Neurophysiology

Behavior, motivation and emotions

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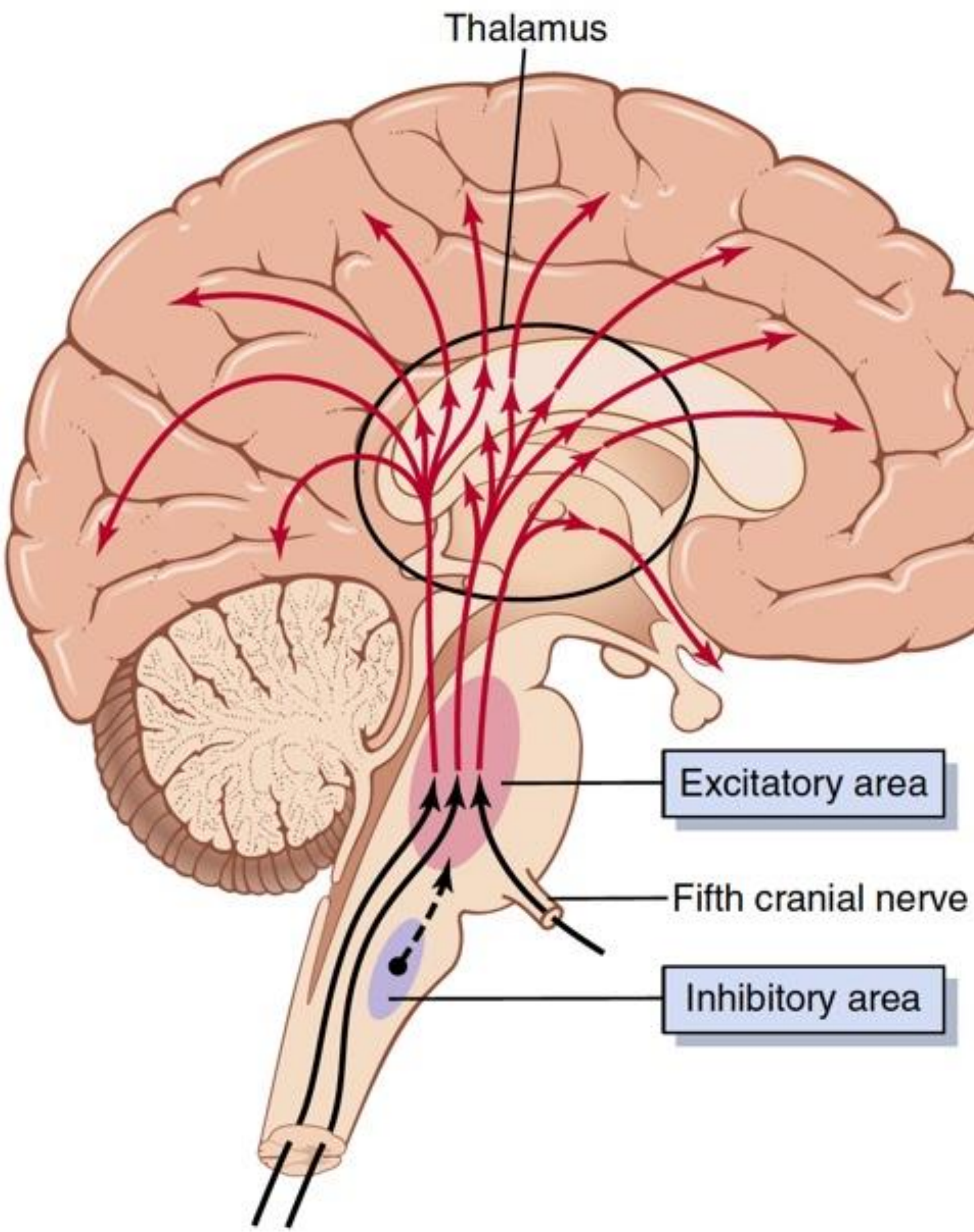
Activating the brain

- Without continuous transmission of nerve signals from the lower brain into the cerebrum, the cerebrum becomes useless.
- Nerve signals in the brain stem activate the cerebrum in two ways:
- (1) by directly stimulating a background level of neuronal activity in wide areas of the brain.
- (2) by activating neurohormonal systems that release specific facilitory or inhibitory hormone-like neurotransmitters into selected areas of the brain.


Thalamus
Excitatory area
Fifth cranial nerve
Inhibitory area

Reticular formation

- The central driving component is an excitatory area located in the reticular substance of the pons and mesencephalon. This area is also called the bulboreticular facilitory area.

- Most of the signals go first to the thalamus, where they excite a different set of neurons that transmit nerve signals to all regions of the cerebral cortex, as well as to multiple subcortical areas.

Reticular formation

- The level of activity of the reticular excitatory area in the brain stem, and therefore the level of activity of the entire brain, is determined to a great extent by the number and type of sensory signals that enter the brain from the periphery.

- Pain signals in particular increase activity in this excitatory area and therefore strongly excite the brain to attention.

Reticular formation

- feedback signals also return from the cerebral cortex back to this same area.
- Therefore, any time the cerebral cortex becomes activated by brain thought processes or by motor processes, signals are sent from the cortex to the brain stem excitatory area, which in turn sends still more excitatory signals to the cortex.
- This process helps to maintain the level of excitation of the cerebral cortex or even to enhance it.

Thalamus

- almost every area of the cerebral cortex connects with its own highly specific area in the thalamus.
- Therefore, electrical stimulation of a specific point in the thalamus generally activates its own specific small region of the cortex.
- Furthermore, signals regularly reverberate back and forth between the thalamus and the cerebral cortex

Reticular formation

- The reticular inhibitory area can inhibit the reticular facilitory area of the upper brain stem and thereby decrease activity in the superior portions of the brain.

