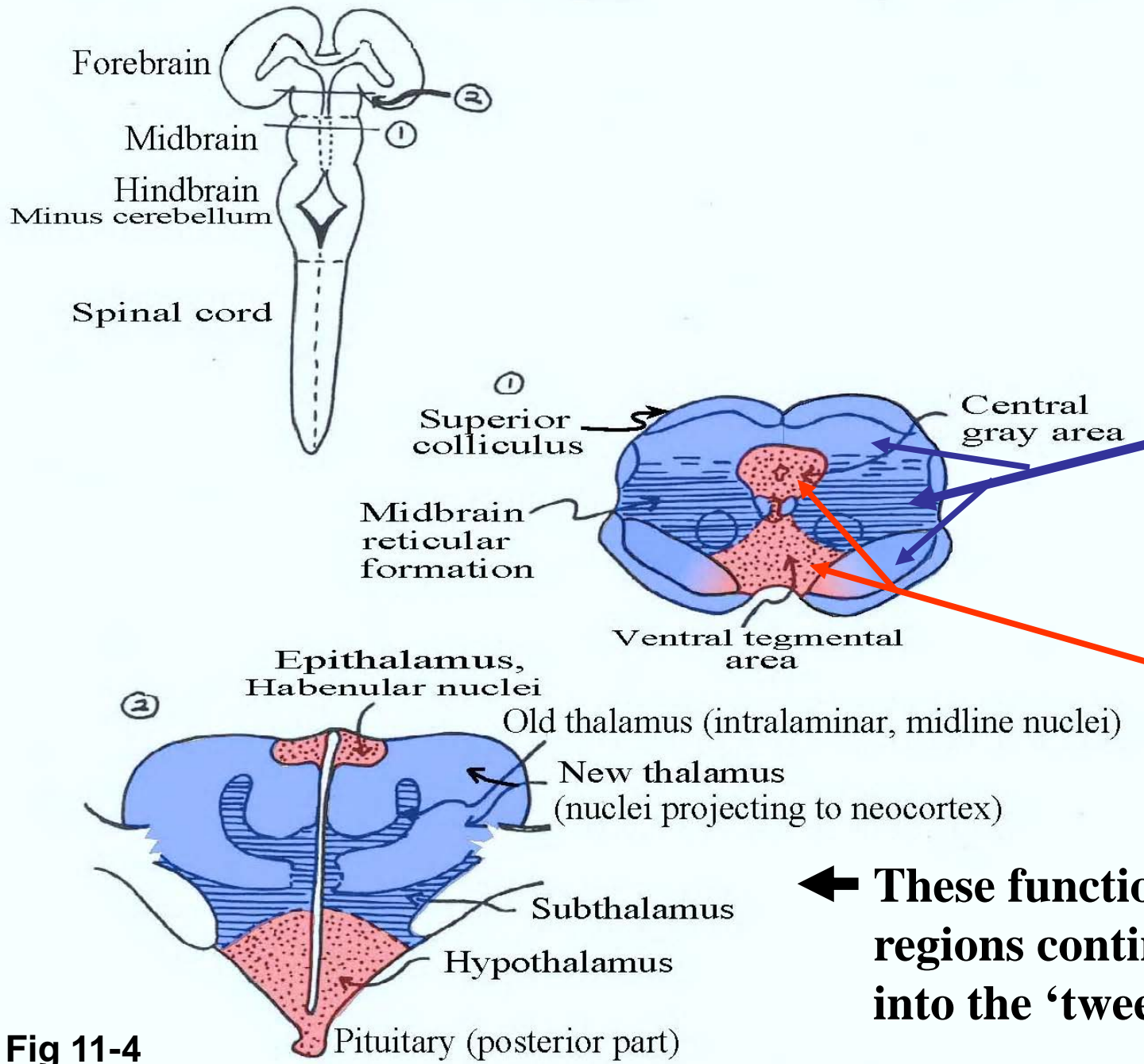


End Session II



Somatic regions

Limbic regions

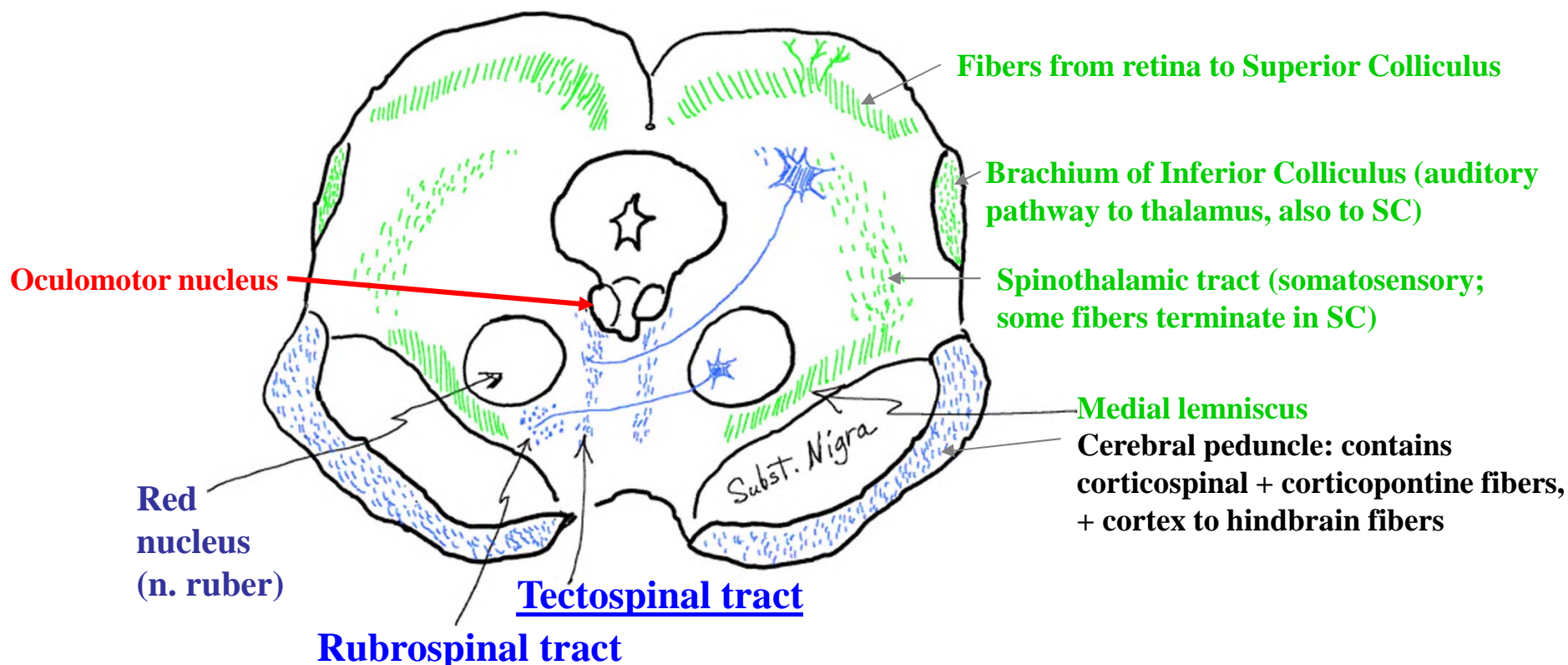
← These functionally distinct regions continue rostrally into the 'tweenbrain.

Fig 11-4

Chapter 11, questions about the somatic regions:

- 4) There are motor neurons located in the midbrain. What movements do those motor neurons control? (These direct outputs of the midbrain are not a subject of much discussion in the chapter.)
- 5) At the base of the midbrain (ventral side) one finds a fiber bundle that shows great differences in relative size in different species. Give examples. What are the fibers called and where do they originate?
- 8) A decussating group of axons called the brachium conjunctivum also varies greatly in size in different species. It is largest in species with the largest neocortex but does not come from the neocortex. From which structure does it come? Where does it terminate? (Try to guess before you look it up.)

Motor neurons of the midbrain that control somatic muscles: the oculomotor nuclei of cranial nerves III and IV. At this level, the oculomotor nucleus of nerve III is present.



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.

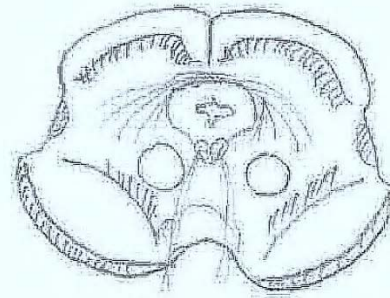
At more caudal midbrain levels, the trochlear nucleus of nerve IV is present.

