

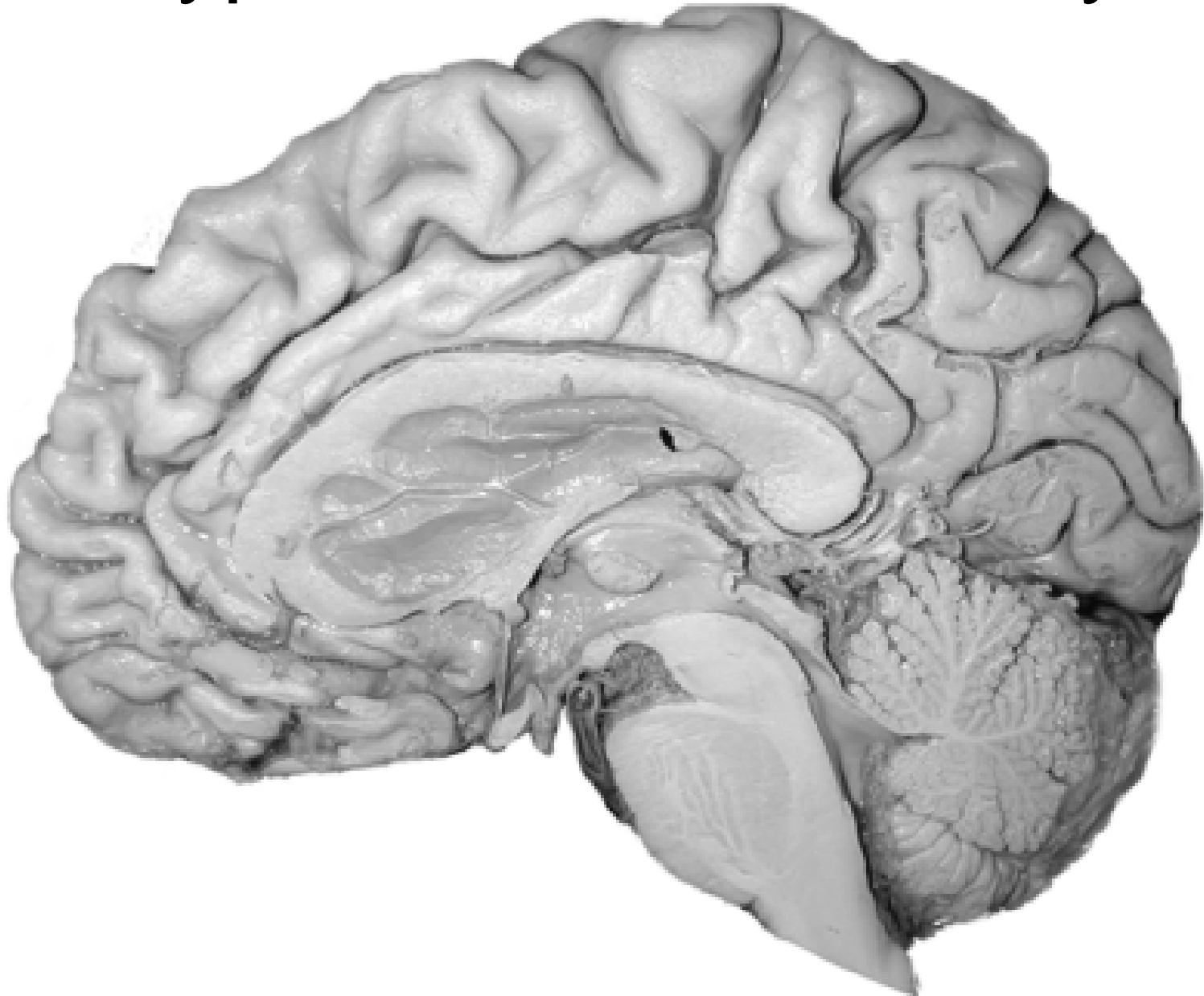
Hypothalamus

Small and essential

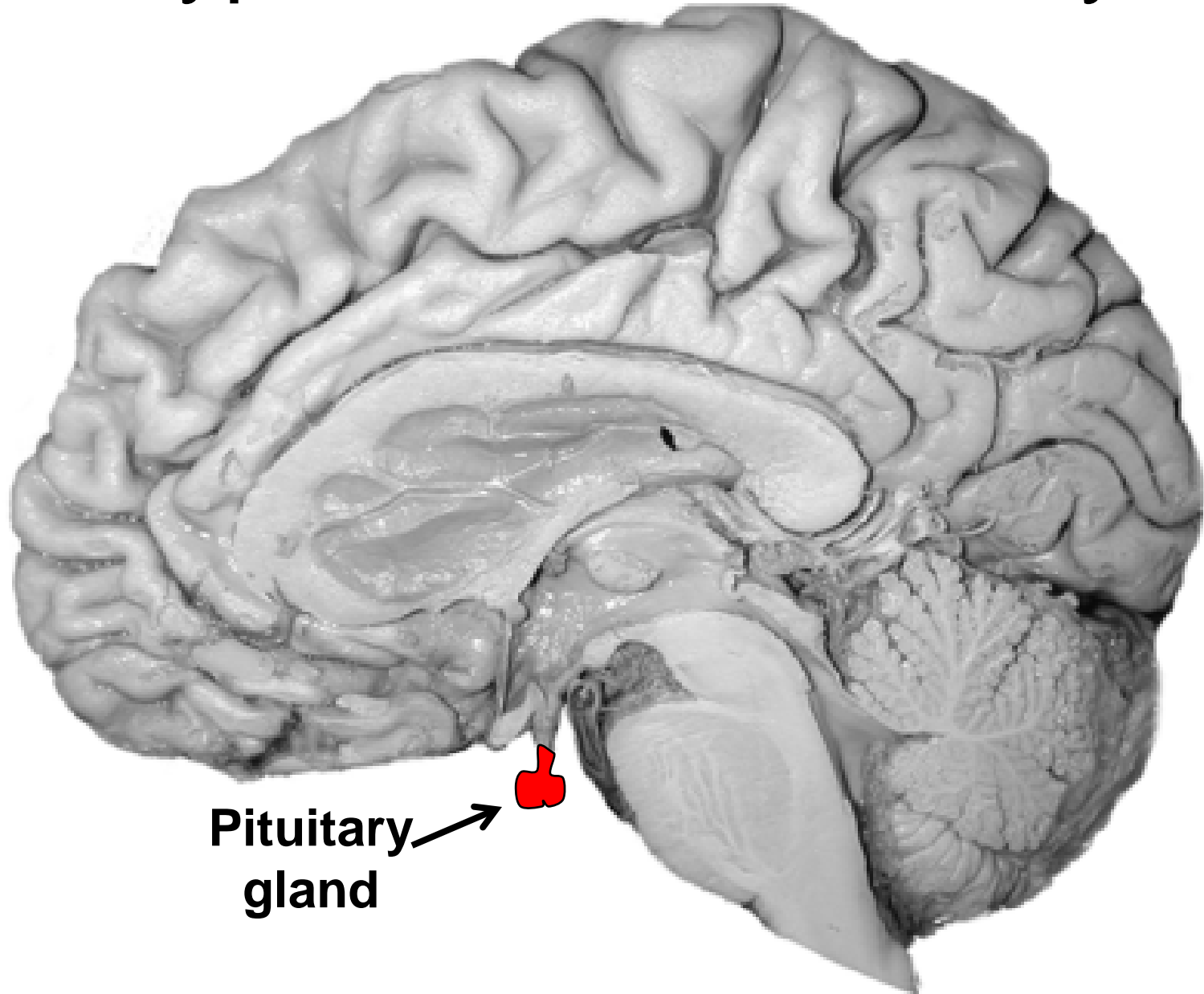
Summary: You can't live without a hypothalamus.