- One of the mechanisms for this activity is to excite serotonergic neurons, which in turn secrete the inhibitory serotonin at crucial points in the brain.

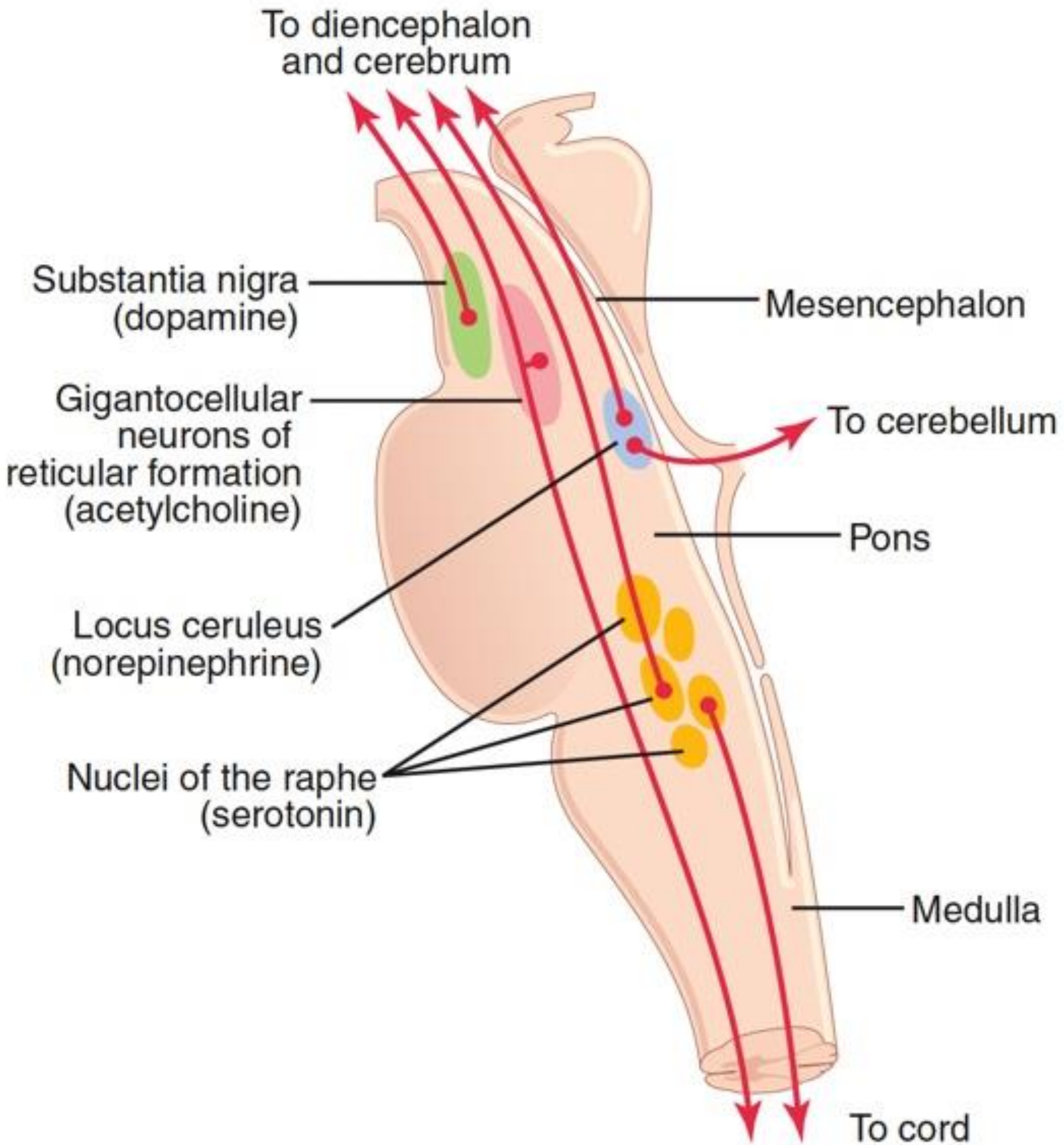
Neurohormonal control of brain activity

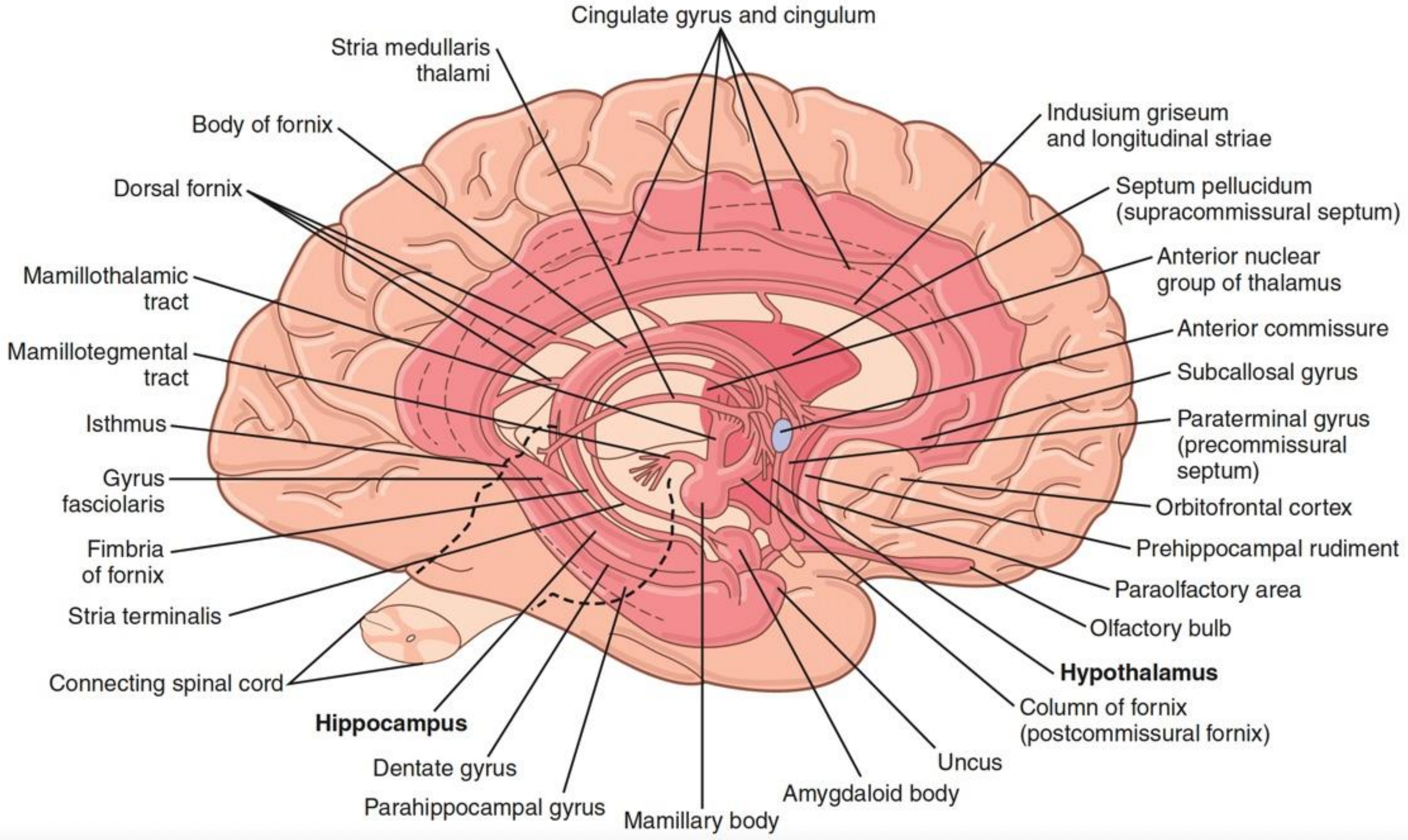
- Often persist for minutes or hours and thereby provide long periods of control.
- These systems have different effects on levels of excitability in different parts of the brain.
- there are multiple neurohormonal systems in the brain, the activation of each of which plays its own role in controlling a different quality of brain function.