Midbrain: Species comparisons

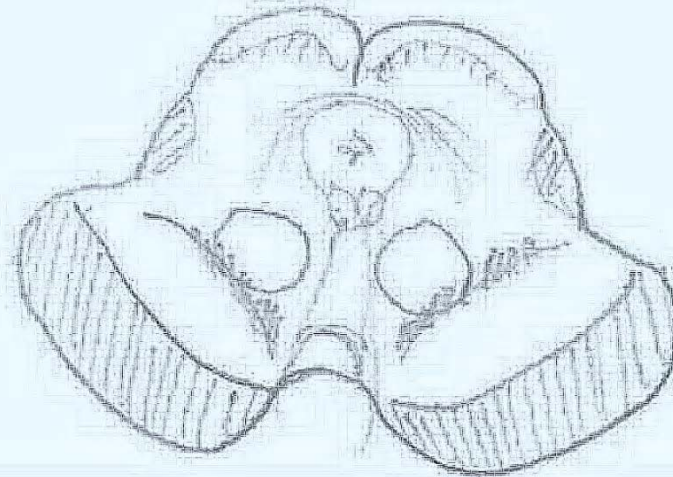
Note the great
differences in the size
of the cerebral
peduncles at the base
of the brain

(Sections are not
drawn to the same
scale)

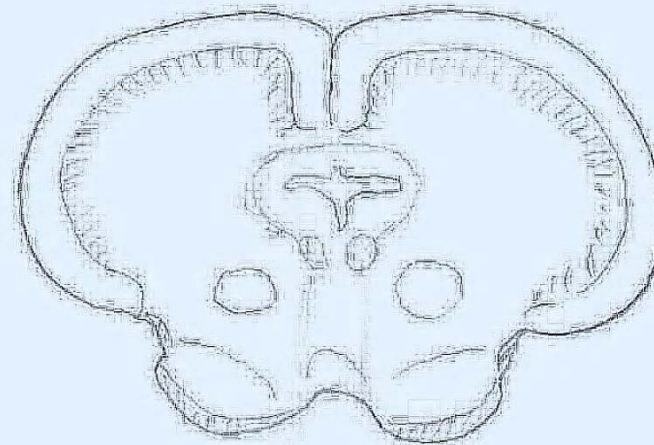
Fig 11-3



Rodent



Human



Tree

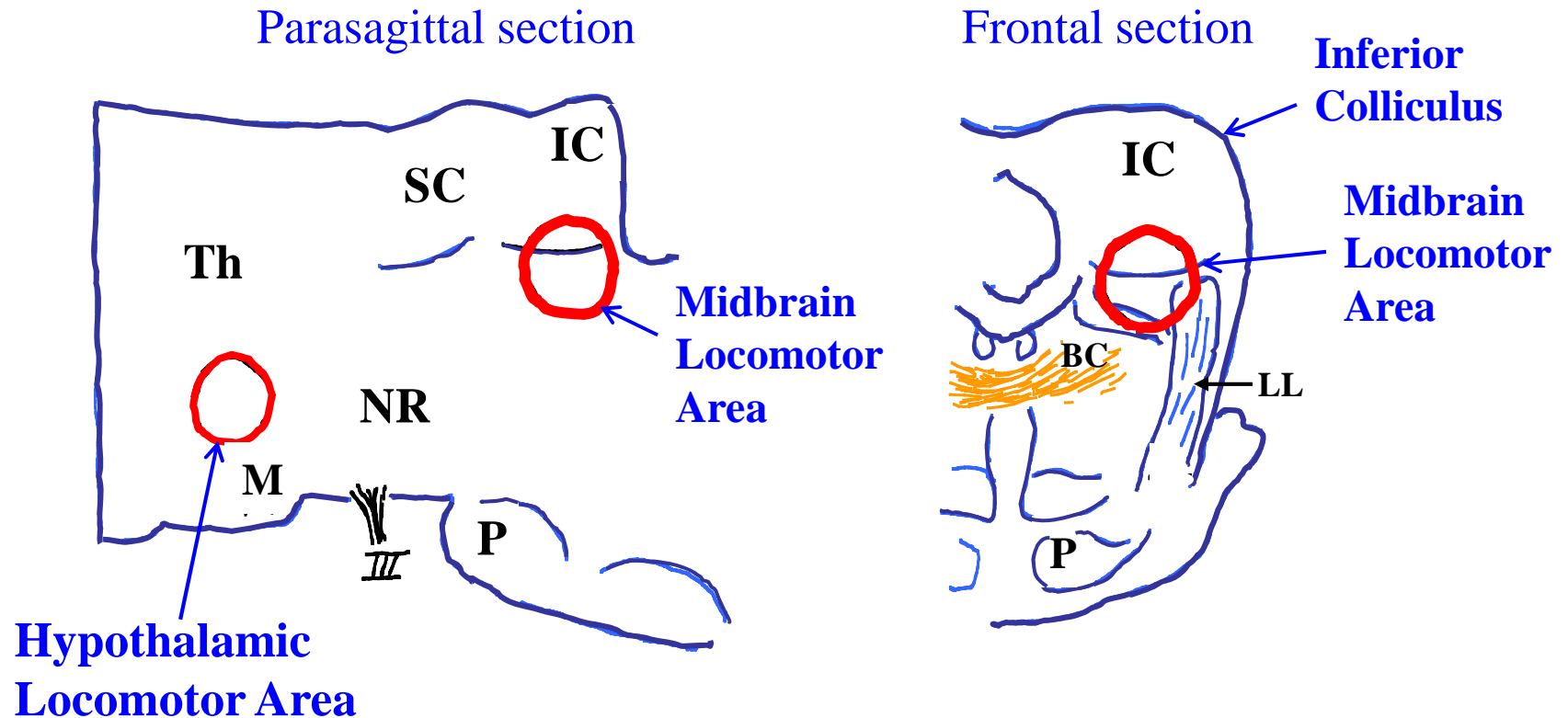
Shrew

(Squirrel is similar)

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

Previously shown: Note the position of “BC”—the brachium conjunctivum, a decussating group of axons from the cerebellum



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

Midbrain Locomotor Region (MLR):

Localization in cat by electrical stimulation studies

Fig 14-1

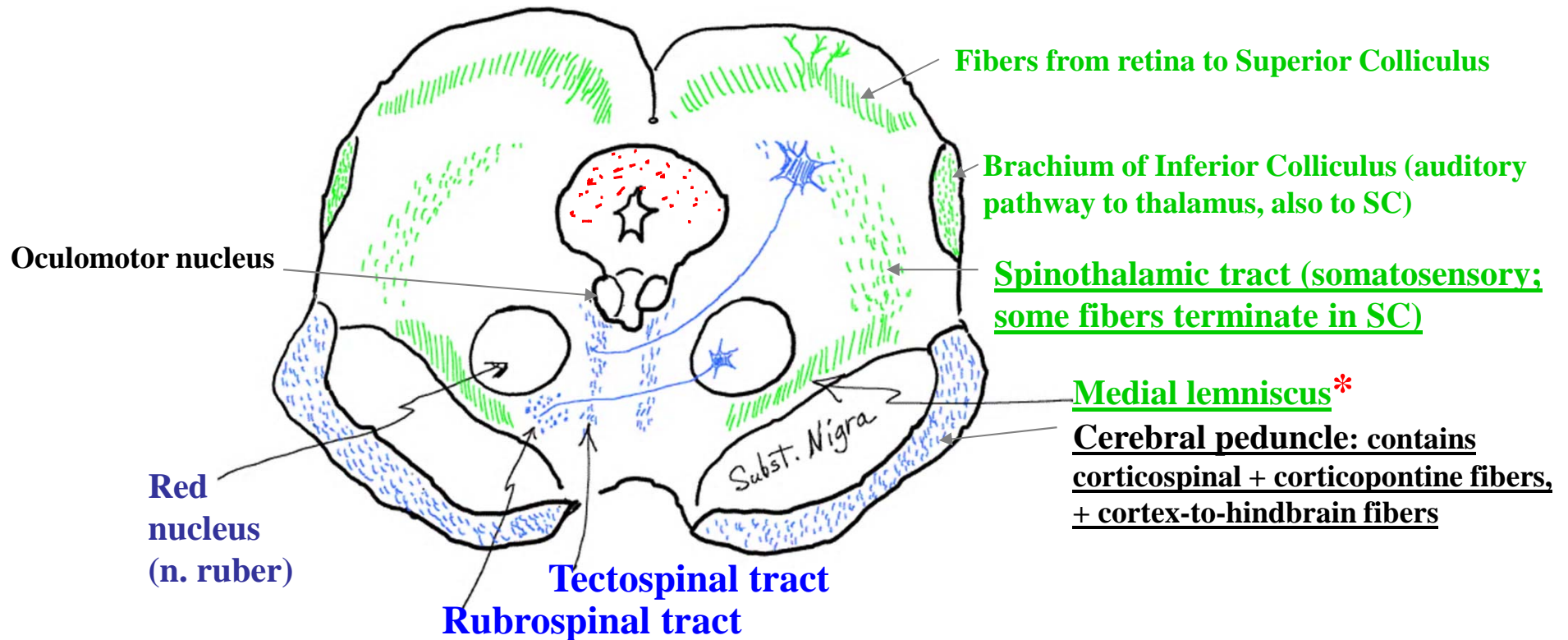
More about long axons that pass through the midbrain

colors on next slide ↓

Summary of long axons passing through the midbrain at SC levels

- Ascending **visceral** sensory: “*Dorsal longitudinal fasciculus*” including many axons from central gray
- Ascending **Somatosensory**
 - *Spinothalamic tract, with spinotectal axons to midbrain tectum*
 - *Medial lemniscus*
 - *Trigeminal lemniscus fibers are found medially in this group of axons. (Thus, the medial-lateral topography of somatosensory axons is reversed from spinal cord.)*
- Ascending **auditory**: axons from inferior colliculus
- Ascending **cerebellar** output to forebrain, also to red nucleus area
- Descending: **Corticofugal** axons of the cerebral peduncle to brainstem and pons and to spinal cord

Long axons passing through the midbrain



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

* **The trigeminal lemniscus joins the medial lemniscus, forming the medial-most axons of this collection of fibers traversing the midbrain and terminating in the posterior part of the ventral nucleus of the thalamus.**

Questions, chapter 11

9) What two major instigators of action are discussed in this chapter on the midbrain? One involves sensorimotor pathways. What about the other one?

