and adrenergic neurons. The blue dots dorsolateral to the inferior olive nucleus indicate the probable position of the ventral superficial reticular area of the medulla.) **(C)** Nuclei in the caudal pontine tegmentum, at the level of the internal genu of the facial nerve. **(D)** Pontine tegmentum at a level rostral to the trigeminal motor nucleus. **(E)** Nuclei at the level of the caudal end of the inferior colliculus.



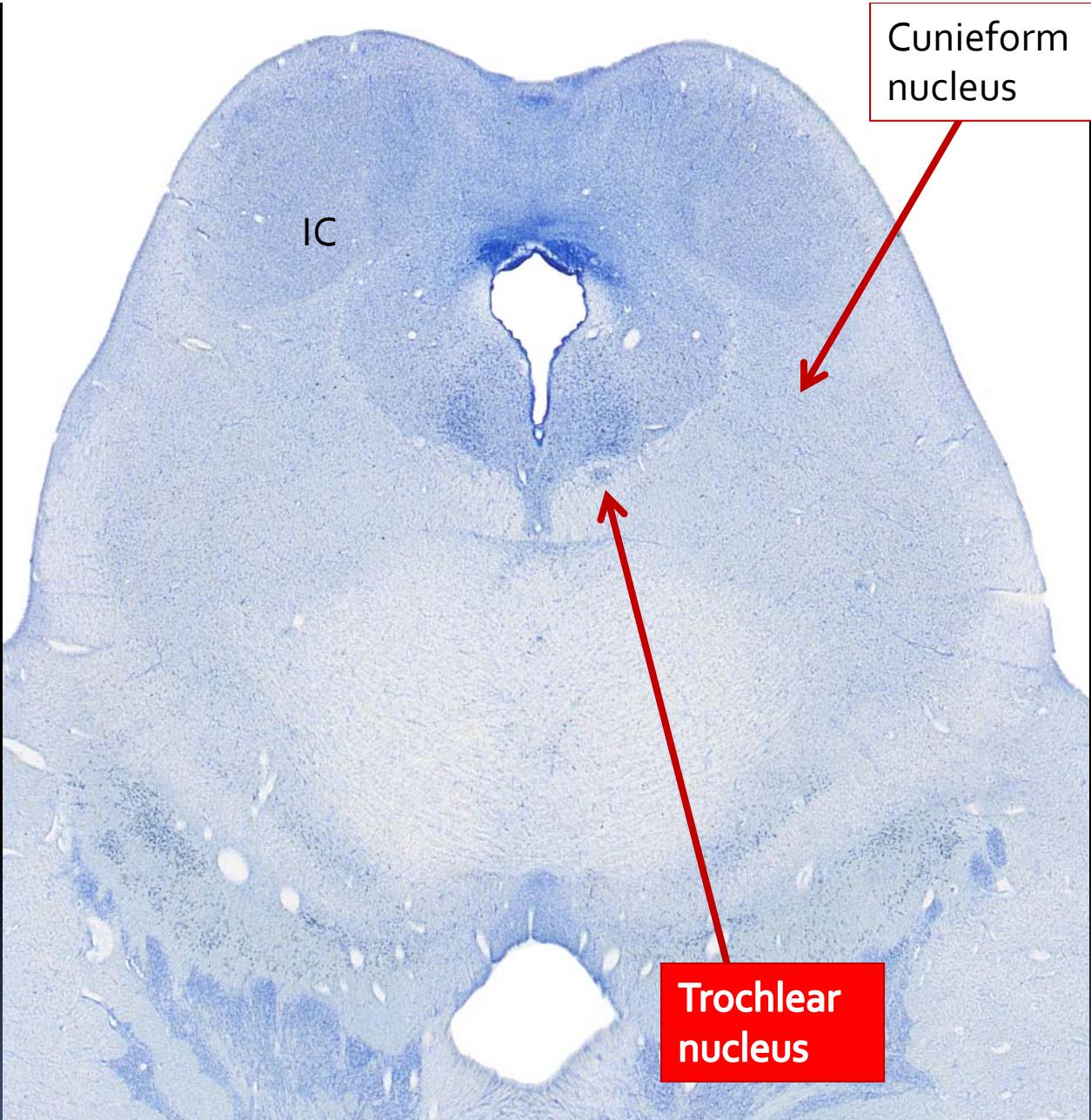
# Mid pons

Acetylcholine  
Norepinephrine  
Serotonin

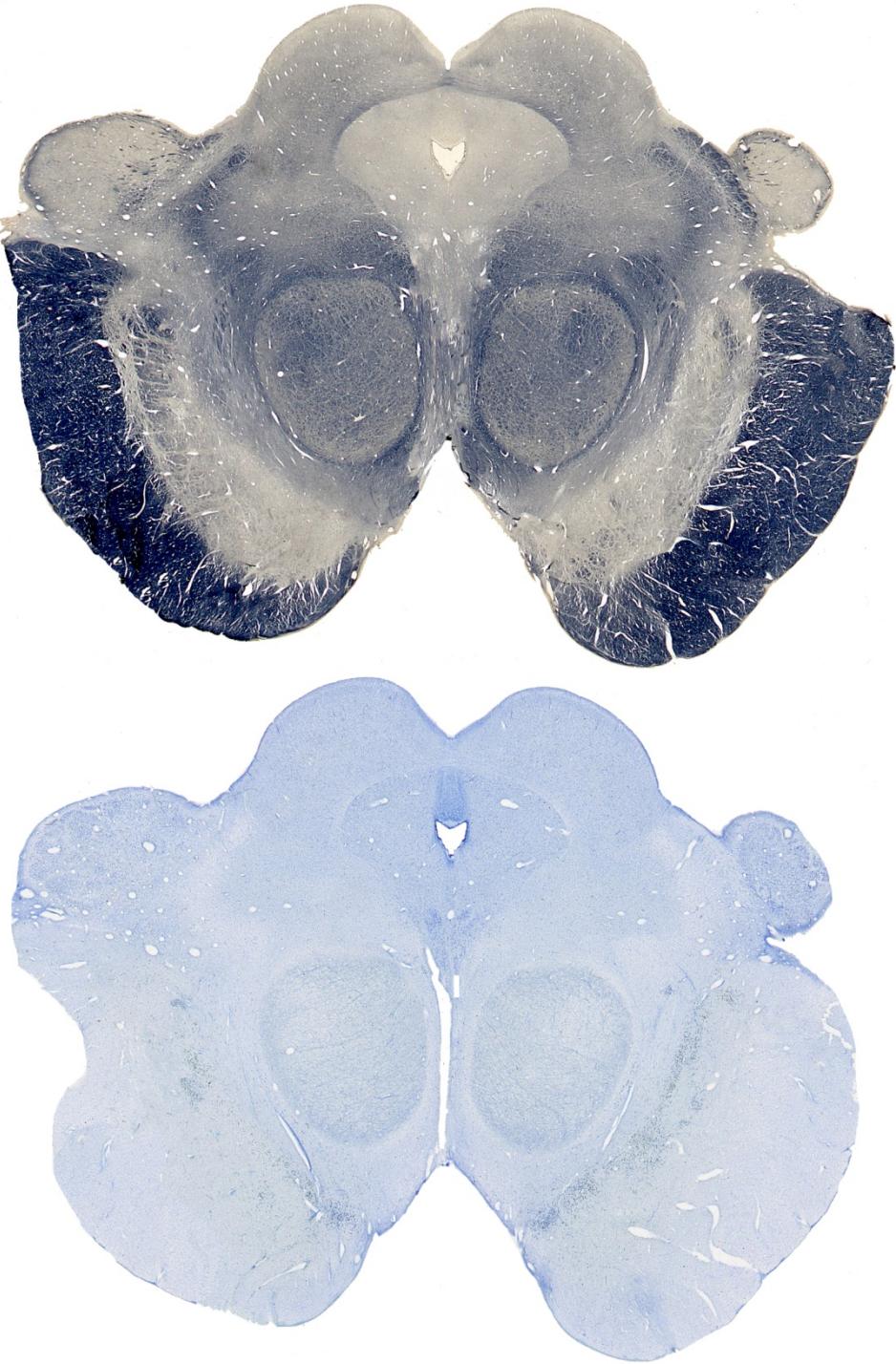
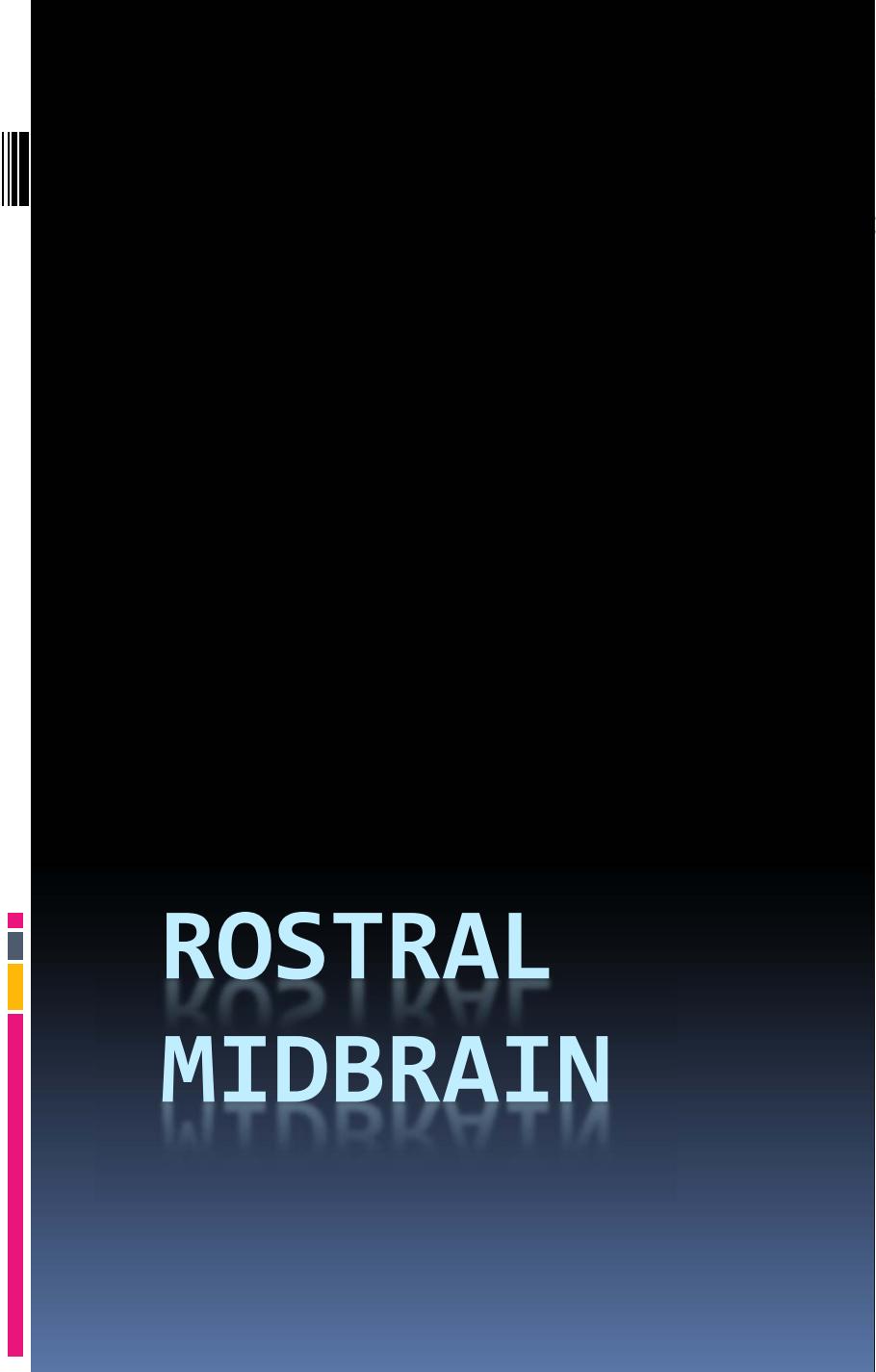




