

**The American Physiological Society
Medical Curriculum Objectives Project**

Complete curriculum objectives available at:
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Neurophysiology

(revised 2012)

Cellular Neurophysiology, Blood Brain Barrier, Cerebrovascular Physiology

A. Physiology of the Neuron

NEU 1. Define, and identify on a diagram of a motor neuron, the following regions: dendrites, axon, axon hillock, soma, and an axodendritic synapse.

NEU 2. Define, and identify on a diagram of a primary sensory neuron, the following regions: receptor membrane, peripheral axon process, central axon process, soma, sensory ganglia.

NEU 3. Write the Nernst equation, and explain the effects of altering the intracellular or extracellular Na^+ , K^+ , Cl^- , or Ca^{2+} concentration on the equilibrium potential for that ion.

NEU 4. Describe the normal distribution of Na^+ , K^+ , and Cl^- across the cell membrane, and using the chord conductance (Goldman) equation, explain how the relative permeabilities of these ions create a resting membrane potential.

NEU 5. Describe ionic basis of an action potential.

NEU 6. Distinguish the effects of hyperkalemia, hypercalcemia, and hypoxia on the resting membrane and action potential.

NEU 7. Explain how the abnormal function of ion channels (channelopathies) can alter the resting membrane and action potential and cause paralysis, ataxia, or night blindness.

NEU 8. Describe the ionic basis of each of the following local graded potentials: excitatory post synaptic potential (EPSP), inhibitory post synaptic potential (IPSP), end plate potential (EPP) and a receptor (generator) potential.

NEU 9. Contrast the generation and conduction of graded potentials (EPSP and IPSP) with those of action potentials.

NEU 10. On a diagram of a motor neuron, indicate where you would most likely find IPSP, EPSP, action potential trigger point, and release of neurotransmitter.

NEU 11. On a diagram of a sensory neuron, indicate where you would most likely find receptor potential or generator potential, action potential trigger point, and release of neurotransmitter.

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NEU 12. Describe how focal depolarization (EPSP) or hyperpolarization (IPSP) of a neuron can initiate action potential initiation by the processes of temporal and spatial summation.

NEU 13. Describe the functional role of myelin in promoting saltatory conduction, contrasting the differences between the CNS and PNS.

NEU 14. Describe the basis for the calculation of the space constant and time constant of neuron process.

NEU 15. Define membrane capacitance and identify how membrane capacitance affects the spread of current in myelinated and unmyelinated neurons.

NEU 16. Describe the effects of demyelination on action potential propagation and nerve conduction and the outcomes for recovery in CNS vs. PNS.

NEU 17. Compare conduction velocities in a compound nerve, identifying how the diameter and myelination lead to differences in conduction velocity. Use these differences to classify sensory nerve fibers as group Ia, Ib, II, III, and IV fibers or as A_{alpha}, A_{beta}, A_{delta}, B, and C fibers.

NEU 18. Describe how inhibitory and excitatory post-synaptic potentials can alter synaptic transmission.

NEU 19. Explain the role of astrocytes in maintaining neuronal milieu.

NEU 20. Describe the molecular mechanisms (initiation, specific receptors, enzymes, and locations in the CNS) underlying enhanced (long-term potentiation) or hindering (long-term depression) synaptic strength.

B. Neurochemistry

NEU 21. Compare electrical and chemical synapses based on velocity of transmission, fidelity, and the possibility for neuromodulation (facilitation or inhibition).

NEU 22. 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 23. Define the characteristics of a classical neurotransmitter.

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NEU 24. Learn the synthetic pathways, inactivation mechanisms and neurochemical anatomy and mechanisms of receptor transduction for the following classical and non-classical neurotransmitters:

- Catecholamines: dopamine, norepinephrine, epinephrine
- Acetylcholine
- Serotonin (5-hydroxytryptamine)
- Histamine
- GABA (γ -aminobutyric acid)
- Glutamate
- Endorphins
- Enkephalins
- Dynorphins
- Substance P
- Nitric Oxide
- Carbon Monoxide
- Endocannabinoid

NEU 25. List the major receptor classifications and representative receptor agonists and antagonists for the above transmitters.

NEU 26. Describe the relationship between neurotransmitter dysfunction and neuropathology.

NEU 27. Diagram the steps that lead to phosphorylation of a channel protein when a G_s protein is activated.

