Lecture #10 Cerebellum

Question 1: Limb ataxia is most closely associated with which cerebellar structure?

a) Fastigial nucleus

b) Intermediate zone

c) Oculomotor vermis

d) Unipolar brush cell

e) Lingula

HINT:

More lateral in the cerebellum corresponds to more lateral or more complex higher motor functions

EXPLANATION:

The flocculonodular lobe (vestibulocerebellum) and the vermis, medial cerebellum, are most closely associated with trunk coordination, trunk ataxia, and loss of balance. The intermediate zone between the vermis and hemispheres is most related to limb function and limb ataxia, abnormal gait, or limb coordination. The lateral cerebellum (hemisphere) is most related to multi-joint movements, finger control, and to motor planning and motor learning.

ANSWER: ['Intermediate zone']

Lecture #10 Cerebellum

Question 2: Which path does NOT end as mossy fibers to the cerebellum?

a) Ventral spinocerebellar

b) Reticulocerebellar

c) Olivocerebellar

d) Dorsal spinocerebellar

e) Pontocerebellar

HINT:

The two cerebellar input types are named for the appearance of their terminations

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Mossy fibers arise from many areas of the central nervous system and make excitatory synapses in the granule cell layer of cerebellar cortex within glomeruli. Mossy fiber glomeruli consist of incoming mossy fiber axon terminals, granule cell dendrites, and inhibitory axon terminals of Golgi cells of cerebellar cortex. Climbing fibers arise exclusively from the inferior olive in the medulla. Each climbing fiber branches to excite a few Purkinje cells with extensive axonal arborizations all over the dendritic tree. Each Purkinje cell receives only one climbing fiber input. In addition to mossy and climbing fiber inputs, there are neuromodulatory inputs to the cerebellum.

ANSWER: ['Olivocerebellar']

Lecture #10 Cerebellum

Question 3: Which tract travels through the superior cerebellar peduncle?

a) Corticospinal

b) Ventral spinocerebellar

c) Olivocerebellar

d) Dorsal spinocerebellar

e) Cuneo spinocerebellar

HINT:

The exception to the superior peduncle being output is exceptional in its decussations

EXPLANATION:

The inferior cerebellar peduncle contains almost entirely inputs. Spinocerebellar, inferior olivary olivocerebellar, vestibulocerebellar, and reticulocerebellar inputs comprise the inferior cerebellar peduncle. The large middle cerebellar peduncle is comprised of pontocerebellar inputs. The superior cerebellar peduncle contains the cerebellar deep nuclear outputs and the ventral spinocerebellar tract input. The ventral spinocerebellar tract begins with ipsilateral second order spinal sensory neurons whose axons cross to become contralateral, ascend to the superior cerebellar peduncle, then recross to return to the ipsilateral side to synapse in the cerebellar granule cell layer as mossy fibers.

ANSWER: ['Ventral spinocerebellar']

Lecture #10 Cerebellum

Question 4: Where does the climbing fiber input to cerebellum originate?

a) Inferior olive

b) Dentate gyrus

c) Dentate nucleus

d) Medial superior olive

e) Superior olive

HINT:

There is a single medullary nucleus that is the sole source of climbing fibers

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Mossy fibers arise from many areas of the central nervous system and make excitatory synapses in the granule cell layer of cerebellar cortex within glomeruli. Climbing fibers arise exclusively from the inferior olive in the medulla. Each climbing fiber branches to excite a few Purkinje cells with extensive axonal arborizations all over the dendritic tree. Each Purkinje cell receives only one climbing fiber input.

ANSWER: ['Inferior olive']

Lecture #10 Cerebellum

Question 5: The mossy fiber input to cerebellar cortex goes to which?

a) GABA synapses to cause inhibition

b) Parallel fiber axons rather than dendrites

c) Glomeruli that have granule cell dendrites

d) The four spinocerebellar tracts

e) Purkinje cell dendrites, wrapping all around them

HINT:

Mossy fibers do not go to the cerebellar cortex layer where the climbing fibers synapse

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Mossy fibers arise from many areas of the central nervous system and make excitatory synapses in the granule cell layer of cerebellar cortex within glomeruli. Mossy fiber glomeruli consist of incoming mossy fiber axon terminals, granule cell dendrites, and inhibitory axon terminals of Golgi cells of cerebellar cortex. Climbing fibers arise exclusively from the inferior olive in the medulla and synapse on Purkinje cell dendrites in the molecular layer of cerebellar cortex.

ANSWER: ['Glomeruli that have granule cell dendrites']

Lecture #10 Cerebellum

Question 6: Which cerebellar neurons are excitatory?

a) Golgi cells

b) Basket cells

c) Stellate cells

d) Granule cells

e) Purkinje cells

HINT:

There are three types of local inhibitory neurons within the cerebellar cortex, and one major inhibitory output neuron

EXPLANATION:

The very numerous granule cells are the only excitatory cells of the cerebellar cortex. The Purkinje cells that provide the output from cerebellar cortex are inhibitory to the deep nuclear cells that receive their axons. The molecular layer of the cerebellar cortex contains two types of GABA-ergic neurons that inhibit the Purkinje cells below them. Basket cells have basket shaped axonal arborizations around Purkinje cell bodies. Stellate cells are small neurons that make inhibitory synapses onto Purkinje cell dendrites. The granule cell layer of cerebellar cortex contains Golgi cells that inhibit granule cells at the mossy fiber glomeruli.

ANSWER: ['Granule cells']

Lecture #10 Cerebellum

Question 7: The climbing fiber input to cerebellar cortex goes to which?

a) Parallel fiber axons rather than dendrites

b) Purkinje cell dendrites, wrapping all around them

c) The four spinocerebellar tracts

d) GABA synapses to cause inhibition

e) Glomeruli that have granule cell dendrites

HINT:

The names of the cerebellar inputs describe their terminations

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Climbing fibers arise exclusively from the inferior olive in the medulla. Each climbing fiber branches to excite a few Purkinje cells with extensive axonal arborizations all over the dendritic tree. Each Purkinje cell receives only one climbing fiber input.

ANSWER: ['Purkinje cell dendrites, wrapping all around them']

Lecture #10 Cerebellum

Question 8: Which neurological problem would be LEAST suggestive of damage to the vermis?

a) Blurred vision due to poor oculomotor control of saccades

b) Reduced tone of postural muscles

c) Loss of balance

d) Reduced hand coordination

e) Drunken gait

HINT:

More lateral in the cerebellum corresponds to more lateral or more complex higher motor functions

EXPLANATION:

The flocculonodular lobe (vestibulocerebellum) and the vermis, medial cerebellum, are most closely associated with trunk coordination, postural tone, trunk ataxia, and loss of balance. The vermis has a region devoted to control of saccadic eye movements. The intermediate zone between the vermis and hemispheres is most related to limb function and limb ataxia, abnormal gait, or limb coordination. The lateral cerebellum (hemisphere) is most related to multi-joint movements, finger control, and to motor planning and motor learning.

ANSWER: ['Reduced hand coordination']

Lecture #10 Cerebellum

Question 9: Which lists the major mossy fiber pathway through the cerebellum via the correct structures in the correct order?

a) mossy fiber>deep nuclear neuron>granule cell>Purkinje cell

b) Purkinje cell>parallel fiber>granule cell>Golgi cell>deep nuclear neuron

c) Purkinje cell>granule cell>parallel fiber>Golgi cell>deep nuclear neuron

d) mossy fiber>granule cell>parallel fiber>Purkinje cell>deep nuclear neuron

e) mossy fiber>deep nuclear neuron>parallel fiber>granule cell>Purkinje cell

HINT:

Consider the initial synaptic site for mossy fibers in the cerebellum

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Mossy fibers arise from many areas of the central nervous system and make excitatory synapses in the granule cell layer of cerebellar cortex within glomeruli. Mossy fiber glomeruli consist of incoming mossy fiber axon terminals, granule cell dendrites, and inhibitory axon terminals of Golgi cells of cerebellar cortex. Granule cell axons rise and bifurcate to become parallel fibers in the cerebellar molecular layer. Parallel fibers synapse at the planar Purkinje cell dendritic trees. Climbing fibers arise exclusively from the inferior olive in the medulla. Each climbing fiber branches to excite a few Purkinje cells with extensive axonal arborizations all over the dendritic tree. Each Purkinje cell receives only one climbing fiber input. Purkinje cell axons project to deep cerebellar nuclei. The axons of deep nuclear cells project out of the cerebellum to the ventral lateral thalamus. In addition to mossy and climbing fiber inputs, there are neuromodulatory inputs to the cerebellum.

ANSWER: ['mossy fiber>granule cell>parallel fiber>Purkinje cell>deep nuclear neuron']

Lecture #10 Cerebellum

Question 10: The cerebellar deep nuclei are which?

a) The major output destination of cerebellar cortex Purkinje cell axons

b) The vermis, intermediate zone, and hemispheres

c) Numbered from I to X, medial to lateral

d) The major input projection to cerebellar cortex Purkinje cell dendrites

e) Excited by Purkinje cell axons

HINT:

The deep nuclei lie within the cerebellar white matter and are the output from the cerebellum

EXPLANATION:

The output neurons of cerebellar cortex, the Purkinje cells, project GABA-ergic axons to the cerebellar deep nuclei. The deep nuclei lie within the cerebellar white matter. Deep nuclear cell axons are the output from the cerebellum, projected mainly to the ventral lateral thalamus to be relayed to motor areas of cortex. The deep nuclei from medial to lateral are the fastigial nucleus, the interposed nuclei (or globose and emboliform nucleus), and the very large dentate nucleus.

ANSWER: ['The major output destination of cerebellar cortex Purkinje cell axons']

Lecture #10 Cerebellum

Question 11: Which two tracts convey mainly upper body information to the cerebellum?

a) Rostral and cuneo cerebellar tracts

b) Ventral and caudal spinocerebellar tracts

c) Propriospinal tracts

d) Dorsal and ventral spinocerebellar tracts

e) Ventral and anterior spinocerebellar tracts

HINT:

Both spinocerebellar tracts that serve the lower body are named for coordinate directions, and so is one of the two that serve the upper body

EXPLANATION:

There are four spinocerebellar tracts, two for the lower body and two for the upper body. The dorsal and ventral spinocerebellar tracts convey information from the lower body. Information in the dorsal spinocerebellar tract is somatic sense. Dorsal spinocerebellar tract signals are lost when sensory nerves are cut. Information in the ventral spinocerebellar tract remains when sensory nerves are cut, showing that it is motor command-related signals rather than sensory signals. Similarly, for the upper body, the cuneocerebellar tract carries sensory signals, and the rostral spinocerebellar tract is believed to carry motor command information.

ANSWER: ['Rostral and cuneo cerebellar tracts']

Lecture #10 Cerebellum

Question 12: How can you best describe and contrast the motor control roles of the cerebellum vs the basal ganglia, respectively?

a) Movement reward vs movement punishment

b) Tremor reduction at rest vs tremor reduction near movement goal

c) Movement punishment vs movement guidance

d) Movement guidance vs movement initiation

e) Movement initiation vs resting posture

HINT:

Consider the effects of cerebellar vs basal ganglia damage

EXPLANATION:

A primary role of the cerebellum is guidance and refinement of ongoing movement and its accurate termination. The basal ganglia are especially important for movement initiation. Cerebellar damage can result in intention tremor as a movement approaches its goal. Basal ganglia damage can result in a tremor at rest that may diminish during movement. Cerebellar damage often causes hypermetria, basal ganglia damage often causes hypometria.

ANSWER: ['Movement guidance vs movement initiation']

Lecture #10 Cerebellum

Question 13: Which describes the output from cerebellar cortex?

a) It is an entirely inhibitory projection of GABA-ergic neurons

b) It is comprised of axons ending primarily in motor cortex

c) It uses the neurotransmitter dopamine

d) It is an entirely excitatory projection of glutamatergic neurons

e) It is comprised of axons that project to spinal cord motor neurons and interneurons

HINT:

Large, flask-shaped neurons in a monolayer provide the output from cerebellar cortex

EXPLANATION:

Purkinje cells are the output neurons of cerebellar cortex. They are GABA-ergic neurons that project to cerebellar deep nuclear neurons. The deep nuclear neurons then project to the ventral lateral thalamus and other areas.

ANSWER: ['It is an entirely inhibitory projection of GABA-ergic neurons']

Lecture #10 Cerebellum

Question 14: A cerebellar glomerulus contains which elements?

a) Granule cell dendrites, Golgi cell axon terminals, mossy fiber axon terminals

b) Granule cell dendrites, Golgi cell dendrites, mossy fiber dendrites

c) Stellate cell axon terminals, basket cell axon terminals, Golgi cell axon terminals

d) Purkinje cell dendrites, granule cell axon terminals, mossy fiber axon terminals

e) Purkinje cell dendrites, granule cell dendrites, mossy fiber axon terminals

HINT:

the cerebellar glomerulus is an input structure not related to the inferior olive

EXPLANATION:

There are two major inputs to the cerebellum, mossy fibers and climbing fibers. Mossy fibers arise from many areas of the central nervous system and make excitatory synapses in the granule cell layer of cerebellar cortex within glomeruli. Mossy fiber glomeruli consist of incoming mossy fiber axon terminals, granule cell dendrites, and inhibitory axon terminals of Golgi cells of cerebellar cortex. Climbing fibers arise exclusively from the inferior olive in the medulla. Each climbing fiber branches to excite a few Purkinje cells with extensive axonal arborizations all over the dendritic tree. Each Purkinje cell receives only one climbing fiber input. In addition to mossy and climbing fiber inputs, there are neuromodulatory inputs to the cerebellum.

ANSWER: ['Granule cell dendrites, Golgi cell axon terminals, mossy fiber axon terminals']

Lecture #10 Cerebellum

Question 15: Which neurological problem would NOT suggest damage to the flocculus?

a) Loss of the ability to alter the vestibulo-ocular reflex to adjust when new glasses are fitted

b) A vestibulo-ocular reflex that is too large

c) Loss of the ability to smoothly track a moving visual target

d) Inability to suppress saccades

e) Loss of visual pursuit

HINT:

The flocculus is responsible for a type of eye movement exclusively found in primates

EXPLANATION:

The nodulus and flocculus comprise the vestibulocerebellum or flocculonodular lobe. The flocculus is required for adaptive adjustment of the vestibulo-ocular reflex and for visual pursuit, the ability to smoothly follow a moving visual target. Only primates have visual pursuit. Non-primates follow moving targets with a series of saccades. Suppression of saccades and other saccade planning is primarily a function of the frontal cortex eye field area. The short latency, automatic generation of saccades is dependent on the superior colliculus.

ANSWER: ['Inability to suppress saccades']

Lecture #10 Cerebellum

Question 16: Which two tracts convey mainly movement command feedback information to the cerebellum?

a) Ventral and anterior spinocerebellar tracts

b) Propriospinal tracts

c) Dorsal and ventral spinocerebellar tracts

d) Ventral and rostral spinocerebellar tracts

e) Rostral and cuneo cerebellar tracts

HINT:

There are four spinocerebellar tracts, two for the lower body and two for the upper body

EXPLANATION:

There are four spinocerebellar tracts, two for the lower body and two for the upper body. The dorsal and ventral spinocerebellar tracts convey information from the lower body. Information in the dorsal spinocerebellar tract is somatic sense. Dorsal spinocerebellar tract signals are lost when sensory nerves are cut. Information in the ventral spinocerebellar tract remains when sensory nerves are cut, showing that it is motor command-related signals rather than sensory signals. Similarly, for the upper body, the cuneocerebellar tract carries sensory signals, and the rostral spinocerebellar tract is believed to carry motor command information.

ANSWER: ['Ventral and rostral spinocerebellar tracts']

Lecture #10 Cerebellum

Question 17: Which two tracts convey mainly lower body information to the cerebellum?

a) Ventral and caudal spinocerebellar tracts

b) Dorsal and cuneo cerebellar tracts

c) Dorsal and ventral spinocerebellar tracts

d) Ventral and anterior spinocerebellar tracts

e) Propriospinal tracts

HINT:

Both spinocerebellar tracts that serve the lower body are named for coordinate directions, and so is one of the two that serve the upper body

EXPLANATION:

There are four spinocerebellar tracts, two for the lower body and two for the upper body. The dorsal and ventral spinocerebellar tracts convey information from the lower body. Information in the dorsal spinocerebellar tract is somatic sense. Dorsal spinocerebellar tract signals are lost when sensory nerves are cut. Information in the ventral spinocerebellar tract remains when sensory nerves are cut, showing that it is motor command-related signals rather than sensory signals. Similarly, for the upper body, the cuneocerebellar tract carries sensory signals, and the rostral spinocerebellar tract is believed to carry motor command information.