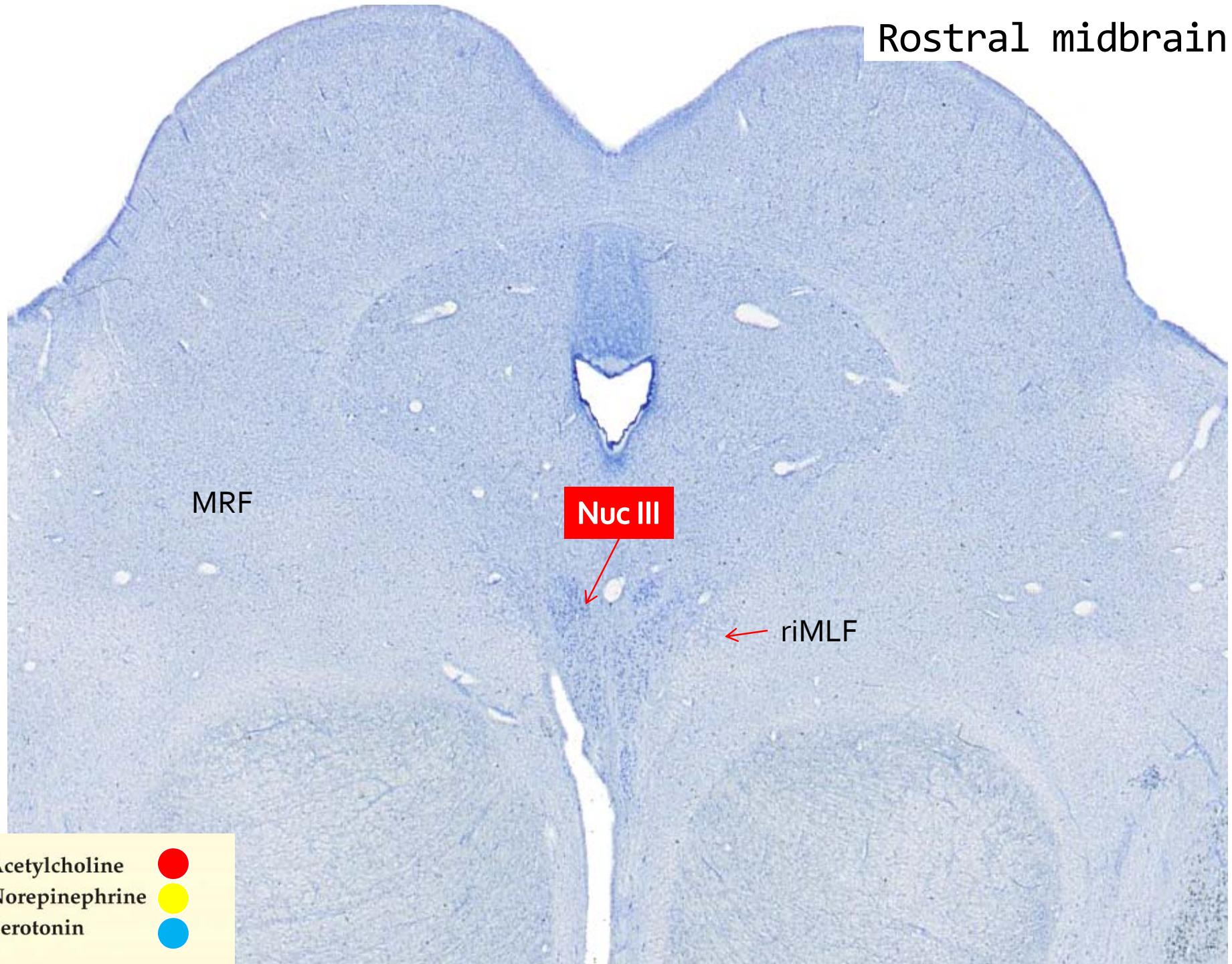
Acetylcholine  
Norepinephrine  
Serotonin



Caudal midbrain



# Rostral midbrain



# Reticular Formation Functions

- Short local connections
  - Cranial nerve reflexes
  - Central pattern generators
  - Cerebellum input & output
  - Gaze centers within brainstem
- Long Connections
  - Mescencephalic and rostral pontine RF modulates forebrain activity
  - Medullary and caudal pontine RF modulate somatic and visceral motor activity

# Local RF Circuits for Cranial Nerve Reflexes

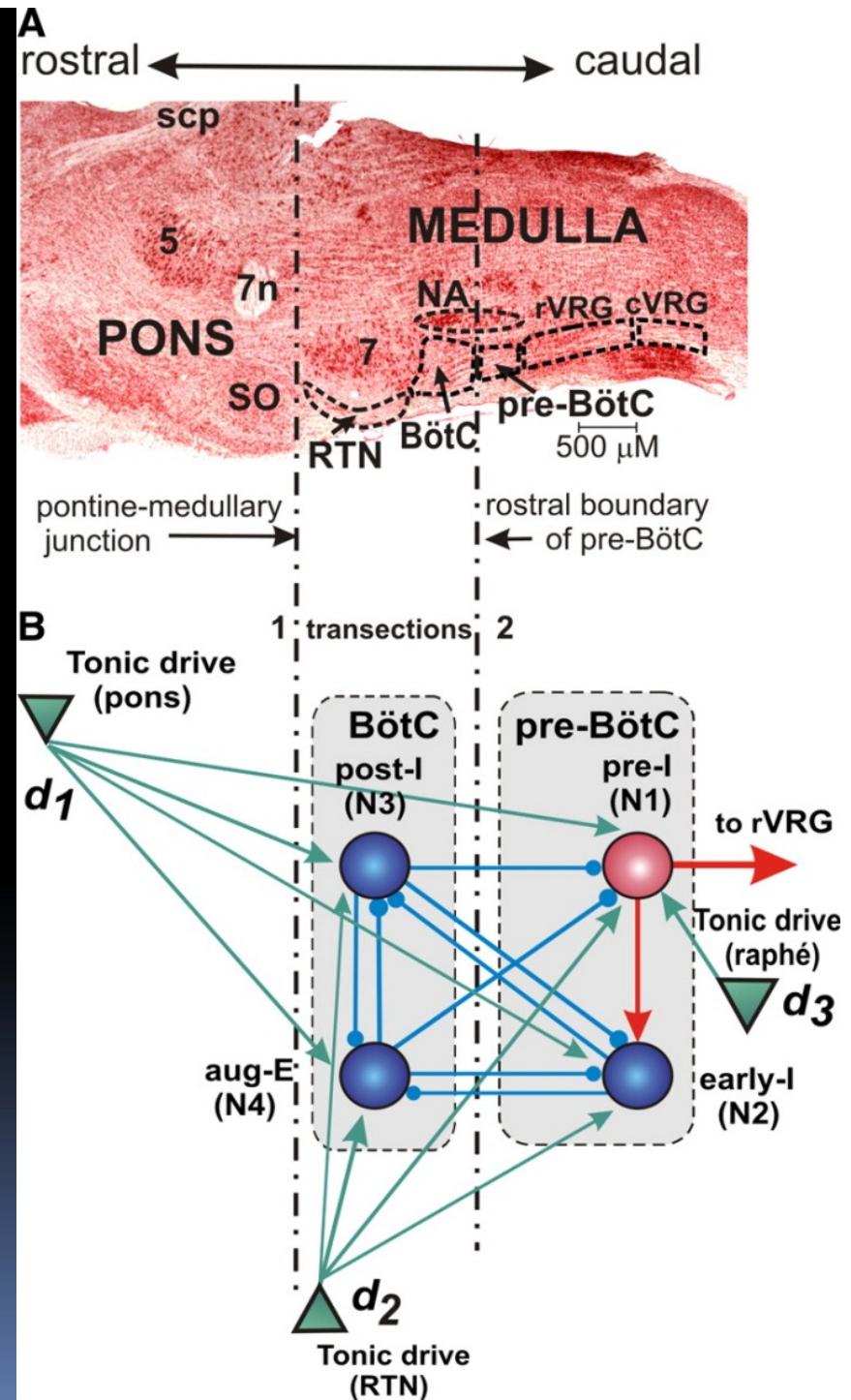
- Corneal blink
  - Input via 5
  - Output via 7
- Gag reflect
  - Input via 5 and 9
  - Output via 9
- Acoustic startle
  - Input via 8
  - Output via RF

# Central Pattern Generator for Chewing

- Location in parvocellular RF
  - Surrounds motor trigeminal nucleus
  - Caudal to facial nuc.
- Chewing circuitry
  - Afferents
    - Trigeminal afferents from lips, oral cavity, muscle spindles in muscles that elevate mandible, & cortical masticatory area in M1
  - Central pattern generator
  - Trigeminal motor for jaw muscles
    - Jaw closing – rostral 2/3 of Motor V
    - Jaw opening – ventromedial middle 1/3 and caudal Motor V

