

## Questions, chapter 25

Oxytocin  
Vasopressin (Anti-diuretic)

4) What hormones are secreted into the bloodstream in the posterior pituitary (neurohypophysis)? Give examples of hormones secreted in the anterior pituitary (adenohypophysis).

Gonadotrophins  
Growth hormone  
Adrenocorticotrophic hormone (ACTH)

5) What is diabetes insipidus?

Effects of damage to the stalk of the pituitary or to the neurohypophysis, blocking ADH secretion: Symptoms include polyuria and polydipsia.

\* 6) What homeostatic mechanisms are associated with the hypothalamus? (Give examples.)

# Hypothalamus: What functions?

- Control of autonomic nervous system and endocrine system
  - Sherrington's characterization: The hypothalamus is the "head ganglion of the autonomic nervous system".
  - Control of endocrine system *via* the pituitary
- **Homeostatic mechanisms** [*see Qs on the following slide*]
  - **e.g., temperature regulation with input from hypothalamic neurons that detect temperature of blood**
- Regulation of cyclic behaviors
  - Examples: Sleeping and waking, feeding, drinking, predatory attack
    - These behaviors fit into a daily cycle of activity
    - This activity cycle is regulated by the endogenous clock, synchronized by the daily light-dark cycle
  - These all show species-typical patterns.

# Questions on readings:

How do Nauta & Feirtag define homeostasis?

*See p. 113*

What is diabetes insipidus?

*See Brodal reading, p. 404*

# Hypothalamus: What functions?

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- **Regulation of cyclic behaviors**
  - **Examples: Sleeping and waking, feeding, drinking, predatory attack**
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# Hypothalamus functions, continued

- **Control of episodic behaviors**
    - **Agonistic** behavior (fighting, fleeing, defending)
      - Evolution of forebrain control because of an early importance of olfactory signals
    - **Reproductive** behavior: Sexual and parental
      - Regulated by hormones controlled by pituitary secretions
      - These secretions influence, and are influenced by, hypothalamus
  - Thus, the hypothalamus acts as the “center” for basic drives.
    - In Swanson’s characterization, the hypothalamus contains neuronal groups situated at the top of a motor-system hierarchy—acting as central pattern controllers *via* connections with more caudal structures.
- [Class 15—see next slide]
- Its activity influences affects (feelings) and their expression in emotional displays.

