PHYSIOLOGY OF CONCIOUSNESS

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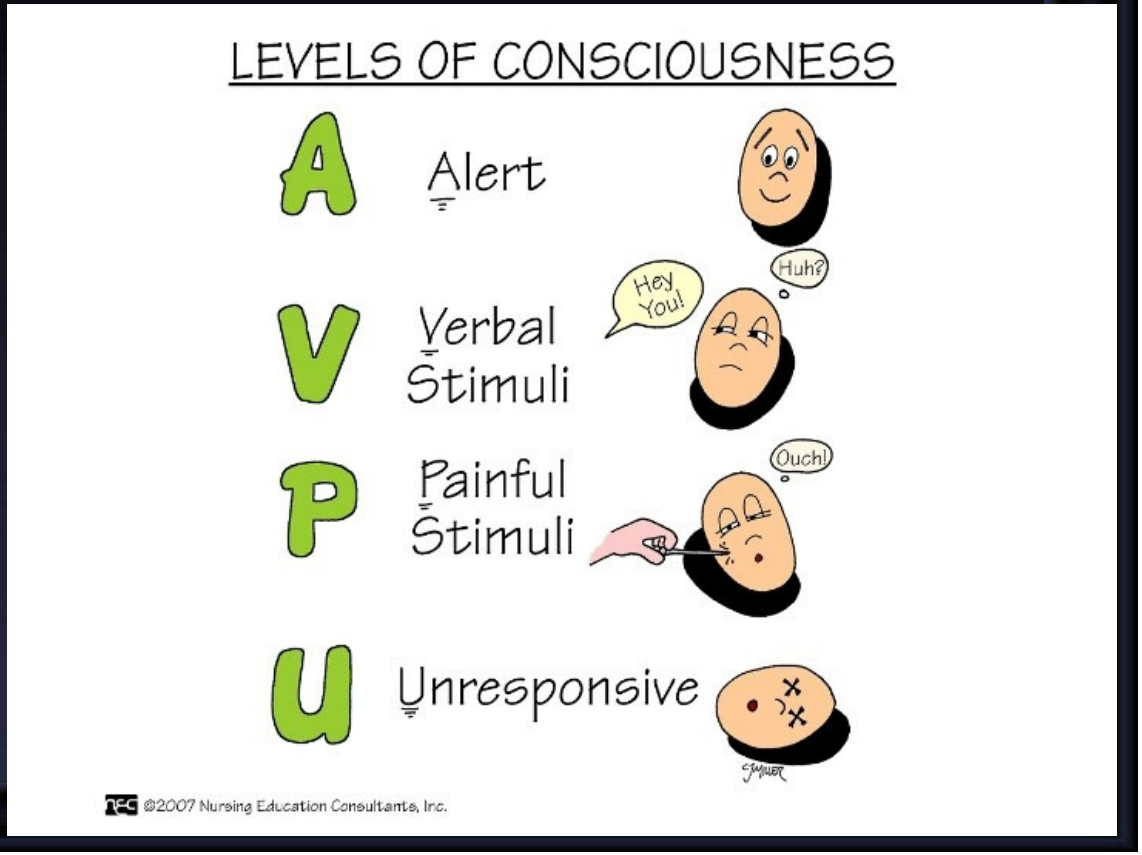


OBJECTIVES

At the end of this lecture the student should be able to :

- **(1) define consciousness and explain the different states of consciousness .**
- **(2) explain what is meant by the " Reticular Activating System "(RAS)**
- **(3) define the location and function of the Bulboreticular Facilitatory Area .**
- **(4) describe how the interaction between the Bulboreticular Facilitatory Area , Thalamus and Cerebral Cortex subserves & sustains consciousness**

OBJECTIVES

At the end of this lecture the student should be able to :

- **(5) explain how a medical person can differentiate between a conscious and unconscious person by means of outward behavior as and physical signs .**
- **(6) describe the role of EEG and evoked potentials in differentiating between a conscious person , a sleeping person , a comatose patient and brain dead patient .**

What is Consciousness?

- Consciousness has been defined by psychologists as our awareness of ourselves and our environment.
- Two awake states: **relaxed awareness** and awareness with **concentrated attention**
  For example : driving (Ganong 24th Ed)

Normal Consciousness	Clouded Consciousness	Coma	Sleep

'Subjective awareness of external world and self, including awareness of the private inner world of one's own mind'

4 Levels of consciousness

- **(1) Normal Consciousness:** state of normal arousal , being fully awake and aware of the self and surroundings
- **(2) Clouded consciousness:** person conscious but mentally confused e.g., in cases of drug or alcohol intoxication, High fever associated (malaria or septicemia , dementia , etc) .
- **(3) Sleep:** person unconscious in relation to the external world & surroundings but is arousable (can be aroused) .
- **(4) Coma:** person unconscious and not arousable

Levels of awareness in Consciousness

- **TOP: Controlled processes** require attention (and interfere with other functions)
- **MIDDLE: Automatic processes** require minimal attention (such as riding your bike)
- **LOWEST:** Minimal or no awareness of the environment

Controlled processes

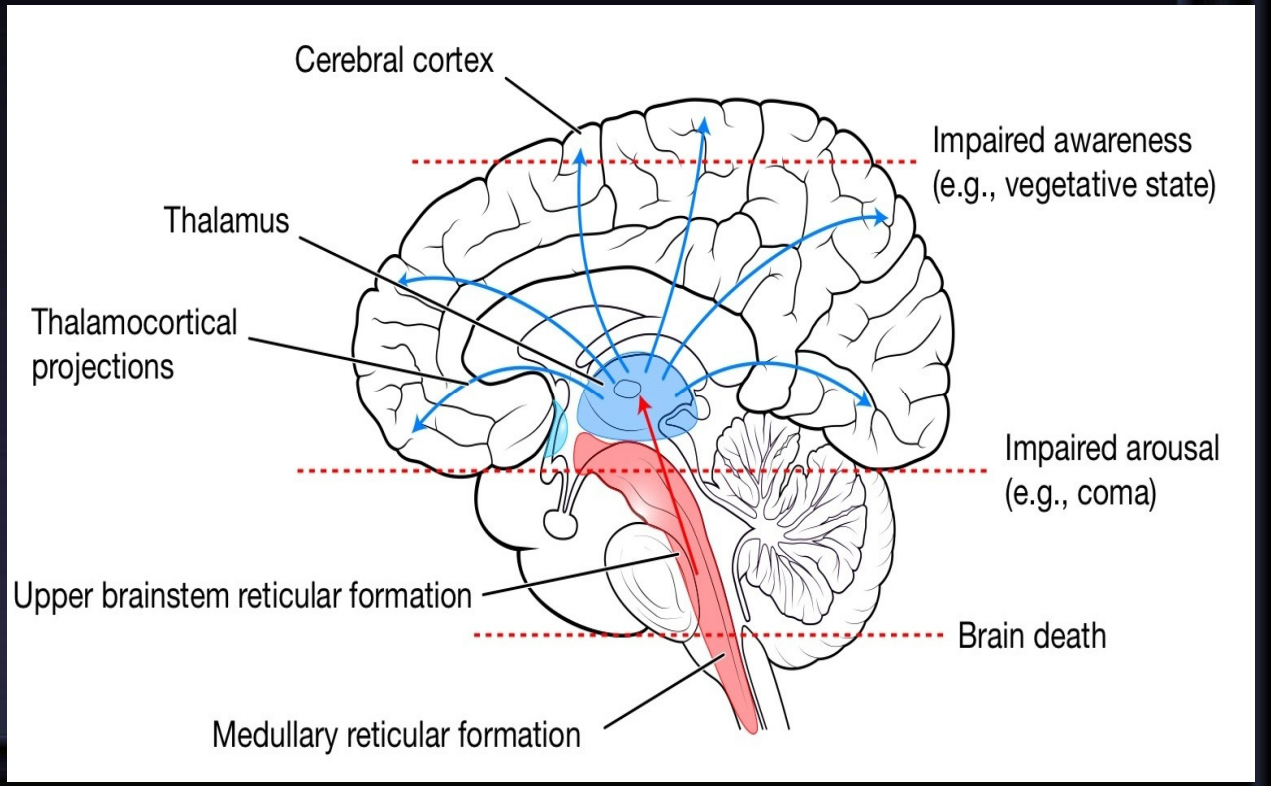
Automatic processes

Daydreaming

Continuum of Consciousness refers to a broad range of experiences , from being sharply alert to being completely unaware and unresponsive.

