Human Physiology, Motor System

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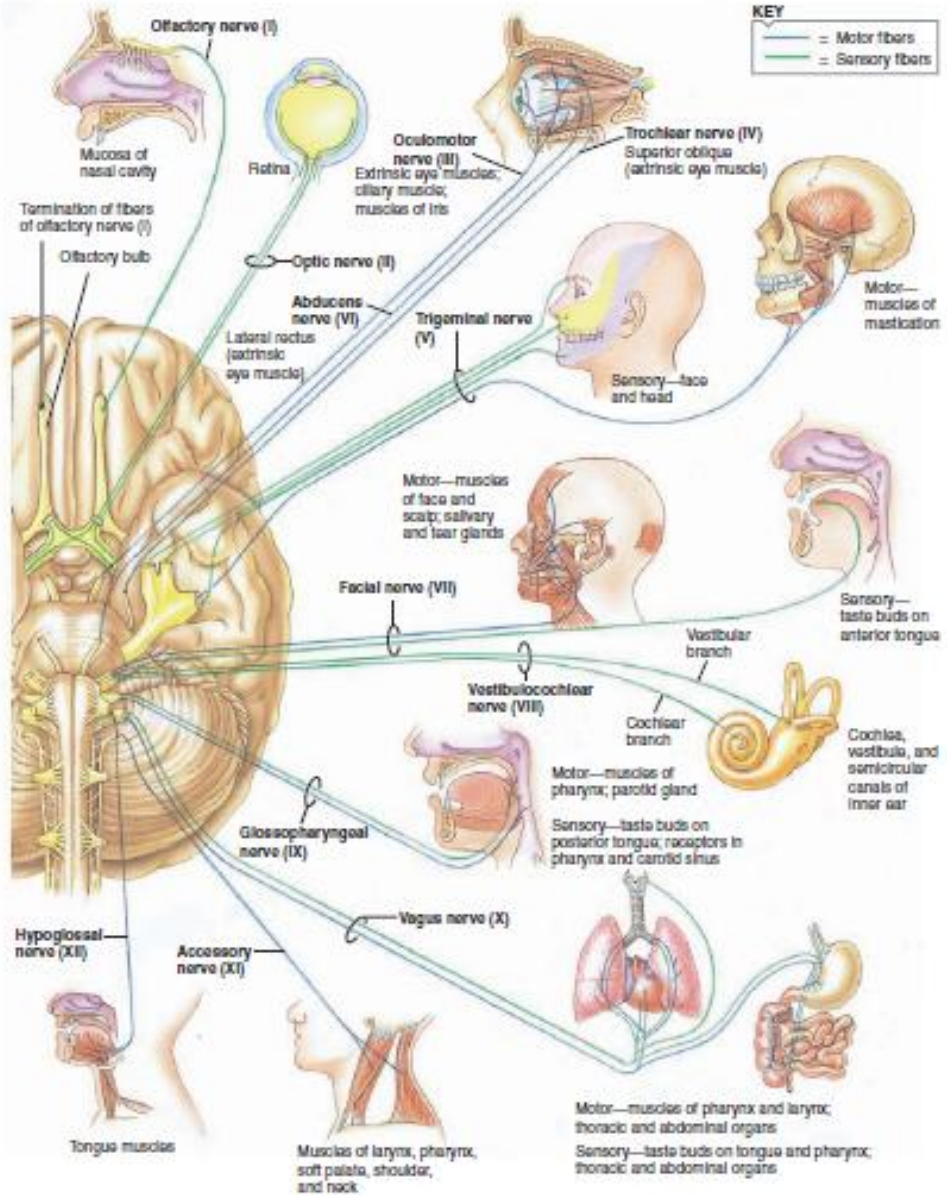
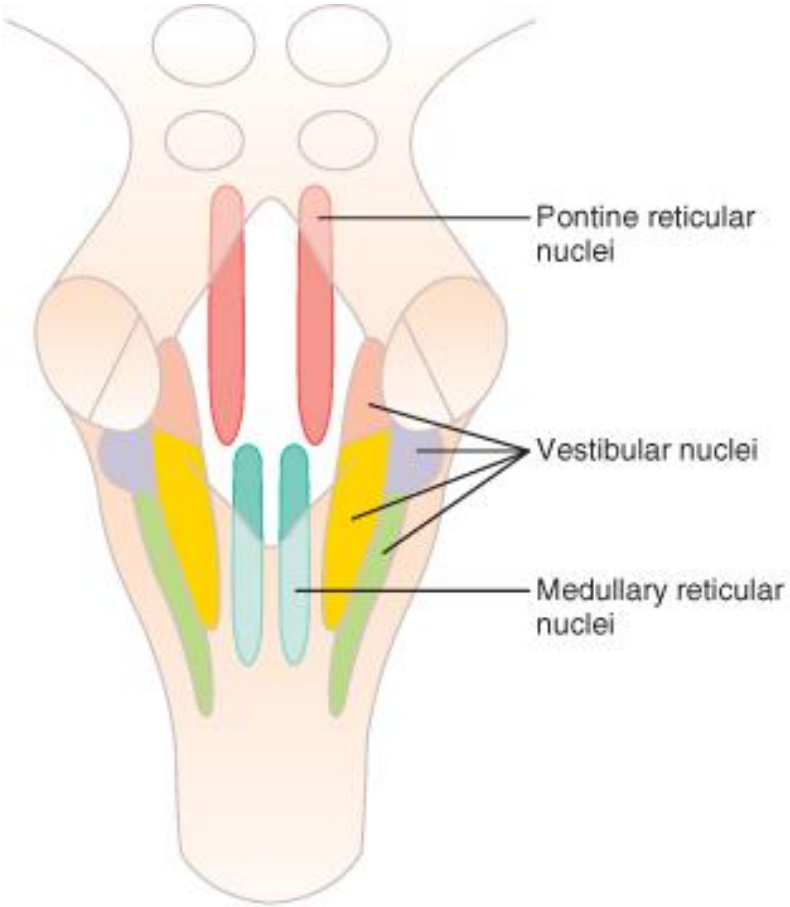
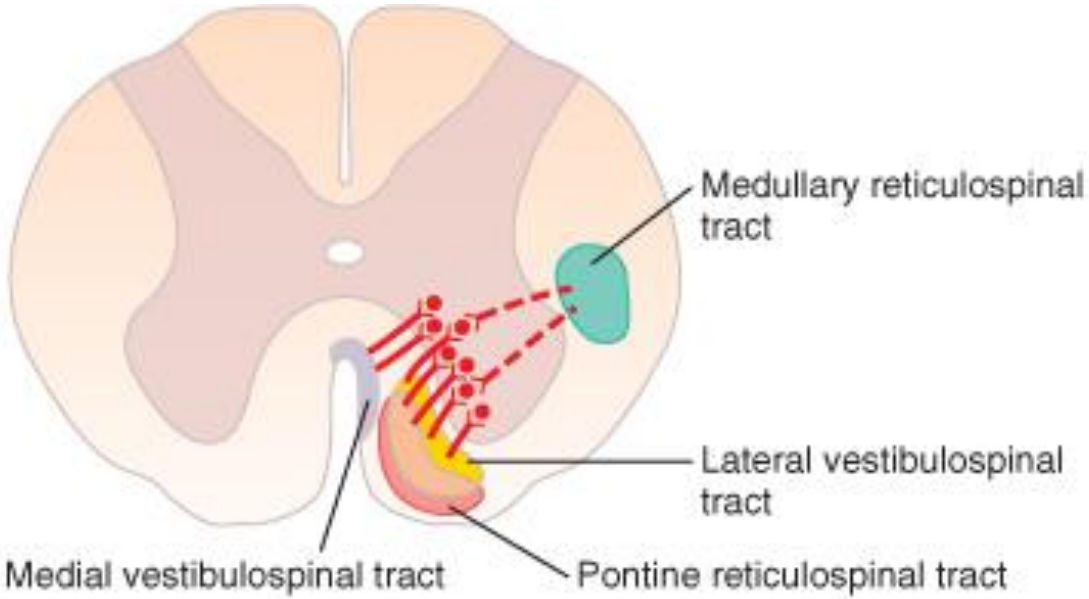
BRAIN STEM

