Reticular Formation and Sleep/Wakefulness

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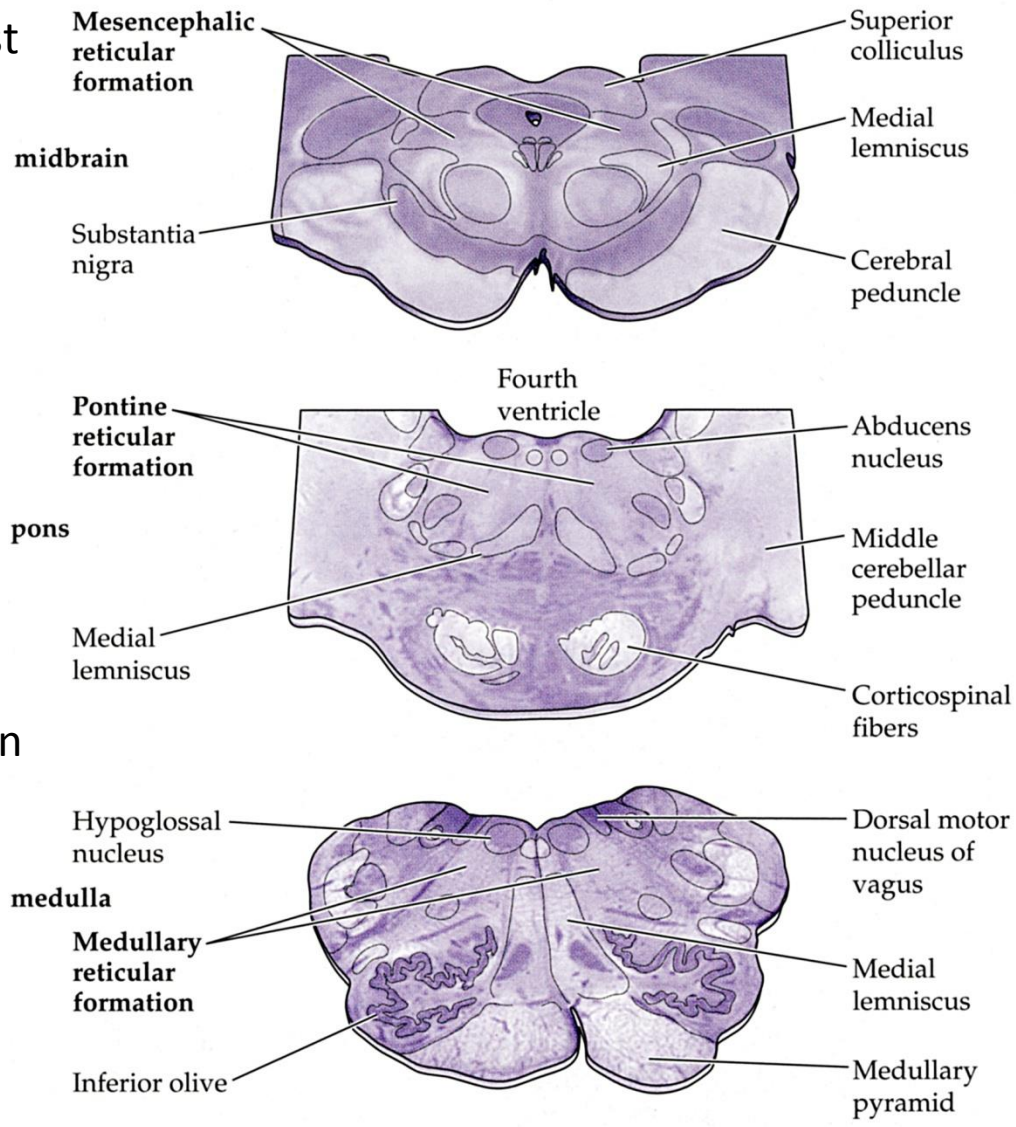
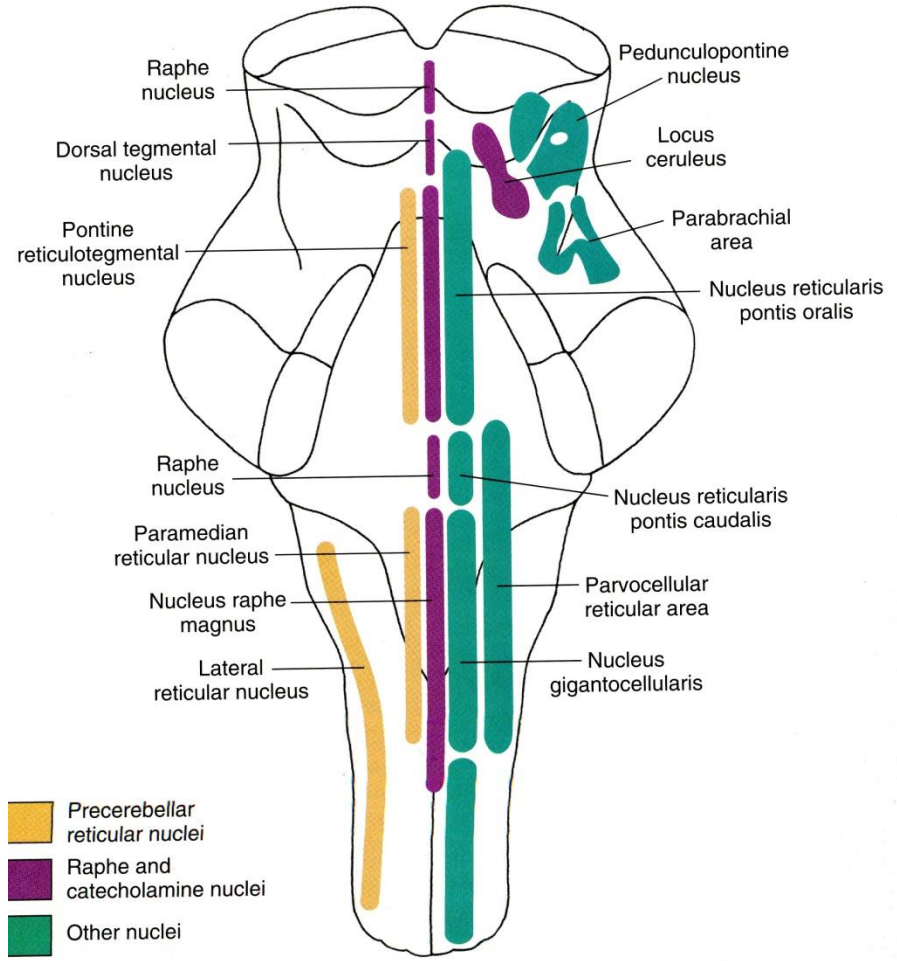
Reticular Formation