# Central Pattern Generator for Respiration

- Respiratory regions in parvocellular RF near nucleus ambiguus
- Pattern generator controls cycle of active inspiration
- Inputs modulate breathing pattern
- Outputs control diaphragm and other muscles



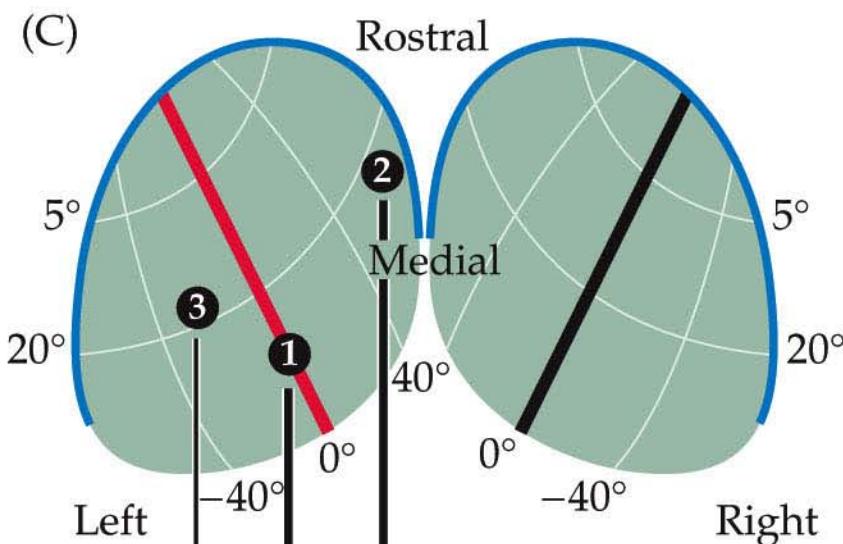
Rubin J E et al. J Neurophysiol 2009;101:2146-2165

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# Motor Function: Pre-cerebellar RF Nuclei

- Inputs to cerebellum from reticular formation
  - Lateral reticular nucleus
  - Paramedian reticular nucleus
  - Pontine reticulotegmental nucleus
- Output from cerebellum
  - To Spinocerebellar tract (Vermal cortex -> Fastigial nucleus -> RF)
  - Vestibulocerebellar (Flocculus-Nodulus -> Fastigial + Vestibular -> RF)

Box 20C(2) From Place Codes to Rate Codes (Part 1)



# Gaze Centers

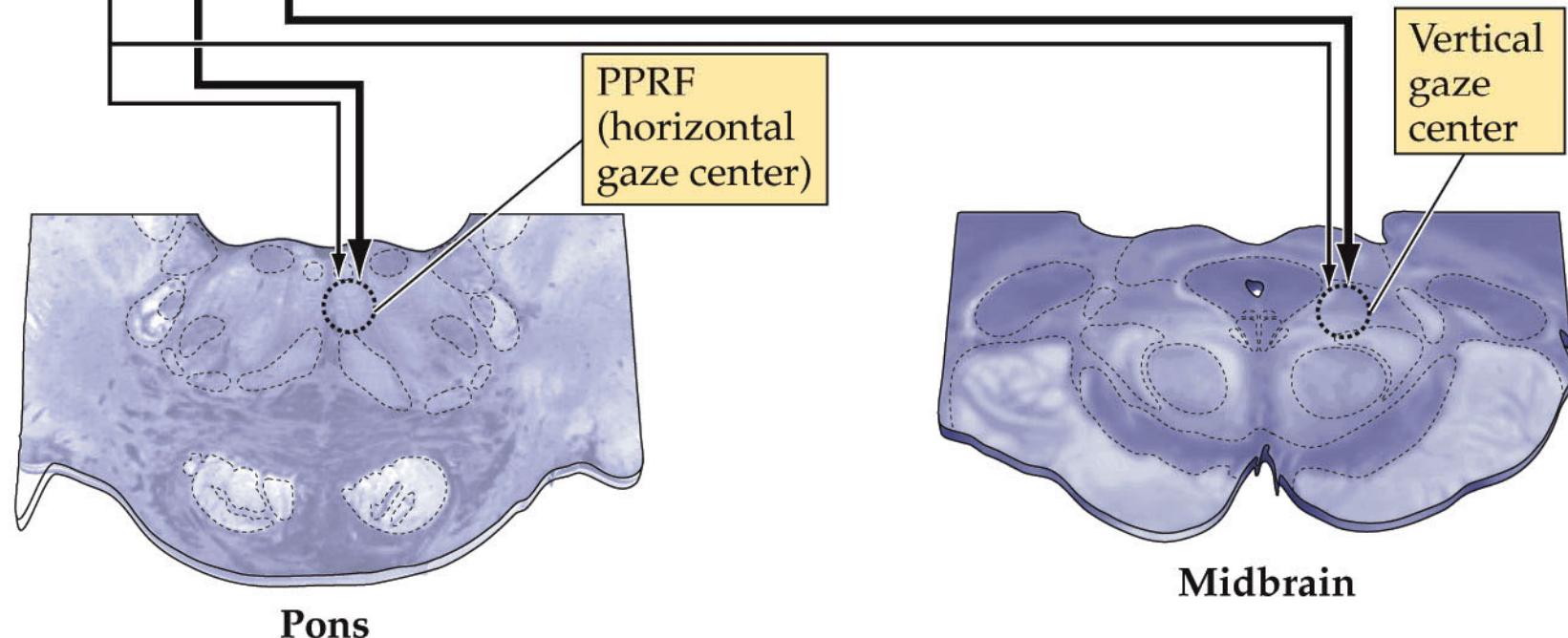
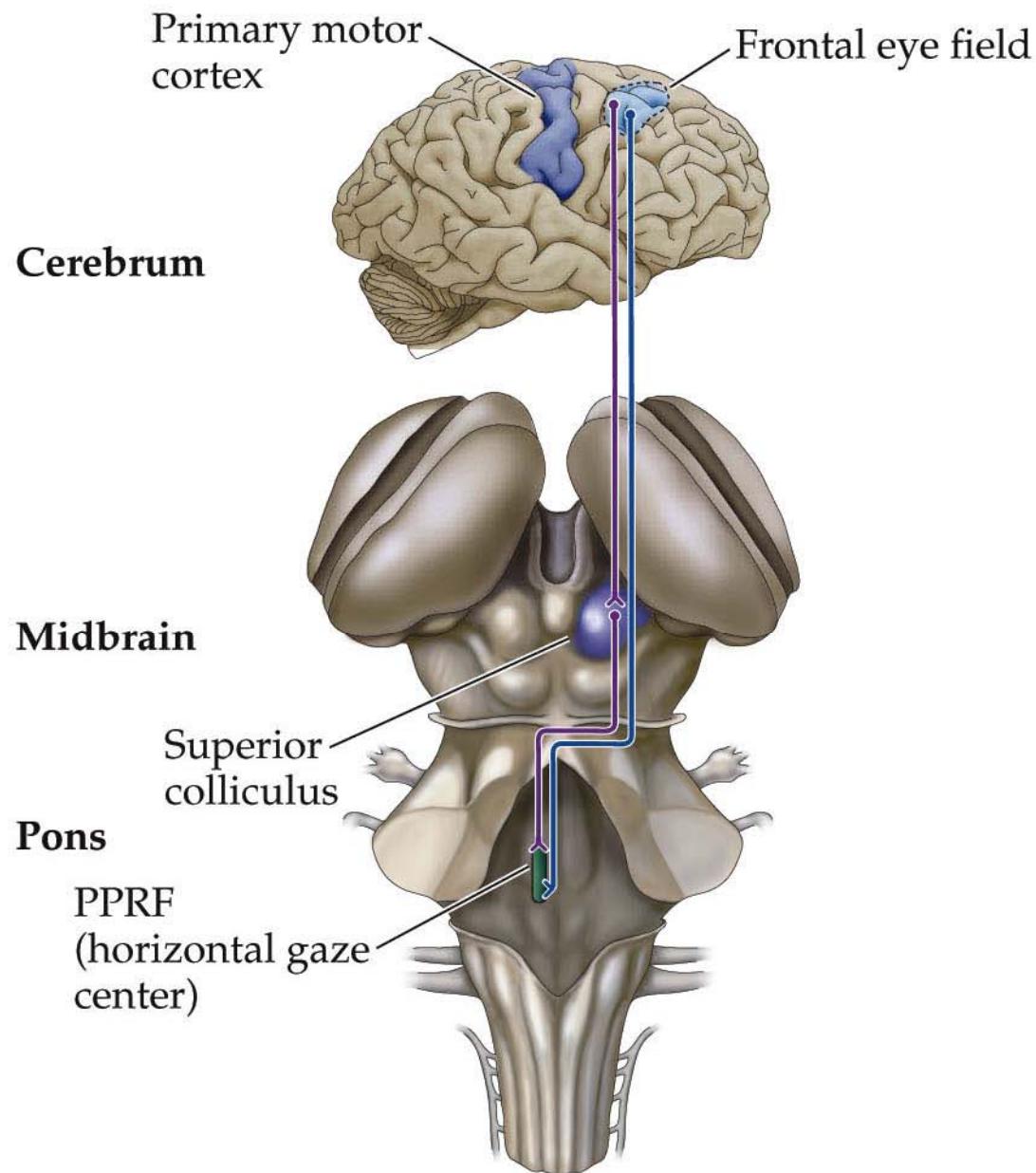


Figure 20.11 Projections from the frontal eye field to the superior colliculus and the PPRF



# Reticular Formation Functions

- Short local connections
  - Cranial nerve reflexes
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  - Medullary and caudal pontine RF modulate somatic and visceral motor activity