Mainly excitatory
wakefulness

Mainly excitatory
dreaming

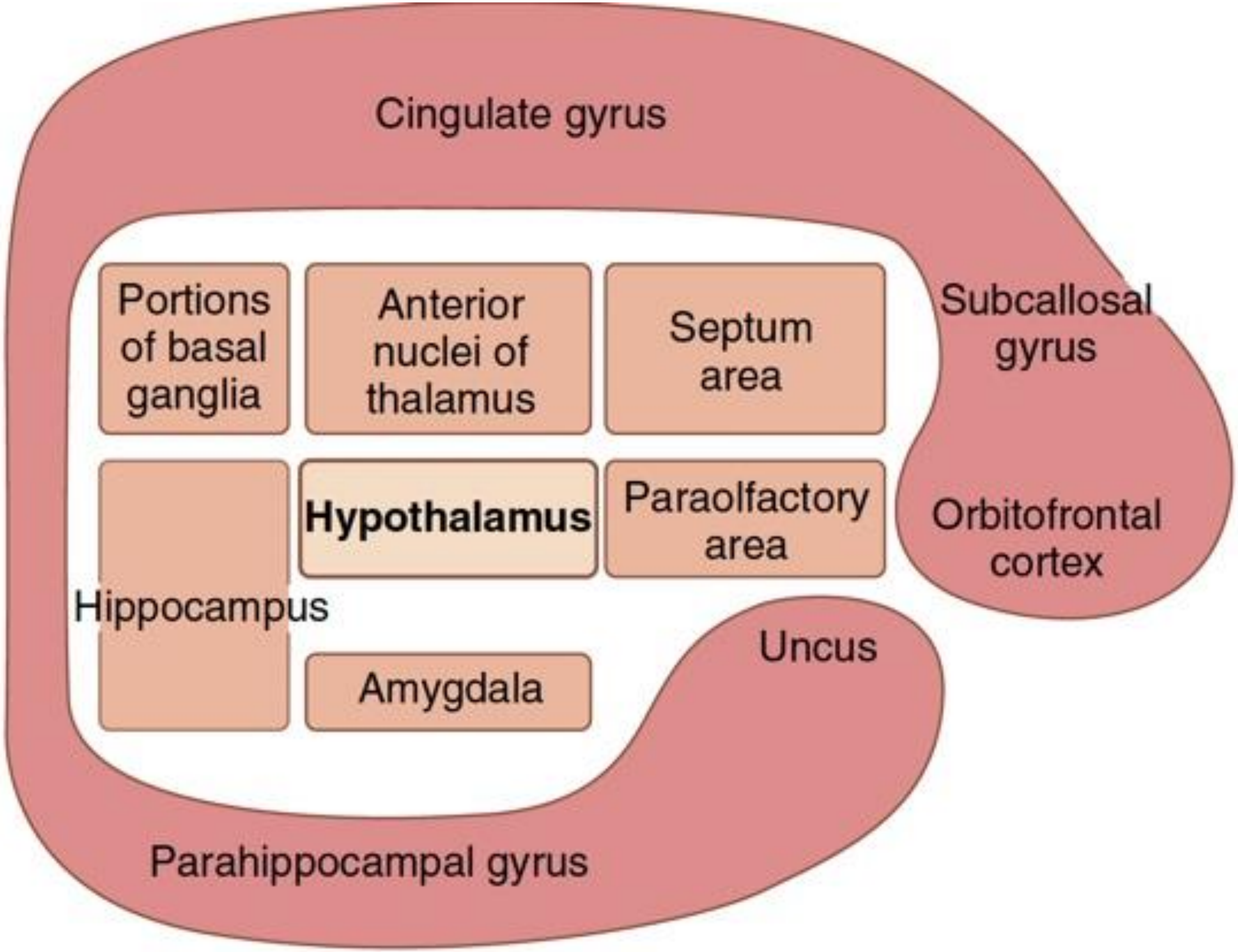
Mainly inhibitory
Suppress pain
Sleep




Cingulate gyrus and cingulum
Stria medullaris thalami
Body of fornix
Dorsal fornix
Mamillothalamic tract
Mamillotegmental tract
Isthmus
Gyrus fasciolaris
Fimbria of fornix
Stria terminalis
Connecting spinal cord
Hippocampus
Dentate gyrus
Parahippocampal gyrus
Mamillary body
Amygdaloid body
Uncus
Column of fornix (postcommissural fornix)
Hypothalamus
Olfactory bulb
Paraolfactory area
Prehippocampal rudiment
Orbitofrontal cortex
Paraterminal gyrus (precommissural septum)
Subcallosal gyrus
Anterior commissure
Anterior nuclear group of thalamus
Septum pellucidum (supracommissural septum)
Indusium griseum and longitudinal striae

Limbic system