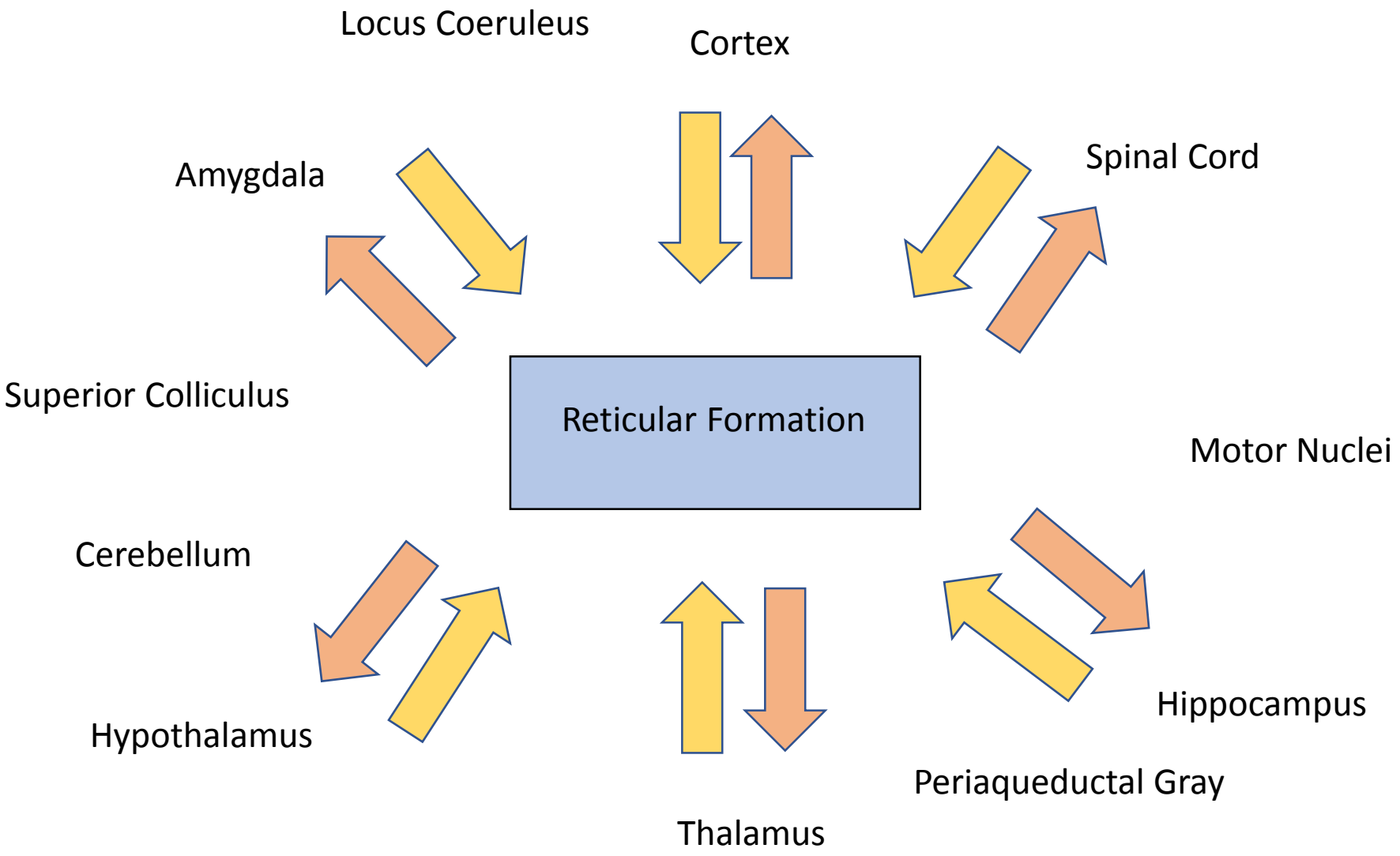
- The reticular formation is the oldest part of our nervous system phylogenetically.
- It is present throughout the midbrain, pons and medulla.
- Typically, the reticular formation is regions of the brainstem between clearly defined nuclei and tracts
- It is groups of neurons embedded in a seeming disorganized mesh of axons and dendrites.



Reticular Formation

- Although seemingly disorganized, over 100 groups of neurons related by function and connections have been identified in the reticular formation.



