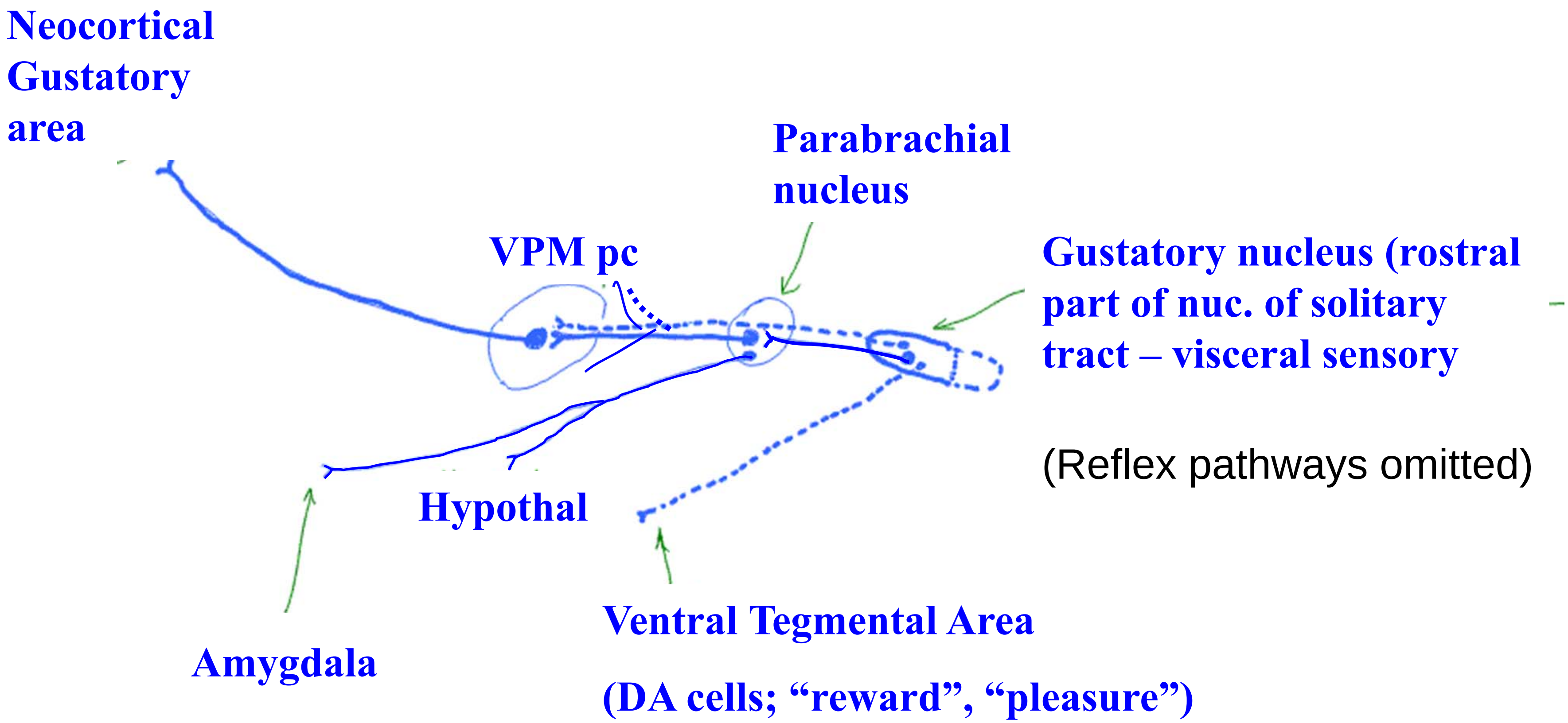
Final review, 9.14_2014

Slides for special study

Mammalian Taste Pathways

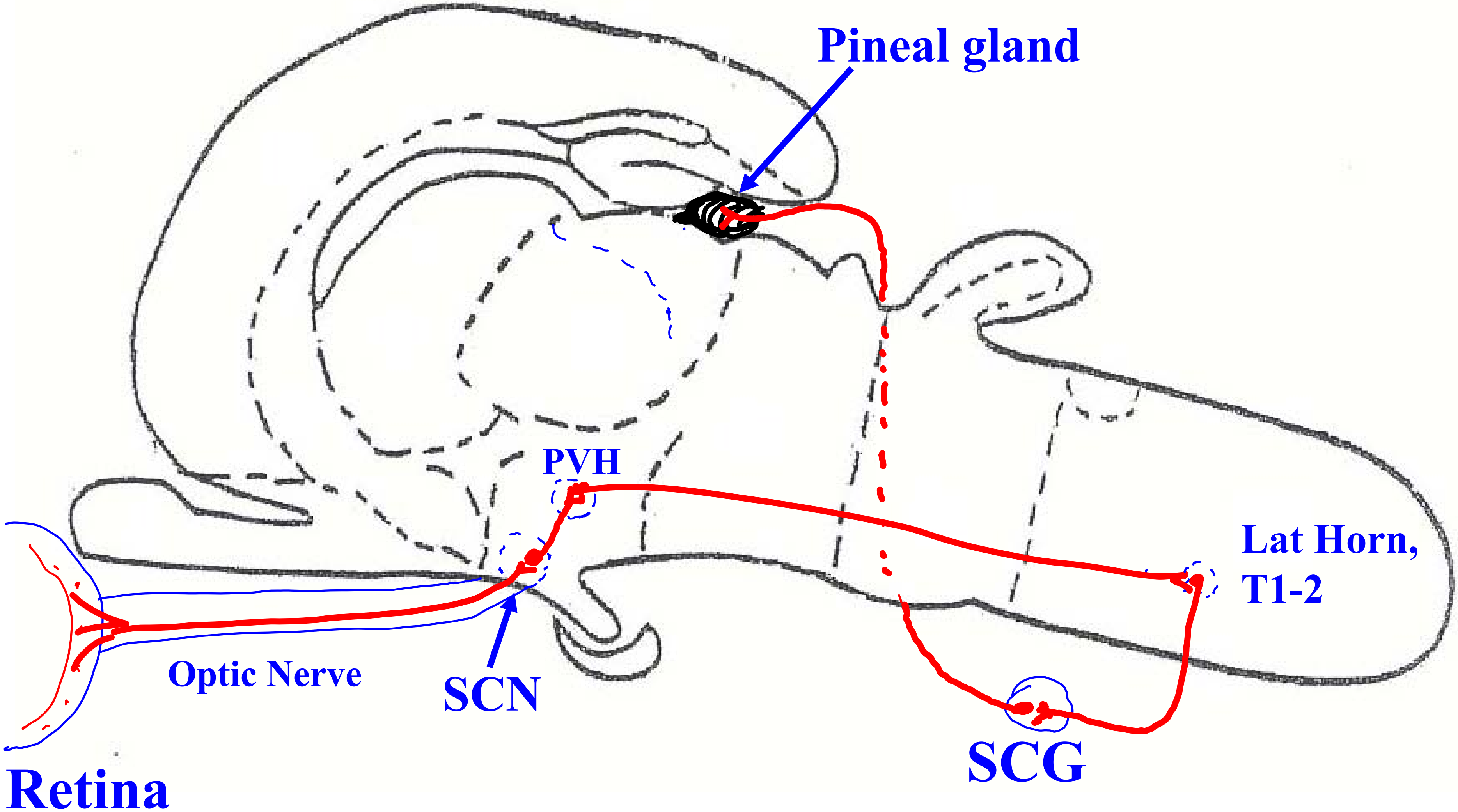


Projections to thalamus outside VPMpc go to paleothalamic cell groups, which project to corpus striatum and also diffusely to neocortex.

Cladogram of jawless vertebrates and an amphibian, below charts of olfactory bulb projections to forebrain

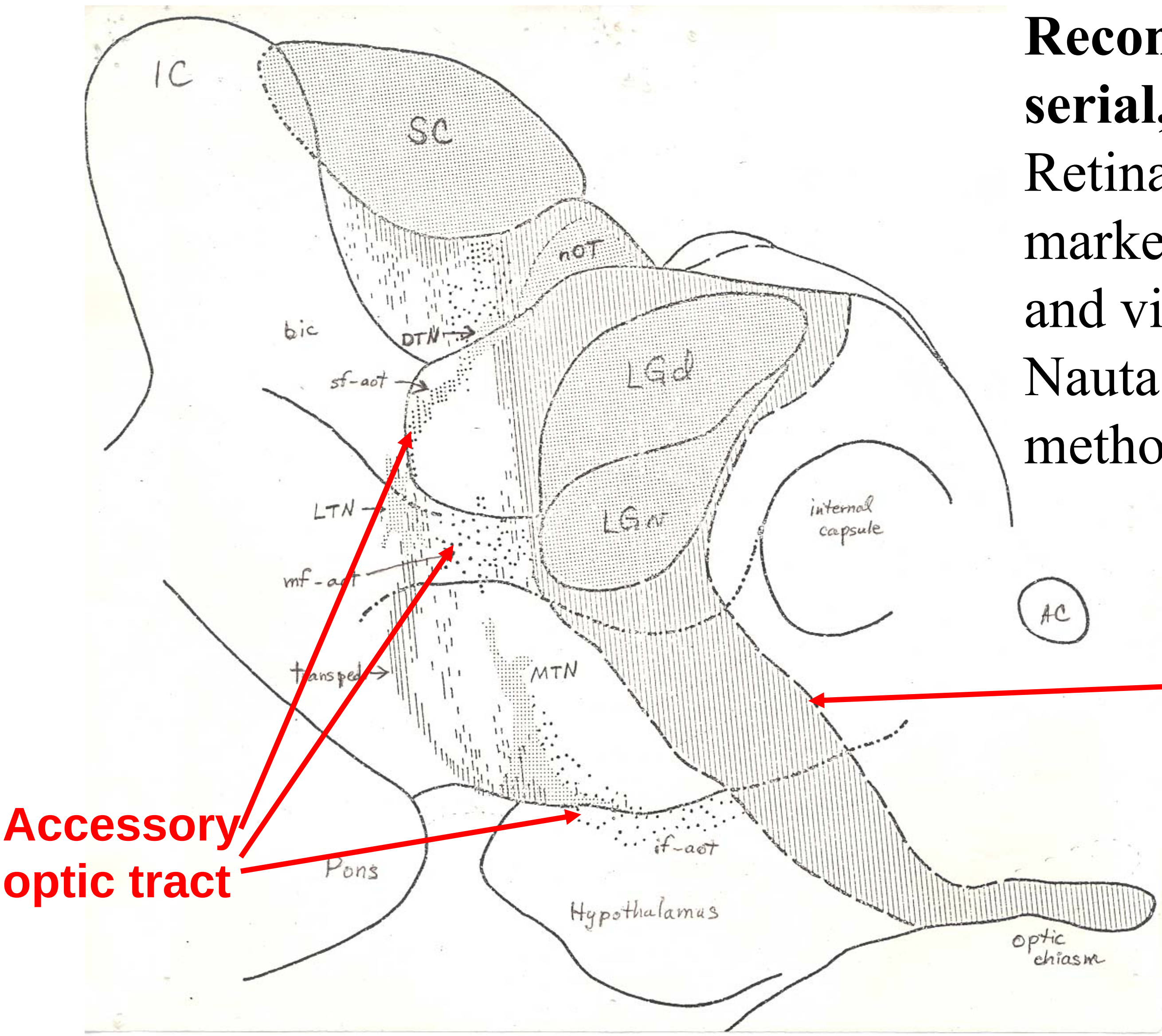
Figure removed due to copyright restrictions. Please see course textbook or:
Wicht, Helmut, and R. Glenn Northcutt. "Secondary Olfactory Projections and Pallial Topography in the Pacific Hagfish, Eptatretus Stouti." *Journal of Comparative Neurology* 337, no. 4 (1993): 529-42.

Pathway for controlling the daily rhythm of melatonin production



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

Adult optic tract (Hamster)

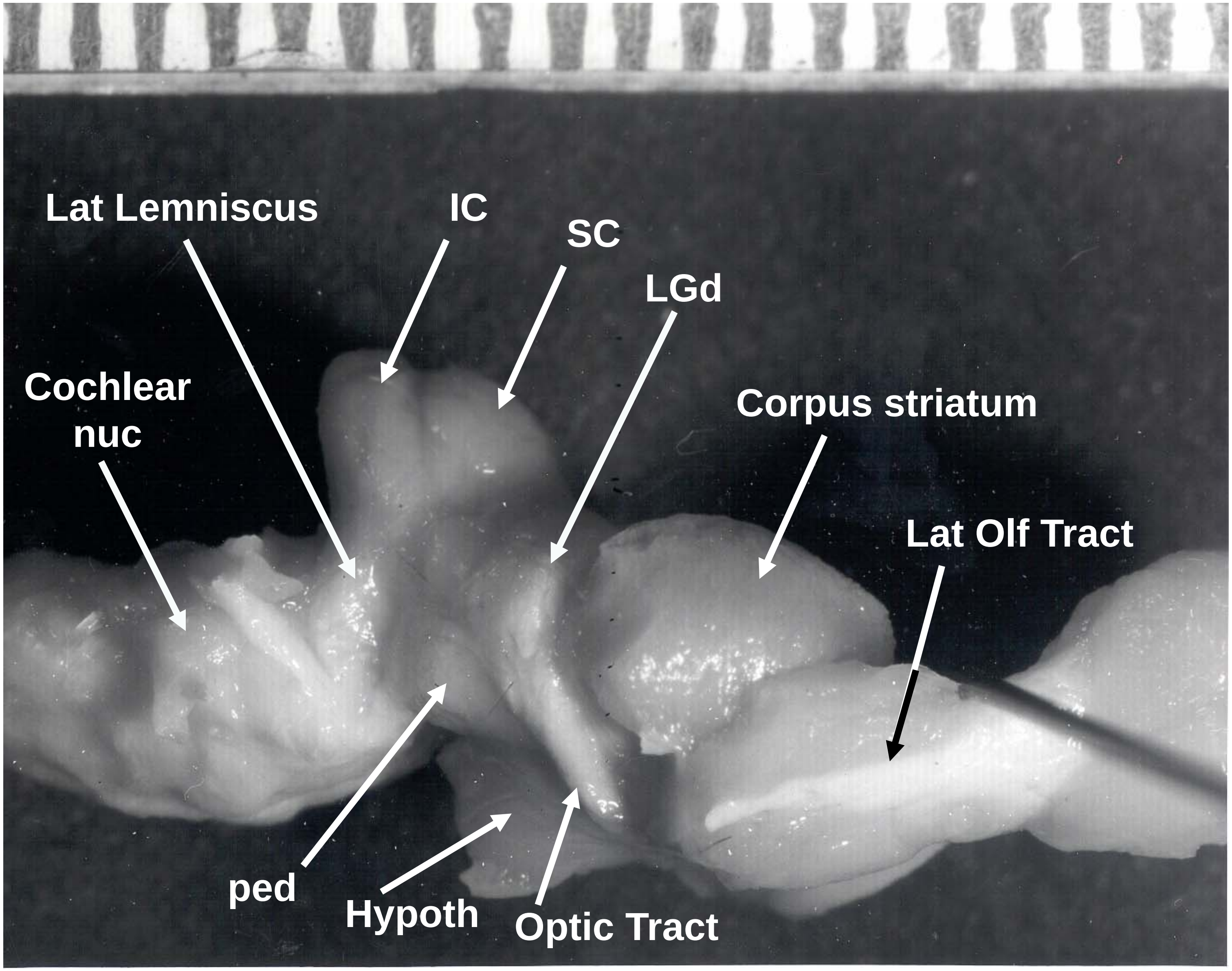


Reconstruction from serial, frontal sections. Retinal projections were marked by degeneration and visualized with a Nauta silver-staining method.

NEXT: **Photos** of brains

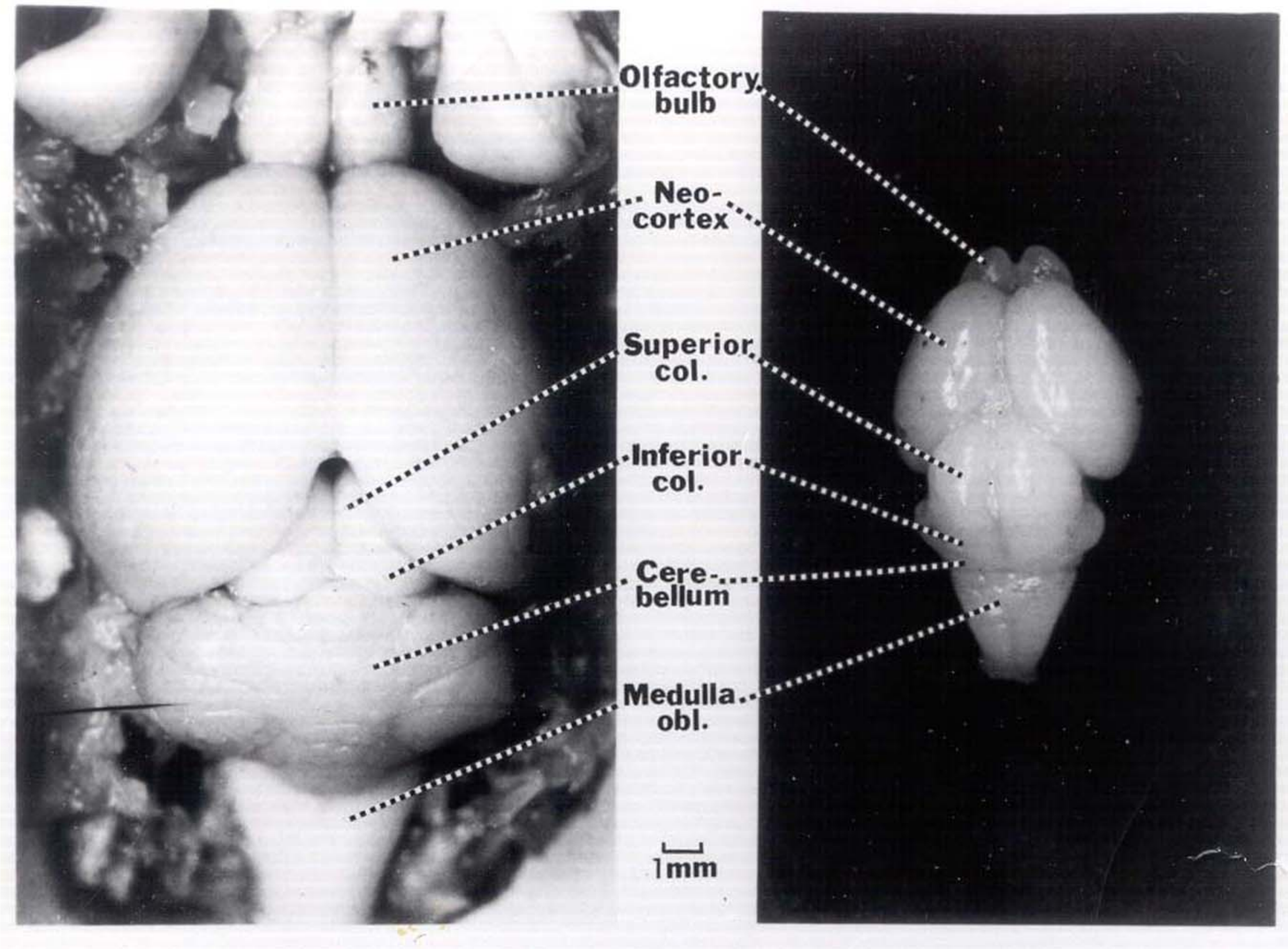
Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Hamster brain with hemispheres & Cb removed, seen from right side