- The entire neuronal circuitry that controls emotional behavior and motivational drives.
- they are an interconnected complex of basal brain elements.
- Located in the middle of all these structures is the extremely small hypothalamus.
- the ring of limbic cortex functions as a two-way communication and association linkage between the neocortex and the lower limbic structures.


Cingulate gyrus
Portions of basal ganglia
Anterior nuclei of thalamus
Septum area
Subcallosal gyrus
Hypothalamus
Paraolfactory area
Orbitofrontal cortex
Hippocampus
Uncus
Amygdala
Parahippocampal gyrus

Limbic system

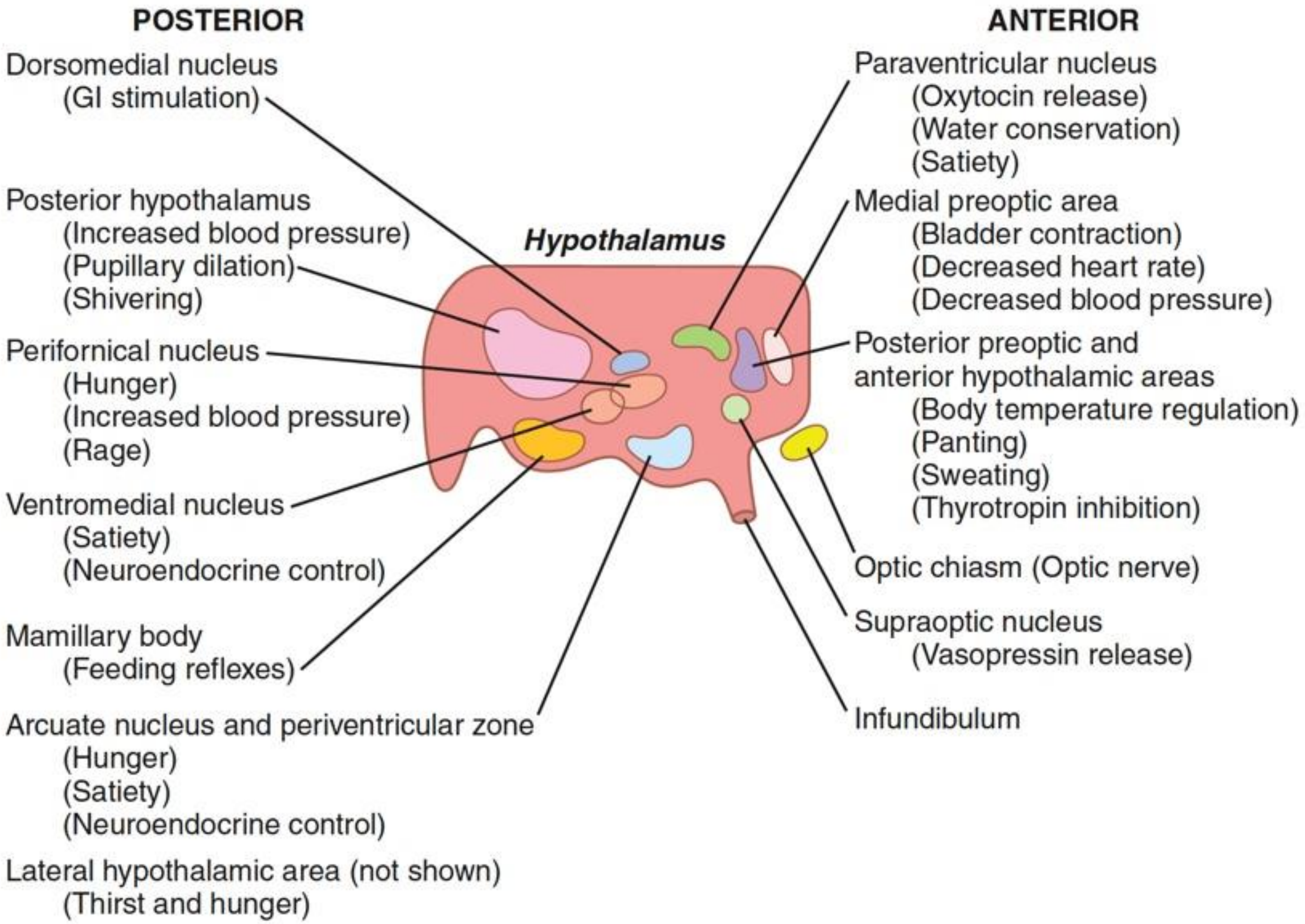
- Many of the behavioral functions elicited from the hypothalamus and other limbic structures are also mediated through the reticular nuclei in the brain stem and their associated nuclei.