- The brain stem is a vital link b/w the spinal cord and higher brain regions
- Way station for command signals from higher centres
- Origin of majority of 12 pairs of cranial nerves
- Neural control centre for CVC, GIT and Respiration
- Role in RAS, regulating equilibrium and posture and in sleep


KEY
= Motor fibers
= Sensory fibers
Olfactory nerve (I)
Mucosa of nasal cavity
Retina
Oculomotor nerve (III)
Extrinsic eye muscles; ciliary muscle; muscles of iris
Trochlear nerve (IV)
Superior oblique (extrinsic eye muscle)
Termination of fibers of olfactory nerve (I)
Olfactory bulb
Optic nerve (II)
Abducens nerve (VI)
Lateral rectus (extrinsic eye muscle)
Trigeminal nerve (V)
Motor—muscles of mastication
Sensory—face and head
Motor—muscles of face and scalp; salivary and tear glands
Facial nerve (VII)
Sensory—taste buds on anterior tongue
Vestibular branch
Vestibulocochlear nerve (VIII)
Cochlear branch
Cochlea, vestibule, and semicircular canals of inner ear
Motor—muscles of pharynx; parotid gland
Glossopharyngeal nerve (IX)
Sensory—taste buds on posterior tongue; receptors in pharynx and carotid sinus
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)
Tongue muscles
Muscles of larynx, pharynx, soft palate, shoulder, and neck
Motor—muscles of pharynx and larynx; thoracic and abdominal organs
Sensory—taste buds on tongue and pharynx; thoracic and abdominal organs

Number and Name	Function(s)
I Olfactory	• Sense of smell
II Optic	• Sense of sight
III Oculomotor	• Movement of the eyeball; constriction of pupil in bright light or for near vision
IV Trochlear	• Movement of eyeball
V Trigeminal	• Sensation in face, scalp, and teeth; contraction of chewing muscles
VI Abducens	• Movement of the eyeball
VII Facial	• Sense of taste; contraction of facial muscles; secretion of saliva
VIII Acoustic (vestibulocochlear)	• Sense of hearing; sense of equilibrium
IX Glossopharyngeal	• Sense of taste; sensory for cardiac, respiratory, and blood pressure reflexes; contraction of pharynx; secretion of saliva
X Vagus	• Sensory in cardiac, respiratory, and blood pressure reflexes; sensory and motor to larynx (speaking); decreases heart rate; contraction of alimentary tube (peristalsis); increases digestive secretions
XI Accessory	• Contraction of neck and shoulder muscles; motor to larynx (speaking)
XII Hypoglossal	• Movement of the tongue





Motor control of brain stem

- Control of cerebral activity through brain stem is by two ways

1- controlled directly by neuronal activity (RAS)