Brain Structures Involved in Consciousness

- Brain stem Reticular formation
- Thalamus
- Hypothalamus
- Ascending projection pathways
- Wide spread area in the cerebral cortex



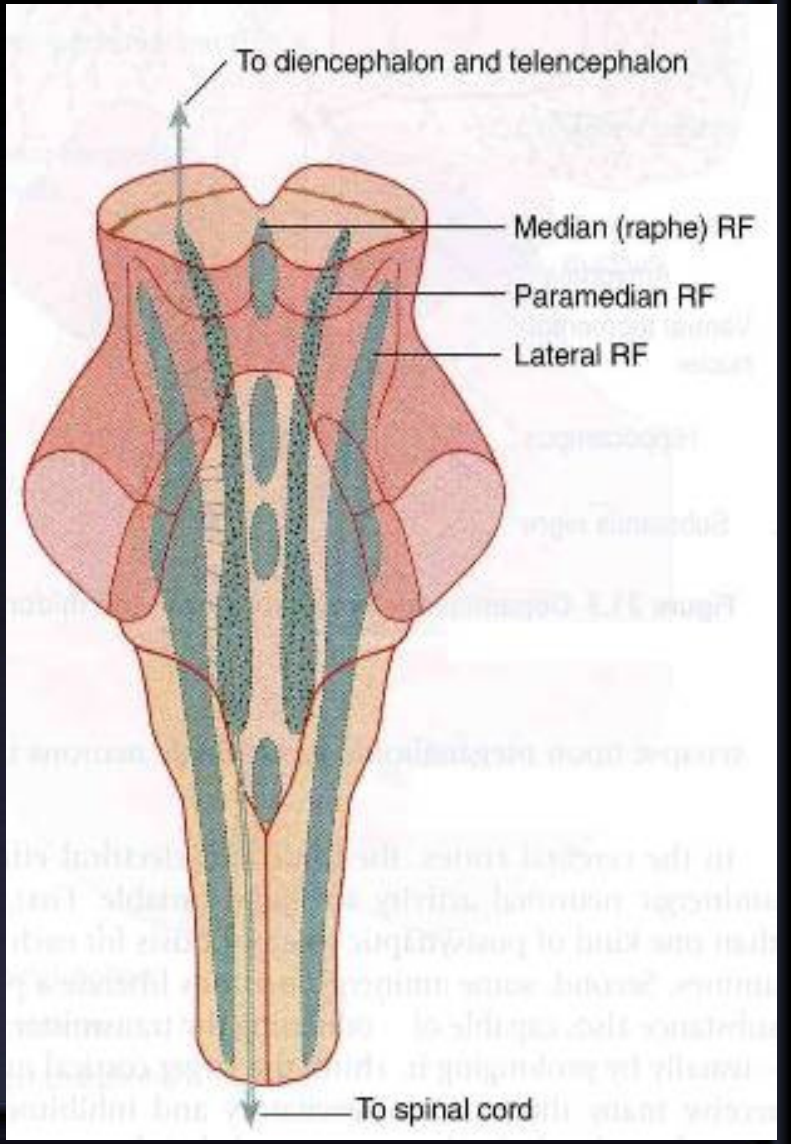
RETICULAR FORMATION

Set of interconnected nuclei that are located throughout the brainstem (Pons, Midbrain, Upper medulla) and the thalamus

- **Role in behavioral arousal**
- **Role in consciousness (sleep/awake cycle)**

Consists of 3 parts:

- Lateral Reticular Formation
- Paramedian Reticular Formation
- Raphe nuclei (Median RF)



Lateral RF Receives…….

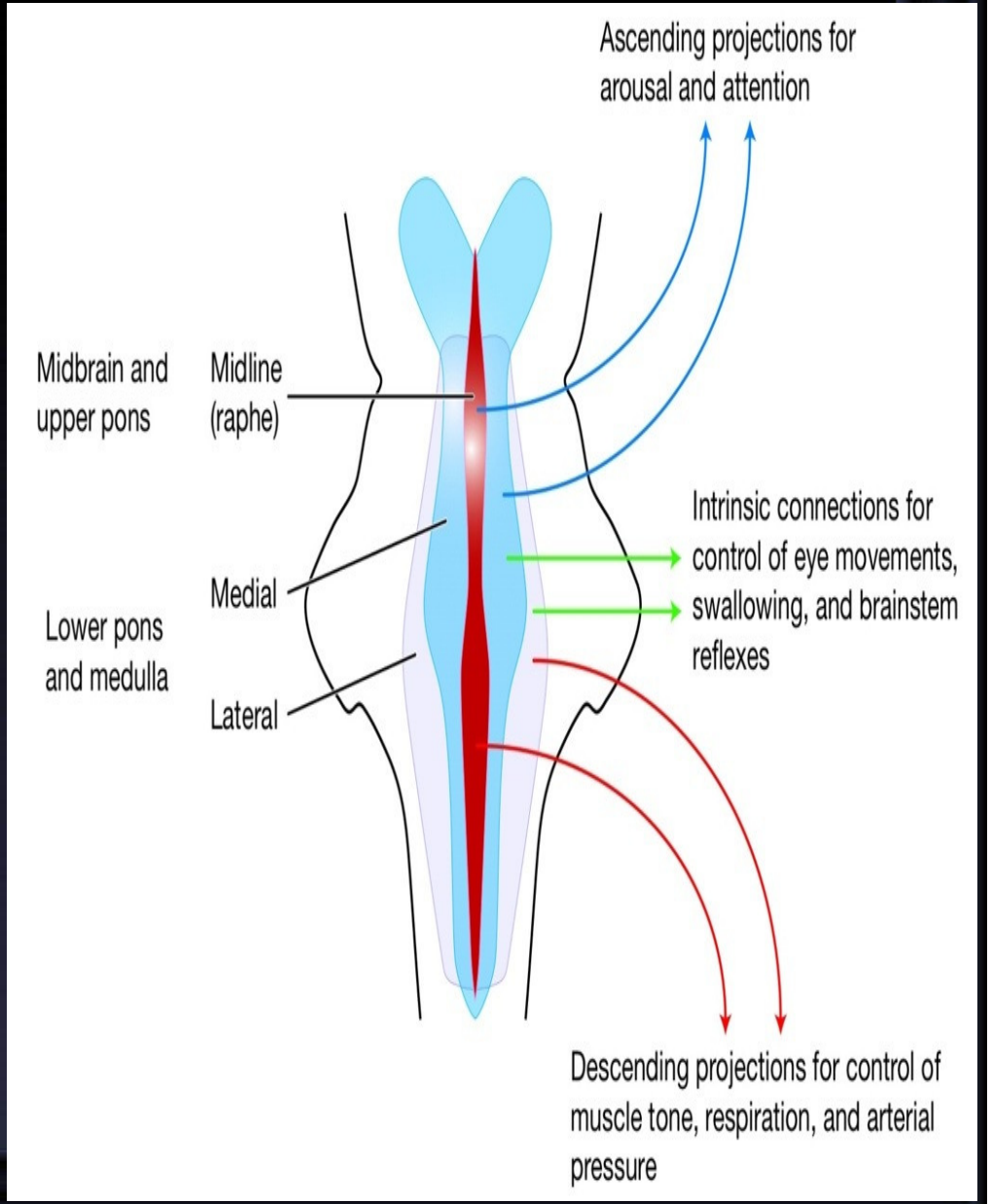
Information from ascending tracts for touch and pain.

