

1) Matching: Write the letter of the best match in the space before each name (11 points)

- | | |
|--|------------------------------------|
| A. Pioneer in biopsychology | |
| B. Chemical synapses | <u>H</u> Fritch and Hitzig |
| C. Neurons in tissue culture | <u>G</u> Ramon y Cajal |
| D. Nerve growth factor | <u>J</u> Charles Scott Sherrington |
| E. Gap junctions | <u>B</u> Otto Loewi |
| F. Induction of CNS development | <u>F</u> Hans Spemann |
| G. Prolific neuroanatomist, Golgi method | <u>K</u> Bror Rexed |
| H. Electrical stimulation of neocortex | <u>C</u> Ross Harrison |
| I. Pharmacological definitions | <u>A</u> Karl Lashley |
| J. Spinal reflexes, physiology | <u>L</u> Walle Nauta |
| K. Layers of the gray matter | <u>D</u> Rita Levi-Montalcini |
| L. Selective stains for degenerating axons | <u>N</u> Hans Kuypers |
| M. Tract tracing by MRI | |
| N. Descending pathways, motor control | |

2) Short definitions: (22 points)

a) Anterograde degeneration

When an axon is transected, the portion of the axon no longer connected to the cell body undergoes "anterograde" degeneration. [When neuronal cell bodies are destroyed, their axons undergo anterograde degeneration.]

b) Motor neuron

A neuron with an axon that leaves the CNS. It terminates on a muscle cell or on a peripheral ganglion.

c) Schwann cell

Glial cell found in peripheral nerves. Schwann cells form myelin in the PNS [by wrapping their membranes around axons].

d) Sensory placode

A thickening of a region of the ectodermal layer of the embryo in which some of the cells become primary sensory neurons.

e) Rhombic lip

A transient neural proliferative zone located in the alar plate of the rostral hindbrain. Neuroblasts migrate from the rhombic lip to form the cerebellum, and to form pre-cerebellar cell groups [like the neurons of the pons (pontine gray), and the inferior olive].

f) Propriospinal axons

Axons from spinal cord neurons that never leave the spinal cord—they connect to other regions of the spinal cord.

g) Cynodont

Mammal-like reptiles that lived at the time of the dinosaurs. Mammals evolved from cynodonts. [Name means “dog toothed”]

h) Filopodia

Filamentous, transient extensions of axonal growth cones [and other cells in early development] that contain actin filaments, enabling contraction, and that have adhesion molecules at their tips. They enable movement of the growth cone.

i) Endogenous activity

Activity that originates from within a cell or organism, not as a result of external stimulation.

j) Mosaic evolution

Evolutionary changes in size of brain structures where the changes are not proportional to size changes in the brain as a whole. Not concerted evolution.

k) Barrel field

A region of the neocortex representing the facial vibrissae of a rodent: Each whisker is represented by a grouping of neurons in a barrel-like arrangement, [with thalamocortical axons found mostly inside each “barrel.”] The arrangement of the neocortical barrels corresponds to the arrangement of the vibrissae on the face.

Short answer questions (56 points)

- 3) What membrane structures had to evolve in order for action potentials in axons to evolve? (2 points)
Voltage-gated ion channels
- 4) What was the major cause of each of the first three major expansions of the forebrain in evolution? (5 points)
#1: olfactory input [1 point]

#2: invasion of non-olfactory inputs by axons from more caudal regions—mostly diencephalon. [2 points]

#3: the evolution of neocortex and its expansion [2 points]

- 5) Why is the face not included in dermatome maps? (2 points)
A dermatome is an area of skin innervated by a spinal nerve.
The face is innervated by a cranial nerve—the 5th, or trigeminal, nerve.
- 6) What cranial nerves carry information from electroreceptors in certain fish? Why is electroreception so useful for these fish? (4 points)
- The lateral line nerves.
 - It makes possible detection and localization of objects in murky waters, where vision is very limited.
- 7) Where do the largest axons in the dorsal roots originate? Describe two of their termination sites within the spinal segment of their dorsal root. (5 points)
- The largest axons originate in muscle spindle organs—the stretch receptors.
 - Terminations
 - on (alpha) motor neurons that innervate striated muscle fibers.
 - on neurons of Clarke’s Column **OR** elsewhere in layer 7 of the spinal gray matter.
- 8) What cells make the cerebrospinal fluid (CSF)? How does the CSF get from the ventricles of the brain into the subarachnoid space surrounding the brain? (5 points)
- Made by cells of the choroid plexus (modified/specialized ependymal cells), mostly in the lateral ventricles [of the cerebral hemispheres]
 - CSF flows through the 3rd ventricle and the Aqueduct of Sylvius into the 4th ventricle, where it can flow out of the ventricles into the subarachnoid space, through the lateral apertures and the median aperture [foramina of Lushka and the foramen of Magendie]
- 9) What is the meaning of the term “pons”? What is a major input, and what is the major output, of the cells of the pontine gray matter? (3 points)
- “Pons” means bridge.
 - Major input from neocortex
 - Major output to cerebellar cortex [Each side of pontine gray projects to the cerebellar cortex on the opposite side.]

10) The neocortex has layers that are not present in the dorsal cortex of reptiles and amphibians. The layers are the more superficial layers 2-4. Those layers contain many inhibitory interneurons that do not arise from the ventricular layer of the developing cortex. Where do they come from? (3 points)

The inhibitory interneurons [GABA-ergic] migrate mainly from the ventricular layer of the subcortical region called the medial ganglionic eminence. They also come from the lateral ganglionic eminence, and, for the more caudal neocortex, from the caudal ganglionic eminence. (The ganglionic eminences are transient, developmental structures in the region that becomes corpus striatum.)

[I am uncertain how much of this an answer should have to get full credit. Judge this from the best answers.]

11) Describe **two** factors that can increase the competitive growth vigor of a developing axon. (2 points)

- The presence of **growth factor** or factors in the tissue.
 - Chemical factors within a neuron, which can change with stage of development, can also affect growth vigor
- Electrical **activity**.
- Reduction or blockage of growth of some of the axons terminal arbors will increase growth vigor in the remaining arbors. OR **pruning** of the axonal arbor.

[Any two of these]

12) Describe a method for inducing regeneration of the severed optic tract in adult hamsters. (3 points)

- Surgical implantation of a segment of peripheral nerve taken from the same animal, placed so it bridges the lesion site.
- Injection of a specific man-made self-assembling peptide solution into the injury site.

13) Before a neocortex evolved, the midbrain had evolved structures for controlling three types of general-purpose movements. Name the structure where the output pathway for each of these movements originates, and the nature of the movements that result from their activity. (6 points)

- Midbrain locomotor area: Locomotion
- Superior colliculus / optic tectum: Orienting movements / turning movements
- Red nucleus/ nucleus ruber: Grasping movements

14) Describe the three lesions in the Lawrence and Kuypers study of the descending motor system pathways. For each lesion, describe the approximate location and **one** axonal pathway (tract) that was disrupted. (6 points)

- Bilateral section of pyramidal tract, ventromedially in the mid-caudal hindbrain/medulla oblongata.
- Unilateral section of the rubrospinal tract, near the lateral edge of the hindbrain.
- Bilateral section of the medial hindbrain pathways—vestibulospinal, fastigiospinal, tectospinal, medial reticulospinal.

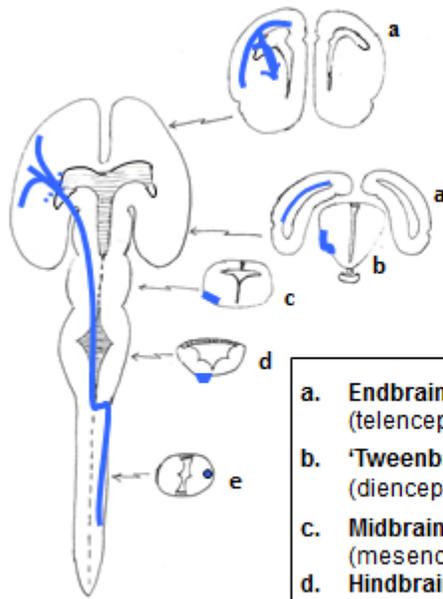
15) Motor neurons that innervate striated muscles are located in the spinal cord and in which brain subdivisions? (2 points)

Hindbrain and midbrain

16) Describe four axonal systems that are very widely projecting—systems where activity changes may change the overall state of the brain. Include the neurotransmitter used by each system and the brain locus where the cell bodies are located. (8 points)

- Acetylcholine** axons from the **basal forebrain**: mostly the **basal nucleus** of Meynart [anterior to the optic chiasm near the ventral surface of the brain]
- Serotonin**-containing axons from the **raphé nuclei of the midbrain and hindbrain**
- Norepinephrine**-containing axons, mostly from the **locus ceruleus** of the **rostral hindbrain** [below the cerebellum in the central gray]
- Dopamine**-containing axons, mostly from the **substantia nigra** and the **ventral tegmental area** of the **ventral midbrain**.

[Answers must give some idea of brain locus for each one, but they do not have to have all the information above.]



Descending axons from somatosensory and motor cortical areas:

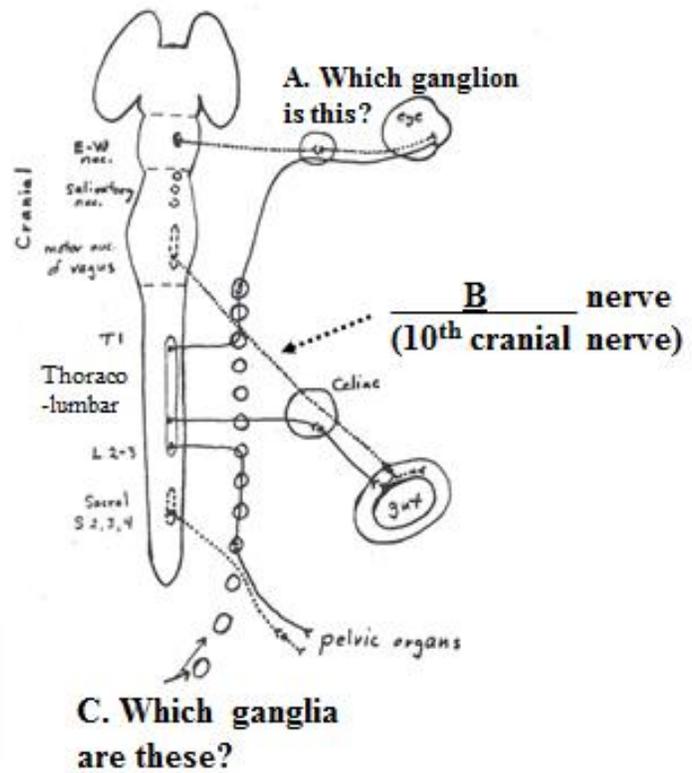
Note the different names at different levels. Fill in the blanks.

a. Endbrain (telencephalon)	Cortical white matter to <u>A</u> capsule
b. 'Tweenbrain (diencephalon)	Cerebral <u>B</u> (includes fibers to 'tweenbrain, midbrain, pons, remainder of hindbrain, spinal cord)
c. Midbrain (mesencephalon)	
d. Hindbrain (rhombencephalon)	<u>C</u> tract
e. Spinal cord	<u>D</u> tract

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17) In the figure above, identify the group of axons as they are named at the various levels of the CNS: (4 points)

- A. internal
- B. peduncle
- C. pyramidal
- D. corticospinal



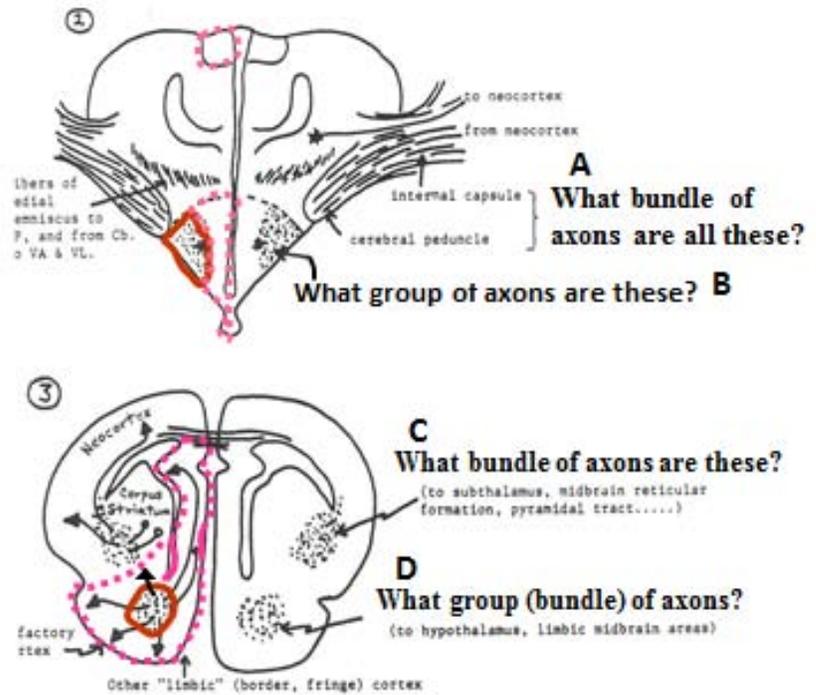
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18) For the figure above, write the appropriate names for A, B, and C: (3 points)

- A. ciliary
- B. vagus
- C. sympathetic [or sympathetic chain]

'Tween- brain and Endbrain

--Identify the
axon groups
indicated



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19) For the figure above, write the appropriate answers to the four questions: (4 points)

- A. Lateral forebrain bundle .
- B. Medial forebrain bundle
- C. Lateral forebrain bundle
- D. Medial forebrain bundle

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