The Hypothalamus

- It controls most of the vegetative and endocrine functions of the body and many aspects of emotional behavior.

- the hypothalamus sends output signals in three directions:

1. Reticular areas in the brain stem.
2. Anterior thalamus and limbic portions of the cortex.
3. Pituitary glands.

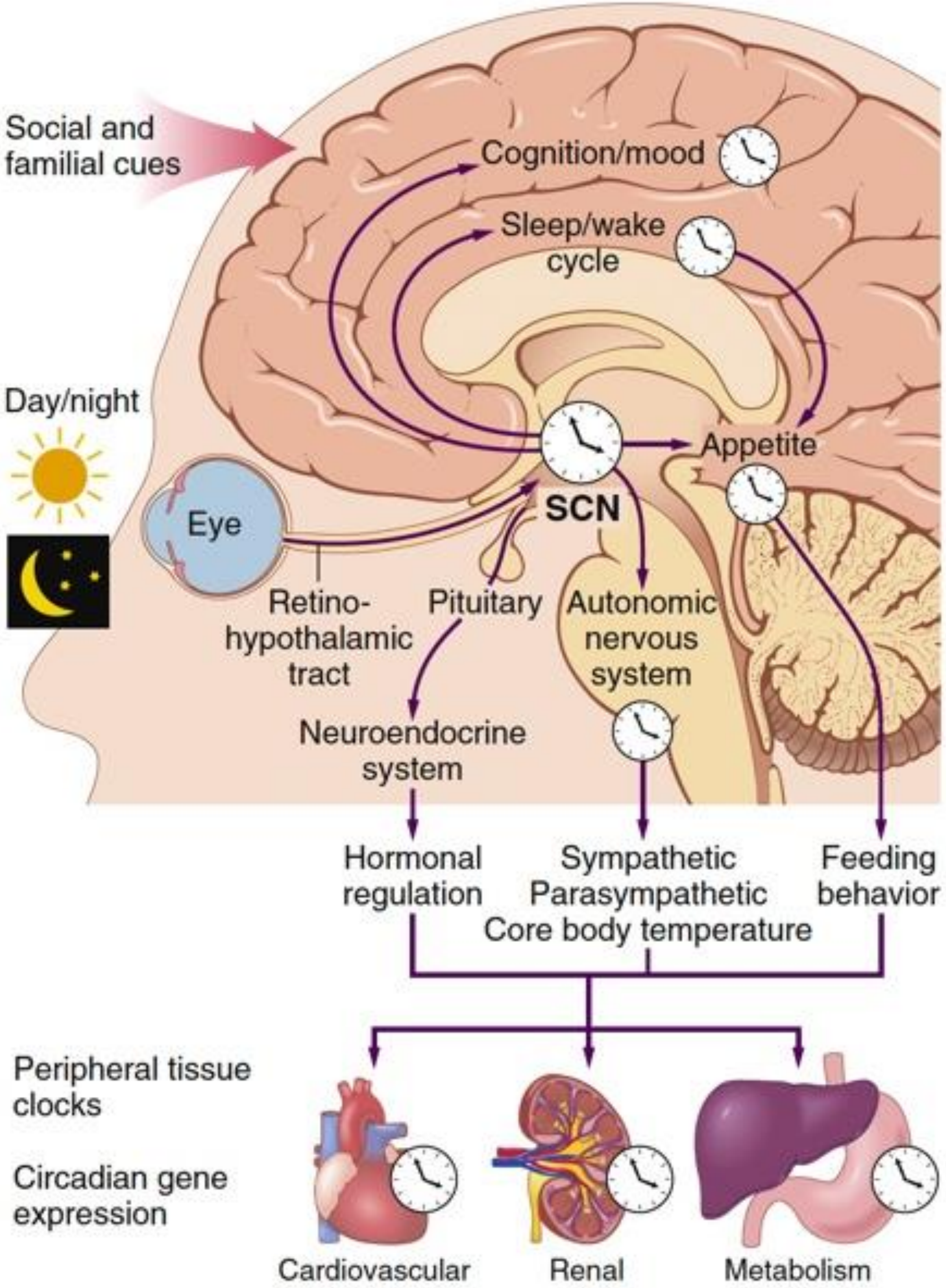


tranquility

Rage

The Hypothalamus

- The suprachiasmatic nucleus (SCN) of the hypothalamus contains about 20,000 neurons and is located above the optic chiasm.
- biological clocks are found in nearly every tissue and organ of the body and capable of maintaining their own circadian rhythms, although their circadian rhythms are usually maintained for only a few days in the absence of signals from the SCN.

