Structure & Function of Nervous Tissue Small Groups

Pre-session Learning Objectives
(students should study these LOs prior to session)

1. **Nervous Tissue**
   
   **1.1. Electrophysiology of the Cellular Membrane (Reviewed from MCM)**
   
   1. Review the significance of the Na+/K+ ATPase for maintaining concentration gradients across the plasma membrane.
   
   2. Review the Nernst equation and the effects of altering either the intracellular or extracellular Na+, K+, Cl- or Ca2+ concentration on the equilibrium potential of that ion.
   
   3. Review the ionic basis of an action potential.
   
   4. Review how membrane capacitance affects the spread of current in myelinated and demyelinated neurons.
   
   5. Review how the axon diameter and myelination lead to differences in conduction velocity.

Potential Resources:
- Kutchai Independent Study Packet (from MCM)
- Ganong’s Review of Physiology Chapter 4. Excitable Tissue: Nerve
- APR Animations:
  - Action Potential Generation
  - Action Potential Propagation

1.1. **Structure & Function**

6. Distinguish neurons from glial cells in terms of their respective size, numbers, physiological functions, and ability to divide in the adult nervous system.

7. Describe the morphological features of a neuron that function in reception of electrical inputs, integration of inputs, propagation of the action potential and transmission of signals to a postsynaptic neuron.

8. Describe the structure and physiological significance of neuropil.

9. Describe the appearance of Golgi stained neurons.

10. Distinguish pseudounipolar, bipolar and multipolar neurons. Give examples of each.

11. Distinguish sensory neurons, motor neurons, interneurons and projection neurons both functionally and structurally.

* LOs indicated in *italics* represent content covered in a previous course.
12. Describe the histological appearance of myelin and its localization along different structural features of neurons. List the cell types that make myelin in the CNS and PNS.

13. **Need objectives on glial cells & glial cell function**

**Potential Resources:**
- Junqueira’s Basic Histology Chapter 9: Nerve Tissue & The Nervous System
- Ganong’s Review of Physiology Chapter 4. Excitable Tissue: Nerve

2. **Introduction to the Anatomy of the Nervous System and Peripheral Nerves**

2.1. **General Concepts**

14. Distinguish the central nervous system (CNS) from the peripheral nervous system (PNS).

15. Distinguish between the grey matter of the nervous system and the white matter of the nervous system in term of the distribution of neuronal somas, the distribution of myelin, the distribution of blood vessels, and the types of glial cells present.

16. Define and use in proper context the following terms: *tract*, *nucleus* (*pl: nuclei*), *nerve*, *ganglion* (*pl: ganglia*).

2.2. **Spinal Nerves**

17. Define a spinal cord segment. Draw representative cross-sections of the spinal cord at the cervical, thoracic, and lumbosacral levels.

18. Draw a typical spinal nerve and label the following features: central canal, ventral and dorsal horns, ventral and dorsal roots, dorsal root (spinal) ganglion, spinal nerve, ventral and dorsal primary rami.

19. Identify the locations of cell bodies of motor and sensory neurons in the spinal cord. Identify the types of neuron fibers located in the following elements of a spinal nerve: ventral root, dorsal root, ventral ramus, dorsal ramus.

2.3. **Peripheral Nerves**

20. Distinguish between the epineurium, perineurium and the endoneurium. Describe the histological components of the nerve-blood barrier.

**Need additional objectives**

**Potential Resources:**
- Junqueira’s Basic Histology Chapter 9: Nerve Tissue & The Nervous System
- Ganong’s Review of Physiology Chapter 4. Excitable Tissue: Nerve
- Blumenfeld – Neuroanatomy through Clinical Cases Chapter 2: Neuroanatomy Overview
- Lectures: Dwyer: “Anatomy, Development & Repair of Nerve Tissue”
- McCollum: “Introduction to the Nervous System”
- APR Animation: Typical Spinal Nerve
3. Neuromuscular junction (NMJ)

3.1. Structure & Function

21. List the major events that occur in transmission at a chemical synapse.

22. Draw the structure of the neuromuscular junction.

23. List the specific events that occur at the neuromuscular junction (motor endplate).

24. State that acetylcholine is released in discrete packets called "quanta", each quantum corresponding to one presynaptic vesicle.

25. Define the miniature endplate potential and state it is due to the spontaneous release of one quantum (vesicle) of acetylcholine.

26. State that at the post-synaptic membrane acetylcholine causes the membrane to become nearly equally permeable to Na⁺ and K⁺ so that the reversal potential of the endplate potential is close to the average of the equilibrium potentials for Na⁺ and K⁺. Given $E_{Na}$ and $E_{K}$, use the chord conductance equation to compute the reversal potential of the endplate potential.