Vestibular information from median vestibular nerve.

Auditory information from superior olivary nucleus.

Visual information from superior colliculus.

Olfactory information via medial forebrain bundle

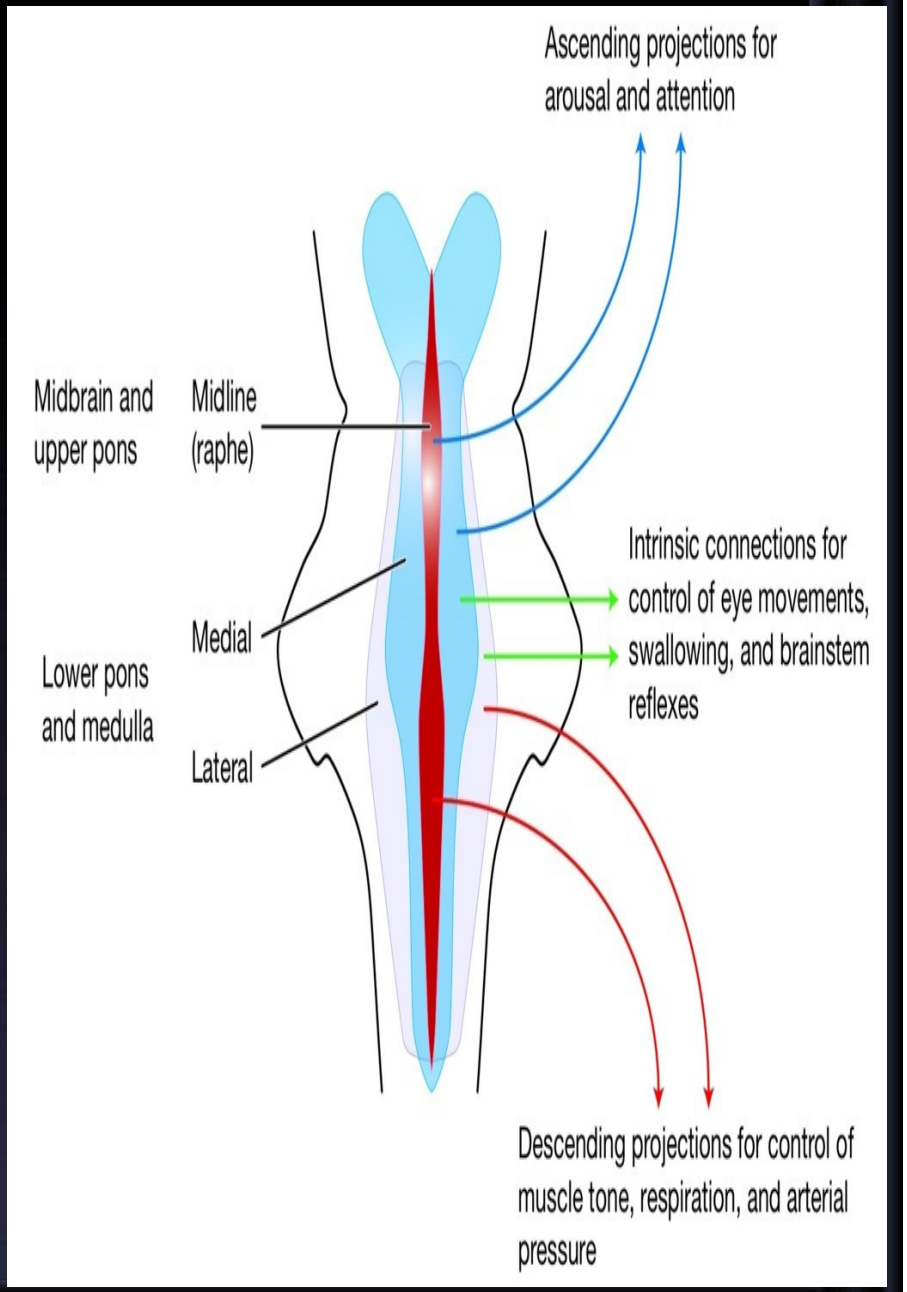


Paramedian RF

- ❖Receives signals from lateral reticular formation
- ❖Noradrenergic neurones & projects onto cerebral hemispheres.
- ❖Ventral tegmentum dopaminergic neurones that project directly onto the cortex.
- ❖Cholinergic neurones project onto the thalamus

Raphe nuclei (Median RF)

Contain serotonergic projections to the brain and spinal cord.



Functions of reticular formation

1. Somatic motor control: Reticulospinal tracts

2. Cardiovascular control: Through cardiac and vasomotor centers of the medulla oblongata.

3. Pain modulation : Pain signals from the lower body >> >> RF >> >> cerebral cortex

RF is origin of the descending analgesic pathways

(act in the spinal cord to block the transmission of some pain signals to the brain)