See p 214

- 1) Sensory inputs : visual, auditory, somatosensory gustatory.
- 2) Motivational states

Old slides not used today:
Midbrain structures with
indications of behavioral functions

The midbrain “correlation centers”

- **Midbrain Locomotor Area:** for approach & avoidance
- **Central Gray Area and Ventral Tegmental Area**
 - The incentives for approach & avoidance: Pain and pleasure
 - Moods (of major adaptive significance) and related emotional expressions
 - Visceral sensory inputs in addition to other inputs
- **Superior Colliculus (SC) or “optic tectum”**
 - With multimodal layers ventral to the visual layers at the surface
 - For escape behavior and for orienting behavior
- **Inferior Colliculus (IC) & Nuclei of the Lateral Lemniscus**
 - Auditory relays to SC and to forebrain
 - Reflexes triggered by sounds
- **Red nucleus:** limb control; grasping

For your reference: another summary

The midbrain “correlation centers”

- **Superior colliculus (SC):**
“optic tectum”
 - Visual inputs to surface layers
 - Auditory, Somatosensory inputs to deeper layers
 - Functions:
 - Novelty detection
 - Head & eye orientation
 - Anti-predator responses
 - Modulators: CGA, corpus striatum, diffuse projection systems
- **Inferior colliculus:**
 - Auditory inputs
 - Relay to SC & thalamus
- **Multimodal regions:**
 - Deeper layers of the SC
 - Reticular formation
 - Including the **MLA**
 - Central gray area (CGA)
- **Red nucleus:**
 - Sensorimotor control of limbs, especially distal muscles

The midbrain (*mesencephalon*)

- Why a midbrain?
- The "correlation centers"
- Motor outputs
- Species comparisons
- Long axon tracts passing through
- Connections with forebrain introduced

A sketch of the central nervous system and its origins

G. E. Schneider 2014

Part 5: Differentiation of the brain vesicles

MIT 9.14 Class 12

Forebrain of mammals

with comparative studies relevant to its evolution

The forebrain (*prosencephalon*)

Topics

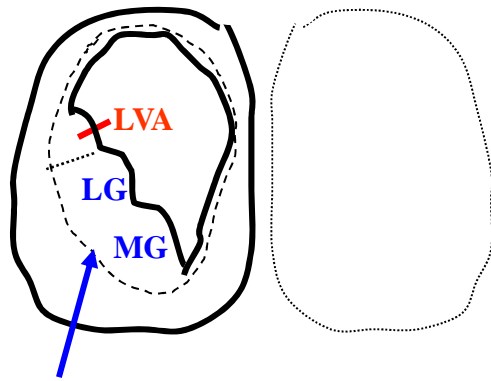
- Major subdivisions and overview of ‘tweenbrain
 - *Thalamus* and *subthalamus*: related more to **somatic** sensory and motor systems
 - *Hypothalamus* and *epithalamus*: related to “**limbic**” system structures of the forebrain
- Origins and course of 2 major pathways: related to
 - 1) somatic sensory & motor systems, and
 - 2) limbic system
- Evidence concerning forebrain evolution

Also: Review of brain structures covered thus far

Questions, chapter 12

- 1) What are the ganglionic eminences of the developing endbrain?
- 2) What are the two largest subdivisions of the diencephalon? Identify also two additional subdivisions. Which of the subdivisions are mostly somatic in nature (connections, functions) and which are mostly limbic in nature?

Rostral end of the thickening neural tube in mammals: descriptive terms



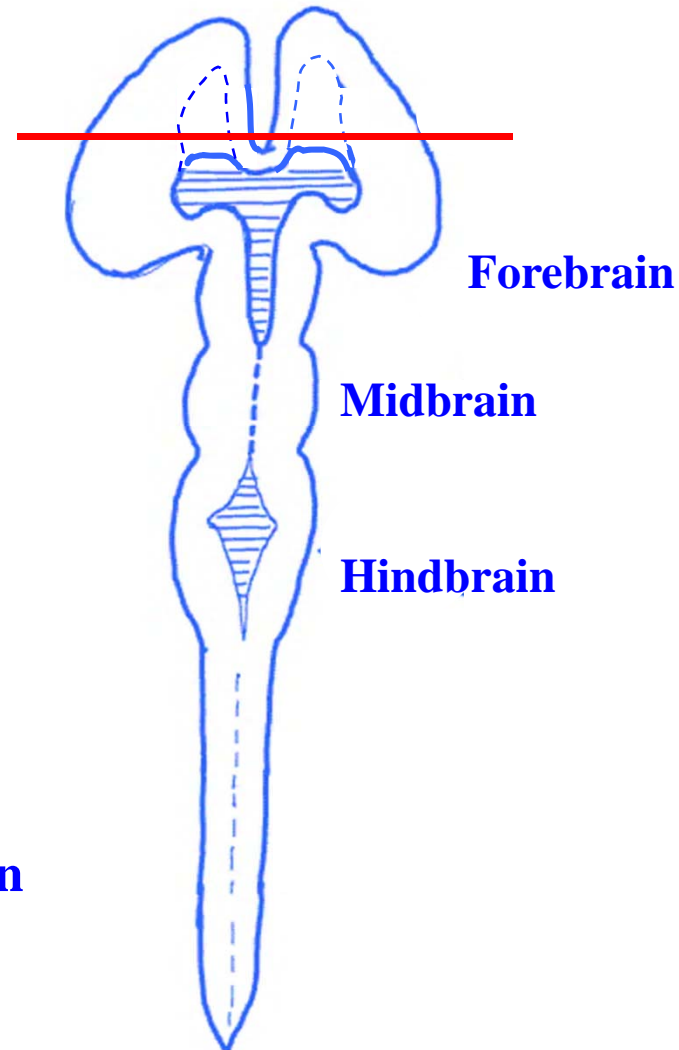
**Thickened
Ventricular**

Layer Germinal layer of mitotic

LVA = Lateral ventricular angle region

LG = Lateral Ganglionic Eminence

MG = Medial Ganglionic Eminence



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.

Preview:

Evidence on endbrain evolution

- Recent data have come from studies of expression patterns of regulatory genes, like the hox genes, in various species.
- Prior to these studies, cross-species comparisons were made using morphological data (cytoarchitecture, fiber architecture, patterns of connections).
- Next: Example of a gene expression study

Hypothetical
 ^ Archetypal embryonic stage

Homeobox gene expression:

Emx-1

Dlx-1

am = amygdala & claustrum

Cx = neocortex

dc = dorsal cortex

dvr = dorsal ventricular ridge

h = hyperpallium

lp = lateral pallium

s = septum

st = striatum

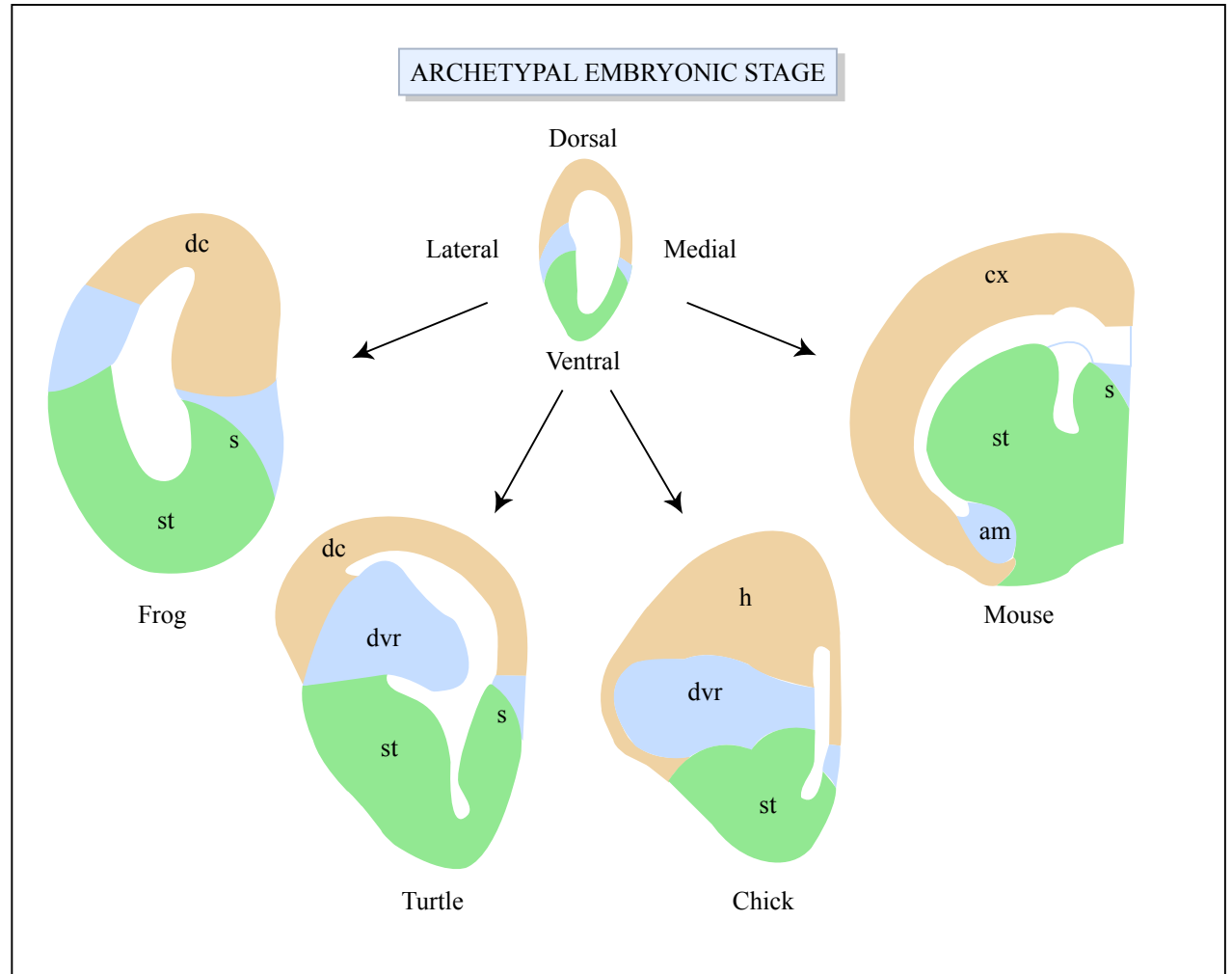


Image by MIT OpenCourseWare.

Evolution of telencephalon based on expression patterns of regulatory genes during development

We will return to these pictures of the endbrain at the end of this class.

- First:
 - Major features of forebrain structure
 - A pause for a brief review of major concepts in brain anatomy

Forebrain

(*prosencephalon*) :

endbrain

(*telencephalon*)

&

'tweenbrain
(*diencephalon*)

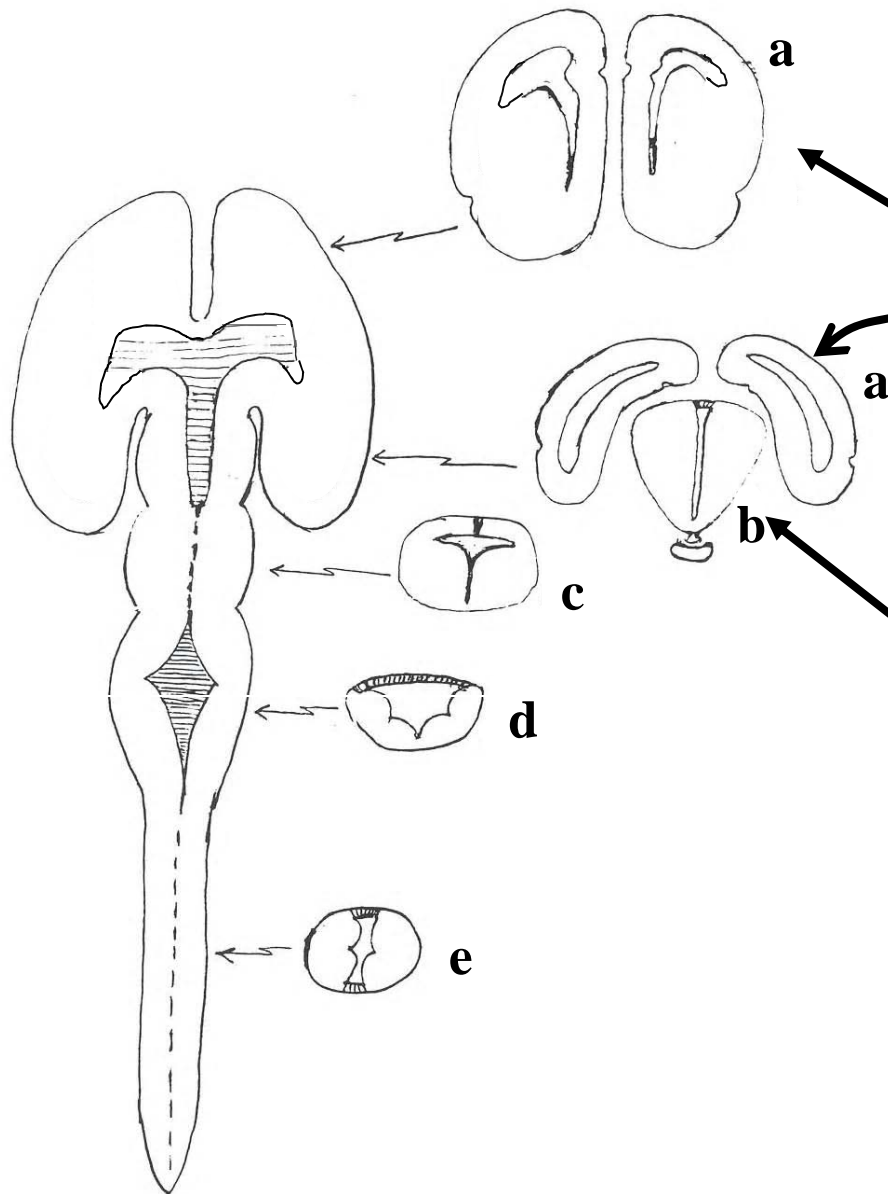


Fig 12-3

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

The forebrain (*prosencephalon*)

- **Major subdivisions and overview**

- *Diencephalon*

- *Hypothalamus (and epithalamus)*

- *Thalamus (and subthalamus)*

- *Telencephalon*

- Pallium

- Corpus striatum (and pallidum)

- Origins and course of 2 major pathways

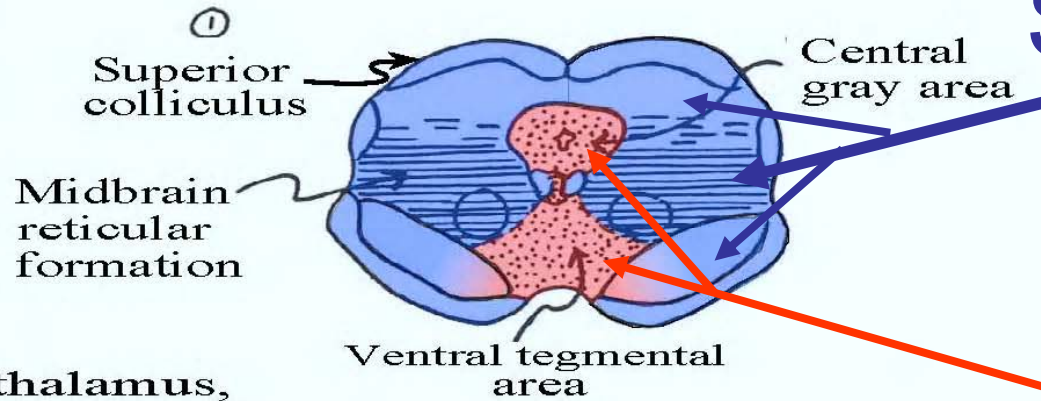
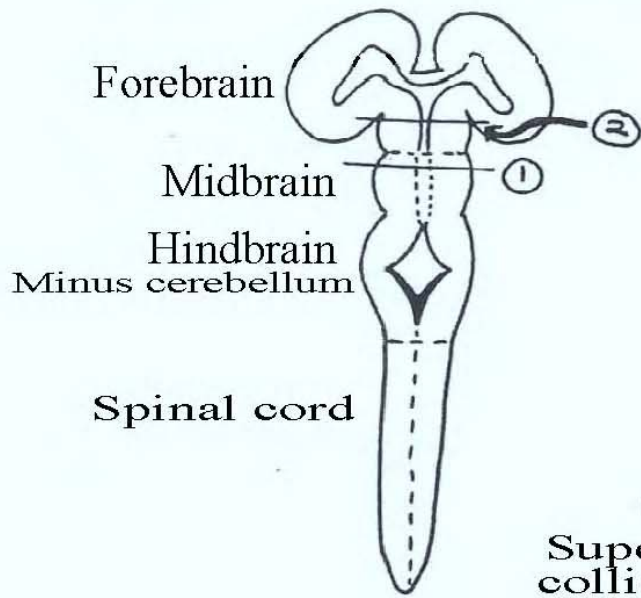
Diencephalon 1:

Hypothalamus & epithalamus

- Visceral inputs
- Connections with endbrain and midbrain:
“Limbic system” connections
- Functions include gating of pathways ascending through thalamus.