27. State that transmitter action is terminated by ACh hydrolysis by acetylcholine-esterase that is located on the postsynaptic membrane. Explain how anti-cholinesterases enhance and prolong the endplate potential.

28. State that much of the choline liberated in the synaptic cleft is actively taken back up by the presynaptic terminal to be used in resynthesizing ACh. State that acetylcholine is synthesized from acetyl CoA and choline by the enzyme choline-O-acetyltransferase in the prejunctional nerve terminal.

Potential Resources:
  Kutchai Instructional Packet: “Transmission at the Neuromuscular Junction”
  Ganong’s Review of Physiology
  Chapter 6. Synaptic & Junctional Transmission
  Chapter 7: Neurotransmitters and Neuromodulators
  Blumenfeld – Neuroanatomy through Clinical Cases Chapter 8: Spinal Nerve Roots
  APR Animations
  Chemical Synapse
  Neuromuscular Junction

4. Nerve Conduction Studies

Need objectives

5. Review of Skin Histology

Need objectives
6. Sensory Receptors and the Transmission of Somatosensory Information

29. List the types of stimuli and receptors that mediate each of the following somatosensory modalities: touch, proprioception, temperature, and pain.

30. Describe the sequence of physiological events by which sensory transduction occurs, beginning with the activation of a receptor and ending with the generation of action potentials.

31. List the stimuli that activate each of the following receptor types and describe how ion channels are affected by their activation: mechanoreceptors, thermoreceptors, and nociceptors.

32. Distinguish between receptor potentials and action potentials in terms of the following: the distance the potential is carried throughout the neuron, and the electrogenic nature of the potential.

33. Describe the “labeled line” concept of sensory processing.

34. Explain how the nervous system distinguishes between strong and weak sensory stimuli. Distinguish between the physiological role of low threshold receptors and high threshold receptors. Distinguish between the rapidly adapting and slowly adapting receptors in terms of how they respond to stimuli.

35. Describe how receptor potentials are transduced into action potentials.

36. 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.

37. Define the term “receptive field”. Describe how the two-point discrimination test can be used to measure receptive field size.

38. List two physical characteristics of axons that determine the conduction velocity of action potentials.

39. Give examples of the type of sensory information conveyed by sensory fibers of each of the following types: Ia, Ib, II, Aβ, A(γ), C. Rank order these sensory fiber types in terms of conduction velocity.

40. Explain how a traumatic injury to a nerve might impair only a single sensory modality even if axons conveying several sensory modalities are present in the injured nerve.

41. List two types of thermoreceptors. List three types of nociceptors. Explain why the brain perceives pain when nociceptors are stimulated.

42. List mechanical and chemical stimuli that activate nociceptors.

43. Explain why the organization of the somatosensory system is described as “somatotopic”.

Potential Resources:
Ganong’s Review of Physiology Chapter 8. Properties of Sensory Receptors
(Need additional resources, existing LOs not covered in any identified texts)
Suggested Nerve Session Activities:

- Session Pre-test – clicker or written MCQs to ensure adequate preparation for session
- Histology image correlations – exercises that reinforce structure/function relationships of nerve
- Pictionary-like activity or worksheet to reinforce spinal cord anatomy & “wiring” (e.g., anatomy of a spinal nerve) and nerve X-sections
- Interpret/predict results of nerve conduction studies for given scenarios/sensory modalities, e.g., predict speed of transmission based on axon diameter and myelination/non-myelination
- Interpret/predict results of nerve biopsy for given scenarios
- Image correlations to review skin histology and locate sensory receptors
- Two-point discrimination tests on students
- Interpret basis of different patterns of sensory loss
- Cases to highlight Nerve conduction/NMJ:
  - Local anesthesia
  - Botulism and snake bites/botox uses
  - MG and Lambert-Eaton
  - Diabetic/alcoholic neuropathy
  - Compression neuropathy

Post-Session Learning Objectives
(Having completed the session, students should now complete the following additional LOs)

1. Neuropathy

44. Describe the histological components of peripheral nerves and their capacity for regeneration in response to injury.

45. Define neurapraxia, axonotmesis and neurotmesis.

46. Define segmental demyelination and describe the process of remyelination. Discuss the significance of the onion bulb formation.

47. Describe the typical reaction of peripheral nerve axons to a focal lesion. Define Wallerian degeneration.

48. Describe the effects of focal demyelination on nerve conduction and its appearance in EMG.

49. Describe the roles of growth cones, myelin sheaths and axonal transport in the regeneration of degenerated peripheral nerve axons.

