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Hypothalamus

PD-INCL *The Anatomy of the Nervous System: From the Standpoint of Development and Function*, SW Ranson

M1 CNS Head and Neck
March 18, 2009

Lecture Outline

- Hypothalamus, localization and adjacent structures (Brief)
- Development
- Regional organization of nuclei
  - Preoptic
  - Supraoptic
  - Tuberal
  - Mammillary
- Functionally related nuclei
  - Endocrine
  - Autonomic
  - Behavioral
- Hypothalamus and its connections to other brain areas and systems
- Blood Supply

Important Terms

- Diencephalon
- Thalamus
- Third Ventricle
- Internal Capsule
- Optic Chiasm
- Anterior Pituitary
- Posterior Pituitary
- Medial Zone
- Lateral Zone
- Medial Preoptic Area
- Lateral Preoptic Area
- Paraventricular Nuc.
- Supraoptic Nuc.
- Suprachiasmatic Nuc.
- Periventricular Nuc.
- Arcuate Nuc.
- Mammillary Bodies
- Medial Forebrain Bundle
- Fornix
- Stria Terminalis
- Mammillothalamic Tract
- Dorsal Longitudinal Fasciculus
- Hypothalamo-hypophyseal Tract
- Tuberoinfundibular Tract

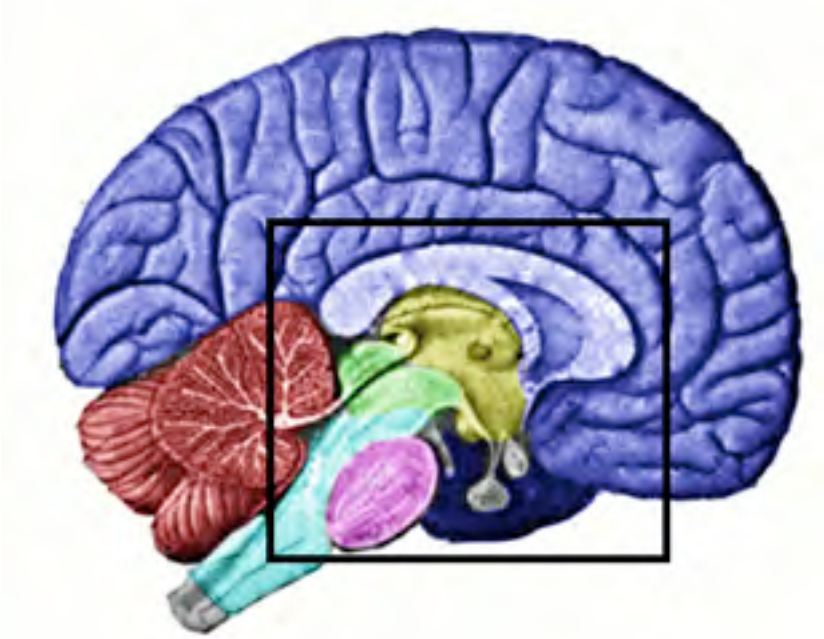
Hypothalamus
Essential Functions

Control of the pituitary gland (Endocrine)

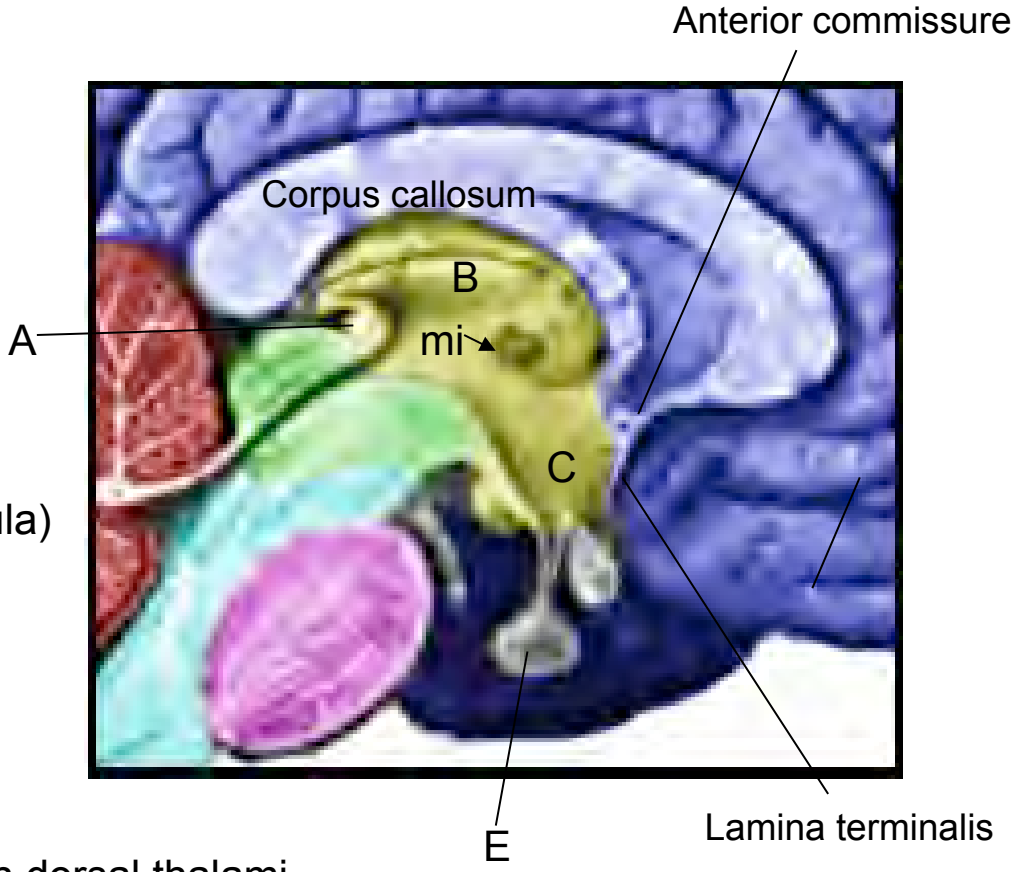
Control of the autonomic nervous system

Control of a variety of behaviors that are essential for survival (of the individual and of the species): eating, drinking, sleep, sexual behavior, parental behavior, and aggression.

Midsagittal view



In the adult brain the diencephalon is completely surrounded by the telencephalon.
Together they form the “forebrain.”



Regions of the Diencephalon:

A. Epithalamus (pineal gland and habenula)
B. Dorsal Thalamus
C. Hypothalamus
D. Ventral thalamus (or subthalamus)
(not visible in this midline section)
E. Posterior pituitary

mi. massa intermedia - adhesion between dorsal thalami

The Hypothalamus

A unique area of the brain that sends and receives hormonal and other molecular signals via the vascular system, as well as neural signals

About 4gm of the 1500gm mass of the brain

Netter's image of hypothalamus removed

Major functions:

- Control of the pituitary gland (both anterior and posterior)
- Control of the autonomic nervous system
- Control of a variety of behaviors that are essential for survival (of the individual and of the species): eating, drinking, sleep, sexual behavior, parental behavior, and aggression.