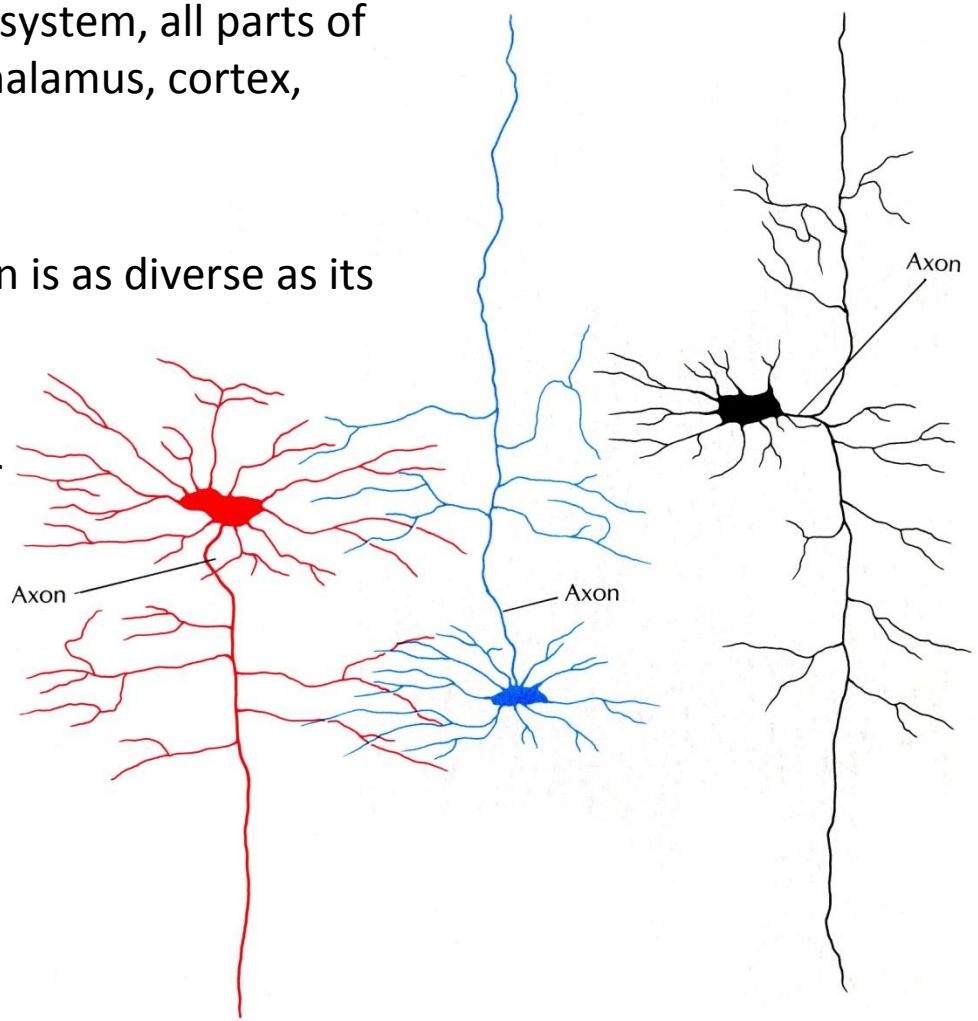

Locus Coeruleus
Cortex
Amygdala
Spinal Cord
Superior Colliculus
Reticular Formation
Motor Nuclei
Cerebellum
Hypothalamus
Hippocampus
Periaqueductal Gray
Thalamus

Reticular Formation

- The reticular formation receives input from all parts of the nervous system… every sensory system, all parts of the motor system, thalamus, hypothalamus, cortex, etc.

- The output of the reticular formation is as diverse as its input.

- Many of the neurons in the reticular formation have large, highly branched dendrites that receive diverse information.



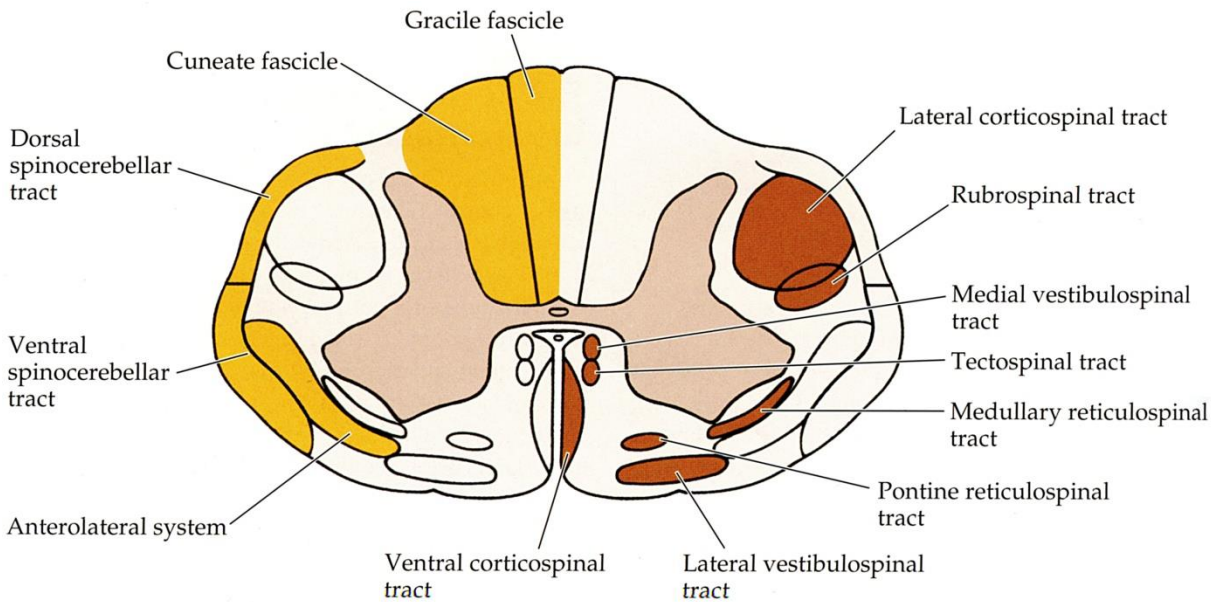
Reticular Formation

- The reticular formation has a major role in regulation of:
    - Motor control
    - Sensory attention
    - Autonomic nervous system
    - Eye movements
    - Sleep and wakefulness