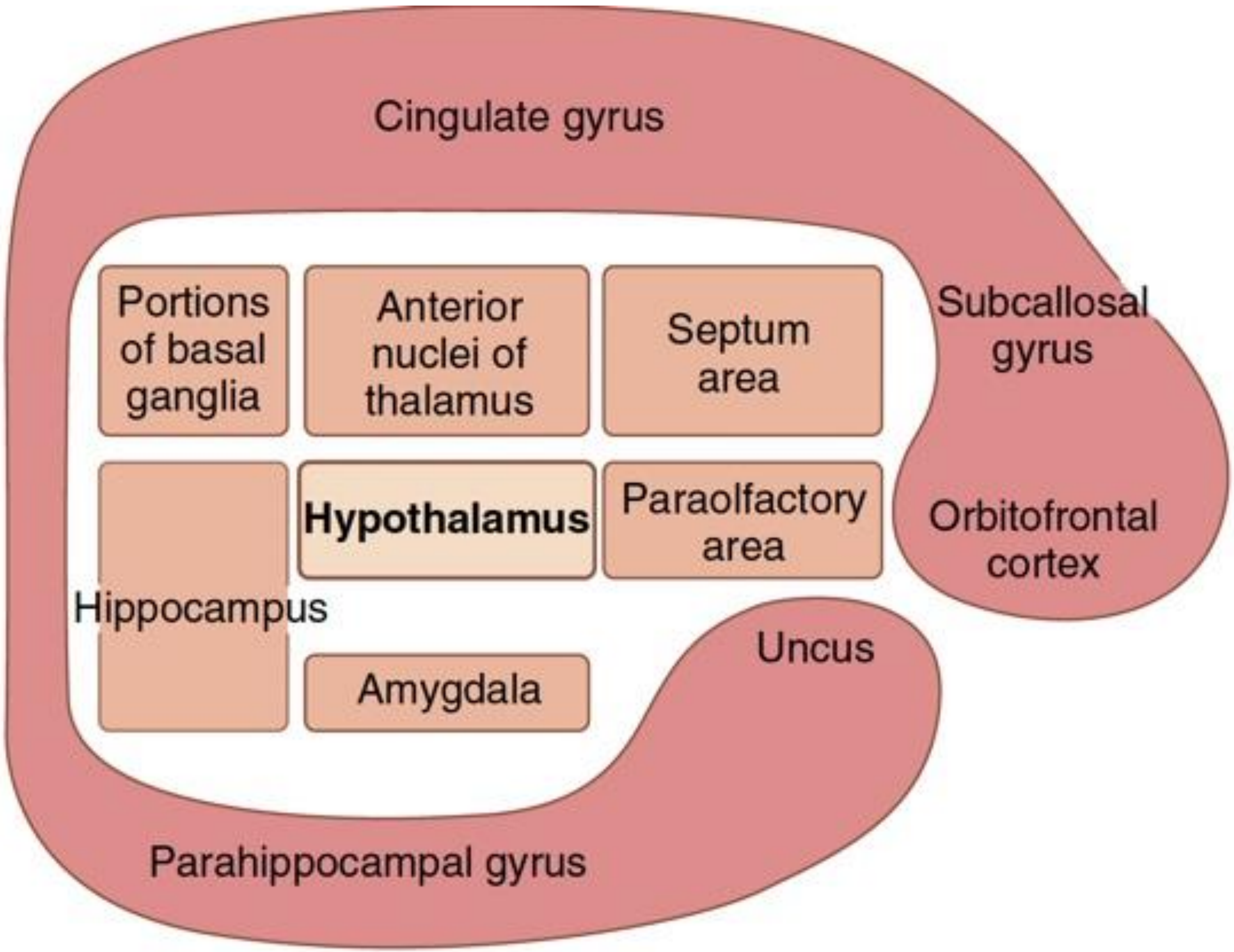

Social and
familial cues
Cognition/mood
Sleep/wake
cycle
Day/night
Appetite
Eye
SCN
Retino-
hypothalamic
tract
Pituitary
Autonomic
nervous
system
Neuroendocrine
system
Hormonal
regulation
Sympathetic
Parasympathetic
Core body temperature
Feeding
behavior
Peripheral tissue
clocks
Circadian gene
expression
Cardiovascular
Renal
Metabolism

The Hypothalamus

- Although the circadian rhythms of the SCN are endogenous and self-sustained, they are altered by environmental changes such as temperature and timing of the light-dark cycle.

Reward or punishment

- Several limbic structures are particularly concerned with the affective nature of sensory sensations—that is, whether the sensations are pleasant or unpleasant.
- These affective qualities are also called reward or punishment, or satisfaction or aversion.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Uncus
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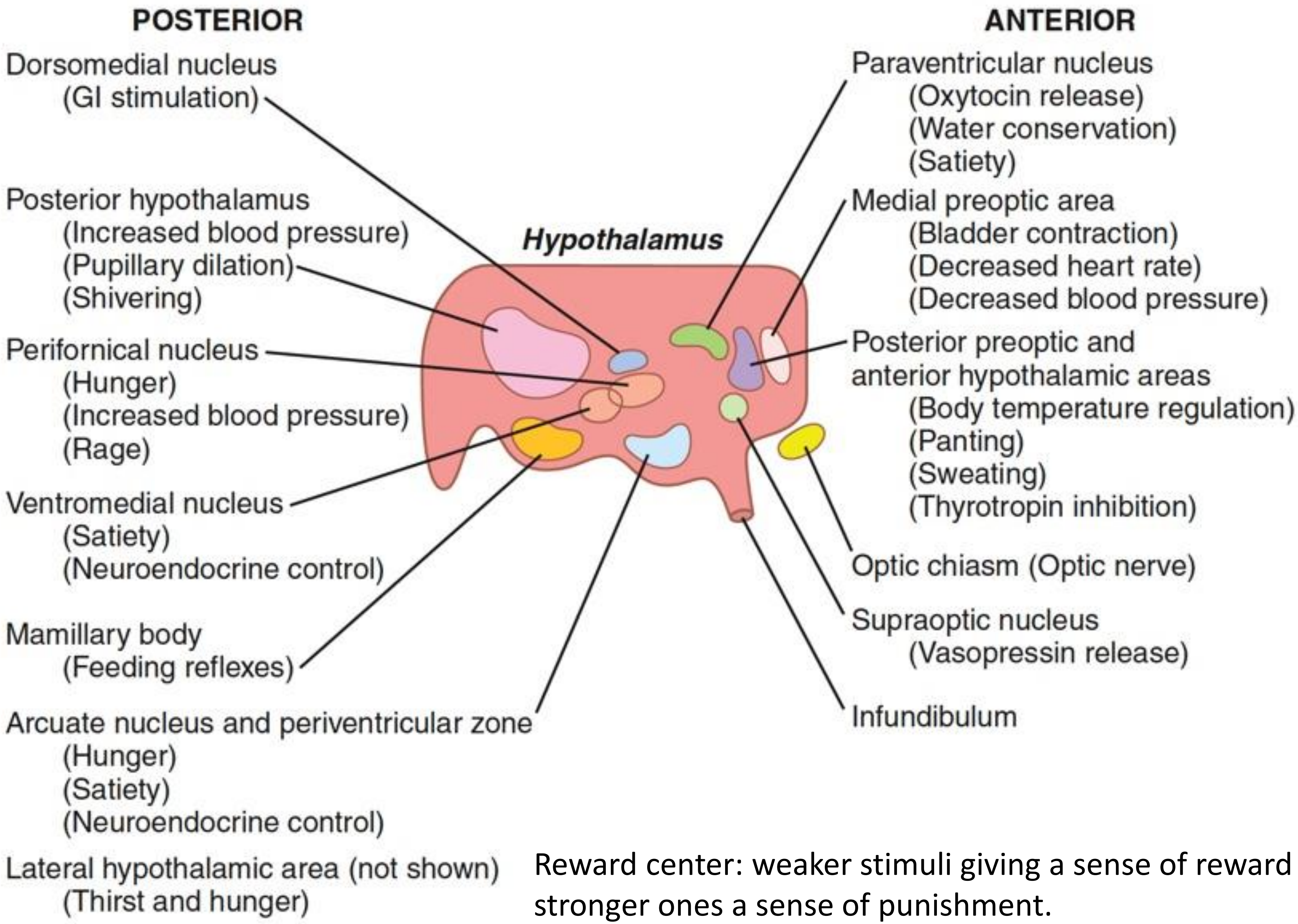
Punishment centers

