9.14 classes #38-39: Frontal sections and REVIEW

Also recommended:

Review post-midterm assignments, quizzes, homework, class notes. Then do it again. Then do it a third time...

Questions:

1. The Papez circuit: What is it? (Specify the major links.) With what function was it associated in Papez' opinion? How could neural activity escape the loop and reach motor neurons?

2. The cerebellum give rise to two major ascending connections that are part of a lower and an upper loop which return to the cerebellum. How does activity in each of these loops "escape" -- to affect motor neurons, and thus behavior?

3. From the visual cortex, there are three major routes (and quite a few additional ones!) for neural activity to reach output circuitry. What are they? What other routes are there from retina to motor neurons? (Describe two.)

4. Compare the olfactory and the somatosensory pathways, from primary sensory neuron to neocortex.

5. For the neocortical mechanisms underlying human language, what thalamic nuclei would you expect to be most important: a) in understanding of speech? b) in production of speech? What is the role of the arcuate fasciculus?

6. If, in early development, the neural tube fails to complete its closure, what dire consequences would occur?

7. In the neuronal proliferation that occurs in early development of the endbrain, there is a stage of cell division in which the total area of cortex expands, and another stage in which the thickness of the cortex increases. Contrast these two stages with respect to consequences of mitoses.

8. In the development of transcortical connections, as in the development of the optic tract, what is meant by a period of "exuberance" in axonal arborization, and by a period of "focalization"? When would you expect programmed cell death to be most important? Why might such PCD occur (what may be the cellular trigger)? What function could it serve?

9. Assume that you would like to find molecular markers of neuronal plasticity, and you are looking for antibodies to mark the more plastic neurons in the developing and

adult CNS. Which proteins may be useful in this regard, because of their role in either synaptic plasticity or in axonal growth? (Name two proteins for marking with antibodies, and give reasons you would select these.)

10. What is "LTP"? Describe one of the connections within the hippocampal formation where you would expect LTP. From the postsynaptic side of this connection, where does the information in this pathway go? (Describe the next specific, synaptic, connection and then describe the pathway out of the hippocampal formation to a non-hippocampal region.)

11. Give a neuroanatomical argument for why you would expect the mammalian corpus striatum to be involved not only in motor control, but in other functions as well.

12. Note three clear differences between neocortex and cerebellar cortex. (Suggestions: locations, developmental peculiarities, cellular architectures, local connections, dendritic geometry.)

13. Describe a sexual dimorphism in the mammalian CNS. What developmental events may underlie this dimorphism? Describe an experiment that could test this idea in developing rodents.

14. It has been suggested that for at least one axis (representing upper vs lower retina) of the retinotopic map in the superior colliculus, chemospecific markers may be redundant for determining the topographic order of axonal connections. How could this axis be determined? Concerning the other axis (representing the naso-temporal axis of the retina), what discovery has confirmed the theory of chemical (molecular) specificity? Was Sperry's notion of some kind of selective adhesive preferences confirmed?

15. How could work on the retinotectal projection in small mammals lead to methods for treatment of spinal injury?

16. How is the problem of developmental determination of neocortical areas related to the problem of developmental determination of the organization and connections of the optic tract? What are some of the key issues in understanding the nature of this problem?

17. It has recently been discovered that neurotrophins are not only present in the developing neocortex, but are influenced by neuronal activity. Describe two possible experiments which could be done to test for a role of neurotrophins in some stage of neocortical development.

18. In contrasting the diencephalon of higher primates (especially, human) with that of a rodent or insectivore, in what major division would you expect the largest differences, and why? Which cell groups should be most different in size? Name one other cell

group where you would expect some marked species differences, and give your reason.

19. Closed "loops" are common in the mammalian CNS. Give 3 - 4 examples of such loops, and, in general terms, the functions they are involved in.

20. Describe some of the problems encountered in experiments with transplants of brain tissue. How can the problems be resolved? What kind of procedures may be better than transplants taken from human embryos, in the future?

21. If you wanted to divide the hindbrain into limbic-related and non-limbic related regions, what are the neuroanatomical experiments you would have to do? (What connections would you want to trace?) What problems may be encountered? How could electrophysiological experiments help?

22. What was Fernando Nottebohm's famous paper, entitled "a brain for all seasons", was about? What animal was he describing? Is there any similarity in the connections he was dealing with to human brain connections? What was the biggest surprise in this work for students of mammalian brain development?

23. What is the especially important neuroanatomical position of the entorhinal cortex ? of the subiculum? (Where are these structures, what are some of their connections, and why do neuroscientists consider them to be of such importance in human brain?)

24. Describe three pathways by which the cerebellum can affect movement. If a person or animal suffers a very large lesion of cerebellum, but the lesion grows slowly, movement may be very little affected, at least when considering simple, basic movements. What structures and pathways do you think could "take over" many functions of cerebellum in such cases?

TERMS/phrases/questions:
(Also, go over the midterm list.)

CORTEX:
Primary sensory cortex (somatosensory, auditory, visual), Association cortex (unimodal for all three modalities, multimodal or heteromodal). Where, what are some intercortical connection pathways?
Basic thalamic cell groups and their relationship to these cortices.
Myelogenesis – what does it tell you about the more "plastic" regions of cortex? How does this relate to GAP-43 expression?
Broca's area, Wernicke's area. Deficits associated with each. How do they talk to other regions of cortex?
Corpus callosum vs anterior commissure –what regions of cortex do they interconnect?
Disconnection syndromes.
Uncinate fasciculus, arcuate fasciculus.
Mesulam's scheme – memorize figure, terms.
Idiotypic cortex; allocortex, isocortex.