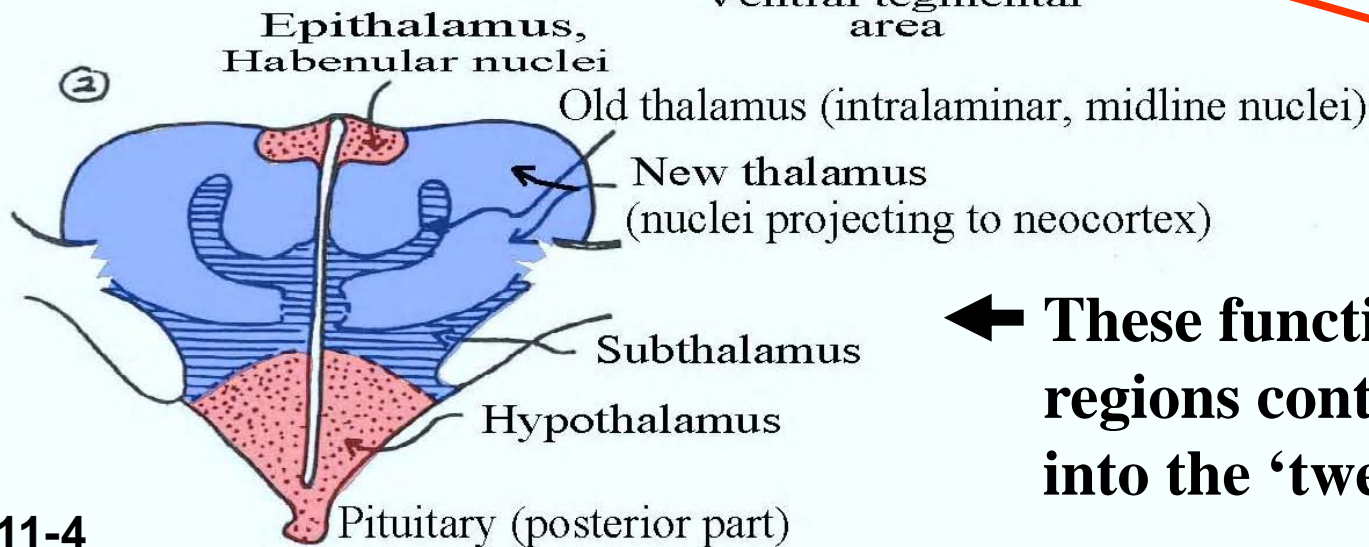
Diencephalon 2:
Thalamus & subthalamus
(= dorsal thalamus & ventral thalamus)

- Somatic inputs from the lemniscal pathways
- Connections from midbrain tectum and tegmentum (somatic parts of midbrain)



Somatic regions

Limbic regions



← These functionally distinct regions continue rostrally into the 'tweenbrain.

Fig 11-4

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

Questions, chapter 12

- 3) In the telencephalon, what are the two major divisions of the pallium (cortex)? What are the two major divisions of the subpallium (striatum)?

- 4) This division of pallial and subpallial regions of the endbrain is supported by the existence of two pathways followed by their output axons, as well as by axons coursing in the opposite direction. What are these two groups of axons called by embryologists and comparative neuroanatomists? What are other names used for all or parts of these two systems in the adult mammal?

The forebrain (*prosencephalon*)

- Major subdivisions and overview

- *Diencephalon*

- *Hypothalamus (and epithalamus)*

- *Thalamus (and subthalamus)*

- ***Telencephalon***

- **Pallium**

- **Limbic cortex**

- **Non-limbic cortex (neocortex)**

- **Striatum**

- **Ventral**

- **Dorsal**

- Origins and course of 2 major pathways

Telencephalon: major structures : names

– Pallium

- **Limbic cortex**

- Olfactory cortex
- Paleocortical & closely related structures

- **Neocortex**

- “Primary” sensory and motor cortical areas
- Unimodal association cortex
- Multimodal association cortex

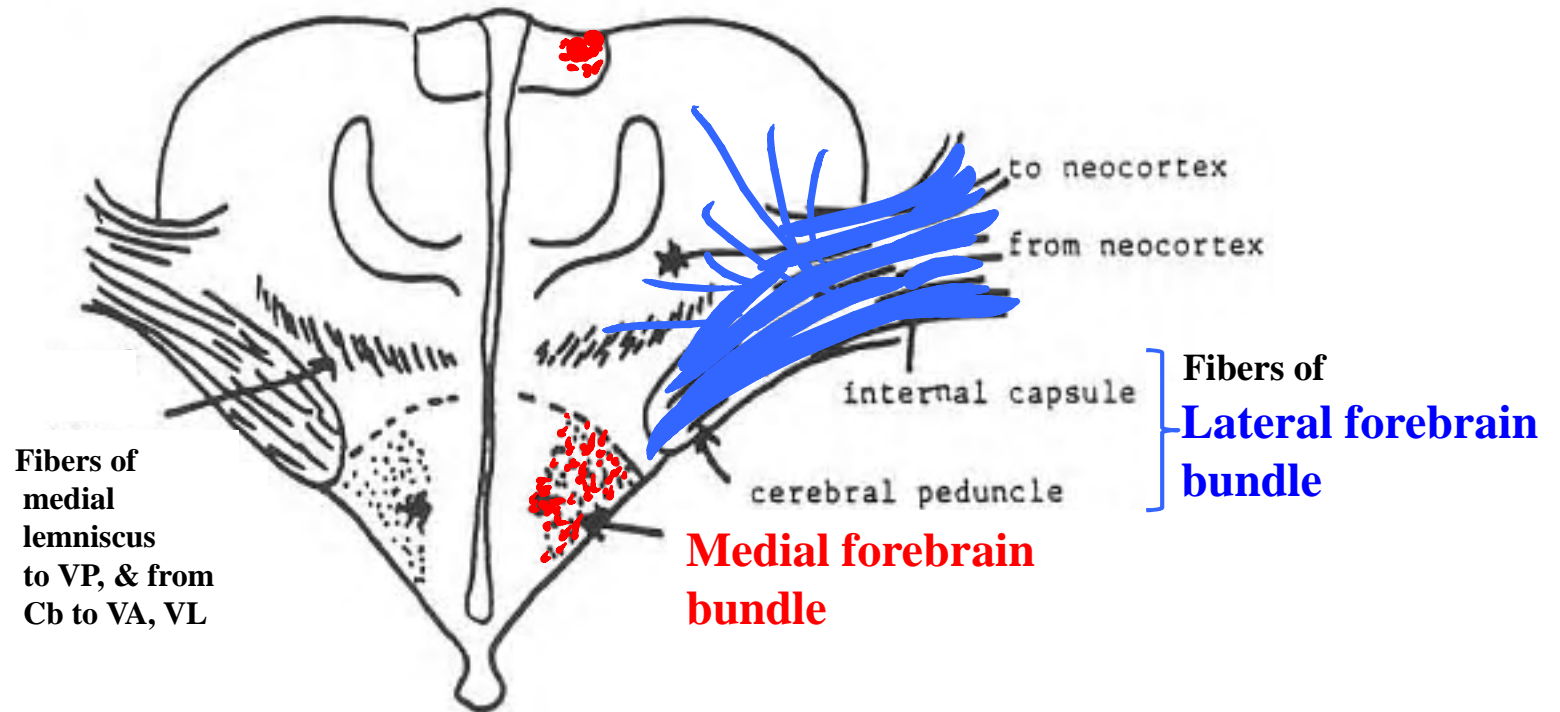
– Striatum (basal ganglia)

- **Ventral striatum** (includes Olfactory Tubercle, n. Accumbens)
- **Dorsal striatum** (sometimes called neostriatum)
- **Globus pallidus** & **ventral pallidum**: output structures of the striatum

The forebrain (*prosencephalon*):

- Major subdivisions and overview
 - *Diencephalon*
 - *Hypothalamus* (and *epithalamus*)
 - *Thalamus* (and *subthalamus*)
 - Telencephalon
 - Neocortex
 - Corpus striatum
 - Limbic endbrain
- **Origins and course of 2 major pathways**
 - One somatic, the other limbic
 - *The distinction of these two pathways strongly supports the separation of the two systems.*