ANSWER: ['Dorsal and ventral spinocerebellar tracts']

Lecture #10 Cerebellum

Question 18: Which layer of the cerebellum contains billions of parallel fibers?

a) Middle cerebellar peduncle

b) Molecular

c) Granule cell

d) Purkinje cell

e) Deep nuclear

HINT:

There are three layers of cerebellar cortex above the cerebellar white matter and deep nuclei

EXPLANATION:

There are three layers of cerebellar cortex above the cerebellar white matter and deep nuclei. The most superficial layer of cerebellar cortex is the molecular layer, which contains billions of parallel fibers and the inhibitory stellate and basket cells. All synapse onto Purkinje cells. Beneath the molecular layer lies a single monolayer sheet of large, flask-shaped Purkinje cell bodies, with characteristic planar dendritic fields that extend into the molecular layer where the parallel fibers pass through the dendrites to make a few synapses on each of thousands of Purkinje cells. The deepest cerebellar cortex layer is the granule cell layer. In the granule call layer are billions of granule cells and the synaptic glomeruli at which granule cells get their input. Also in the granule cell layer are the inhibitory Golgi cells which make inhibitory synapses onto granule cell dendrites in the glomeruli. Incoming mossy fibers are the third element of the glomeruli.

ANSWER: ['Molecular']

Lecture #10 Cerebellum

Question 19: What are the inputs to cerebellar deep nuclei and their excitatory (+) or inhibitory (-) effects?

a) Dentate cell axons (+), climbing fiber collaterals (-), Purkinje cell axons (+)

b) Mossy fiber collaterals (-), dentate cell axons (-), Purkinje cell axons (-)

c) Mossy fiber collaterals (+), climbing fiber collaterals (+), Purkinje cell axons (-)

d) Fastigial cell axons (+), climbing fiber collaterals (+), Purkinje cell axons (+)

e) Golgi cell axons (+), mossy fiber collaterals (+), granule cell axons (-)

HINT:

Consider where inputs to the cerebellum branch and terminate

EXPLANATION:

Purkinje cells are large GABA-ergic neurons that provide the output from cerebellar cortex. Most Purkinje cells project to cerebellar deep nuclei, which send axons out of the cerebellum to the thalamus and other areas. Purkinje cells are the main inhibitory input to deep nuclear cells. Mossy and climbing fiber excitatory inputs to the cerebellum branch and send a collateral axon to excite the deep nuclei.

ANSWER: ['Mossy fiber collaterals (+), climbing fiber collaterals (+), Purkinje cell axons (-)']

Lecture #10 Cerebellum

Question 20: Damage to which part of the cerebellum is correlated to decomposition of movement?

a) Vermis

b) Hemispheres

c) Fastigial nucleus

d) Nodulus

e) Uvula

HINT:

More lateral in the cerebellum corresponds to more lateral or more complex higher motor functions

EXPLANATION:

The flocculonodular lobe (vestibulocerebellum) and the vermis, medial cerebellum, are most closely associated with trunk coordination, trunk ataxia, and loss of balance. The intermediate zone between the vermis and hemispheres is most related to limb function and limb ataxia, abnormal gait, or limb coordination. The lateral cerebellum (hemisphere) is most related to multi-joint movements, finger control, and to motor planning and motor learning.

ANSWER: ['Hemispheres']

Lecture #10 Cerebellum

Question 21: Which cerebellar neurons are inhibitory to Purkinje cells?

a) Basket and Golgi cells

b) Granule and Golgi cells

c) Stellate and basket cells

d) Granule and basket cells

e) Granule and deep nuclear cells

HINT:

the neurons that inhibit Purkinje cells are found in the outer molecular layer

EXPLANATION:

The molecular layer of the cerebellar cortex contains two types of GABA-ergic neurons that inhibit the Purkinje cells below them. Basket cells have basket shaped axonal arborizations around Purkinje cell bodies. Stellate cells are small neurons that make inhibitory synapses onto Purkinje cell dendrites.

ANSWER: ['Stellate and basket cells']