# From class on motor systems:

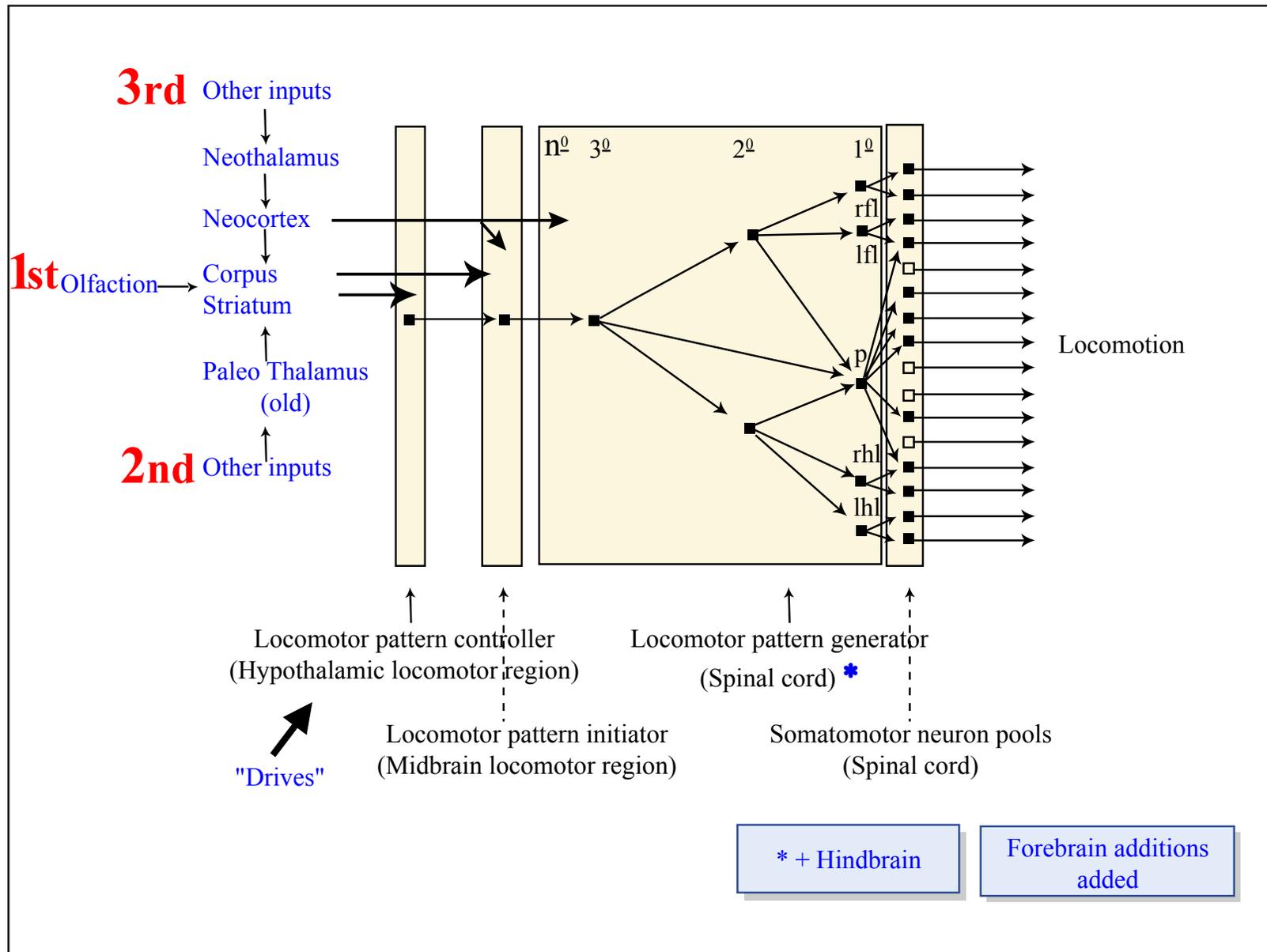


Image by MIT OpenCourseWare.

(Does neocortex really act independently of the biological drives?)

## Questions, chapter 25

- 7) Give specific examples of appetitive and of consummatory behavior. Which parts of the CNS would you expect to be strongly involved in the control of these two types of behavior?

# Limbic System

## *topics*

1. Two arousal systems in the midbrain:  
limbic and non-limbic
2. Hypothalamus: What specific functions?
- 3. Consummatory and appetitive behavior distinguished**
4. Feeding, hunger and other basic drives;  
electrically elicited aggression in cats
5. Drive and reward involve distinct axons.

# Consummatory and appetitive behavior distinguished *via* three types of studies

1. Effects of forebrain removals in cats and rats (“decerebration” experiments, mentioned earlier) *Ch. 7*
2. Effects of partial disconnection of forebrain motivation systems from more caudal mechanisms of Fixed Action Patterns (FAPs) *following slides*
3. Modeling the two types of mechanism in computational neuroethology *see following slides about simulation work by Blumberg + Yoon et al. at MIT.*

[ Advance 4 slides ]

**REVIEW:** *of ch 7*

## Complete forebrain removals or disconnections in cats and rats (“decerebration” experiments)

- Lack of normal appetitive behavior, with no seeking of food or a mate
  - Thus, there is a lack of spontaneous behavior
- They retain much consummatory behavior
  - Eating responses such as mouth opening, chewing and swallowing (in response to oral stimulation)
  - Pain-elicited aggressive responses
  - Sexual postures and reflexes

## x Partial disconnection of forebrain motivation systems from more caudal mechanisms of FAPs

- Large lesions of caudal midbrain in cats (*Walter Randall, 1964; findings that have been too much neglected*)
  - **Fragments of consummatory behavior are lost or abnormally organized.** The animals regulate their food intake, but prey-catching and eating became grossly abnormal.
    - Abnormally constant approach-to-prey behavior
    - Each mouthful of food treated as a prey-object (carrying with head held high, then “killing” bites)
    - Fishing behavior in response to empty bowl of water
    - No ambush positioning, pouncing; no grooming after eating; loss of normal searching, digging and scratching associated with elimination

x

# What was wrong with Randall's cats?

- Hypothesis: **lost higher control**
  - Forebrain systems (of drives) normally act as patterning systems, altering the relative dominance of various response systems. This control is disturbed. *depending on levels of motivations*
  - Another way to see it: A behavioral pattern controller has been partially disconnected from a midbrain pattern initiator (Swanson).
- These are two ways to conceptualize the same hypothesis.
  - The first stresses an organizing aspect of motivation systems. (To the extent that the organization is learned, it is very likely that it involves the corpus striatum as well.)
  - The second comes from the diagram of the hierarchy of motor control systems.