NEU 28. Diagram the steps that lead to an increase in intracellular Ca^{2+} and activation of protein kinase C following activation of a G_q protein.

NEU 29. Describe how changes in neuronal membrane chloride ion transporters can cause GABA to be an excitatory or an inhibitory transmitter.

C. Cerebrovascular System

NEU 30. Describe the local factors affecting brain blood flow and contrast their effectiveness with that of autonomic regulation of cerebral blood flow. Understand the role of blood flow in relation to fMRI.

NEU 31. Describe cerebrovascular disorders (stroke, hemorrhage, aneurysm, migraine headache) as to primary cause and effect, including how excitotoxic mechanisms can lead to neuronal death following stroke or injury.

D. Cerebrospinal Fluid, Blood Brain Barriers

NEU 32. Diagram the adult ventricular system and relate it to its embryological development.

NEU 33. Identify on a diagram the meninges and subarachnoid spaces; differentiate a subarachnoid from an epidural hemorrhage by location, symptoms, and CT scan.

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- NEU 34. Describe formation and reabsorption of cerebral spinal fluid (CSF), including the anatomy and function of the choroid plexus.
- NEU 35. Contrast the barrier mechanisms between the blood brain barrier and the blood CSF barrier and the consequences of barrier break down.
- NEU 36. Describe the impact of the blood brain barrier for the CNS distribution of intravenously administered hydrophilic and hydrophobic drugs.
- NEU 37. Locate and describe the function of circumventricular organs.
- NEU 38. Describe the normal pressure, flow, volume (ventricular vs. cisternal), and composition of the CSF.
- NEU 39. Contrast the difference between a communicating and a non-communicating hydrocephalus.
- NEU 40. Describe how CSF composition can vary in certain pathological conditions.
- NEU 41. Describe the consequences of sampling CSF from the lumbar cistern when the CSF pressure is above normal.

Sensory Processes

A. Somatosensory

- NEU 42. Describe the cutaneous and proprioceptive mechanoreceptors and their function: Pacinian corpuscles, Meissner's corpuscles, Ruffini endings, Merkel cell, A-delta and C free nerve endings, Golgi tendon organ, muscle spindle.
- NEU 43. Describe the submodalities of somatic sensibility subserved by the Dorsal Column-Medial Lemniscus system and by the spino-thalamic system, respectively.
- NEU 44. Define the terms receptor sensitivity, receptor specificity, and receptive field. Correlate these definitions with the types of receptors transmitting information to the Dorsal Column-Medial Lemniscus system and to the spino-thalamic system, respectively.
- NEU 45. Contrast the proprioceptive pathways to the cerebellum with those to the cerebral cortex.
- NEU 46. List the receptors and afferent nerve fibers that subserve vibration, discriminative touch, joint position sense, thermoreception and nociception.

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- NEU 47. Define rapidly and slowly adapting sensory reception and correlate these with the types of sensory receptors serving the Dorsal Column-Medial Lemniscus system and the spinothalamic system, respectively.
- NEU 48. Describe the steps in sensory transduction and action potential generation at a mechanoreceptor and at a nociceptor.
- NEU 49. Use the Weber-Fechner Law to determine the relationship between afferent neuronal firing frequency and perception of a stimulus.
- NEU 50. Define the concept of a dermatome and explain the dermatomal organization of the head and body.
- NEU 51. Trace the borders of the dermatomes.
- NEU 52. Define the concept of a somatosensory receptive field and explain how dermatomes and receptive fields are related.
- NEU 53. Explain how the peripheral innervation density is related to receptive field size.
- NEU 54. Define two-point discrimination and tell how it is related to peripheral innervation density and receptive field size.
- NEU 55. Explain how peripheral innervation density distorts the dermatomal organization (topographical pattern) of the postcentralgyrus.
- NEU 56. Discuss what is meant by the Fine Touch System and be able to trace its connections to the cerebral cortex.
- NEU 57. Discuss what is meant by the Pain/Temperature/Coarse Touch System and be able to trace its connections to the cerebral cortex.
- NEU 58. List the neural components of the Dorsal Column-Medial Lemniscus system and its Trigeminal analogs.
- NEU 59. Describe the functional properties of the Dorsal Column-Medial Lemniscus system.
- NEU 60. Describe how afferent surround inhibition improves spatial two-point discrimination.
- NEU 61. Describe the topographic representation of the body at the level of the dorsal column nuclei, the ventrobasal thalamus, and the somatic sensory cortex.
- NEU 62. Describe the factors that contribute to the high somatic sensory acuity of the hands and face.