Reticulospinal & Reticulbulbar Projections

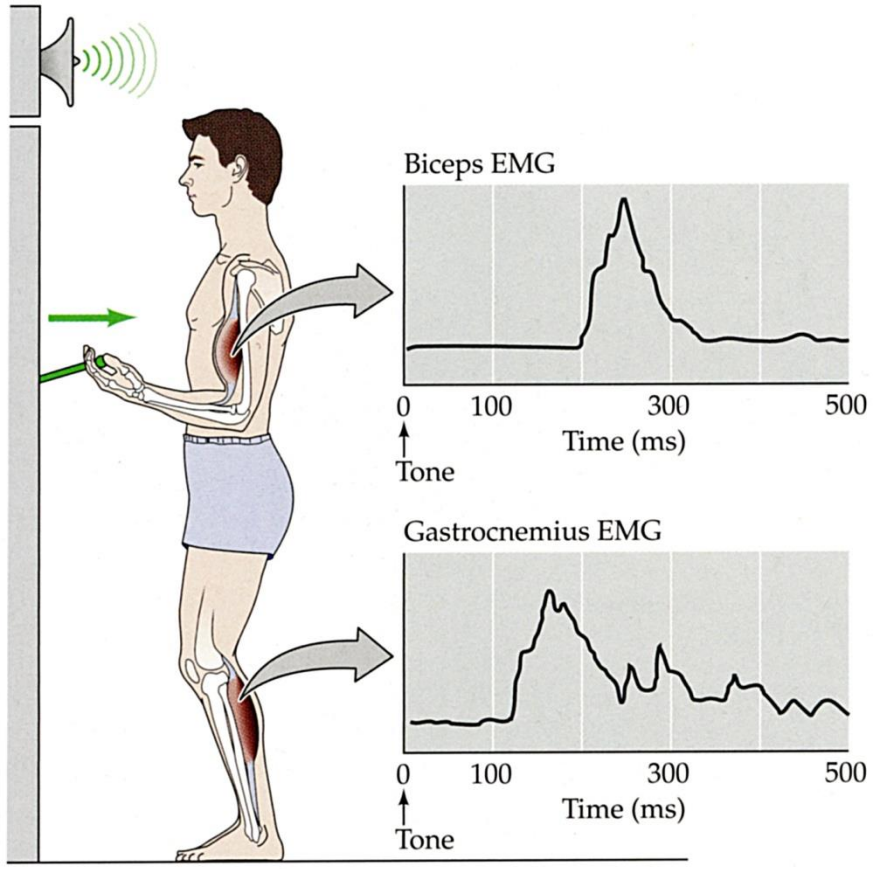
- Reticular formation (RF) in the lower pons and medulla receives motor information from premotor cortex, motor cortex and cerebellum as well as proprioceptive and vestibular sensory information.

- RF sends axons to cranial nerve motor nuclei and to ventral horn of the spinal cord via the reticulospinal tracts.



Reticulospinal & Reticulbulbar Projections

- Reticular formation (RF) initiates ‘accompanying’ movements.
- Accompanying movements are subconscious and are needed in support of a consciously initiated movement. These movements are often needed to maintain balance.
- Accompanying movements may precede the conscious movement.
- RF is required for this type of movement.



Reticulospinal & Reticulbulbar Projections

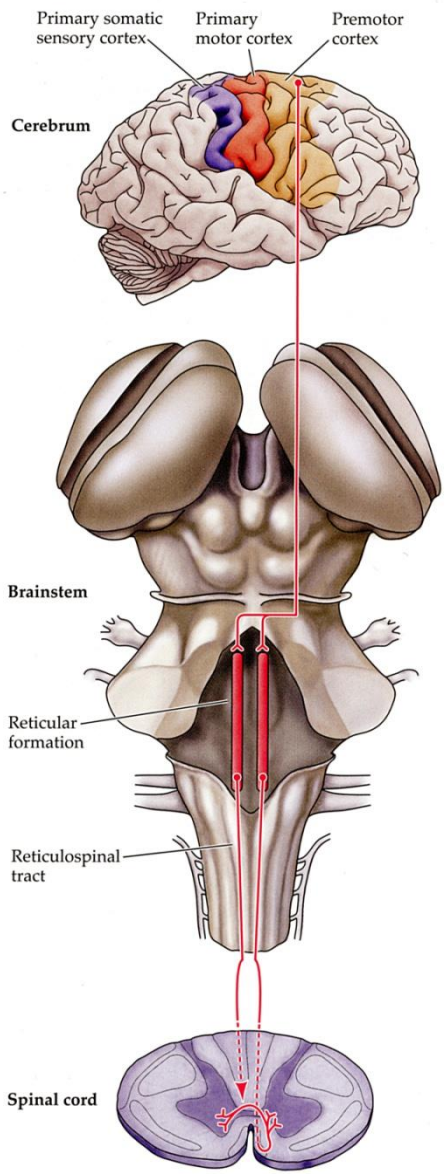
- Reticular formation (RF) integrates visceral sensory information to influence somatic motor neuron activity.

- Breathing, for example, is regulated by axons from RF to cervical spinal cord. Motor neurons in cervical spinal cord control the diaphragm.