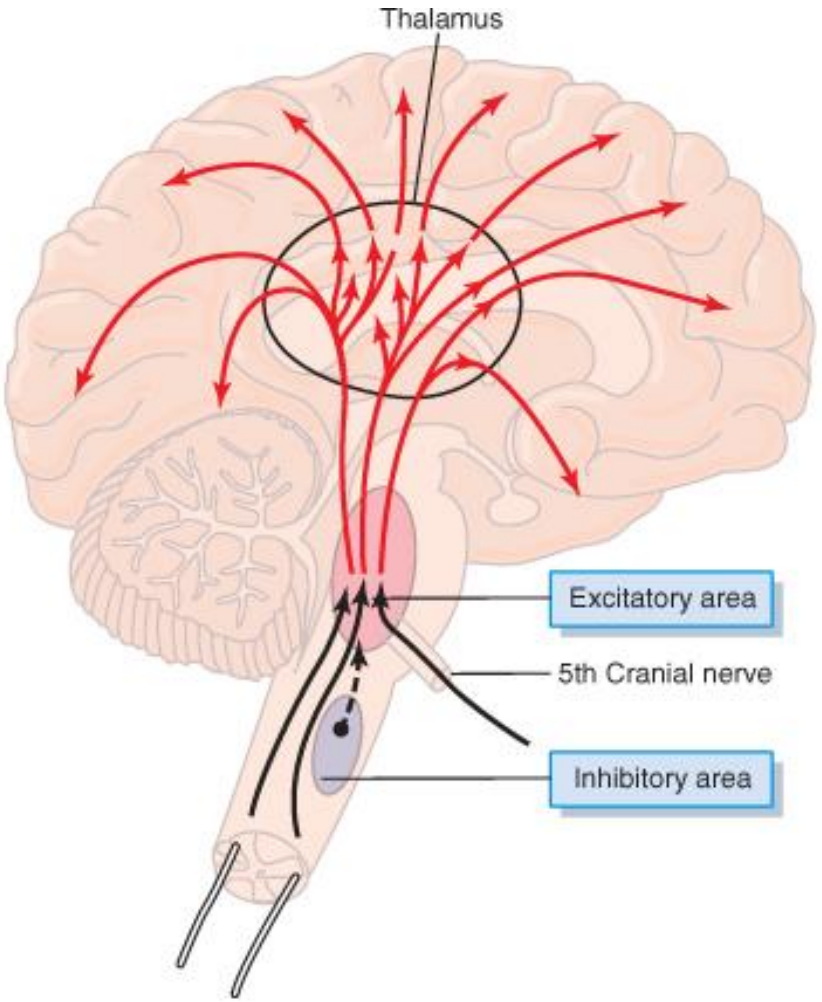
2- by activating neurohormonal system

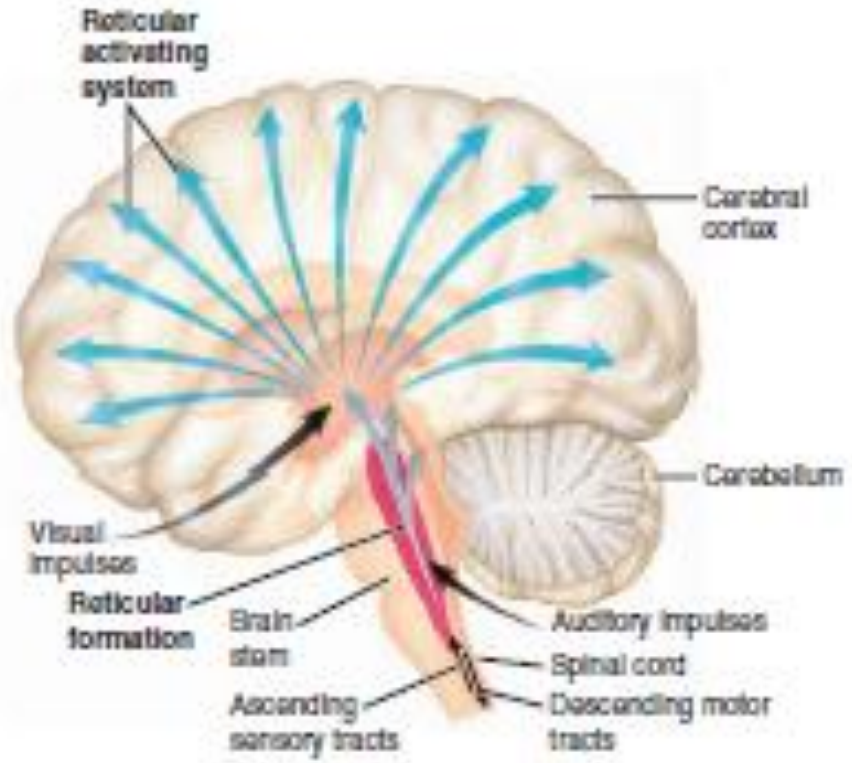
Direct control (RAS) is by 2 ways:

1- reticular excitatory area(bulbo reticular facilitatory area)