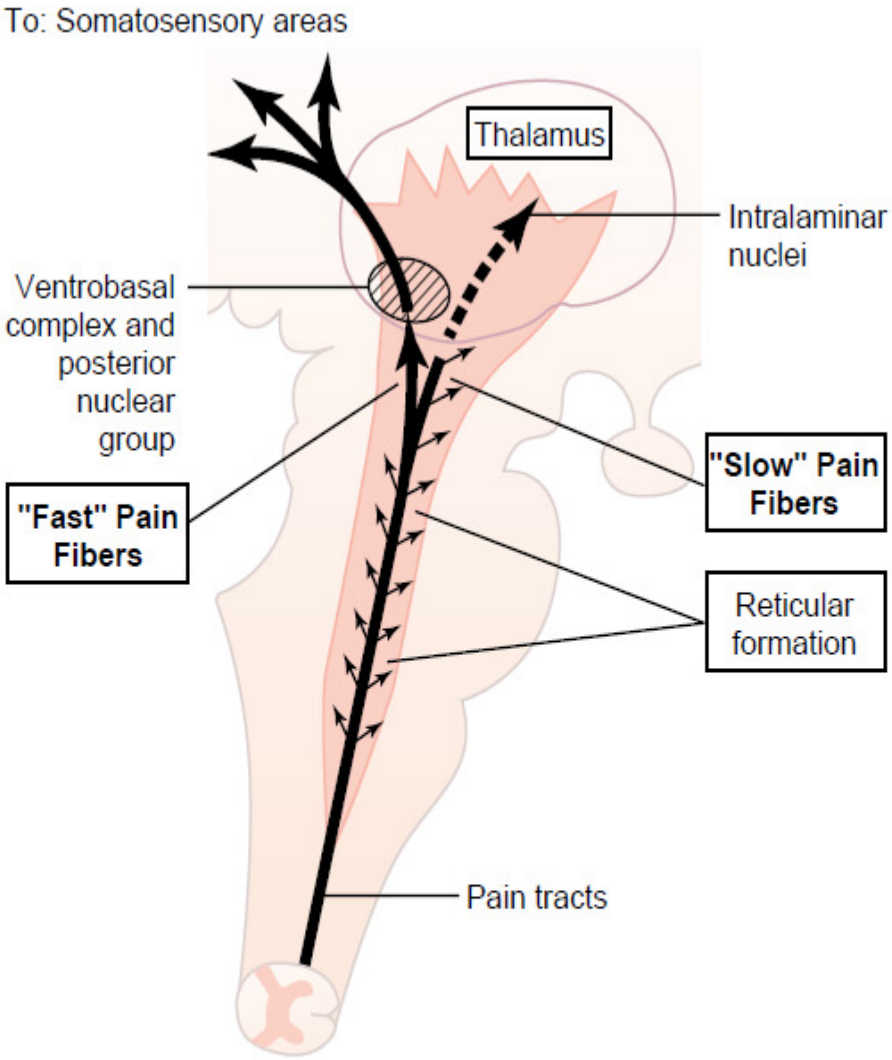


Figure 48–3

Transmission of pain signals into the brain stem, thalamus, and cerebral cortex by way of the *fast pricking pain pathway* and the *slow burning pain pathway.*

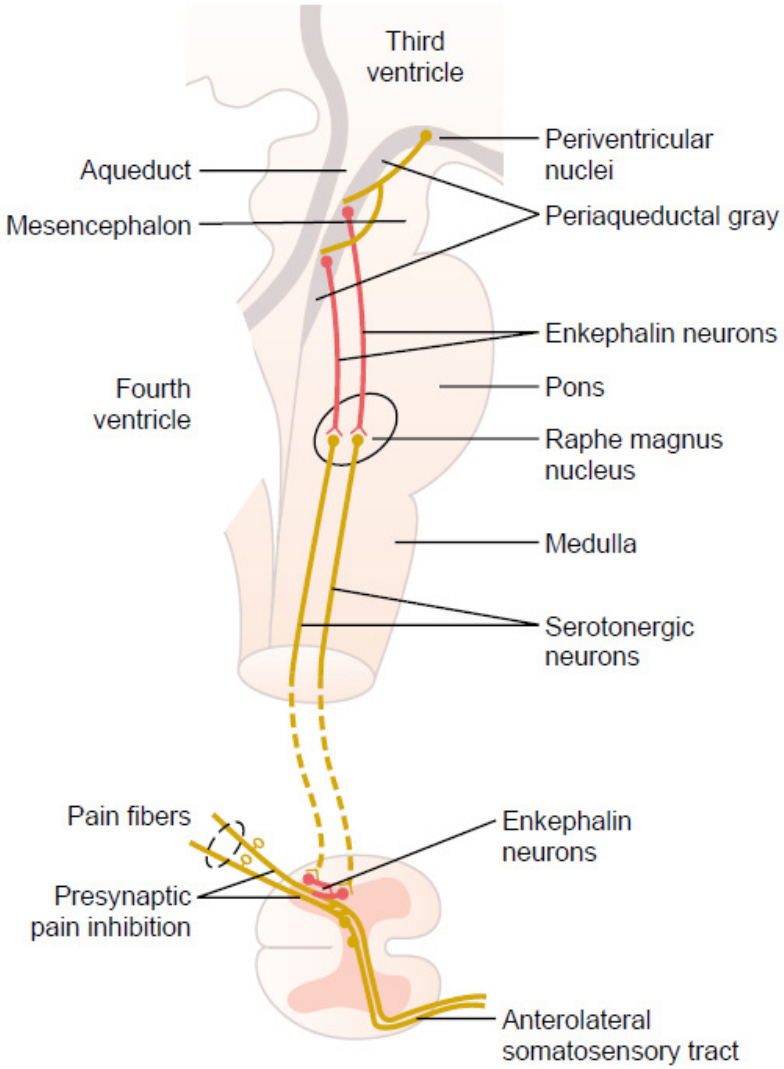


Figure 48–4

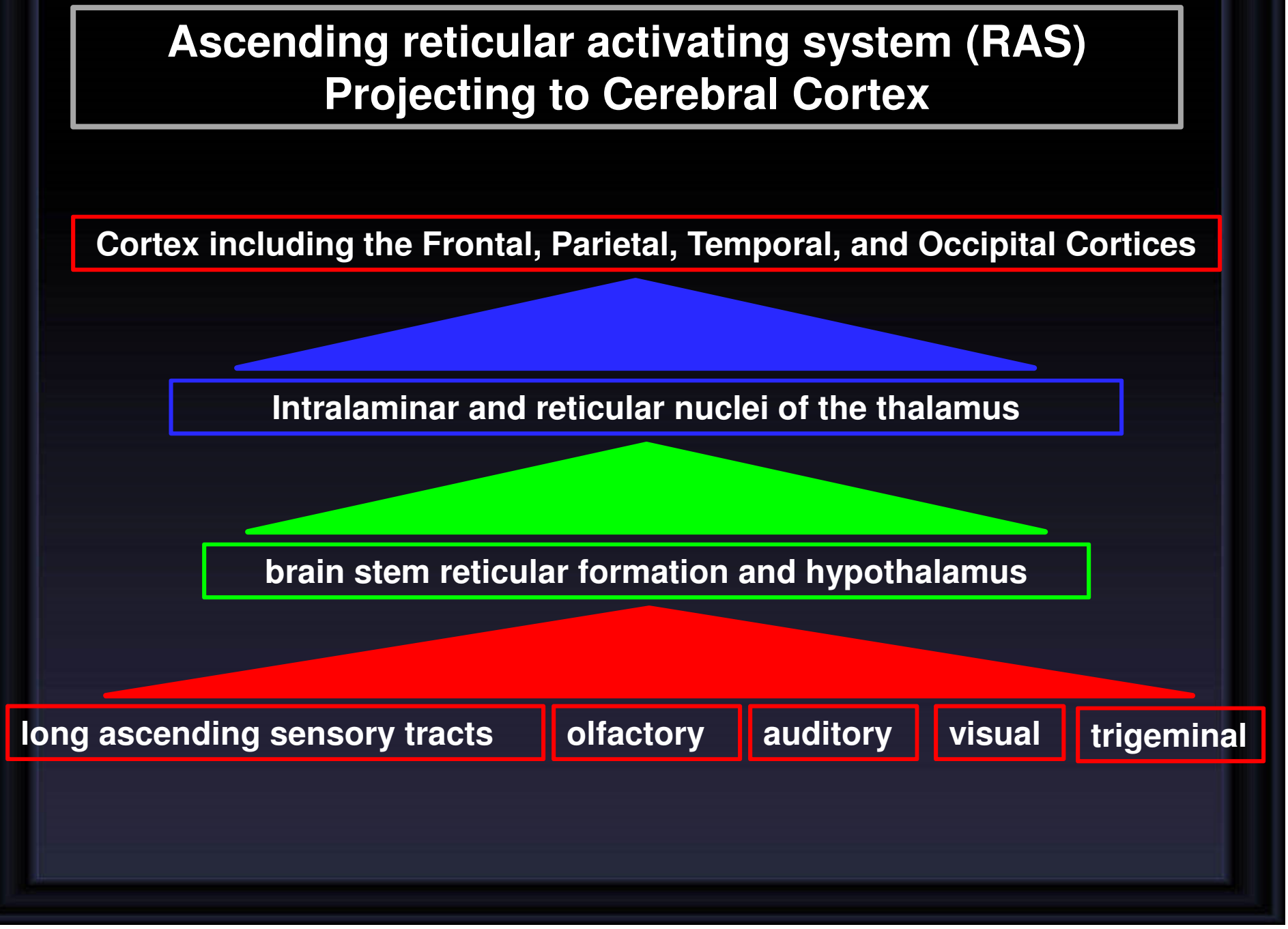
Analgesia system of the brain and spinal cord, showing (1) inhibition of incoming pain signals at the cord level and (2) presence of *enkephalin-secreting neurons* that suppress pain signals in both the cord and the brain stem.