- Aquiduct of Sylvius.
- Periventricular area of hypothalamus.
- Less potent punishment areas are found in some locations in the amygdala and hippocampus.
- It is particularly interesting that stimulation in the punishment centers can frequently inhibit the reward and pleasure centers completely, demonstrating that punishment and fear can take precedence over pleasure and reward.

Punishment centers

- An emotional pattern that involves the punishment centers of the hypothalamus and other limbic structures and that has also been well characterized is the rage pattern.

- Normally, the rage phenomenon is held in check mainly by inhibitory signals from the ventromedial nuclei of the hypothalamus. In addition, portions of the hippocampi and anterior limbic cortex, help suppress the rage phenomenon.



tranquility

Rage

Reward center: weaker stimuli giving a sense of reward and stronger ones a sense of punishment.

Reward centers

- Exactly the opposite emotional behavior patterns occur when the reward centers are stimulated: placidity and tameness.

Reward and punishment

- Almost everything that we do is related in some way to reward and punishment.
- If we are doing something that is rewarding, we continue to do it; if it is punishing, we cease to do it.
- Therefore, the reward and punishment centers undoubtedly constitute one of the most important of all the controllers of our bodily activities, our drives, our aversions, and our motivations.

Role of reward and punishment in learning and memory

- Animal experiments have shown that a sensory experience that causes neither reward nor punishment is hardly remembered at all.

- Electrical recordings from the brain show that a newly experienced sensory stimulus almost always excites multiple areas in the cerebral cortex.

Habituation

- However, if the sensory experience does not elicit a sense of either reward or punishment, repetition of the stimulus over and over leads to almost complete extinction of the cerebral cortical response—that is, the animal becomes habituated to that specific sensory stimulus and thereafter ignores it.

Reinforcement

- If the stimulus does cause reward or punishment rather than indifference, the cerebral cortical response becomes progressively more and more intense during repeated stimulation instead of fading away, and the response is said to be reinforced.
- An animal builds up strong memory traces for sensations that are either rewarding or punishing but, conversely, develops complete habituation to indifferent sensory stimuli.

The Hippocampus

- Almost any type of sensory experience causes activation of at least some part of the hippocampus, and the hippocampus in turn distributes many outgoing signals to the anterior thalamus, hypothalamus, and other parts of the limbic system, especially through the fornix, a major communicating pathway.
- Thus, the hippocampus is an additional channel through which incoming sensory signals can initiate behavioral reactions for different purposes.

The Hippocampus

- As in other limbic structures, stimulation of different areas in the hippocampus can cause almost any of the different behavioral patterns such as pleasure, rage, passivity, or excess sex drive.

The Hippocampus

- Another feature of the hippocampus is that it can become hyperexcitable.
- For example, weak electrical stimuli can cause focal epileptic seizures in small areas of the hippocampi.
- These seizures often persist for many seconds after the stimulation is over.
- During hippocampal seizures, the person experiences various psychomotor effects, including olfactory, visual, auditory, tactile, and other types of hallucinations that cannot be suppressed as long as the seizure persists.

The Hippocampus and memory

- Subjects with lesion in the hippocampus are capable of short-term memory for seconds up to a minute or two, although their ability to establish memories lasting longer than a few minutes is either completely or almost completely abolished. This phenomenon, called anterograde amnesia.

- Memory consolidation.

Amygdala

- Olfaction
- The amygdala receives neuronal signals from all portions of the limbic cortex, as well as from the neocortex of the temporal, parietal, and occipital lobes—especially from the auditory and visual association areas.

- Because of these multiple connections, the amygdala has been called the “window” through which the limbic system sees the place of the person in the world.

Amygdala

- In turn, the amygdala transmits signals (1) back into these same cortical areas, (2) into the hippocampus, (3) into the septum, (4) into the thalamus, and (5) especially into the hypothalamus.

- In general, stimulation in the amygdala can cause almost all the same effects as those elicited by direct stimulation of the hypothalamus, plus other effects.

