Lecture #07 Cerebral Cortex Organization

Question 1: Which is characteristic of layer II of neocortex?

a) Layer II neurons develop later than neurons in layers III-VI

b) Layer II is the site of the fusiform neurons

c) Layer II neurons are called callosal neurons because many their axons have interhemispheric terminations via the corpus callosum

d) Layer II is the layer most purely comprised of stellate neurons

e) Layer II is the thalamic input layer

HINT:

Use a process of elimination to find the answer

EXPLANATION:

Migration of projection neurons to their respective layers in the cortex follows an inside-out pattern, with later maturing neurons migrating through earlier maturing neurons to reside in more superficial, lower number, layers. Thus, layer 2 neurons are the latest developing neurons, with layer 3 neurons maturing just before them. (Layer 1 is ignored; it has very few neurons with unknown functions.) Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas. Layer 3 has larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['Layer II neurons develop later than neurons in layers III-VI']

Lecture #07 Cerebral Cortex Organization

Question 2: Which cortical layer receives major thalamic input?

a) 2

b) 6

c) 4

d) 5

e) 3

HINT:

It is called the input layer; most cortical inputs arrive here via a relay

EXPLANATION:

Layer 4 is the input layer of neocortex, receiving a heavy, topographically organized projection of axons from the thalamus. Almost all input to the cortex must be relayed via the thalamus. Layers 5 and 6 are the main output layers of neocortex. Layer 5 contains the largest neurons with long axons that project to other parts of the brain below cortex. Most layer 6 neurons project back to the thalamic area that provides input to layer 4. Layer 1 has almost no neurons and has an unknown function. Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['4']

Lecture #07 Cerebral Cortex Organization

Question 3: Which neurons contribute most to cortico-cortical connections?

a) Modified pyramidal cells of layer 6

b) Corticostriate neurons of layer 5 and 6

c) Layer 1 neurons

d) Pyramidal neurons of layers 2 and 3

e) Chandelier cells

HINT:

The neurons most closely associated with cortical processing contribute most to cortico-cortical connections

EXPLANATION:

Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons, mainly in layer 3, that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['Pyramidal neurons of layers 2 and 3']

Lecture #07 Cerebral Cortex Organization

Question 4: How are cortical layers 4 and 6 alike?

a) Both are mainly pyramidal cells

b) Both have connections with the thalamus

c) Brodmann was unable to distinguish one form the other

d) Both are mainly involved in cortico-cortical processing

e) Both project long axons to subcortical structures

HINT:

Consider both input and output

EXPLANATION:

Layer 4 is the input layer of neocortex, receiving a heavy, topographically organized projection of axons from the thalamus. Almost all input to the cortex must be relayed via the thalamus. Most layer 6 neurons project back to the thalamic area that provides input to layer 4.

ANSWER: ['Both have connections with the thalamus']

Lecture #07 Cerebral Cortex Organization

Question 5: What does the frontal lobe do?

a) Perform arithmetic calculations

b) Control movement and executive functions

c) Respond to visual objects in the contralateral lower visual hemifield

d) Recognize faces

e) Identify meaningful objects by name

HINT:

The frontal lobe is often considered the highest part of the brain

EXPLANATION:

The occipital lobe is visual. It receives input relayed from the retina by the lateral geniculate nucleus of the thalamus. The temporal lobe also has visual functions, related to higher level processing, for example face recognition by the ventral occipito-temporal cortex or fusiform gyrus. The temporal lobe also has the primary auditory cortex and higher auditory areas. Wernicke’s language area on the left hemisphere is mainly in the temporal lobe. Much of temporal lobe information is directed to the hippocampus and amygdala of the limbic system. The parietal lobe also has some of Wernicke’s area. The parietal lobe is mostly concerned with multi-modal sensory integration, attention, and spatial aspects of motor control. The frontal lobe has primary motor cortex and premotor areas. More anterior, dorsolateral, and ventral on the frontal lobe are areas that serve the highest executive functions, decision-making, and short term memory.