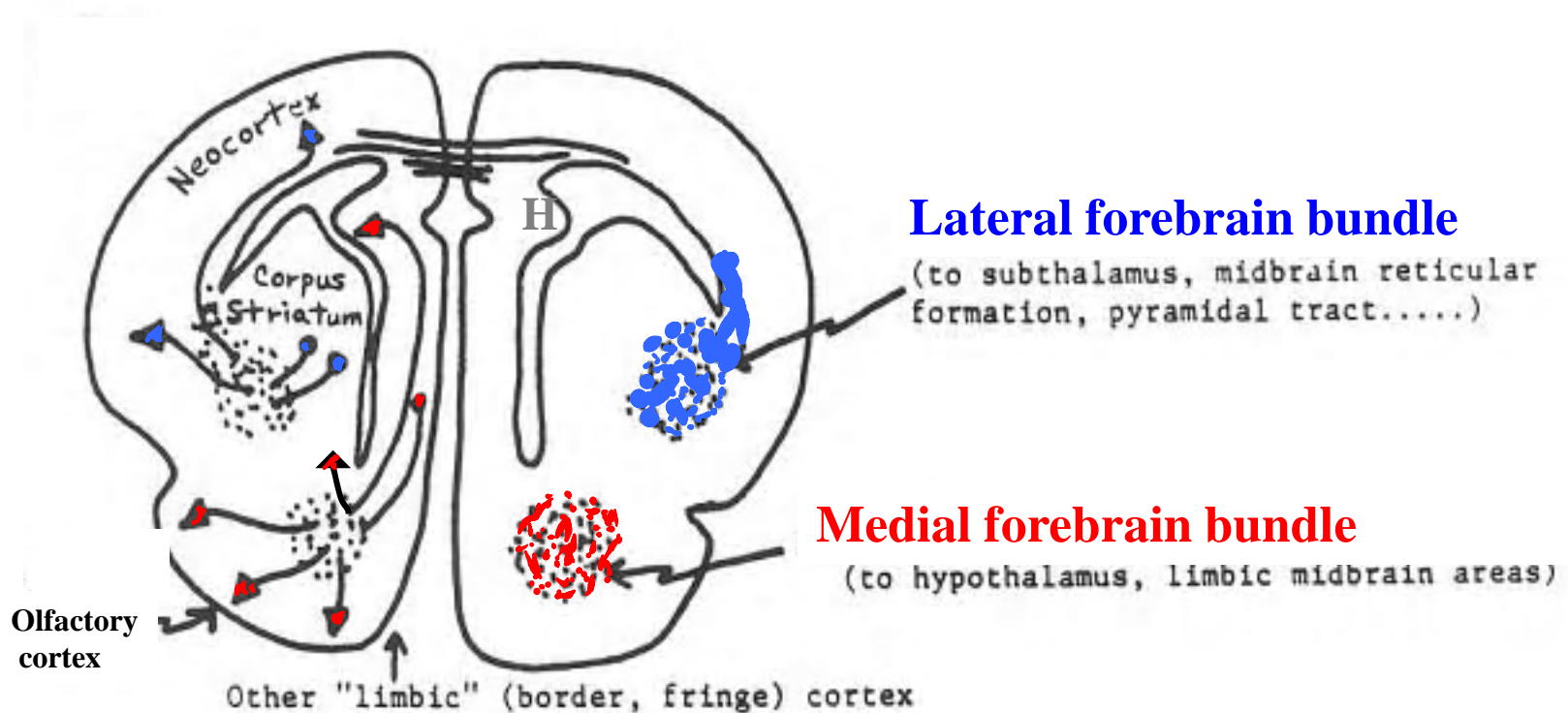
'Tweenbrain (diencephalon)



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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 12-4

Endbrain (telencephalon)



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Fig 12-5

Origins and course of 2 major pathways:

- **Lateral forebrain bundle, to and from:**
 - *Striatum*
 - *Neocortex, via:*
 - Neocortical white matter,

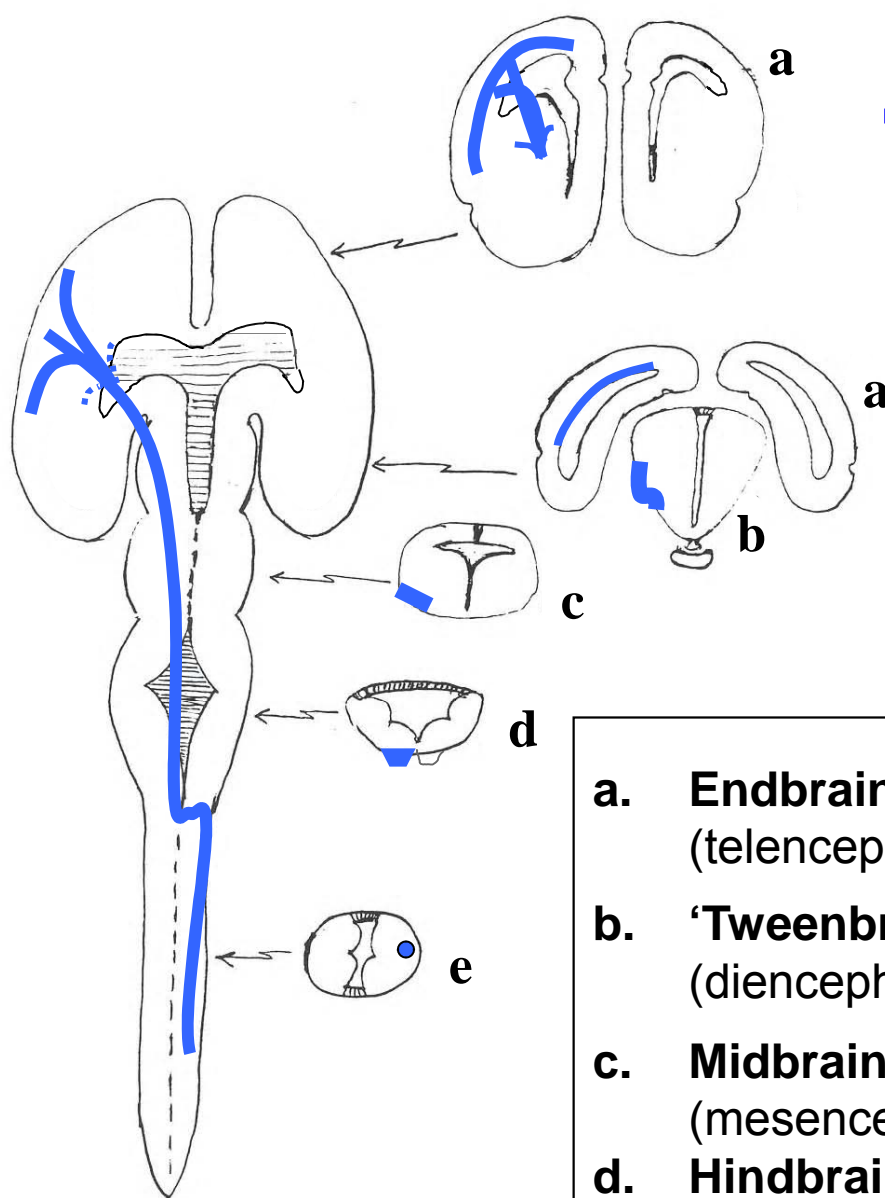
Outputs of neocortex via
Internal capsule-Cerebral peduncle-Pyramidal tract

(See following slide)
- **Medial forebrain bundle, to and from:**
 - Olfactory cortex
 - Limbic cortex
 - Subcortical limbic endbrain structures: amygdala, ventral striatum, basal forebrain
 - lateral hypothalamic area
 - limbic midbrain areas

The lateral forebrain bundle:

major origins and course

Note the different names at different levels. All these names occur frequently in discussions of brain structure and connections



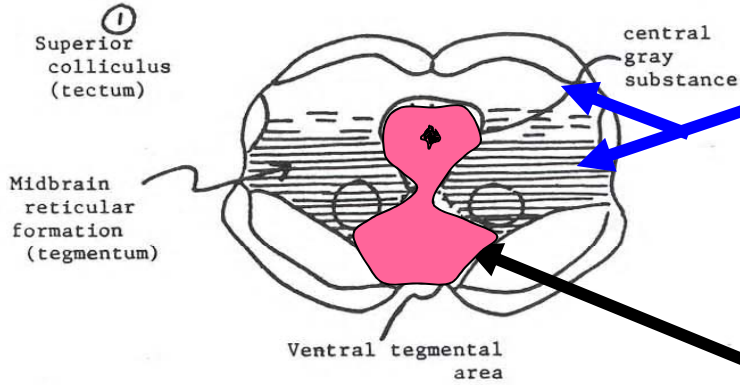
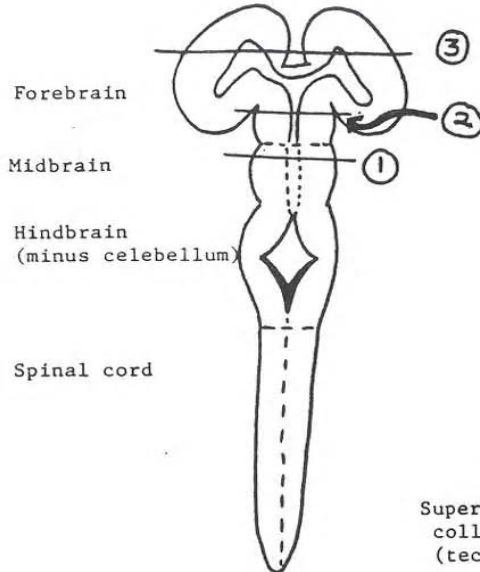
- | | | |
|--|---|--|
| a. Endbrain
(telencephalon) | — | Cortical white matter to Internal capsule |
| b. 'Tweenbrain
(diencephalon) | — | Cerebral peduncles
(includes fibers to 'tweenbrain, midbrain, pons, remainder of hindbrain, spinal cord) |
| c. Midbrain
(mesencephalon) | — | |
| d. Hindbrain
(rhombencephalon) | — | Pyramidal tract |
| e. Spinal cord | — | Corticospinal tract |

