Final review, 9.14_2014

Slides for special study
Mammalian Taste Pathways

Neocortical Gustatory area

Parabrachial nucleus

VPM pc

Gustatory nucleus (rostral part of nuc. of solitary tract – visceral sensory

Hypothal

Ventral Tegmental Area

Amygdala

(VDA cells; “reward”, “pleasure”)

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:
Pathway for controlling the daily rhythm of melatonin production

Pineal gland

PVH

Optic Nerve

SCN

SCG

Lat Horn, T1-2

Retina

Courtesy of MIT Press. Used with permission.
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

Courtesy of MIT Press. Used with permission.
Hamster brain with hemispheres & Cb removed, seen from right side

Courtesy of MIT Press. Used with permission.
Hamster brain, adult and newborn

Olfactory bulb
Neocortex
Superior col.
Inferior col.
Cerebellum
Medulla obl.

1 mm

Courtesy of MIT Press. Used with permission.
REVIEW:

Stretched section through optic tract from chiasm to superior colliculus

optic tract

Sch

LGBv

LGBd

LP

PT

Sc

2 layered
hamster or rat LGBd

4 layered LGBd

4 layers in monkey & human.
Two major routes from retina to endbrain in phylogeny

Fig 22-2

Courtesy of MIT Press. Used with permission.

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

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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)*
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 cochlear nucleus
REVIEW:

Endbulb of Held
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.


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Pathways for object localization and identification in primates

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Fig 23-18
Fig 23-19

Courtesy of MIT Press. Used with permission.
Pallium began small:

European Hedgehog

West African Hedgehog

Short-tailed opossum

Prairie vole

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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).


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

Courtesy of MIT Press. Used with permission.
Hierarchic control of locomotor behavior

Fig 14-2
Figure removed due to copyright restrictions. Please see course textbook or:
Site in cat hypothalamus where electrical stimulation causes mood of predatory attack

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

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

Fig 26-7a

Association areas
(neocortex)

Cingulate cortex

Anterior nuclei of thalamus

Tegmental nuclei

Mammillary bodies

Hippocampus

Dentate gyrus

Hippocampal formation

Paralimbic areas, entorhinal area

Septal area

(Subiculum)

(Ach)

Courtesy of MIT Press. Used with permission.
Papez’ circuit brought up to date: What are the **inputs** to this circuit? What are the **outputs**?

- Association areas (neocortex)
- Cingulate cortex
- Paralimbic areas, entorhinal area
- Anterior nuclei of thalamus
- Mammillary bodies
- Hypothalamus
- Septal area
- Hippocampus
- Dentate gyrus
- Hippocampal formation

**Legend**:
- \( \text{mt} \) = mammillothalamic tract
- \( \text{fx} \) = fornix bundle (output of hippocampus)
- \( \text{Ach} \) = acetylcholine used as neurotransmitter

Courtesy of MIT Press. Used with permission.
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

Fig 26-9
Terms:

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

Fig 28-2

Courtesy of MIT Press. Used with permission.
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.
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.
Fig 29.5

Courtesy of MIT Press. Used with permission.
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?

Courtesy of MIT Press. Used with permission.
Eyes, optic nerves, optic tracts; split optic chiasm

Fig 29-7

Courtesy of MIT Press. Used with permission.
Major afferents of dorsal striatum:

- DA axons from the substantia nigra
- Sensory inputs via the paleothalamus
- Inputs via the neocortex
Pathways in red are inhibitory, except where indicated by +. Note the "Double Inhibition".

More ancient outputs have been added (in blue).

Omits the dopamine reward pathways and the ventral striatum.

Image by MIT OpenCourseWare.
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
Fig 30-11

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REVIEW:

Archetypal embryonic stage

- 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

Courtesy of MIT Press. Used with permission.
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)

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Fig 15-6

Virginia opossum

Brush-tailed possum

Rat

Galago

Courtesy of MIT Press. Used with permission.
Hedgehog neocortex, salamander dorsal pallium, turtle dorsal cortex

(Striedter p 270)

Note the differences in trajectories of axons from the thalamus (in red).
Fig 33-1

Spiny excitatory (glutamatergic) neurons

Projection (pyramidal) neurons

Stellate neuron

Non-spiny inhibitory (GABAergic) interneurons

Layer
L1
L2
L3
L4
L5
L6
SP

Cortex

Spinal cord, brainstem, thalamus, striatum, cortex

Thalamus, cortex

Courtesy of MIT Press. Used with permission.
Fig 33-10

Courtesy of MIT Press. Used with permission.
Major functional modules of the CNS

Fig 33-16

Courtesy of MIT Press. Used with permission.
Fig 34-9

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