x

## Modeling appetitive and consumatory behavior mechanisms in computational neuroethology

- Simulations of cockroach neural control of feeding (Randall Beer, 1990)
  - Distinct appetitive and consummatory components
- Synthetic characters: MIT projects inspired by ethology and the anatomy of the limbic system
  - B. **Blumberg**, 1994-2004 at MIT Media Lab
  - S.-Y. Yoon: “Affective synthetic characters” (2000)
    - Active screen characters that are not simply animated cartoons
    - They have drives that build up over time and activate appetitive behavior (locomotion, searching).
    - Specific stimuli trigger consummatory behaviors.
    - Characters show habit learning and acquisition of “affective tags”.
      - Specific stimuli become associated with “good” or “bad” affects; this changes future responses to them.
  - The characters are very human-like or animal-like, despite a lack of most abilities that can be defined as cognition.

## **Simulation of motivated behaviors:**

*The logic of the software mimics the logic of neuroanatomical circuitry*

Figure removed due to copyright restrictions.  
Please see: Yoon, Song-Yee, Robert C. Burke, et al. "Interactive Training for Synthetic Characters." *AAAI/IAAI 2000* (2000): 249-54.

# Personality traits in synthetic screen characters

Trucker

Salesman

Dude

Figure removed due to copyright restrictions.

Please see: Yoon, Song-Yee, Robert C. Burke, et al. "Interactive Training for Synthetic Characters." *AAAI/IAAI 2000* (2000): 249-54.

Distinct personalities determined by parameter settings in simulated drives.  
Perception of distinct personalities verified by experiment.

# Limbic System

## *Topics*

1. Two arousal systems in the midbrain:  
limbic and non-limbic
2. Hypothalamus: What specific functions?
3. Consummatory and appetitive behavior distinguished
4. **Feeding, hunger** and other basic drives;  
electrically elicited **aggression** in cats
5. Drive and reward involve distinct axons.

## Questions, chapter 25

8) Where would you expect hunger and satiety cues to influence the CNS? Why?

# The motivational state underlying feeding

- **If midbrain is highest level of CNS:**
  - Eating reflexes & consummatory patterns, but little regulation
    - Whether starved or full of food, same responses of chewing, licking, swallowing
  - No hunger or satiety
  - No active seeking of food (No appetitive behavior)
- **Therefore:** forebrain mechanisms appear to be critical for normal motivational control

# Feeding regulation in brief

- Normal vs. anencephalic infants:
  - Both eat reflexly (rooting, sucking, swallowing)
  - Only the normal babies show satiety, by responding to stomach distention
- Inputs to hunger drive mechanism of hypothalamus\*: Multiple cues for hunger and satiety

\* *Some studies have implicated subthalamic involvement as well.*

x

## Feeding regulation in brief, *continued*

- Inputs to hunger drive mechanism of hypothalamus: Multiple cues for hunger and satiety
  - Inputs through the vagus nerve (10<sup>th</sup> cranial nerve), e.g.,
    - Mechanoreceptor inputs
      - Stomach distention
      - Throat sensations
  - Factors in blood, detected by hypothalamic neurons
    - Blood sugar level (not as significant as some texts imply)
    - Other blood factors
- What these various inputs accomplish: Short-term and long-term regulation of feeding.
  - Short-term: How long do I eat, how much do I eat
  - Long-term: Total food intake in a day