Amygdala

- can also cause:
- Several types of involuntary movement.
- Sexual activities.
- Stimulation of certain amygdaloid nuclei can also cause a pattern of rage and punishment. Stimulation of other amygdaloid nuclei can give reactions of reward and pleasure.

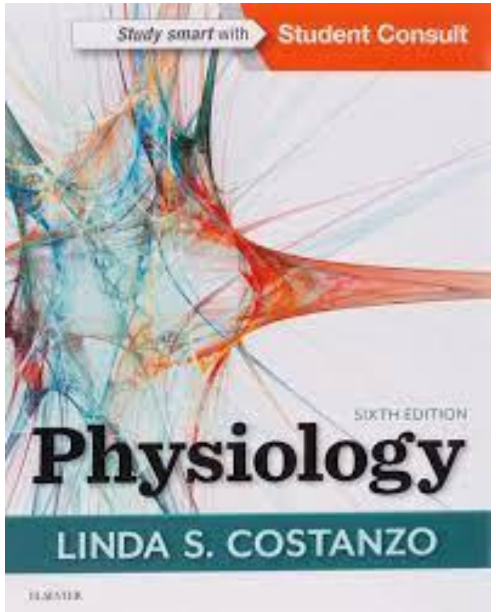
Amygdala

- the amygdala is believed to make the person’s behavioral response appropriate for each occasion.

The limbic cortex

- the limbic cortex in effect functions as a cerebral association area for control of behavior.
- many behavioral patterns can be elicited by stimulation of specific portions of the limbic cortex.

References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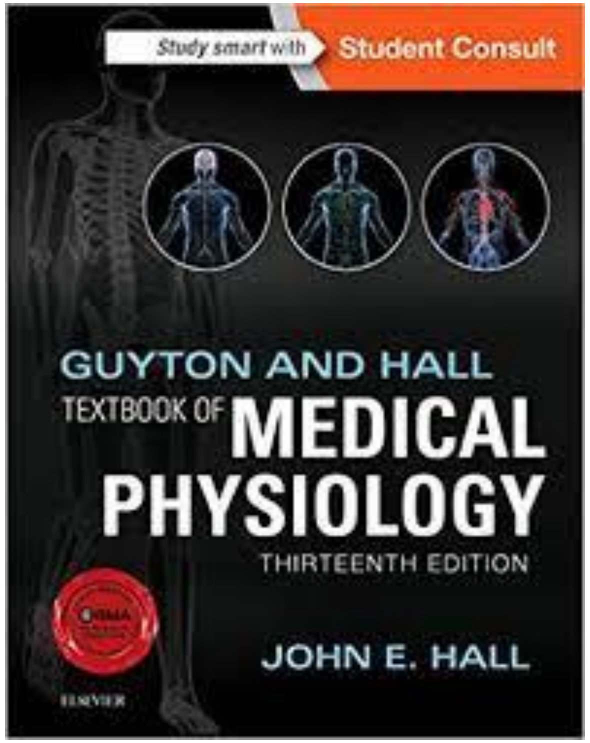
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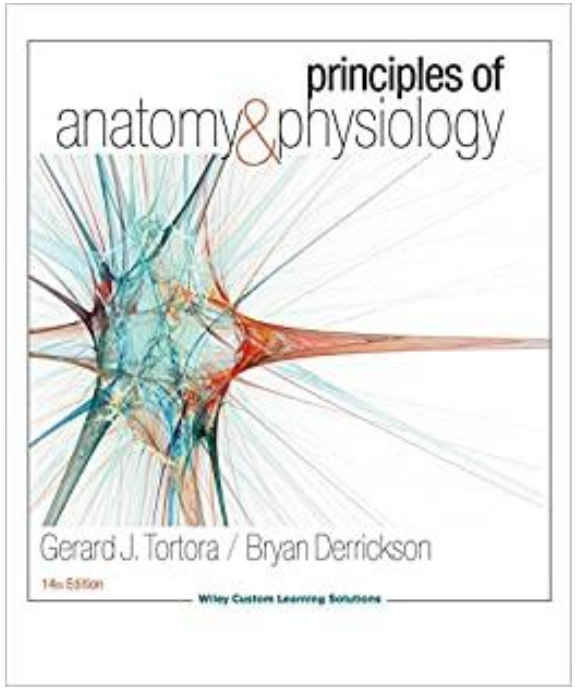
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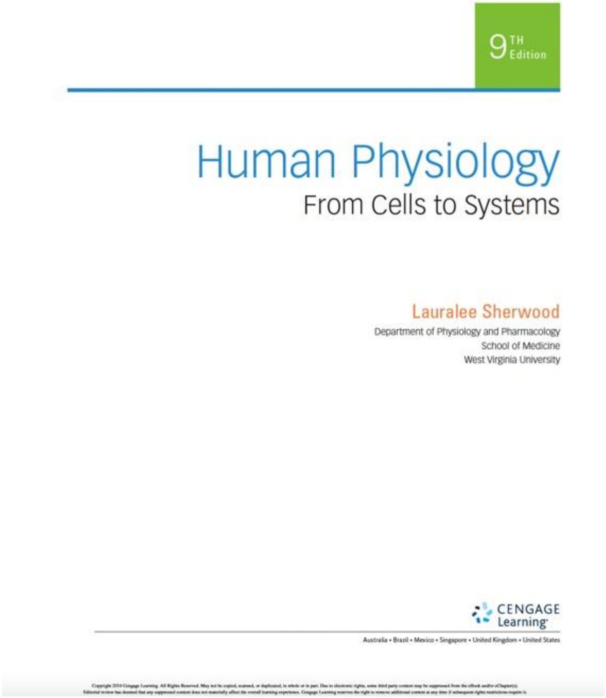
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