- Located at the junction between the brain stem and the forebrain
- Medial hypothalamus: interface between the brain and the endocrine system
 - Blood volume
 - Metabolic rate
 - Lactation
 - Stress
- Hypothalamus: major interface between the limbic system & the autonomic nervous system
 - Eating
 - Thermoregulation
 - Blood pressure
- Hypothalamus also sets our biological clock
 - Sleep/wakefulness

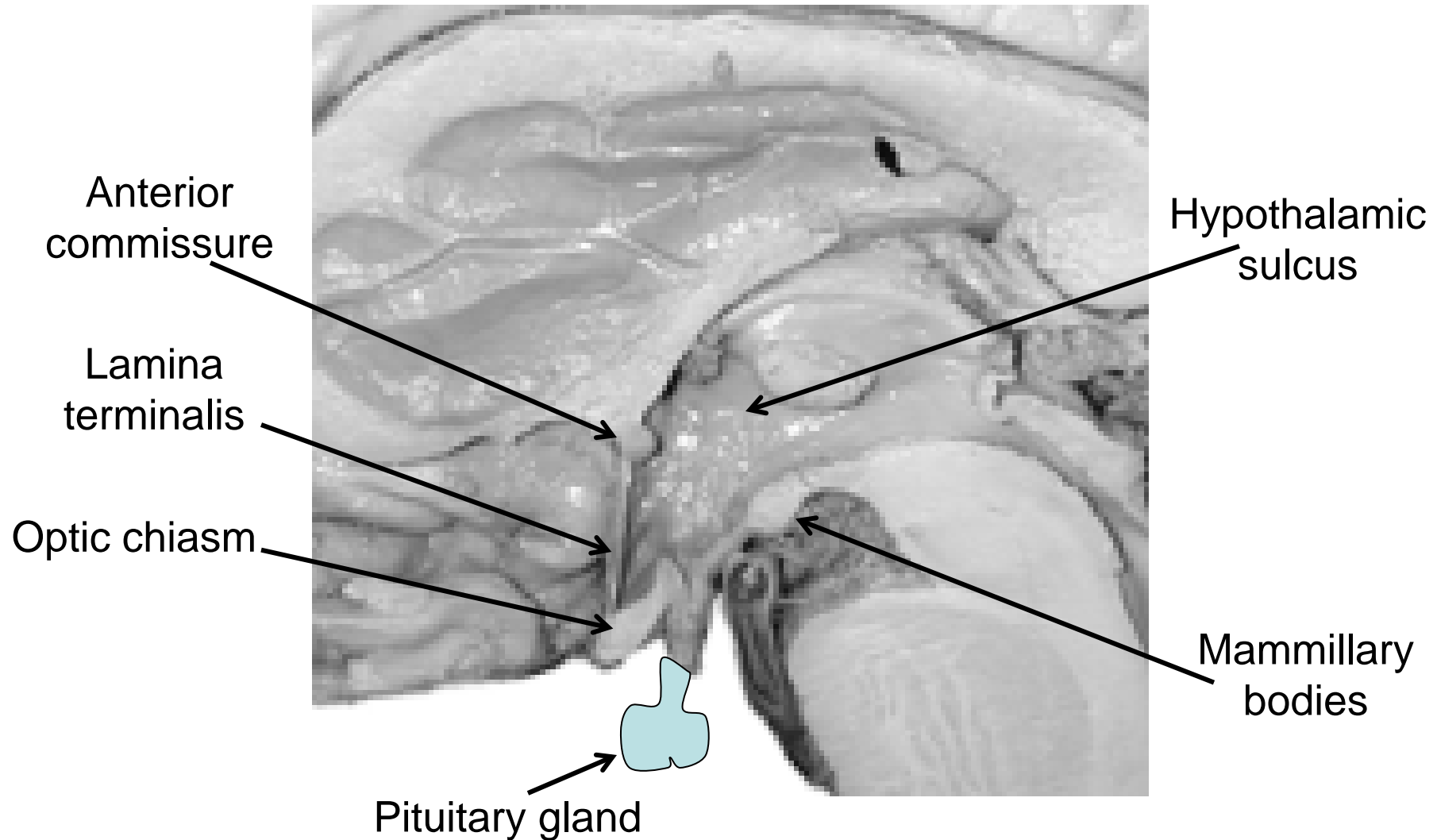
Hypothalamus: anatomy



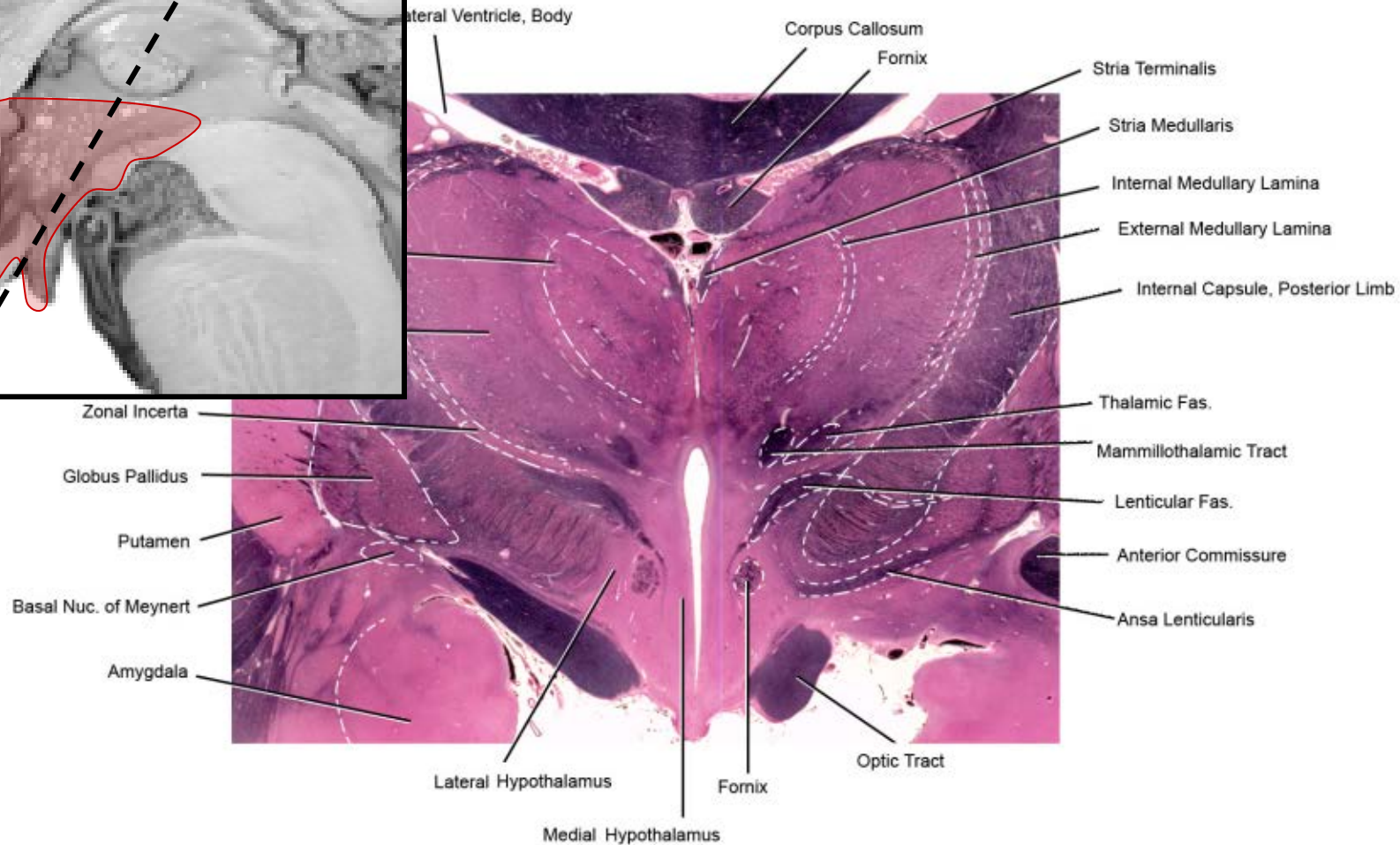
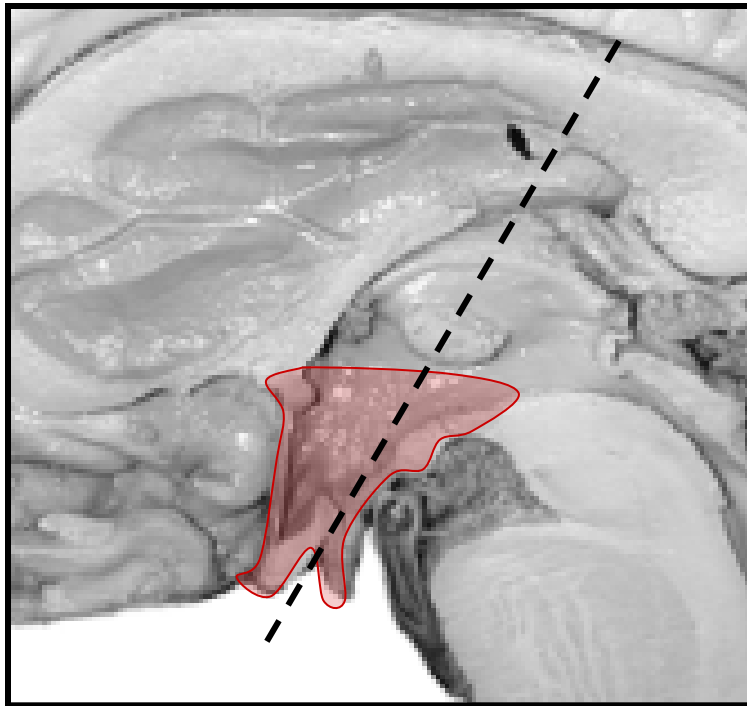
Hypothalamus: anatomy



