The American Physiological Society
Medical Curriculum Objectives Project
Complete curriculum objectives available at:
http://www.the-aps.org/education/MedPhysObj/medcor.htm

Neurophysiology

Electrophysiology

NEU 1. Define, and identify on a diagram of a neuron, the following regions: dendrites, axon, axon hillock, soma, and synaptic cleft.

NEU 2. Write the Nernst equation, and explain the effects of altering either the intracellular or extracellular Na^+, K^+, Cl^-, or Ca^{2+} concentration on the equilibrium potential for that ion.

NEU 3. Describe the normal distribution of Na^+, K^+, Ca^{2+}, and Cl^- across the cell membrane, and using the chord conductance equation, explain how the relative permeabilities to these ions create a resting membrane potential.

NEU 4. Describe ionic basis of an action potential.

NEU 5. Contrast the generation and conduction of graded potentials with that of action potentials, identifying on the neuron the area in which each occurs.

NEU 6. Describe the basis for the calculation of the space constant and time constant of neuron process.

NEU 7. Define membrane capacitance and identify how membrane capacitance affects the spread of current in myelinated and demyelinated neurons.

NEU 8. Compare conduction velocities in a compound nerve, identifying how the diameter and myelination lead to differences in conduction velocity, and the use of these differences to classify neurons as group Ia, Ib, II, III, IV fibers or as A_{alpha}, A_{beta}, A_{delta}, b, and c fibers.

NEU 9. Describe the ionic basis for inhibitory and excitatory post-synaptic potentials and how these changes can alter synaptic transmission.

NEU 10. Distinguish the effects of hyperkalemia, hypercalcemia, and hypoxia on the resting membrane and action potential.

NEU 11. Describe the effects of demyelination on action potential propagation and nerve conduction.

Neurochemistry

NEU 12. Compare electrical and chemical synapses transmission based on velocity of

conduction, fidelity, and the possibility for neuromodulation (facilitation or inhibition).

NEU 13. Describe chemical neurotransmission, listing in correct temporal sequence events beginning with the arrival of a wave of depolarization at the pre-synaptic membrane and ending with a graded potential generated at the post-synaptic membrane.

NEU 14. Define the characteristics of a neurotransmitter.

NEU 15. Learn the synthetic pathways, inactivation mechanisms and neurochemical anatomy and mechanisms of receptor transduction for the following neurotransmitters:

1. Catecholamines (DA, NE, E)
2. Acetylcholine (Ach)
3. Serotonin (5-hydroxytryptamine; 5-HT)
4. Histamine
5. GABA (gamma-aminobutyric acid)
6. Glutamate
7. Endorphins
8. Enkephalins
9. Dynorphins
10. Substance P

NEU 16. Learn the major receptor classifications and representative receptor agonists and antagonists for the above transmitters.

NEU 17. Describe the relationships between neurotransmitter dysfunction and neuropathology.

Cerebrospinal Fluid, Blood Brain Barriers

NEU 18. Diagram the adult ventricular system and relate it to its embryological development.

NEU 19. Identify on a diagram the meninges and subarachnoid spaces.

NEU 20. Describe formation and reabsorption of cerebral spinal fluid, including the anatomy and function of the choroid plexi.

NEU 21. Describe the normal pressure, volume, and composition of the CSF.

NEU 22. Describe how CSF can vary in certain pathological conditions.

NEU 23. Describe the endothelial basis of the blood-brain barrier, and predict the consequence of this barrier for the central nervous system distribution of intravenously administered hydrophilic and hydrophobic drugs.

Spinal Cord Physiology

NEU 24. Distinguish between postsynaptic inhibition and presynaptic inhibition and provide examples of each.

NEU 25. Describe the anatomical location, function, and afferent neurotransmission of muscle spindle and Golgi tendon organs.

NEU 26. Trace the neuronal activity initiated by striking the patellar tendon with a percussion hammer (the patellar tendon reflex) that leads to contraction of a muscle. Contrast this reflex with the inverse myotactic reflex.

NEU 27. Describe the role of the gamma efferent system in the stretch reflex, and explain the significance of alpha-gamma co-activation.

NEU 28. Describe the properties of the flexor reflex initiated by touching a hot stove. Identify when pain is sensed, when flexor contraction occurs, and the neuronal connections and role of the crossed extensor reflex.