50. Identify the recovery time involved in acute compressive neuropathies such as Saturday night palsy or crutch palsy of the radial nerve.

Potential Resources:
Lecture: Dwyer: “Development & Repair of Nerve Tissue and Nerves”
Robin’s Basic Pathology Chapter 23: The Nervous System
2. Toxins Affecting Synaptic Transmission at the NMJ

2.1. *Clostridia botulinum* & Botulinum Toxin

51. **Need Mirco objectives appropriate for MSI system**

52. Discuss the mechanism of action and clinical applications of botulinum toxin. Describe possible side effects associated with the use of this drug.

*Need additional objectives on the following substances: Curare, guanidinium neurotoxins, conotoxins*

**Potential Resources:**
- Harrison’s Online
  - Chapter 134: Botulism
  - Chapter 391: Disorders caused by Reptile Bites and Marine Animal Exposures

3. Disorders of Neuromuscular Transmission

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

54. Distinguish the two forms of myasthenia gravis. Indicate why myasthenia gravis is considered to be the prototypical autoimmune disorder.

55. **Need objectives pertaining to role of thymectomy in Myasthenia gravis.**

56. **Need objectives pertaining to implications of thymoma for myasthenia gravis.**

57. Describe the physiological basis of Lambert-Eaton syndrome and botulism.

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

59. Discuss myasthenia gravis and Lambert-Eaton syndrome in terms of epidemiology, etiology and pathogenesis, morphology and clinical course.

**Potential Resources:**
- Robin’s Basic Pathology Chapter 21: The Musculoskeletal System
- Blumenfeld’s Neuroanatomy through Clinical Cases Chapter 8: Spinal Nerve Roots
- Harrison’s Online Chapter 381: MG and other Diseases of the NMJ

3.1. Treatment of Diseases of Neuromuscular Transmission
3.1. Acetylcholinesterase Inhibitors (Neostigmine, Pyridostigmine, Edrophonium)

60. List the steps in synthesis, storage, release and inactivation of acetylcholine.

61. Compare the two major acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE) with respect to anatomical location, sites of synthesis, and function.

62. Relate the onset of action of acetylcholinesterase inhibitors, routes of administration, and the duration of action of acetylcholinesterase inhibitors to their clinical applications. Pay particular attention to their use in the treatment and/or diagnosis of myasthenia gravis.

63. Explain why acetylcholinesterase inhibitors are reversible or irreversible, and indicate which acetylcholinesterase inhibitors are in each category.

64. List therapeutic uses for and adverse side effects of acetylcholinesterase inhibitors, paying particular attention to their use in myasthenia gravis. Explain the importance of drug half-life in the treatment and diagnosis of myasthenia gravis.

Potential Resources:

4. Local Anesthetics (Amides: lidocaine, bupivacaine, mepivacaine, ropivacaine; Esters: tetracaine, 2-chloroprocaine, procaine)

65. Describe the mechanism by which local anesthetics produce their effects on neuronal tissue.

66. Describe the nomenclature by which local anesthetics are classified & be able to categorize different local anesthetics.

67. Explain how the duration of local anesthesia can be prolonged by coadministration of a local anesthetic with epinephrine.

68. Describe the CNS and cardiovascular side effects that can be expected when a local anesthetic is inadvertently injected.

Potential Resources:

Additional Week 1 Independent Study

1. Development of the Spinal Cord, Spinal Column & Meninges

69. Discuss the significance of the neuroepithelium in the development of the central nervous system.

70. Distinguish the basal and alar plates of the neural tube and relate these embryonic structures to features of the adult spinal cord.
71. Compare the transverse levels of the medullary cone (conus medullaris) in newborns and adults.

72. Distinguish the embryonic tissue sources of the annulus fibrosis and the nucleus pulposis of an intervertebral disc. Define chordoma.

73. Discuss meningomyelocele, meningocele, and spina bifida occulta in terms of relative frequency, gestational age of occurrence, etiology, pathogenesis, morphology and clinical features.

Potential Resources:
Lecture: McCollum “Development of the spinal cord and vertebral column”
Jorde et al. Medical Genetics pp. 233-234

Structure & Function of Muscle Tissue/Neuromuscular Function Small Groups

Pre-Session Learning Objectives:

1. Skeletal Muscle Structure & Function

74. Identify the diagnostic features of skeletal muscle and compare these with those of smooth and cardiac muscle.

75. Identify the intracellular locations where contractile filaments are attached to the plasma membranes of muscle cells.

76. Compare and contrast red and white skeletal muscle fibers.

77. Describe the relationship between muscle fibers, stroma and tendons.

78. Draw and label a skeletal muscle at all anatomical levels, from the whole muscle to the molecular components of the sarcomere. At the sarcomere level, include at two different stages of myofilament overlap.