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

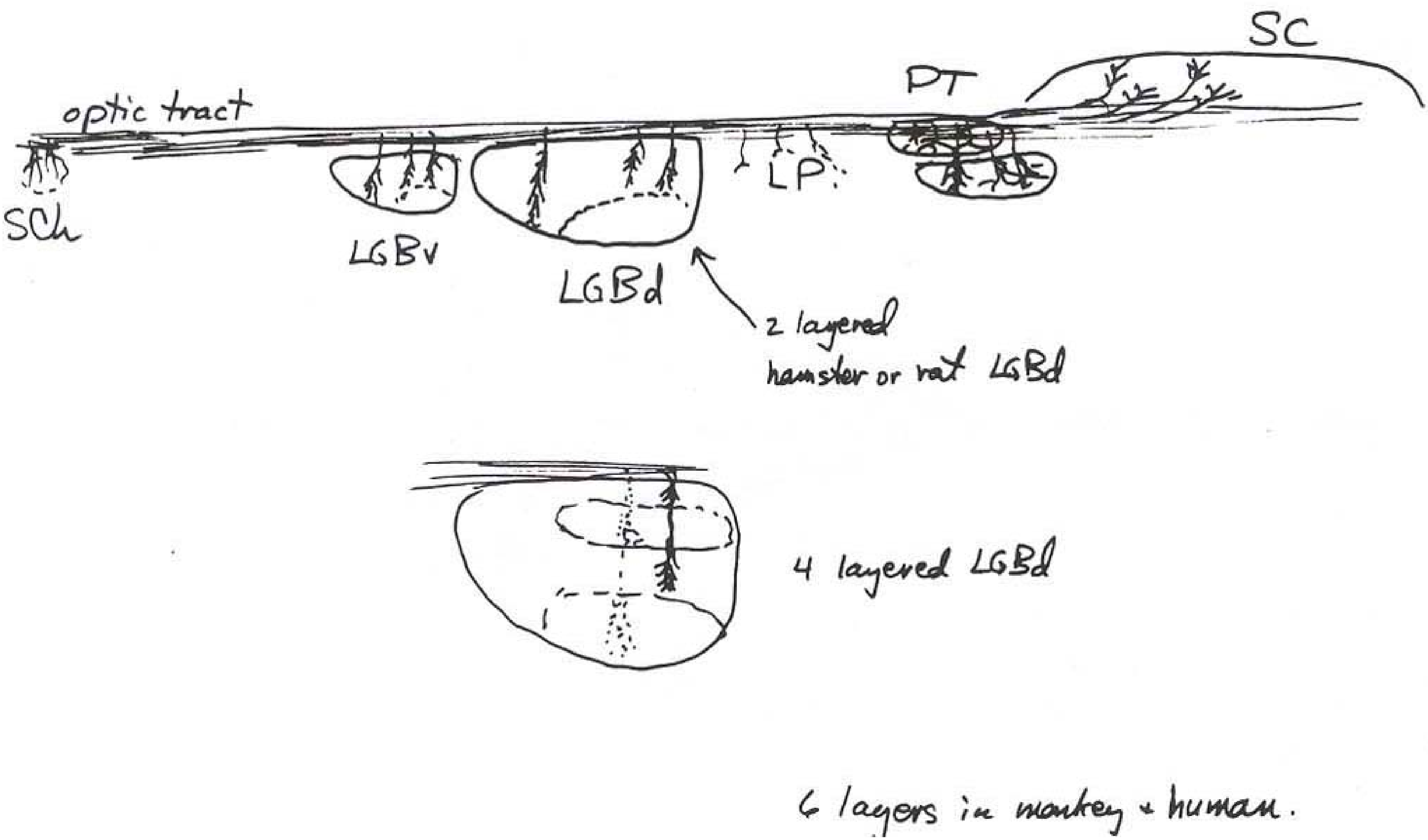
Hamster brain, adult and newborn

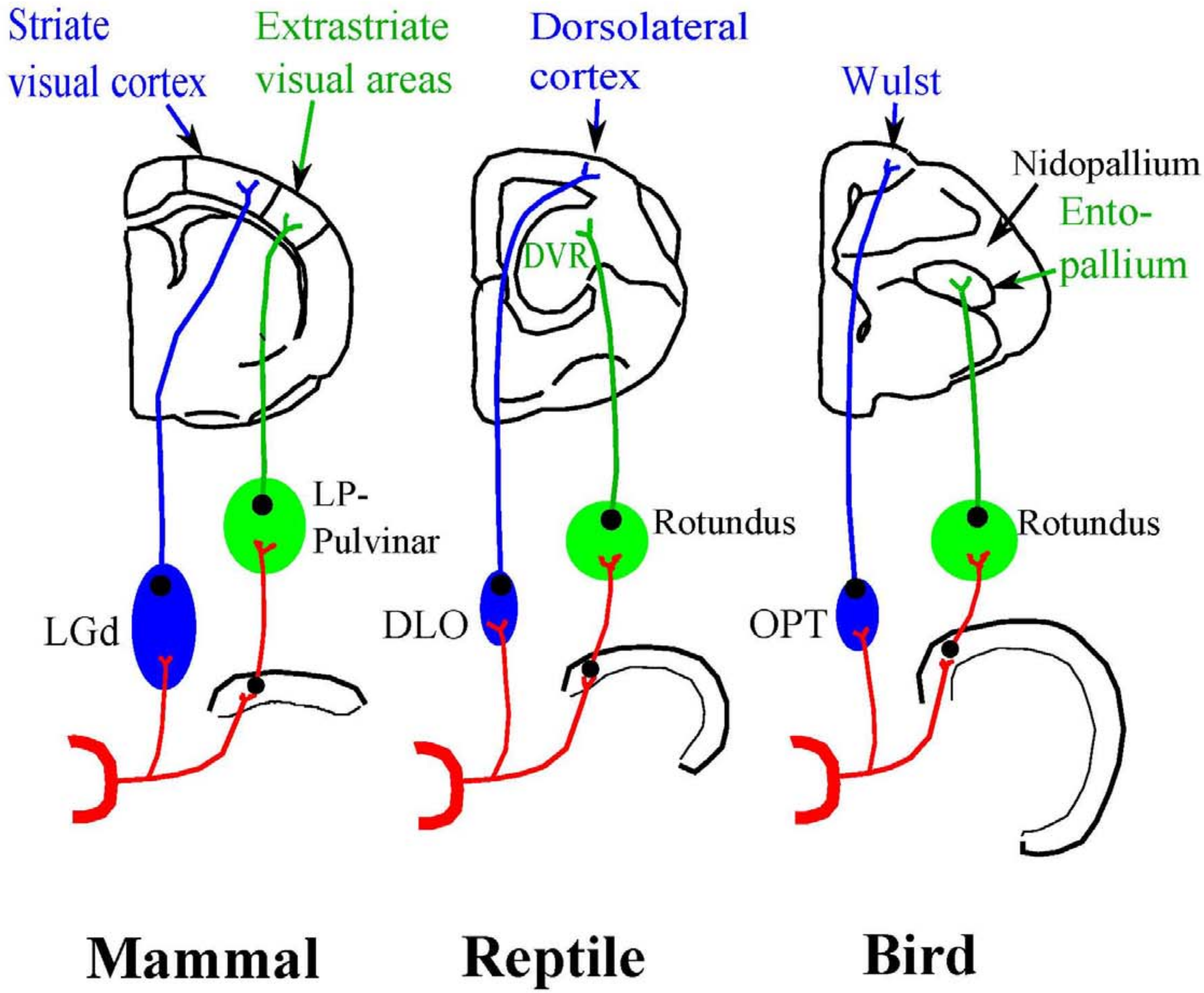


Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

REVIEW:

Stretched section through optic tract from chiasm to superior colliculus





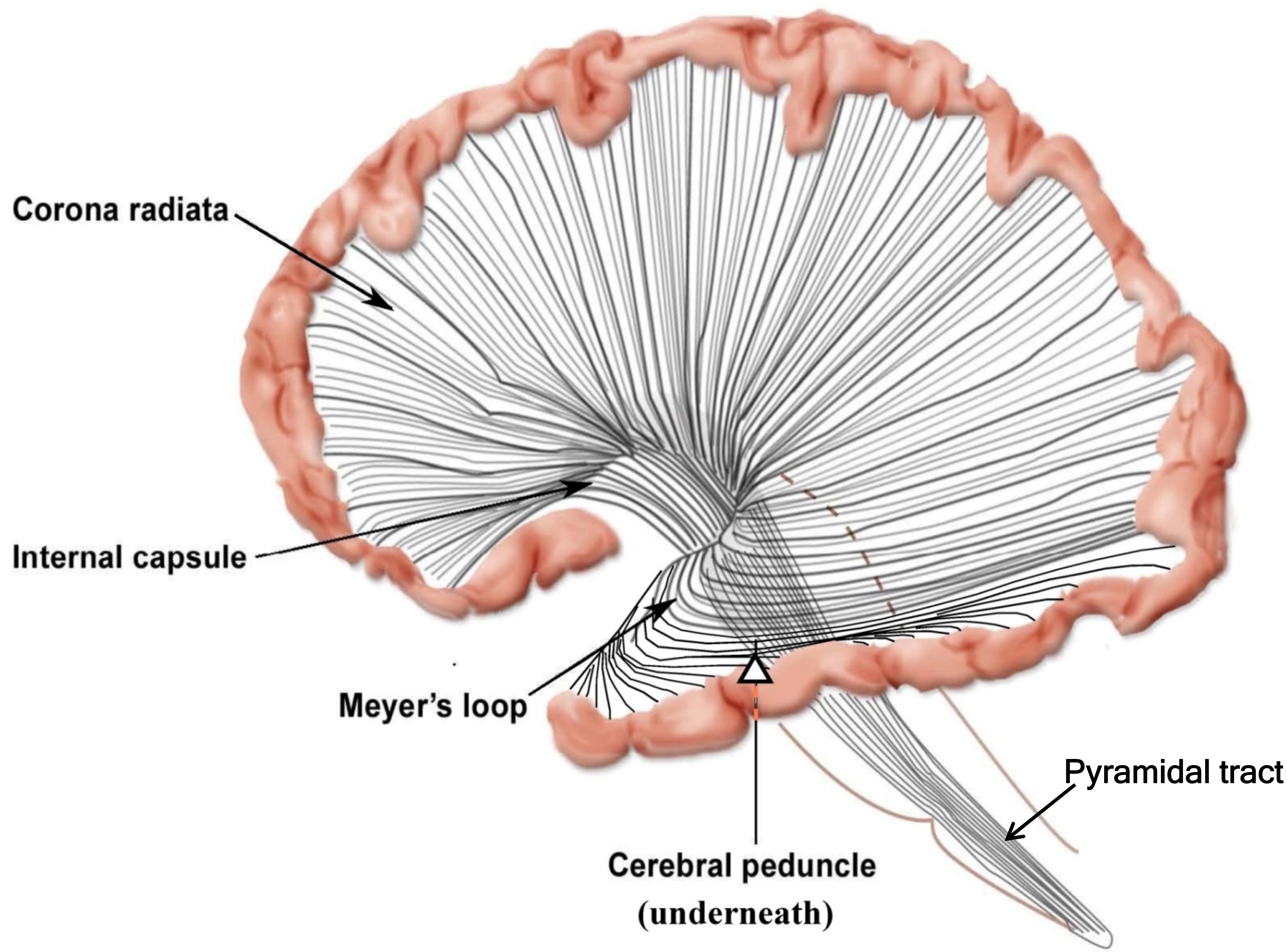
Two major routes from retina to endbrain in phylogeny

Fig 22-2

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

Distortion of the internal capsule by the formation of a temporal lobe in development

Figure removed due to copyright restrictions.



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 22-8

Part of the optic radiations are pulled into the temporal lobe as neocortex expands. This part, Meyer's loop, represents the upper visual field.

Types of connectivity among cell groups such as multiple neocortical areas:

1. **Regular** (absolute; connections only with nearby cells)
2. **"Small world"** architecture (regular plus some randomly placed longer connections)
3. **Random**

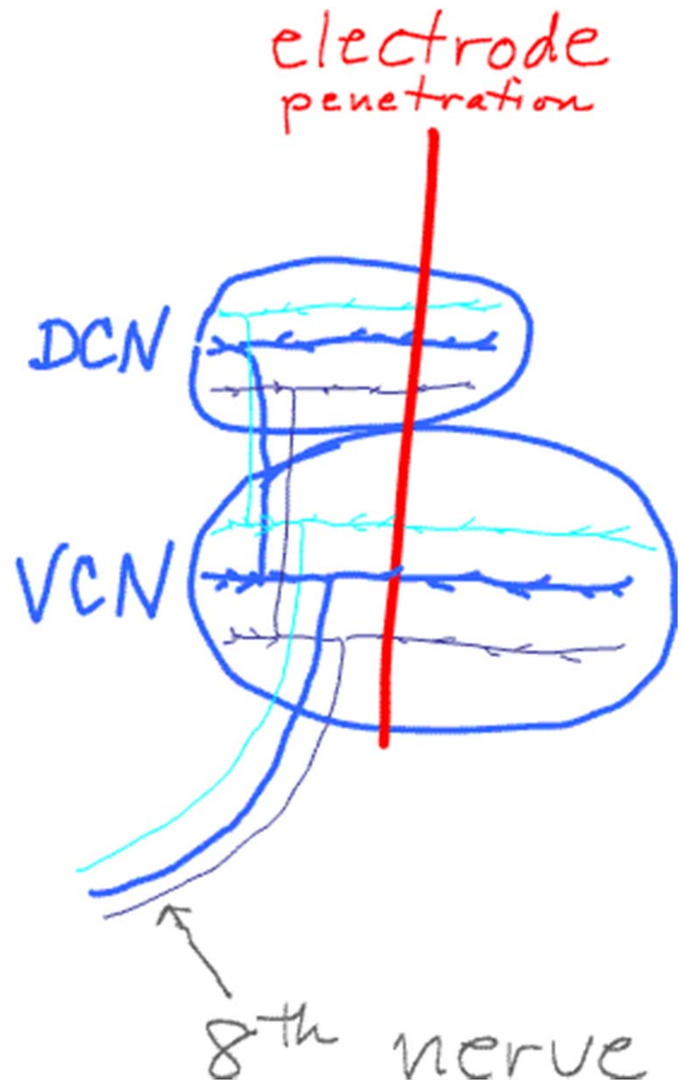
Note how separation comes down with randomness.

Note also the quantity of axons required.

(from Striedter p. 249)

Figure removed due to copyright restrictions.

Tonotopic organization in the cochlear nuclei results from the topographic organization of projections from the cochlea *via* the 8th nerve to the axonal endings.

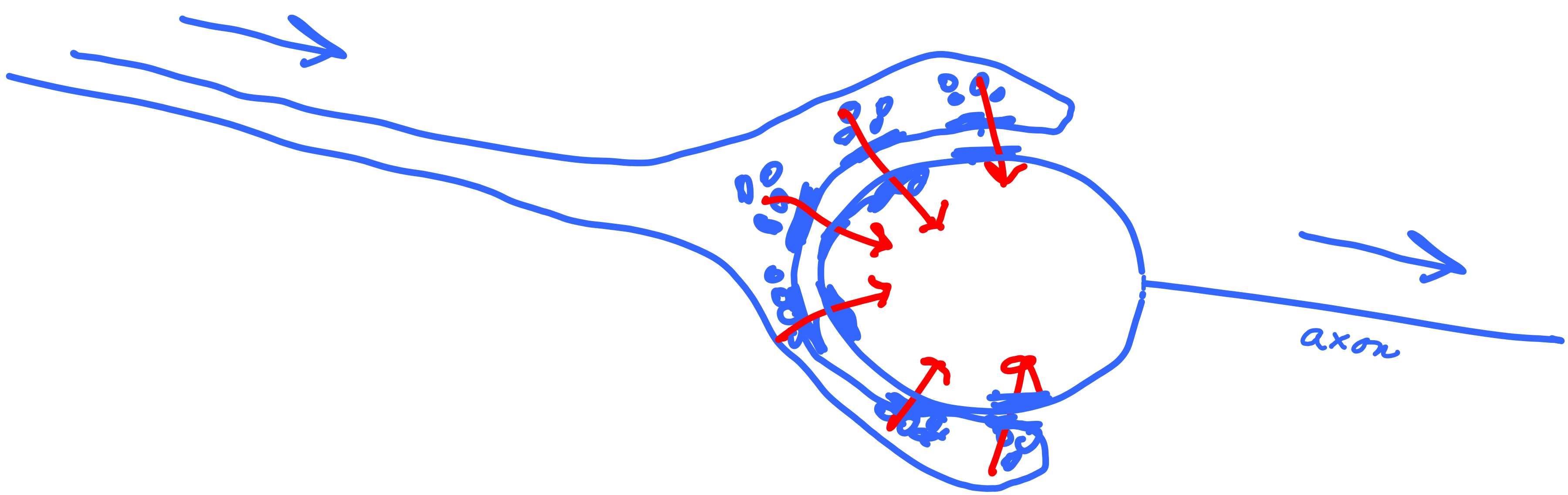


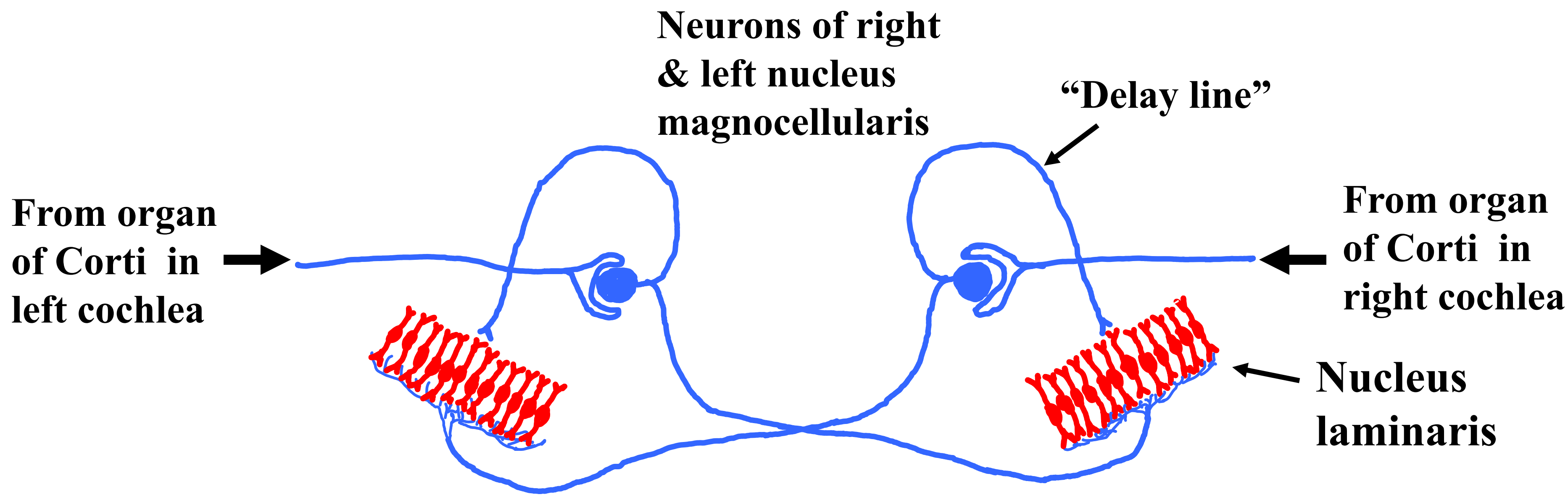
DCN, dorsal cochlear nucleus

VCN, ventral coclear nucleus

REVIEW:

Endbulb of Held





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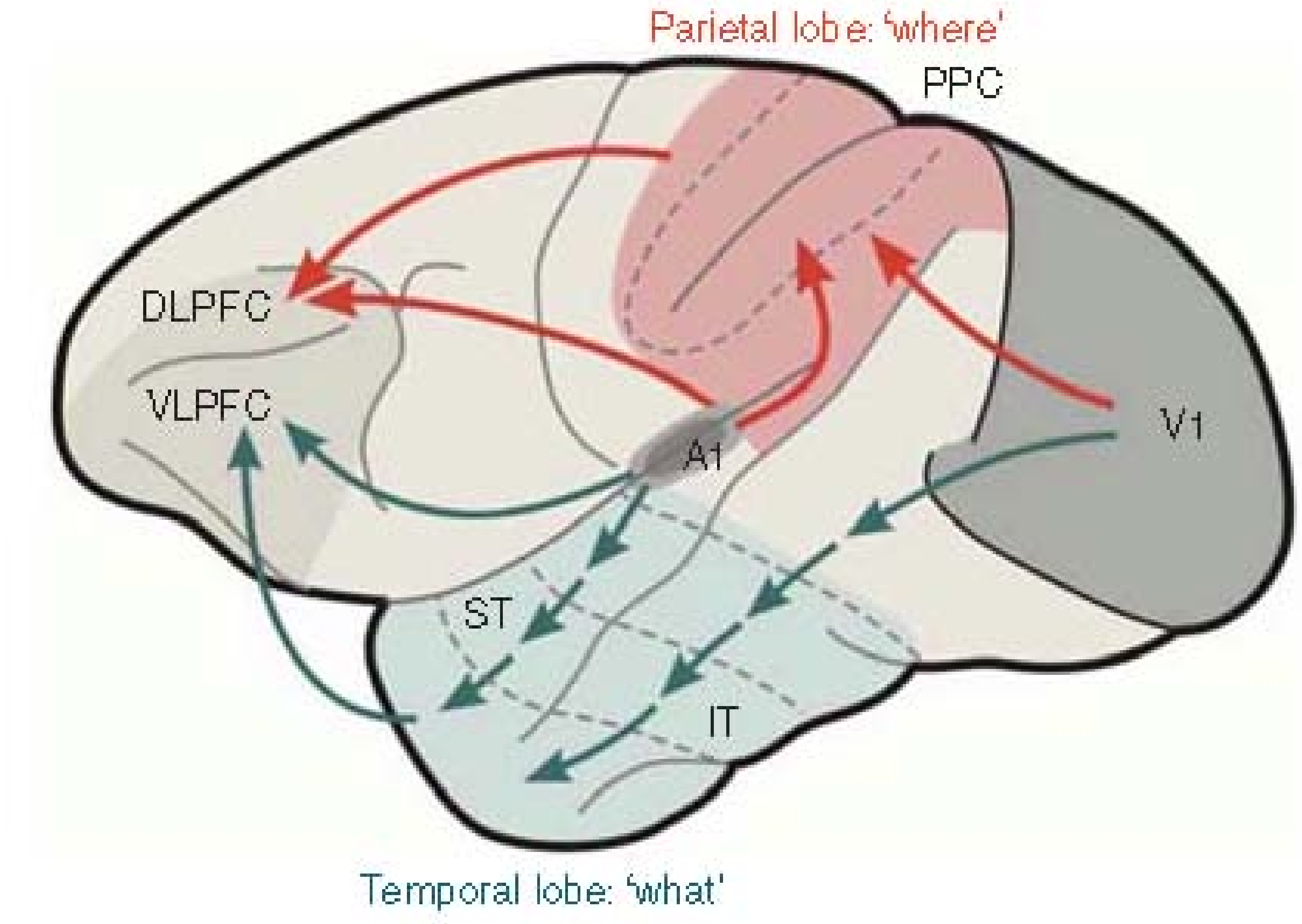
Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Axon of 8th nerve in chicken ends on a neuron of nucleus magnocellularis, part of the cochlear nucleus.

Many such neurons exist on both sides; their axons project to dendrites of nucleus laminaris on both sides of the brain. The neurons there appear to act as coincidence detectors. They are activated when inputs from the two sides arrive simultaneously.

RESULT: With simple assumptions about conduction rates of axons from all of the nuc. magnocellularis neurons, one can see how a map of azimuthal positions could be present in nuc. laminaris.

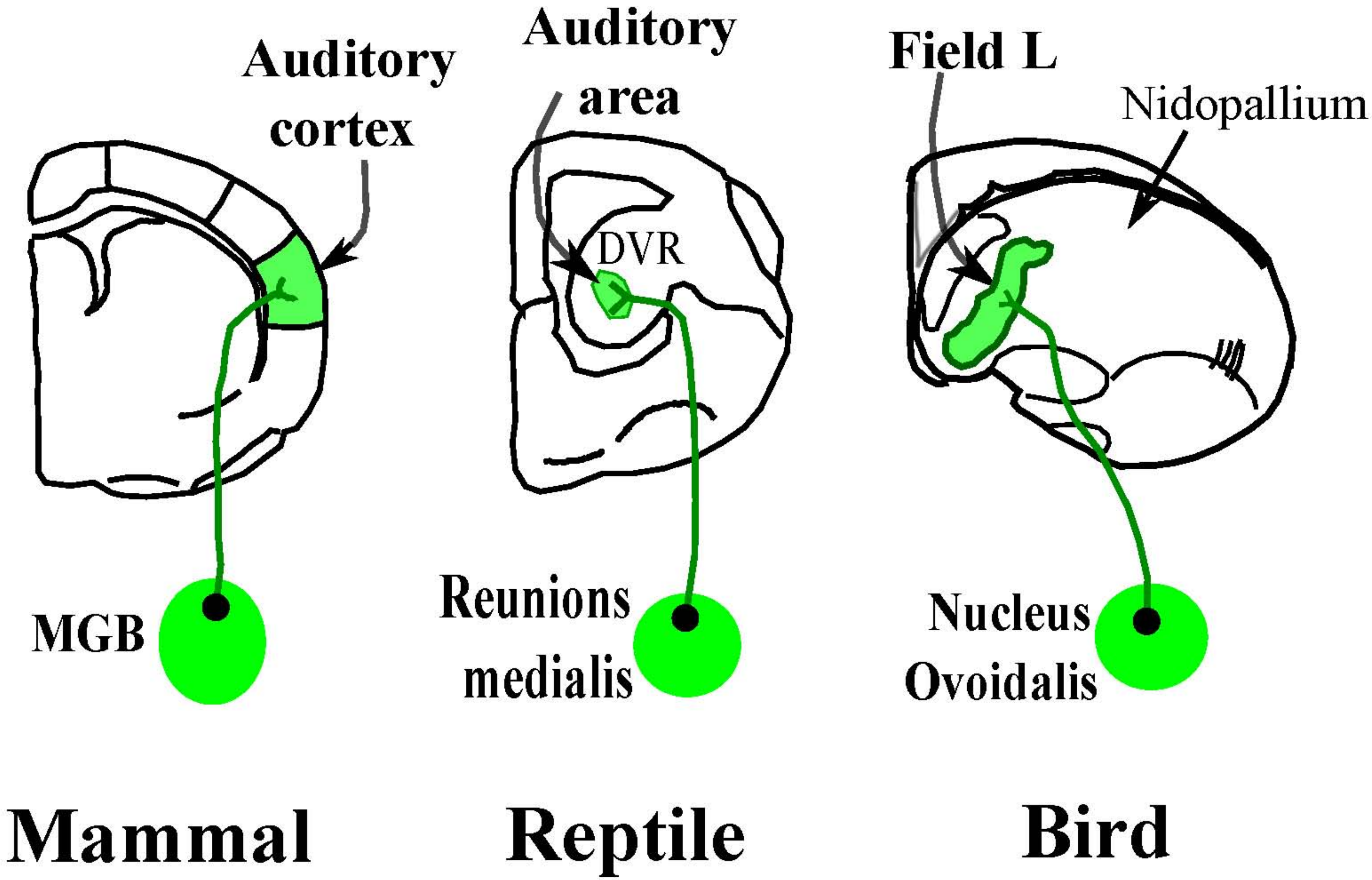
→The axons of that nucleus project to the midbrain.



Pathways for object localization and identification in primates

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

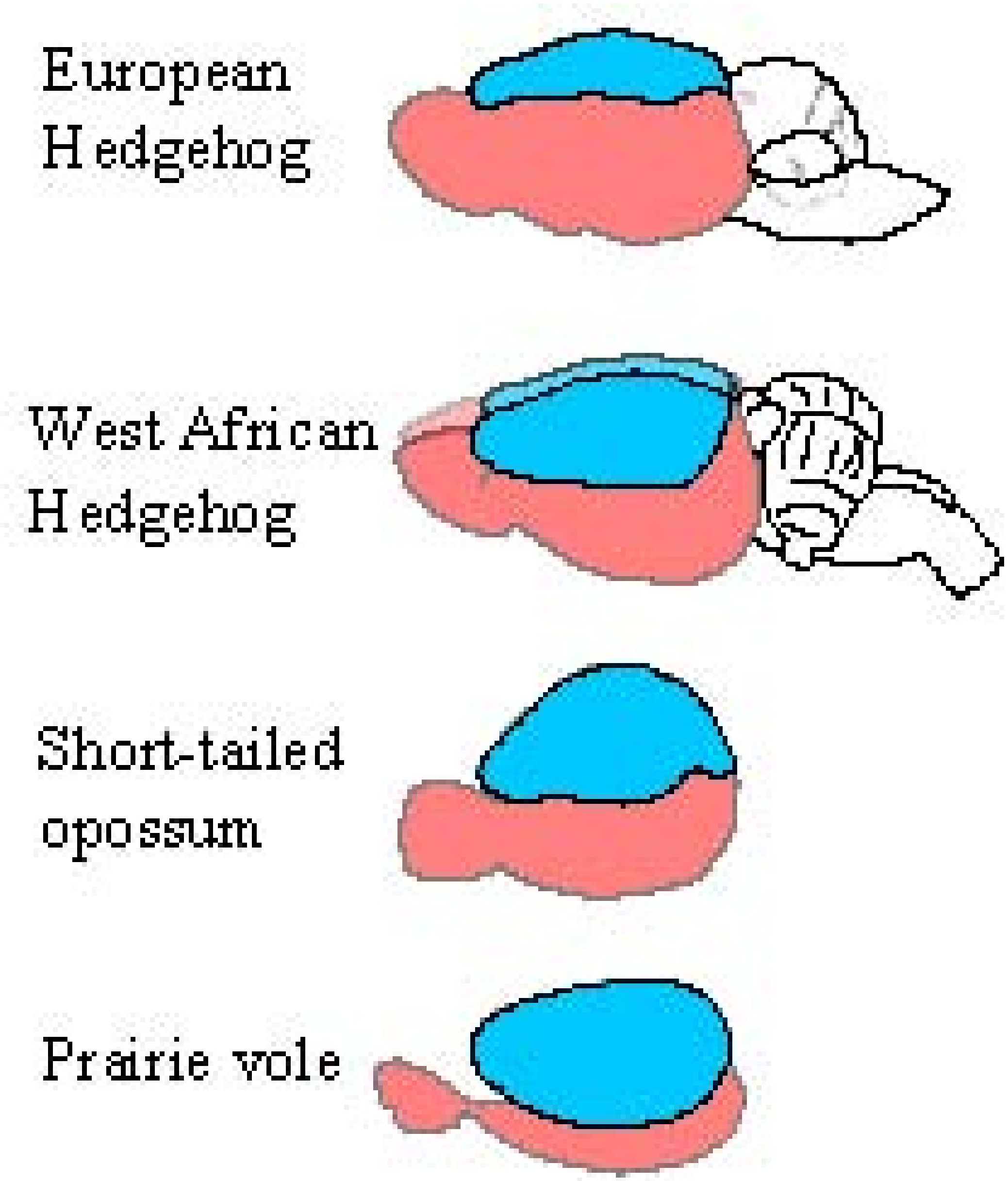
Fig 23-18



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 23-19

Pallium began small:



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 24-6

Evolution of corpus striatum and rest of endbrain: speculations

1. Beginnings: a link between olfactory inputs and motor control: The link becomes “Ventral striatum”. It was a modifiable link (capable of experience-induced change).

2. Non-olfactory inputs invade the striatal integrating mechanisms (*via* paleothalamic structures).

3. Early expansions of endbrain: striatal and pallial. Non-olfactory inputs to pallium

4. Pre-mammalian & then mammalian expansions of cortex and striatum: For the striatum, the earlier outputs and inputs remain as connections with neocortex expand.

Figure 1. Postulated beginnings in primitive chordates

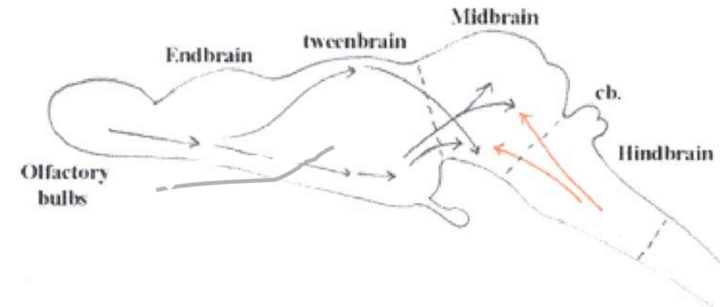


Figure 2. Other inputs reached deeper striatal layers

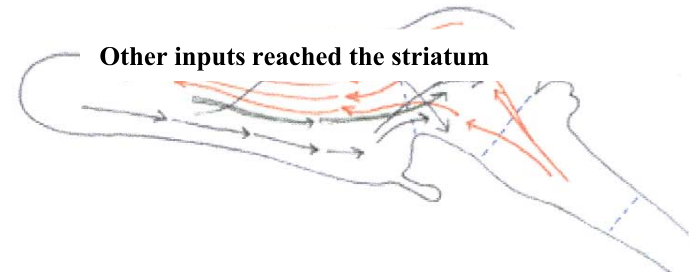


Figure 3. Early expansion of striatal and adjacent " limbic" areas

areas

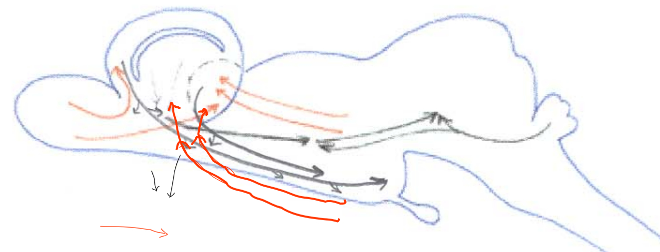
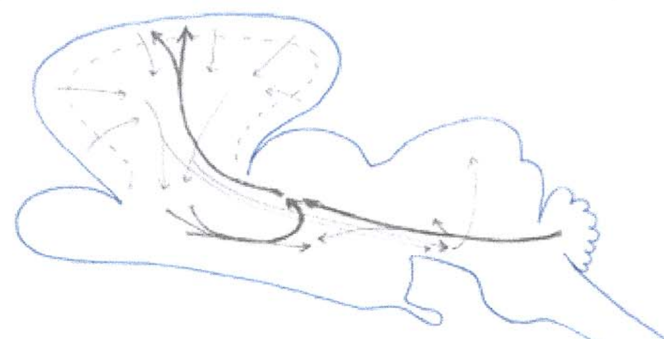
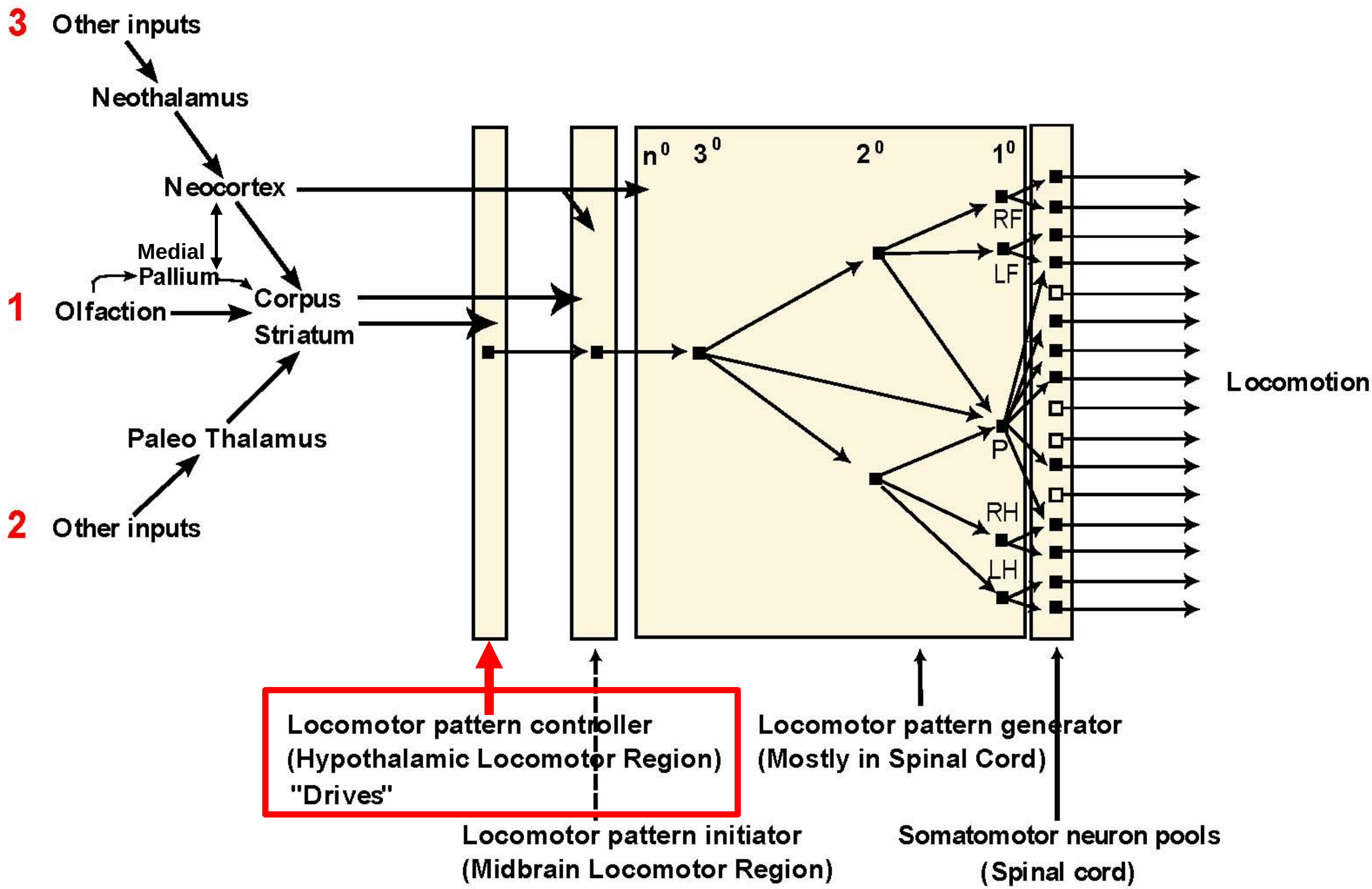