- RF also has essential roles in regulating blood pressure and heart rate largely through connections with brainstem and spinal cord autonomic preganglionic neurons.

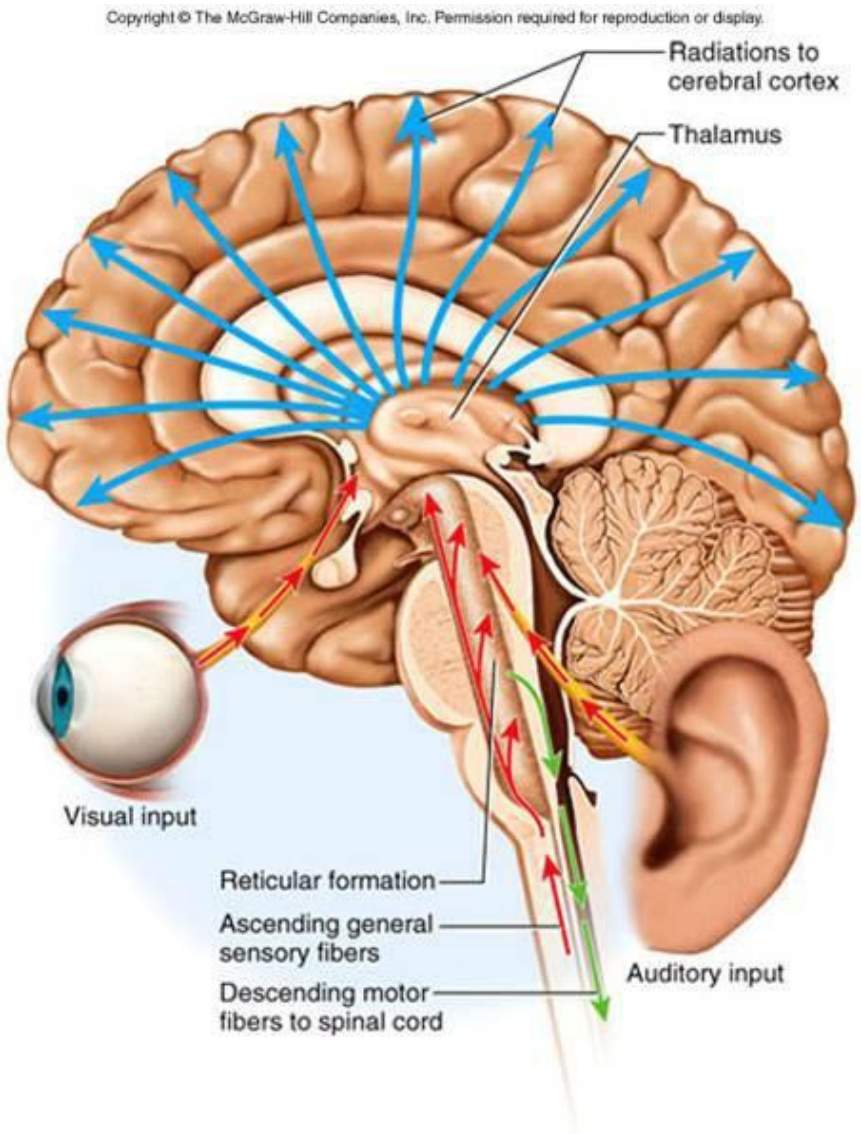
Reticulospinal & Reticulbulbar Projections

- Connections of the reticular formation are bilateral.
- RF influences motor neuron activity through interneurons.