79. Draw a myosin molecule and label the subunits (heavy chains, light chains) and describe the function of the subunits.

80. Diagram the structure of the thick and thin myofilaments and label the constituent proteins.

81. Describe the relationship of the myosin-thick filament bare zone to the shape of the active length:force relationship.

82. Diagram the chemical and mechanical steps in the cross-bridge cycle, and explain how the cross-bridge cycle results in shortening of the muscle.

83. List the steps in excitation-contraction coupling in skeletal muscle, and describe the roles of the sarcolemma, transverse tubules, sarcoplasmic reticulum, thin filaments, and calcium ions.

84. Describe the roles of ATP in skeletal muscle contraction and relaxation.
85. List in sequence the steps involved in neuromuscular transmission in skeletal muscle and point out the location of each step on a diagram of the neuromuscular junction.

86. Distinguish between an endplate potential and an action potential in skeletal muscle.

87. List the possible sites for blocking neuromuscular transmission in skeletal muscle and provide an example of an agent that could cause blockage at each site.

Potential Resources:
Junqueira’s Basic Histology Chapter 10: Muscle Tissue
Ganong’s Review of Physiology Chapter 5. Excitable Tissue: Muscle
APR Animations:
Skeletal Muscle
Sliding Filament
Excitation-Contraction Coupling
Cross-bridge cycle

2. Skeletal Muscle Metabolism (Reviewed from MCM)

88. Review the response of all of the metabolic pathways below to energy demand (ATP, ADP, and AMP levels), oxygen availability (indicated by NADH, NAD⁺), Ca²⁺, feedback regulation, and allosteric regulation. Recall important coenzymes and cofactors in these pathways: glycolysis, glycogenolysis, TCA cycle, oxidative phosphorylation, oxidation of fatty acids and ketones.

89. Review creatine synthesis in the body and its activation by creatine (phospho)kinase in muscle.

90. Review the sources of glucose used by muscle during exercise and how this relates to the enzyme defects underlying glycogen storage diseases that affect skeletal muscle function.

91. Review the fuel metabolism of resting muscles in the fed and starved state. Compare this with the fuel metabolism of muscles at different intensities and durations of exercise.

92. Review how fuel utilization changes during exercise with changes in hormone release.

93. Review the regulation of glycogenolysis, glycolysis, TCA cycle and fatty acid oxidation, including the regulation of pathway enzymes and carnitine-mediated transport of fatty acids into mitochondria.

94. Review the role of the Cori cycle during anaerobic muscle metabolism.

95. Review branched-chain amino acid metabolism and identify the coenzyme-requiring steps and the anaplerotic roles of the metabolites in the TCA cycle.

96. Review the role of the glucose/alanine cycle in providing fuel for muscle and elimination of nitrogen.

97. Review the production of glutamine from other amino acids and the physiological purpose of glutamine export from muscle to the liver and kidney.

Potential Resources:
3. Musculoskeletal Function

98. Discuss the functional consequences of the parallel and series arrangement of myofibrils in a skeletal muscle.

99. Describe how the arrangement of a skeletal muscle to the skeleton can influence mechanical performance of the muscle.

100. Define a motor unit and describe the order of recruitment of motor units during skeletal muscle contraction of varying strengths. Relate motor units to the normal checkerboard appearance of muscles in cross section.

101. Describe the relationship between muscle force production and the frequency of action potential generation.

102. Understand the coordination of synergists and antagonists on the skeletal framework.

Potential Resources:

4. Joints

Need objectives on different types of joints and their features.

103. Distinguish the following features of a synovial joint: capsule, synovial membrane, articular cartilage, fibrocartilage.

104. Distinguish intrinsic vs. extrinsic accessory ligaments of synovial joints.

105. Describe the innervation of joints and the muscles that act upon them.

106. Compare the vascularity and healing potential of the different tissues that form synovial joints.

107. Define bursae and describe their function. Define bursitis.

108. Describe what is meant by joint “stability” and relate this concept to a joint’s mobility and susceptibility to injury. Distinguish passive from dynamic stabilization of joint.

109. Be able to distinguish synovial fluid, fat, bone, cartilage, ligaments and muscles in T1- and T2-weighted MR images.

Potential Resources:

Junqueira’s Basic Histology Chapter 8: Bone
APR Animation: Synovial Joint
Radiology 101:
   Chapter 1: Basic Principles
   Chapter 5: Musculoskeletal System
UVa Online Resource
Lecture: Barr: “Imaging of Bone and Joints”
5. Spinal Reflexes

110. Identify the location of alpha motor neurons in the spinal cord and describe the distribution (somatotopic organization) of alpha motor neurons supplying axial and limb skeletal muscles.