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- NEU 63. Describe signs and symptoms of Dorsal Column-Medial Lemniscus system dysfunction.
- NEU 64. List the neural components of the spino-thalamic system and its trigeminal analogues.
- NEU 65. List functional properties of the spino-thalamic system.
- NEU 66. Differentiate between fast and slow pain and identify the peripheral nerve fibers and central connections that account for these different types of pain.
- NEU 67. Describe how endogenous opiates may modulate the pain experience.
- NEU 68. Describe the deficits caused by lesions in the spino-thalamic system.
- NEU 69. Describe the mechanism of referred pain of visceral origin.
- NEU 70. Describe the concept of dorsal horn mechanism of gating pain.

B. Visual System

- NEU 71. Describe the gross structure of the eye and basic physiological optics.
- NEU 72. 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 73. Describe the process of accommodation, contrasting the refraction of light by the lens in near vision and in far vision.
- NEU 74. Describe the refractive deficits that account for myopia, hyperopia, presbyopia, and astigmatism and their correction by eyeglasses and contact lenses.
- NEU 75. List the structure and cell types of the human retina.
- NEU 76. Describe the basic biochemistry of the photo-transduction process, the “dark current,” and the photoreceptor response to capturing a photon.
- NEU 77. Explain the chromatic and luminance properties of the different photoreceptor types.
- NEU 78. Understand the intrinsic circuitry of the retina and its functioning.
- NEU 79. Understand the connectivity and synaptic interactions of photoreceptors, horizontal cells, and bipolar cells in the construction of center-surround antagonistic receptive fields.

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NEU 80. Delineate the receptive field properties of photoreceptors, bipolar cells, and retinal ganglion cells and their neuronal responses to light.

NEU 81. Define antagonistic center-surround receptive fields.

NEU 82. Name the major retinal neurotransmitter for retinal throughput.

NEU 83. Describe how different post-synaptic receptors create depolarizing or hyperpolarizing responses and how they are organized to create different on-center and off-center responses and the antagonistic surrounds.

NEU 84. Describe the electrical responses produced by bipolar cells, horizontal cells, amacrine cells, and ganglion cells, and comment on the function of each.

NEU 85. Differentiate between scotopic and photopic vision.

NEU 86. Explain the differing light sensitivities of the fovea and optic disk.

NEU 87. Trace the projections of the visual hemifields onto the retina (nasal/temporal).

NEU 88. Diagram the central visual pathways.

NEU 89. Draw the retino-thalamo-cortical pathway.

NEU 90. Explain how the crossing of optic nerve fibers accounts for visual field representations at each stage.

NEU 91. Review the midbrain path of the accessory visual system for the pupillary light reflex.

NEU 92. Describe the structural and functional specializations of the lateral geniculate nucleus (LGN).

NEU 93. Recognize the receptive field properties of LGN neurons and primary visual cortex neurons.

NEU 94. Explain the general functional organization of V1.

NEU 95. Recognize how center-surround antagonistic receptive fields are combined to report complex parameters, such as orientation specificity and motion detection.

NEU 96. Differentiate between the general organization and functional specializations of the dorsal and ventral extrastriate visual streams.

NEU 97. Understand binocular disparity and its relationship to stereopsis.

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NEU 98. 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 99. Describe the processing of information in the visual cortex and the consequence of a lesion in the higher visual association areas.

NEU 100. Differentiate the retino-geniculo-cortical pathway from extrastriate visual projections systems.

NEU 101. Describe the functioning of the pupillary light reflex and its diagnostic value.

NEU 102. Sketch the major lesion deficits after key disruptions in the retino-geniculo-cortical pathway.

NEU 103. Predict the visual field deficits resulting from the following lesions in the visual pathway: retinal lesion, optic nerve lesion, optic chiasm, optic tract, LGN, optic radiations, and primary visual cortex.

NEU 104. Name the major lesion deficits and the most likely place of the lesion incident.

NEU 105. Name the most common syndromes after central lesions of visual processing areas.