Figure 4. Pre-mammalian, and then mammalian expansions



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

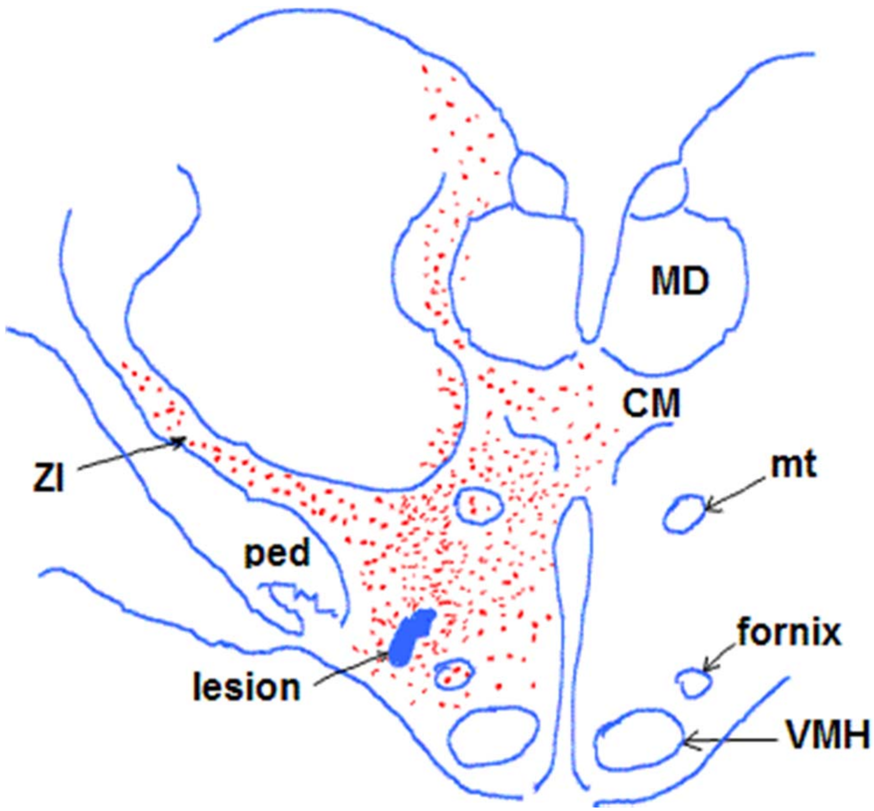


Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Hierarchic control of locomotor behavior

Fig 14-2

Figure removed due to copyright restrictions. Please see course textbook or:
Brownstein, Michael J., James T. Russell, et al. "Synthesis, Transport, and Release of Posterior Pituitary Hormones." *Science* 207, no. 4429 (1980): 373-8.



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

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

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.

Papez' circuit with additions

mt = mammillothalamic tract

fx = fornix bundle

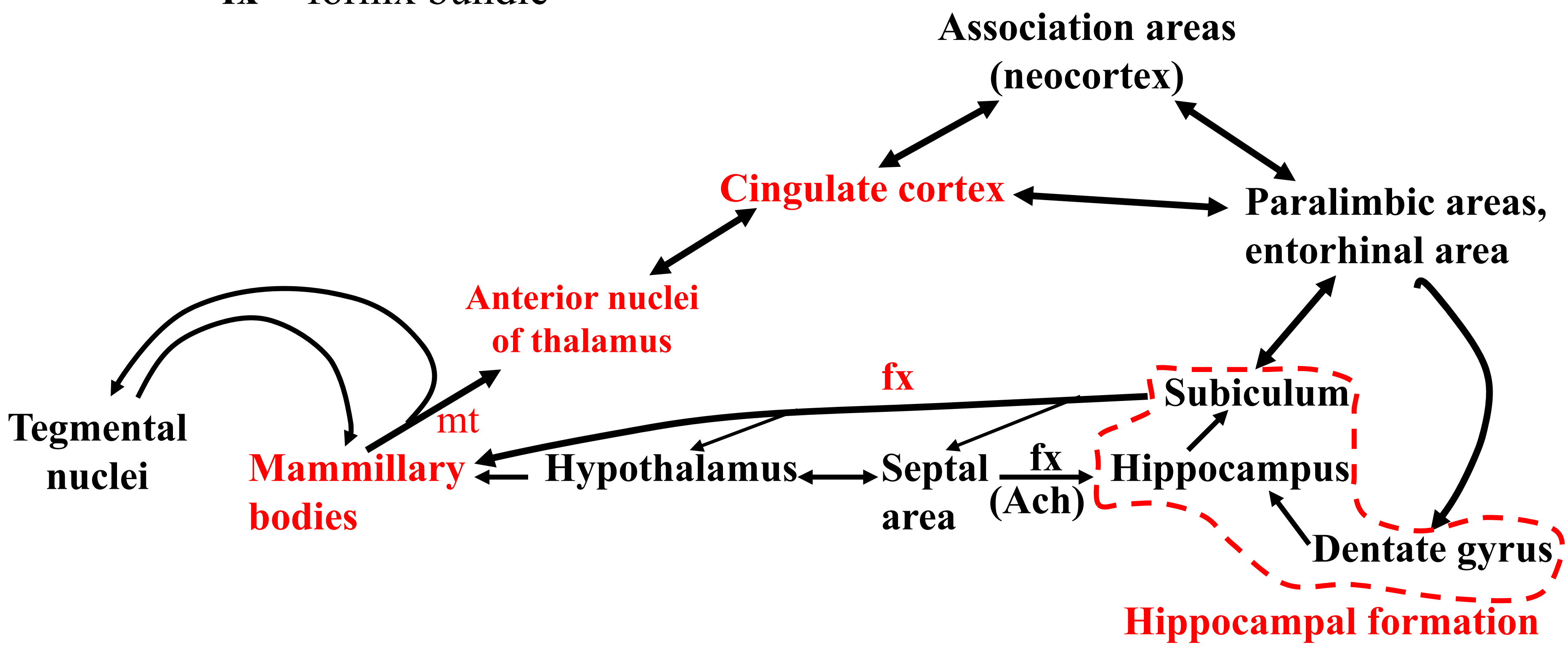


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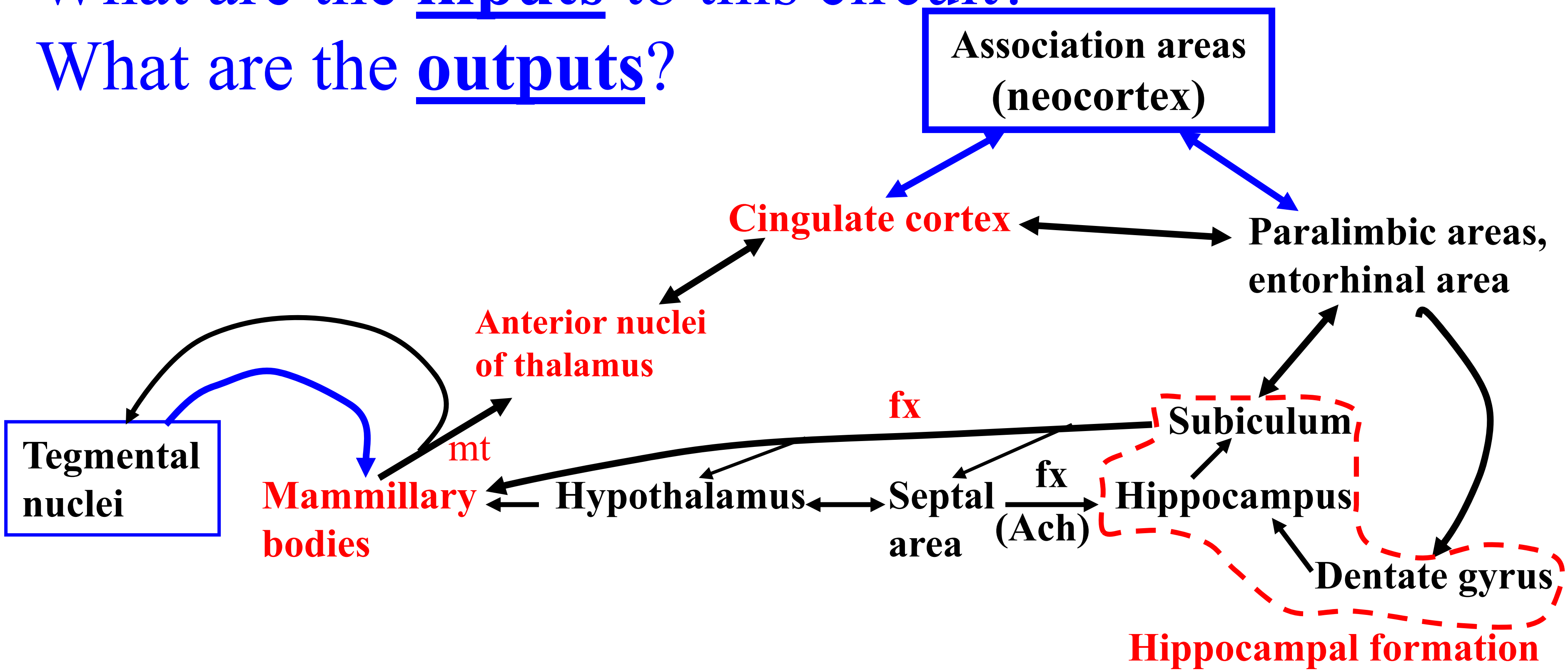
Fig 26-7a

Bringing it up to date

Papez' circuit brought up to date:

What are the **inputs** to this circuit?

What are the **outputs**?



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

mt = mammillothalamic tract

fx = fornix bundle (output of hippocampus)

Ach= acetylcholine used as neurotransmitter

Through the neocortex to the limbic system:

Transcortical pathways from specialized sensory and motor areas through association cortex to limbic system:

Such transcortical connections increased in quantity and importance in larger mammalian brains.

Modified from Mesulam's fig. 1-6

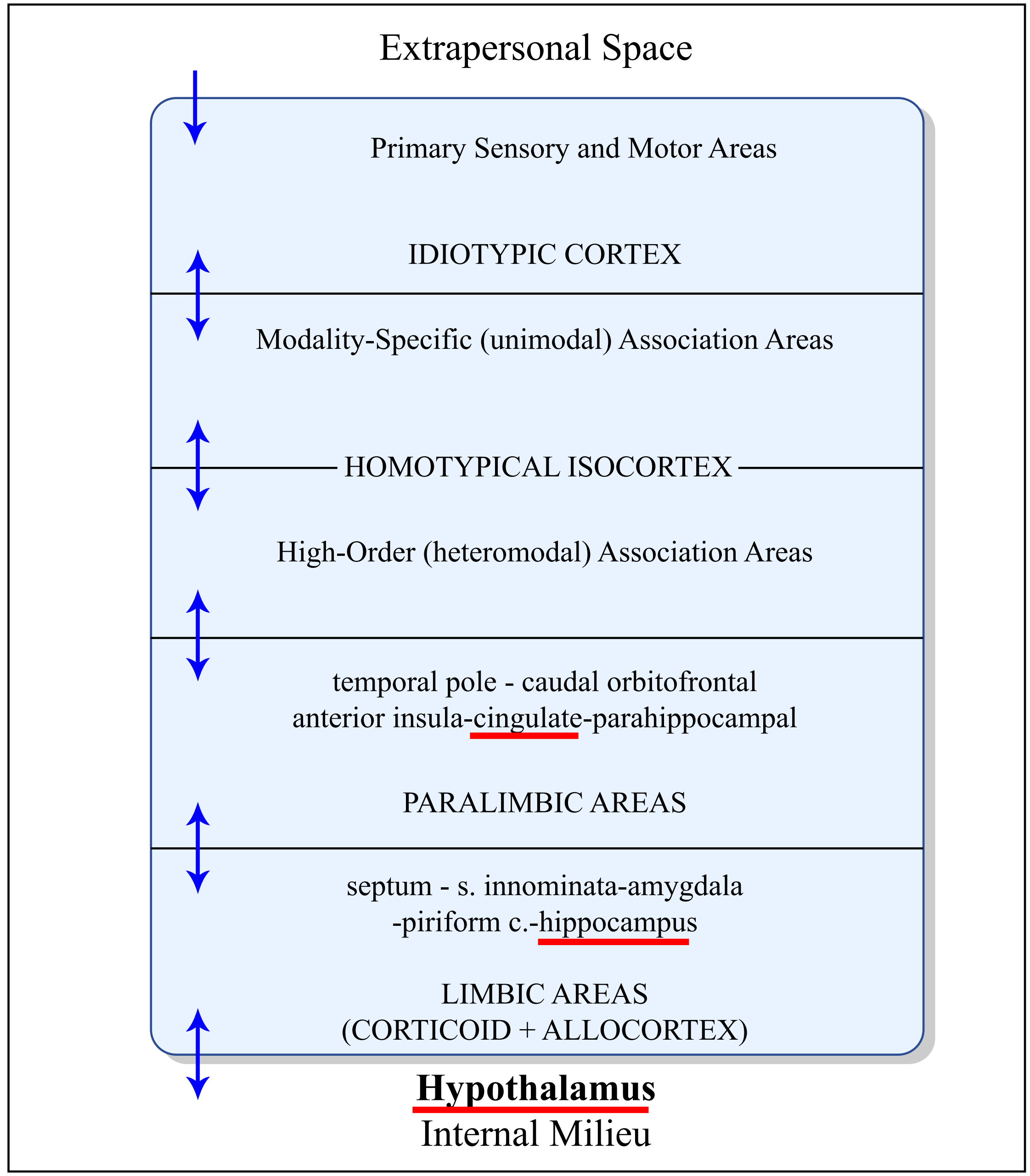
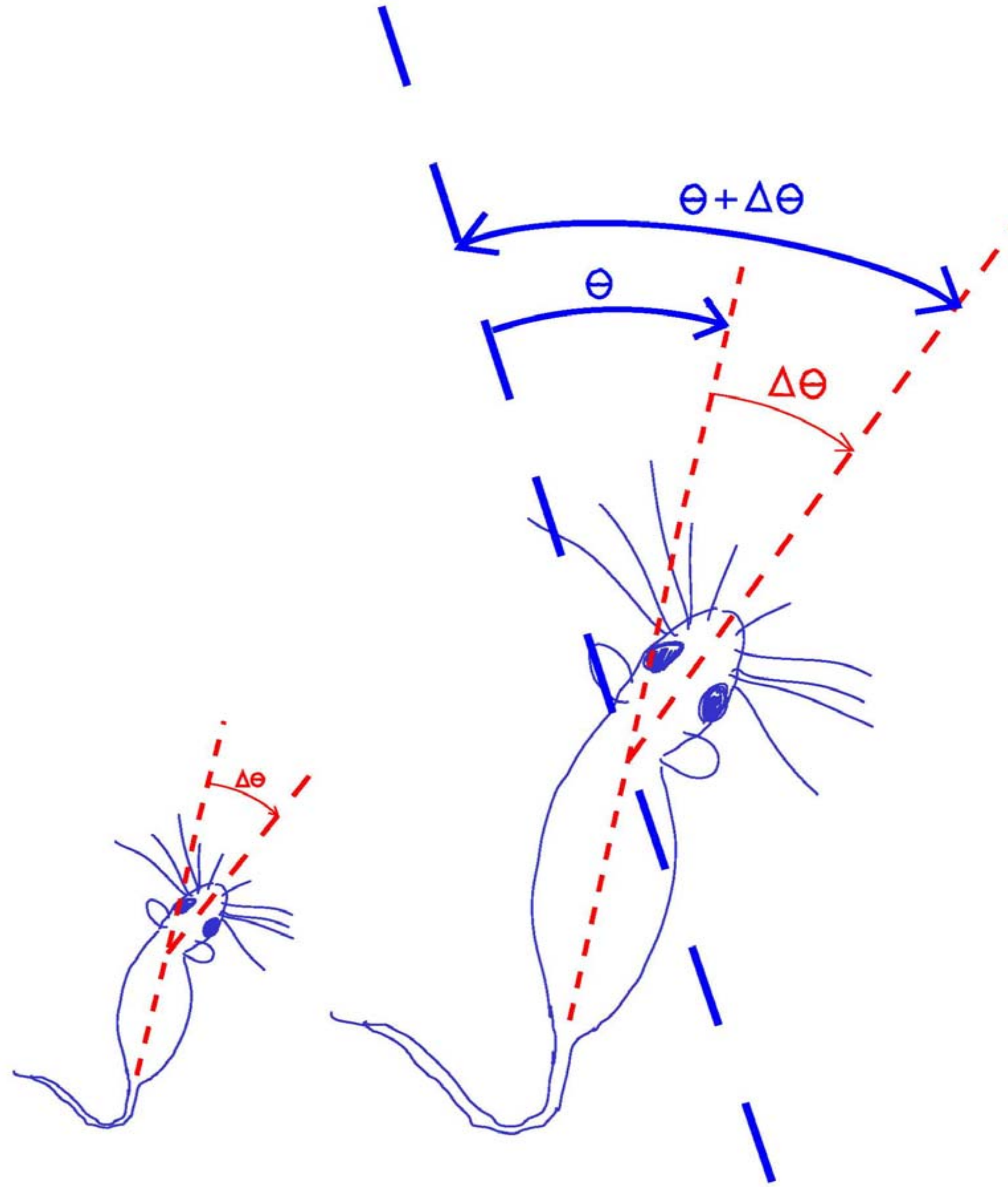


Image by MIT OpenCourseWare.