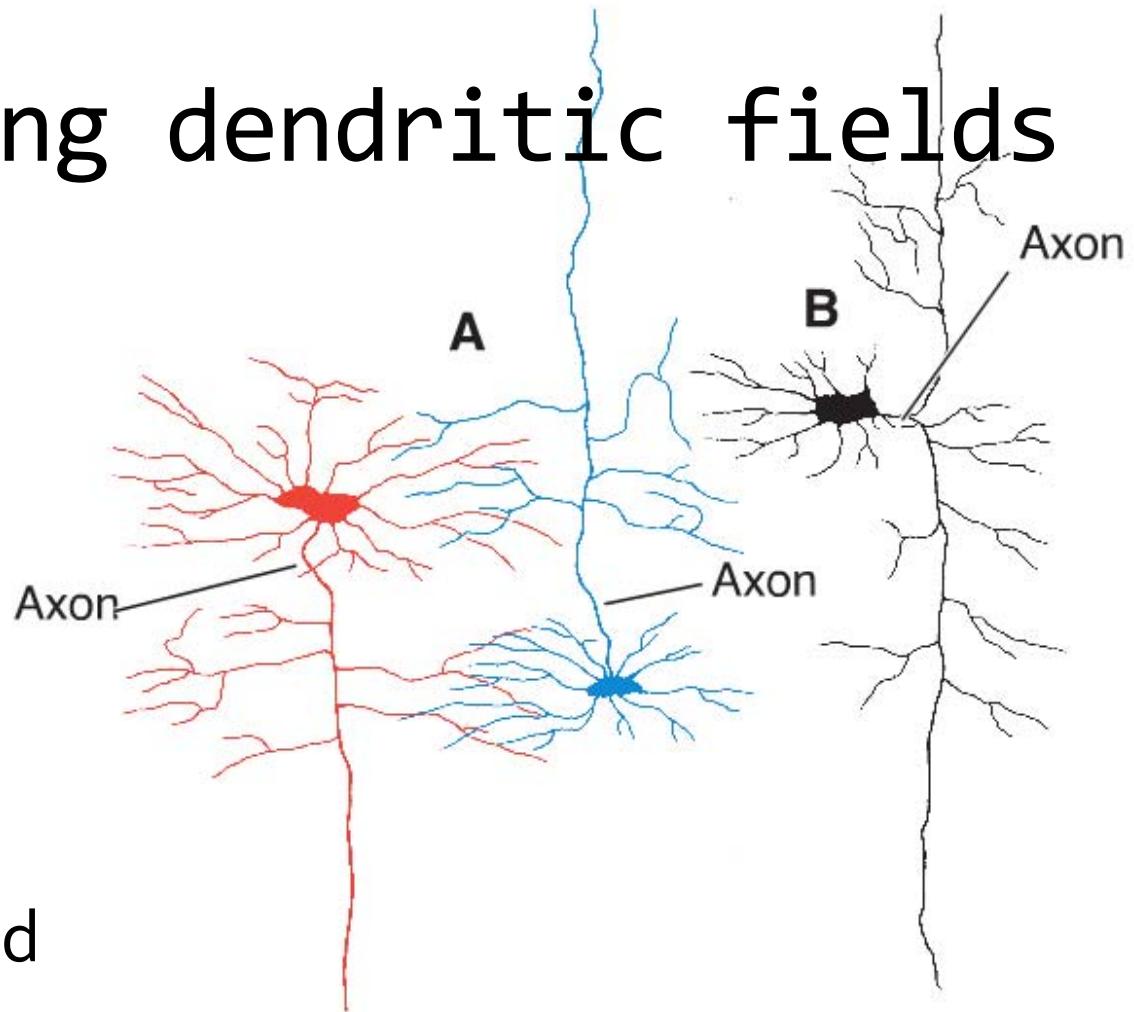
# Long Connection Circuitry of RF

- Central Medial Nuclei
- Neurons
  - Large dendritic fields
  - Dendritic fields are heavily overlapping
- Inputs
  - Many sources
  - Highly overlapping (not topographic)
  - Axons may be ascending or descending or both
- Outputs
  - Many targets
  - Long distances

# Overlapping dendritic fields

## Axons

- Local connections
- Long distance connections
- Usually both
- Some axons ascend and descend the neuraxis



**FIGURE 9-5** Neurons of the reticular formation. **(A)** Interaction between dendrites and collateral axonal branches of neurons with ascending (blue) and descending (red) projections. **(B)** A neuron whose axon divides into long ascending and descending branches.

# Long Connections of RF

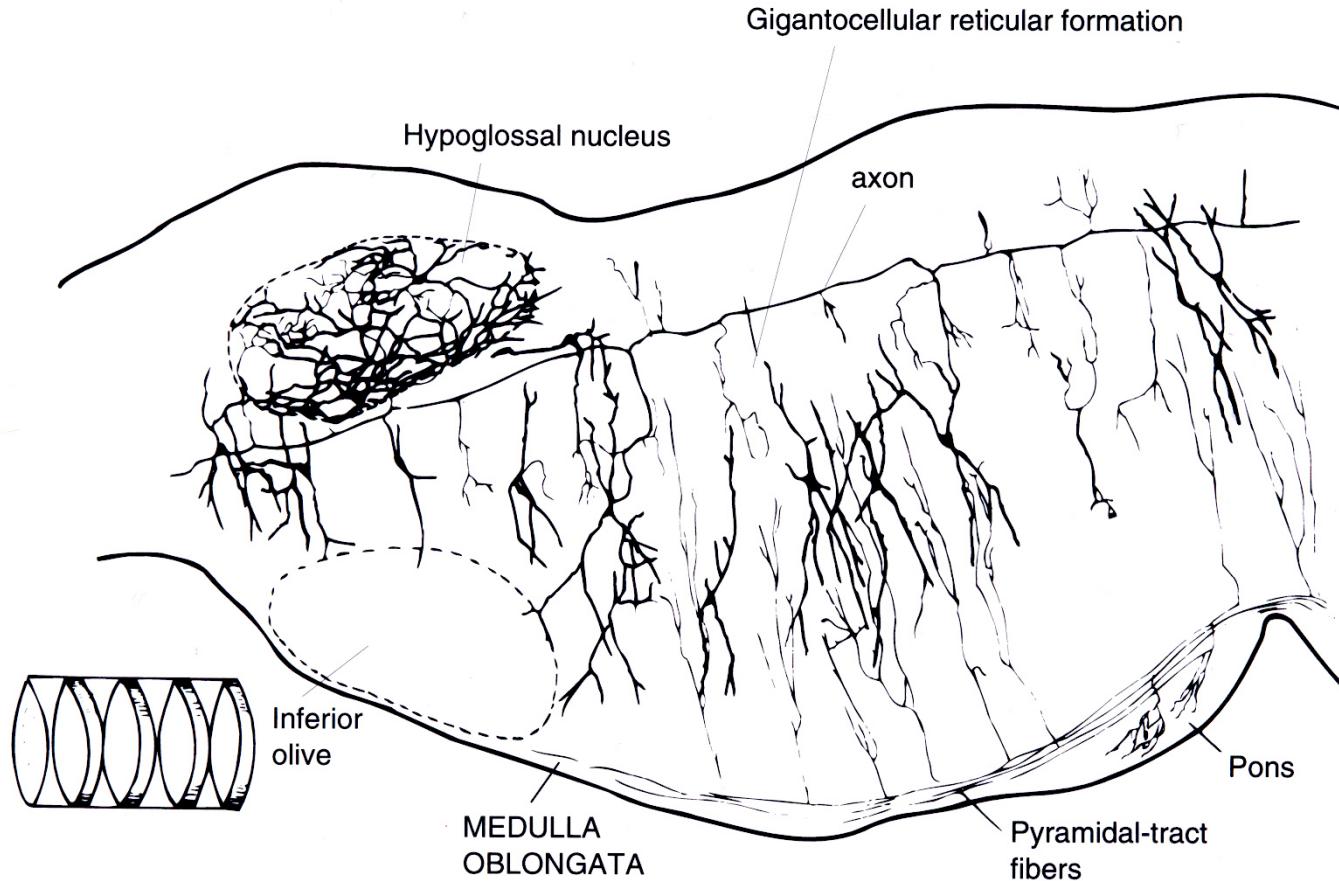
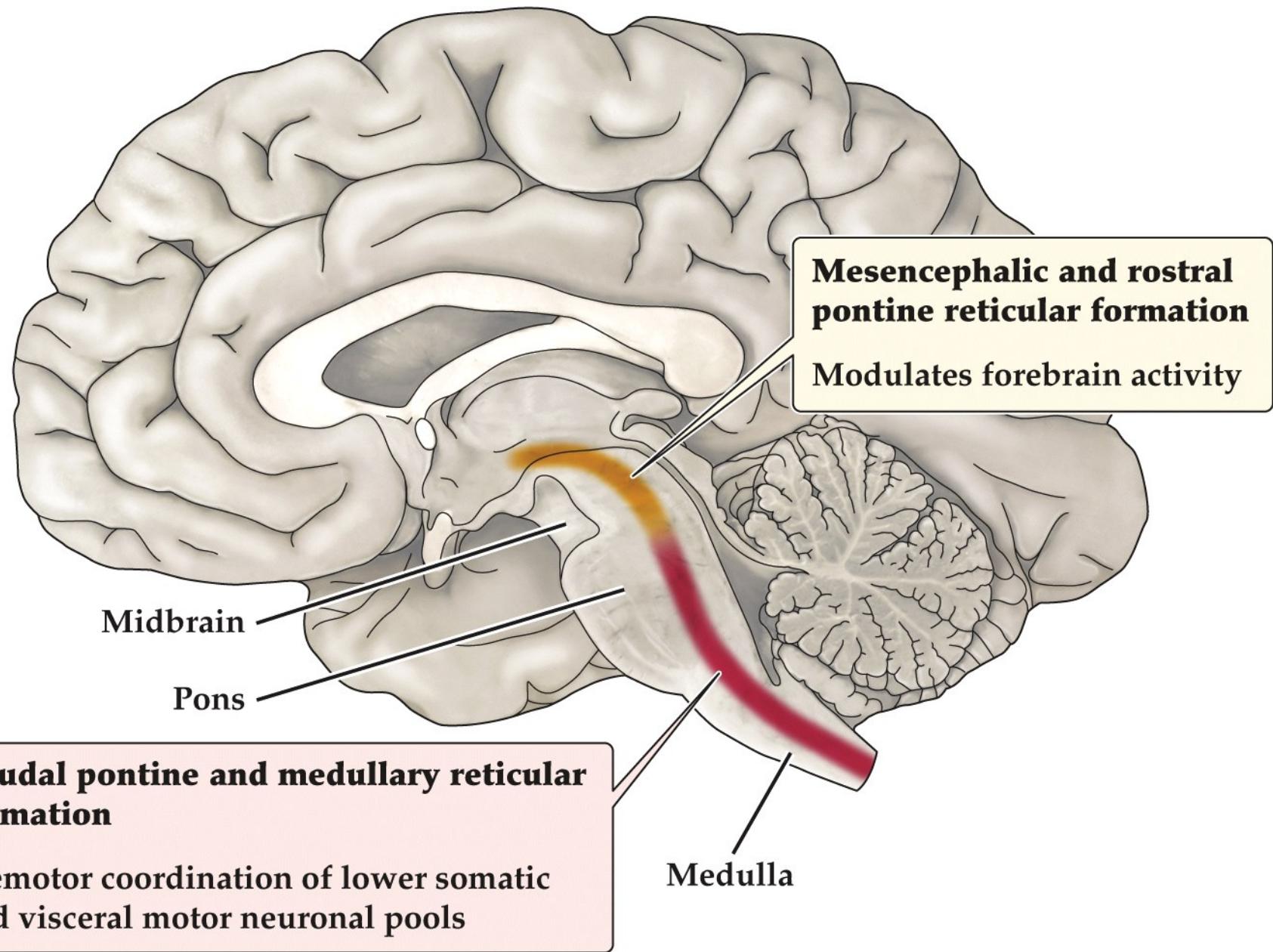