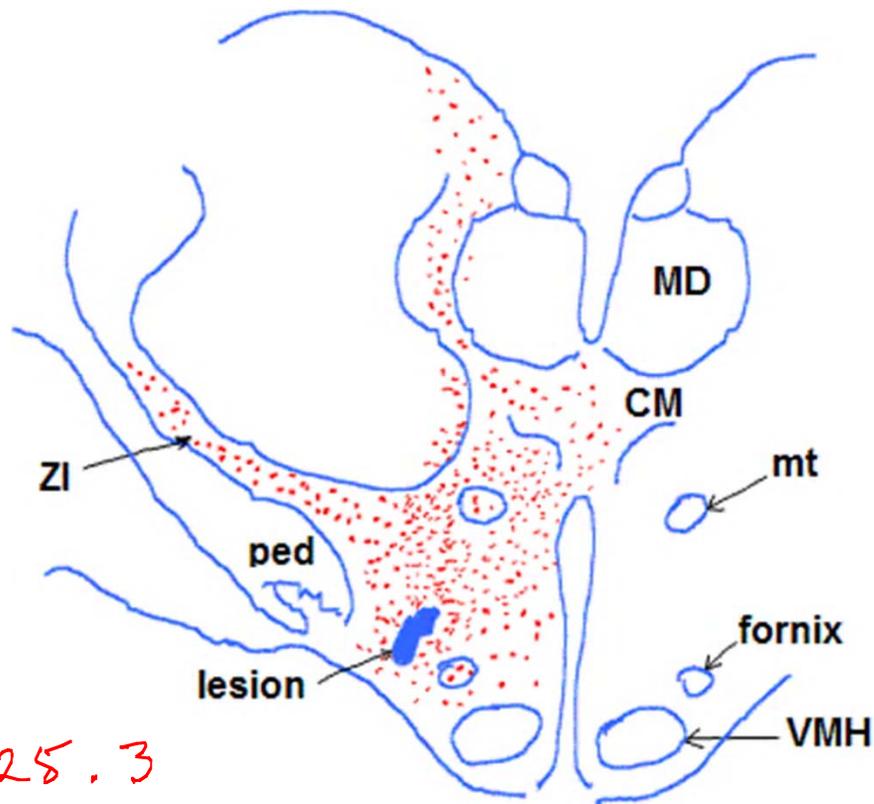
# Electrically elicited drive states

- **Hunger** can be elicited in satiated rats by electrical stimulation of some points in the lateral hypothalamus.
- **Other motivational states** can also be elicited:
  - Chicken studies by von Holst and von St Paul
  - Cat studies at Yale by J.P. Flynn et al., using **electrically elicited aggression, especially predatory aggression**
  - Many other examples have been found, especially in studies of rats, e.g., a drive for gnawing.

Some neuroscientists now reject such studies because of their lack of specificity. However: 1) A mixture of drives is what animals normally experience. 2) The behavioral results speak for themselves.

## Questions, chapter 25 (continued)

- What recently developed technique is replacing the use of such electrical stimulation using electrodes? *Optogenetics*
  - What are its advantages? *High specificity is possible, with restriction of activation to certain neurons*
- 9) What evidence indicates that attack motivation in cats is separate from hunger?
- Evidence of very different goals.  
e.g., mouse vs. tuna fish in dish.*



**Site in cat hypothalamus where electrical stimulation causes mood of predatory attack**

Note: The labeled axons are certainly not all involved in predatory attack.

Fig 25.3

Courtesy of MIT Press. Used with permission.  
 Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.

**Lesion at electrode tip caused degeneration of axons from the area around the stimulation site, and their terminals. Axonal projections go to subthalamus and “old thalamus.”**

**The old thalamus includes the midline nuclei—sources of widespread projections to thalamus and to cortex. It also includes the intralaminar nuclei, which project to both corpus striatum and neocortex.**

# In the well-studied case of predatory aggression in cats, how critical is the hypothalamus?

Experiments used hypothalamic or midbrain stimulation to elicit the mood of predatory attack:

- Experiments with circumsections of hypothalamus (severing its connections with lower structures) show that **stimulation of midbrain limbic structures (CGA) is sufficient** to elicit the attack.
- **But** without the hypothalamus there is reduced initiation of the behaviors,
- and presumably less modulation (regulation) by forebrain activities.

# Limbic System

## *topics*

1. Two arousal systems in the midbrain:  
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electrically elicited aggression in cats
5. **Drive and reward involve distinct axons.**

*reading only*

# Drive and reward involve distinct axon populations

- Separation of axon populations in the medial forebrain bundle, passing through lateral hypothalamus.
  - Use of differences in refractory period for different sizes of axons (by Deutsch *et al.*)
- RESULTS:
  - **Drive:** due mainly to descending connections
  - **Reward:** Positive reward depends heavily on dopamine-containing axons projecting forward from the midbrain.
  - The two axon populations are of different size, and hence they have different refractory periods.

# **A sketch of the central nervous system and its origins**

G. E. Schneider 2014

## **Part 9: Hypothalamus & Limbic System**

**MIT 9.14 Class 28**

**Core pathways of the limbic system,  
and remembering meaningful places**

(Limbic system 2)

*Chapter 26*

# Limbic system structures

## *Topics*

- today → • Hypothalamic cell groups
- “Papez’ circuit” and the limbic endbrain
- The various structures of the limbic system
- Connections between limbic and non-limbic system structures
- Limbic forebrain activity and mental states
- Review of some major pathways

## Questions, chapter 26

- 1) The hypothalamus has two major divisions, medial and lateral. What is a major difference between these two divisions?