NEU 106. Discuss and describe the syndrome of spatial hemineglect.

NEU 107. Identify one or two cognitive visual deficits.

NEU 108. Define the following terms: visual perimeter, visual acuity, optic disc, astigmatism, glaucoma, macular degeneration, myopia, hyperopia, achromatopsia, protanopia, deuteranopia, protanomaly, deuteranomaly, tritanopia, and tritanomaly.

NEU 109. Contrast the following vision tests: Snellen chart, Sloan letters, Landolt C, Amsler grid, Ishihara test, astigmatism wheel, and perimetry testing. Describe the aspect of the visual system for which each tests and explains how each test works to reveal dysfunction or pathology.

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C. Smell and Taste

- NEU 110. Describe the location, structure, and afferent pathways of taste receptors.
- NEU 111. Describe the location, structure, and afferent pathways of smell receptors.
- NEU 112. Describe the structure and functions of the first central relay station for olfactory information, its afferent input, and efferent output.
- NEU 113. Describe the structure and function of the central taste centers.
- NEU 114. Explain the term molecular receptive range.
- NEU 115. Explain the terms topography, spatial topography, and functional topography.
- NEU 116. Describe the olfactory cilium and the family of olfactory receptor genes housed in its membrane.
- NEU 117. Name the basic taste sensations, i.e., identify the five distinct gustatory modalities.
- NEU 118. Describe the cells of a taste bud.
- NEU 119. Explain how taste receptors are activated and explain the mechanism of taste transduction for each taste quality.
- NEU 120. Explain how olfactory receptors are activated and explain the mechanism of olfactory transduction.
- NEU 121. Name and discuss disorders of the chemical senses.
- NEU 122. Identify the three cranial nerves that transmit taste information to the cerebral cortex.
- NEU 123. Describe the structure and function of the central olfactory centers beyond the olfactory bulb.

D. Auditory System

- NEU 124. Describe the function of the outer, middle, and inner ear structures in the mechano-electrical transduction process of sound energy into nerve impulses.
- NEU 125. List the mechanical structures involved in sound detection.

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NEU 126. Describe the nerves and muscles in and around the middle ear and pathologies involving them.

NEU 127. Draw the human audibility curve and explain the changes that occur with aging.

NEU 128. Explain the frequency analysis performed by the cochlea on the basis of its physical properties.

NEU 129. Identify the neuronal elements of the organ of Corti.

NEU 130. Explain how deformations of the basilar membrane are converted into action potentials in auditory nerve fibers.

NEU 131. Diagram the auditory pathways including all central connections.

NEU 132. Describe how pitch, loudness, and localization of sounds in space are coded by central auditory neurons.

NEU 133. Distinguish conductive, central, and sensorineural deafness, and list the tests used to assess them.

NEU 134. Describe the development of the inner ear and list the major embryonic malformations.

NEU 135. List the function of some hearing aids/prostheses.

NEU 136. Define the following terms: conduction deafness, neural deafness, tinnitus, and presbycusis.

NEU 137. Describe the following hearing tests and explain how they contribute to the diagnosis of hearing disorders: audiometry, Weber test, Rinne test, and auditory brainstem response testing.

E. Vestibular System

NEU 138. Describe the three-dimensional structure of the membranous labyrinth.

NEU 139. Identify the components of the labyrinth innervated by the eighth cranial nerve.

NEU 140. Differentiate semicircular canals and otoliths.

NEU 141. List the mechanical structures involved in movement detection and relate their function to the components of the labyrinth.