NEU 29. Describe the clinical tests and findings that allow a physician to distinguish between upper and lower motorneuron disorders, including the Babinski sign.

NEU 30. Describe the anatomy and functions of the major ascending and descending spinal cord tracts, including any crossing of midline.

NEU 31. Describe the use of dermatones, sensory deficits, and motor deficits to identify local spinal cord lesions, and spinal cord hemisection. Describe the immediate and long-term consequences of spinal cord transection.

Nerve Conduction/EMG Studies

NEU 32. Describe the procedure used for measuring nerve conduction velocity.

NEU 33. Describe the repetitive nerve stimulation procedure for assessing the integrity of the neuromuscular junction.

NEU 34. Compare the different EMG findings in neuropathy and myopathy.

NEU 35. Describe the physiological deficit and the consequence for patients with myasthenia gravis.

Autonomic Nervous System

NEU 36. Contrast the sympathetic and parasympathetic branches of the autonomic nervous system based on: spinal cord division of origin, length of preganglionic and postganglionic neurons, neurotransmitters and receptors at the ganglionic and target organ synapse.

NEU 37. List the sensory input of the ANS.

NEU 38. List the major central nervous system control centers of the ANS.

NEU 39. Describe the functional effects of normal and abnormal ANS activity or lack of activity.

Brainstem Reflexes

NEU 40. Describe the function of the following brain stem reflexes: cardiovascular baroreceptor, respiratory stretch receptor.

NEU 41. For each brain stem reflex, list the stimulus and its receptor, the afferent pathway, the brain stem nuclei involved, the efferent pathway and the resulting effect.

NEU 42. Contrast the effects of intra-axial and extra-axial brain stem lesions

Cerebrovascular System

NEU 43. Describe the local factors affecting brain blood flow, and contrast their effectiveness with that of autonomic regulation of cerebral blood flow.

NEU 44. Describe cerebrovascular disorders (stroke, aneurysm, migraine headache) as to primary cause and effect, including how excitotoxic mechanisms can lead to neuronal death following stroke or injury.

Somatosensory System

NEU 45. Define and contrast point localization and two-point discrimination in psychophysical and neurophysiological terms. Explain why the threshold for two-point discrimination changes in different areas of the body surface, e.g., lips, fingertips and back.

NEU 46. List the submodalities of discriminative touch.

NEU 47. Describe the following cutaneous and proprioceptive mechanoreceptors and their function: Pacinian corpuscles, Meissner's corpuscles, Ruffini endings, Merkle cell, A-delta and C free nerve endings, Golgi tendon organ, muscle spindle.

NEU 48. Describe functional organization at all levels and submodalities served by the dorsal column-medial lemniscal and the equivalent components of the trigeminal system.

NEU 49. Differentiate between feed-forward and feedback inhibition within neuronal circuits, and provide physiological examples of each.

NEU 50. Contrast the proprioceptive pathways to the cerebellum with that to the cerebral cortex.

NEU 51. Differentiate the submodalities of nondiscriminative touch, temperature and nociception based on receptor transduction mechanism, localization within the spinal gray matter, and central termination of the pathways.

NEU 52. Describe functional organization at all levels and submodalities served by the anterolateral system and the equivalent components of the spinal trigeminal system.

NEU 53. Describe the control of pain perception, including central processing and the role of endorphins.

NEU 54. Describe gating mechanism theory for control of pain transmission, and relate it to the use of TENS (transcutaneous electrical nerve stimulation) and spinal cord stimulation.

NEU 55. Describe pain perception and the central pain syndrome, for example, the thalamic pain syndrome.

NEU 56. Describe the peripheral and central mechanisms of primary hyperalgesia and secondary hyperalgesia.

NEU 57. Describe the mechanism of referred pain of visceral origin.

Visual System

NEU 58. Describe the refraction of light as it passes through the eye to the retina, identifying the eye components that account for refraction of light at the center of the eye and away from the center.

NEU 59. Describe the process of accommodation, contrasting the refraction of light by the lens in near vision and in far vision.

NEU 60. Describe the refractive deficits that account for myopia, hyperopia, presbyopia, and astigmatism, and their correction by eyeglasses or contact lenses.

NEU 61. Describe the electrical responses produced by bipolar cells, horizontal cells, amacrine cells, and ganglion cells, and comment on the function of each.