*Medial: various distinct cell groups seen in histological sections. No obvious bundles of long axons*

*Lateral: Axons of medial forebrain bundle throughout. Neurons scattered among these axons.*

# Hypothalamic cell groups

*Per Brodal's chapter 19: questions; discussion*

- Which major hypothalamic division can be divided into multiple distinct nuclei?
  - This was done, for example, by Le Gros Clark in 1936: see next slide.
  - See also Larry Swanson's more detailed figure 6.11
  - Comparison of human with rat/mouse/hamster *next slides*
- How can the remainder of the hypothalamus be characterized? *(see previous slide)*

# Cell groups of the human medial hypothalamus

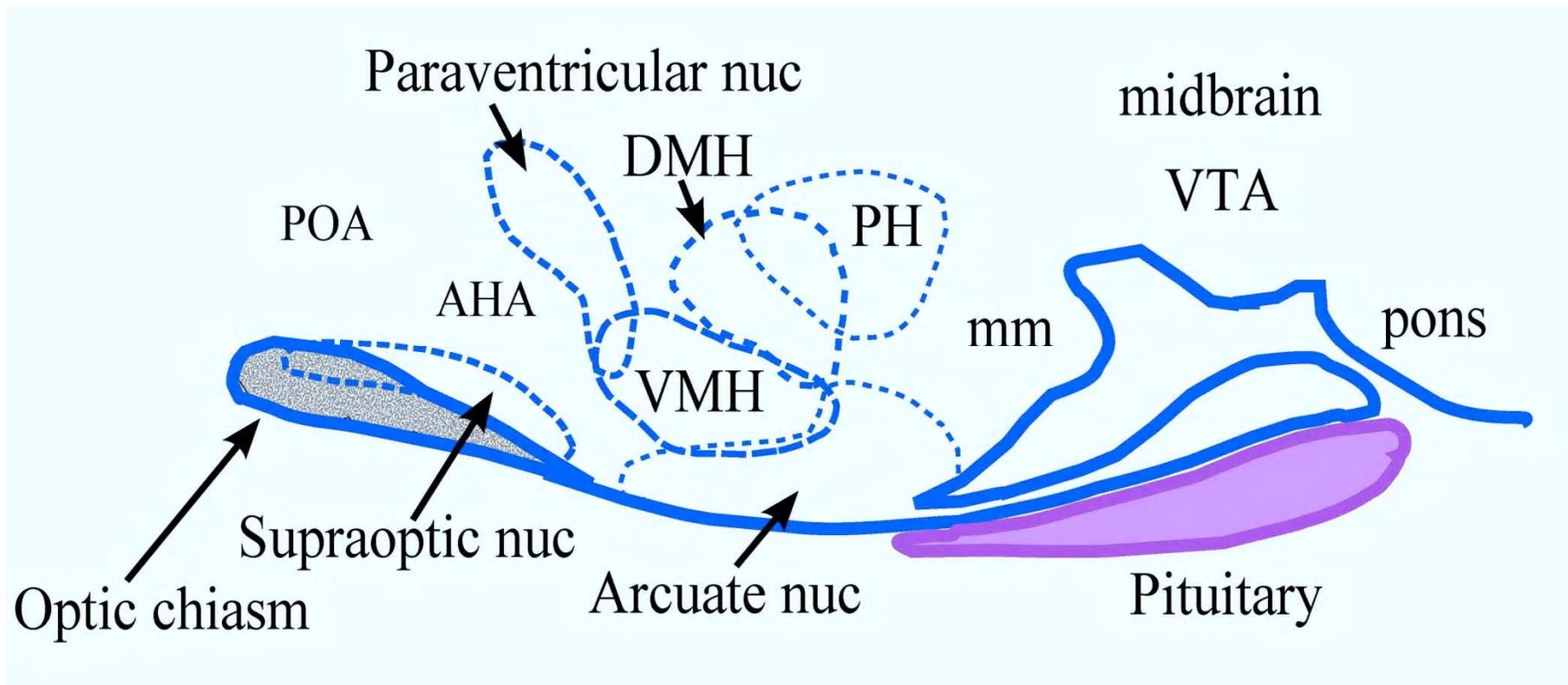
Figure removed due to copyright restrictions.

Please see:

Clark, WE Le Gros. "The Topography and Homologies of the Hypothalamic Nuclei in Man." *Journal of Anatomy* 70, no. Pt 2 (1936): 203.