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- NEU 142. Explain the biophysics and receptor mechanism of the labyrinthine hair cells.
- NEU 143. List the neuronal pathways coming from the labyrinth and the systems they address.
- NEU 144. List the most important vestibular and associated reflexes.
- NEU 145. Outline the steps of the optokinetic reflex.
- NEU 146. Explain how optokinetic and vestibular nystagmus interact.
- NEU 147. Identify the causes of the major vestibular syndromes.
- NEU 148. Discuss the embryology of the labyrinth and some of the genes necessary for its development.
- NEU 149. Describe the structure, normal stimulus, transduction at the receptor level, and function of the otolith organs.
- NEU 150. Describe the structure, normal stimulus, transduction at the receptor level, and function of the semicircular canals.
- NEU 151. Describe the central connections of the vestibular nerve (the targets of the primary nerve fibers and the targets of the second-order neurons) and relate these to the three or four major functions of the vestibular apparatus.
- NEU 152. List and describe caloric and rotational tests of vestibular function.
- NEU 153. Describe the neural mechanisms of vestibular nystagmus, caloric testing, and the direction of nystagmus to the direction of rotation or which ear (left or right) was irrigated with cold or warm water and the effect of consciousness.
- NEU 154. Describe the following tests of the vestibular system and explain how they are used in diagnosis: posturography, electronystagmography, rotary chair test, Dix-Hallpike test, Halmagyi head jerk, Fukuda stepping test, and caloric reflex test.
- NEU 155. List and describe clinical signs of vestibular system dysfunction.
- NEU 156. Define the following terms: otolith, endolymph, vertigo, linear acceleration, angular acceleration, frontal gaze center, pontine horizontal gaze center, inter-nuclear ophthalmoplegia, benign paroxysmal positional vertigo (BPPV), Ménière's disease, and labyrinthitis.
- NEU 157. List the extraocular muscles.

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NEU 158. Describe the approximate orientations and kinematic actions of the extraocular muscles.

NEU 159. Explain the spatial coordination of eye movements.

NEU 160. List the major types of eye movements.

NEU 161. Differentiate the key oculomotor deficits based on their symptoms.

NEU 162. Identify the major supranuclear brain centers involved in oculomotor control.

NEU 163. Name and delineate the major pathways underlying eye movement control.

NEU 164. Describe the different kinds of gaze (voluntary eye movements and reflex eye movements).

NEU 165. Define the following terms: vergence, divergence, saccade, optical nystagmus, vestibular nystagmus, strabismus, oculomotor apraxia, and oculomotor nerve palsy.

NEU 166. Describe the following tests of oculomotor function and explain how each reveals specific deficits in the oculomotor system: saccade test, ocular following test, smooth pursuit test, vergence/divergence test, optokinetic tests, electronystagmography, and vestibulo-ocular reflex test.

Effectors and Command Systems

A. Autonomic Nervous System

NEU 167. Define the sympathetic and parasympathetic systems.

NEU 168. Differentiate the components of the sympathetic and parasympathetic systems.

NEU 169. Contrast the functions of the sympathetic and parasympathetic systems.

NEU 170. Compare and contrast terms and concepts related to the sympathetic and parasympathetic systems, including: the central location of cell body of origin, number of synapses between CNS and effector organs, degree of myelination, and general effects on target tissues.

NEU 171. Define and contrast pre- and postganglionic autonomic neurons, and white and gray rami communicantes.

NEU 172. List the cranial and sacral nerves that produce parasympathetic outflow.

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- NEU 173. Describe the sensory input and roles for visceral afferent fibers of the ANS.
- NEU 174. Define the anatomical and functional relationships of the autonomic ganglia and plexus.
- NEU 175. Locate the main anatomical regions that make up the central ANS.
- NEU 176. Describe ways the ANS contributes to homeostasis.
- NEU 177. Describe the synaptic characteristics, receptors, and neurotransmitters for the parasympathetic and sympathetic division of the ANS.
- NEU 178. Describe the function of non-adrenergic, non-cholinergic fibers in the ANS.
- NEU 179. Explain the relatively diffuse action of the sympathetic division compared with the parasympathetic division.
- NEU 180. Describe the ANS signaling mechanism and the effects of sympathetic and parasympathetic stimulation of lungs, heart, arteries, and veins; gastrointestinal function; renal function; and sexual function.
- NEU 181. Describe signs and symptoms of ANS dysfunction that may accompany lesions that affect the ANS. Include Horner's Syndrome, medullary dysfunction, common visceral dysfunction, and multiple system atrophy (Shy-Drager syndrome).

B. Descending Control of Movements

- NEU 182. Define motor unit and how it relates to myotomes of the body.
- NEU 183. Describe the metabolic and physiological characteristics of the three main types of motor units.
- NEU 184. Explain how motor units are normally recruited to increase muscular force and what the functional advantages are of this recruitment order.
- NEU 185. Discuss the underlying physiological mechanisms in which muscular force can be increased by increasing the rate at which action potentials are transmitted to the muscle from the CNS.
- NEU 186. Describe excitation-contraction coupling in skeletal muscle.
- NEU 187. Explain the molecular mechanisms for force generation in skeletal and smooth muscles.