Thalamus

- Located n the mid-part of the diencephalon
- Cholinergic projections from the thalamus are responsible for:
  - Activation of the cerebral cortex.
  - Regulation of flow of information through other thalamic nuclei to the cortex via projections into reticular nuclei.
  - Tuberomammillary nucleus in the hypothalamus projects to the cortex and is involved in maintaining the awake state.

As a result, individuals with bilateral lesions of thalamic intralaminar nuclei are lethargic or drowsy

Ascending reticular activating system (RAS) Projecting to Cerebral Cortex



ANATOMICAL COMPONENTS OF RAS

RAS circuits originate in the upper brainstem reticular core and project through synaptic relays in the thalamic nuclei to the cerebral cortex

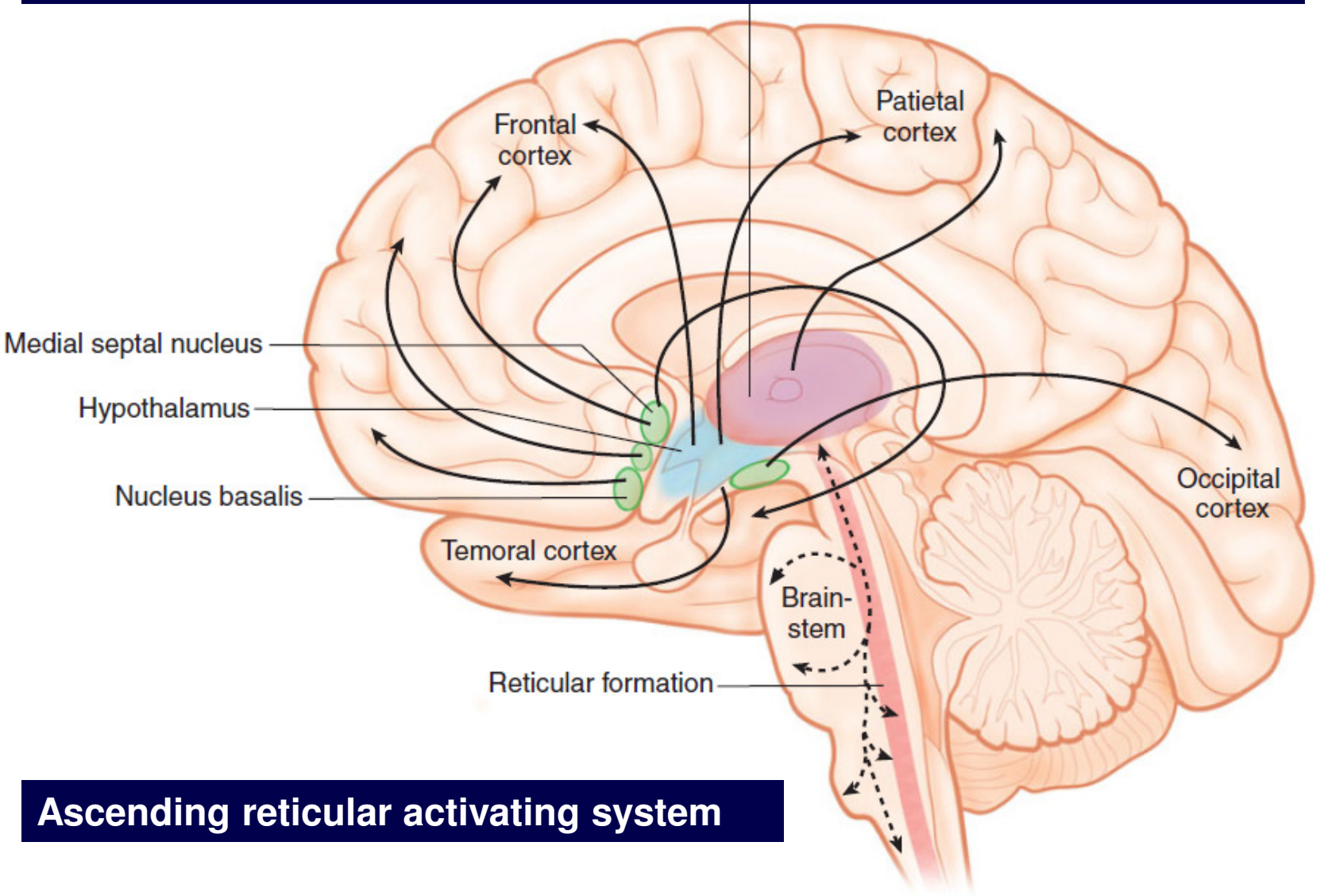
FUNCTIONS OF RAS

1- Regulating sleep-wake transitions: EEG desynchronization (RAS suppress cortical waves) wakefulness and REM sleep

2-Attention: mediate transitions from relaxed wakefulness to of high attention

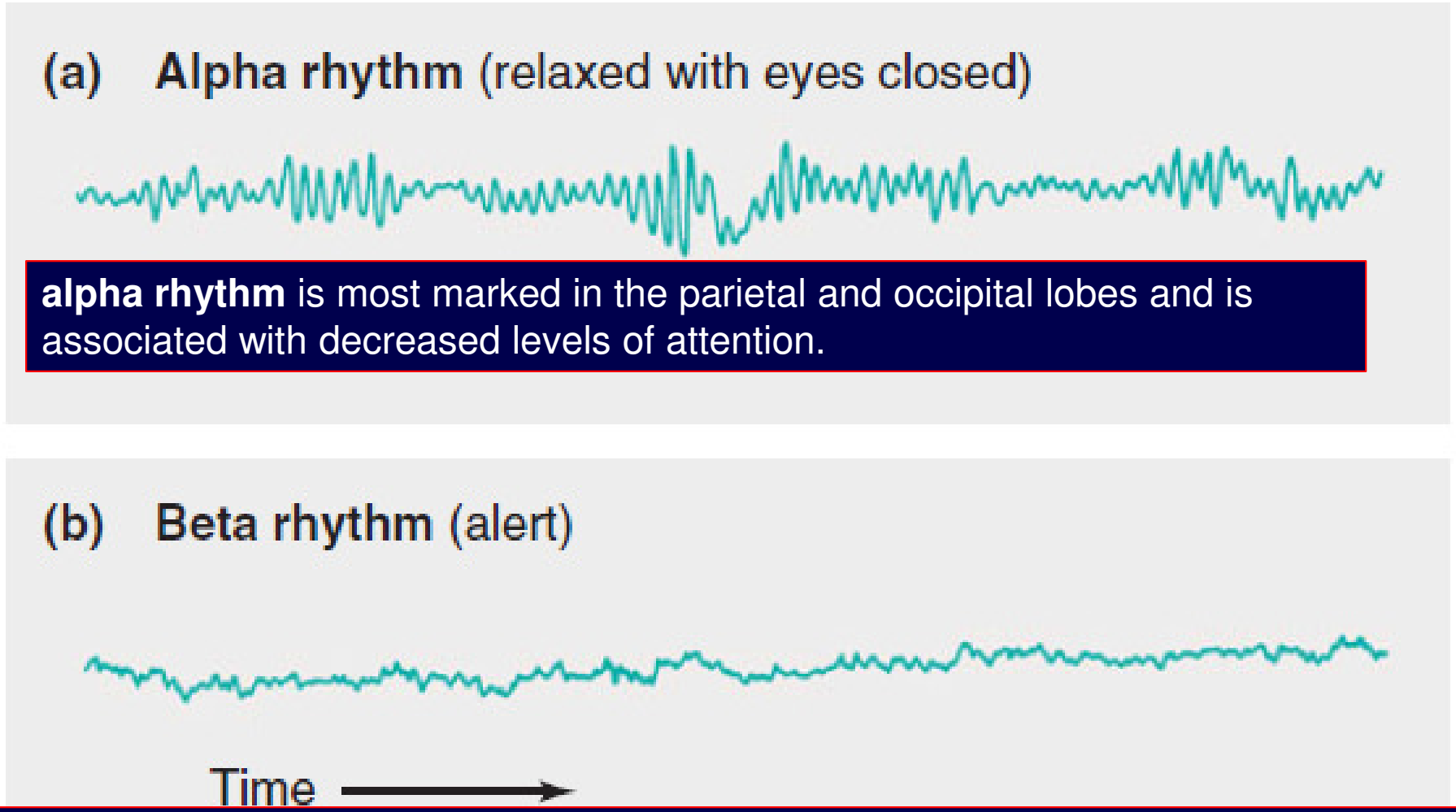
3-Learning: involved in learning, memory, self-control or inhibition and motivation