Development

Hypothalamus

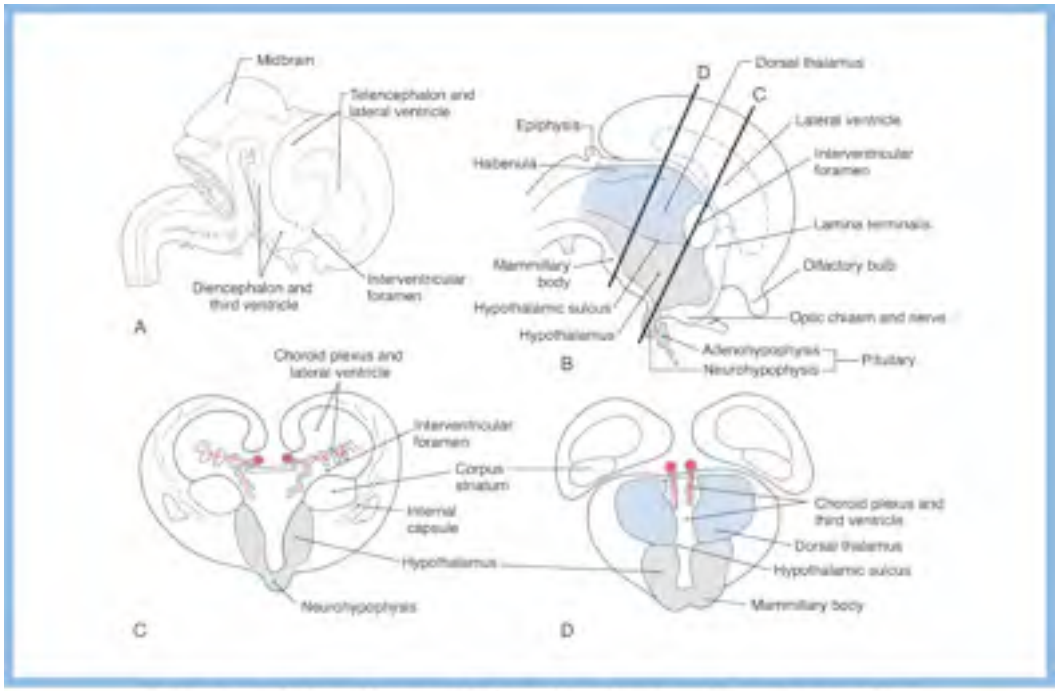
Part of prosencephalon

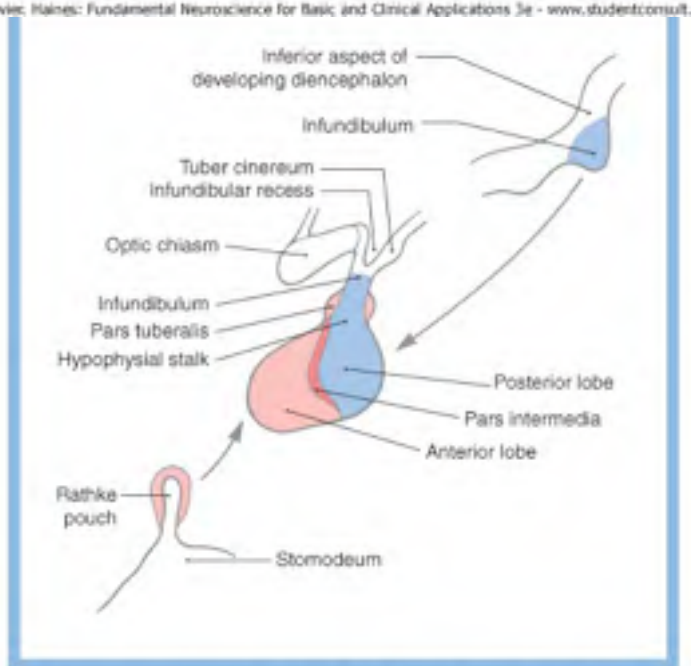
Continuous with alar plate

Pituitary

Posterior Lobe (Pars nervosa) Arises from the floor of the developing diencephalon.

Anterior Lobe (Adenohypophysis) Arises from the roof of the developing oral cavity = Rathke's pouch

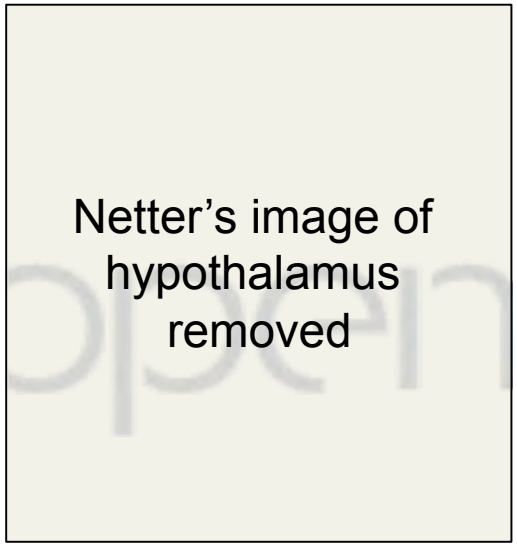




PD-INCL Haines, *Fundamental Neuroscience for Basic and Clinical Applications*, Elsevier

The hypothalamus is a matrix of nuclei.

It is described as four areas (preoptic, supraoptic, tuberal, mamillary) each with nuclei that have distinctive functions.



The Preoptic Area

Netter's image of preoptic area removed

MPOA (medial preoptic area)

regulates:

- male sexual behavior
- parental behavior

MPOA neurons

- express estrogen & androgen receptors
- controlled by endocrine feedback from testes, ovaries, and adrenals

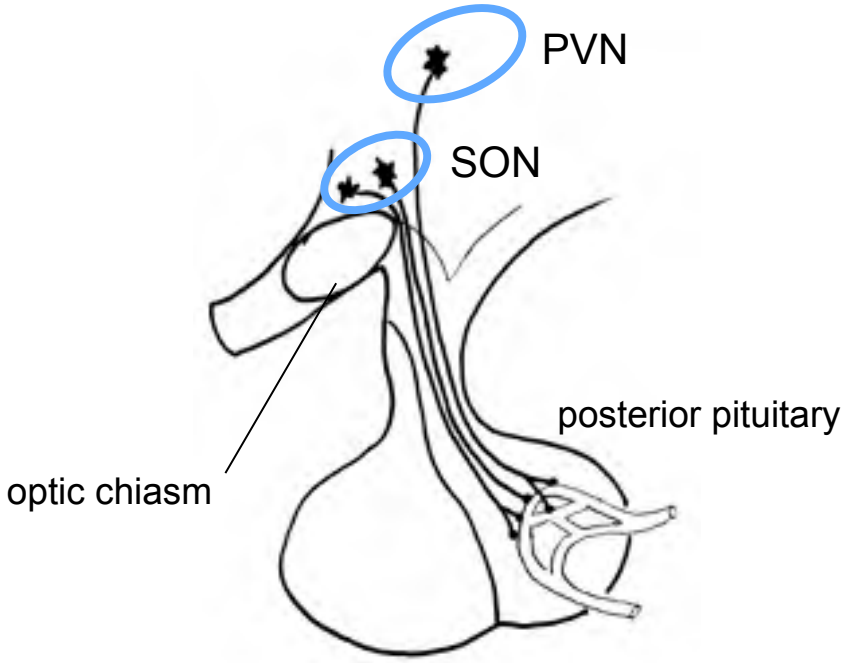
LPOA (lateral preoptic area)

- important in thermoregulation, both behavioral (panting) and autonomic heat dissipation; vasodilation, sweating

The Supraoptic Area

Netter's image of supraoptic area removed

The paraventricular and supraoptic nuclei contain magnocellular neurons that produce oxytocin and vasopressin. Their axons release these peptides onto the capillaries of the posterior pituitary.