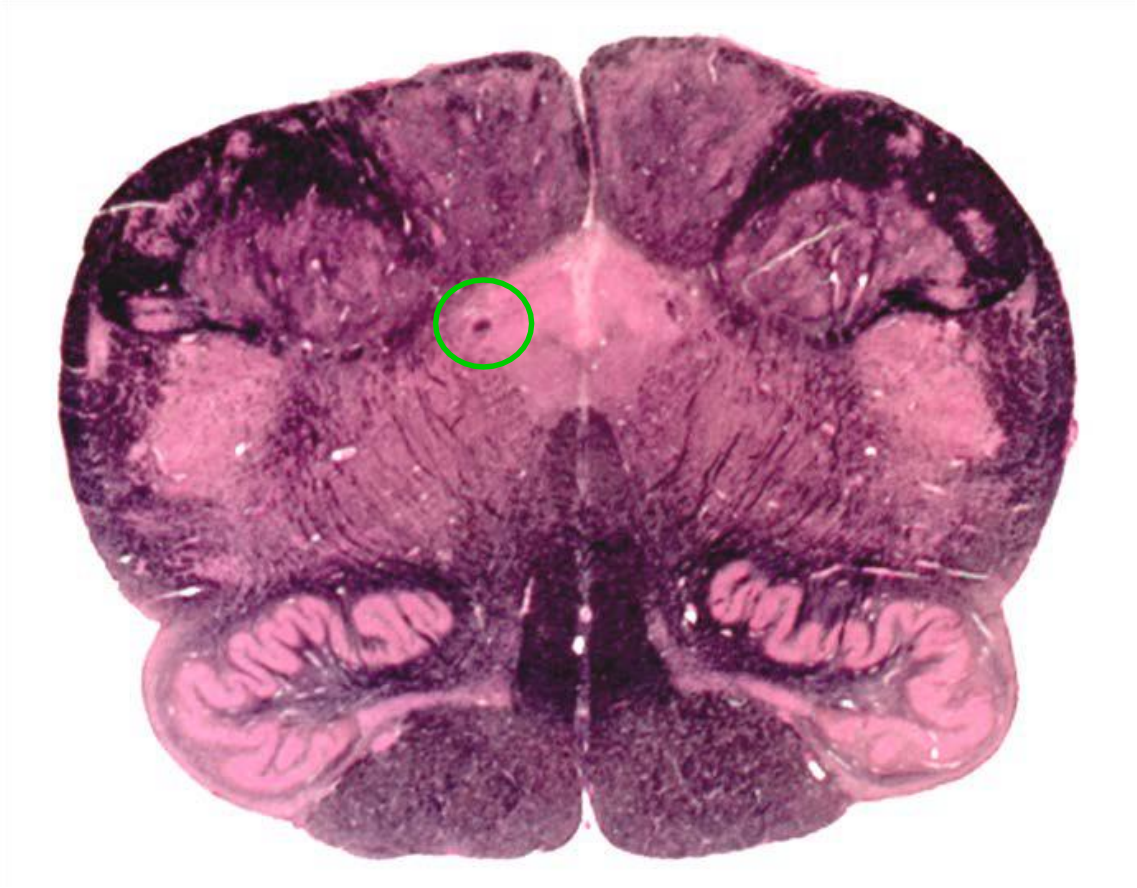
Sensory Attention

- Helps in filtering sensory information via reticulo-thalamic neurons
- Touch, temperature, pain, auditory, and visual stimuli
- Can help to reduce irrelevant stimuli



Autonomic Nervous System

- The reticular formation affects autonomic functions like
  - Breathing
  - Heart rate and blood pressure
  - Vomiting, gagging, and coughing
- The glossopharyngeal (CN IX) and vagus (CN X) nerves are important efferents



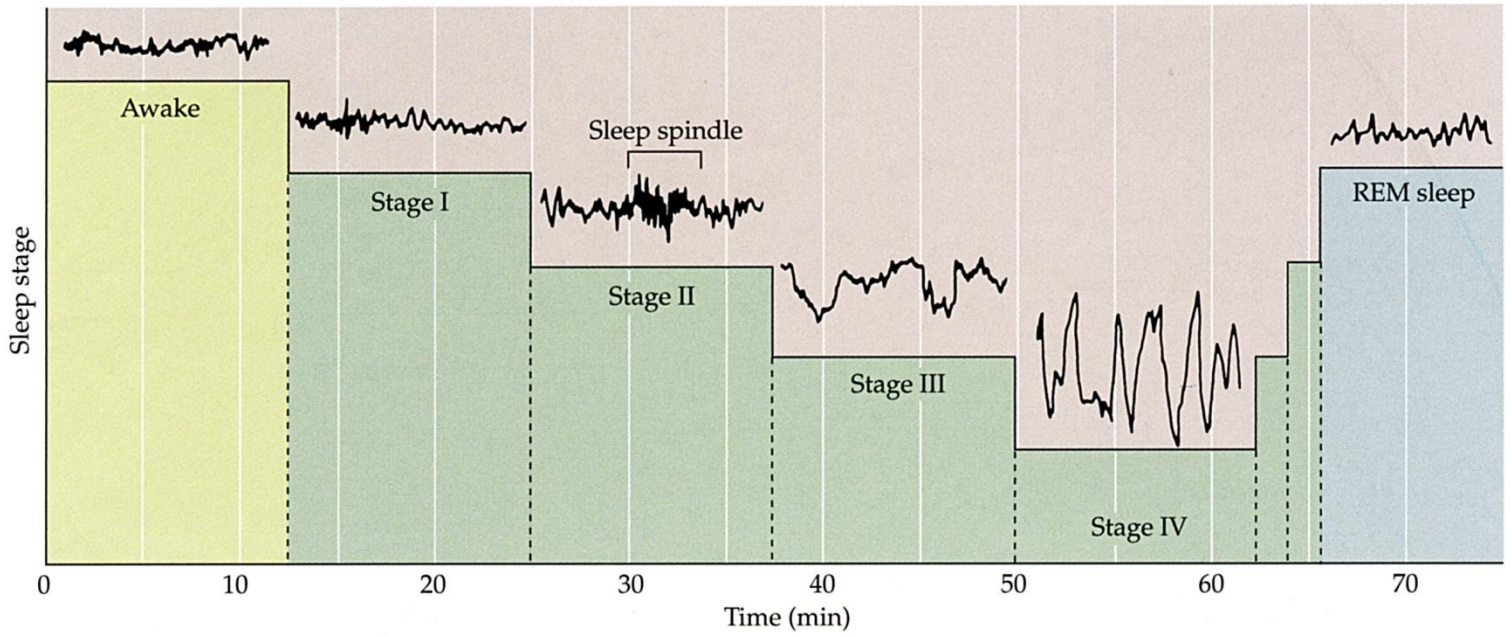
Sleep & Wakefulness

- Sleep and wakefulness are **both** active processes.

- Sleep and wakefulness are controlled by areas of the reticular formation in the midbrain and upper pons.