Fig 26-9

Terms:

- Allocentric direction
- Egocentric direction
- Head direction cells (HD cells)



Sense of direction and of directional change

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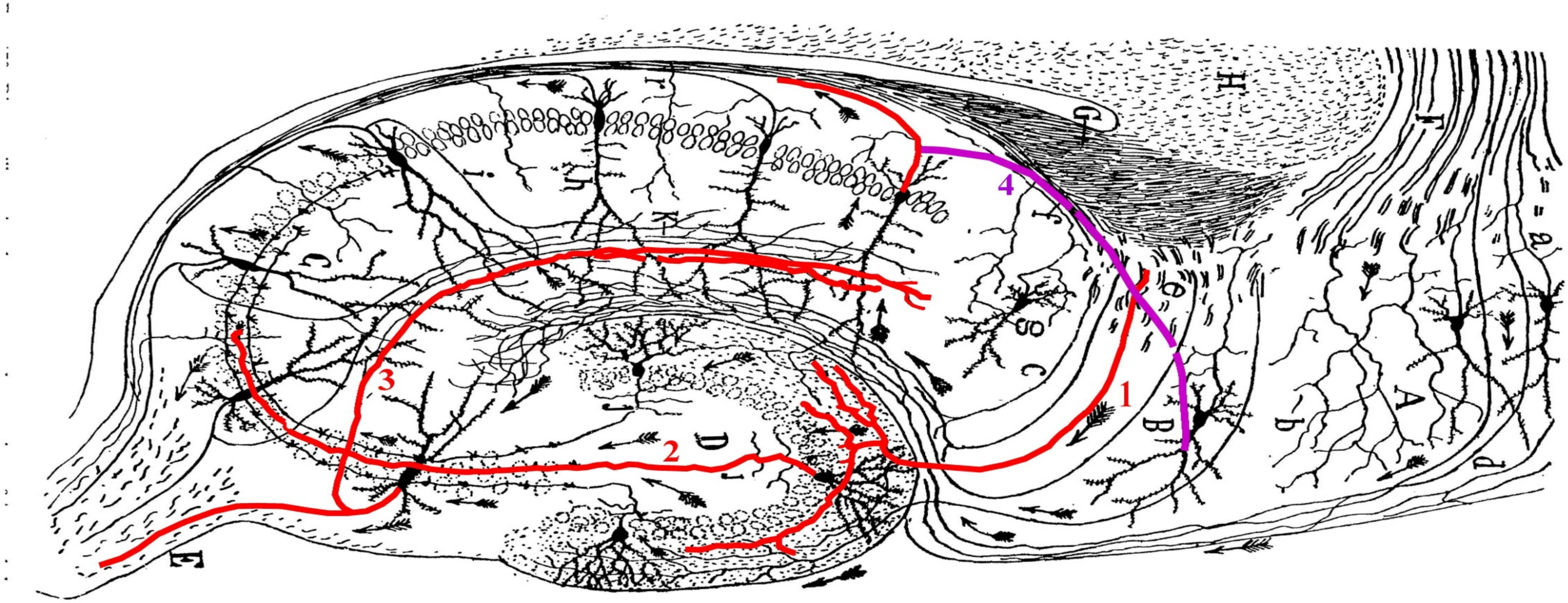
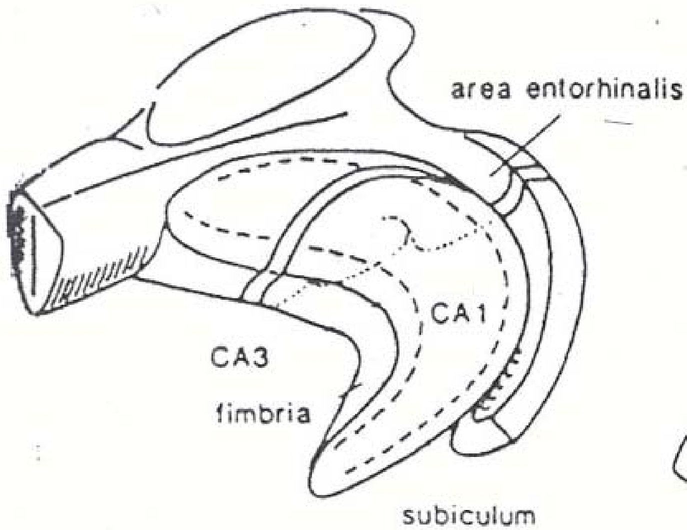
Fig 28-2

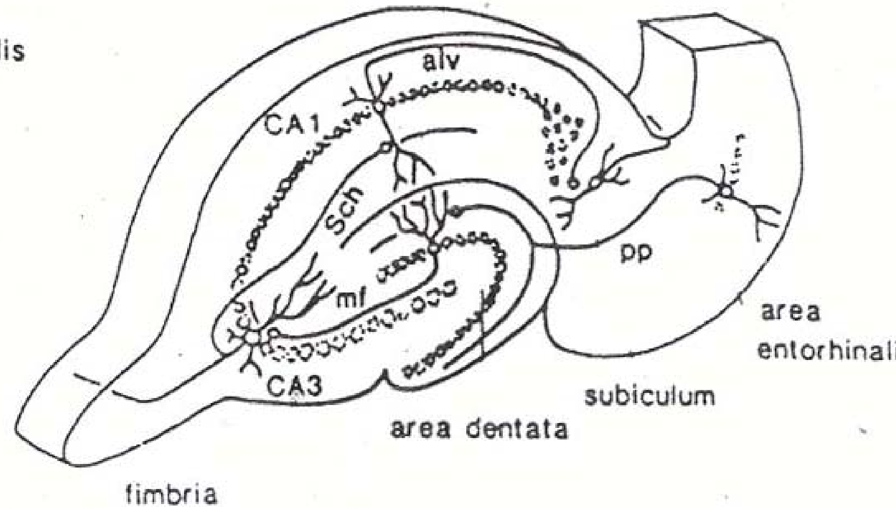


From entorhinal cortex to dentate gyrus to CA3 (*via* mossy fibers) to CA1 (*via* Schaffer collaterals of CA3 cell axons) to subiculum

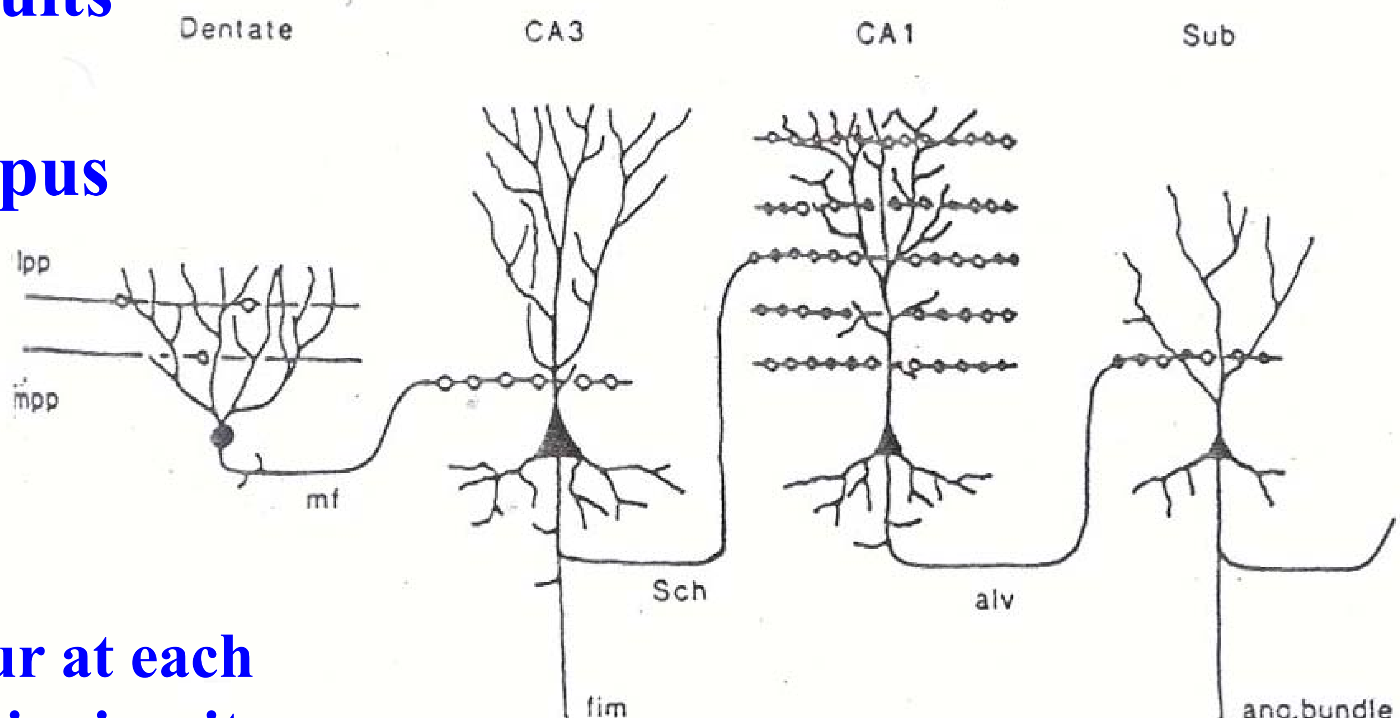
Hippocampus:
input through the "perforant path" (axon 1),
then through 3 synapses to the subiculum

Fig 28-10a





Local circuits in the hippocampus



LTP can occur at each synapse in this circuit.

Evolution of corpus striatum and rest of endbrain: speculations [from class 26]

1. Beginnings: a link between olfactory inputs and motor control: The link becomes "Ventral striatum". It was a modifiable link (capable of experience-induced change).

2. Non-olfactory inputs invade the striatal integrating mechanisms (*via* paleothalamic structures).

3. Early expansions of endbrain: striatal and pallial. Non-olfactory inputs to pallium [Note the two pathways going caudally from the olfactory system.]

4. Pre-mammalian & then mammalian expansions of cortex and striatum: For the striatum, the earlier outputs and inputs remain as connections with neocortex expand.

Figure 1. Postulated beginnings in primitive chordates

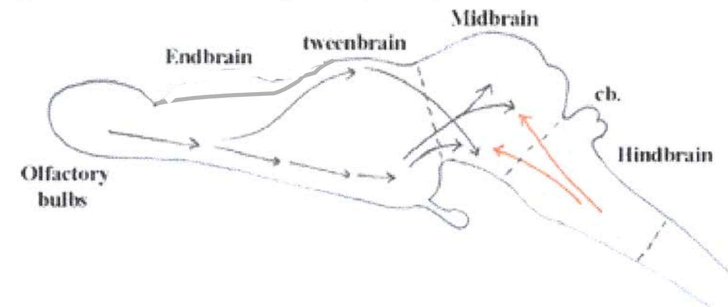


Figure 2. Other inputs reached the striatum

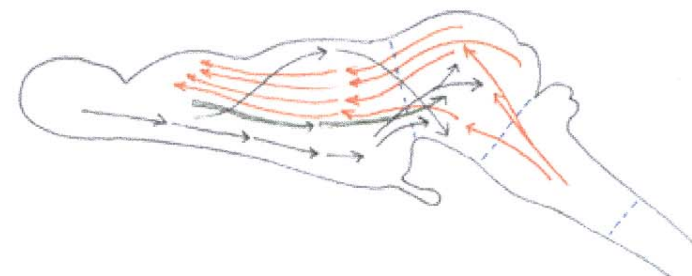


Figure 3. Early expansion of striatal and adjacent " limbic' areas

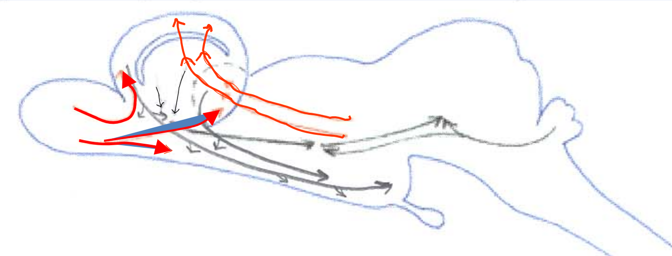
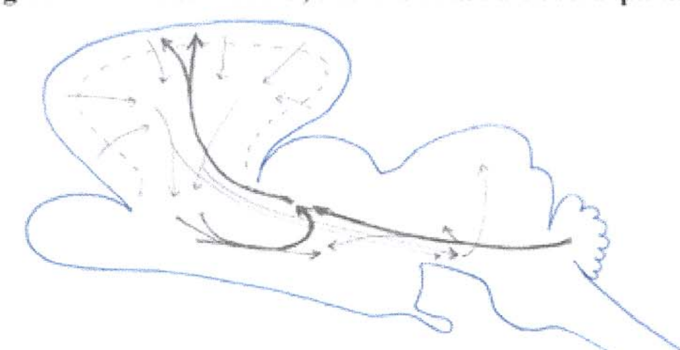


Figure 4. Pre-mammalian, and then mammalian expansions

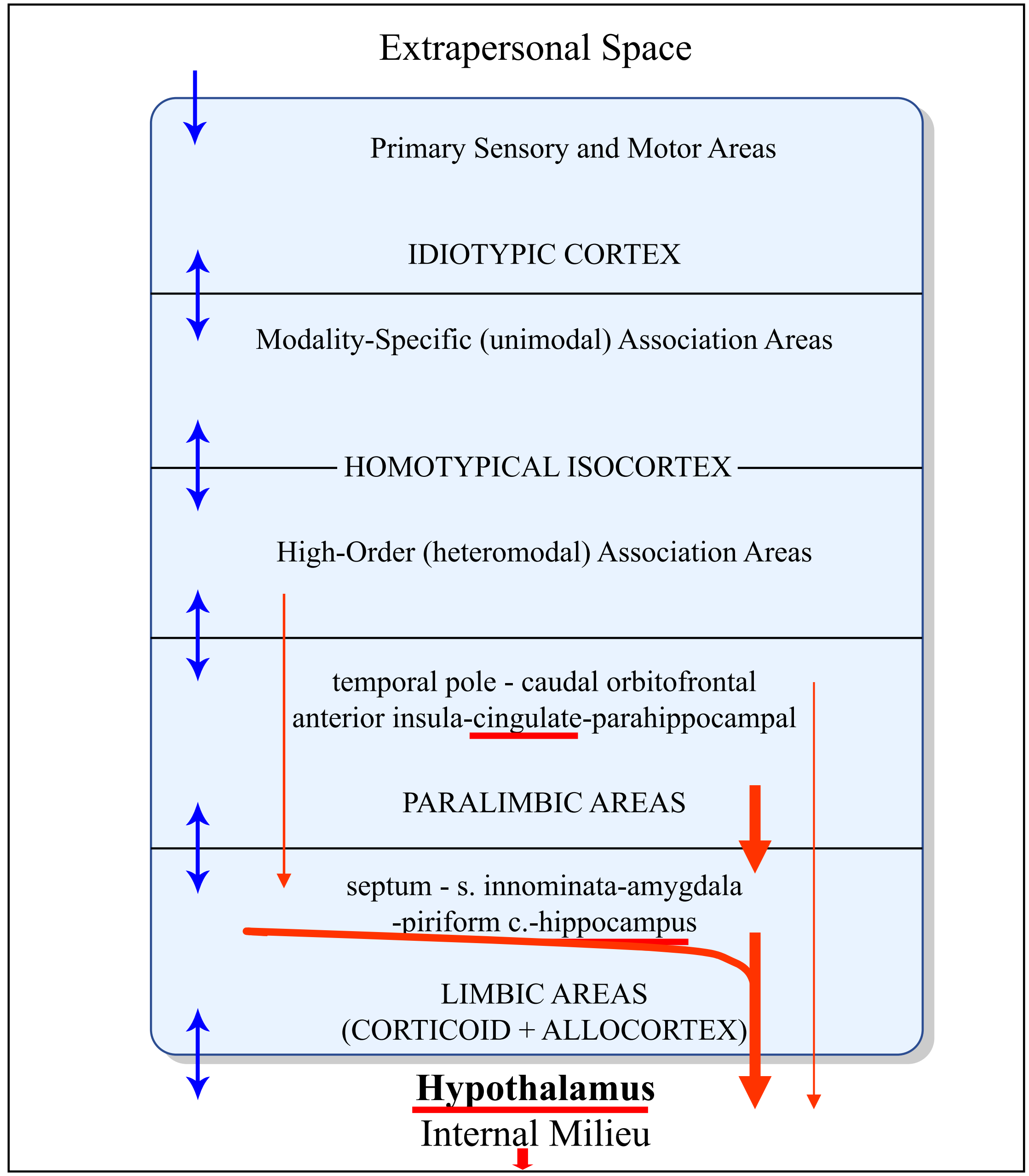


Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Mesulam, fig. 1-6

In red, the connections from neocortex that most directly influence the autonomic nervous system.

The **amygdala** is a major player in this kind of connection. We focus on the amygdala next.



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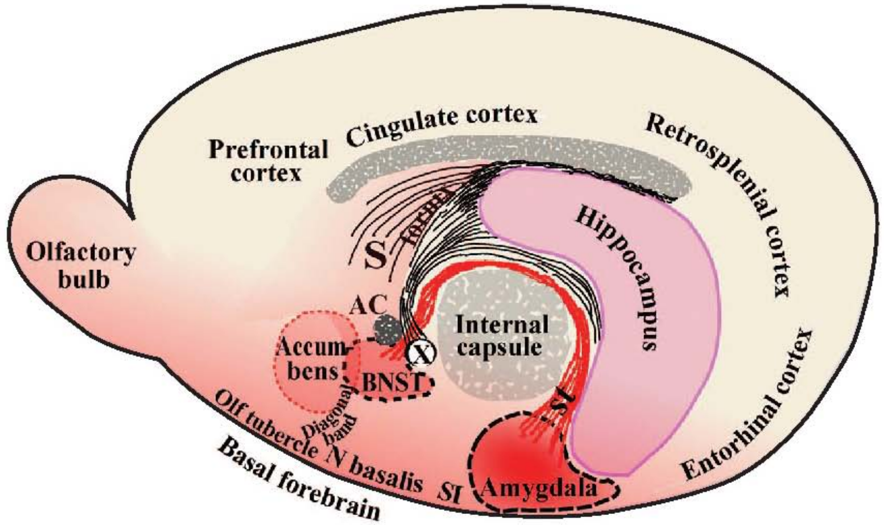