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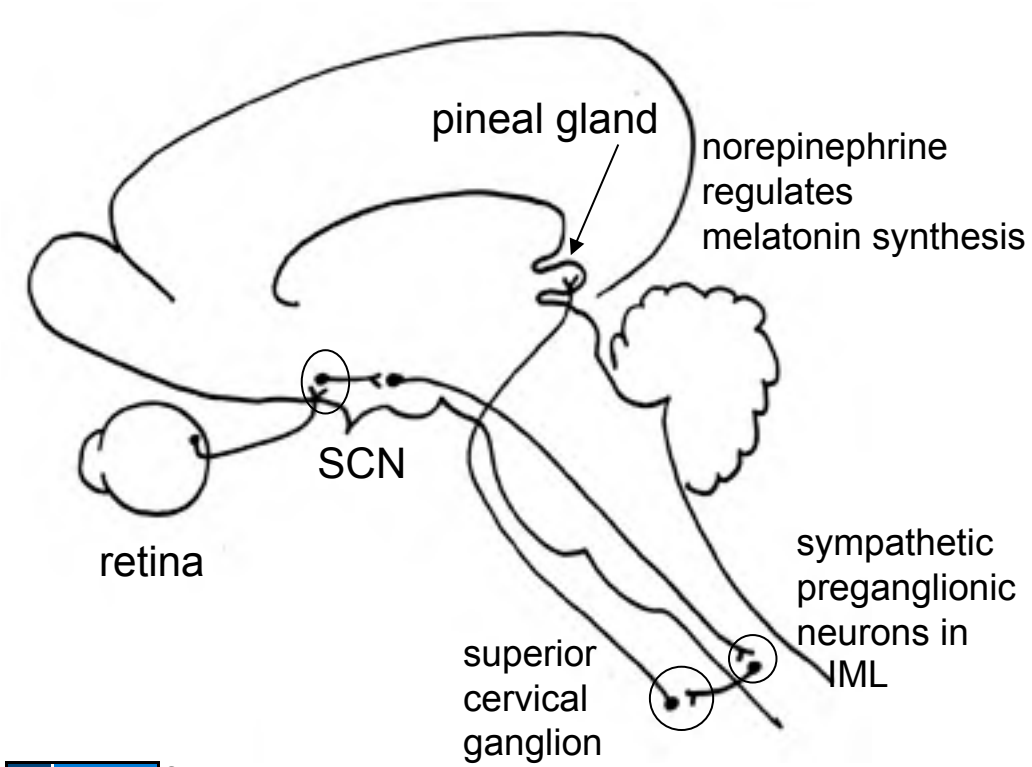
The Supraoptic Area

Netter's image of supraoptic area removed

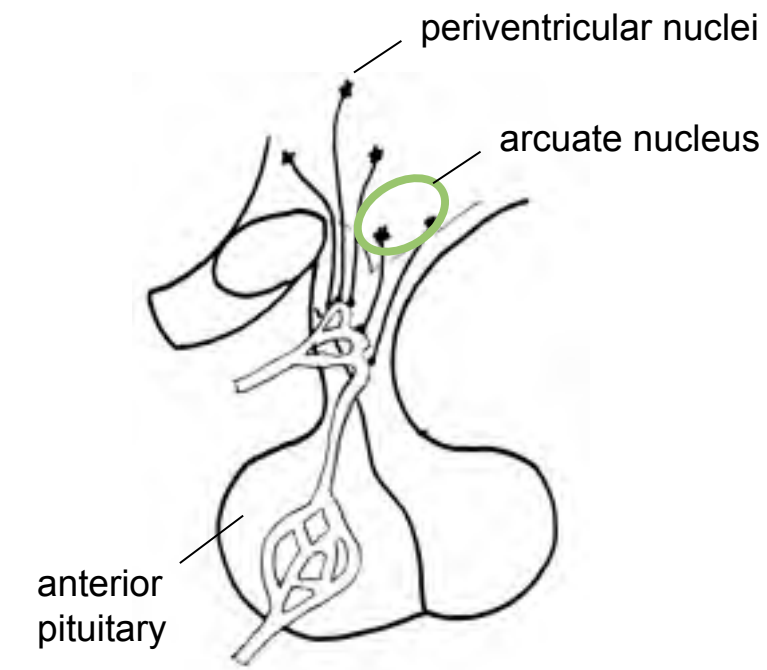
Cells in the suprachiasmatic nuclei are circadian oscillators that entrain endocrine functions and behaviors to the 24-hour light-dark cycle.



Netter's image of tuberal area removed

Periventricular and Arcuate neurons express receptors for a variety of hormones and provide feedback regulation through a portal venous system to the trophic-hormone-producing cells of the anterior pituitary.

(list of factors to follow)



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unlike many other endocrine tissues, the ant. pit. is so dependent on the hypothal that it is not tansplantable

The Tuberal Area

Netter's image of tuberal area removed

Ventromedial nucleus

- neurons express estrogen, androgen and progesterone receptors
- control female sexual behavior and aggression.

The Mammillary Area

Netter's image of mammillary area removed

The mammillary bodies receive input from the hippocampus via the fornix. They project to the anterior nucleus of the thalamus through the mammillothalamic tract.

Damage to the mammillary bodies and their connections with the hippocampus produces anterograde amnesia (as seen in Korsakoff's syndrome).

Mammillary nuclei (bodies) part of limbic system

The Lateral Hypothalamic Area (LHA)

Sympathetic autonomic function: Lateral and posterior hypothalamus

Parasympathetic autonomic function: Medial and anterior hypothalamus

Netter's image of hypothalamus removed

The MFB

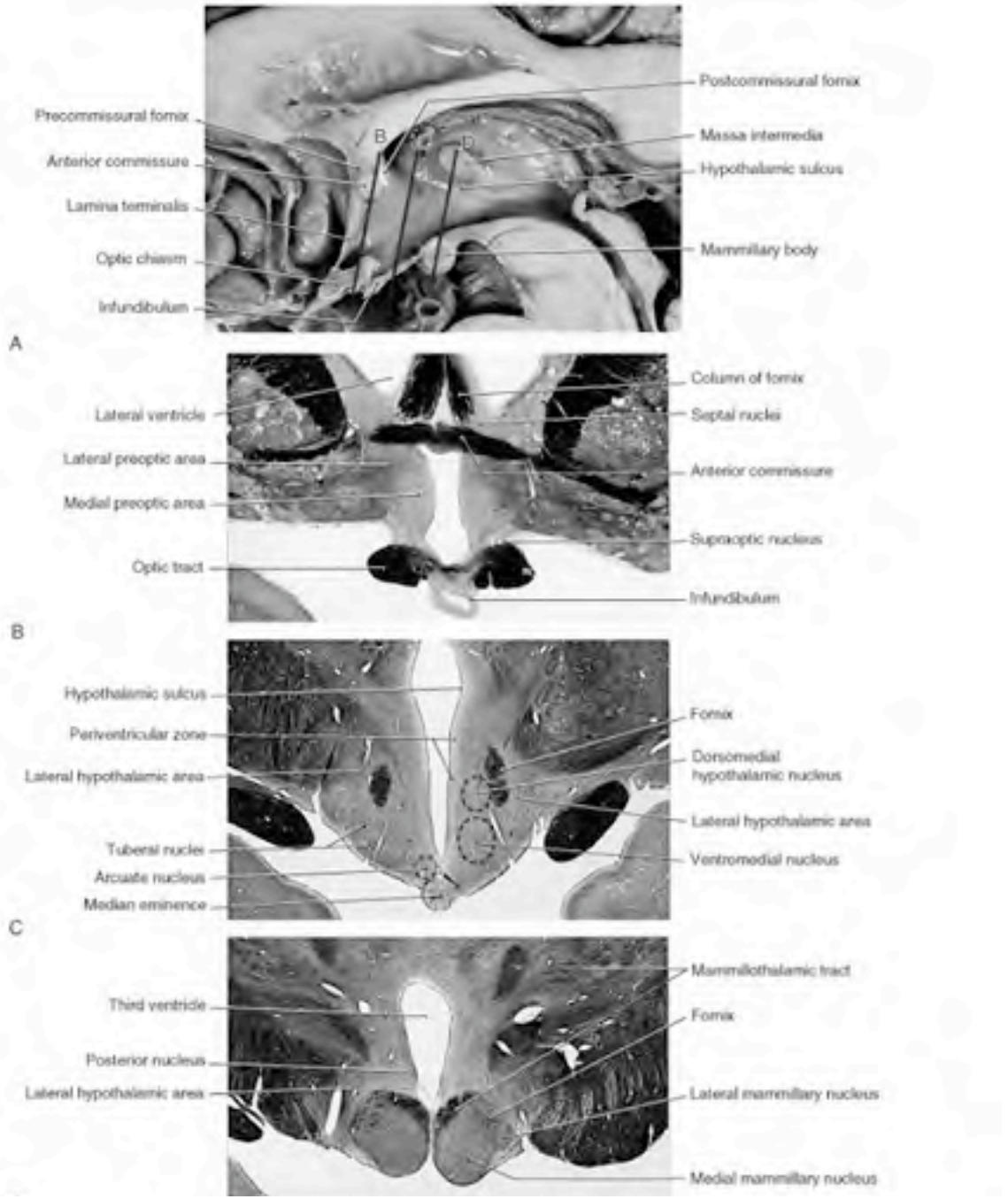
- runs through the LHA
- contains both ascending and descending fibers.
- connects limbic areas, hypothalamus, and brain stem (includes parasympathetic connections)
- some fibers reach spinal cord sympathetic neurons