The system is nonspecific, whereas the classic ascending sensory pathways are specific for different modalities



Ascending reticular activating system

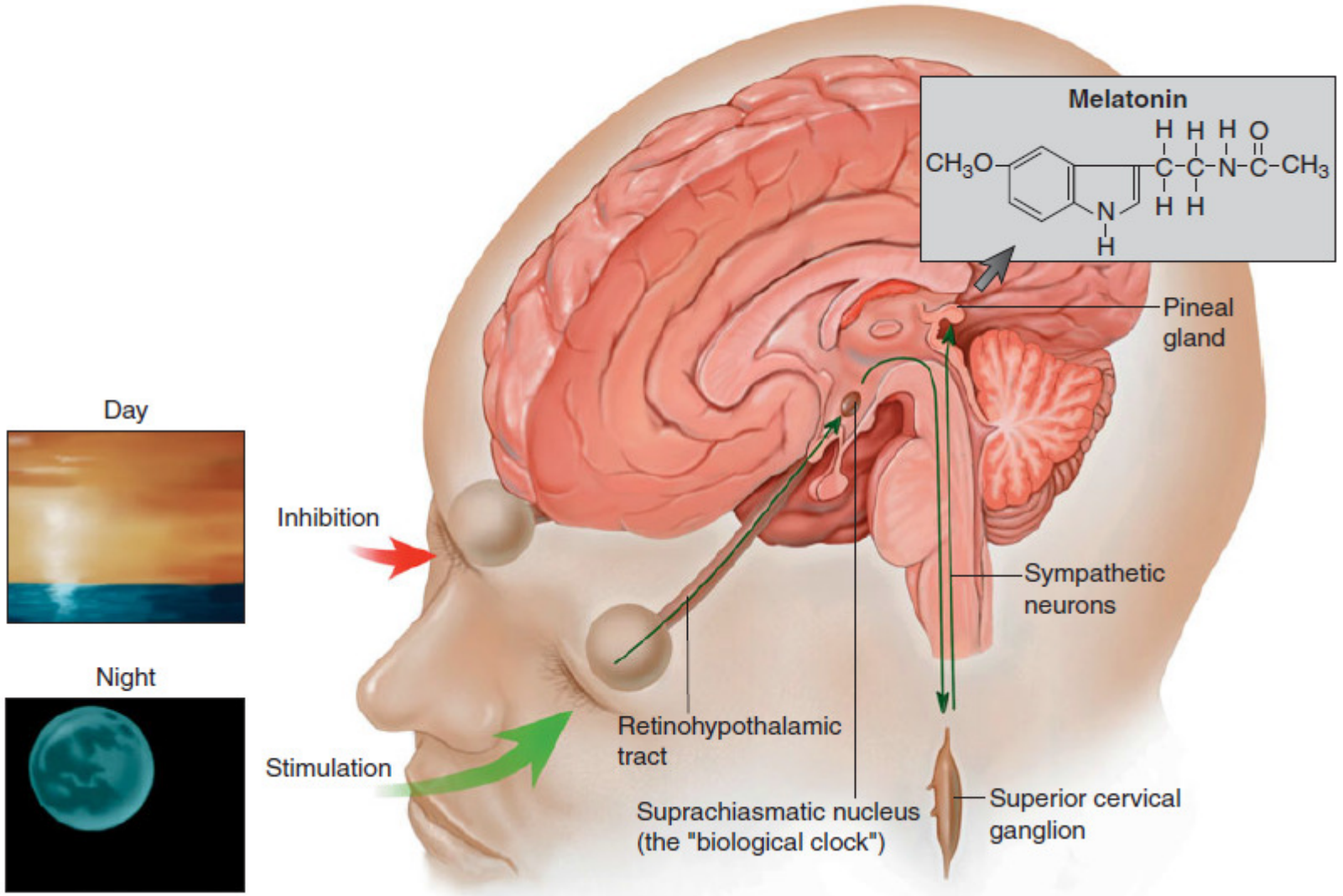
EEG records showing the alpha and beta rhythms. When attention is focused on something, the 8–13 Hz alpha rhythm is replaced by an irregular 13–30 Hz low-voltage activity, the beta rhythm. This phenomenon is referred to as alpha block, arousal, or the alerting response.



alpha rhythm is most marked in the parietal and occipital lobes and is associated with decreased levels of attention.

beta rhythm can be produced by any form of sensory stimulation or mental concentration, such as solving arithmetic problems.

The diurnal change of Melatonin in light–dark cycle.
↑during the dark period of the day and ↓during daylight hours



MT 1 receptors inhibiting adenylyl cyclase and resulting in sleepiness.
MT 2 receptors stimulate phosphoinositide hydrolysis for light–dark cycle.