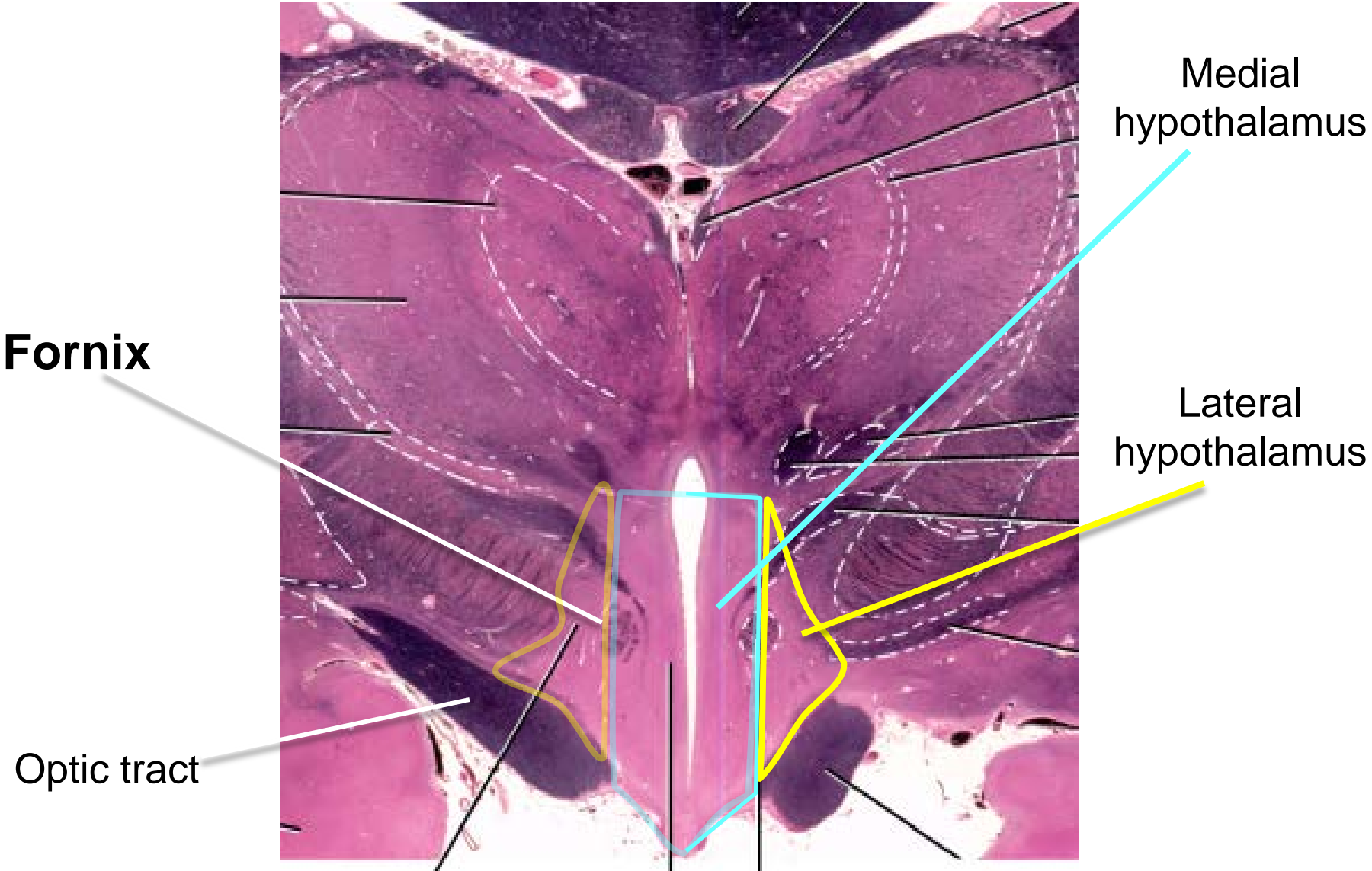
Hypothalamus: anatomy



Hypothalamus: anatomy



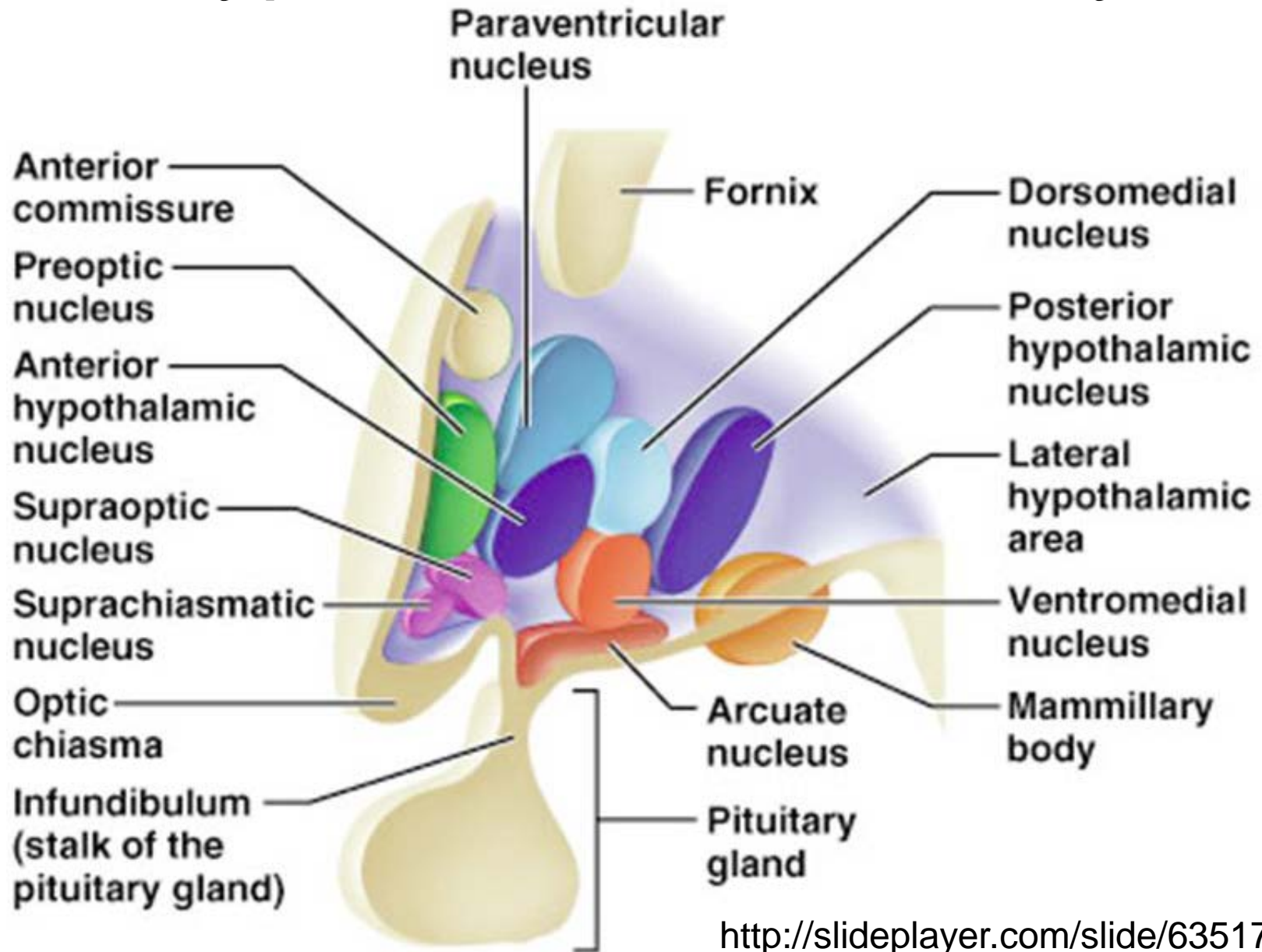
Fornix: medial vs. lateral hypothalamus



Inputs & outputs



Hypothalamus: anatomy



Hypothalamus as an endocrine organ

- Endocrine organs
 - Release hormones into blood
 - These hormones act on other tissues or organs
 - Insulin, adrenalin, cortisol, and thyroid hormone are all endocrine hormones

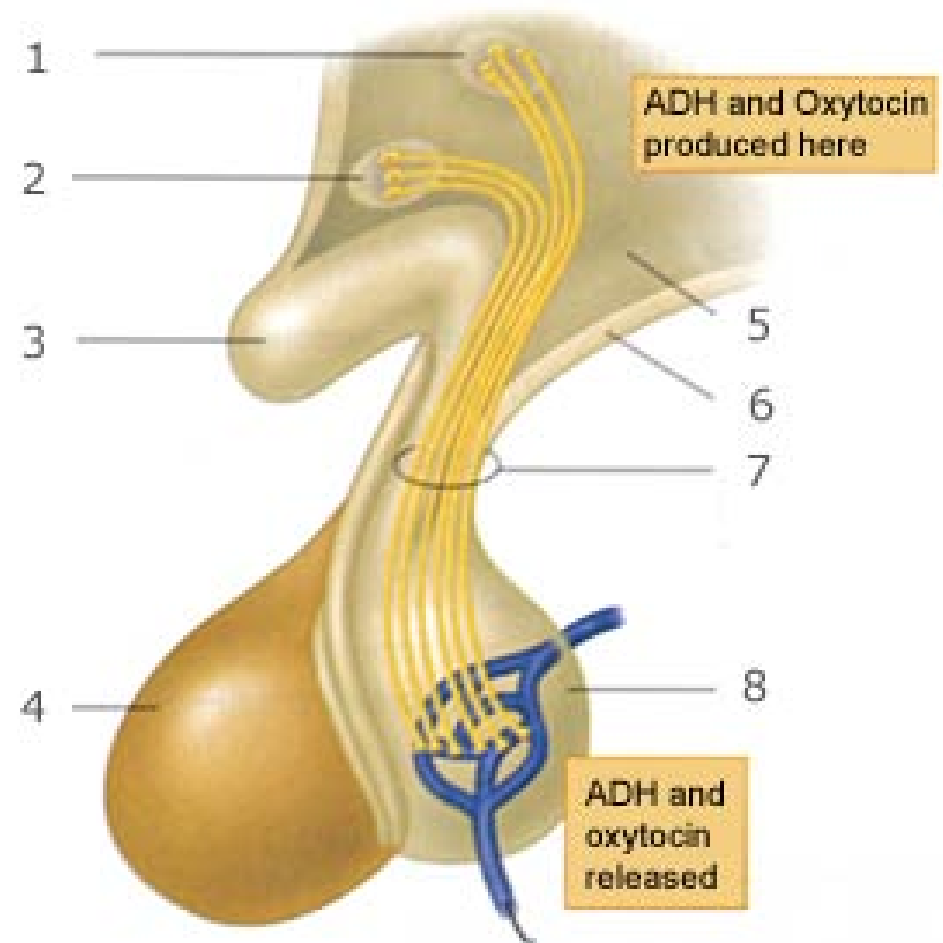


Hypothalamus as an endocrine organ

- Hypothalamus makes hormones that are released from the pituitary
 - Anti-diuretic hormone
 - Oxytocin
- Hypothalamus releases hormones that control the pituitary's release of other hormones
 - Thyrotropin-releasing hormone
 - Corticotropin-releasing hormone
 - Growth hormone-releasing hormone
 - Somatostatin
 - Etc.

Two hypothalamic hormones are released from the *posterior* pituitary

- Hypothalamus directly projects to ***posterior*** pituitary
 - Vasopressin (ADH)
 - Oxytocin
- Hormones made in cells in supraoptic n. & paraventricular n.
- Axons release these hormones into blood in posterior pituitary



Antidiuretic hormone (ADH; vasopressin)

- Increases blood volume
 - Decreases urine production by increasing reabsorption of water into bloodstream
- Made by magnocellular (i.e. big) neurons in supraoptic n. (**not** suprachiasmatic n. or preoptic n.) and also paraventricular n.
- Cells sense osmolarity (i.e. concentration of salt in blood): increased salt → increased firing
- *Release inhibited by ethanol*

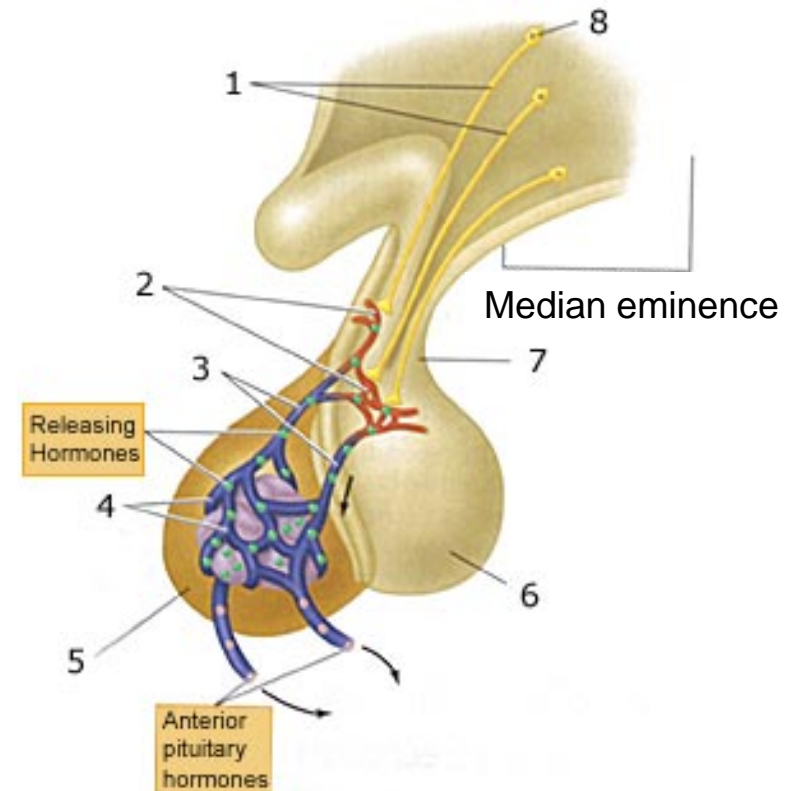


Oxytocin

- Reproduction: acts on uterus & breasts
 - Uterine contraction during birth
 - Milk ejection reflex
- “Love hormone”?
- More social bonding & empathy *within one’s group*
 - Increases trust; decreases fear; increases generosity
 - Promotes monogamous behavior in males
- Magnocellular neurons in supraoptic n. and also paraventricular n.

Hypothalamic hormones affect *anterior* pituitary's release of hormones

- Hypothalamic hormones made in arcuate n. & paraventricular n. (ventromedial hypothalamus)
- These hormones are released into ***hypothalamic-hypophyseal portal circulation***
- Blood carries hormones to pituitary → modulate release of pituitary hormones



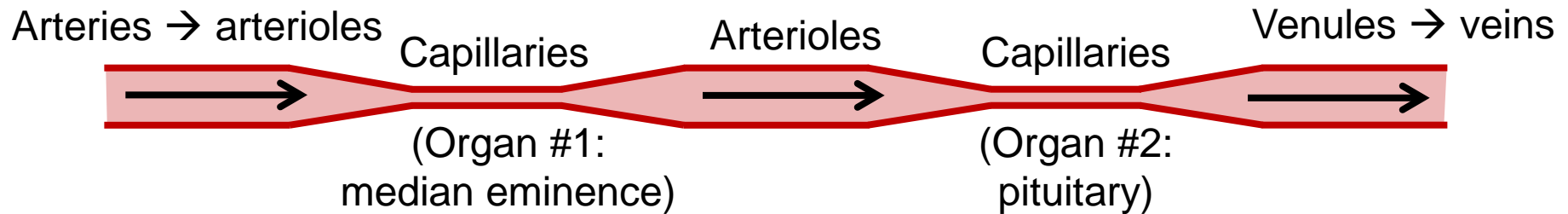
What is a “portal system”?

A “portal circulation” exists when a second capillary bed follows the first

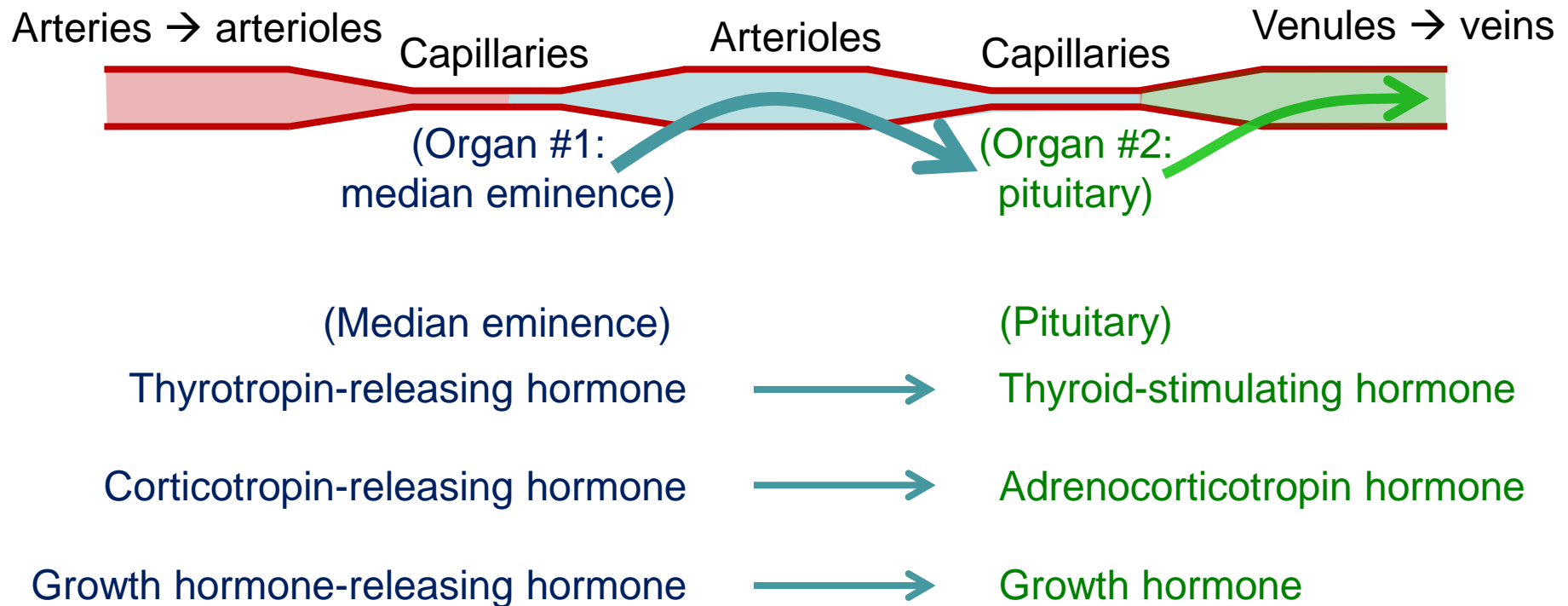
--Normal circulation supplies one organ



--A portal circulation supplies **two** organs

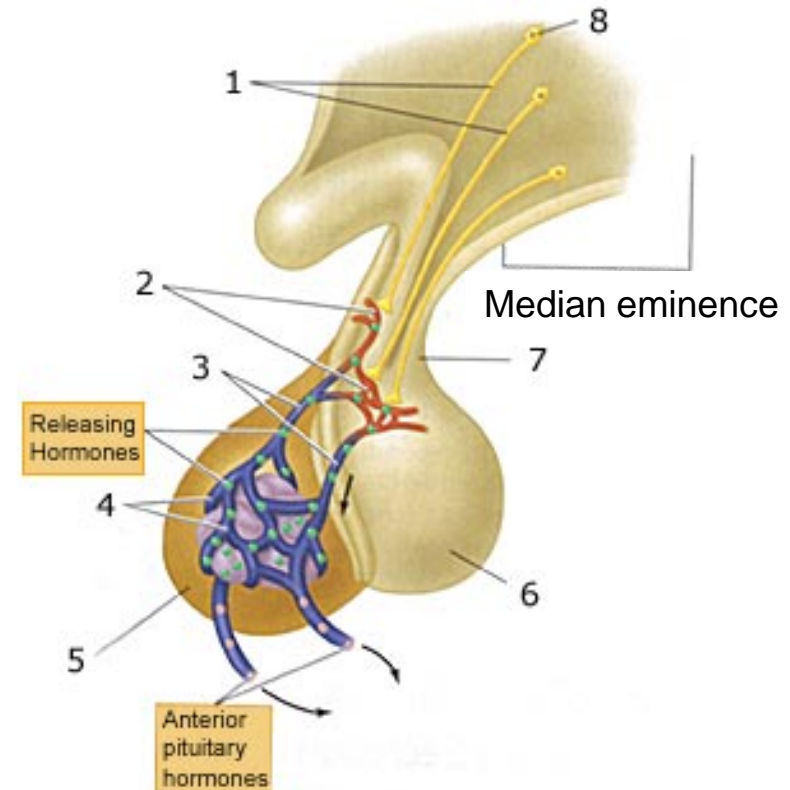


The hypothalamic-hypophyseal portal system carries *hypothalamic releasing hormones* to the pituitary



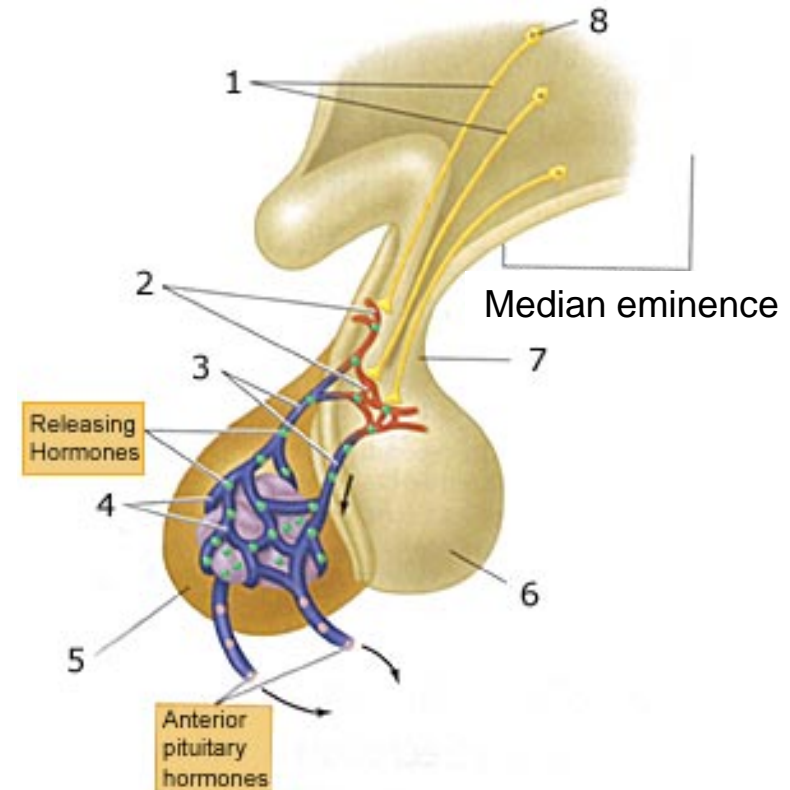
Thyrotropin-releasing hormone (TRH): release into portal system

- TRH is released from median eminence into portal circulation → anterior pituitary
- Causes release of thyroid-stimulating hormone
- Thyroid stimulating hormone → general circulation to thyroid
- Causes release of thyroid hormone → sets basal metabolic rate



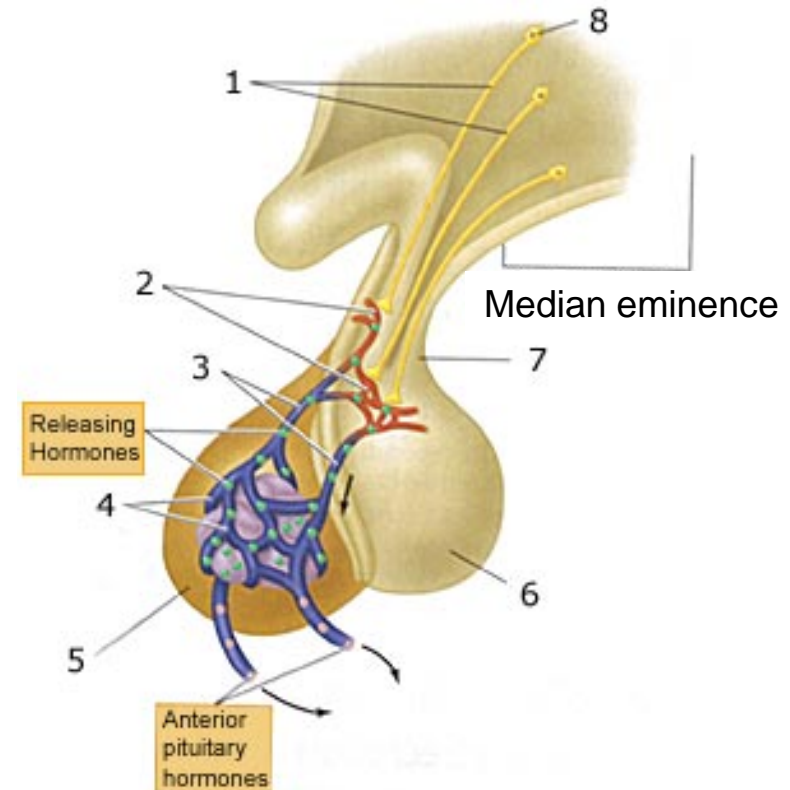
Corticotropin-releasing hormone (CRH)

- CRH is released from median eminence into portal circulation → anterior pituitary
- Causes release of adrenocorticotropic hormone (ACTH) in response to stress
- ACTH → general circulation to adrenal cortex
- Causes release of cortisol from adrenal cortex



Some hypothalamic hormones *inhibit* release: somatostatin

- Somatostatin is released from median eminence into portal circulation → anterior pituitary
- ***Inhibits*** release of growth hormone from pituitary
- Opposes action of growth hormone-releasing hormone



Regulation of endocrine function

- Feedback control of hormone synthesis:
 - Hormones may directly inhibit the synthesis or release of hypothalamic releasing hormones
 - Thyroid hormone decreases TRH
 - Cortisol decreases ACTH

Hypothalamus vs. pituitary: Keeping the hormones straight

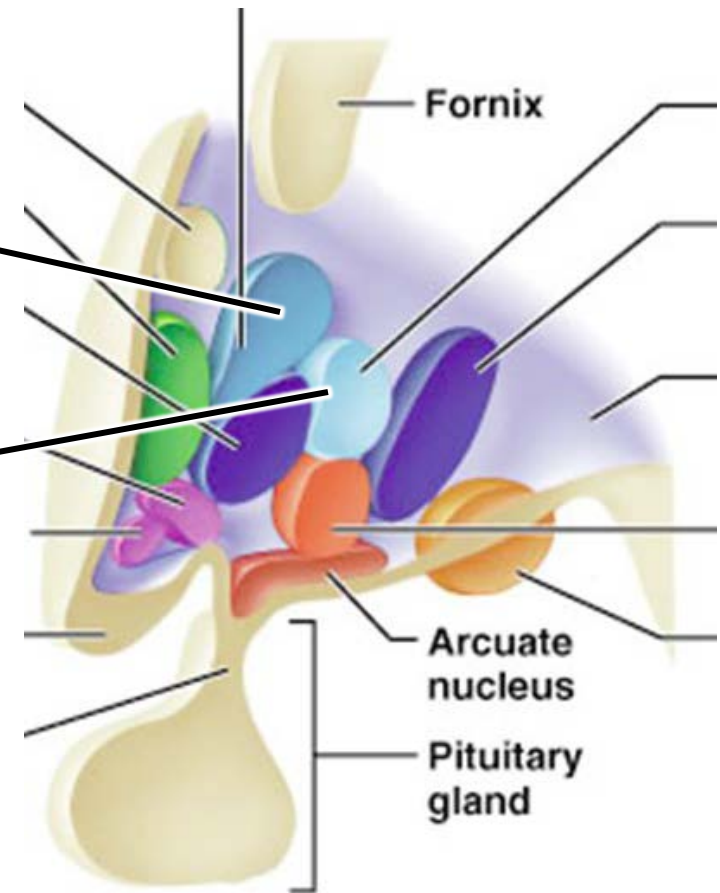
- Hypothalamic hormones: **hyphenated** (mostly)
 - Corticotropin-**releasing** hormone (CRH)
 - Thyrotropin-**releasing** hormone (TRH)
 - Growth hormone-**releasing** hormone (GH-RH)
 - **Exception**: somatostatin
- Pituitary hormones
 - Adrenocorticotrophic hormone (ACTH)
 - Thyroid stimulating hormone (TSH)
 - Growth hormone (GH)
 - Etc.

Hypothalamus & the autonomic nervous system

- Mediated through sympathetic & parasympathetic nervous systems
 - Blood pressure
 - Thermoregulation
- Autonomic effects not mediated directly through sympathetic or parasympathetic nervous systems
 - Feeding
 - Circadian rhythms

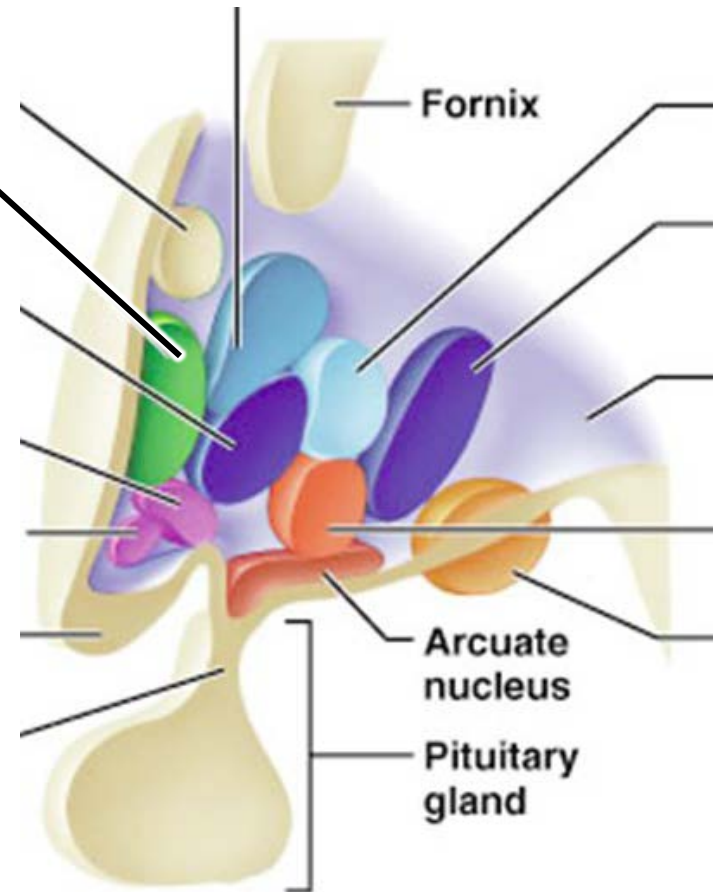
Blood pressure

- Paraventricular n. of hypothalamus *reduces long-term increases in BP*
- Dorsomedial n. of hypothalamus *increases BP and heart rate to stress: classic sympathetic effects*



Thermoregulation

- Preoptic nucleus of hypothalamus
 - 20% of preoptic neurons activated by warmth
 - Directly sensitive
 - Also receive input from skin
 - Firing reduces body heat
 - Activates vasodilation
 - Inhibits vasoconstriction
 - Ultimately activates sweating



Thermoregulation

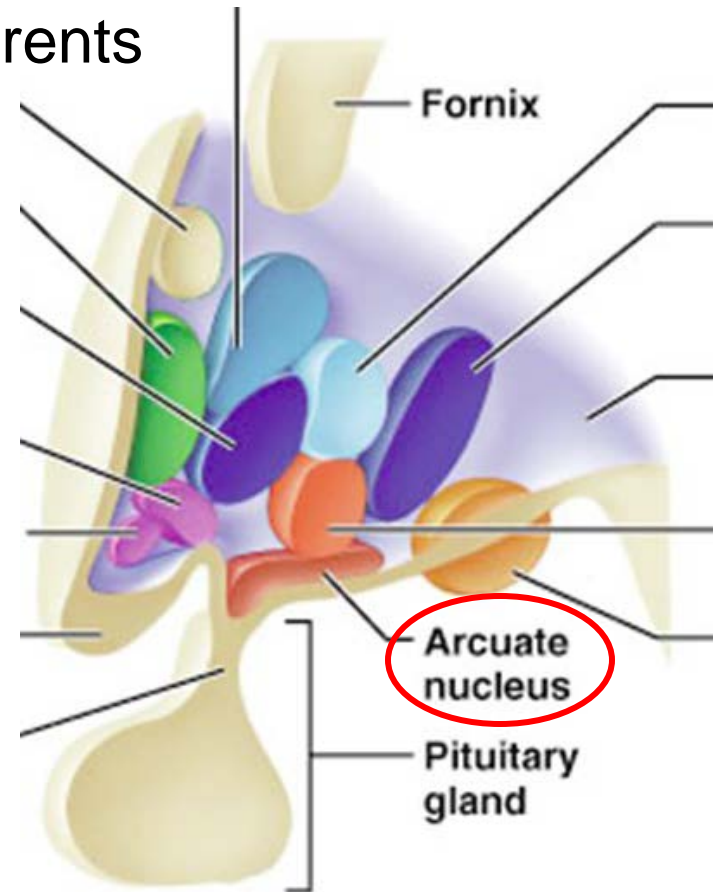
- Exposure to cold → hypothalamic activation of descending excitatory systems
 - Skeletal muscle activity → heat : shivering
 - Activation of sympathetic nervous system
 - brown adipose tissue (brown fat) → heat
 - “Non-shivering thermogenesis”

Eating

- Stimulation of lateral hypothalamus → eating
 - Lesions → aphagia (lack of eating)
- Stimulation of medial hypothalamus → decreased eating
 - Lesions → hyperphagia (excessive eating)

Eating

- Arcuate nucleus of hypothalamus responds to caloric intake
 - Receives input from visceral afferents
 - Responds to glucose; fatty acids
- Also responds to hormones
 - Leptin
 - Ghrelin





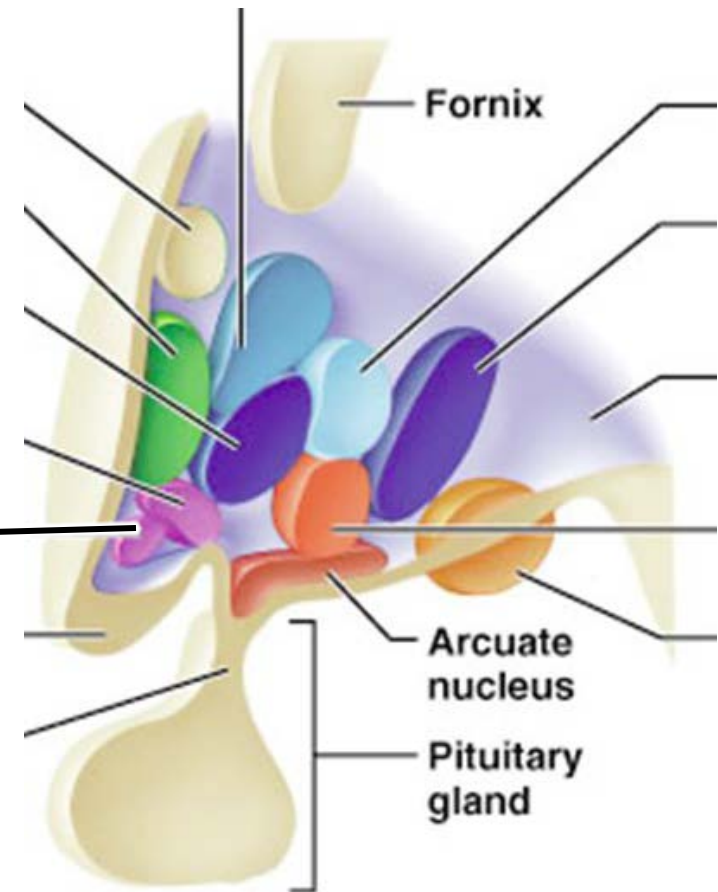
Eating

- Arcuate nucleus: receptors for leptin & ghrelin
 - Leptin: hormone secreted by white fat cells
 - Leptin levels = measure of stored energy
 - Inhibits hunger
 - Mutations → obese mice & humans + hyperphagia
 - Ghrelin: secreted by stomach when empty
 - Secretion increases with time after meal
 - Stomach filling inhibits secretion

Circadian rhythms

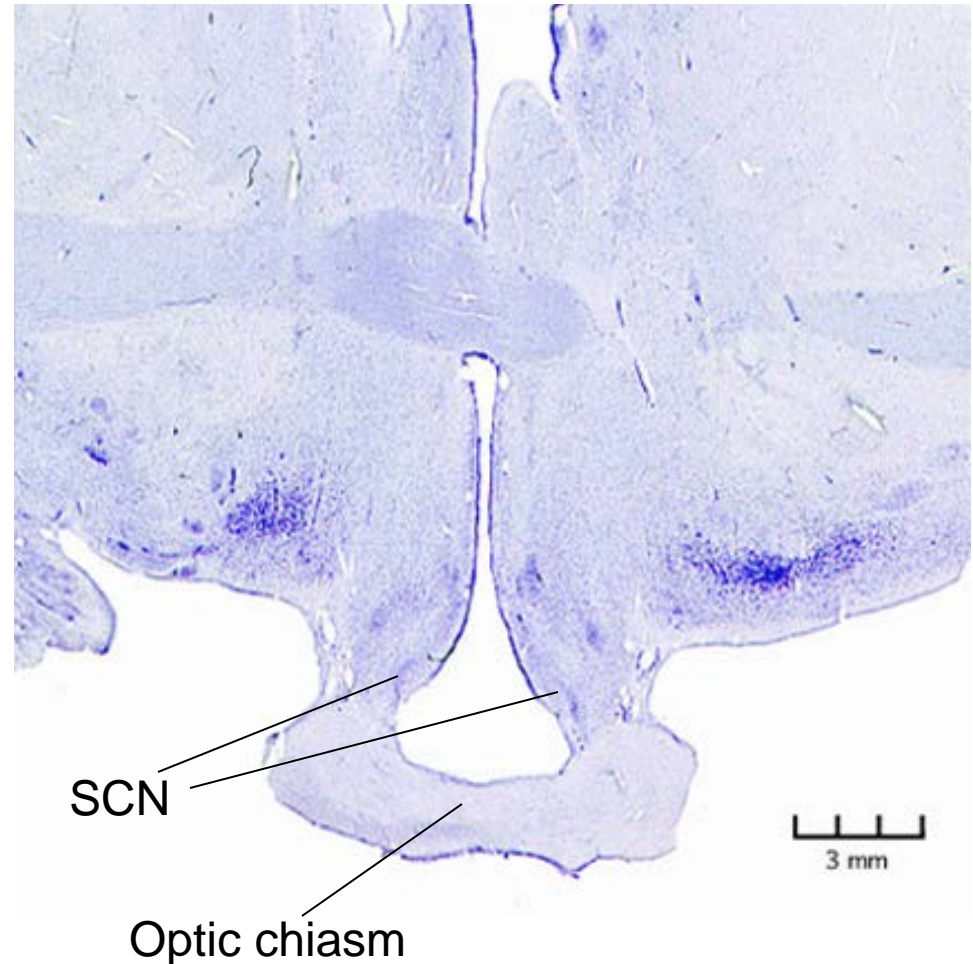
(Latin, “approximately a day”)

- Regulation of our daily rhythm
 - Eating
 - Sleeping
 - Defecating
 - Periods of activity
- Suprachiasmatic n. —————



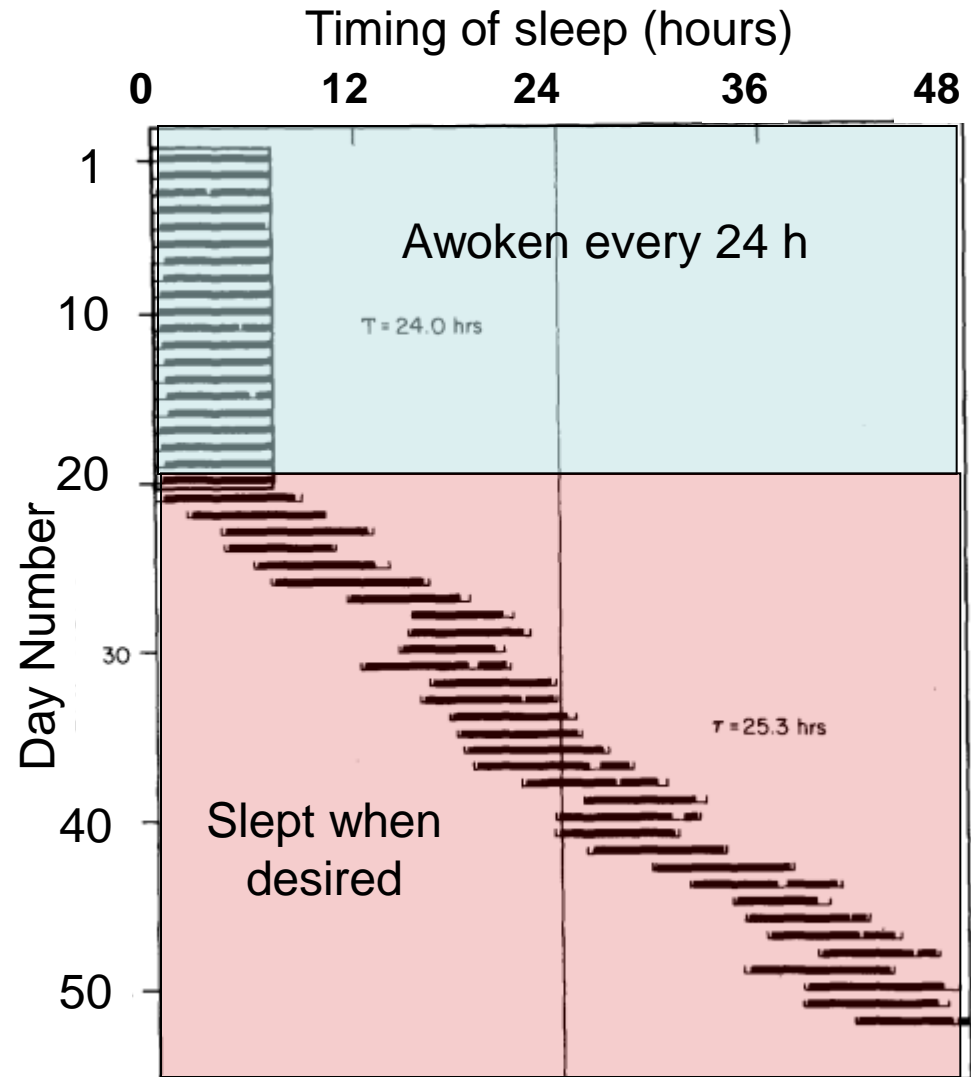
Circadian pattern generation

- Suprachiasmatic nucleus (SCN)
- **SMALL**: only 10,000 neurons
- “master clock”



Intrinsic circadian rhythm runs slow

- Laboratory experiment; 20- y.o. male
- With no light cues, 25.3 hr sleep cycle
- Similar intrinsic rhythm also seen in SCN tissue slices



Setting the circadian beat

- Light sets the circadian clock
 - Input from eyes: retino-hypothalamic pathway
 - Light-sensitive retinal ganglion neurons
- SCN expresses melatonin receptors
 - Melatonin is secreted by pineal
 - Secretion increases at night