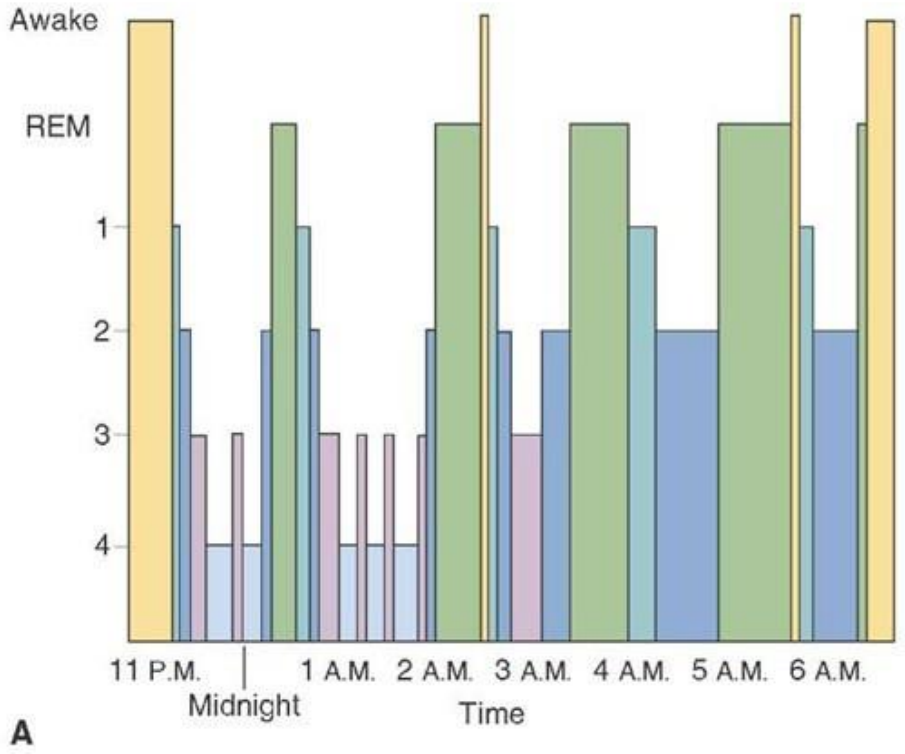
Sleep & Wakefulness

- Ideally, spend 1/3 of every day sleeping
- Sleep has five stages:
  - The first four stages (non-REM sleep) are characterized by progressively decreasing frequency and increasing amplitude of EEG cortical activity.
  - The fifth, rapid eye movement (REM) sleep, is characterized by high frequency and low amplitude EEG cortical activity, similar to the awake state.



Sleep & Wakefulness

- Stages I through IV take about 1 hour; REM sleep lasts about 10 minutes, and then the cycle repeats.
- Many physiological processes that are slowed during non-REM sleep increase during REM sleep.
- Somatic muscle activity is reduced during REM sleep.
- Most dreaming takes place during REM sleep.



Sleep & Wakefulness

Non REM or Slow Wave Sleep (SWS)

- Muscle Activity
- Little dreaming
- Few eye movements
- Slowing of breathing
- Reduced BP

Rapid Eye Movement (**REM**) Sleep

- Reduced muscle activity
- Frequent dreaming
- Increased eye movements
  Enhanced breathing
- Increased BP

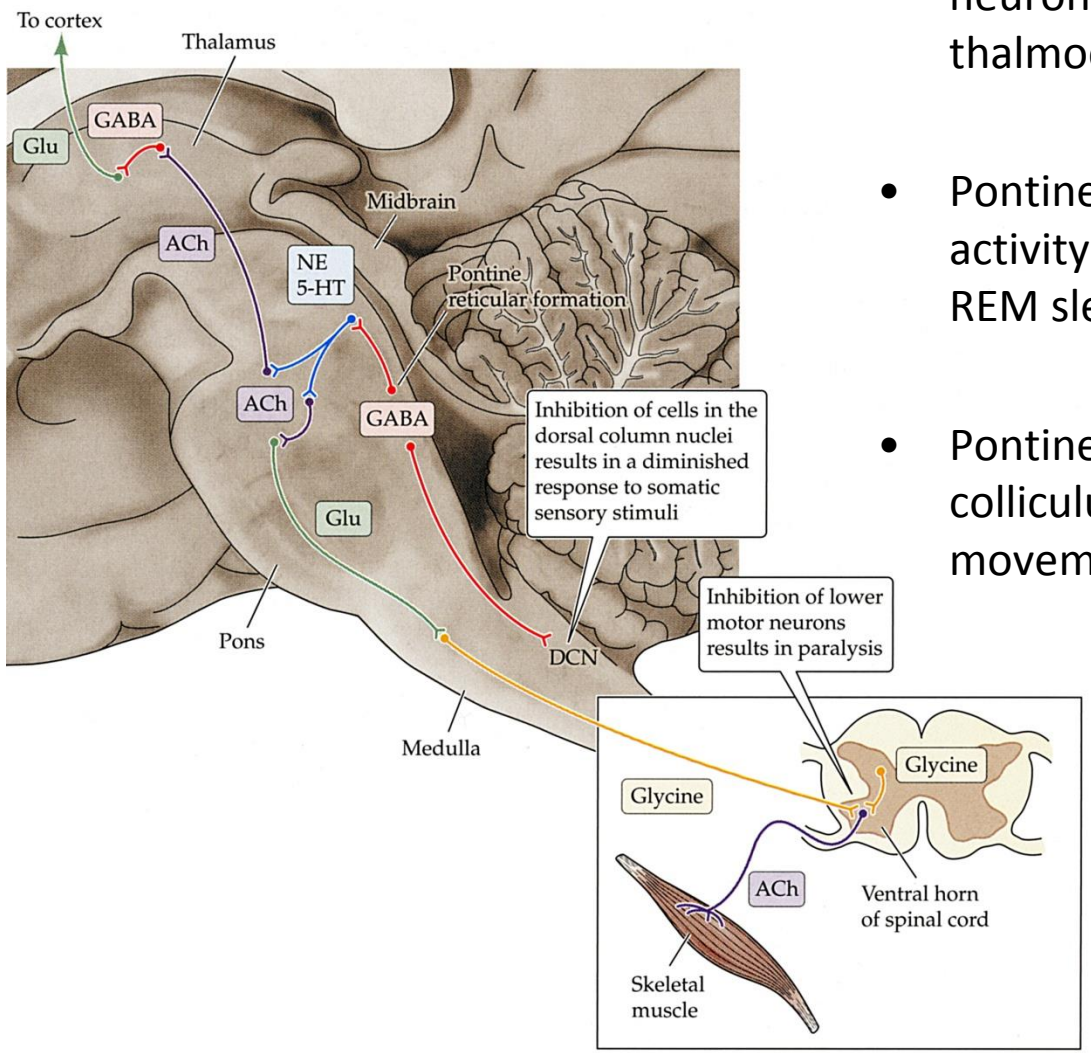
Sleep & Wakefulness

- Non-REM sleep is characterized by an inactive brain in an active body.
- REM sleep is characterized by an active brain in an inactive body.