NEU 62. Contrast the transduction process for rods and the three types of cones, including the range of spectral sensitivity, including the ionic basis of these responses.

NEU 63. Describe the neuronal circuitry basis for antagonist center-surround receptive fields of

retinal ganglion cells.

NEU 64. Describe the receptive field properties of all neuron types in the visual pathway (retina to lateral geniculate to visual cortex). Describe how convergence, divergence, and afferent surround inhibition affect visual neuron receptive fields.

NEU 65. Predict the visual field defects resulting from the following lesions in the visual pathway: retinal lesion, optic nerve lesion, optic chiasm, optic tract, lateral geniculate nucleus, optic radiations, primary visual cortex.

NEU 66. Describe the topographic representation of the visual field within the primary visual cortex, including the topics of retinotopic organization, orientation selectivity, and ocular dominance.

NEU 67. Describe the processing of information in the visual cortex, and the consequence of a lesion in the higher visual association areas.

NEU 68. List and compare four functional properties of scotopic and photopic vision.

NEU 69. Explain the differing light sensitivities of the fovea and optic disk.

Smell and Taste

NEU 70. Describe the olfactory receptors and transduction mechanisms.

NEU 71. Describe olfactory pathways.

NEU 72. Describe taste receptors and transduction mechanisms.

NEU 73. Describe taste pathways.

Auditory System

NEU 74. Describe the function of the outer ear, middle ear, and inner ear, listing in order the mechanical structures over which sound energy is transmitted to auditory receptors.

NEU 75. Draw the human audibility curve and explain the changes that occur with aging.

NEU 76. Explain the frequency analysis performed by the cochlea on the basis of its physical properties.

NEU 77. Explain how deformations of the basilar membrane are converted into action potentials in auditory nerve fibers.

NEU 78. Diagram the auditory pathway including all central connections.

NEU 79. Describe how pitch, loudness, and localization of sounds in space is coded by central auditory neurons.

NEU 80. Distinguish conductive, central, and sensorineural deafness, and list the tests used to assess them.

Vestibular System

NEU 81. Describe the structure, normal stimulus, transduction at the receptor level, and function of the otolith organs.

NEU 82. Describe the structure, normal stimulus, transduction at the receptor level, and function of the semicircular canals.

NEU 83. Describe the central connections of the vestibular nerve (the two targets of first order afferents and the four targets of second order afferents), and relate these to the three major functions of the vestibular apparatus.

NEU 84. Describe the neural mechanisms of nystagmus, past pointing, and caloric testing, and relate the direction of the nystagmus to the direction of rotation or which ear (left or right) was irrigated with cold or warm water.

NEU 85. List and describe four clinical signs of vestibular system dysfunction.

NEU 86. Describe the different kinds of gaze (voluntary) eye movements and reflex eye movements.

Medial and Lateral System Control of Movement

NEU 87. Draw a “box” diagram of motor control systems, including cerebral cortex, basal ganglia, cerebellum, thalamus, brainstem motor nuclei, and spinal cord. Indicate with arrows the flow of information among these structures and, ultimately, to the alpha and gamma motor neurons.

NEU 88. Draw a cross section of the spinal cord and discuss the organization of the sensory and motor components of gray matter. Describe the somatotopic arrangement of motor neuron pools.

NEU 89. List the medial and lateral motor systems. Describe their origin, pathway, and termination within the spinal cord. Compare their functions in motor control.

NEU 90. Describe the effects of lesions in medial and lateral systems.

Cerebellum and Basal Ganglia

NEU 91. Describe the roles of the cerebellum in the regulation of skilled movement.

NEU 92. List three functional divisions of the cerebellum, detailing the input and output connections of each. Be able to differentiate the functions of each and their integration with lateral and medial motor systems.

NEU 93. Draw and label the circuitry of the cerebellar cortex, assign the functional role of each neuron type and give its synaptic action (excitatory/inhibitory). Be able to describe how this circuit functions as a timing mechanism and how it produces synergy in opposing muscle groups.

NEU 94. On the basis of input-output organization, somatotopic organization, and overall function, predict the neurological disturbances that can result from disease or damage in different regions of the cerebellum.

NEU 95. Contrast the spinal proprioceptive pathways to the cerebellum with those to the cortex.

NEU 96. List and describe the major interconnections between components of the basal ganglia and the motor cortex. Identify the neurotransmitters determining the flow of information in the system.

NEU 97. Describe the overall function of the basal ganglia in movement control and initiation in association with medial and lateral motor systems.

NEU 98. List the appropriate signs of rigidity, dyskinesias, akinesia, and tremor for Parkinsonism, chorea, hemiballism, and athetosis. Assign a likely lesion site or chemical system defect for each clinical syndrome.

NEU 99. Describe the rationale for treatment of Parkinsonism with anticholinergic drugs, L-DOPA, or transplantation of catecholamine-producing cells.

Cerebral Cortex

NEU 100. Describe the medial to lateral, rostral to caudal, and surface to white matter organizations of the primary motor cortex and the premotor cortex. Draw those regions on a sketch of the brain and also locate the supplementary motor cortex.

NEU 101. Compare the effects of electrical stimulation of motor cortex and premotor cortex, relating the expected results to the control of voluntary movement.

NEU 102. Describe the origin, course, and termination of the pyramidal tract.

NEU 103. Compare the consequences of upper motor neuron loss to lower motor neuron loss. Describe the consequences of pyramidal tract transection.

NEU 104. Draw a "flow diagram" for the brain regions involved in planning, initiating, and properly executing a skilled voluntary movement.

NEU 105. Identify Brodmann areas for visual, auditory, somatic sensory, motor, and speech areas.

NEU 106. Identify the cortical areas that receive projections from the following thalamic nuclei: ventral lateral, dorsomedial, pulvinar, medial geniculate, lateral geniculate, ventral posterolateral, and posteromedial.

NEU 107. Describe the cortical areas important for language.

NEU 108. Describe the cortical area important for spatial relations.

NEU 109. Describe the functions of the prefrontal association cortex.

NEU 110. Define and explain the physiological basis of evoked potentials and the electroencephalogram (EEG). List the main clinical uses of each.

NEU 111. Describe the primary types of rhythms that make up the EEG and the behavioral states that correlate with each.

NEU 112. Describe the origin of spontaneous electrical activity of the cerebral cortex.

NEU 113. Distinguish EEG activity from evoked potentials and the uses of evoked potentials.

Sleep

NEU 114. Describe the behavioral, EEG, and other characteristics of the stages of slow-wave sleep and rapid-eye-movement (REM) sleep. Explain the changes in sleep stages associated with aging, drugs, and sleep deprivation.

NEU 115. Distinguish slow wave sleep and paradoxical sleep.

NEU 116. Describe the neural systems important for the regulation of sleep-waking.

NEU 117. Describe the neurochemical systems important for sleep and waking.

NEU 118. Describe narcolepsy and sleep apnea.

NEU 119. Describe the mechanisms important in the production of coma.

NEU 120. Describe the changes in the sleep cycle across the life cycle.

Seizure Disorders

NEU 121. Recognize normal and abnormal EEG records.

NEU 122. Describe characteristics of generalized and partial seizures.

Hypothalamus

NEU 123. Describe the structure of the hypothalamus, including the major hypothalamic nuclei and areas.

NEU 124. Describe the major functions of the hypothalamus and its nuclei/areas.

NEU 125. Describe the role and mechanisms of the hypothalamus as it relates to thirst, hunger, temperature regulation, and the defense mechanism.

Limbic System

NEU 126. Describe the major components of the limbic system.

NEU 127. Describe the major afferent and efferent connections of the hippocampus.

NEU 128. Describe the major afferent and efferent connections of the amygdala.

NEU 129. Describe reinforcement functions of the limbic system.

NEU 130. Describe the functions of the hippocampus.

NEU 131. Describe the functions of the amygdala.

NEU 132. Describe the role of dopamine in the limbic system in disorders of thought and disorders of mood.

Aging of the Brain

NEU 133. Describe the gross, histological and biochemical changes that occur in the brain through aging.

NEU 134. Describe dementia.

NEU 135. Describe the characteristics of Alzheimer's disease.

Memory and Lateralization

NEU 136. List the parts of the brain that appear to be involved in memory in mammals, and summarize the proposed role of each in memory processing and storage.

NEU 137. Explain the mechanisms proposed for short term and long-term memory storage.

NEU 138. List the major differences in hemispheric function in humans.