2- reticular inhibitory area

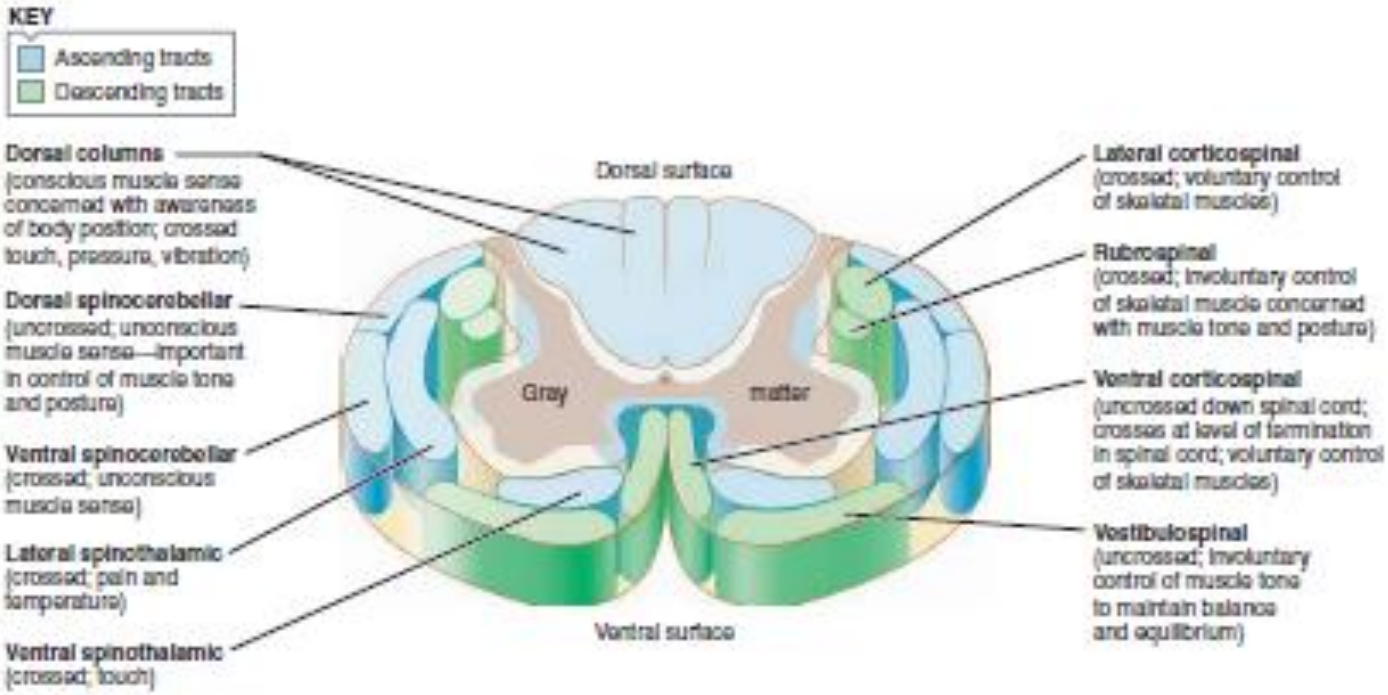
Pontine & Medullary reticular system

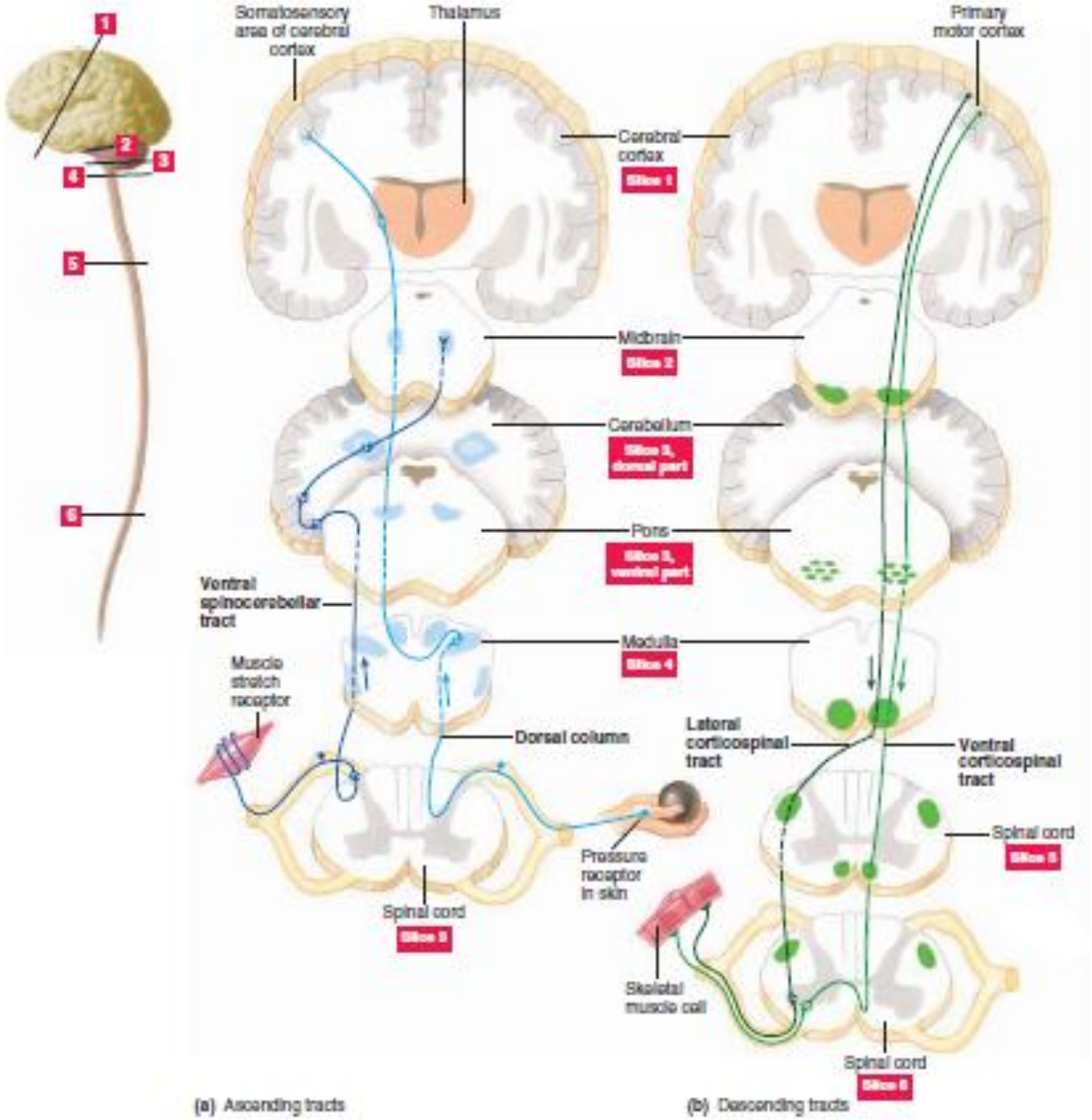



Reticular activating system
Cerebral cortex
Cerebellum
Visual impulses
Reticular formation
Brain stem
Auditory impulses
Spinal cord
Ascending sensory tracts
Descending motor tracts

Descending tracts through brain stem

1. Cortico spinal tract
2. Rubrospinal tract
3. Reticulospinal tract
4. Vestibulospinal tract
5. Tactospinal tract

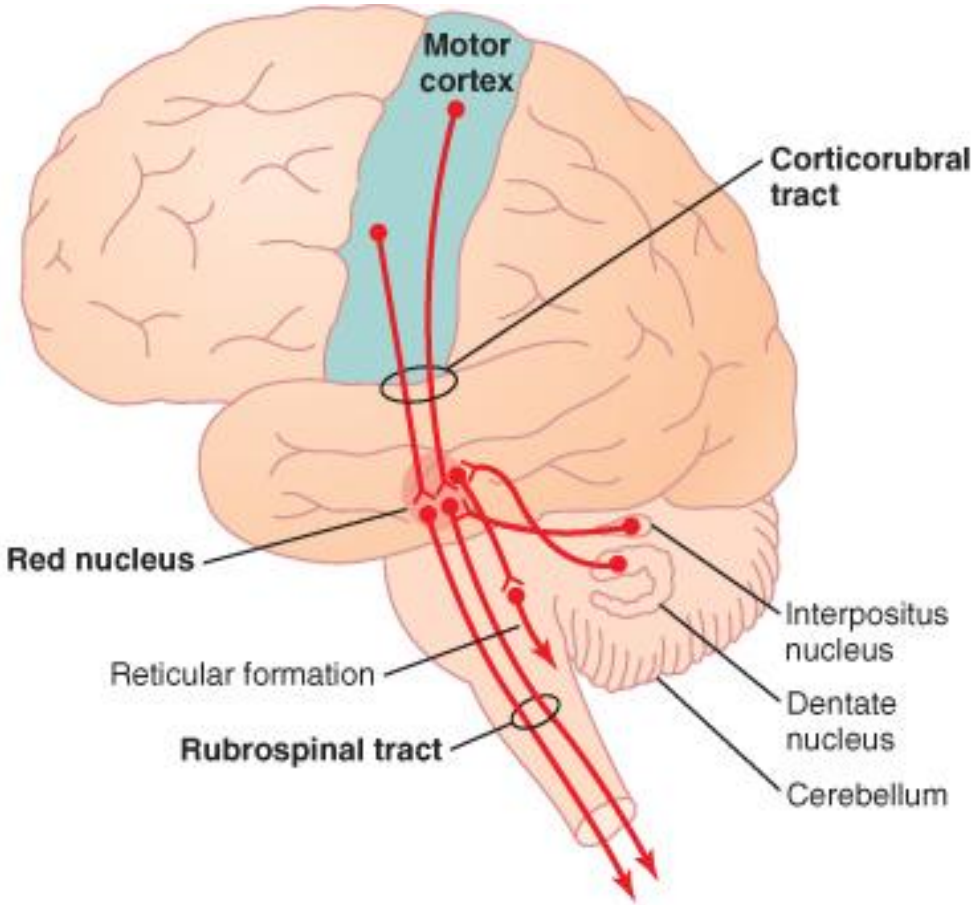

KEY
Ascending tracts
Descending tracts
Dorsal columns
(conscious muscle sense concerned with awareness of body position; crossed touch, pressure, vibration)
Dorsal spinocerebellar
(uncrossed; unconscious muscle sense—important in control of muscle tone and posture)
Ventral spinocerebellar
(crossed; unconscious muscle sense)
Lateral spinothalamic
(crossed; pain and temperature)
Ventral spinothalamic
(crossed; touch)
Dorsal surface
Gray
matter
Ventral surface
Lateral corticospinal
(crossed; voluntary control of skeletal muscles)
Rubrospinal
(crossed; involuntary control of skeletal muscle concerned with muscle tone and posture)
Ventral corticospinal
(uncrossed down spinal cord; crosses at level of termination in spinal cord; voluntary control of skeletal muscles)
Vestibulospinal
(uncrossed; involuntary control of muscle tone to maintain balance and equilibrium)

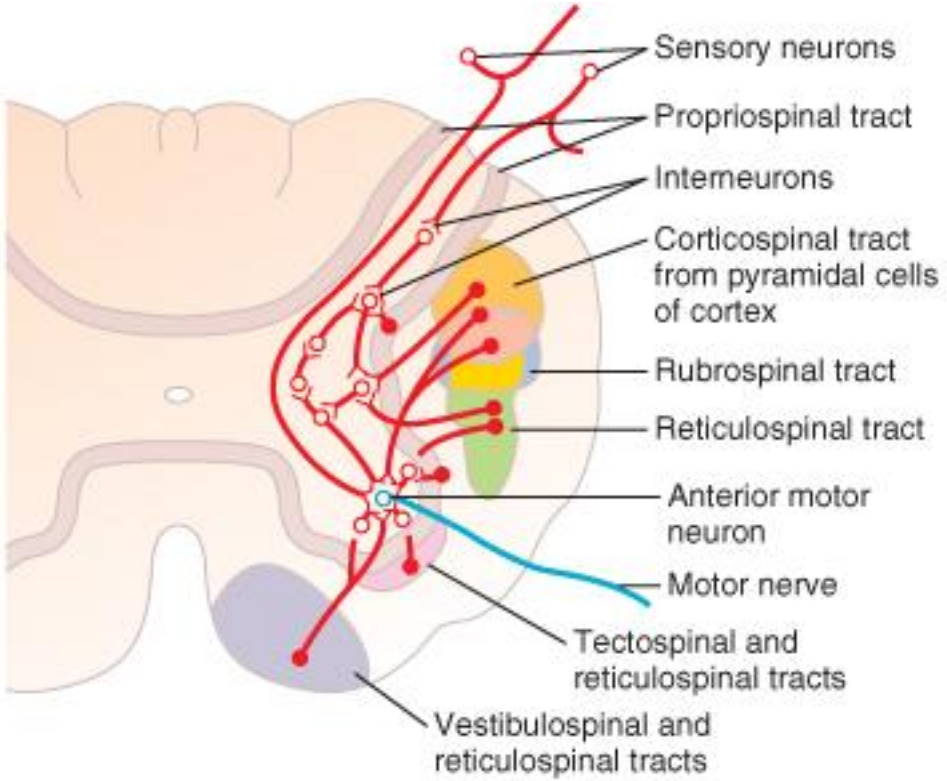

1
2
3
4
5
6
Somatosensory area of cerebral cortex
Thalamus
Primary motor cortex
Cerebral cortex
Slice 1
Midbrain
Slice 2
Cerebellum
Slice 3, dorsal part
Pons
Slice 3, ventral part
Medulla
Slice 4
Ventral spinocerebellar tract
Muscle stretch receptor
Dorsal column
Lateral corticospinal tract
Ventral corticospinal tract
Spinal cord
Slice 5
Pressure receptor in skin
Skeletal muscle cell
Spinal cord
Slice 6
(a) Ascending tracts
(b) Descending tracts

Rubrospinal tract (corticorubro spinal tract)

- Site (mesencephlon)
- Inputs to red nucleus (corticorubral & corticospinal fibers)
- Pathway
- Termination (interneurons of intermediate grey matter of cord)
- Functions

1) Magnocellular portion of red nucleus has a somatographic representation of all the muscles of body
2) Serves as an accessory route for transmission of relatively discrete signals from motor cortex to spinal cord





By activating neurohormonal system

- Four neurohormonal systems

1- Locus ceruleus and nor epinephrine system

2- Substantia nigra and dopamine system

3- Raphe nuclei and serotonin system

4- Gigantocellular neurons in reticular excitatory area and acetylcholine system

Locus ceruleus and nor epinephrine system

- Site (posteriorly at the juncture of pons and mesencephlon)
- Nerve fibres spread throughout the brain
- Secrete nor epinephrine
- Nor epinephrine generally excites the brain
- It has inhibitory effect in few brain areas because of inhibitory receptors at certain neuronal synapses
- Important role in causing dreaming in REM sleep

Substantia nigra and dopamine system

- Site (anteriorly in superior mesencephlon)
- Send neurons to caudate nucleus and putamen
- Secrete dopamine
- It is an inhibitory neurotransmitter in the basal ganglia but in some other areas of brain it is possibly excitato

The raphe nuclei and serotonin system

- Site (in the midline of pons and medulla)
- Send fibres to cerebrum , diencephalon and spinal cord
- Secrete serotonin
- The serotonin secreted at the cord has the ability to suppress pain
- The serotonin released in the cerebrum plays an essential inhibitory role in normal sleep

Neurons of reticular excitatory area and acetylcholine system

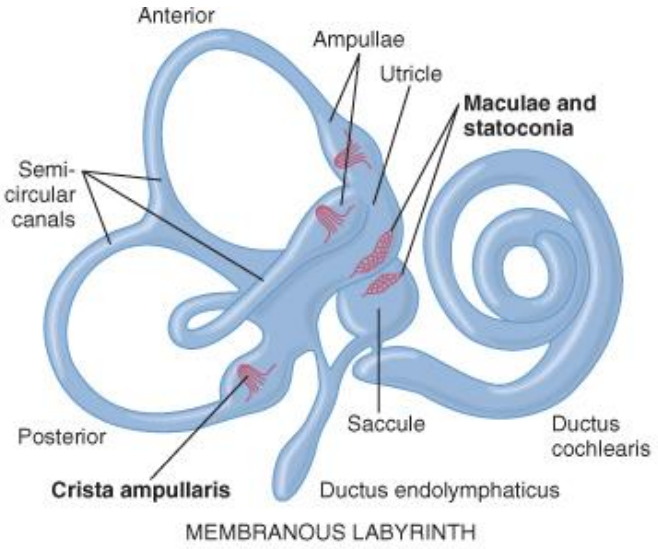
- Gigantocellular neurons in reticular excitatory area of pons and mid brain
- Fibres from these large cells divide immediately in to two branches
- One to higher levels of brain and other to spinal cord
- Secrete acetylcholine
- Excitatory neurotransmitter

Role of brain stem in Maintenance of equilibrium-Vestibular nuclei

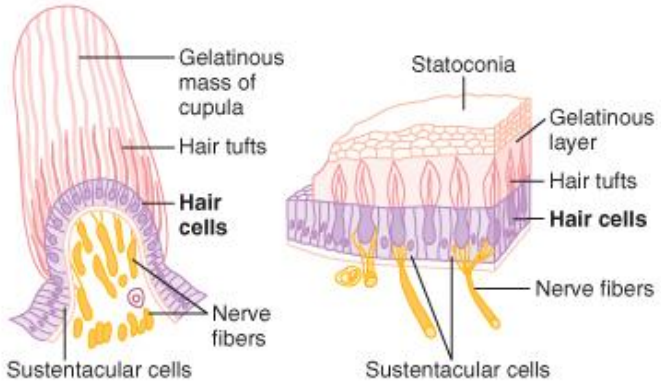
- Location
- They give lateral and medial vestibulospinal tracts
- Functions

1. Function in association with pontine reticular nuclei to control the antigravity muscles
2. They help to maintain equilibrium in response to signals from vestibular apparatus

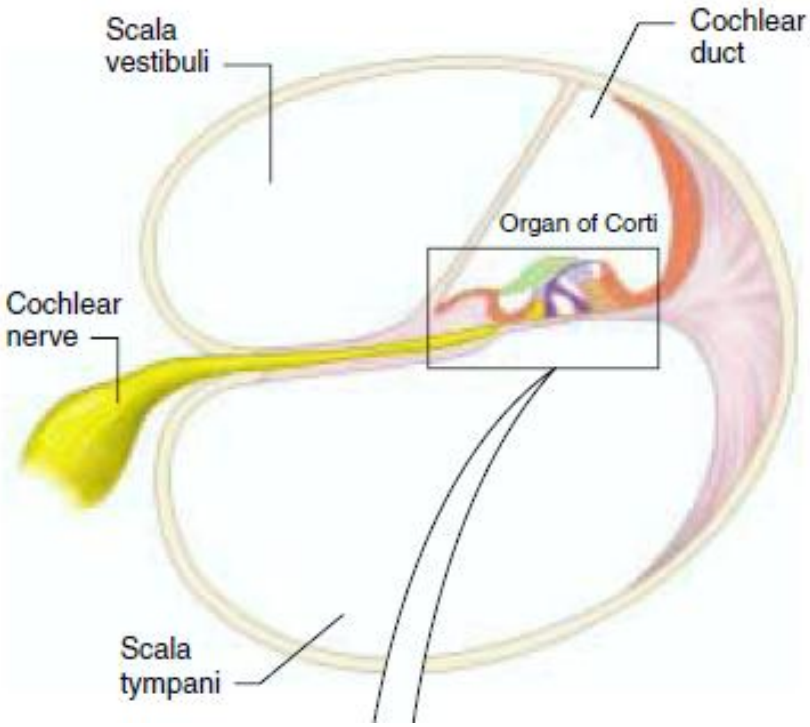
Vestibular Apparatus

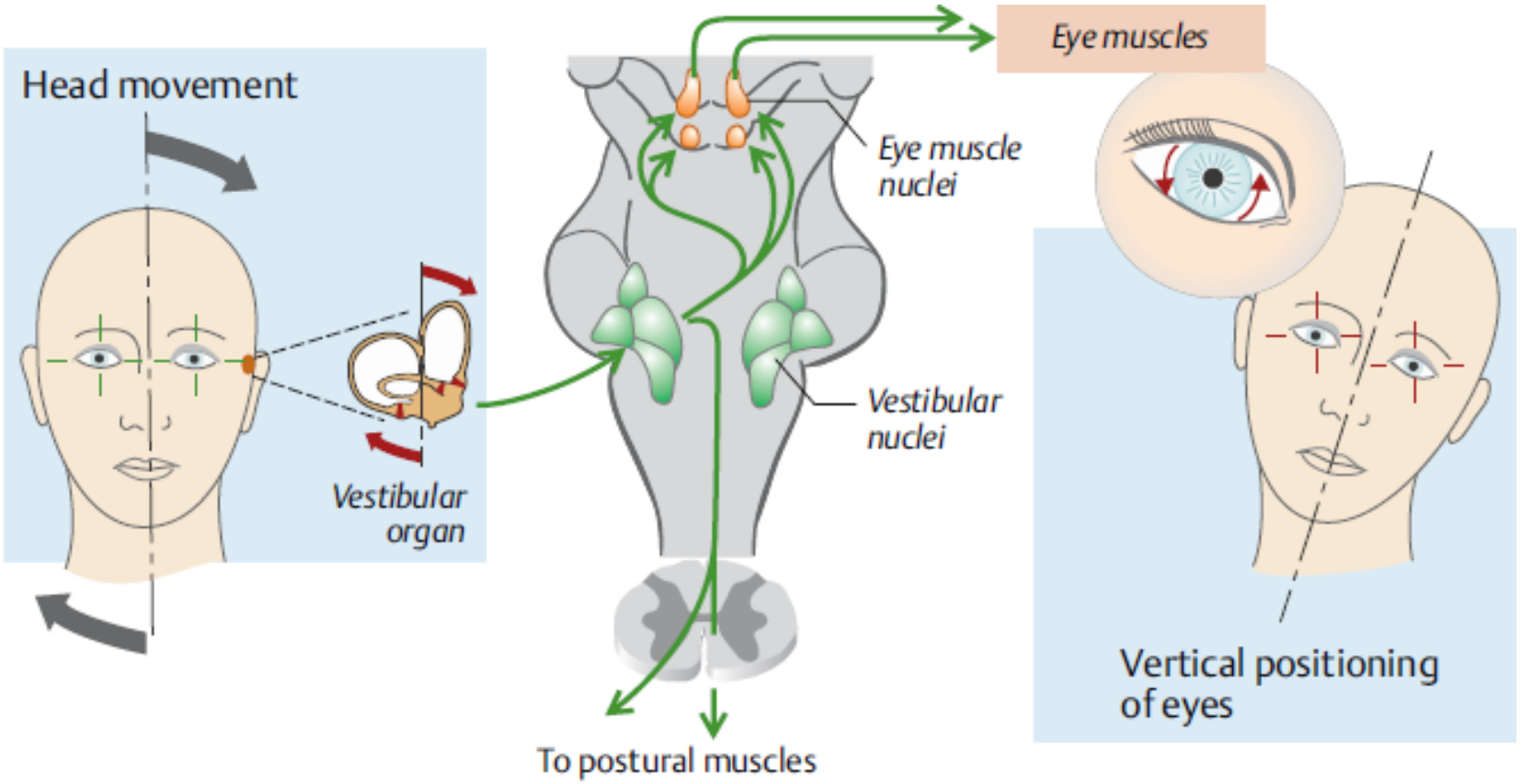


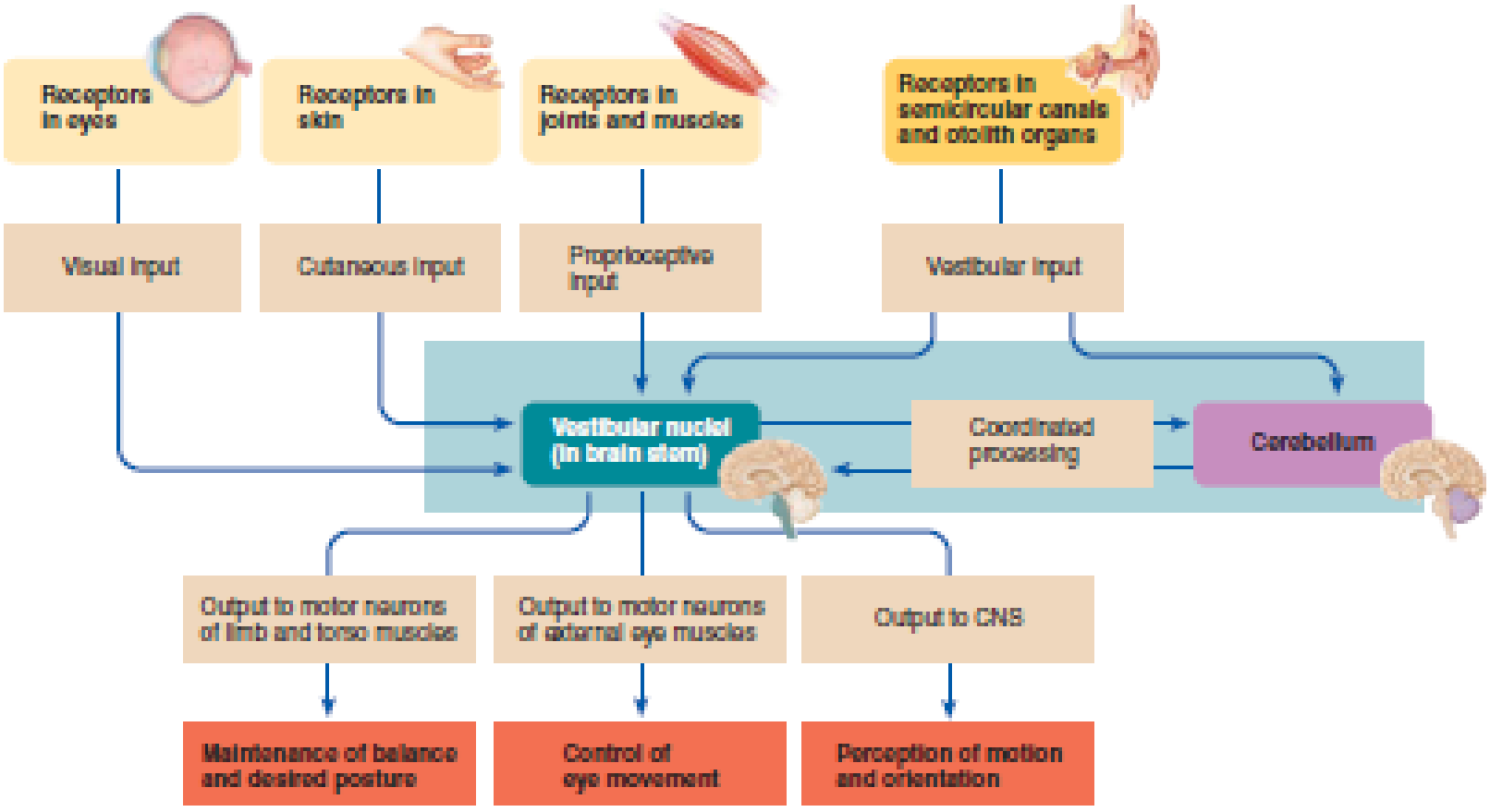
MEMBRANOUS LABYRINTH



CRISTA AMPULLARIS AND MACULA




Head movement
Vestibular organ
Eye muscles
Eye muscle nuclei
Vestibular nuclei
To postural muscles
Vertical positioning of eyes


Receptors in eyes
Receptors in skin
Receptors in joints and muscles
Receptors in semicircular canals and otolith organs
Visual input
Cutaneous input
Proprioceptive input
Vestibular input
Vestibular nuclei (in brain stem)
Coordinated processing
Cerebellum
Output to motor neurons of limb and torso muscles
Output to motor neurons of external eye muscles
Output to CNS
Maintenance of balance and desired posture
Control of eye movement
Perception of motion and orientation

Sleep

- Consciousness
- Stages of consciousness

1- Maximum alertness

2- Wakefullness

3- Sleep (Several different types)

4- Coma

- Sleep-wake cycle
- Sleep is an active process of unconsciousness from which the person can be aroused by sensory or other stimuli

Types

- Slow wave sleep
- Paradoxical sleep or rapid eye movement sleep (REM

Slow wave sleep

Duration (30-45 minutes)

→ most sleep during each night

→ deep restful sleep

→ physical changes

Decrease peripheral vascular tone

Decrease blood pressure

Decrease respiratory rate

Decrease BMR

Stages of slow wave sleep

- Four stages
- **Stage 1**

→when person becomes drowsy and begins to sleep

→lasting only a few minutes

→eyes make slow rolling movements

→EEG becomes less regular

→one is most easily awakened

- **Stage 2**

→slightly deeper

→may last for 5-15 min.

→eye movements almost cease

→EEG: sleep spindle

- **Stage 3**

→eye and body movements are absent

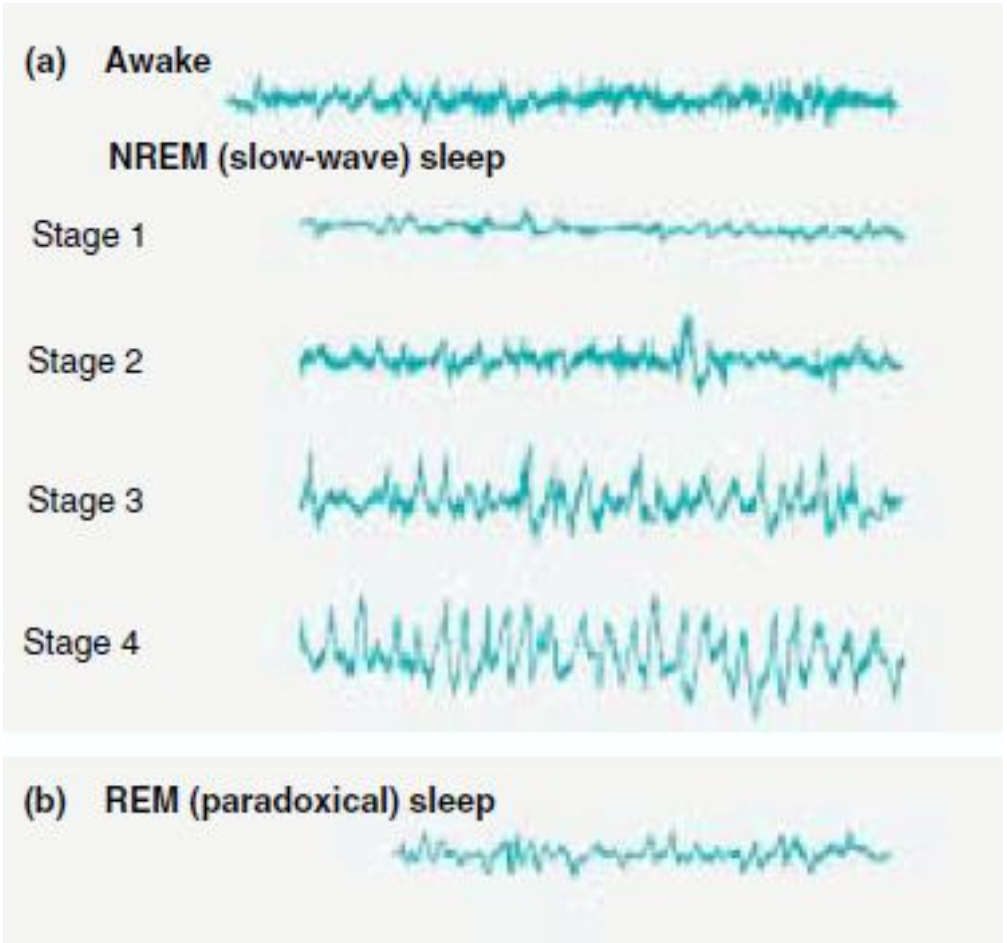
→EEG: frequency of brain waves becomes progressively slower

- **Stage 4**

→deepest stage of sleep

→EEG: delta waves

Children have more total sleep time and stage 4 sleep than adults


(a) Awake
NREM (slow-wave) sleep
Stage 1
Stage 2
Stage 3
Stage 4
(b) REM (paradoxical) sleep

REM Sleep

- Duration (10-15-minutes)
- Associated with active dreaming and active eye muscle movements
- Muscle tone throughout the body is depressed
- Heart rate and respiratory rate usually becomes irregular
- Brain is highly active in REM sleep and EEG shows a pattern of brain waves similar to those that occur during wakefulness

	TYPE OF SLEEP	
Characteristic	**Slow-Wave Sleep**	**Paradoxical Sleep**
EEG	Displays slow waves	Similar to EEG of alert, awake person
Motor Activity	Considerable muscle tone; frequent shifting	Abrupt inhibition of muscle tone; no movement
Heart Rate, Respiratory Rate, Blood Pressure	Minor reductions	Irregular
Dreaming	Rare (mental activity is extension of waking-time thoughts)	Common
Arousal	Sleeper easily awakened	Sleeper hard to arouse but apt to wake up spontaneously
Percentage of Sleeping Time	80%	20%
Other Important Characteristics	Has four stages; sleeper must pass through this type of sleep first	Rapid eye movements

Theories of Sleep

- The sleep wave-wake cycle is controlled by interaction among three neural systems

1-Arousal system

2-Slow-wave sleep centre

3-Paradoxical sleep centre

- The function of sleep is unclear
- Narcolepsy