Four Neurohormonal Systems in the Human Brain stem

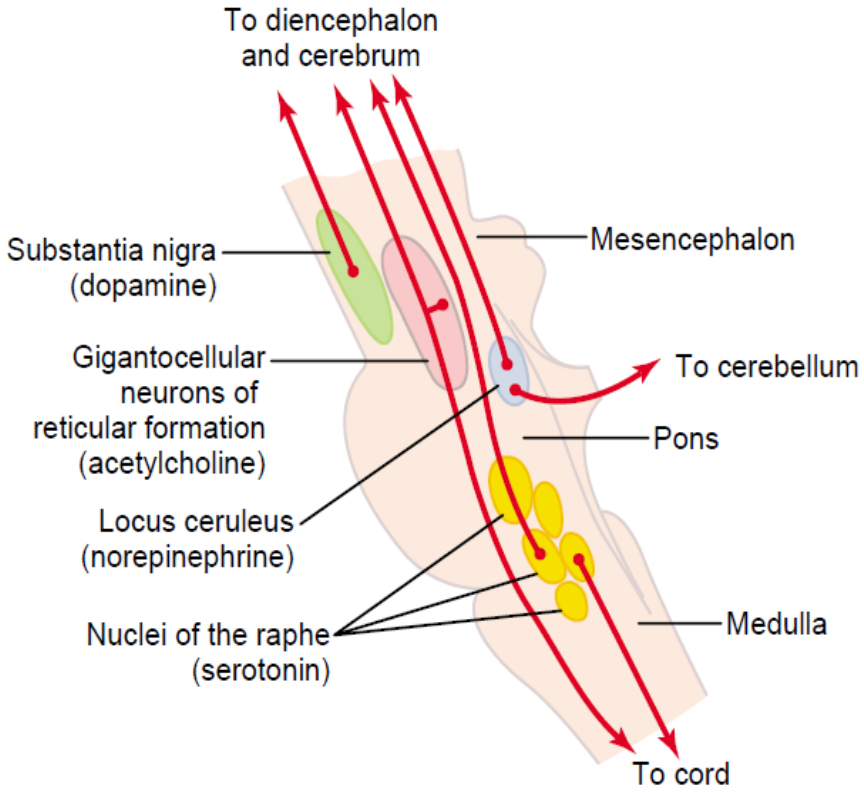


Figure 58–3

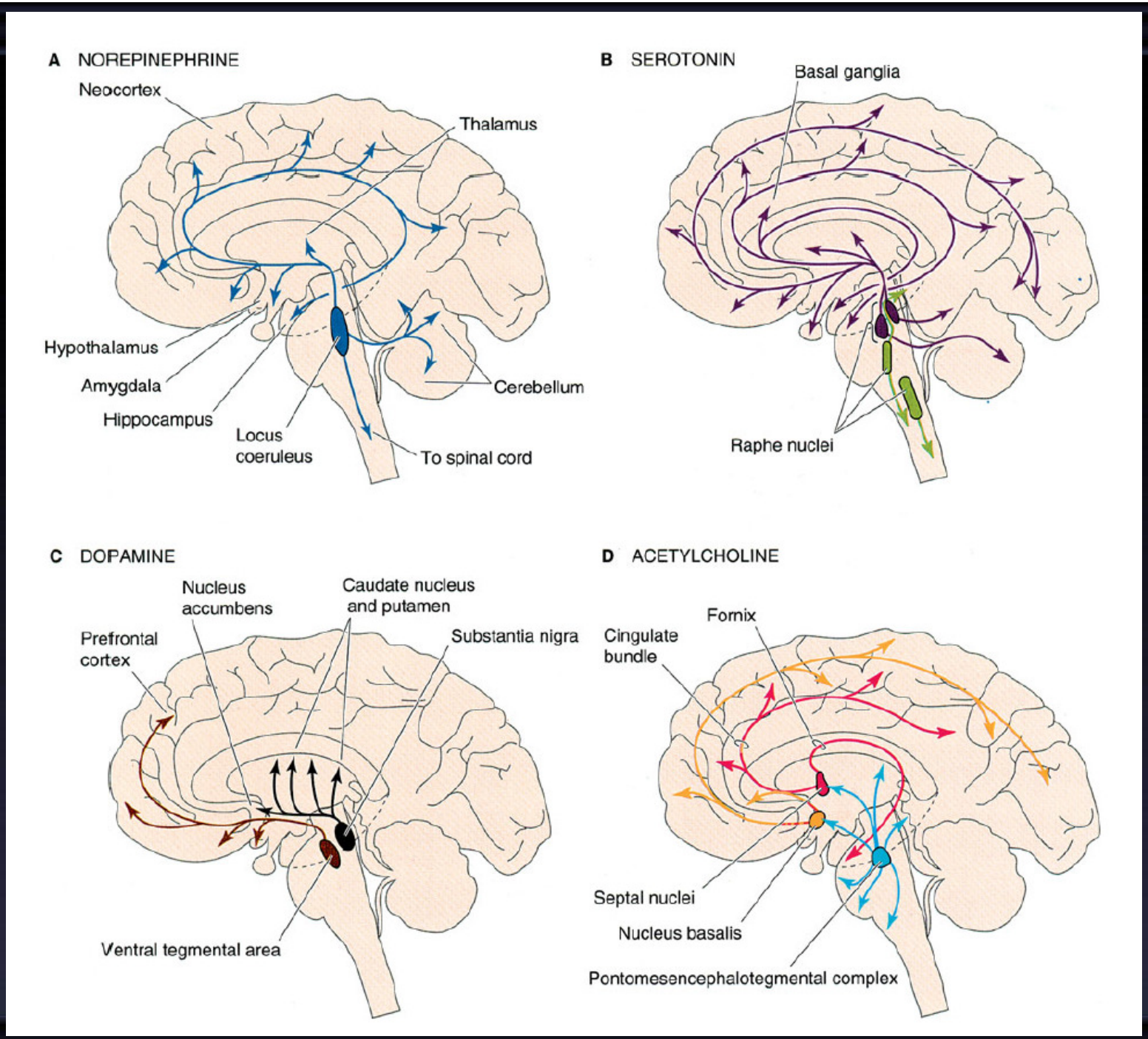
Multiple centers in the brain stem, the neurons of which secrete different transmitter substances (specified in parentheses). These neurons send control signals upward into the diencephalon and cerebrum and downward into the spinal cord.

1. *The locus ceruleus and the norepinephrine system. important role in causing dreaming, eading to REM sleep.*

2. *The substantia nigra and the dopamine system control movements (Parkinson's D)*

3. *The raphe nuclei and the serotonin system. At Cord supress pain and in higher centers related to normal sleep wake cycle*

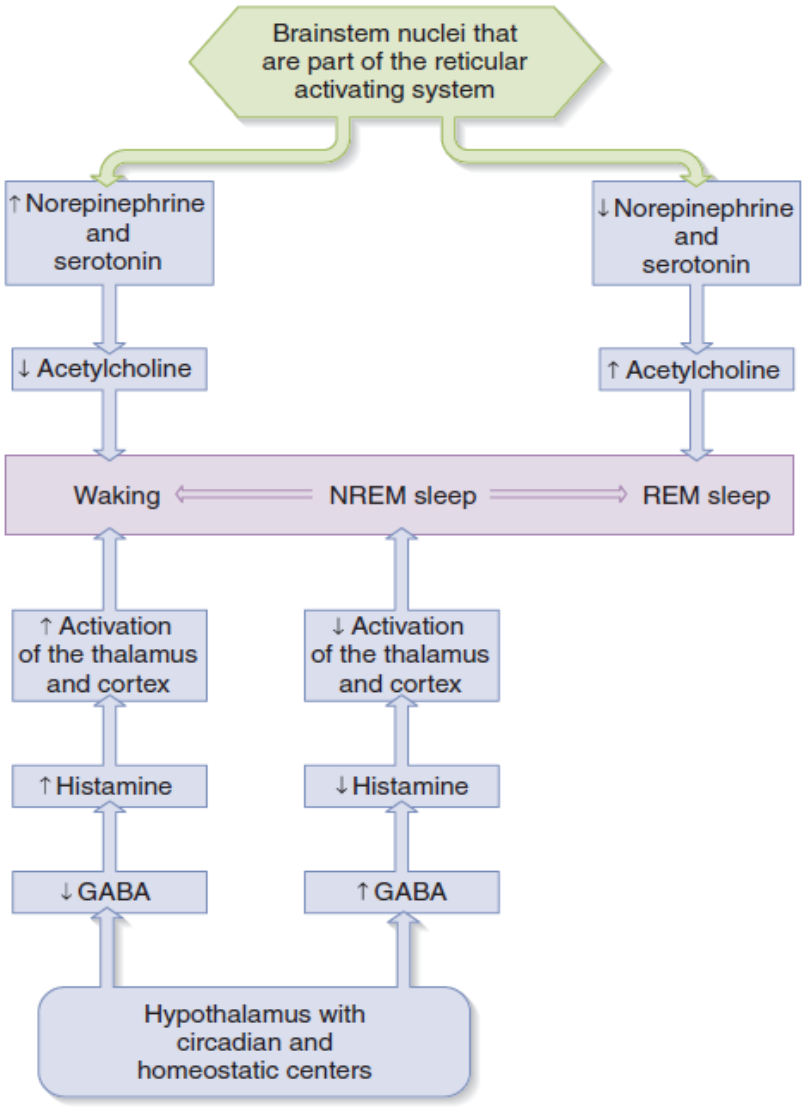
4. *The gigantocellular neurons of the reticular excitatory area and the acetylcholine system.*
Activation of these acetylcholine neurons leads to an acutely awake and excited nervous system.