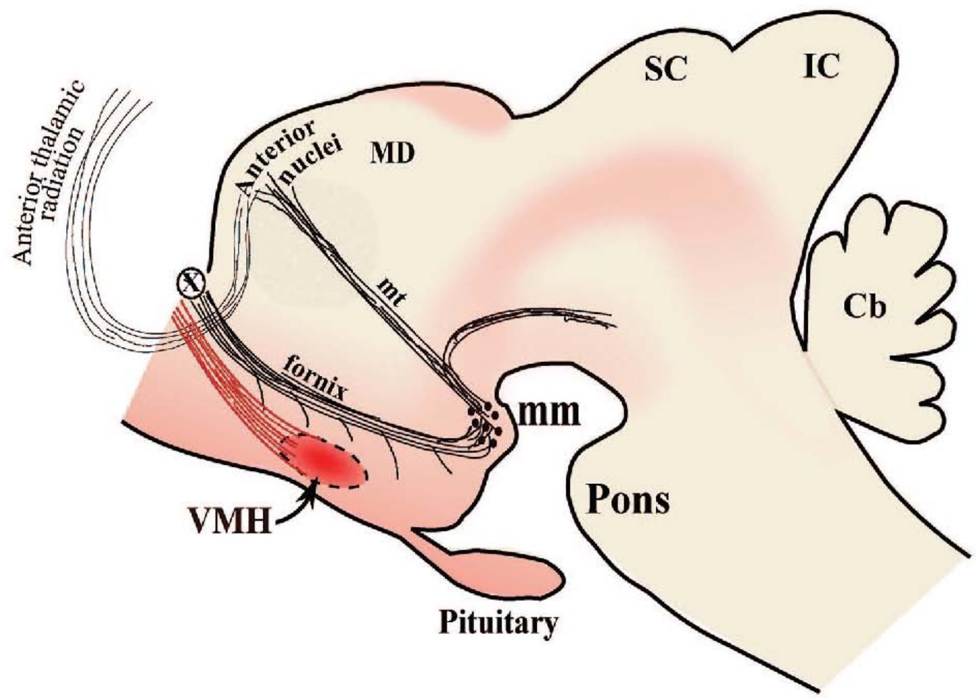


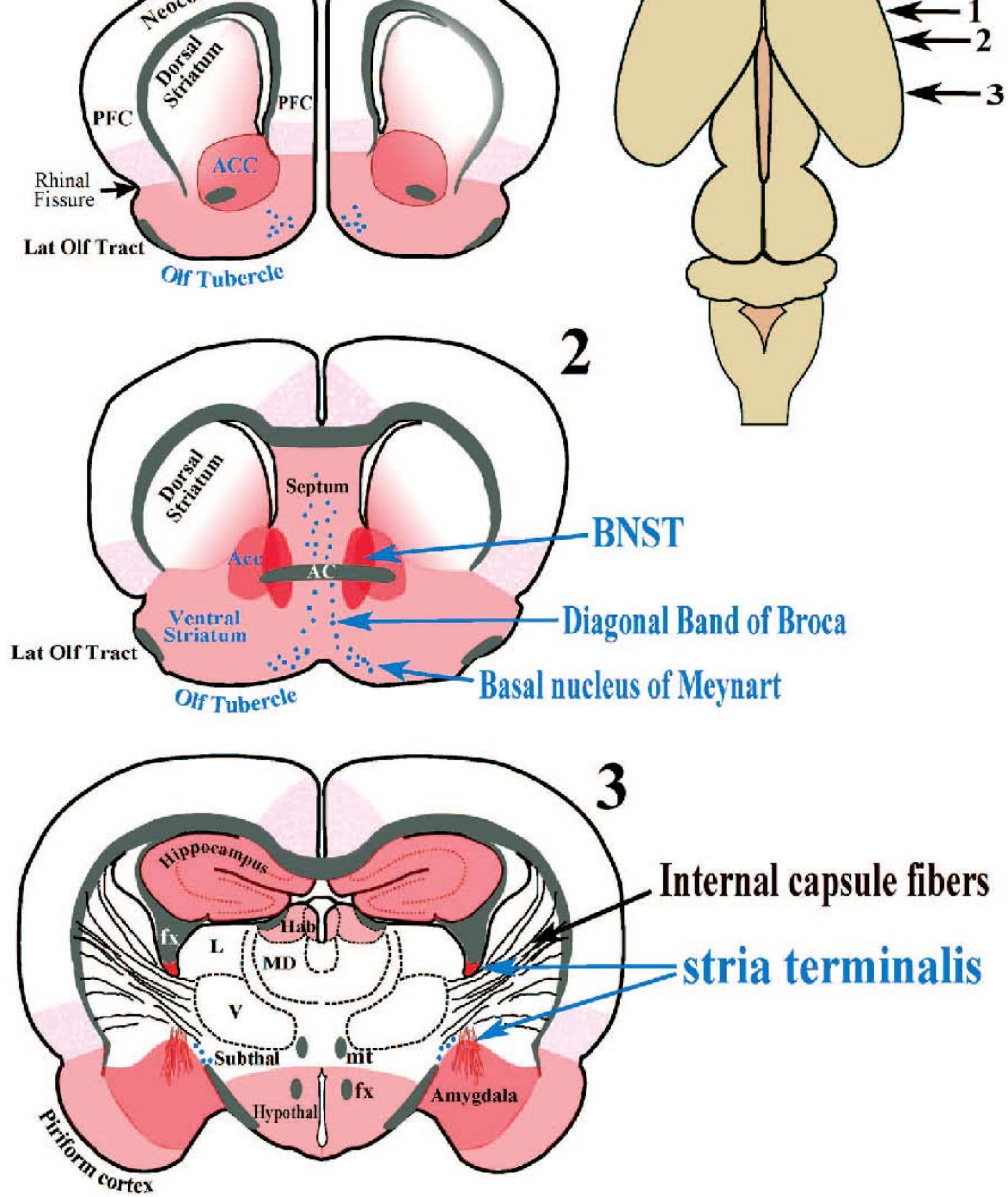
Fig 29.5

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

Frontal sections: the limbic system of rodent

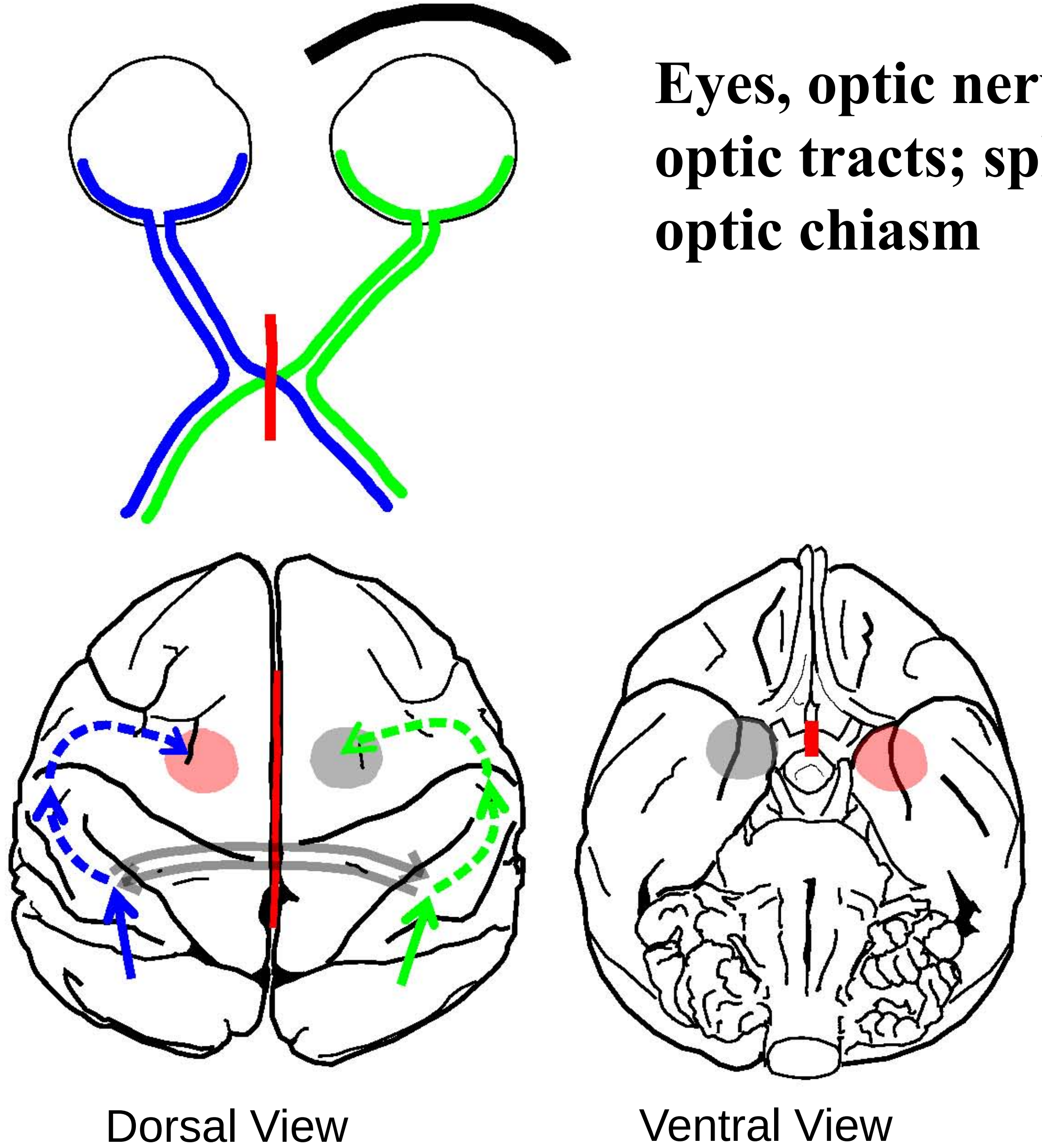
Find the Amygdala, the Stria Terminalis, and the Bed Nucleus of the Stria Terminalis

Can you also identify the positions of the fornix fibers from the hippocampal formation?



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

Eyes, optic nerves, optic tracts; split optic chiasm



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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 29-7

Major afferents of dorsal striatum:

- DA axons from the substantia nigra
- **Sensory inputs via the paleothalamus**
- Inputs via the neocortex

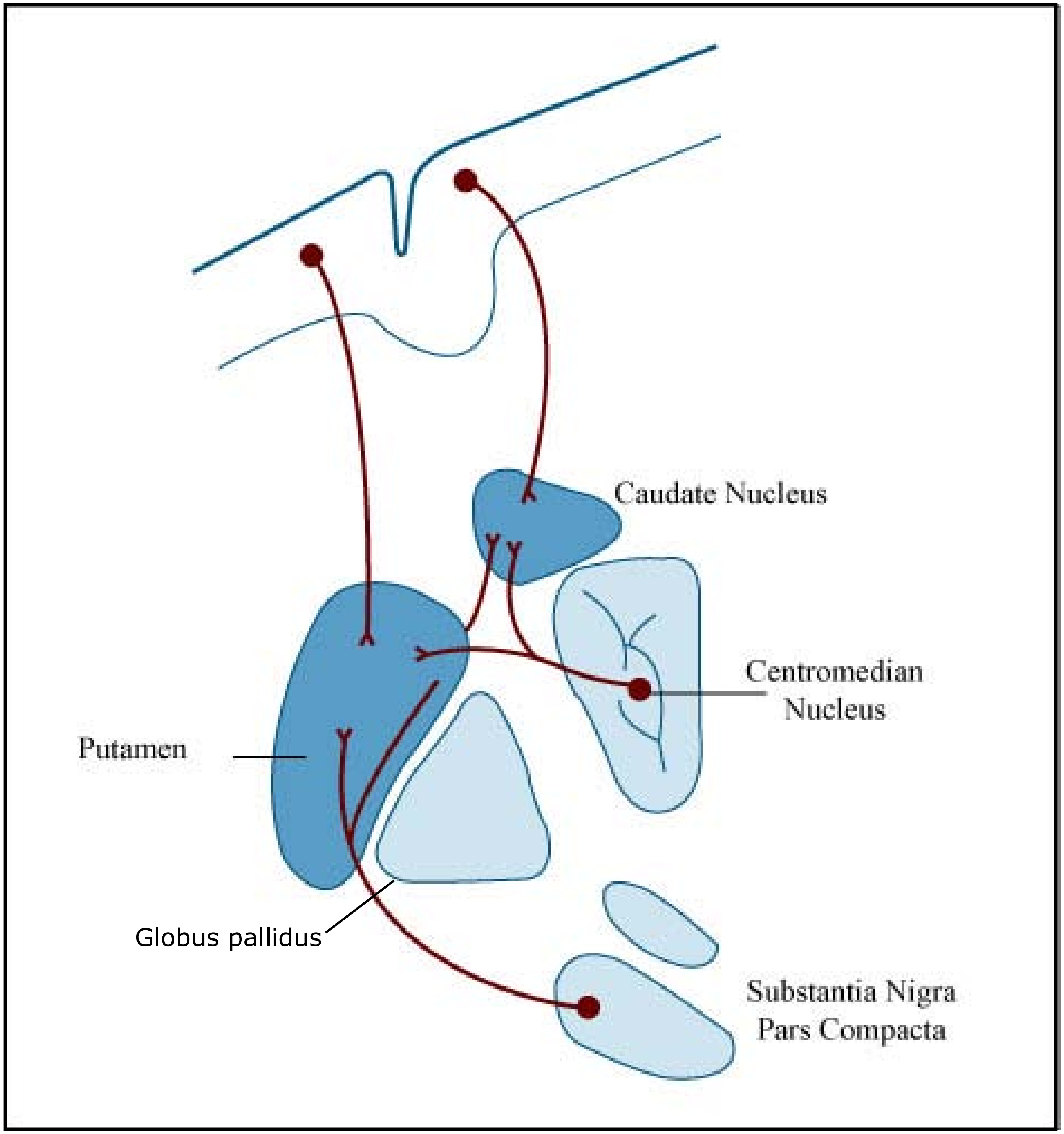


Image by MIT OpenCourseWare.

Fig 30-2

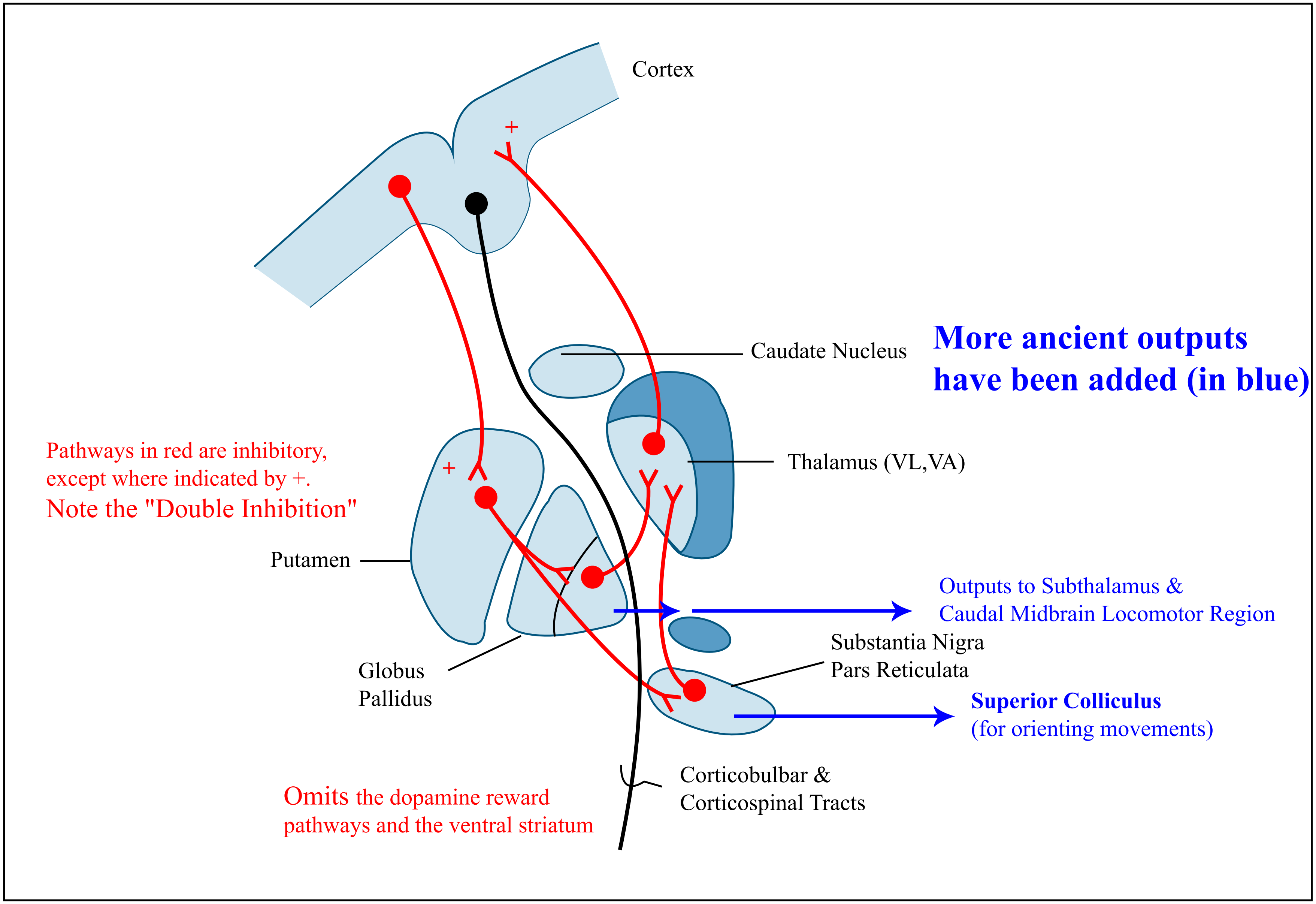


Image by MIT OpenCourseWare.

Fig 30-8

Dominant inputs to the dorsal striatum in mammals come from the neocortex

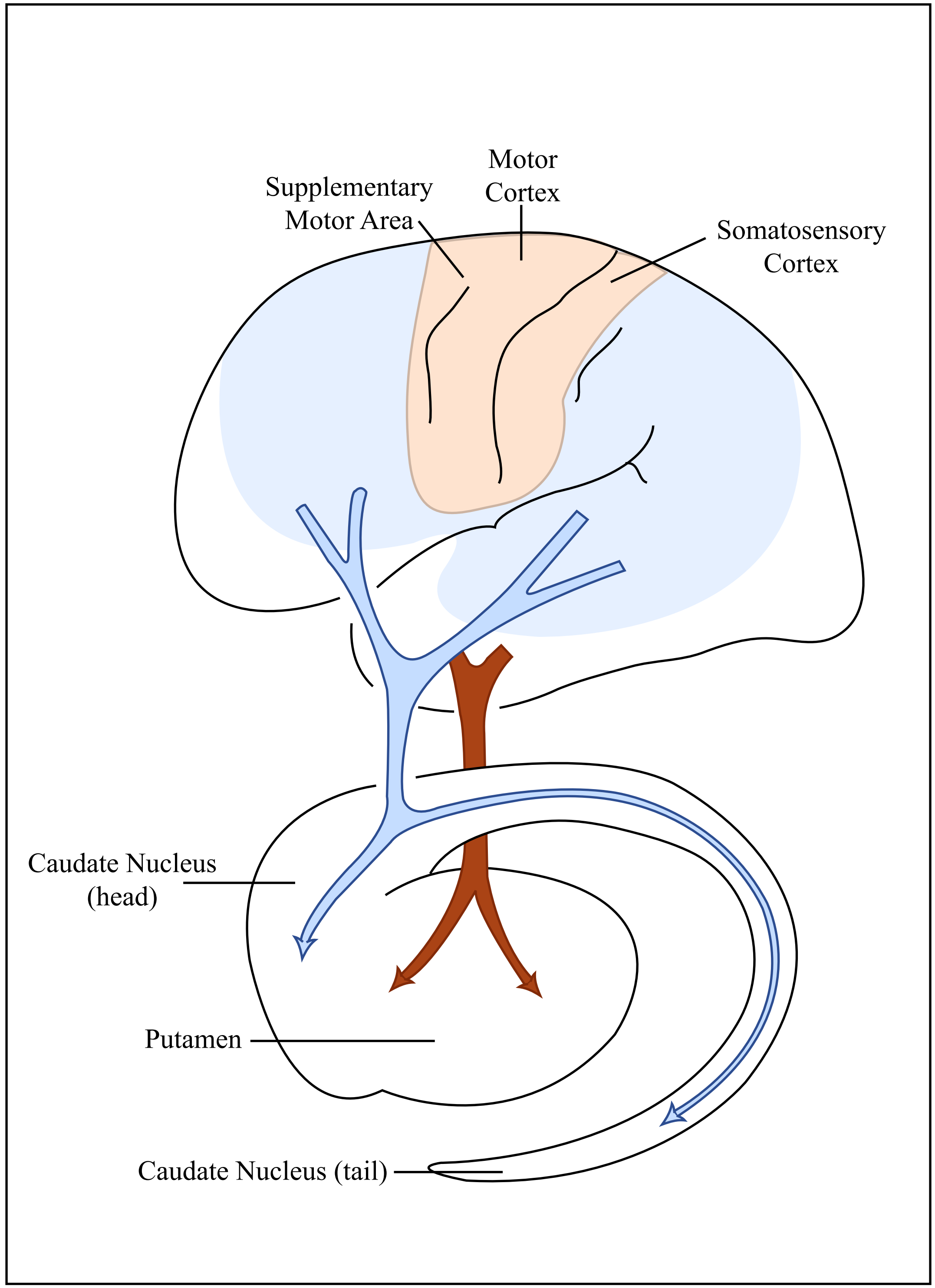
Topography of cortico-striatal projections in primates:

Sensorimotor areas to **Putamen**;

Prefrontal areas to **Head of Caudate**;

Posterior areas to **Caudate (tail & medial head)**

Fig 30-10a



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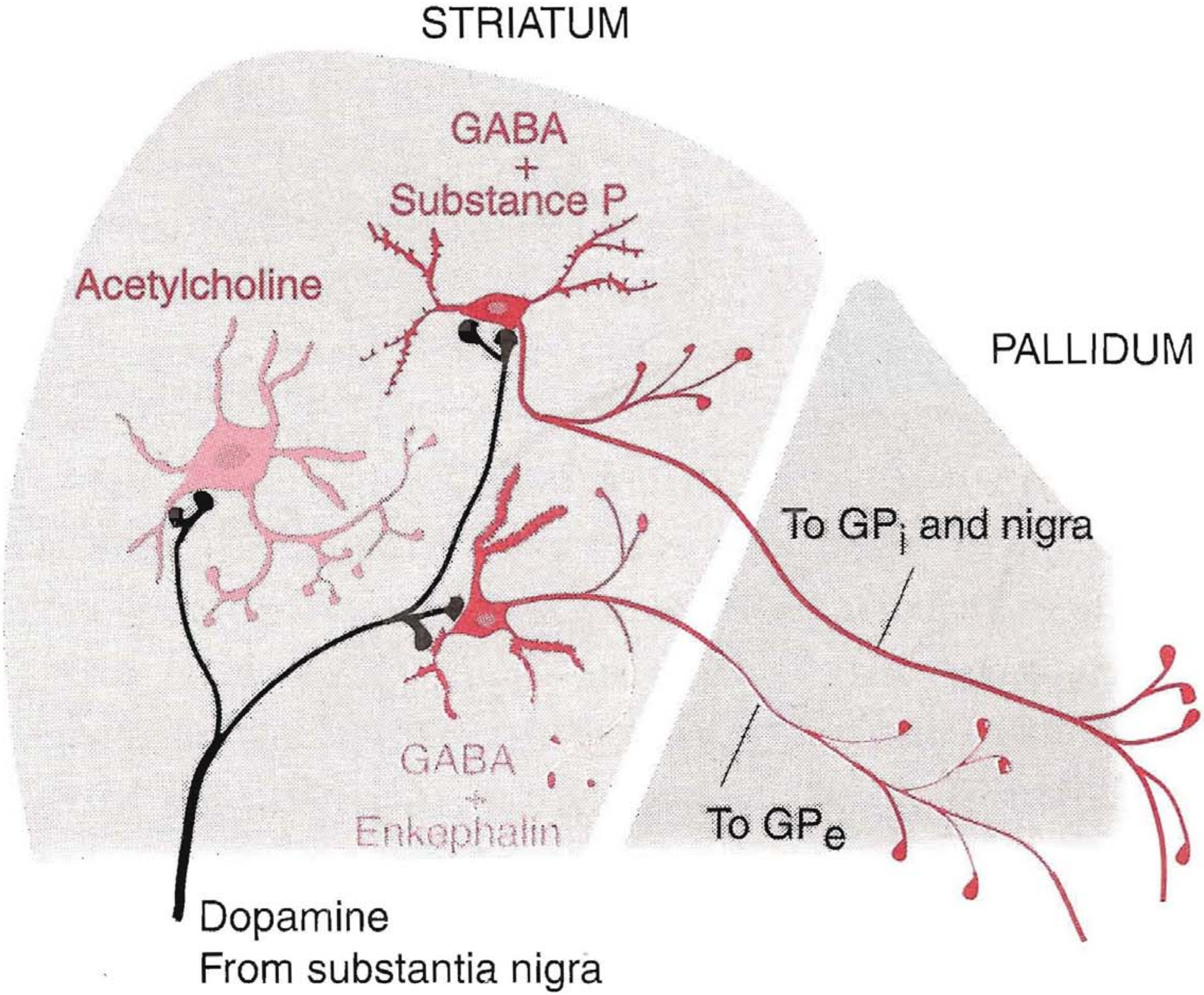

Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Fig 30-11

REVIEW:

Archetypal embryonic stage

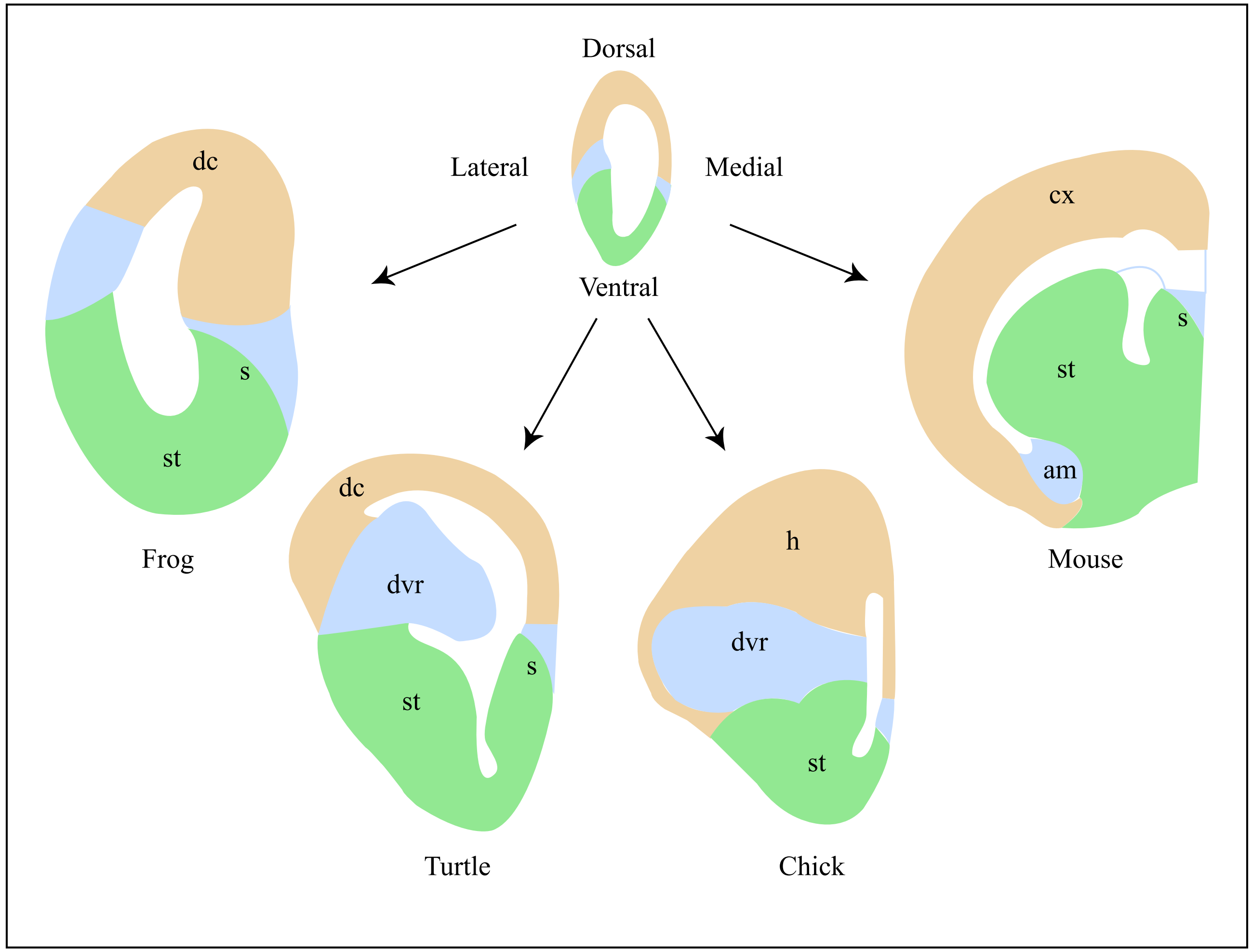

Image by MIT OpenCourseWare.

cx = neocortex

dc = dorsal cortex (pallium)

dvr = dorsal ventricular ridge

h = hyperpallium

s = septum

st = striatum

Homeobox gene expression: Emx-1 Dlx-1

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

Fig 12-2

Human neocortex: 3 cytoarchitectural methods:

The dominant cell type is the pyramidal cell.

Is there a consistent pattern of connections of these neocortical cells?

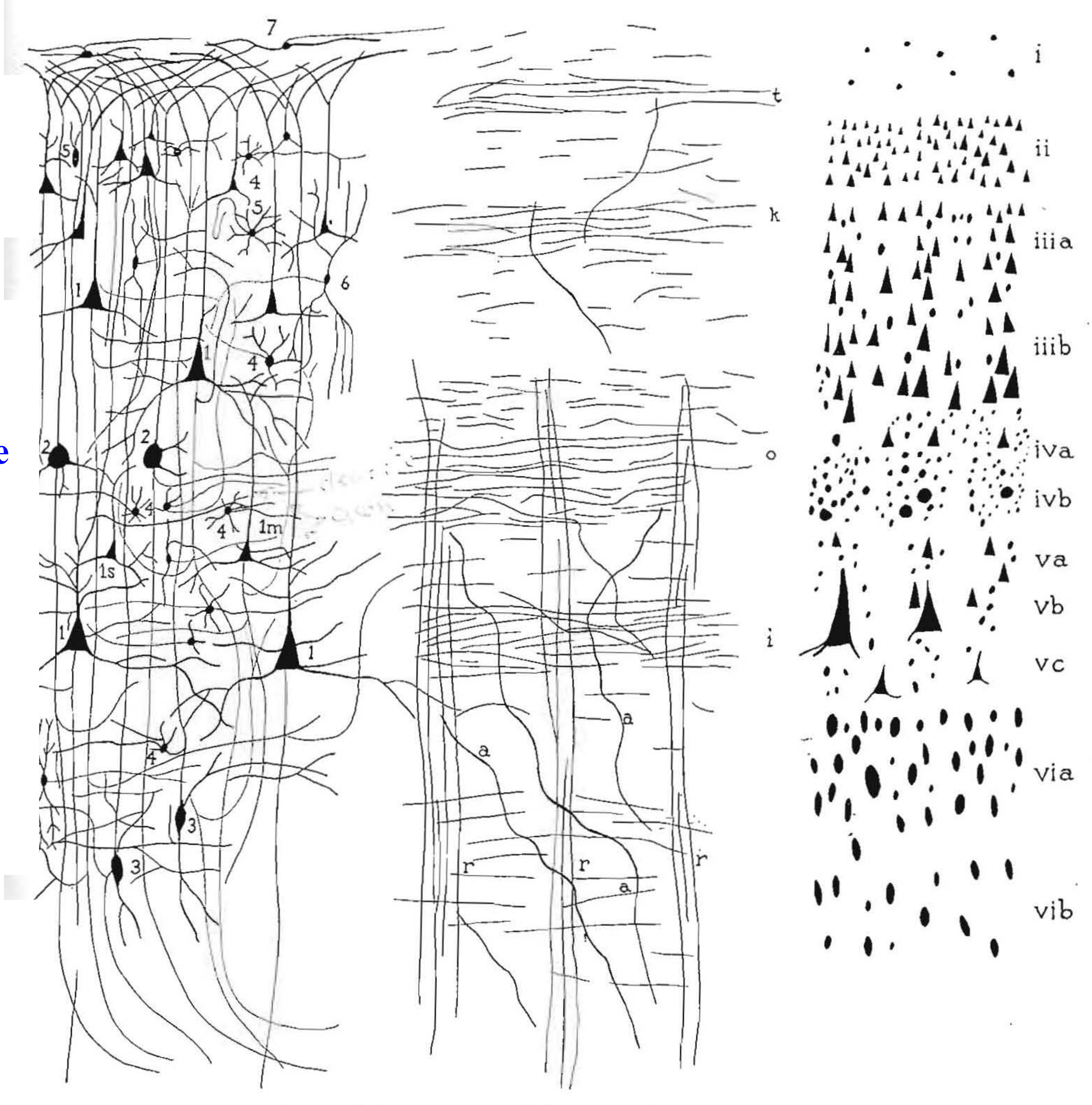

Fig 32-1a

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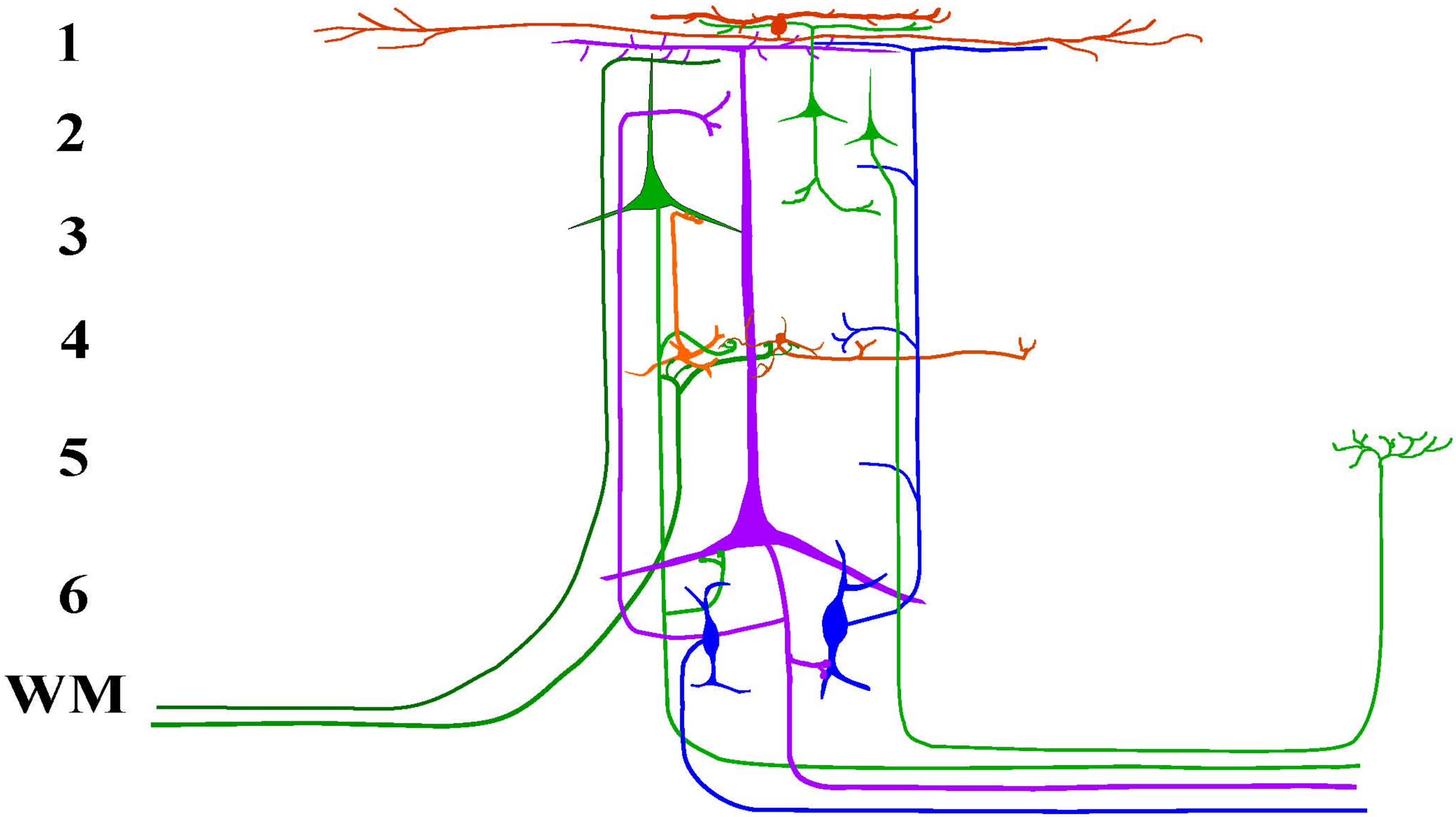

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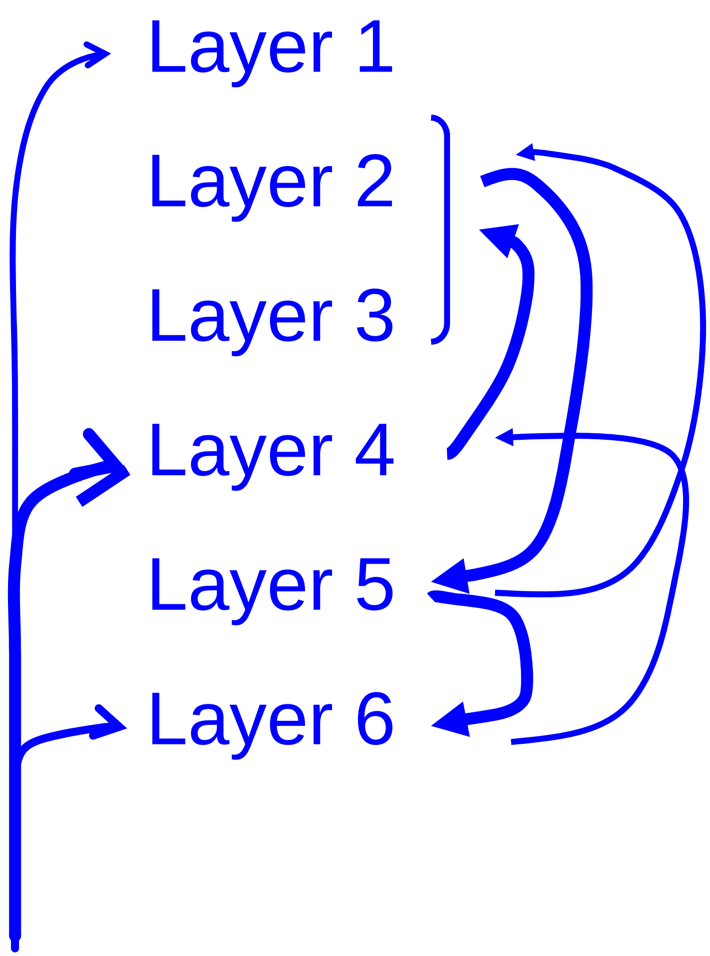
Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Sketch of a column of cells in the neocortex. Note the different types of axons: afferent, efferent, association

Fig 32-2

Connections of neurons in the different cortical layers

(We described this once before, but less schematically: see fig 32.2.)



Omits all lateral interconnections and long-distance projections

Why does layer 1 have no outputs?

The girdle of paralimbic areas: olfactocentric & hippocampocentric
(from Mesulam)

Figure removed due to copyright restrictions.