VISUAL SYSTEM:
Retinal layers, photoreceptors, rods, cones, amacrine cells, horizontal cells, ganglion cells, optic fiber layer.
Relative positions of these. Distribution in center *vs* periphery.
Fovea, optic nerve head, formation of blind spot.
Center-surround receptive fields; simple cells in cortex – oriented receptive fields.
Parallel pathways. M and P pathways. Motion perception; color/form perception. Upper, lower stream.
Magnocellular, parvocellular geniculate layers.
Ipsilateral/ contralateral geniculate layers.
Visual field representations along the visual pathway – what is the effect of lesions?
Calcarine sulcus, Meyer's loop, magnification factor – foveal representation.

Development of optic tract, laminin/integrin, NCAM, fasciculation vs de-fasciculation (NCAM vs PSA-NCAM), elongation vs arborization. Glial channels along nerve/optic stalk.
At chiasm, ipsi vs contra routing of retinal axons;
Map formation. Crude map first, based on chemospecificity. Sperry's experiments on eye rotation. Fine tuning of map depends on activity.
NMDA receptors: Ca++ entry, retrograde signal. Cells that fire together wire together.
Ephrins, eph receptors – complementary gradients. Response of nasal axons *vs* temporal axons. Ephrins are chemo-repellant. Stripe assay (Bonhoeffer) to test selectivity of axon growth.
Inhibitory factors: on oligodendrocytes (glycoproteins); proteoglycans on midline glia; proteoglycans on astrocytes at the glial scar.
Supportive substrate: peripheral nerve grafts; growth factors produced by Schwann cells.
Extrinsic vs intrinsic factors that influence axon growth.
Concept of critical age. How do you test this?

Protomap *vs* protocortex. Importance of cell cycle in laminar fate. Importance of cell cycle in determining size of structure.
Ocular dominance columns. Visual deprivation. Competition – for what? NMDARs.

CEREBELLUM:
Layers, cell types, afferents (sources), peduncles (what input? – afferents vs efferents: from where, to where). Spinocerebellar projection, proprioception. Inferior olive. Deep cerebellar nuclei. Cortical interneurons.
Ascending projections: VA/VL (motor cortex), Red nucleus.
How does cerebellum affect motor system?

Origin of cerebellar neurons: granule cells (GCs), germinal trigone or rhombic lip for external granular layer (EGL). Tangential migration, then radial migration downward to GC layer. Ventricular zone gives rise to all other cell types, including the interneurons. Contribution from mesencephalon and mesencephalon. [Math1 gene necessary for GCs cells.]
Bcl-2 overexpression and increases in P cell numbers – some apoptosis of P cells.
Dependence of GCs on P cells. If P cells die, there is a decrease in # of GCs. SHH present on P cells, its receptor Patched is present on proliferating GCs.
NMDARs necessary for G cell migration. Also, K+ channel protein (weaver mutation).
Netrins define borders of cerebellum. Netrin receptors found on GCs – mutation of receptor – granule cells migrate into inferior colliculus.

Reelin: reeler mouse. Reelin protein necessary for P cell migration. In reeler: P cells fail to migrate and GCs are decreased in number.

CNS REGENERATION:
Abortive regeneration. Sprouting vs true regeneration. Schwab experiments –extrinsic factors that inhibit axon growth. Chen et al experiments on intrinsic factors and how bcl-2 can be used to partially overcome these.
So and Aguayo experiments on peripehral nerve grafts. What do they tell you about the capacity of CNS neurons to regenerate? How do trophic factors fit into this picture?
Schwann cells vs oligodendrocytes.
Transplantation; what types of tissue? Age, type of preparation, source, locus of graft. Imaging to assess transplant survival. Why is growth in vivo so slow?
What is a xenograft – mouse-to-rat transplants. How would you observe their fate?

OLFACTORY SYSTEM & TASTE:
Glomeruli, Mitral cells, primary and secondary neurons, central projections.
Piriform cortex, amygdala, entorhinal cortex, olfactory tubercle, anterior olfactory nucleus, pre-piriform cortex, peri-amygdaloid region.
Neuronal precursors in adult brain.
Nucleus gustatorius, nucl of the solitary tract, cranial nerves (VII, IX, also X), VPM.

HYPOTHALAMUS & LIMBIC SYSTEM:
Exceptions to the blood brain barrier.

Papez circuit.
Hypothalamus and limbic midbrain interconnections.
Descending projections, direct connections to spinal cord, reciprocal connections.
Hypothalamus and cortex.
Diabetes insipidus.
Sexual dimorphism, relation to sexual preferences, relation to bird song.
How do you make a female canary sing?
How does tissue culture show a role for sex steroids in development?
Basolateral and corticomedial amygdala – sensory inputs (olfactory, auditory)
Stria terminalis

HIPPOCAMPUS:
Hippocampus (Ammon's horn) vs hippocampal formation (sensory inputs)
Synapses where LTP occurs
Perforant path, dentate gyrus, rganule cells, pyramidal cells, CA1, CA2, CA3.
Fornix as a two-way street.
Paul MacLean's popular but erroneous idea about the structure/evolution of the mammalian brain (triune brain).

Sources of neocortical inputs to hypothalamus and autonomic nervous system.