111. Compare the motor neuron pools supplying axial and limb muscles with respect to the following characteristics: interconnectivity across spinal cord segments; contralateral spinal cord projections.

112. Compare the functions of excitatory and inhibitory interneurons in the spinal cord.

113. Define proprioception and list the mechanoreceptors involved in this sensation. Distinguish the types of information conveyed by these mechanoreceptors. Distinguish intrafusal and extrafusal muscle fibers and identify the type of motor neuron that innervates each.

Potential Resources:
Ganong’s Review of Physiology Chapter 9. Reflexes
(Need Additional Resources; existing LOs not covered)

Suggested Muscle Session Activities:

- Session Pre-test – clicker or written MCQs to ensure adequate preparation for session
- Histology image correlations – exercises that reinforce structure/function relationships of muscle
- Pictionary-like activity or worksheet to reinforce sarcomere structure, muscle fibers and muscle X-sections
- Interpret/predict EMG readings for given scenarios
- Interpret/predict muscle biopsies for given scenarios
- Interpret/predict serum kinase levels for given scenarios
- Exercises demonstrating different types of muscle contractions and different muscle functions (lever analogy & joints?)
- Perform and map spinal reflexes
- Localize spinal cord lesions
- Cases to highlight muscle contraction/musculoskeletal function:
  - Polio
  - Muscular dystrophy
  - Mitochondrial myopathy
  - Dermatomyositis
Post-Session Learning Objectives:

1. Mechanics and Energetics of Skeletal Muscle Contraction

114. Explain the relationship of preload, afterload and total load in the time course of an isotonic contraction.

115. Distinguish between an isometric and isotonic contraction.

116. Distinguish between a twitch and a tetanus in skeletal muscle and explain why a twitch is smaller in amplitude than a tetanus.

117. Draw the length versus force diagram for muscle and label the three lines that represent passive (resting), active, and total force. Describe the molecular origin of these forces.

118. Explain the interaction of the length:force and the force:velocity relationships.

119. Draw force versus velocity relationships for two skeletal muscles of equal maximum force generating capacity but of different maximum velocities of shortening.

120. Using a diagram, relate the power output of skeletal muscle to its force versus velocity relationship.

121. Describe the influence of skeletal muscle tendons on contractile function.

Potential Resources:

2. Spinal Reflexes

122. Draw and label the components and signals (inhibitory/excitatory) involved in the stretch reflex (include agonist and antagonist muscles).

123. Relate the stretch reflex to muscle tone and the maintenance of posture.

124. Identify the spinal cord segments tested by the following muscle reflexes: biceps, triceps, brachioradialis, patellar tendon, Achilles (calcaneal) tendon.

125. Define each of the clinical terms: hyperreflexia, hyporeflexia, aplexia, atonia.

126. Draw and label the components and signals (inhibitory/excitatory) involved in the golgi tendon reflex.

127. Draw and label the elements of the gamma loop. Describe the role of the gamma efferent system in the stretch reflex and explain the significance of alpha-gamma co-activation.

128. Draw and label the components and signals (inhibitory/excitatory) involved in the flexor withdrawal/crossed-extensor reflex.

Potential Resources:
Ganong’s Review of Physiology Chapter 9. Reflexes
APR Animation: Reflex Arc
3. **Clinical Presentation & Evaluation of Neuropathic and Myopathic & Neuropathic Disorders**

129. Discuss the utility of clinical evaluation, EMG, serum creatine kinase (CK) levels, nerve biopsy and muscle biopsy in the diagnosis of neurogenic and myopathic disorders.

130. Distinguish fibrillations from fasciculations.

131. Describe the changes that occur within skeletal muscle cells as a consequence of denervation. Compare denervation atrophy with disuse atrophy.

132. Define fiber type grouping as it applies to the reinnervation of skeletal muscle cells.

**Potential Resources:**
- Blumenfeld’s Neuroanatomy through Clinical Cases Chapter 9: Major Nerve Plexuses and Peripheral Nerves
- Robbin’s Basic Pathology
  - Chapter 21: Musculoskeletal System
  - Chapter 23: Nervous System
- Harrison’s Online Chapter e31: Electrodiagnostic Studies of the Nervous System

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**TBL Session I**

**Pre-Session Learning Objectives:**

*Exercise, Exercise Physiology & Nutrition Application*

(Zhen Yan, Art Weltman, Robin Shroyer, Selina Noramly, Howard Kutchai)

1. **Bioenergetics & Advanced Skeletal Muscle Metabolism**

133. Review *(from MCM)* the concepts of cellular energy transformation (bioenergetics).

134. Calculate the daily energy expenditure (DEE) based on physical activity and estimated basal metabolic rate (BMR).

135. Relate the concept of Gibbs free energy ($\Delta G$) to the potential for ATP to provide energy for mechanical and transport work in muscles cells and the generation of ATP from metabolic processes under anaerobic and oxidative conditions.