“A diagram showing the hypothalamic nuclei projected on to the lateral wall of the third ventricle. This diagram has been made by taking a tracing from a photograph of the brain which was afterwards serially sectioned in a sagittal plane. The extent of the nuclei was reconstructed from the serial sections.” *From Le Gros Clark, 1936*

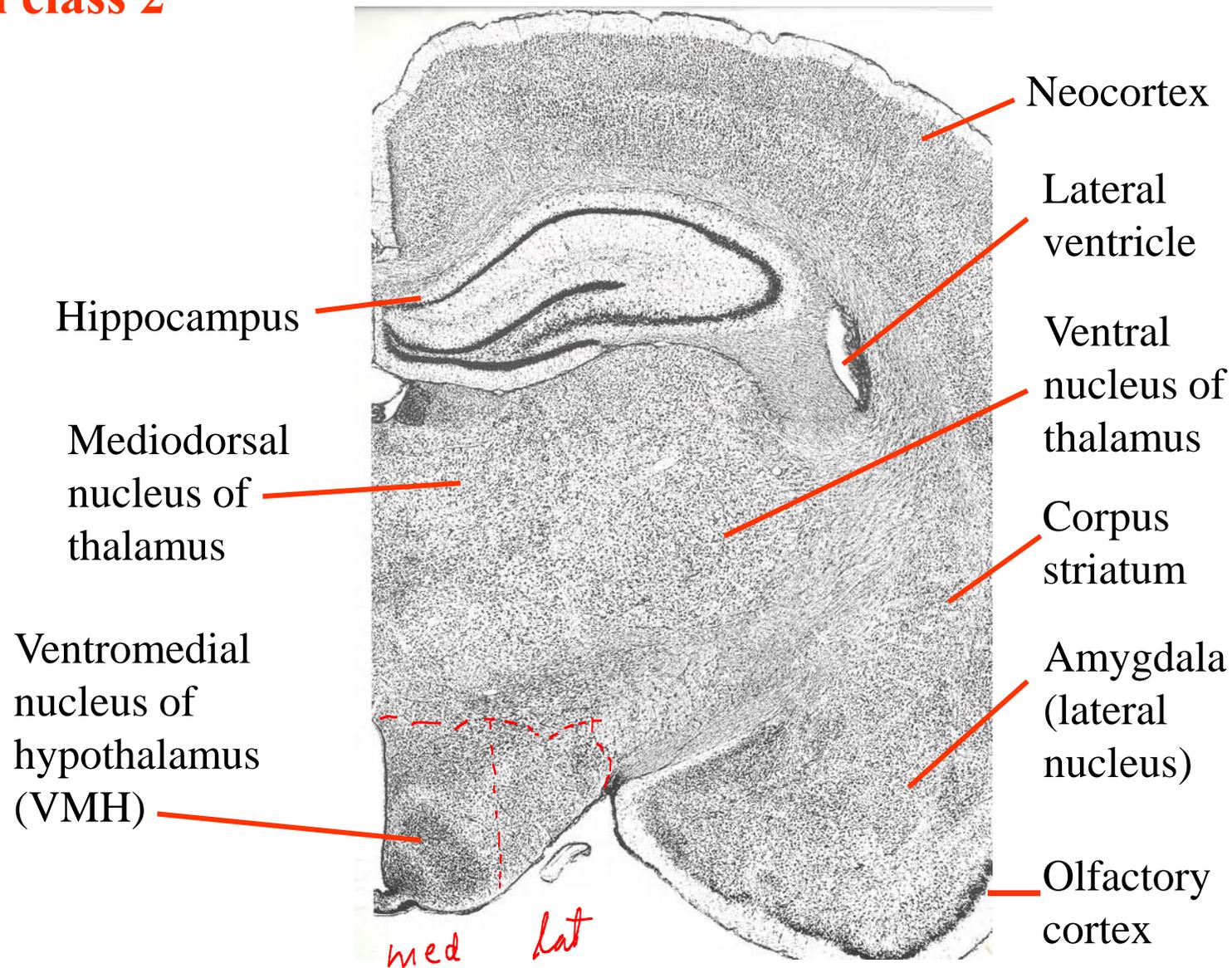
# Rat / mouse / hamster: Schematic parasagittal section



Courtesy of MIT Press. Used with permission.  
Schneider, G. E. Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind. MIT Press, 2014. ISBN: 9780262026734.

**Fig 26-2**

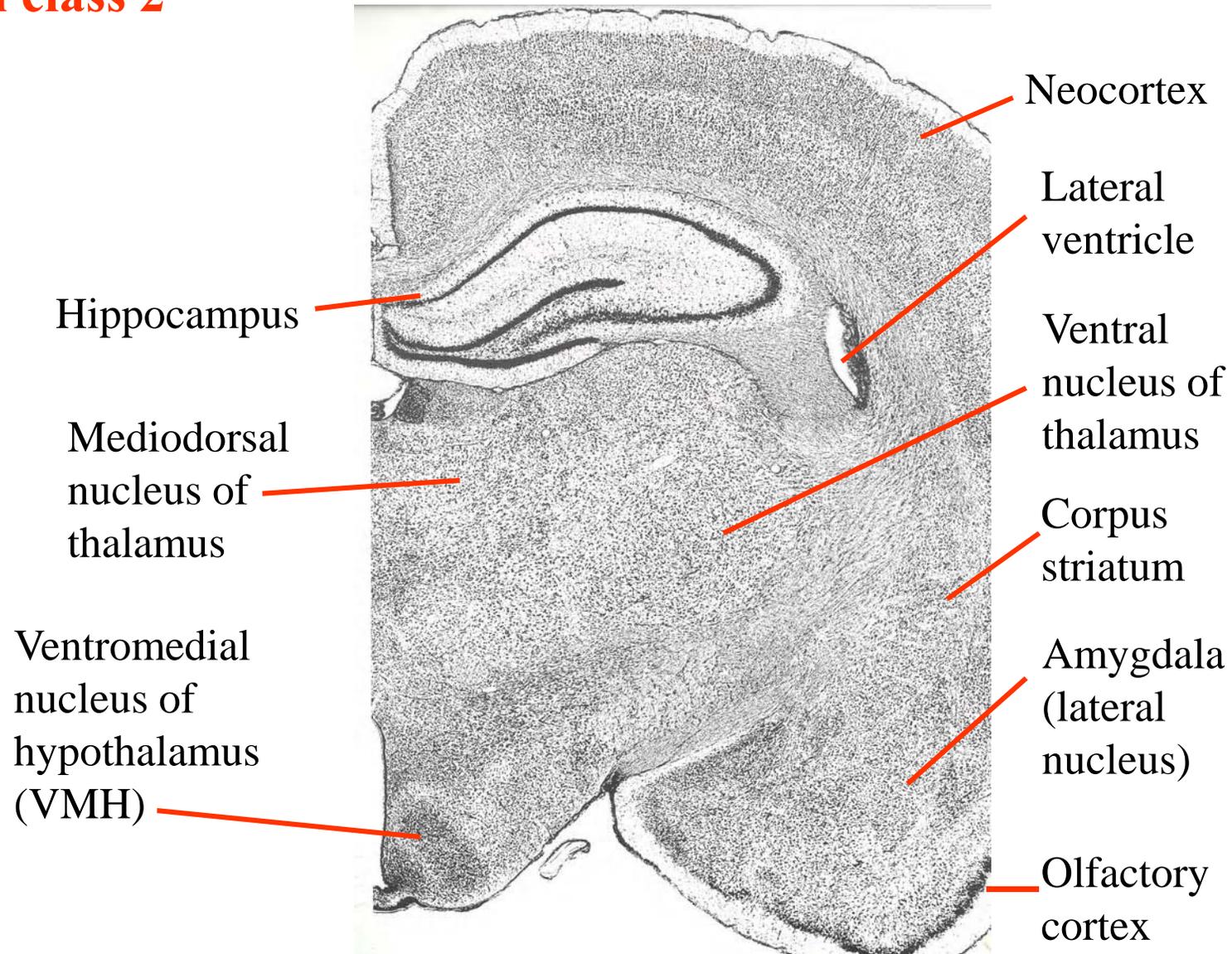
## From class 2



## Rat brain, coronal section, Nissl stain (cell bodies)

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## Questions, chapter 26

2) Information about the internal environment of the body reaches the hypothalamus via two major means. What are they?

1 via bloodstream

2 via sensory pathways

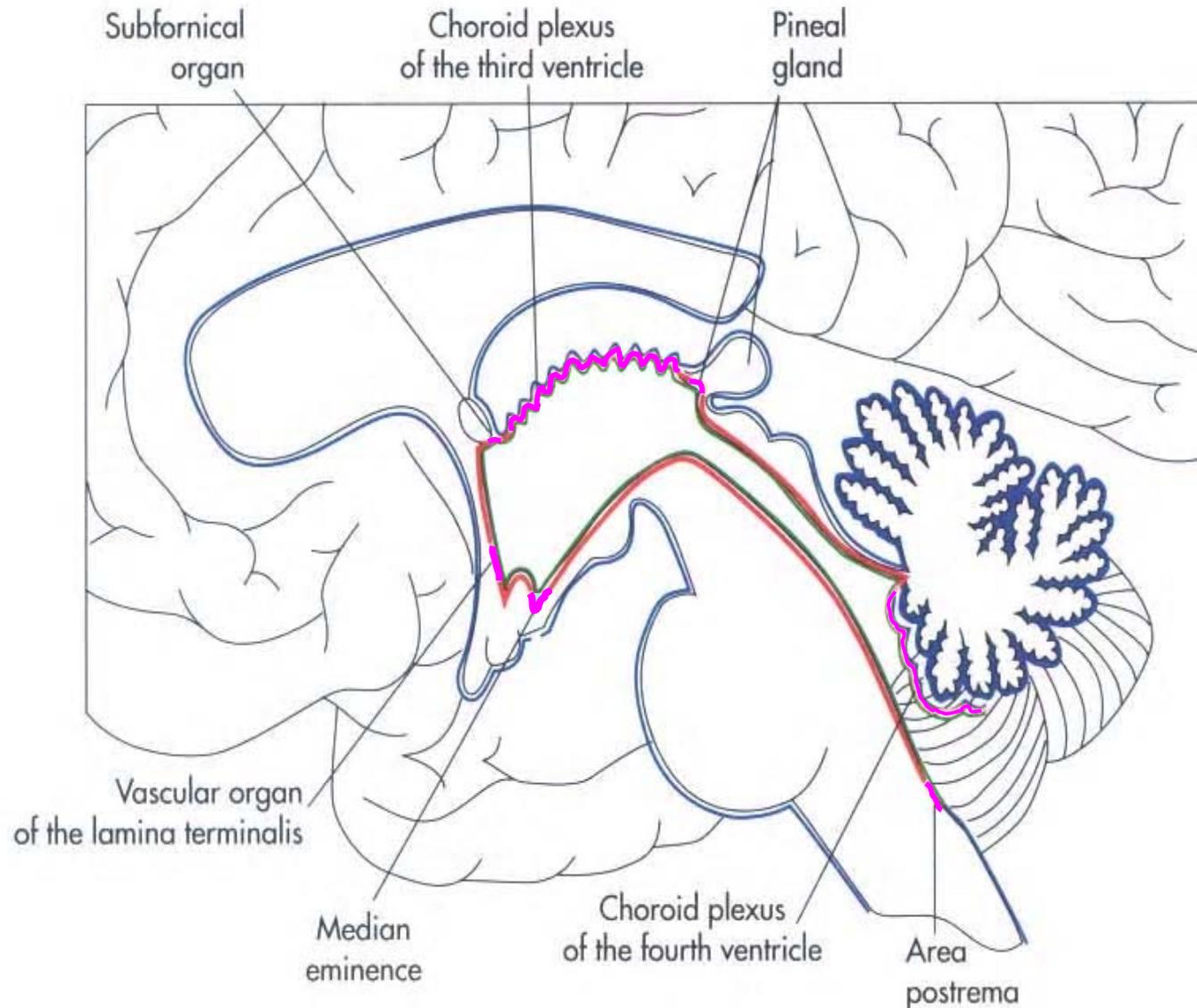
# Hormones and the blood-brain barrier:

## *Question on Brodal reading*

How can a circulating hormone like angiotensin II control hypothalamic neurons even though it does not pass through the blood-brain barrier?

*weak BBB or no BBB in specific regions:*

***See p 401 box. What is the subfornical organ?***



**Shown in pink: Sites in the walls of the third and fourth ventricles where a blood-brain barrier is lacking**

**Fig 26-3**

Courtesy of MIT Press. Used with permission.  
 Schneider, G. E. Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind. MIT Press, 2014. ISBN: 9780262026734.

# HRP, injected into the bloodstream, passes through leaky blood-brain barrier in the median eminence region of the monkey hypothalamus

Figure removed due to copyright restrictions.

Please see course textbook or: Broadwell, Richard D., Brian J. Balin, et al. "Angioarchitecture of the CNS, pituitary gland, and intracerebral grafts revealed with peroxidase cytochemistry." *Journal of Comparative Neurology* 260, no. 1 (1987): 47-62.

## Fig 26-4

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## 9.14 Brain Structure and Its Origins

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