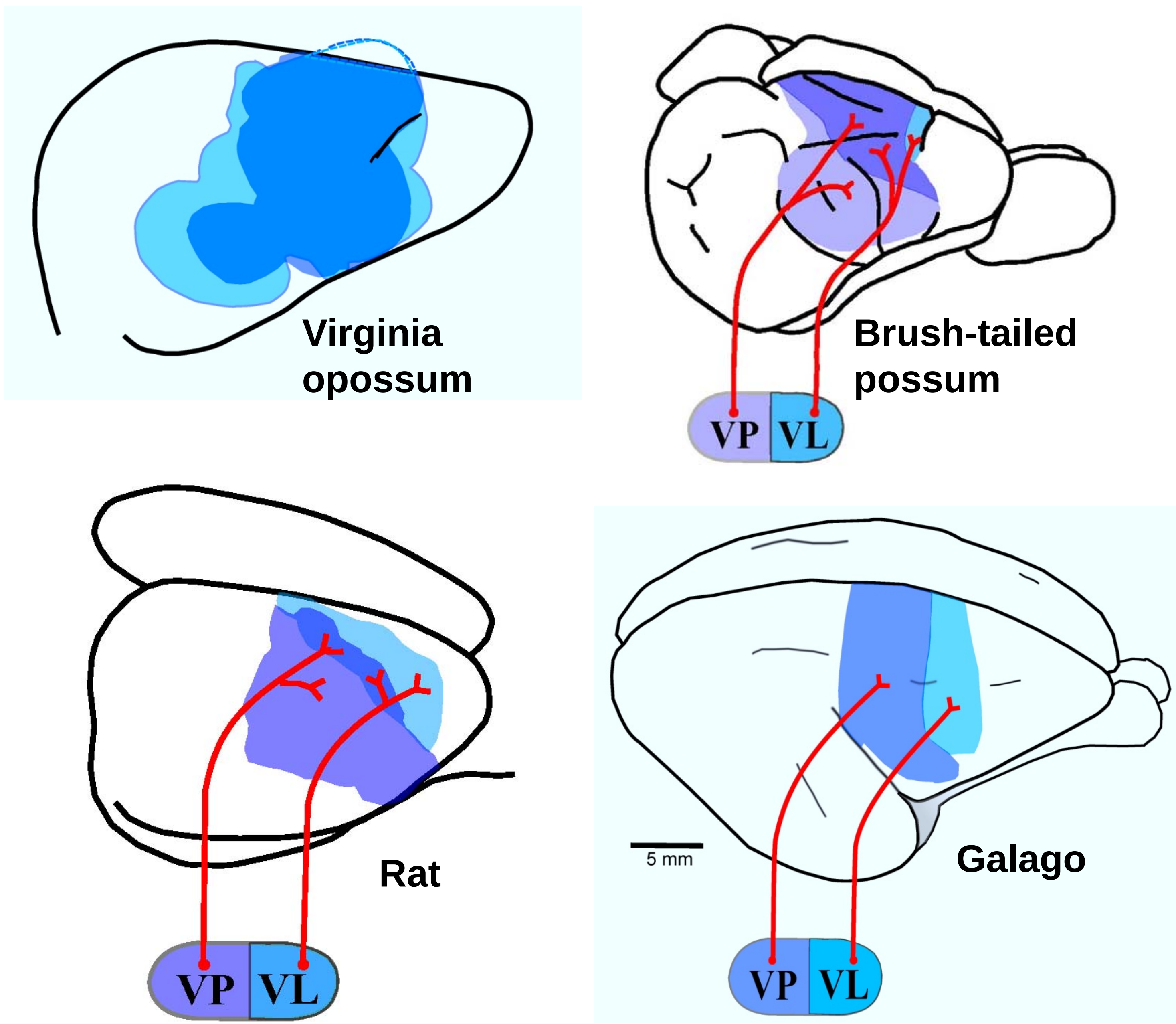


Fig 15-6

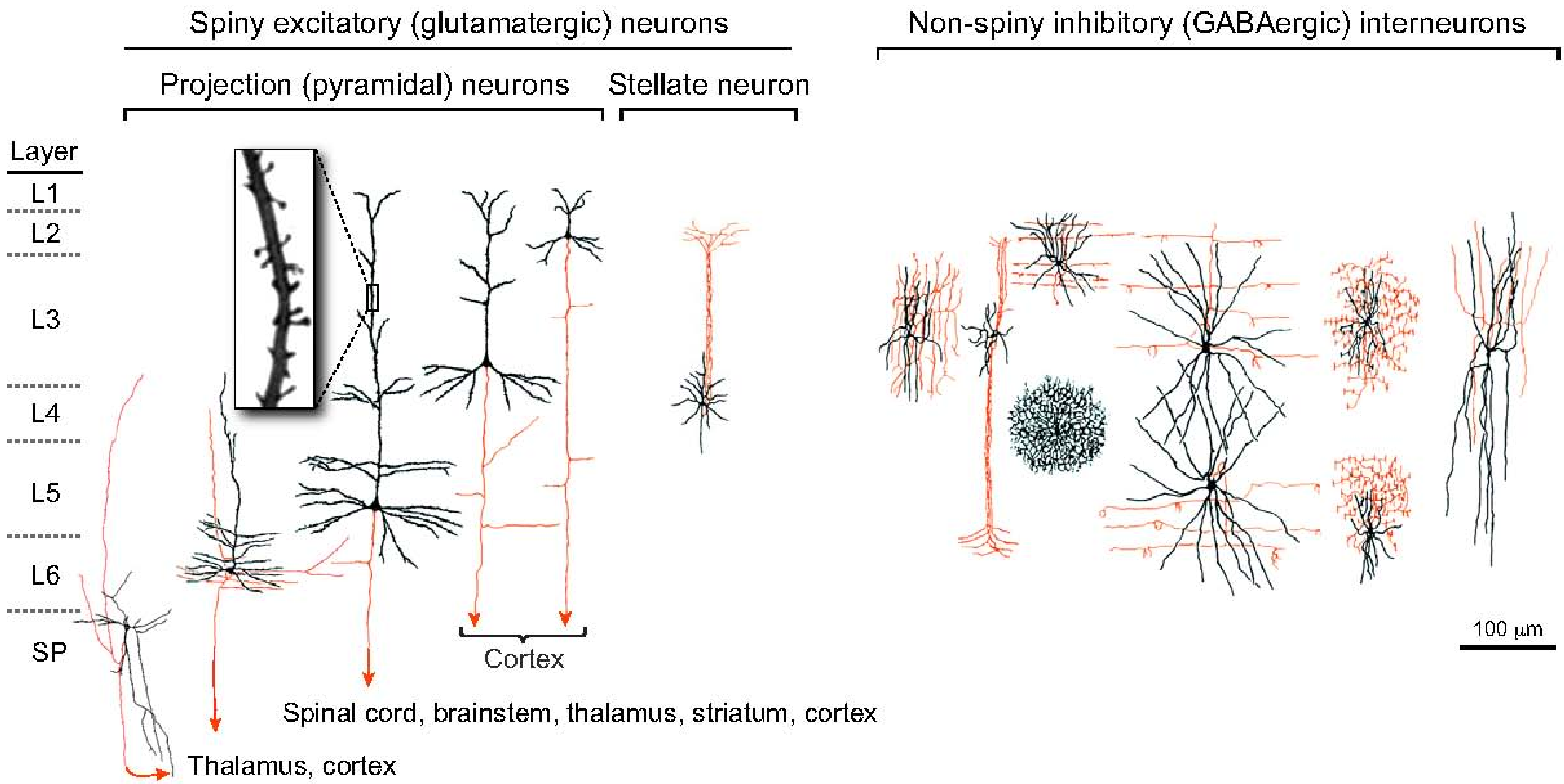
Schneider, G. E. *Brain Structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN:9780262026734.

Hedgehog neocortex, salamander dorsal pallium, turtle dorsal cortex

(Striedter p 270)

Note the differences in trajectories of axons from the thalamus (in red).

Figure removed due to copyright restrictions.



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 33-1

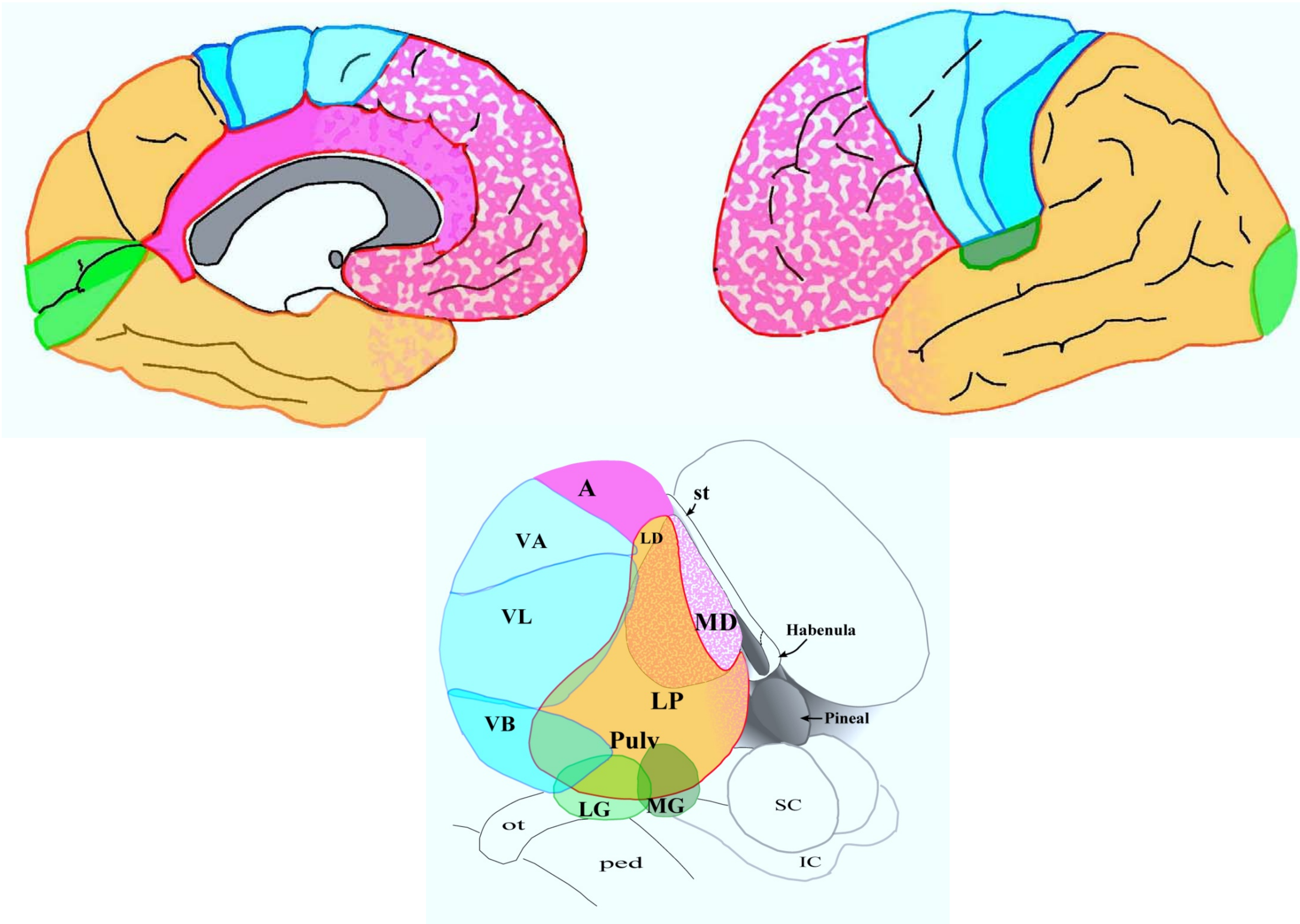
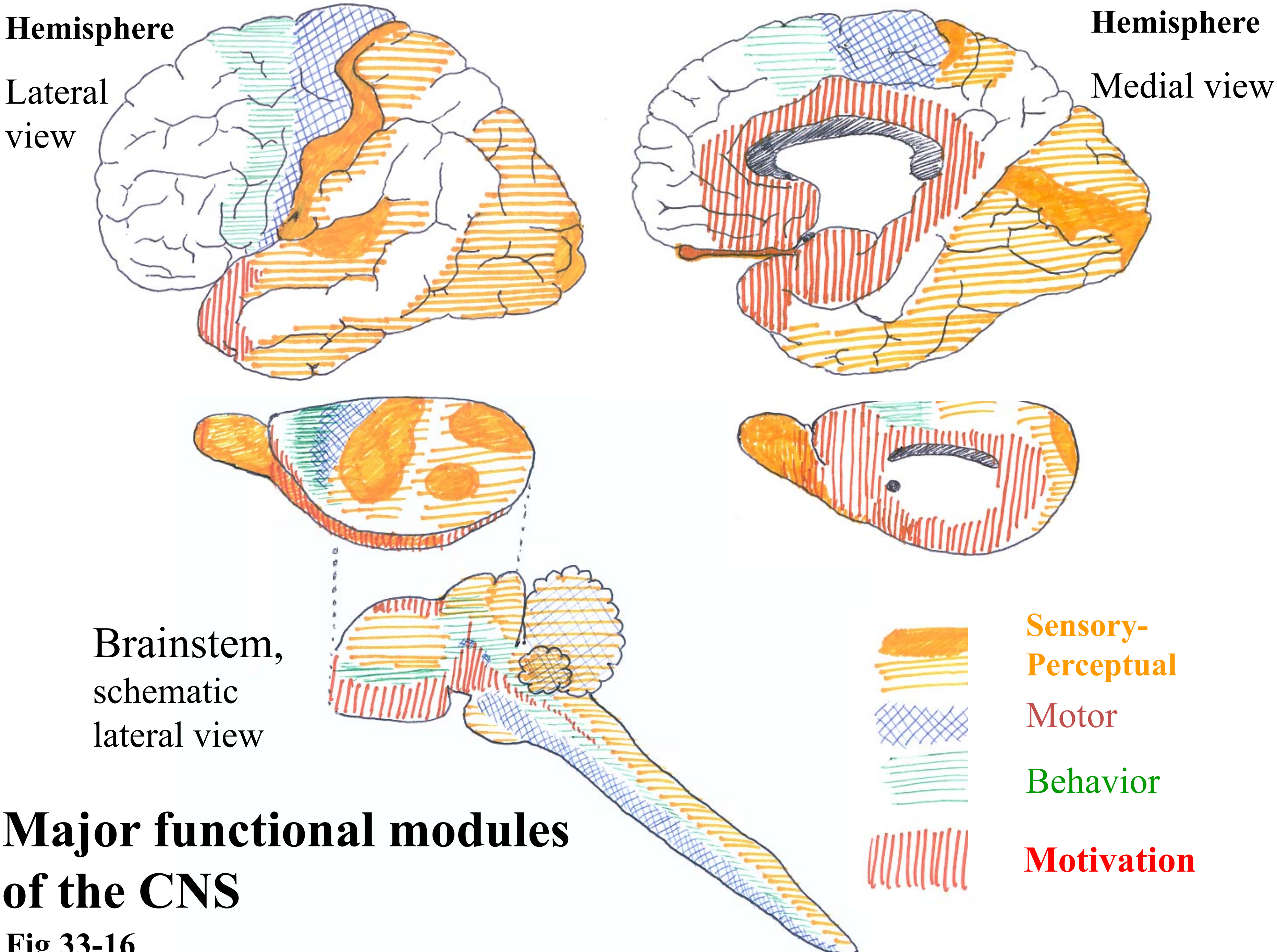


Fig 33-10

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



Major functional modules of the CNS

Fig 33-16

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

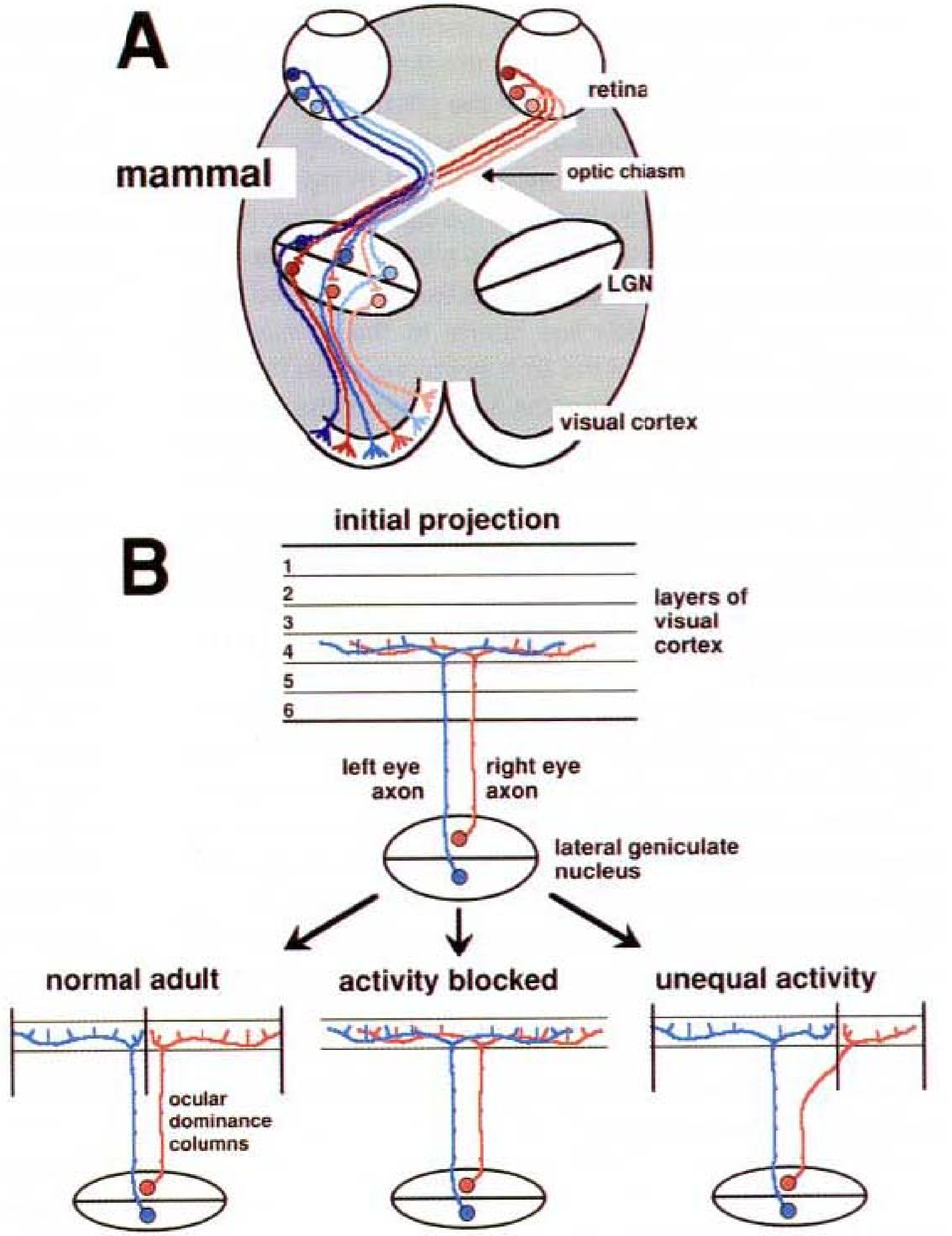


Fig 34-9

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