ANSWER: ['Control movement and executive functions']

Lecture #07 Cerebral Cortex Organization

Question 6: Which is characteristic of local interneurons of neocortex?

a) Local interneurons are usually excitatory and use the neurotransmitter glycine

b) Local interneurons are most prevalent in layer V

c) Local interneurons are often stellate in shape

d) Local interneurons are often pyramidal in shape

e) Local interneurons receive their input from the dendritic spines of layer IV neurons

HINT:

Local interneurons are also called Golgi type II neurons

EXPLANATION:

The most general, but not encompassing, subdivision of cortical neuron morphology is into stellate or granular Golgi type II local interneurons and pyramidal Golgi type I long axon projection neurons.

ANSWER: ['Local interneurons are often stellate in shape']

Lecture #07 Cerebral Cortex Organization

Question 7: Damage to which area would most likely lead to the inability to remember a phone number for long enough to dial it?

a) Occipital association cortex

b) Limbic efferents

c) Parietal association cortex

d) Prefrontal association cortex

e) Temporal association cortex

HINT:

The same region in non-human primates is responsible for successful delayed responses to obtain hidden rewards

EXPLANATION:

The higher function areas of prefrontal cortex are divided into dorsolateral and ventromedial. Dorsolateral prefrontal cortex is required for working memory, short term memory, for example temporary memory of an address or phone number. Ventromedial prefrontal cortex is considered the highest cortical region, serving abstract functions including emotional responses through its connections with the limbic system, long term goals, and personality.

ANSWER: ['Prefrontal association cortex']

Lecture #07 Cerebral Cortex Organization

Question 8: Which are the largest cortical neurons?

a) Layer 4 cells of calcarine sulcus cortex

b) Betz cells of motor cortex

c) Stellate cells of fusiform gyrus cortex

d) Stellate cells calcarine sulcus cortex

e) Layer 6 cells of fusiform gyrus cortex

HINT:

The largest cortical neurons have the longest axons

EXPLANATION:

Layer 5 contains the largest neurons with long axons that project to other parts of the brain below cortex. The largest of these are the giant Betz cells of primary motor cortex, Brodmann’s area 4, which can approach 100 microns in cell body diameter. The Betz cells innervate distal musculature of the limbs and must maintain a long, large axon.

ANSWER: ['Betz cells of motor cortex']

Lecture #07 Cerebral Cortex Organization

Question 9: Which best describes the laminar organization of the cerebral cortex?

a) The neocortex has 3 laminae: stellate, pyramidal, and white matter

b) The neocortex has 6 laminae, with main input to layer IV and outputs from II, III, V, and VI

c) Dendritic spines provide output from stellate neurons to pyramidal neurons in a pial-to- white matter lamination

d) The allocortex has 6 laminae, with pyramidal cells primarily in layer IV

e) The neocortex has 6 laminae of white matter, though layer IV may be nearly absent in agranular cortex areas

HINT:

Contrast neocortex with archicortex and paleocortex

EXPLANATION:

Allocortex, including paleocortex and archicortex, has roughly 3 layers (or 4), with variable appearance. Neocortex has a strikingly uniform 6 layer structure with well-defined functions for layers 2 through 6. Thalamic input is to layer 4, layers 2 and 3 are cortico-cortical processing layers, layer 5 is the long axon output layer, and layer 6 projects back to thalamus.

ANSWER: ['The neocortex has 6 laminae, with main input to layer IV and outputs from II, III, V, and VI']

Lecture #07 Cerebral Cortex Organization

Question 10: Which sense has its primary cortical area in temporal cortex?

a) Auditory

b) Visual

c) Olfactory

d) Somatic

e) Proprioceptive

HINT:

Use a process of elimination

EXPLANATION:

Primary visual cortex area V1 is in the occipital lobe, area 17, striate cortex, or calcarine cortex. Primary somatic cortex S1 (including proprioceptive inputs to area 3a) is on the postcentral gyrus, areas 3, 1, and 2 of the anterior parietal lobe. Primary olfactory cortex is in ventral frontal and temporal paleocortex. Primary auditory cortex, Heschl’s gyrus, is in the medial temporal lobe.