Sleep & Wakefulness

- The amount of REM sleep a person gets per night decreases with age:
  - ~8 hours at birth
  - ~ 2 hours at 20 years of age
  - ~45 minutes at 70 years of age

Sleep & Wakefulness

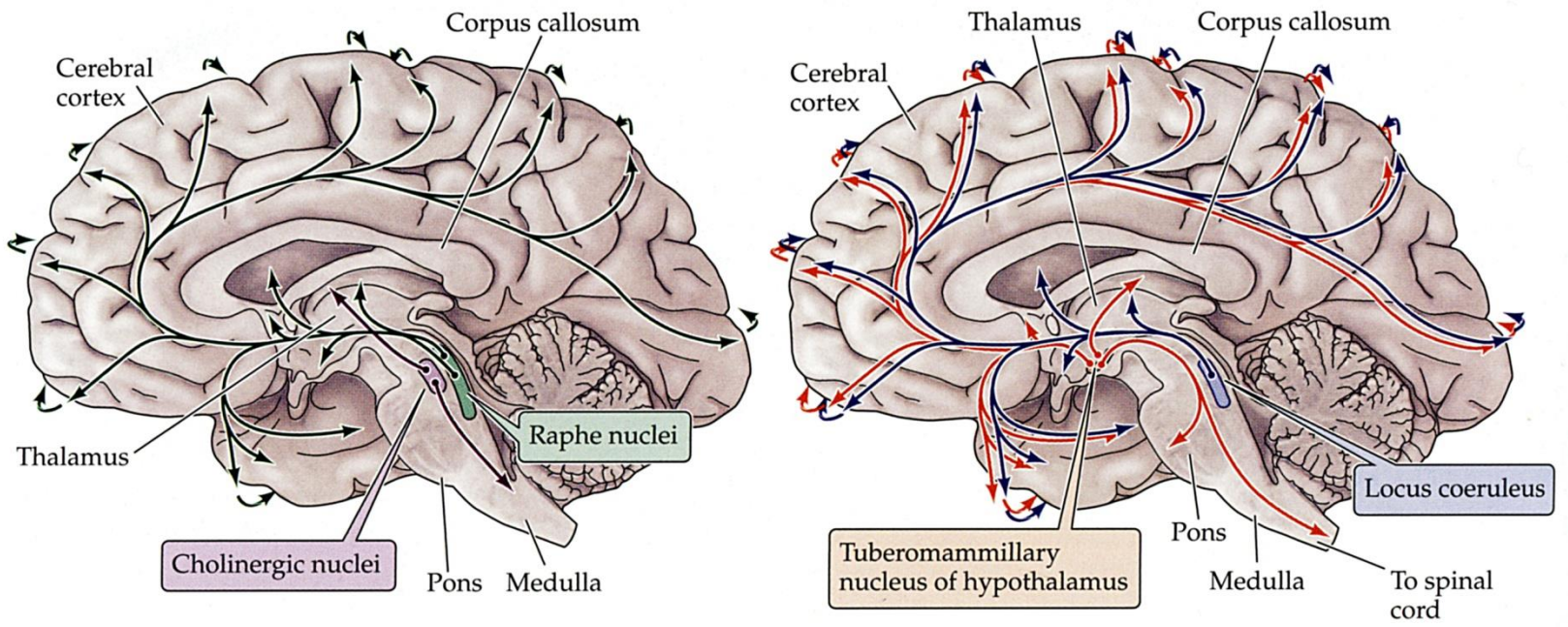


- Cholinergic axons from the reticular formation to thalamus activate GABAergic neurons in thalamus, which inhibit thalmocortical axons during REM sleep.
- Pontine reticulospinal axons inhibit the activity of spinal motor neurons during REM sleep.
- Pontine RF projection to the superior colliculus is required for the rapid eye movements during REM sleep.

Sleep & Wakefulness

- The reticular activating system from midbrain and pons is required for wakefulness.

- Noradrenergic neurons in the locus coeruleus and serotonergic neurons in the raphe nucleus of the reticular formation project to cortex and are required for wakefulness.



Sleep & Wakefulness

- The lack of sleep results in mental and physical fatigue, poor decision-making, impaired learning, emotional irritability, and an increased risk of migraine and epileptic seizures.

- Chronic insomnia results in death.

- We have little understanding of how sleep ‘restores’ the brain

In a paper published last month, it was shown that:

- The extracellular space in the brain of an awake mouse accounts for 14% of the brain volume; during sleep this increases to 23%.

- CSF flows through the extracellular space, and this flow increases 95% during sleep.

- Noradrenaline is responsible for the loss of extracellular space when awake.

- β-amyloid, a peptide linked to Alzheimer's disease, is cleared from the extracellular space during sleep.

Xie et al. (2013)

Science 342:373-377

Sleep Disorders

- Insomnia
- Narcolepsy
- Sleepwalking
- Night Terrors
- Restless Leg Syndrome
- Sleep Apnea