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NEU 188. Discuss the functions of skeletal muscle that pertain during climbing up a hill versus descending a hill and how the molecular mechanisms of contraction mediate these functions.

NEU 189. Discuss the influence of the elastic properties of tendons on motor performance.

NEU 190. Discuss the relationship between motion of the lower limb and electromyographic activity of lower limb muscles during the step cycle. Explain how the inertial properties of the limb segments result in an apparent dissociation between movement and muscular activity.

NEU 191. Describe the concept of central pattern generator and list the motor activities that are supported by these circuits.

NEU 192. Describe the enteric nervous system, its anatomy and function. Discuss what patterns of activity are supported by the enteric nervous system.

NEU 193. Describe the functional relationship between the enteric and immune systems.

NEU 194. Explain the rhythmic patterns of activity that arise from circuits in the hypothalamus.

NEU 195. Describe two hypothesized mechanisms for pattern generation in the CNS and internal organs.

NEU 196. Describe the somatotopic arrangement of motor neuron pools in the spinal cord.

NEU 197. Describe the functions of the medial and lateral motor pathways. Describe their origins and terminations within the spinal cord.

NEU 198. Describe the effects of lesions in the medial and lateral descending motor pathways.

Sensorimotor Integration and Internal Regulation

A. Spinal Cord - Brainstem Physiology

NEU 199. Understand the functional basis of lower motor neurons in the spinal cord and brainstem. Describe the locations of cell body, axon, and their neuromuscular junction.

NEU 200. Understand the functional basis of upper motor neurons in the cerebral cortex and their synaptic connections with interneurons and lower motor neurons in spinal cord and brainstem. Describe the locations of cell body, axon, and somatotopic organization.

NEU 201. Distinguish between postsynaptic inhibition and presynaptic inhibition between neurons and provide examples of each.

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NEU 202. Describe the anatomical location, function, and afferent neurotransmission of muscle spindle and Golgi tendon organs.

NEU 203. Trace the neuronal activity initiated by striking the patellar tendon with a percussion hammer (patellar tendon reflex) that leads to contraction of a muscle. Contrast this reflex with the inverse myotactic reflex.

NEU 204. Describe the role of the gamma efferent system in the stretch reflex and explain the significance of alpha-gamma co-activation. Contrast the actions of static and dynamic gamma motor neurons.

NEU 205. 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 206. Describe the clinical tests and findings that allow a physician to distinguish between upper and lower motor neuron disorders, including the Babinski sign, clonus, and clasp knife response.

NEU 207. Describe the anatomy and functions of the major ascending tracts (anterolateral and dorsal column-medial lemniscus systems) and descending spinal cord tract (cortico-spinal tract, CST), including crossing of midline.

NEU 208. Describe the use of dermatomes, sensory deficits, and motor deficits to identify spinal cord lesions, including spinal cord hemisection. Describe the immediate and long-term consequences of spinal cord versus spinal nerve transaction.

NEU 209. Describe the use of dermatomes, sensory deficits, and motor deficits to identify brainstem lesions, including lateral medullary infarction, base of pons infarction, and medial midbrain infarction. Describe the immediate and long-term consequences of cranial nerve (PNS) transaction versus brainstem (CNS) infarction.

NEU 210. Describe the function of the following brainstem reflexes: cardiovascular baroreceptor, respiratory stretch receptor, cough reflex, pupillary light reflex, gag reflex, and blink reflex.

NEU 211. For each brainstem reflex, list the stimulus and its receptor, the afferent pathway, the brainstem nuclei involved, the efferent pathway, and the resulting effect.

NEU 212. Describe the function and location of the brainstem reticular formation. Explain its role in pain perception and modulation, level of consciousness, integration of brainstem reflexes, and the location of noradrenergic, serotonergic, and dopaminergic nuclei.

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B. Diencephalon Function

NEU 213. Describe the hypothalamus in terms of body homeostasis and integration with the ANS.

NEU 214. Relate the functions of the supraoptic and paraventricular nuclei to water balance and thirst behavior and their response to circumventricular osmoreceptors.

NEU 215. Describe the control of body temperature, appetite, defecation, micturition, heart rate, arterial pressure, sexual reproductive activity, lactation, and growth.

