

Questions for special emphasis:

The final exam will be based on some of these questions and on the selected slides.

Questions may be simplified to allow for shorter answers.

Brain state changes

1. Describe, with names and neurotransmitters that you can remember, three neuronal systems in which activity can influence the state of much of the entire brain.

Olfactory and gustatory systems

2. Contrast concerted and mosaic evolution. Give an example of each. The examples do not have to come from studies of olfactory or gustatory systems.
3. Describe the pathway for taste impulses, from tongue to neocortex, in mammals. What forebrain structures other than neocortex are reached by ascending taste pathways?
4. How is the anatomy and function of the accessory olfactory bulb in mammals different from the rest of the bulb?
5. What are olfactory glomeruli (location, major components, specificity)?
6. What have studies of functional activation indicated about topographic specificity in the olfactory bulb of rats?
7. Contrast compensatory sprouting and compensatory stunting of axonal projections of olfactory tract axons of developing hamsters.
8. How are the projections of the olfactory bulb in the sea lamprey and the hagfish different from those projections in amphibia, reptiles and mammals?

Visual systems

9. What is most likely the most primitive projection of the retina? (It was discovered more recently than the other major retinal projections.) What is a very important function of that projection?
10. The pineal gland is influenced by light, most directly in many species by a “pineal eye” on top of the head. How does light influence the pineal in mammals, influencing the daily rhythm of melatonin production? Describe the final link in the pathway to the pineal.
11. Describe the hypothesis that early in evolution, bilateral retinal projections became mostly contralateral projections. Why was this adaptive, and how did it influence the evolution of other major decussations in the brain?

12. What are the major terminations of the optic tract in the order they are reached by the retinofugal axons?
13. What midbrain structure controls orienting responses to visual stimuli (turning towards novel or otherwise interesting stimuli)? What other responses does it control? What kinds of plasticity occur in this structure?
14. Why do the large primates have a lateral geniculate body that has an inverted U shape, rather than the almond shape of the same structure in rodents?
15. Describe the two major routes from the retina to the endbrain in mammals.
16. What are two additional routes for information from the retina to reach the endbrain?
17. Prior to the evolution of neocortex or Wulst, visual information reached the endbrain through the older parts of the thalamus. Describe a common projection pattern of such a structure, as found in modern mammals.
18. What is “Meyer’s loop”? In what animals is it found?
19. Visual cortex has expanded in total area a large amount in the evolution of the primates. What are the two major means this has been accomplished?
20. Two major transcortical routes from occipital visual cortical areas to association cortical areas have been emphasized in modern neuroscience. Describe these two routes and their functional differences.

Auditory systems

21. Auditory stimuli can trigger aversion in many animals. Innate aversion to very loud sounds depends on brain stem pathways that reach what midbrain region? Learned aversion responses to specific sounds depend on different ascending pathways. Describe such a pathway.
22. As early mammals evolved from mammal-like reptiles, changes in the middle ear occurred. What was the major change, and what was the major functional effect that was adaptive for the small nocturnal mammals living on the forest floor?
23. What in the cochlea corresponds to the tonotopic maps (a place code for encoding sound frequency) of the cochlear nuclei?
24. Distinguish between the lateral lemniscus, the brachium of the inferior colliculus, and the auditory radiations.
25. Describe a Calyx of Held and its function.

26. What are major differences in functions of a) the pathway from the cochlear nuclei directly to the inferior colliculus, and b) the pathway from the cochlear nuclei to the trapezoid body of the hindbrain.
27. What are the two major ascending auditory system pathways distinguished by their function? How are they different in the midbrain?
28. Studies of functional activation of neocortical areas has led to the discovery of two major transcortical pathways in the auditory system. Describe these pathways and their relation to the visual system.
29. What is the nucleus laminaris in birds? Answer by describing its location, its inputs, its function, and the corresponding structure in mammals.
30. Compare the map of space in the superior colliculus formed by visual inputs and the map formed by auditory inputs: location, plasticity, sources of inputs.
31. Pattern detection in the neocortex: contrast the visual cortex and the auditory cortex. Give examples.
32. Give examples of “mosaic evolution” in dorsal midbrain structures of mammals.
33. Describe the location of the major terminal area in the endbrain of the ascending auditory pathway in birds.

Forebrain intro

34. Which of the 12 standard cranial nerves are attached to the forebrain? Which additional cranial nerves are attached to the forebrain in some animals?
35. What method has been the most informative for representing relative brain size in a wide variety of species? How have the data been graphed?
36. What is the likely cause of the differentiation of the dorsal striatum from the ventral striatum? What adaptive advantage did the striatum have over the midbrain tectum?
37. The cortical areas located at the margins of the mammalian hemispheres, appear to be the most ancient, judging from comparative neuroanatomical observations. What are those two areas, located a) at the lateral margins and b) at the medial and caudal margins, called?
38. Name or describe a major function for each of these two types of cortex. In early vertebrate evolution, both of these functions depended on what sensory input?
39. Feedback from sensory systems that enabled connections in the early striatum to change came *via* dopamine-containing axons. Where are these dopamine cells located in mammals?

40. From what part of the primitive endbrain did the neocortex evolve? What kinds of data support this?

Limbic system: hypothalamus

41. What structure is the central controller of the autonomic nervous system and the endocrine system? It is also very important for what other function, or type of function?
42. Who was the first scientist/neurologist to use the term “limbic” for the structures that have been found to be most closely connected with the above structure? He wrote about “the great limbic lobe.”
43. What are some major differences in axonal inputs to the two arousal systems of the mammalian midbrain?
44. Describe the two means of hypothalamic control of the pituitary.
45. What connection is disturbed in diabetes insipidus? What are the main symptoms?
46. The hypothalamus can be considered an important part of the motor system. How is it involved in the control of locomotion?
47. The hunger drive is controlled by the hypothalamus. Describe two important types of inputs to the system that controls hunger.
48. The region of the hypothalamus where stimulation can cause the “biting attack” mood in cats projects to other parts of the diencephalon. Which parts? How could these projections cause widespread changes in brain state?
49. How does hypothalamus send influences to the cerebral cortex?

Limbic system: core pathways

50. How can a scientist find brain areas where the blood-brain barrier is weak?
51. Give an example of a function of a weak blood-brain area.
52. Give two examples of sensory inputs to the hypothalamus.
53. What is the circuit described by James Papez in a 1937 paper? What function did he ascribe to structures of this circuit? What is an important endbrain structure involved in this function that he omitted from his circuit?

Limbic system: hormones, sex differences, sexual preferences

54. When are sex differences in gonadal hormone levels at a peak in human development?

55. When do male-female differences in the sexually dimorphic nucleus of the preoptic area of the hypothalamus start to appear in human brains? What is one other male-female difference in human brain structure?
56. Why do some human beings develop a female body and brain despite being genetically male and having testes rather than ovaries?
57. What is the meaning of the title of one of Fernando Nottebohm's papers: "A brain for all seasons"?
58. What data from Eric Vilain indicates that hormones cannot explain all aspects of sexual differentiation in brains of mammals?

Limbic system: hippocampus

59. Describe the pathway whereby head-direction information reaches the endbrain. How might this information be relevant to place cells in the hippocampus?
60. What connections indicate that the neocortex is of critical importance in the function of the hippocampus in mammals?
61. Describe the "perforant path" – its origin and destination. In what brain areas did the information carried by this pathway originate?
62. What is the difference in location of the main body of the hippocampus of large primates and its location in the rat?
63. Describe the hippocampal rudiment.
64. In what sense are evolutionary changes in hippocampal connections like the evolutionary changes in striatal connections? (Striedter p. 291)
65. What structure gives rise to the most direct pathway from subcortical regions to the hippocampus? What neurotransmitter does it use?
66. Describe one phenomenon of axonal growth or sprouting in the adult hippocampus.

Limbic forebrain and amygdala

67. Compare the stria terminalis and the fornix: source, major terminations, axon trajectories.
68. What are two kinds of evidence for the functional importance of the amygdala in the linking of affects with perceived objects or conspecifics?
69. The amygdala can be considered to be a caudal part of the limbic striatum. What kind of habits does the amygdala control?

70. The more rostral parts of this region are in the basal forebrain. What are three structures within the basal forebrain? What happens in this region in Alzheimer's Disease?
71. Describe Downer's experiments (1962) in monkeys with unilateral amygdectomy in a split-brain monkey.

Corpus striatum

72. Compare the primitive striatum (& pallidum) of early vertebrates (as judged from comparative neuroanatomy) with the highly evolved striatum of modern mammals. What part of the striatum has expanded the most? Name at least five major components.
73. The striatum, directly and through the globus pallidus, projects to the midbrain. What functions can it influence through these midbrain connections, and what structures in the midbrain receive the projections?
74. Describe the feedback pathways in mammals that are important for striatal plasticity, carrying reward signals.
75. How does sensory input reach the dorsal striatum? There are two important routes.
76. What is the ansa lenticularis?
77. What is the "double inhibition" of pathways through the striatum? What neurotransmitter is involved? What kind of movement disorders caused by striatal pathology are a consequence of the "double inhibition" of striatal pathways?
78. What is the similarity in the nature of neocortical projections to the striatum and to the cerebellum (*via* the pons)? What does this similarity suggest about the functions of striatum and of cerebellum?
79. What is the major neuronal pathology in Parkinson's Disease? How could stem cells be used to treat the disease? (What must the cells be able to do? Where would they have to be placed?)
80. How is locus of a transplant of embryonic nigra cells within the striatum of a Parkinson's patient related to possible functional effects?

Neocortex

81. Contrast different routes for sensory information to travel from primary sensory cortical areas, e.g., visual cortex, to motor output systems. Describe at least three routes. You need not describe the route all the way to motor neurons, but describe it to the brainstem level.
82. How does human ability to cook food promote larger brain size? (See the discussion of energy requirements of various organs, Allman p 166f.)

83. How is neocortex of mammals different in its cytoarchitecture from the older types of cortex present in non-mammals?
84. What are the two major cell types in the neocortex?
85. What is a structure in birds that appears to be homologous to neocortex in mammals?
86. Much (or even all, according to some authors) of the neocortex can be divided into two functional regions based on connections with two paralimbic regions that evolved connections that served different types of function. How can these two regions be characterized?
87. What functional type of neocortex evolved into motor cortex?
88. Motor cortex, like primary sensory cortex, is adjacent to association areas of the frontal lobe. What are these areas called, and what is a simple way to characterize their functions?
89. Evolutionary expansions of sensory neocortex have occurred in what two different ways?
90. What is the major difference in thalamocortical axon trajectories described for reptiles and for mammals?
91. Neocortex is unique among various types of cortex in having many small stellate cells called granule cells. Where are these cells found, i.e., which layers are granular layers in the neocortex?
92. What neocortical area is an exceptional type in that it has few granule cells?
93. Describe two connections that occur within a column of neocortex, in every neocortical region. Where are the largest numbers of connections of axons from the dorsal thalamus found?
94. For four of Brodmann's areas found in mammalian neocortex, give the number and also a frequently used name of the area.
95. Name the two major bundles of output axons from the forebrain. For each of these, name or describe two types of axon.
96. How does olfactory information reach the neocortex?
97. Describe the neocortical territories (areas projected to) of the basic thalamic cell groups:
 - Geniculate bodies ("external geniculates")
 - i. LGBd,
 - ii. MGB
 - Ventral thalamus:

- i. ventral posterior nuclei (ventrobasal) (VPL, VPM);
- ii. ventral anterior and ventral lateral (VA-VL)
- Lateral thalamus, including the pulvinar nucleus (LD, L, LP, Pulvinar, Po)
- Medio-dorsal thalamic nucleus (MD)
- Anterior nuclei (AD, AV, AM)
- Intralaminar and midline nuclei

98. What are high-order association areas, according to Mesulam? What thalamic regions project to these areas? How does Mesulam characterize their major transcortical connections?
99. Which areas of the human neocortex show the most postnatal development? What measures of development have been used?
100. What idea was presented in class to explain why the dorsal thalamus has evolved as an obligatory way-station for most information passing to the endbrain?
101. According to Pasco Rakic, what simple changes in gene expression could account for the human neocortex becoming so much larger in area and also thicker than in ancestors that were much closer to apes in neocortical size?
102. What three types of migration of neuronal precursor cells were described in class? What types have been found to occur in the neocortex?
103. Describe briefly one experiment that has shown an important role of sensory experience in thalamocortical development in a mammal.
104. What changes in Wernicke's area of the human brain appear to result from greater education, according to Golgi studies by Arnold Scheibel and collaborators (Allman ch 7, p 202)?

Other topics

105. Where in the CNS of mammals is there neuron turnover, with generation of new neurons and replacement of older ones? How can one label neurons being born in adults?
106. What brains of extant species (i.e., give the name of the group) probably resemble the brains of very early mammals?

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9.14 Brain Structure and Its Origins

Spring 2014

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