A NORepinephrine
Neocortex
Thalamus
Hypothalamus
Amygdala
Hippocampus
Locus coeruleus
Cerebellum
To spinal cord
B SEROTONIN
Basal ganglia
Raphe nuclei
C DOPAMINE
Nucleus accumbens
Caudate nucleus and putamen
Prefrontal cortex
Substantia nigra
Ventral tegmental area
D ACETYLCHOLINE
Fornix
Cingulate bundle
Septal nuclei
Nucleus basalis
Pontomesencephalotegmental complex

Alternating activity of brain stem and hypothalamic neurons influence different states of consciousness

Wakefulness and REM sleep are at opposite extremes.

- When the activity of norepinephrine- and serotonergic neurons (locus coeruleus and raphe nuclei) is ↑, there is ↓ activity in acetylcholine neurons in the pontine reticular formation leading to wakefulness.
- The reverse of this pattern leads to REM sleep.
- In NREM sleep ↑ in GABA and ↓ in histamine promote NREM sleep via deactivation of the thalamus and cortex. Wakefulness occurs when GABA is ↓ and histamine↑.



- locus coeruleus →norepinephrine
- raphe nuclei → serotonin
- preoptic neurons in the hypothalamus → GABA
- posterior hypothalamus → histamine
- hypothalamic → orexin
- Pontine reticular formation → Acetylcholine

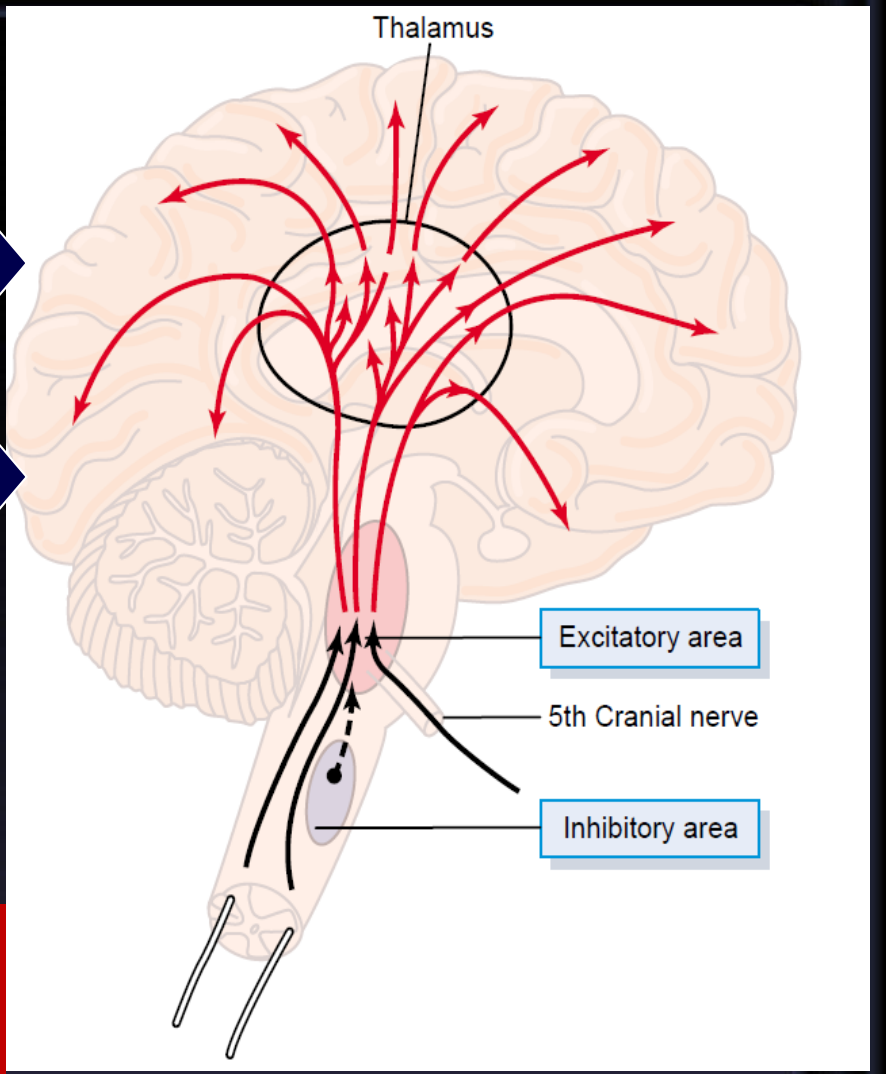
Excitation of the Excitatory Area by Peripheral Sensory Signals.

Cutting the brain stem above the point where the 5th CN enters the pons → coma

Cutting the brain stem below the point of 5th CN entry in pons → averts coma

Positive feedback by Feedback Signals Returning from the Cerebral Cortex in response to projections to cortex leading to an "awake" mind and maintains wakefulness.

A Reticular Inhibitory Area Located in the Lower Brain Stem excite serotonergic neurons to suppress pain and cause sleep



Regularly reverberatory signals back and forth between the thalamus and the cerebral cortex increases thinking

RAS dysfucntion

If RAS is depressed:

- An under-aroused cortex
- Difficulty in learning
- Poor memory
- Little self-control
- lack of consciousness or even coma.

If the RAS is too excited,

- Over aroused cortex
- Hyper-vigilance (sensory sensitivity)
- Touching everything
- Talking too much
- Restless
- Hyperactive.

Indicators of Level of Consciousness

Appearance & Behavior :

Posture (sitting , standing ?)

Open eyes ?

Facial expression ?

Responds to stimuli (including the examiner's questions about name , orientation in time & place ? & other general Qs like who is the president ?)

Vital signs :

Pulse , BP, respiration , pupils , reflexes , particularly brainstem reflexes , etc)

EEG → Each of these states (wakefulness , sleep , coma and death) has specific EEG patterns .

Cortical Evoked potentials: in cases of Brain Death .

Altered States

Altered states of consciousness are achieved when using psychoactive drugs, meditation, hypnosis or lack of sleep.

- **Meditation** refers to a set of techniques that promote a heightened sense of awareness.
  - can involve body movements and posture, focusing of attention on a focal point, or control of breathing
  - can induce relaxation, lower blood pressure, and can be associated with a sense of euphoria
- **Hypnosis** is an altered state of heightened suggestibility. The hypnotic state is characterized by:
  - Narrow and focused attention
  - Imagination
  - Passive receptive attitude
  - Reduced reaction to pain
  - Heightened suggestibility