Real Sections

Supraoptic

Tuberal

Mammillary



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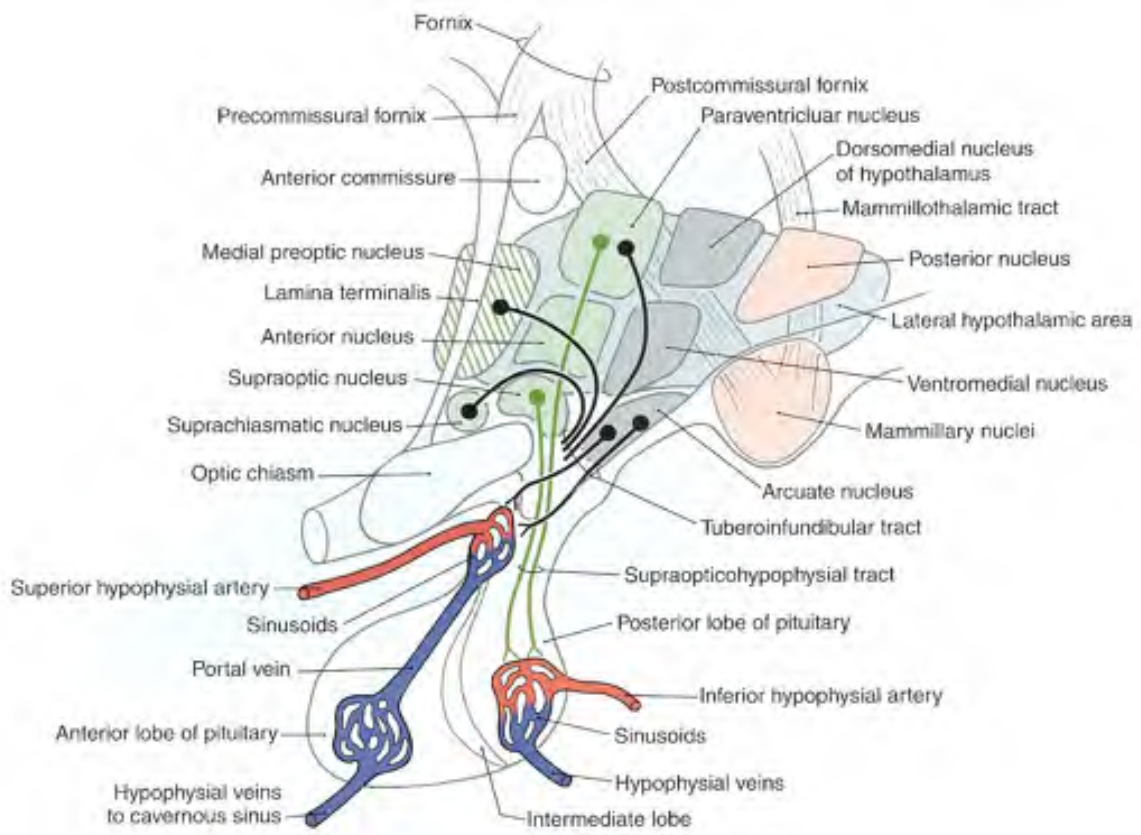
Hypothalamus:

Endocrine Function

Paraventricular and supraoptic nuclei: regulate water balance, produce Antidiuretic Hormone (ADH, a.k.a. vasopressin) and oxytocin. Destruction causes Diabetes Insipidis

Preoptic Nuclei: Contain sexually dimorphic nuclei, regulate release of gonadotropic hormone

Arcuate Nuclei (Tuberal Nuclei): produce hypothalamic releasing factors, contains dopaminergic neurons that inhibit prolactin release, contains beta endorphin – a role in opiate analgesia

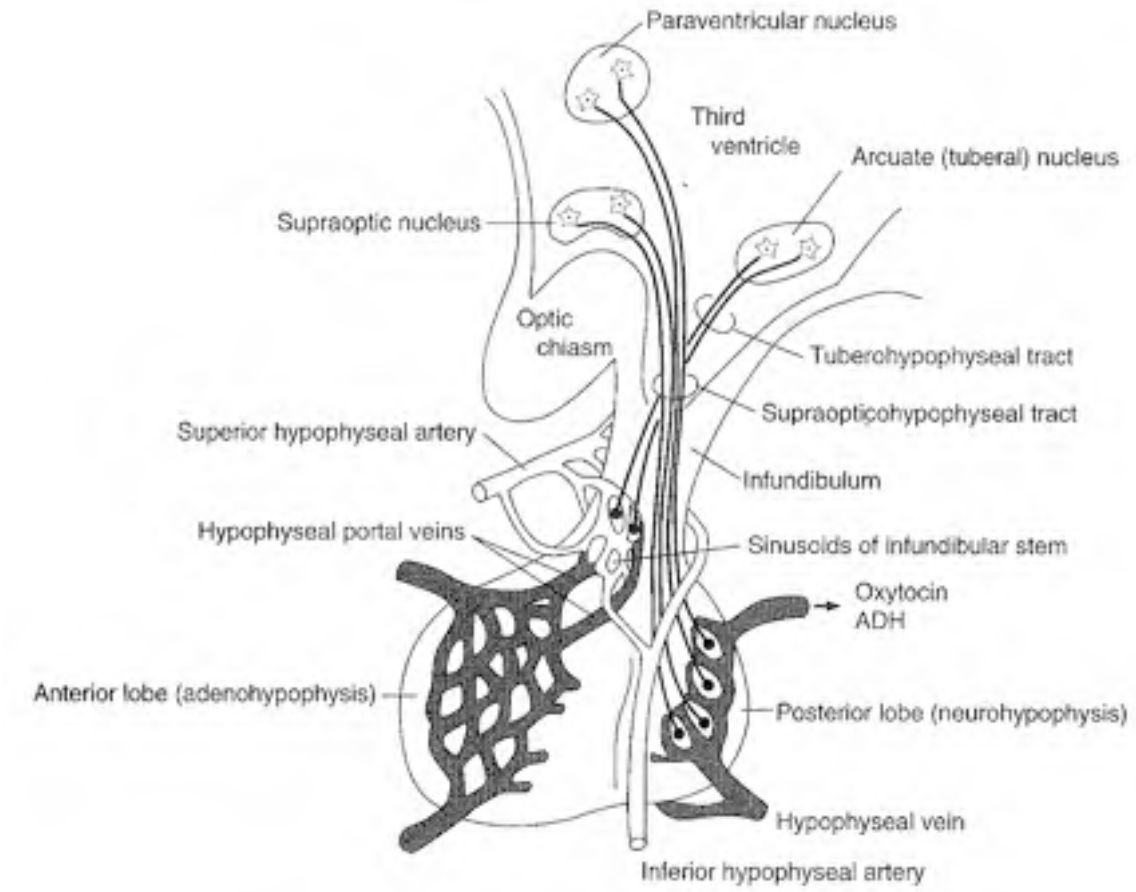


PD-ineL Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5

ENDOCRINE FUNCTION

1. **DIRECT:** From **supraoptic** and **paraventricular** nuclei via -**hypothalamo-hypophyseal tract** - secretion of neuroendocrine products (OXYTOCIN, VASOPRESSIN) into general circulation via vasculature of posterior pituitary.

2. **INDIRECT:** From **Tuberal** nuclei (arcuate) via **tuberoinfundibular tract-** Secretion of releasing hormones (e.g. GHRF, LRF) into portal plexus which influences release (of other substances -GH, LH, TSH, ACTH, FSH, PROLACTIN,) by anterior pituitary.



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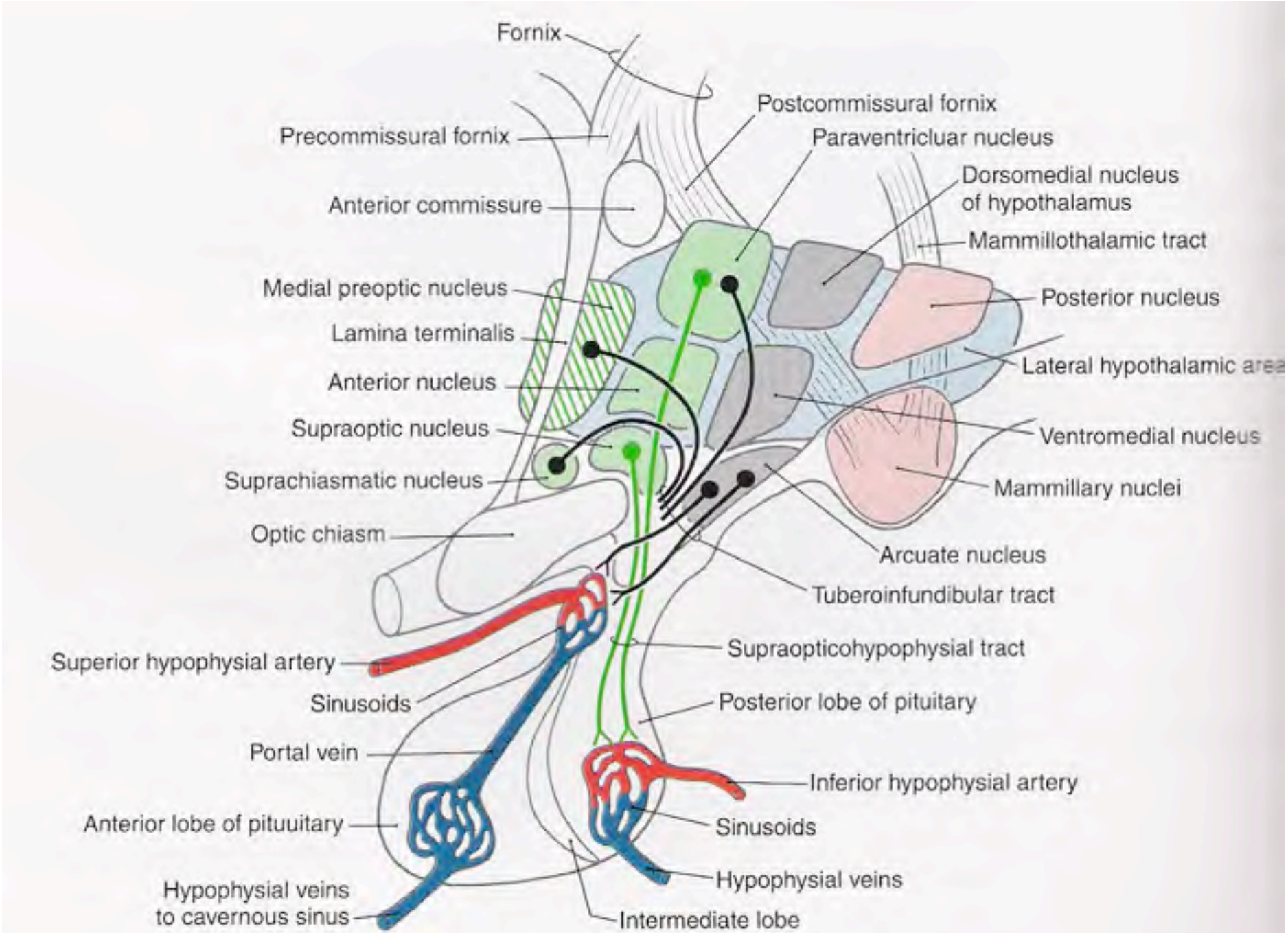
Nucleus	Releasing Hormone	Pituitary Hormone
Medial Preoptic	Gonadotropin-releasing h. Thyrotropin-releasing h. Corticotrophin-releasing h. Growth hormone-releasing inhibitor h.	Gonadotropins Thyrotropin Corticotropin Inhibits release of Growth Hormone
Anterior	Growth hormone-releasing inhibitor h.	Inhibits release of Growth Hormone
Supraoptic	Corticotrophin-releasing h.	Oxytocin and Vasopressin Corticotropin
Paraventricular	Thyrotropin-releasing h. Corticotrophin-releasing h. Growth hormone-releasing h. Growth hormone-releasing inhibitor h.	Oxytocin and Vasopressin Thyrotropin Corticotropin Growth Hormone Inhibits release of Growth Hormone
Ventromedial	Growth hormone-releasing h.	Growth Hormone
Dorsomedial	Growth hormone-releasing h. Thyrotropin-releasing h.	Growth Hormone Thyrotropin
Arcuate	Gonadotropin-releasing h. Growth hormone-releasing h. Prolactin-releasing inhibition h.	Gonadotropins Growth Hormone Prolactin Inhibition
Lateral Hypothalamic Zone	Thyrotropin-releasing h. Growth hormone-releasing h. Growth hormone-releasing inhibitor h.	Thyrotropin Growth Hormone Inhibits release of Growth Hormone



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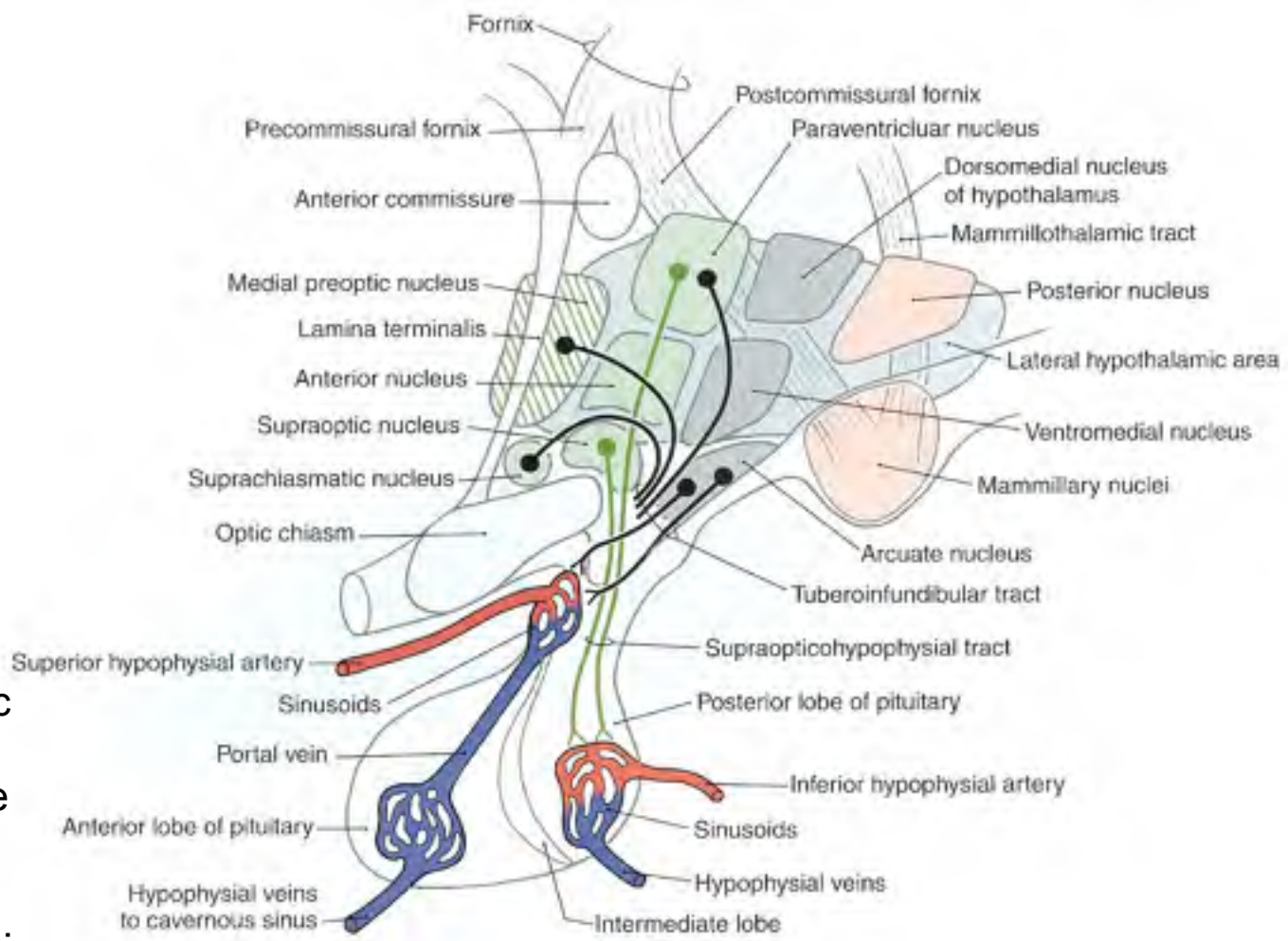
Hypothalamus:

Autonomic Function:

<u>Anterior Nucleus:</u> thermal regulation (dissipation), stimulation of parasympathetic NS, destruction results in hyperthermia

<u>Posterior Nucleus:</u> thermal regulation (conservation of heat) stimulation of sympathetic NS, destruction results in inability to thermoregulate

<u>Suprachiasmatic Nucleus</u>: receives input from retina, mediates circadian rhythms



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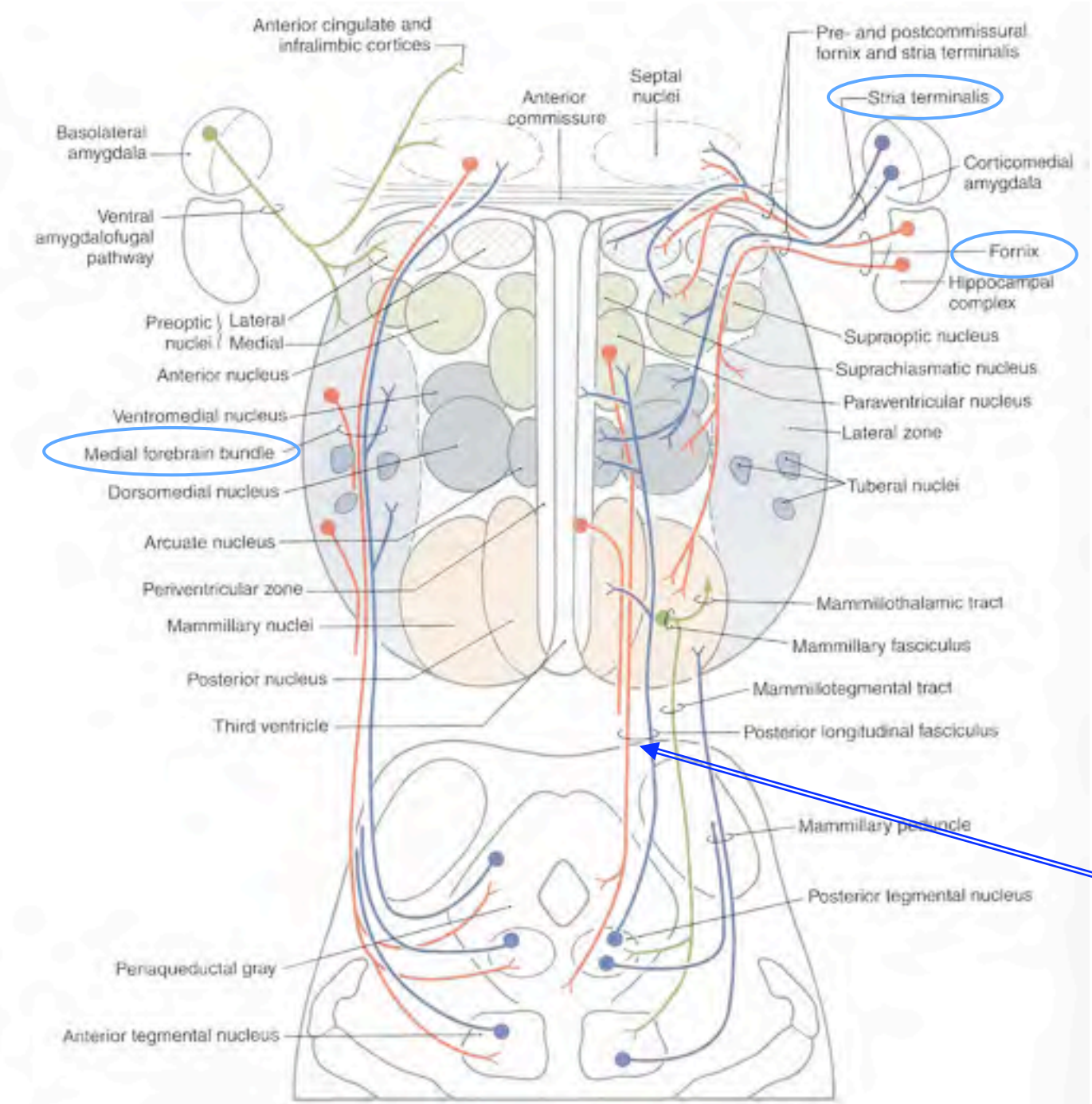

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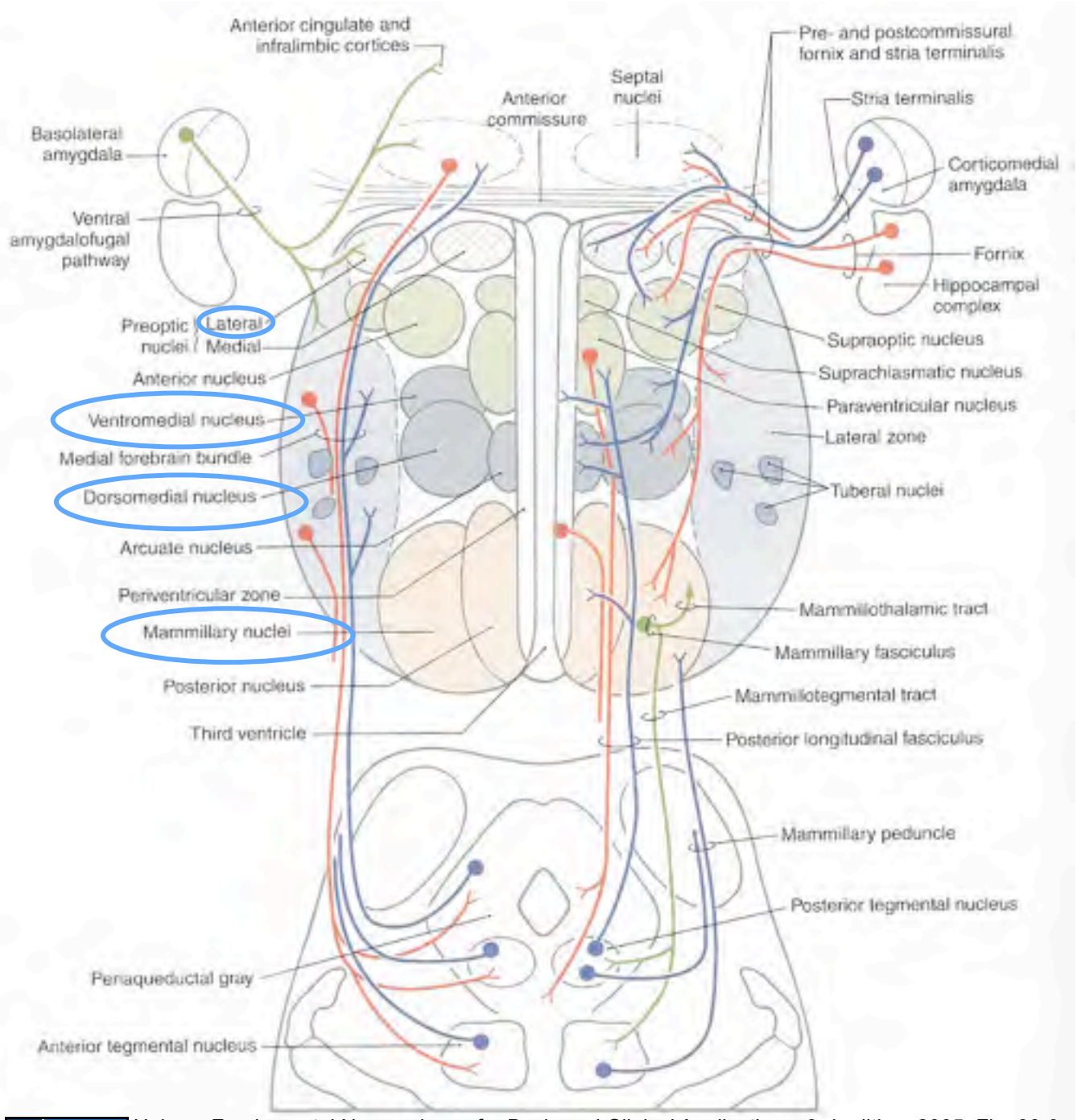
AUTONOMIC FUNCTION

"Head Ganglion" of autonomic system: Regulates almost all autonomic functions such as: body temperature (**preoptic area**), heart rate, blood pressure, bladder contraction, hunger (**paraventricular**).

Connections to reticular system and raphe nuclei of brainstem – **Dorsal Longitudinal Fasciculus.**

Dorsal (posterior) Longitudinal Fasciculus



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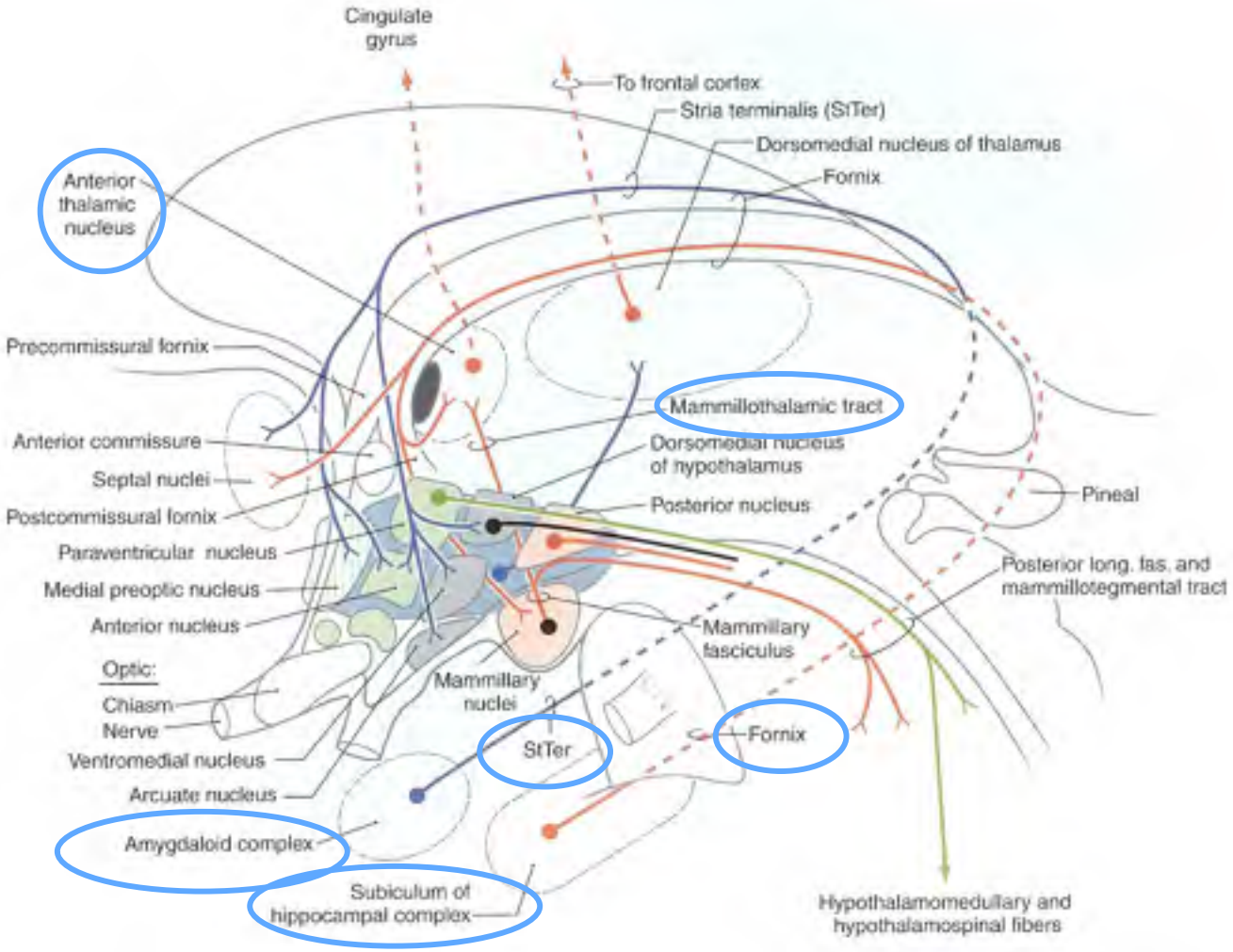
Limbic Function:

<u>Dorsomedial nucleus:</u> emotional behavior, stimulation results in obesity and savage behavior (sham rage)

<u>Ventromedial nucleus:</u> satiety center, destruction results in obesity and savage behavior, stimulation inhibits feeding.

<u>Lateral nucleus:</u> feeding center, stimulation induces eating. Destruction results in loss of appetite, anorexia, starvation

<u>Mammillary nucleus</u>: input from hippocampal formation, lesions result in memory deficits. Projects to anterior nucleus of the thalamus



PD-INCL Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-8

LIMBIC FUNCTION:
Regulation of emotional behavior (anger, rage, sexual activity, etc.).
Pathways to and from parts of limbic system parallel each other:

1. AMYGDALA via **stria terminalis**

2. HIPPOCAMPUS & SUBICULUM via **fornix** (to and from mammillary bodies)

3. SEPTAL NUCLEI, OLFACTORY CORTEX, SUBICULUM via **medial forebrain bundle** (MFB)

4. THALAMUS - **Mammillo-thalamic tract**

MAJOR CONNECTIONS OF HYPOTHALAMUS

I. LIMBIC SYSTEM

1. **MEDIAL FOREBRAIN BUNDLE**

septal nuclei, olfactory regions ⟷ HYPOTHALAMUS & brain stem

2. **FORNIX**

Hippocampal Complex ⟷ Mammillary Bodies of Hypothalamus

3. **STRIA TERMINALIS**

Amygdala ⟷ Hypothalamus

4. **MAMMILLOTHALAMIC TRACT**

Hypothalamus ⟷ Thalamus (anterior nucleus

AUTONOMIC CONNECTION

5. **DORSAL (posterior) LONGITUDINAL FASCICULUS**

Hypothalamus ⟺ Brain Stem Reticular Formation

Hypothalamus ⟺ Brain Stem Nuc (e.g. vagus)

Intermediolateral Cell Column

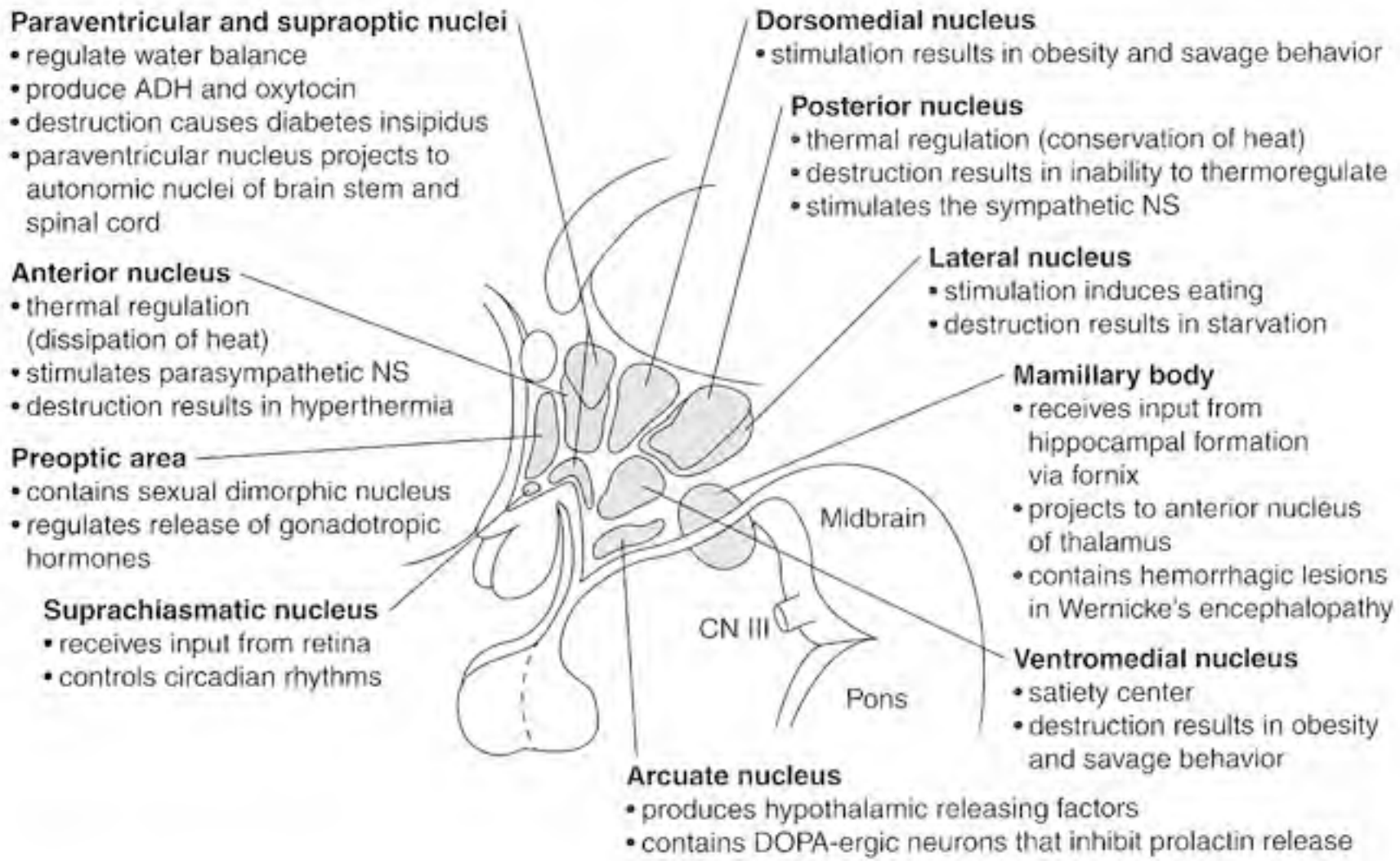
ENDOCRINE CONNECTIONS

6. Hypothalamo-Hypophyseal TRACT

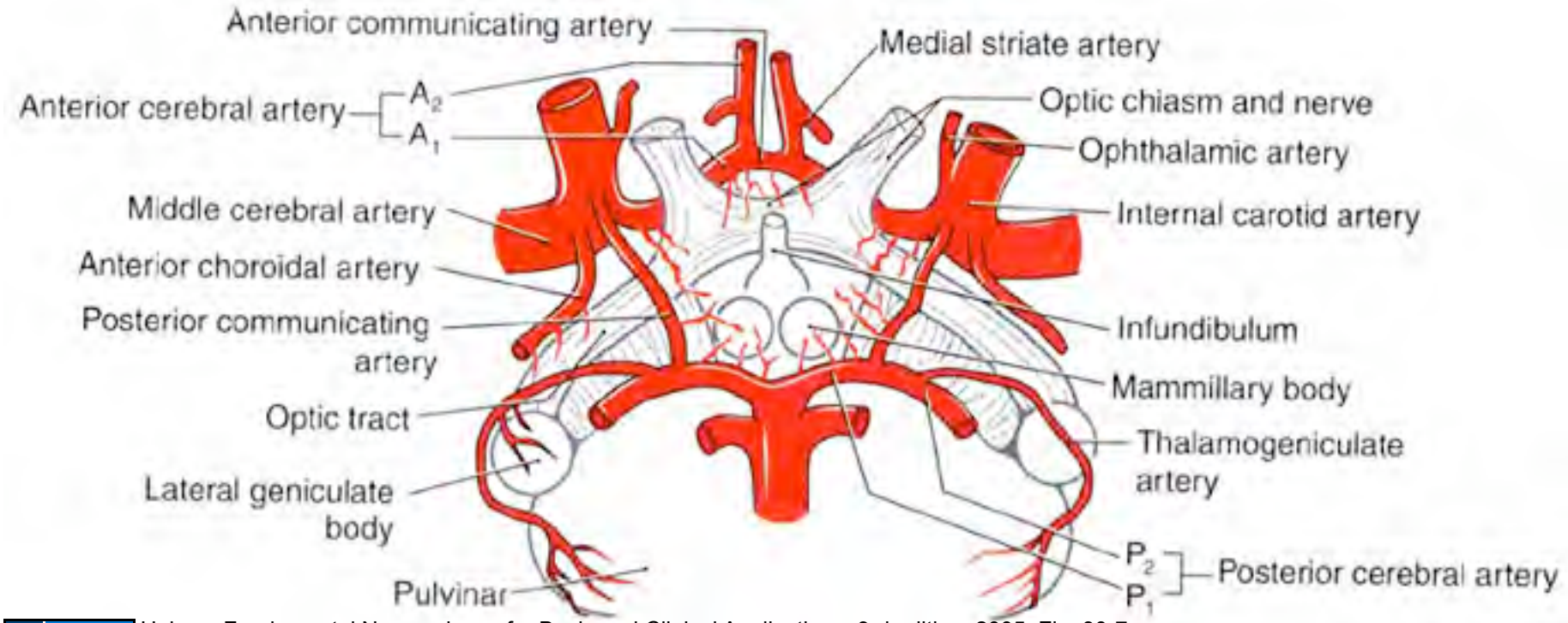
Hypothalamus ⟹ Neurohypophysis

7. **Tuberoinfundibular Tract**

Tuberal Nuclei ⟹ Sinusoids, Portal Veins ⟹ Adenohypophysis



The **hypothalamus** is supplied with blood by small branches of the Circle of Willis



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