Figure 15.4 *Orientation of dendrites in the reticular formation.* Sagittal section through the medulla (rat). Note the long, straight dendrites, which are typical of the neurons of the reticular formation, in contrast to the neurons of a cranial nerve nucleus (the

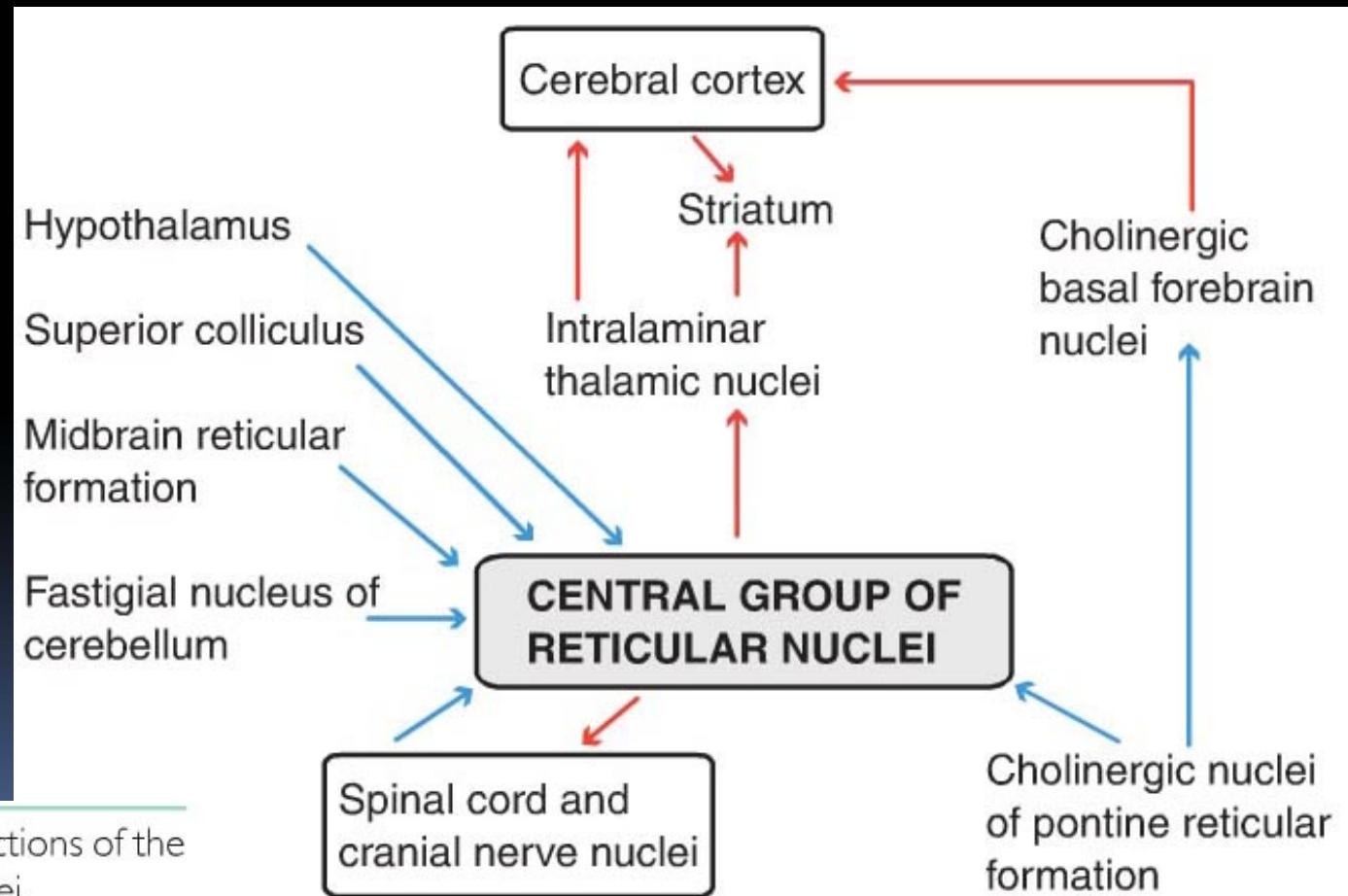
hypoglossal) and other specific brain stem nuclei. A long axon with numerous collaterals extending ventrally in the transverse plane is also shown. Collaterals of the pyramidal tract fibers also enter the reticular formation. From Scheibel and Scheibel (1958).

## Box 17D The reticular formation



# Whole Body Reactions And Reflexes: Central Group of Reticular Nuclei

- Reticulospinal tract (descending) – Motor pathway
- Reticulothalamic tract (ascending) – Somatosensory/pain
- Startle, muscle tone, posture, attention



Kiernan JA (2009)

**FIGURE 9-4** Major connections of the central group of reticular nuclei.

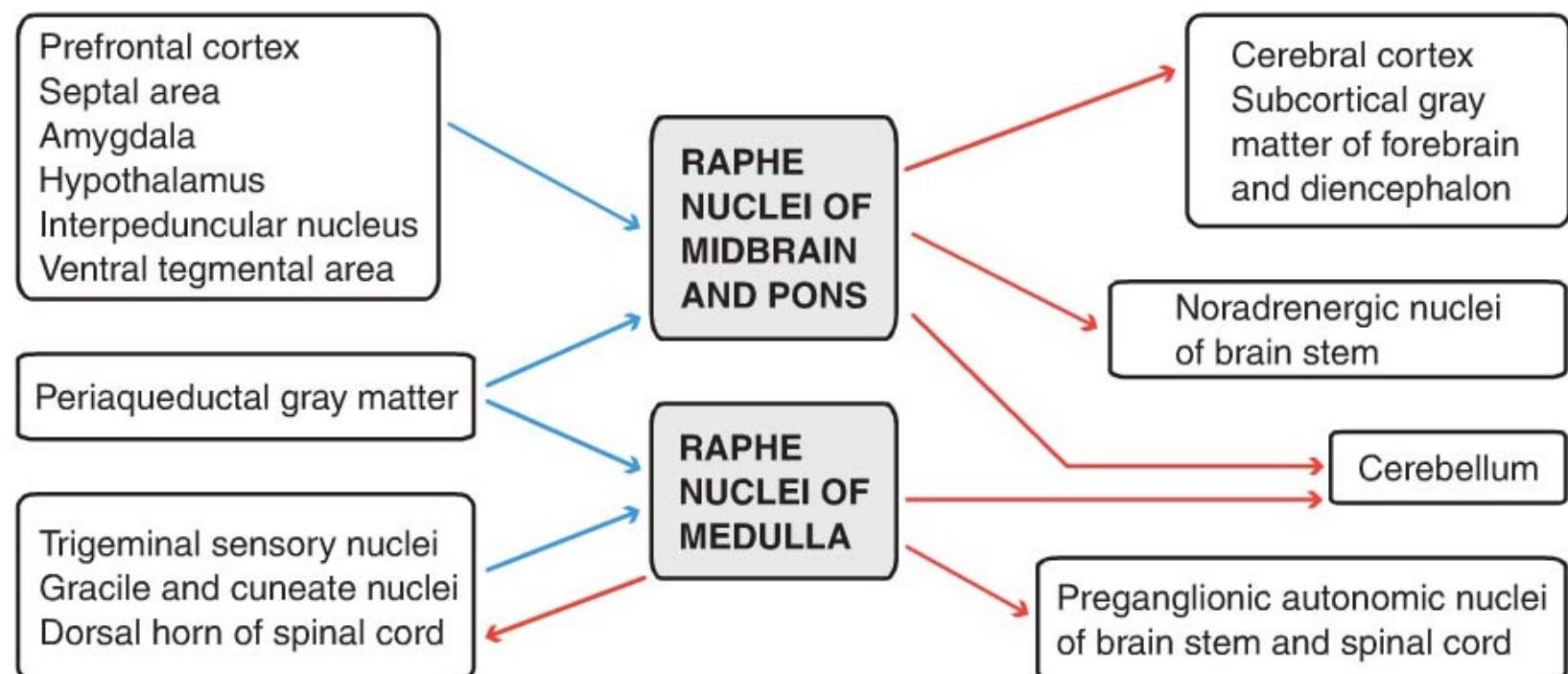
Raphe  
nuclei:  
Serotonergic  
neurons



tryptophan hydroxylase (TPH); TPH<sub>2</sub> *in situ* shows location of serotonin