Fig 12-6

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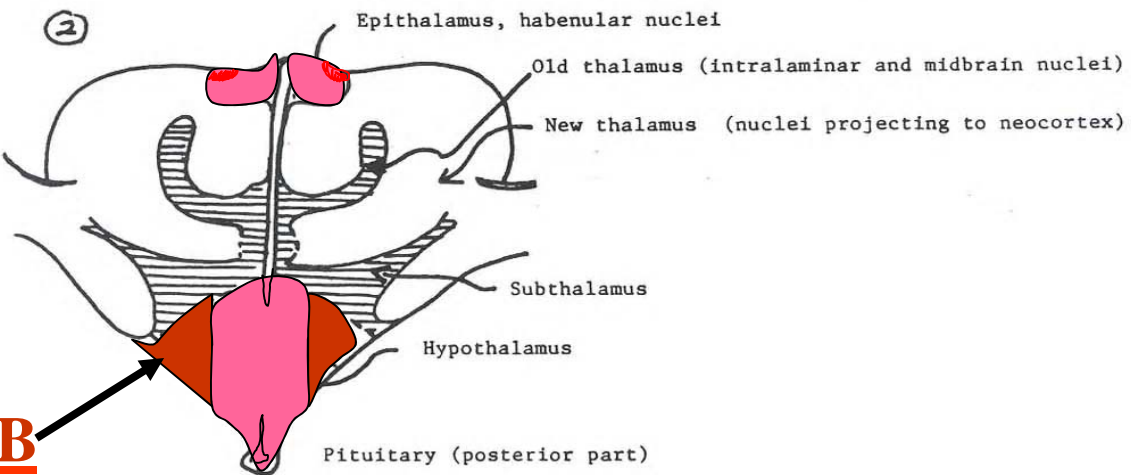
Schneider, G. E. *Brain structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.

REVIEW



Somatic regions

“Limbic” regions

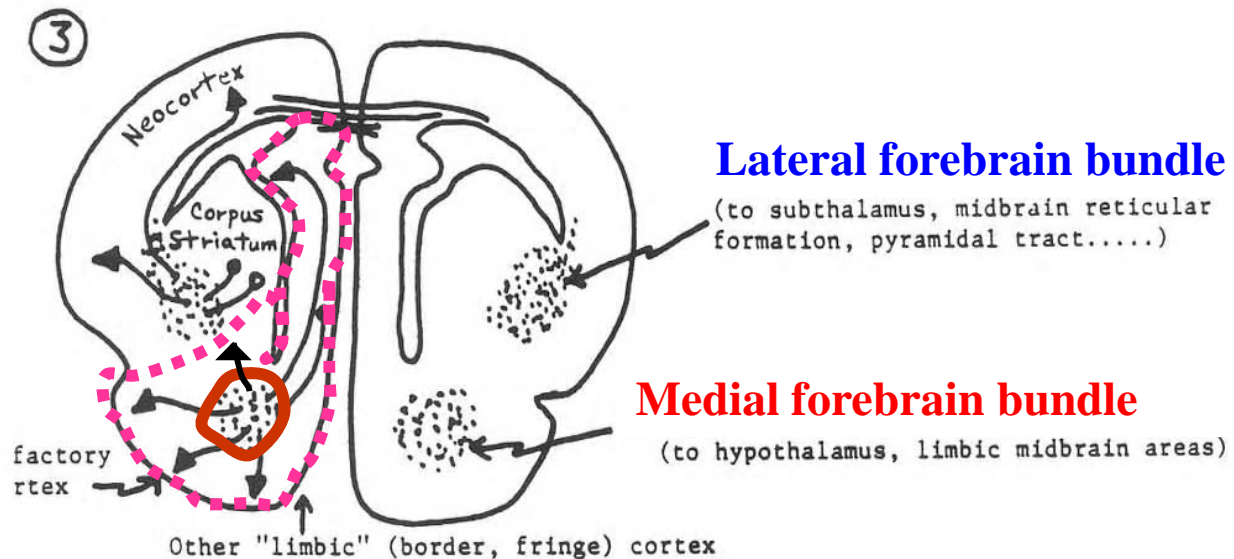
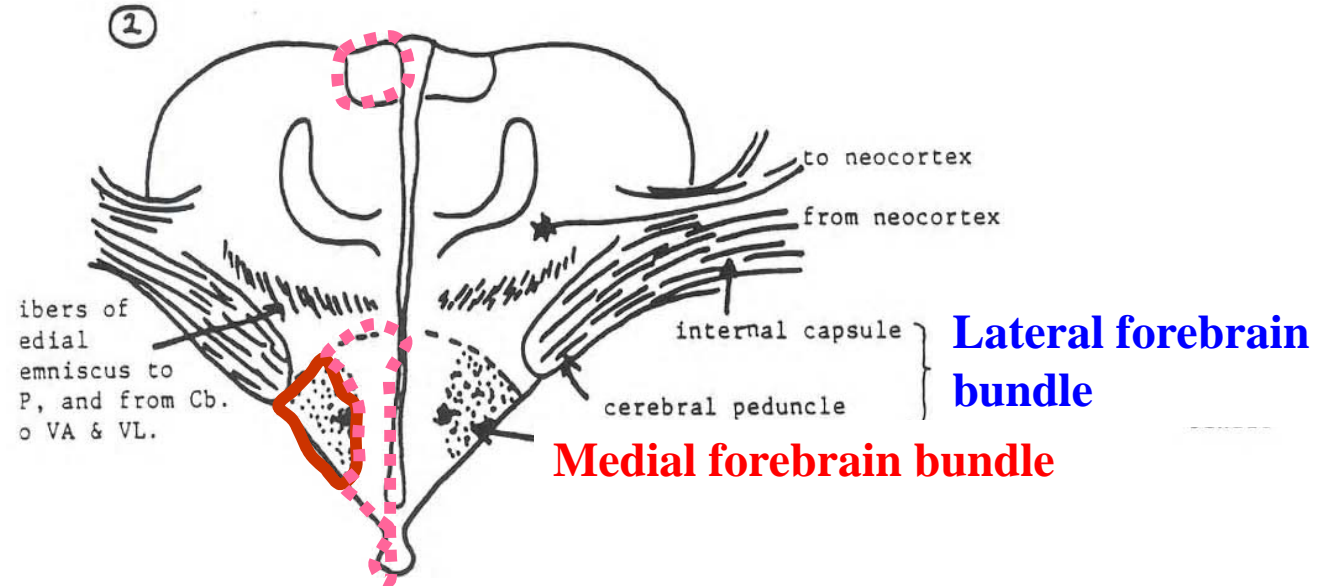


MFB

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

REVIEW:

'Tween-brain and Endbrain limbic & MFB



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

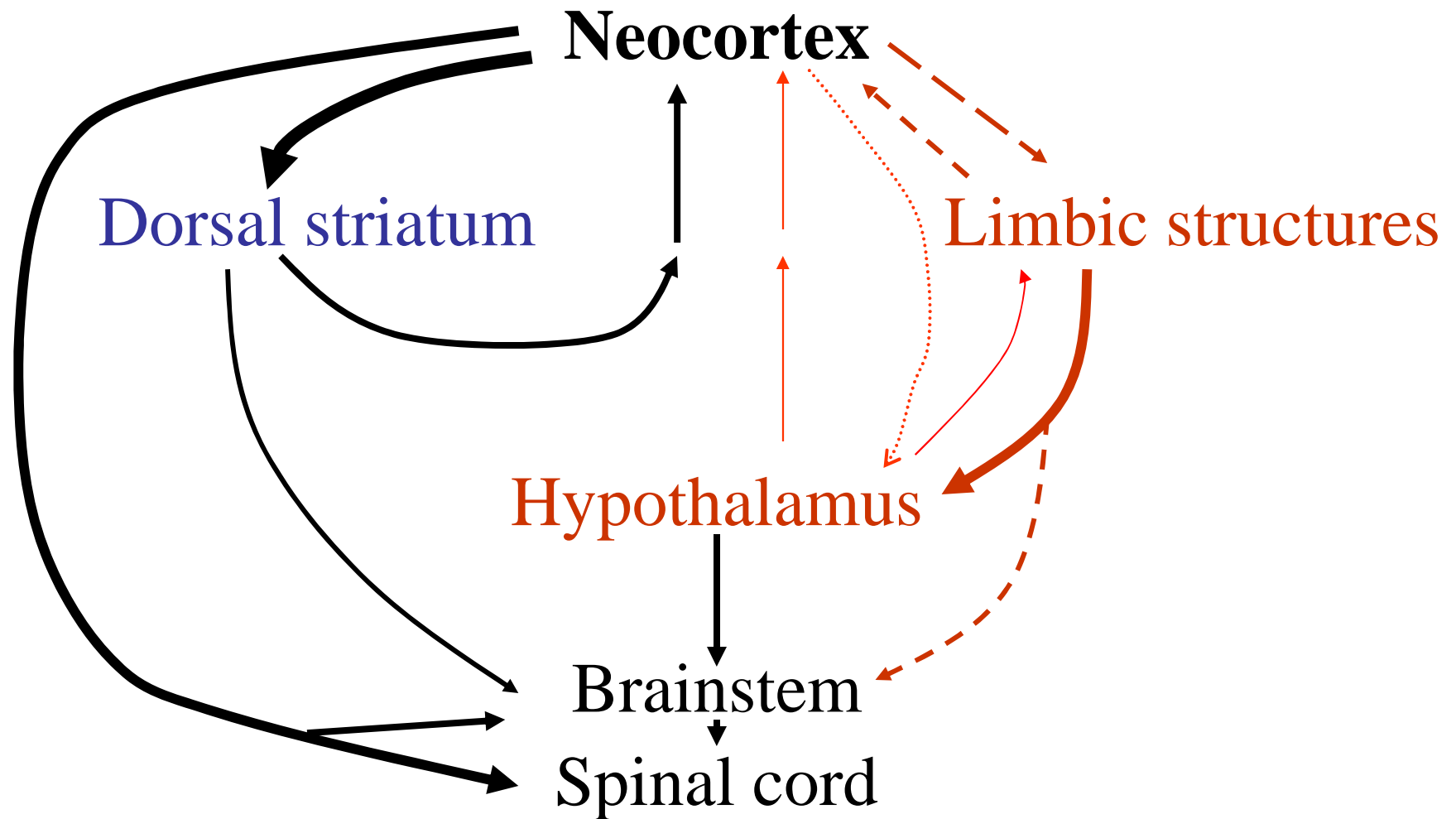
Questions, chapter 12

- 5) What is a striking difference in the outputs from the neocortex on the one hand and from the corpus striatum on the other?

The neocortex is involved in
both major systems

A schematic summary

Some Major Endbrain Connections



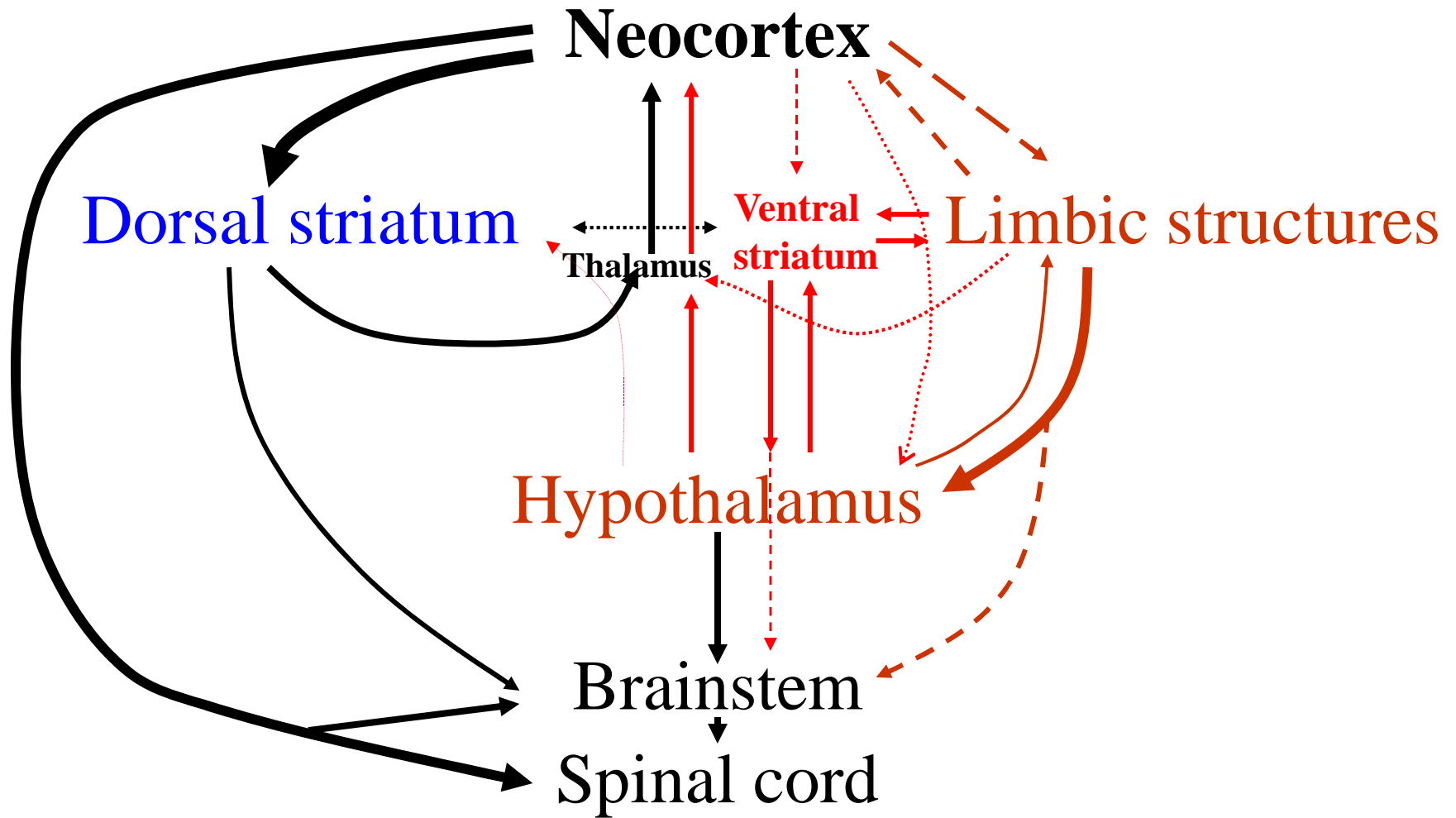
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Schneider, G. E. *Brain structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.

This leaves out a great many details!

- Note that the ventral striatum is lumped together with “limbic” structures. *(common in many neuroanatomy texts)*
- Ventral striatum is critical in habit formation, and is ~~probably~~ *believed to be* the most primitive part of the corpus striatum in evolution.
- Reward and punishment mechanisms exist with a special role of ascending projections, e.g., from taste and pain systems.
- Next picture: The schematic summary is augmented somewhat

Some Major Endbrain Connections



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

“Striatum” (dorsal & ventral) as used here includes the output structures—the pallidum (dorsal, ventral)

Check your knowledge of brain structures:

Neuroanatomy review

- Subdivisions of CNS; definitions of cell types
 - Shapes of the neural tube at various levels
- Sensory channels of conduction; dermatomes
- Diaschisis: lesion-produced deafferentation causes a functional depression of neurons
- Evolution of neocortex with major ascending and descending pathways to it and from it
- Spinal cord structure; differences between levels
- Propriospinal system
- Autonomic N.S. and its components
- Hindbrain organization; distortions of the basic plan
- Cranial nerves: the 5th (trigeminal nerve)

Neuroanatomy review continued

- Midbrain: tectum and tegmentum; species differences; outputs for three major types of movement
- Diencephalon: two major and two additional subdivisions (functional/structural)
- Telencephalon: the endbrain (cerebral hemispheres and basal forebrain); origins of two major pathways for descending axons (Both contain some ascending axons also.)
- Some major axonal pathways in mammals:
 - *Spinoreticular, trigeminoreticular tracts (mostly ipsilateral)*
 - *Spinothalamic tract*; longest axons reach the ventrobasal nuc. of thalamus (VB = VPM and VPL)
 - Dorsal columns, connecting to the medial lemniscus pathway, which projects to the ventrobasal nuc. of thalamus
 - Corticospinal & corticopontine pathways (the former connect to all levels of CNS, the latter connecting to the pons, hence to cerebellum)

Questions, chapter 12

- 6) What are neuromeres? What are prosomeres?
- 7) Describe the neuromeres of the diencephalon.

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9.14 Brain Structure and Its Origins

Spring 2014

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