136. List the energy sources of muscle contraction and rank the sources with respect to their relative speed and capacity to supply ATP for contraction.

137. Construct a table of structural, enzymatic, and functional features of fast-glycolytic and slow-oxidative fiber types from skeletal muscle.
138. Describe the role of the myosin crossbridges acting in parallel to determine active force and the rate of crossbridge recycling to determine muscle speed of shortening and rate of ATP utilization during contraction.

139. Understand how ATP production is matched to ATP consumption in fast and slow skeletal muscle cells.

140. Relate the fuel utilization and function of the different muscle fiber types to their content of mitochondrial, myoglobin, glycogen, and glycolytic enzymes.

141. Apply the principles of bioenergetics to explain how creatine phosphate is used for energy storage and ATP production.

142. Describe the biological activation of creatine phosphate and indicate why it is a better energy reservoir than ATP.

143. Describe the differences in metabolic regulation between skeletal muscle and liver, including specific tissue responses and hormonal responses.

144. Describe the relationship between aerobic exercise and insulin requirements. Identify its underlying basis.

145. Discuss how skeletal muscle is more “equipped” for branched-chain amino acid metabolism than is the liver.

146. Discuss the metabolism of aspartate by the purine nucleotide cycle and the importance of this cycle in exercising muscle.

2. Exercise & Muscle Adaptation

147. Discuss how fuel utilization changes during exercise with changes in blood flow.

148. Define muscular fatigue and muscle cramps. List some intracellular factors that can cause fatigue.

149. Understand developmental changes in skeletal muscle cells and how these are subsequently modified through activity and training.

150. Explain how anaerobic threshold, muscle fatigue, gender and age can alter exercise performance.

3. Exercise Physiology

Need objectives

4. Nutrition & Fitness Training

Need objectives

Potential Resources:
Intro to the ANS/Thermoregulation Application
(Karen Fairchild, Melanie McCollum, Jim Garrison)

1. Smooth and Cardiac Muscle

151. Describe the cellular junctions present in smooth and cardiac muscle, but that are lacking in skeletal muscle.

Need additional objectives

Potential Resources:
Junqueira’s Basic Histology Chapter 10: Muscle Tissue
Ganong’s Review of Physiology Chapter 5. Excitable Tissue: Muscle

2. Introduction to the Autonomic Nervous System

2.1. General Concepts

152. Distinguish the tissues innervated by the somatic nervous system (i.e., somatic neurons) from those innervated by the autonomic (visceral) nervous system (i.e., visceral neurons).

153. Identify the three divisions of the autonomic nervous system and compare their functions and general distribution.

154. Compare the somatic and autonomic systems with respect to the number of motor neurons required to innervate effector organs. Distinguish the preganglionic nerve/fiber from the postganglionic nerve/fiber in terms of location of the neuronal cell body and myelination of axons.

155. Compare and contrast the sympathetic and parasympathetic subdivisions of the ANS in terms of the locations of preganglionic and postganglionic neuron cell bodies. Distinguish paravertebral (chain), prevertebral (pre-aortic) and terminal ganglia.

156. Compare and contrast sympathetic and parasympathetic preganglionic and postganglionic neurons with respect to the neurotransmitters they release and the receptors targeted.

2.2. Autonomic Innervation of Body Wall Viscera

157. List the three types of body wall viscera innervated by the sympathetic system. Compare the innervation of sweat glands to that of blood vessels and arrector pili muscles.

158. Identify where, along a spinal nerve, the cell bodies of the postganglionic sympathetic neurons destined to innervate body wall viscera reside. Distinguish a paravertebral ganglion from a dorsal root ganglion anatomically and functionally.

159. Identify the spinal cord segments that contain preganglionic sympathetic neurons. Identify the region of the gray matter in which these cells reside. For a single spinal cord segment,
identify the route the fiber of a preganglionic sympathetic neuron takes to exit the spinal cord and reach its corresponding paravertebral ganglion.

160. Describe the formation of the sympathetic chain by the ascending and descending fibers of preganglionic sympathetic neurons. Identify the location of the sympathetic chain relative to the vertebral column.