# Raphe nuclei: Serotonergic neurons

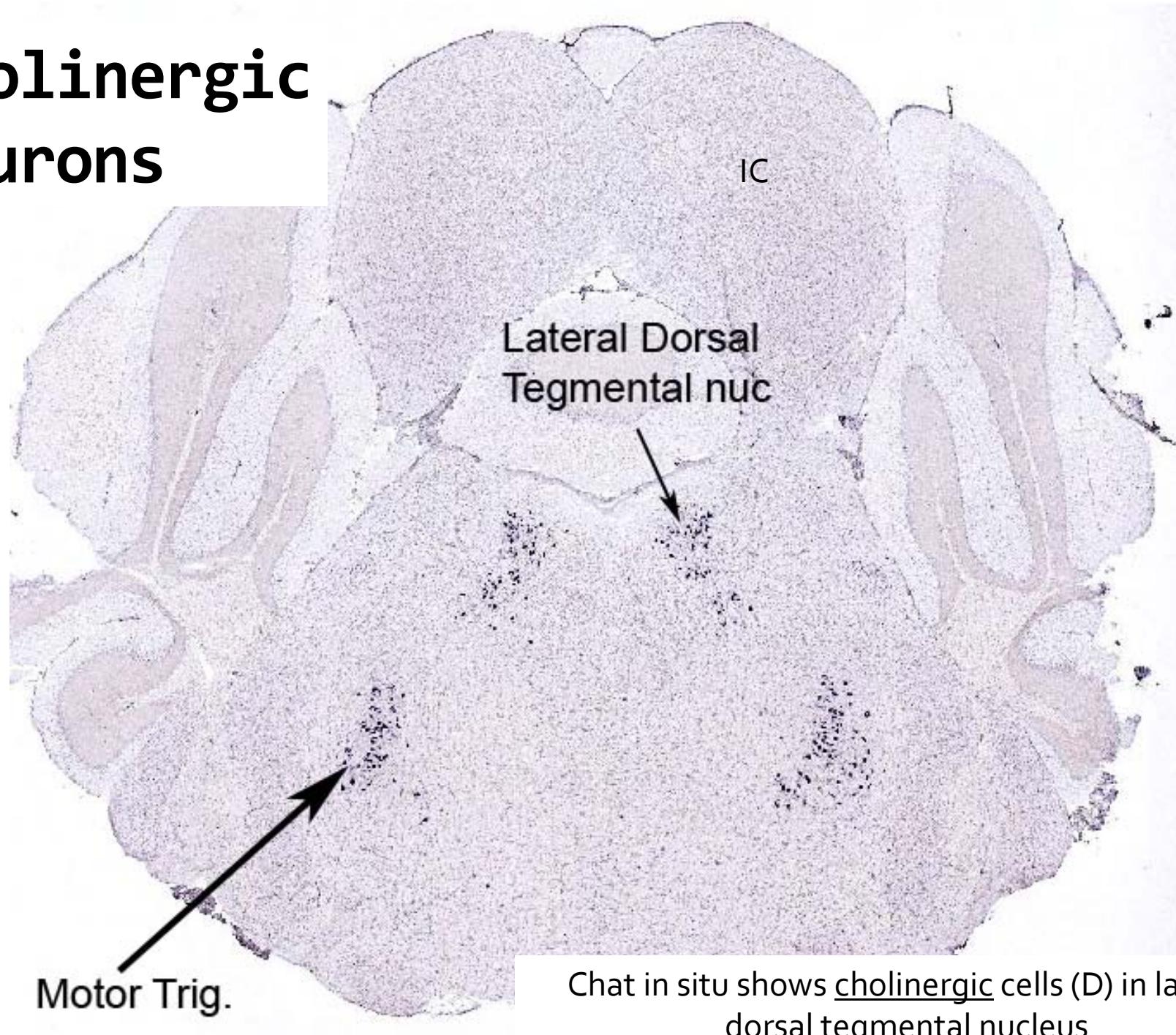
- Descending outputs
  - Control of pain via PAG inputs and output to dorsal horn of spinal cord
  - Autonomic controls
- Ascending outputs goes to most forebrain regions
  - Active in deep sleep



**FIGURE 9-3** Major connections of the serotonergic raphe nuclei.

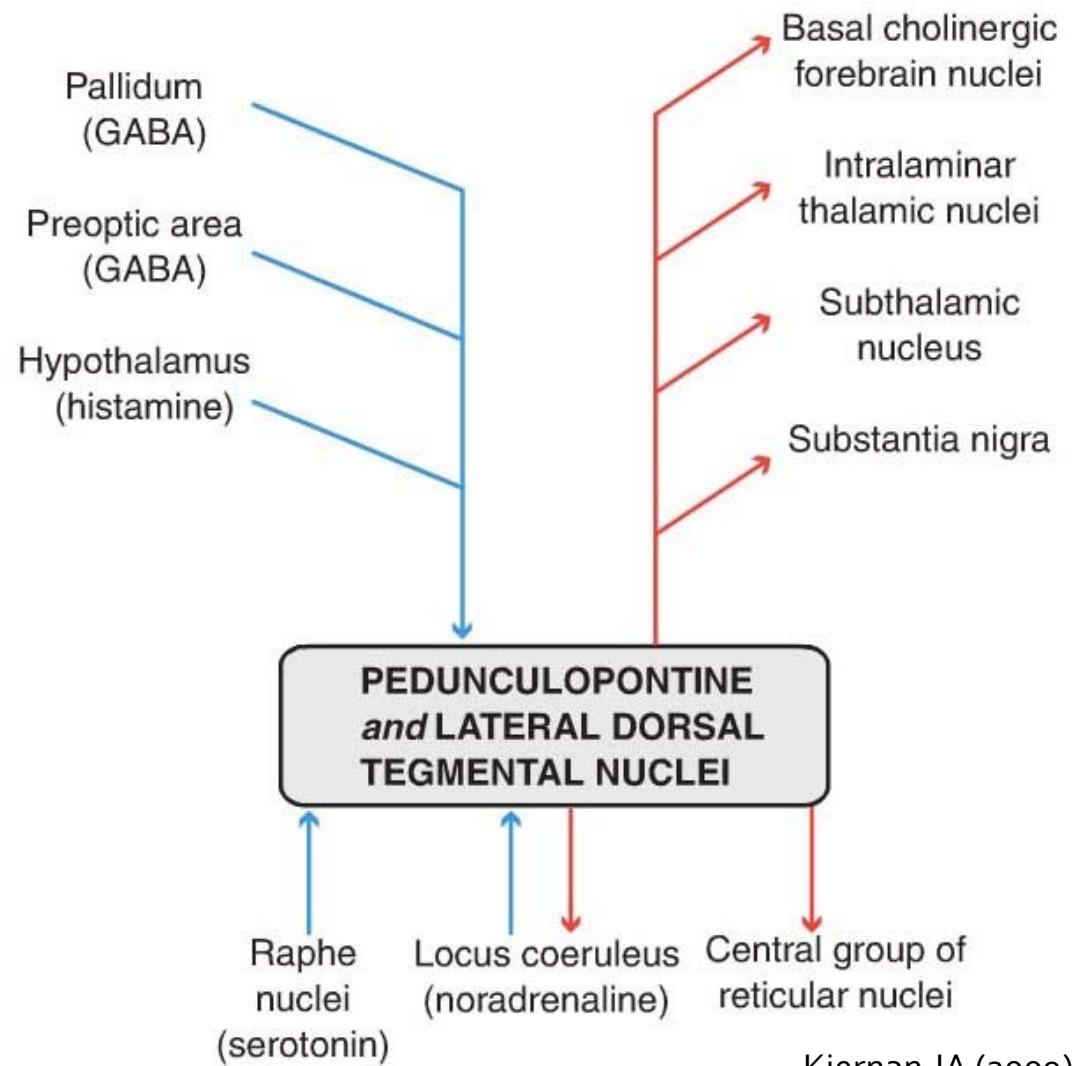
Kiernan JA (2009)

# Cholinergic neurons



# Cholinergic neurons

- Inputs
  - RF
  - Hypothalamus
  - Basal ganglia
- Outputs
  - RF
  - Intralaminar Thalamus
  - Basal forebrain
- Consciousness and REM sleep

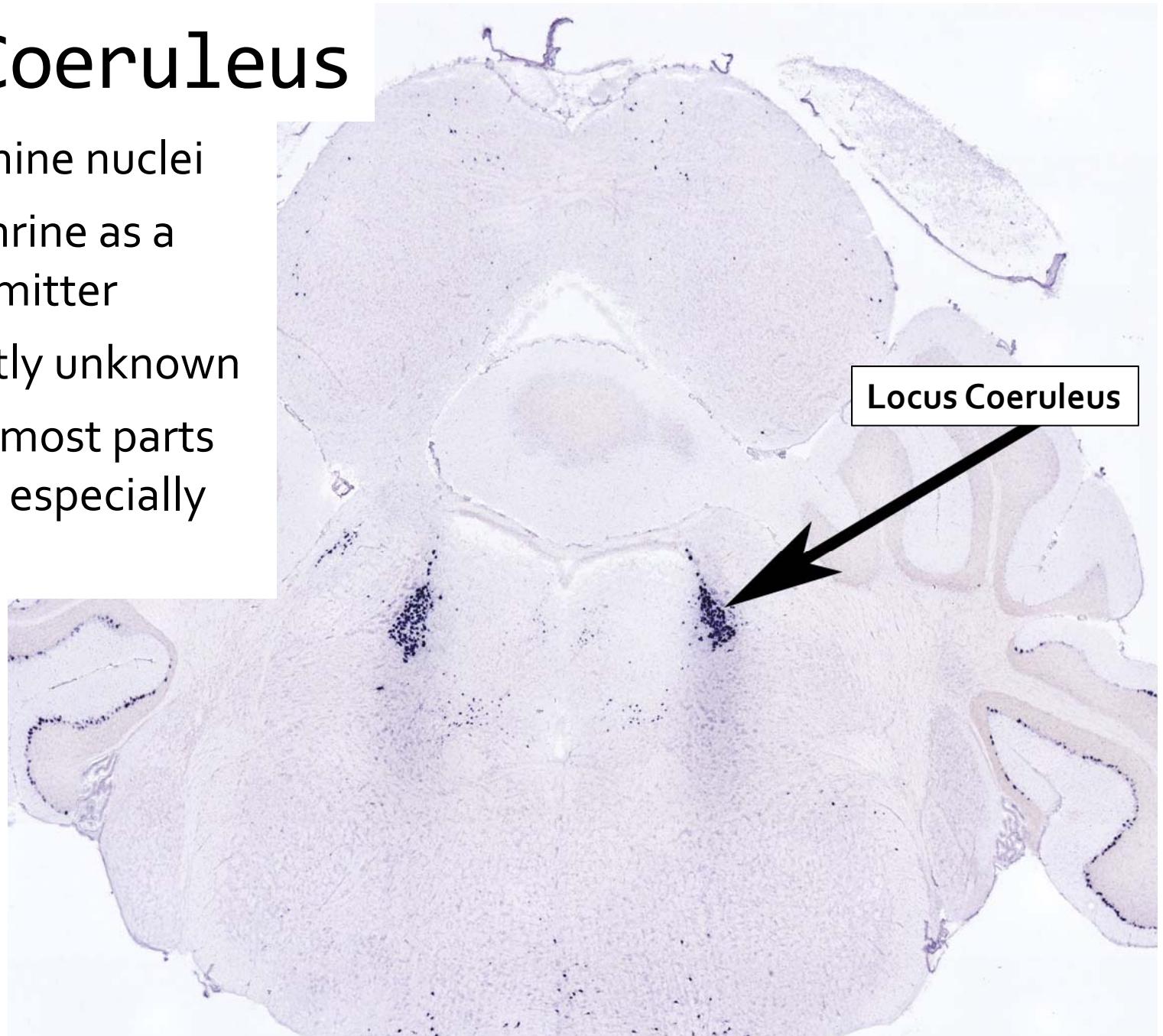


**FIGURE 9-6** Major connections of the cholinergic nuclei of the brain stem.

Kiernan JA (2009)