ANSWER: ['Auditory']

Lecture #07 Cerebral Cortex Organization

Question 11: Damage to which specific part of the brain was most likely responsible for personality changes observed in the famous patient Phineas Gage?

a) Right parietal cortex

b) Dorsolateral frontal cortex

c) Inferotemporal cortex

d) Ventromedial prefrontal cortex

e) Temporal pole

HINT:

Personality is considered a higher order executive function

EXPLANATION:

The higher function areas of prefrontal cortex are divided into dorsolateral and ventromedial. Dorsolateral prefrontal cortex is required for working memory, short term memory, for example temporary memory of an address or phone number. Ventromedial prefrontal cortex is considered the highest cortical region, serving abstract functions including emotional responses through its connections with the limbic system, long term goals, and personality.

ANSWER: ['Ventromedial prefrontal cortex']

Lecture #07 Cerebral Cortex Organization

Question 12: Which is characteristic of layer VI of neocortex?

a) Layer VI neurons are most often stellate in shape

b) Layer VI sends the main cortical output of axons to the thalamus

c) Layer VI has the fewest projection neurons of any layer

d) Layer VI receives the main input of axons from the thalamus

e) Local interneurons are most prevalent in layer VI

HINT:

Layer 6 gets input from layer 4 and contains neurons that project out of the cortex

EXPLANATION:

The cerebral neocortex receives most of its input via thalamic projections into layer 4, the input layer of cortex. This input is topographically organized, with specific thalamic nuclei projecting to specific cortical area. Neurons of cortical layer 6, in turn, project back to the same parts of thalamus that provide input to an area. This is the main role of layer 6.

ANSWER: ['Layer VI sends the main cortical output of axons to the thalamus']

Lecture #07 Cerebral Cortex Organization

Question 13: What type of cortex makes up the largest proportion of the cerebrum?

a) Archicortex

b) Paleocortex

c) Limbic cortex

d) Heterogenetic cortex

e) Neocortex

HINT:

Most of the cerebral cortex has 6 layers

EXPLANATION:

In humans, 90% or more of the cortex is neocortex that includes over 50 cytoarchitonically and functionally defined areas. Non-neocortical areas include the hippocampus in the temporal lobe, which is archicortex, and much of olfactory cortex in orbital frontal cortex, which is paleocortex.

ANSWER: ['Neocortex']

Lecture #07 Cerebral Cortex Organization

Question 14: What is best developed in macro-osmic cortex?

a) Neocortex

b) Pallium

c) Homogenetic cortex

d) Archicortex

e) Paleocortex

HINT:

homogenetic and isogenetic are names for 6 layered cortex

EXPLANATION:

Humans are said to have micro-osmotic cortex, with little olfactory tissue. Dogs, in contrast, are said to have macro-osmotic cortex, including a larger proportion of paleocortex olfactory cortex than found in humans. In humans, 90% or more of the cortex is neocortex that includes over 50 cytoarchitonically and functionally defined areas. Non-neocortical areas include the hippocampus in the temporal lobe, which is archicortex, and much of olfactory cortex in orbital frontal cortex, which is paleocortex.

ANSWER: ['Paleocortex']

Lecture #07 Cerebral Cortex Organization

Question 15: Which two cortical layers are believed to be most involved in intrinsic cortical processing, the so called thinking layers?

a) 5 and 6

b) 2 and 3

c) 1 and 6

d) 4 and 5

e) 4 and 6

HINT:

These are neither major input nor major subcortical output layers

EXPLANATION:

Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['2 and 3']

Lecture #07 Cerebral Cortex Organization

Question 16: Which two layers, respectively, are the main input and output layers of cerebral cortex?

a) 6 and 5

b) 6 and 1

c) 1 and 6

d) 5 and 6

e) 4 and 5

HINT:

Input is from the thalamus, output is via long axons to lower brain centers

EXPLANATION:

Layer 4 is the input layer of neocortex, receiving a heavy, topographically organized projection of axons from the thalamus. Almost all input to the cortex must be relayed via the thalamus. Layers 5 and 6 are the main output layers of neocortex. Layer 5 contains the largest neurons with long axons that project to other parts of the brain below cortex. Most layer 6 neurons project back to the thalamic area that provides input to layer 4. Layer 1 has almost no neurons and has an unknown function. Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['4 and 5']

Lecture #07 Cerebral Cortex Organization

Question 17: What does the temporal lobe do (not counting Heschl's gyrus auditory cortex)?

a) Process spatial relations

b) Recognize objects and faces

c) Respond to visual objects in the lower visual field

d) Discriminate musical tone pitch

e) Direct attention

HINT:

Recall the location of the fusiform cortex

EXPLANATION:

The occipital lobe is visual. It receives input relayed from the retina by the lateral geniculate nucleus of the thalamus. The temporal lobe also has visual functions, related to higher level processing, for example face recognition by the ventral occipito-temporal cortex or fusiform gyrus. The temporal lobe also has the primary auditory cortex and higher auditory areas. Wernicke’s language area on the left hemisphere is mainly in the temporal lobe. Much of temporal lobe information is directed to the hippocampus and amygdala of the limbic system. The parietal lobe also has some of Wernicke’s area. The parietal lobe is mostly concerned with multi-modal sensory integration, attention, and spatial aspects of motor control. The frontal lobe has primary motor cortex and premotor areas. More anterior, dorsolateral, and ventral on the frontal lobe are areas that serve the highest executive functions, decision-making, and short term memory.

ANSWER: ['Recognize objects and faces']

Lecture #07 Cerebral Cortex Organization

Question 18: Which two cortical layers, respectively, receive input from and project output back to the diencephalon?

a) 5 and 6

b) 4 and 6

c) 1 and 2

d) 2 and 5

e) 3 and 6

HINT:

The projections are to and from the thalamus

EXPLANATION:

The cerebral neocortex receives most of its input via thalamic projections into layer 4, the input layer of cortex. This input is topographically organized, with specific thalamic nuclei projecting to specific cortical area. Neurons of cortical layer 6, in turn, project back to the same parts of thalamus that provide input to an area.

ANSWER: ['4 and 6']

Lecture #07 Cerebral Cortex Organization

Question 19: What lies at a depth between the corona radiata and superior longitudinal fasciculus?

a) Inferior longitudinal fasciculus

b) Arcuate fasciculus

c) Uncinate fasciculus

d) Tapetum

e) Short association fibers

HINT:

The superior longitudinal fasciculus contains long association fibers

EXPLANATION:

The corona radiata is the incoming and outgoing axons that end or arise in the cortical cellular layers. Beneath the corona radiata lie the short cortico-cortical association axons mainly from layer 2 (and 3). Beneath the short association fibers are found the long association fibers, including the superior and inferior longitudinal fasciculi and the arcuate fasciculus.

ANSWER: ['Short association fibers']

Lecture #07 Cerebral Cortex Organization

Question 20: Why are cortical layers 2 and 3 often described as a single layer 2-3?

a) Both are involved in cortico-cortical processing

b) Brodmann was unable to distinguish one from the other

c) Both have stellate cells

d) Both project long axons to subcortical structures

e) Both have granular cells

HINT:

Layers 2 and 3 contain the neurons that form the corpus callosum and other types of cortico-cortical neurons

EXPLANATION:

Layer 4 is the input layer of neocortex, receiving a heavy, topographically organized projection of axons from the thalamus. Almost all input to the cortex must be relayed via the thalamus. Layers 5 and 6 are the main output layers of neocortex. Layer 5 contains the largest neurons with long axons that project to other parts of the brain below cortex. Most layer 6 neurons project back to the thalamic area that provides input to layer 4. Layer 1 has almost no neurons and has an unknown function. Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum.

ANSWER: ['Both are involved in cortico-cortical processing']

Lecture #07 Cerebral Cortex Organization

Question 21: What cortical layer has the least neurons?

a) 6

b) 1

c) 3

d) 2

e) 5

HINT:

There is one neocortical layer with unknown function

EXPLANATION:

Layer 1 has almost no neurons and has an unknown function. Layer 4 is the input layer of neocortex, receiving a heavy, topographically organized projection of axons from the thalamus. Almost all input to the cortex must be relayed via the thalamus. Layers 5 and 6 are the main output layers of neocortex. Layer 5 contains the largest neurons with long axons that project to other parts of the brain below cortex. Most layer 6 neurons project back to the thalamic area that provides input to layer 4. Layers 2 and 3 are the cortico-cortical processing layers. Layers 2 and 3 contain small pyramidal neurons that project locally and to other nearby cortical areas, as well as larger pyramidal neurons that send an axon to the corresponding area of the contralateral hemisphere via the corpus callosum

ANSWER: ['1']