Potential Resources:
Ganong’s Review of Physiology Chapter 17: The Autonomic Nervous System
Lecture: McCollum “Introduction to the Autonomic Nervous System – Innervation of Body Wall Viscera”

3. Thermoregulation & Control of Skin Function

3.1. Review of Skin Function (Reviewed from MCM)

Need objectives

3.2. Neuroendocrine Effects on the Skin and Cutaneous Circulation

161. Describe the neuroendocrine control mechanisms of eccrine sweat glands, apocrine sweat glands, sebaceous glands, and the cutaneous circulation

3.2. General Concepts of Thermoregulation

162. Diagram the thermal balance for the body, including heat production (metabolism, exercise, shivering) and heat loss (convection, conduction, radiation, and evaporation). Identify those mechanisms that shift from heat production to heat loss when environmental temperature exceeds body core temperature.

163. Define the thermoregulatory set point. Diagram the negative feedback control of body core temperature, including the role of the hypothalamic set point.

164. Contrast the stability of body core with that of skin temperature. Include the role of cutaneous blood flow and sweating on skin temperature.

165. Identify the mechanisms for maintaining thermal balance in the following environments: desert (120°F), snow skiing (10°F), falling through ice into a lake (water temp 37°F), and snorkeling in 80°F water.

166. Explain how the change in core temperature that accompanies exercise differs from the change in core temperature produced by influenza, which alters the thermoregulatory set point.

167. List and describe the physiological changes that occur as a result of acclimatization to heat and cold.

Potential Resources:
Ganong’s Review of Physiology
Chapter 10: Pain and Temperature
Chapter 18: Hypothalamic Regulation of Hormonal Functions
Harrison’s Online
Chapter 17: Fever and Hyperthermia
TBL Session 2

Pre-Session Learning Objectives:

Myopathy/Neuropathy Application
(Bart Nathan, Jim Mandell, Wendy Golden, Howard Kutchai, Mary Kate Worden)

1. Peripheral Neuropathies

168. Discuss Guillain-Barre Syndrome in terms of etiology, pathogenesis, morphology and primary clinical findings.

169. Discuss the following hereditary peripheral neuropathies in terms of etiology (including genetics, if applicable), pathogenesis, morphology and primary clinical findings: Hereditary Motor and Sensory Neuropathy (HMSN) Type I (Charcot-Marie-Tooth Disease), HMSN Type III (Dejerine-Sottas Disease), Refsum disease.

170. Discuss the following infectious peripheral neuropathies in terms of etiology (including genetics, if applicable), pathogenesis, morphology and primary clinical findings: leprosy, diphtheria, herpes zoster, AIDS-associated neuropathy.

171. Discuss the following acquired metabolic and traumatic peripheral neuropathies in terms of etiology (including genetics, if applicable), pathogenesis, morphology and primary clinical findings: diabetic neuropathy, carpal tunnel syndrome, plantar (Morton) neuroma.

2. Myopathies

2.1. Primary Myopathies

172. Discuss spinal muscular atrophy in terms of etiology, pathogenesis, morphology and clinical features.

173. Describe the structure and function of dystrophin and the role of its multiple genetic promoters.

174. Compare Duchenne, Becker, limb girdle and myotonic muscular dystrophies in terms of the following variables: mode of inheritance, age and sex of incidence, muscles primary involved, pathogenesis, morphologic features, clinical manifestations, prognosis.

175. Define floppy infant syndrome.
176. Discuss the following metabolic myopathies in terms of etiology, pathogenesis, morphology and clinical features: phosphorylase deficiency, acid maltase deficiency, and lipid storage myopathies.

177. Describe the genetic basis and clinical presentations of Myoclonic Epilepsy with Ragged Red Fibers (MERRF) and Mitochondrial Myopathy, Encephalopathy, Lactic Acidosis and Stroke (MELAS). Describe the etiology and clinical significance of “ragged red fibers”.

178. Distinguish chronic progressive external ophthalmoplegia (CPEO) from Kearns-Sayre syndrome (KSS).

179. Discuss the metabolic basis of the muscular symptoms and clinical findings associated with the following conditions or diseases. Where applicable consider how the enzyme, nutrient, or biological factor deficiencies lead to altered muscle function and exercise physiology:
   - glycogen storage diseases
   - myoadenylate deaminase deficiency
   - mitochondrial myopathies (MERRF, MELAS, recurrent myogloburias)
   - iron deficiency
   - carnitine deficiency
   - carnitine plamitoyl transferase II deficiency
   - branched-chain aminoacidurias.

2.2. Secondary Myopathies

180. Discuss the following inflammatory myopathies in terms of etiology, pathogenesis, clinical presentation, histopathologic findings and prognosis: dermatomyositis, polymyositis and inclusion body myositis.