# Locus Coeruleus

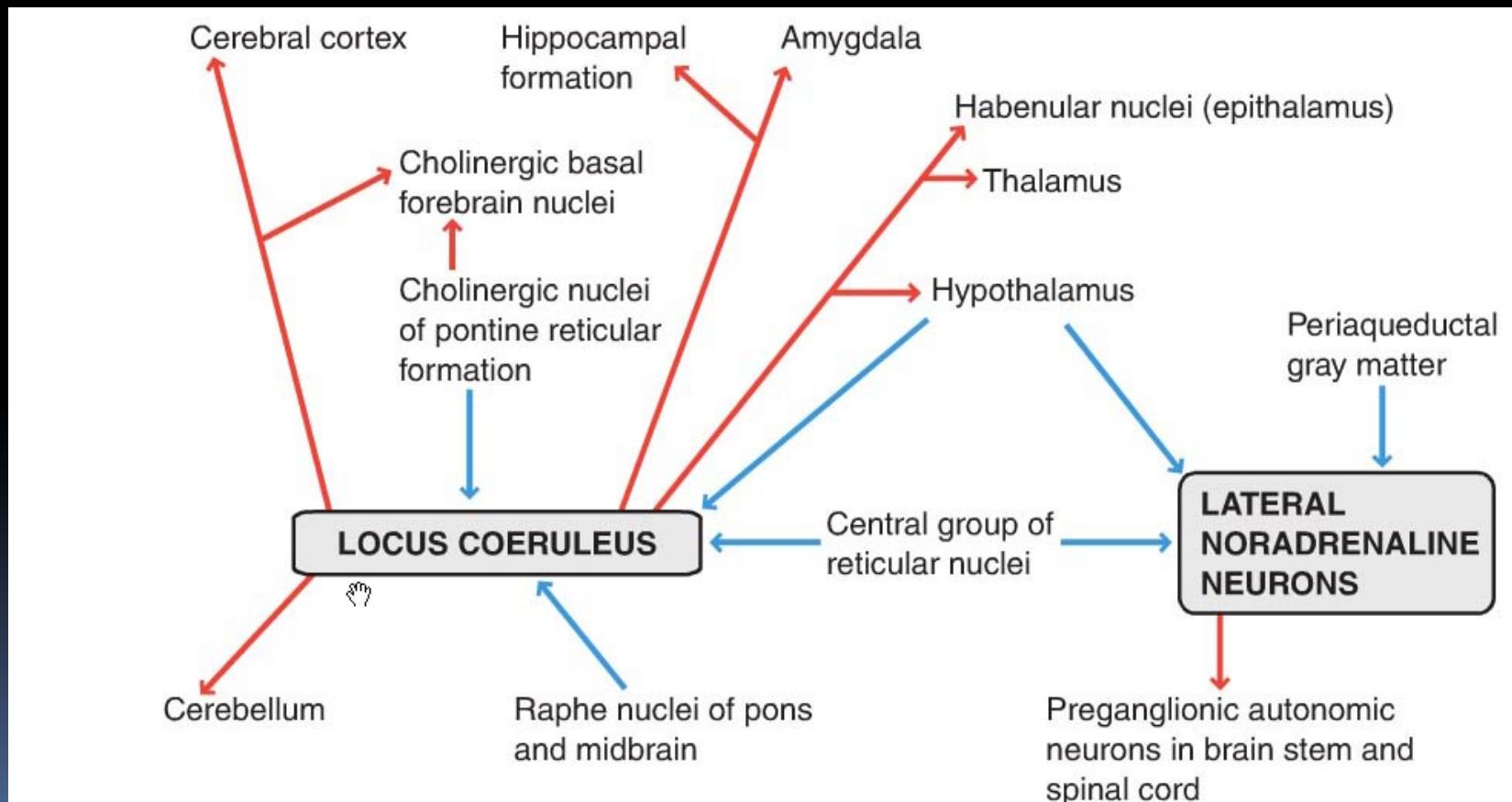
- Catecholamine nuclei
- Norepinephrine as a neurotransmitter
- Inputs mostly unknown
- Outputs to most parts of the CNS, especially forebrain



Tyrosine hydroxylase *in situ* shows location of locus coeruleus

# Catecholamine nuclei

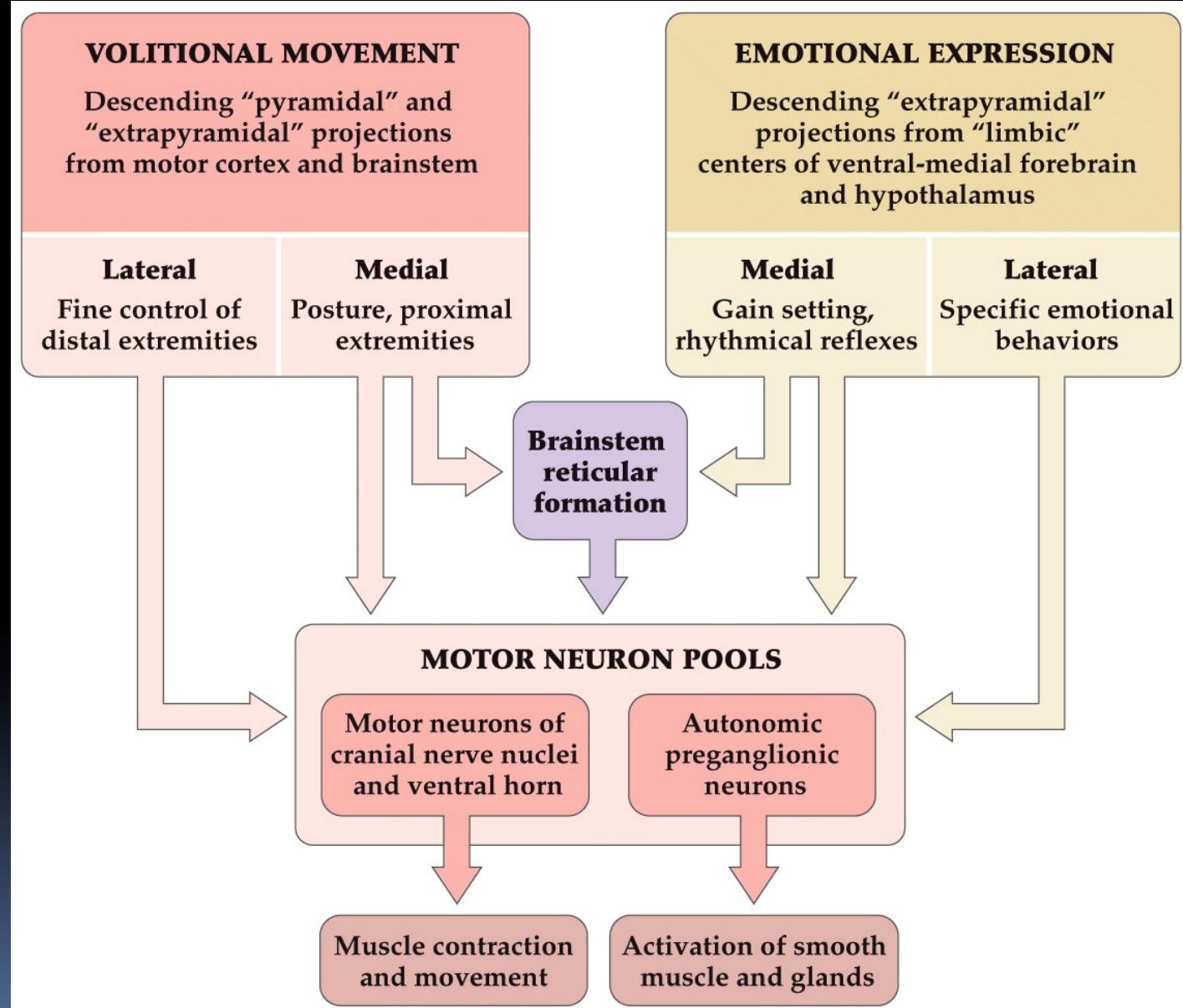
- Spontaneous activity modulated by other RF inputs
- Locus coeruleus sends axons with many branches to forebrain
- Lateral neurons send axons descending to autonomics



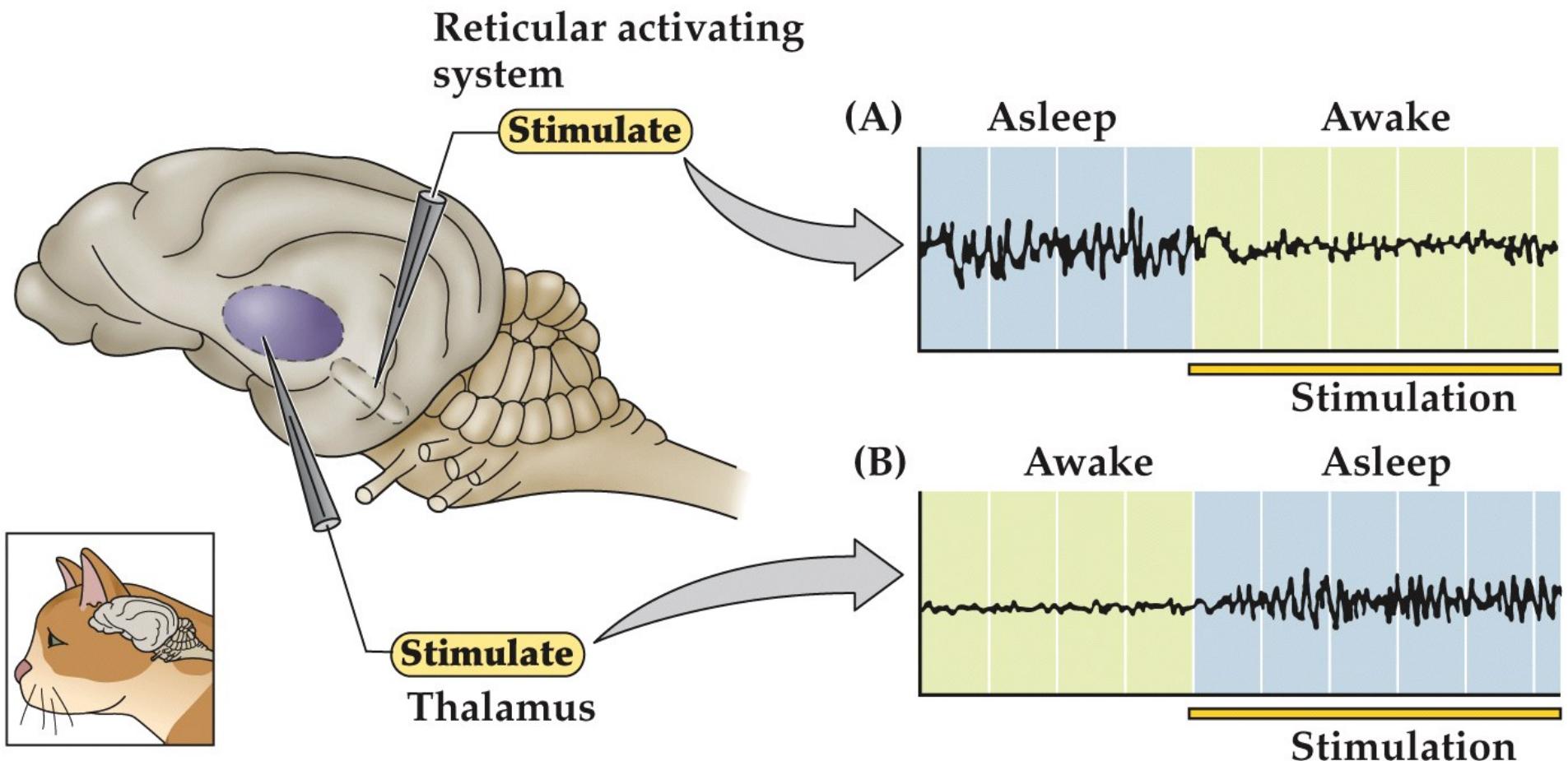
**FIGURE 9-7** Major connections of the noradrenergic nuclei of the brain stem.

# Motor Control and Emotion

Figure 29.2  
Descending systems that control somatic and visceral motor effectors in the expression of emotion



# Sleep and Wakefulness



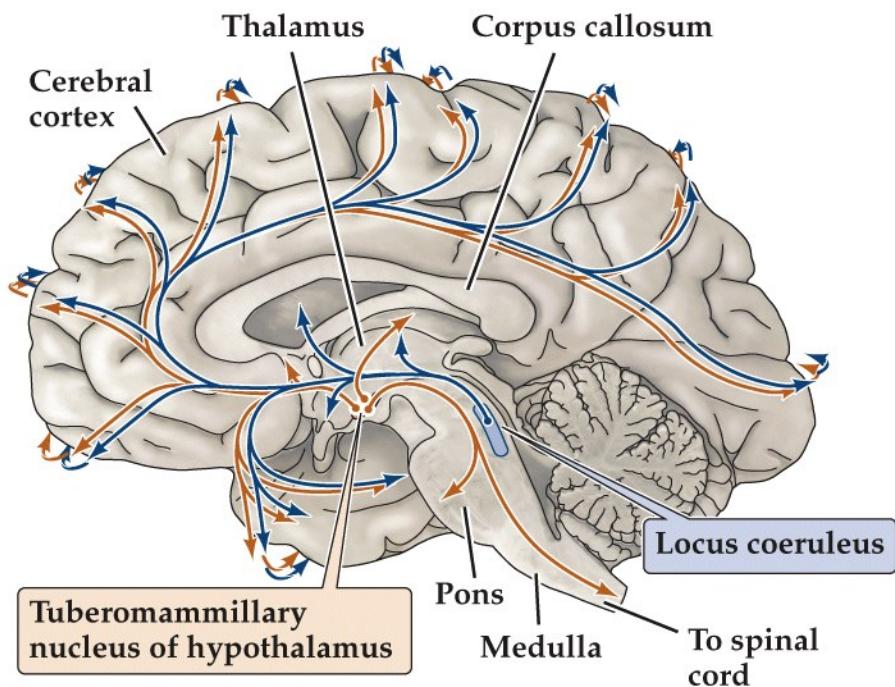
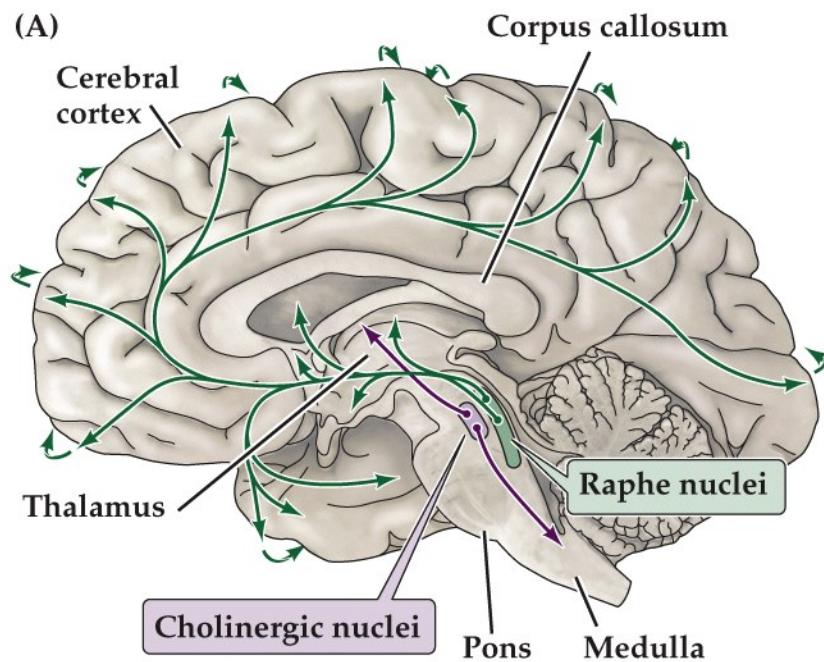
NEUROSCIENCE 5e, Figure 28.9

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- A. Electrical stimulation of cholinergic neurons near junction of pons and medulla
- B. Low frequency electrical stimulation of thalamus

Figure 28.11 Important nuclei in regulation of the sleep–wake cycle (Part 1)

## Sleep and arousal



NEUROSCIENCE 5e, Figure 28.11 (Part 1)

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**TABLE 28.1 Summary of the Cellular Mechanisms that Govern Sleep and Wakefulness**

BRAINSTEM NUCLEI RESPONSIBLE	NEUROTRANSMITTER INVOLVED	ACTIVITY STATE OF THE RELEVANT BRAINSTEM NEURONS
<b>Wakefulness</b>		
Cholinergic nuclei of pons–midbrain junction	Acetylcholine	Active
Locus coeruleus	Norepinephrine	Active
Raphe nuclei	Serotonin	Active
Tuberomammillary nuclei	Histamine	Active
Lateral hypothalamus	Orexin	Active
<b>Non-REM sleep</b>		
Cholinergic nuclei of pons–midbrain junction	Acetylcholine	Decreased
Locus coeruleus	Norepinephrine	Decreased
Raphe nuclei	Serotonin	Decreased
<b>REM sleep</b>		
Cholinergic nuclei of pons–midbrain junction	Acetylcholine	Active (PGO waves)
Raphe nuclei	Serotonin	Inactive
Locus coeruleus	Norepinephrine	Inactive

**NEUROSCIENCE 5e, Table 28.1**

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- In general, less activity in RF during sleep
- REM sleep looks more like wakefulness due to cholinergic RF activity

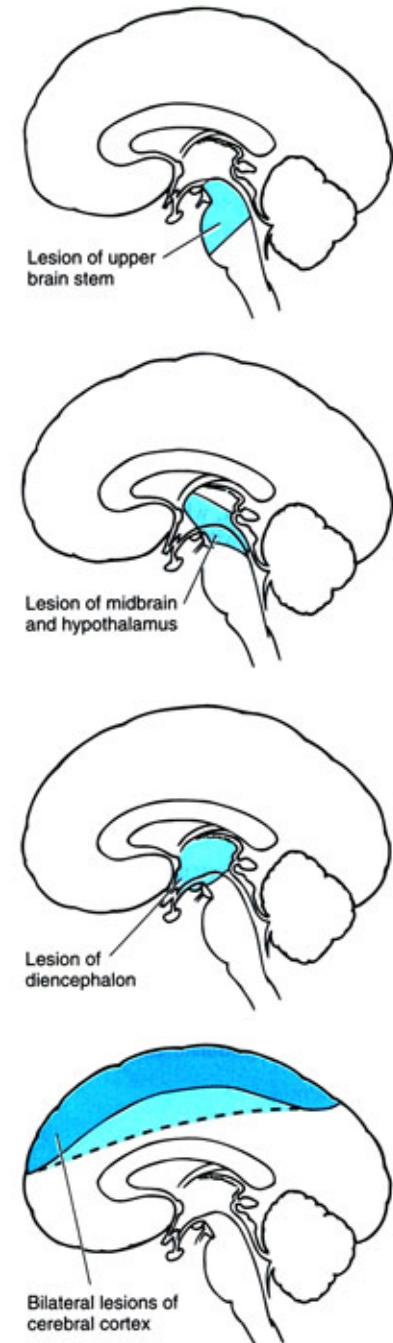
# Consciousness and Coma

Waxman SG (2003) Clinical Neuroanatomy, Lange Med Books

**Table 18–1.** Glasgow Coma Scale. A practical method of assessing changes in level of consciousness, based on eye opening and verbal and motor responses. The response can be expressed by the sum of the scores assigned to each response. The lowest score is 3, and the highest score is 15.

Variable	Examiner's Test	Patient's Response	Assigned Score
Eye opening	Spontaneous	Opens eyes on own.	4
	Speech	Opens eyes when asked to do so in a loud voice.	3
	Pain	Opens eyes when pinched.	2
	Pain	Does not open eyes.	1
Best motor response	Commands	Follows simple commands.	6
	Pain	Pulls examiner's hand away when pinched.	5
	Pain	Pulls a part of body away when pinched.	4
	Pain	Flexes body inappropriately to pain (decorticate posturing).	3
	Pain	Body becomes rigid in an extended position when pinched (decerebrate posturing).	2
	Pain	Has no motor response to pinch.	1
Verbal response (talking)	Speech	Carries on a conversation correctly and tells examiner where and who he or she is and the month and year.	5
	Speech	Seems confused or disoriented.	4
	Speech	Talks so examiner can understand words but makes no sense.	3
	Speech	Makes sounds examiner cannot understand.	2
	Speech	Makes no noise.	1

Slightly modified and reproduced, with permission, from Rimel RN, Jane JA, Edlich RF: Injury scale for comprehensive management of CNS trauma. JACEP 1979;8:64.



**Figure 18–2.** Lesions that cause coma or loss of consciousness.