NEU 216. Describe the impact of leptin on hypothalamic nuclei and its interaction with the sympathetic nervous system.

NEU 217. Locate the following hypothalamic nuclei and describe their main function(s): arcuate nucleus, posterior nuclei, anterior nuclei, pre-optic nucleus, paraventricular nucleus, supraoptic nucleus and suprachiasmatic nucleus, periventricular nuclei and lateral nuclei.

NEU 218. Describe the function of retinal melanopsin and destruction to the input to the supraoptic nucleus on sleep-wake cycle, drinking, and hormone secretion.

NEU 219. Identify the cortical areas that receive have reciprocal connections with the following thalamic nuclei: ventral lateral, dorsomedial, pulvinar, medial geniculate, lateral geniculate, ventral posterolateral, and posteromedial.

NEU 220. Describe the functions of the reticular and intralaminar thalamic nuclei on cortical arousal and consciousness.

NEU 221. Describe how the anterolateral system conducting afferent pain and temperature interacts with the thalamus.

NEU 222. Describe the appearance of coma and its progression to a vegetative state.

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Brain and Behavior

A. Cerebral Cortex

NEU 223. Describe the major areas of the cerebral cortex and their roles in perception and motor coordination. Identify the Brodmann areas for visual, auditory, somatosensory, motor, and speech areas.

NEU 224. Explain the function of somatotopic maps, where are they found in the CNS, and what they represent. Contrast them with tonotopic and retinotopic maps.

NEU 225. Describe kinesthesia and how is it mediated by the cerebral cortex.

NEU 226. Describe the major differences in human cerebrum in terms of the representational and categorical functions.

NEU 227. Describe the location of short-term (working) memory and long-term memory and the requirement of a functional medial temporal lobe and medial diencephalic structures and tracts for declarative memory function.

NEU 228. Describe the characteristics of Alzheimer's disease and contrast it with senile dementia.

NEU 229. Outline the common functional changes seen in the CNS with normal aging and associate them with gross, histological, or biochemical changes.

NEU 230. Describe the concept of motor memory and contrast how it differs from declarative memory function.

NEU 231. Describe the origin, course, termination, and consequences of damage to the corticospinal tract. Contrast the effects of pyramidal tract lesions to lesions of motor cortex.

NEU 232. Compare and contrast the consequences of infarction of the anterior, middle, and posterior cerebral arteries.

NEU 233. Draw a flow diagram for the brain regions involved in planning, initiating, and executing skilled voluntary movements.

NEU 234. Describe the clinical presentation of apraxia and what might account for it.

NEU 235. Describe the cortical areas important for language and the connections between them.

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NEU 236. Describe the cortical mechanisms involved during grasping a jar with one hand and unscrewing the cap with the other. Explain the kinds of control mechanisms important for each part of the task.

NEU 237. Compare and contrast the functions of the medial and dorsolateral prefrontal cortex.

NEU 238. Describe the classic lesions of the human cortex and the associated symptoms.

B. Cerebellum

NEU 239. List the three functional divisions of the cerebellum, detailing the input and output connections of each. Describe how these areas are integrated with the lateral and medial motor pathways.

NEU 240. Draw and label the circuitry of the cerebellar cortex and deep nuclei. Assign the functional role to each neuron type and give its synaptic action (excitatory or inhibitory).

NEU 241. Describe what is known about the role of the cerebellum in the regulation of skilled movement and in motor learning.

NEU 242. Predict the neurological disturbances that can result from disease or damage in different regions of the cerebellum.

NEU 243. Contrast the spinal proprioceptive pathways to the cerebellum with those to the cortex.

C. Basal Ganglia

NEU 244. List and describe the major interconnections between components within the basal ganglia and between the basal ganglia and the cerebral cortex. Identify the associated neurotransmitters.

NEU 245. Describe the overall function of the basal ganglia in the initiation and control of movement.

NEU 246. List the appropriate signs of rigidity, dyskinesia, akinesia, and tremor for Parkinson's disease, Huntington's chorea, hemiballismus, athetosis and dystonia. Assign a likely lesion site or chemical system defect for each clinical syndrome.

NEU 247. Describe the rationale for treatment of Parkinson's disease with L-DOPA, pallidectomy, and deep brain stimulation.

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NEU 248. Describe the mesolimbic dopaminergic control in the reward behavior pathway and the consequences of addiction.

D. Limbic System

NEU 249. Describe the main functions of the limbic system (LS) and associate them with one or more major anatomical structures of the LS.

NEU 250. Relate how the amygdala interacts with the cerebral cortex to produce cognitive emotional behaviors.

NEU 251. Describe the role of the olfactory system in LS.

NEU 252. Relate the interactive nature of the LS and the ANS and how changes in body homeostasis change with changes in emotion.

NEU 252. Predict how lesions of various components of the LS would cause specific symptoms in humans.

E. Sleep

NEU 253. Describe the three states of human brain activity based on EEG, EOG and EMG records.

NEU 254. Distinguish characteristics and parasomnias common only to non-rapid eye movement sleep (NREM).

NEU 255. Distinguish characteristics and parasomnias common only to rapid eye movement sleep (REM).

NEU 256. Outline the current understanding of regulatory mechanisms in the brainstem and diencephalon regulating the appearance of NREM, REM and wake states. Include the neurotransmitters and the mechanism of the ultradian rhythm underlying the sleep-wake cycle.

NEU 256. Describe the symptoms of narcolepsy, sleep apnea, disorders of initiating and maintaining sleep, and REM sleep behavior disorder.

NEU 257. Describe how respiration, cardiovascular, renal, gastrointestinal, eye movement, muscle, and endocrine function change from wake to NREM and REM states.

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F. Seizure Activity

NEU 258. Describe possible underlying causes or damage to the brain that might cause disordered cortical neuronal electrical activity known as a seizure and distinguish a seizure from epilepsy.

NEU 259. Recognize the difference between a generalized onset and a local-focal onset seizure based on EEG.

NEU 260. Explain the possible role of the intralaminar and midline thalamic nuclei on the appearance of disordered electrical activity in both cerebral hemispheres almost simultaneously.

NEU 261. Distinguish the major characteristics of the major seizure disorders: Grand mal, Absence seizure (Petite mal), simple partial and complex partial seizures, and status epilepticus.

Physiological Assessment of the PNS and CNS

A. Nerve Conduction/EMG Studies

NEU 262. Describe the procedure use for measuring nerve conduction velocity.

NEU 263. Describe the repetitive nerve stimulation procedure for assessing the integrity of the neuromuscular junction.

NEU 264. Compare the different EMG findings in neuropathy and myopathy.

NEU 265. Describe the physiological deficit and the consequence for patients with myasthenia gravis.

B. Electroencephalogram

NEU 266. Explain the electrophysiological basis and origin of the electroencephalogram (EEG).

NEU 267. Describe the common clinical EEG frequency bands and the behaviors associated with them.

NEU 268. Explain how the EEG is used to analyze and generate evoked potentials for clinical use.

NEU 269. Describe the physiological deficit and the consequence for patients with myasthenia gravis.

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C. Electrooculogram

NEU 270. Describe the procedure for measuring eye movement and velocity.

NEU 271. Describe the origin of the electrooculogram and its uses clinically.

D. Brain Imaging Techniques

NEU 272. Explain the difference between the brain/spinal cord computerized tomography (CT) and magnetic resonance image (MRI).

NEU 273. Contrast the use of CT versus MRI for identifying deep brain structures, acute brain hemorrhage, tumors, and edema.

NEU 274. Describe the manipulations of MRI to produce T1, T2, and FLAIR images and identify the approach best suited for comparing and identifying demyelination, edema near CSF, and gliosis.

NEU 275. Compare the use of FLAIR MRI with diffusion weighted imaging for detection of water diffusion within the brain.

NEU 276. Describe the use of magnetic resonance spectroscopy for measuring brain neurochemicals.

NEU 277. Understand the use of diffusion tensor imaging to identify major brain tract functionality (tractography).

E. Proteomics and Genomics

NEU 278. Describe the prominent brain protein abnormality associated with progressive dementia, Alzheimer's disease, and Parkinsonism.

NEU 279. Describe how genetic mutations have advanced basic understanding of brain function.

F. Gait Analysis

NEU 280. Define "kinematics" and describe the use of motion analysis to obtain kinematic measurements.

NEU 281. Explain what information can be obtained using a force plate. Discuss how this information can be combined with the results of motion analysis to understand the dynamics of locomotion.