181. Identify the clinical and pathological features of toxic myopathies.

182. Define diabetic amyotrophy and identify its etiology.

Potential Resources:
   - Blumenfeld’s Neuroanatomy through Clinical Cases Chapter 9: Major Nerve Plexuses and Peripheral Nerves
   - Robbin’s Basic Pathology
     - Chapter 21: Musculoskeletal System
     - Chapter 23: Nervous System
   - Jorde et al. Medical Genetics pp. 80-81; 92-96; 134;
   - Harrison’s Online
     - Chapter 23: Weakness and Paralysis
     - Chapter 382: Muscular Dystrophies
     - Chapter 379: Peripheral Neuropathy
     - Chapter 380: GBS and other Immune-mediated Neuropathies
     - Chapter 356: Glycogen Storage Diseases

Clinical Anatomy Application
(Bobby Chhabra, Mary Bryant, Michelle Barr, Jim Garrison, Chris Burns, Melanie McCollum)
1. Tendon & Ligaments

1.1. General Concepts

183. Distinguish regular and irregular dense connective tissues.

184. Identify the types of fibers present in tendons and describe their typical arrangement. Identify the function of tendons.

185. Characterize the attachment of tendons to cartilage, bone and muscle.

186. Discuss the turnover, repair, healing potential and graft of tendons.

187. Describe the different healing potential of a paratenon tendon and a mesotenon tendon.

Potential Resources:

1.2. Clinical Concepts

188. Need objectives on the effect of steroids and quinolones on tendons.

189. Quinolones contraindicated in the pediatric patient.

Potential Resources:

1.3. Agents Used to Treat Tendonitis and Bursitis

1.3.1. Nonsteroidal Anti-Inflammatory Agents (Introduced in MCM)

190. Review the biosynthesis, physiological and pharmacological effects of the eicosanoids, with emphasis on the role of prostaglandins and leukotrienes as mediators of inflammation.

191. Review the mechanism of action common to all nonsteroidal anti-inflammatory drugs (NSAIDs).

192. Review the adverse affects and drug interactions of the following nonsteroidal anti-inflammatory drugs (NSAIDS):
   - Salicylic acid derivatives
   - Indole and indene acetic acids
   - Heteroaryl acetic acids
   - Propionic acids
   - Oxicams

193. Review the therapeutic uses and adverse effects of the celecoxib.

194. Review (compare and contrast) the pharmacological properties of selective cyclooxygenase-2 inhibitors and non-selective cyclooxygenase inhibitors.

195. Review the pharmacodynamics, pharmacokinetics, therapeutic uses, and adverse effects of acetaminophen.
196. Review (compare and contrast) the pharmacological properties of acetaminophen with those of NSAIDs.

197. Need additional objectives specific to uses in the treatment of tendonitis and bursitis.

1.3.2. Glucocorticoids (betamethasone, hydrocortisone, cortisone, dexamethasone – introduced in MCM)

198. Review the chemistry and structure, pharmacokinetics and pharmacodynamic actions of glucocorticoids in relation to their use as anti-inflammatory agents.

199. Review the toxicities associated with the use of glucocorticoids.

Need additional objectives specific to uses in the treatment of tendonitis and bursitis.

Potential Resources:

2. Overuse Injuries and Soft-tissue Trauma

2.1. Muscle Healing & Rehabilitation

200. Define overuse injury and repetitive strain injury.

201. Describe the self-repair of muscle fibers following microtrauma.

202. Identify the physiological effects of excessive force on muscle fibers.

203. Identify indications for the use of heat and cold to treat musculoskeletal injuries.

204. Discuss the rationale of RICE (Rest, Ice, Compression and Elevation) in the treatment of acute musculoskeletal injuries.

205. Define ergonomics. Discuss the role of Physical and Occupational Therapy in preventing occupational injury.

Potential Resources:

2.2. Treatment of Musculoskeletal Over-Use Injuries

2.2.1. Muscle Relaxants: Direct-acting Cholinergic Agents (Curare, Nicotine, Succinylcholine, Tubocurarine, Cisatracurium, Rocuronium, Mivacararium)

206. Describe the physiology and pathophysiology of transmission at the neuromuscular junction as it relates to pharmacology.

207. Differentiate between depolarizing and competitive neuromuscular antagonists.

208. Compare and contrast depolarizing and competitive neuromuscular antagonists with respect to their use, limitations and adverse effects.
209. Explain the rationale for the combination use of antimuscarinic and anticholinesterase agents in reversal of neuromuscular blockade.

210. Explain why nicotine is not used clinically (except as a smoking deterrent), and its historical, social and toxicological significance.

Potential Resources:

Need additional objectives relating to deep hand infection (Staph aureus?)

Potential Resources: