

# FUNCTION OF THE HUMAN BODY

## LEARNING OBJECTIVES

### I. MEDICAL KNOWLEDGE

By the end of FHB, students will be able to do each of the following.

#### Cellular Physiology

1. Define the distribution of solutes between the intracellular and extracellular compartments.
2. Define passive, active and secondary active transport across the cell membrane.
3. Define the equation and the variables that determine the flux of an uncharged solute by simple diffusion, i.e. Fick's law of diffusion.
4. Define the role of membrane voltage, concentration gradient and membrane permeability in the movement of charged solutes across the cell membrane.
5. Define the concept of tonicity and osmotic pressure.
6. Define the Nernst equation and how it describes the electrochemical equilibrium of an ion.

#### Electrical Excitability and the Neuronal Action Potential

7. Describe the time and voltage characteristics of the neuronal action potential.
8. Define the role of membrane resistance and internal resistance in neuronal conduction.
9. Define the space (length) constant and its role in neuronal conduction.
10. Describe the ionic current mechanisms responsible for the neuronal action potential.
11. Describe the molecular characteristics of the Na<sup>+</sup> channel and its gating properties.
12. Define the absolute and relative refractory periods and their cellular mechanisms.
13. Explain how myelination affects neuronal conduction.
14. Explain the effects of changes in plasma [Ca<sup>2+</sup>] on neuronal membrane excitability.
15. Explain the effects of elevated plasma [K<sup>+</sup>] on the neuronal action potential and conduction.

#### Nervous System

16. Describe the key functional parts of a typical neuron (location and functional role).
17. Explain differences between electrical and chemical synapses.
18. Describe the steps in normal neuromuscular transmission.
19. Explain excitatory post-synaptic potentials (EPSPs) and inhibitory post-synaptic potentials (IPSPs).
20. Compare & contrast small molecule neurotransmitters and neuropeptides.
21. Explain how information is spatially and temporally *integrated* and *coded* in neurons.
22. Compare & contrast receptor (or generator) potentials and EPSPs.
23. Identify the 6 main components of the CNS.

#### Neurohistology

24. Distinguish the location and appearance of the major types of neurons and glia in the CNS and PNS
25. Identify the major structural features of a typical neuron
26. Identify the major structural features of a synapse
27. Understand the appearance and functional elements of CNS and PNS myelin
28. Understand the process of nerve repair in the CNS/PNS
29. Identify the connective tissue construction of the CNS/PNS

30. Identify the histology of the peripheral nerve
31. Identify the major structural features and cellular concepts of spinal cord/brain

### **Striated Muscle**

32. Describe the characteristics of cardiac, skeletal and smooth muscle and their similarities and differences.
33. Draw and label a skeletal muscle sarcomere (including identifying the key proteins).
34. Describe the steps in skeletal muscle excitation-contraction (E-C) coupling from activation at the neuromuscular junction to contraction and relaxation of muscle.
35. Diagram the chemical and mechanical steps in the crossbridge cycle and explain how the crossbridge cycle results in shortening of the muscle.
36. Draw the length-tension relationships for skeletal muscle and explain why the curves are that shape.
37. Draw the force-velocity curve for skeletal muscle and explain why it is that shape.
38. Describe the difference between isometric & isotonic muscle contraction.

### **Smooth Muscle**

39. Distinguish between the characteristics of the regulatory systems for striated (actin linked) and smooth muscle (myosin linked).
40. Diagram the cellular pathways involved in excitation-contraction coupling in smooth muscle and label the structures and biochemical substrates involved.
41. Contrast electro-mechanical and pharmaco-mechanical coupling.
42. Describe how tonic contractions in smooth muscle can be energy efficient.

### **Muscle Histology**

43. Identify histologic and ultrastructural detail of the three muscle types
44. Determine and identify the architectural makeup of the sarcomere
45. Understand the differences in the contractile machinery utilized by the three muscle types.

### **Cardiac Electrophysiology**

46. Define the sequence of electrical activation (conduction) in the heart.
47. Identify the action potential configuration of SA node, atrial, AV node and ventricular muscle cells in the heart.
48. Explain the role of gap junctions in normal and abnormal cardiac conduction.
49. Compare and contrast the structure-function relationships of SA node, AV node, atrial and ventricular muscle cells.
50. Define the relationship between extracellular  $[K^+]_o$  and the cardiac resting membrane potential.
51. Explain the ionic current mechanisms responsible for fast and slow response action potentials.
52. Define the P-R interval and QRS complex and how they can be used to evaluate cardiac conduction in different tissue of the heart.
53. Explain how gap junctions, space constant and action potential upstroke determine electrical conduction between cardiac cells.
54. Explain how parasympathetic (acetylcholine) and sympathetic (norepinephrine) nervous activity regulates conduction through AV nodal tissues in the heart.

55. Explain how autonomically-induced changes in conduction through the AV node are manifest on the EKG.
56. Explain the relationship between resting membrane potential and Na<sup>+</sup> channel availability, rate of rise of the action potential upstroke and conduction velocity.
57. Define the absolute and relative refractory periods in heart.
58. Explain the cellular mechanisms responsible for the absolute and relative refractory periods in the heart.
59. Compare and contrast the refractoriness of slow and fast response tissues.
60. Identify the ventricular muscle refractory periods on the EKG.
61. Describe the R on T phenomena and its potential pathophysiological significance.
62. Explain the effect of heart rate on action potential duration (interval-duration relationship) and how it affects the Q-T interval of the EKG.
63. Define pacemaker automaticity.
64. Explain the hierarchy of cardiac pacemaker activity throughout the heart.
65. Explain how changes in threshold potential, slope of diastolic depolarization and maximum diastolic potential can alter pacemaker activity, i.e. heart rate.
66. Define overdrive suppression and its functional effects on cardiac function.
67. Explain how parasympathetic and sympathetic nervous activity affects the slope of diastolic depolarization and/or maximum diastolic potential to alter heart rate.
68. Explain the cellular (ionic) mechanisms by which acetylcholine and norepinephrine affect changes in heart rate.
69. Explain how changes in pacemaker rate are manifest on the EKG.
70. Define cardiac arrhythmia (dysrhythmia).
71. Define altered automaticity, re-entry of excitation and triggered activity, and how each mechanism can cause cardiac dysrhythmias.
72. Describe the cellular mechanisms responsible for altered automaticity, re-entry of excitation and triggered activity.
73. Explain potential causes for altered automaticity, re-entry of excitation and triggered activity.
74. Compare and contrast early after-depolarizations (EADs) and late after-depolarizations (DADs) of triggered activity.
75. Identify common types of cardiac dysrhythmias on an EKG recording, including sinus tachycardia, sinus bradycardia, 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> degree heart block, atrial and ventricular fibrillation and ventricular tachycardia.
76. Define alternative anti-arrhythmic therapies including anti-arrhythmic drugs, cardiac ablation, cardioversion and implantable defibrillators.

### **Myocardial Excitation - Contraction Coupling**

77. Define the function of different cellular structures (structure-function relationship) involved in cardiac excitation-contraction (E-C) coupling.
78. Explain how the cellular mechanisms responsible for cardiac E-C coupling.
79. Define the structural and functional differences between cardiac and skeletal muscles.
80. Explain the cellular mechanisms underlying the inotropic effects of catecholamines, cardiac glycosides and Ca<sup>2+</sup> channel blocking agents.
81. Define how heart rate affects the force of contraction, i.e. force-frequency relationship.

82. Define the cellular mechanisms by which an increase in heart rate, decrease in heart rate, a premature beat and the beat following a premature beat affect cardiac contractility.

### **Cardiac Muscle Mechanics**

83. Define isometric and isotonic contraction.
84. Define resting and active tension development in the cardiac muscle.
85. Define preload, afterload, contractility and heart rate, and how each determines cardiac output.
86. Explain how changes in preload affect total isometric tension development and velocity of shortening of an isotonic contraction.
87. Explain how changes in afterload affects total isotonic tension development and velocity of shortening of cardiac muscle.
88. Explain how changes in contractility affect total isometric tension development, velocity of shortening of an isotonic contraction and rate of relaxation of cardiac muscle contraction.

### **The Cardiac Cycle**

89. Describe and draw the cardiac cycle (Wiggers diagram).
90. Identify the phases of the cardiac cycle as delineated by valve openings and closings.
91. List the normal values for the pressures (all chambers & vessels) and volumes (RV & LV) for the cardiac cycle and the appropriate units of measurement.
92. Explain the mechanisms responsible for the a, c, v waves of the venous pulse.
93. Explain the causes of the first, second, third and fourth heart sounds.

### **Cardiac Function**

94. Draw and explain a normal LV pressure-volume diagram, and the changes in stroke volume produced by changes in preload, afterload, and contractility.
95. Define the various factors that determine and affect preload, afterload and contractility.
96. Define myocardial hypertrophy and identify the potential causes.

### **Coupling of the Heart and the Peripheral Vasculature**

97. Define venous return and cardiac output.
98. Explain how venoconstriction or venodilation, venous capacitance, breathing, venous valves, cardiac relaxation, cardiac contraction, contraction of leg muscles, blood volume each determine venous return.
99. Describe the relationship between central venous pressure (CVP) and venous return.
100. Describe the relationship between cardiac function, CVP and venous return by drawing a normal venous return-cardiac output curve.
101. Describe how the normal relationship between cardiac output, CVP and venous return are altered changes in cardiac function, peripheral venous tone or blood volume.
102. Describe the circulatory and cardiac adjustments to hemorrhage.

### **Hemostasis and Blood Coagulation**

103. Describe the process of hemostasis as a multicomponent physiologic network.
104. Define the biochemical mechanism involved in the process of blood coagulation.
105. Define the intrinsic pathway of coagulation.
106. Define the extrinsic pathway of coagulation.

107. Define the process of fibrinolysis.
108. Know the mechanism of action of the anticoagulant drugs.
109. Know the mechanism of action of the thrombolytic drugs.

### **Histology of Blood Vessels (Vascular System)**

110. Identify the histological and ultrastructural appearance of the various types of blood vessels.
111. Compare and contrast the wall structures of arterial and venous systems.
112. Compare and contrast the different types of capillaries and describe their organ/tissue specific functions.
113. Compare and contrast lymphatic architecture with that of the venous system.

### **Hemodynamics**

115. Explain Poiseuille's law and how it relates to blood flow, pressure and resistance.
116. Define blood viscosity its role in normal circulatory function.
117. Define laminar and turbulent blood flow.
118. Define Reynold's number and its relationship to blood flow.
119. Explain how turbulent blood flow contributes to heart sounds, murmurs and endothelial cell damage.
120. Define Bernoulli's principle and its application to the circulatory system.
121. Define the Laplace relationship and its application to a dilated heart, pressure within capillaries and aneurysms.
122. Explain how a large wall thickness/lumen diameter ratio increases the regulation of vascular resistance.
123. Define the relationships between velocity of blood flow and vessel cross sectional area.
124. Explain series and parallel resistances in the circulatory system.

### **Blood – Histology**

125. State, in percentages and absolute numbers, how much each of the formed elements in peripheral blood contribute to both a differential count and a hematocrit measurement.
126. State the percentage of normal blood volume and composition of plasma.
127. Identify (at the light and ultrastructural level) the specific blood cells in a slide or photomicrograph of a blood smear and state their function(s). If a cell contains granules, know the specific contents of the granules.
128. State the role of spectrin in maintaining the biconcave disc shape of erythrocytes.
129. Understand the function of Erythrocyte Rouleaux formation in peripheral capillaries.
130. State how HbS differs from normal hemoglobin and understand the consequences of HbS to erythrocyte structure and function.
131. State the role of specific and azurophilic granules in the degradation of phagocytosed bacteria and viruses. Understand the role of NADPH oxidase.
132. State the clinical importance of the externum and internum of the “cat’s eye” granules in eosinophils.
133. State the similarities and differences between basophils and mast cells.
134. List three types of lymphocytes stating their functions and relative percentages in peripheral blood.
135. State the similarities and differences between monocytes and neutrophils
136. List the members of the innate and adaptive immune systems. State their function(s).

137. State the contents, size and function in clot formation of the granules found in platelets.

### **The Systemic Circulation**

138. Explain the pulse pressure profiles throughout the circulatory system.

139. Explain how elastin, smooth muscle and collagen function as structural components of the vascular wall.

140. Define compliance.

141. Explain how vessel wall compliance affects arterial and venous pressures.

142. Explain the windkessel (hydraulic filtering) properties of the aorta.

143. Define the pressure pulse.

144. Define mean arterial pressure and how to calculate it.

145. Define the main determinants of systolic and diastolic arterial pressures and how they are altered by changes in arterial compliance.

146. Explain how the autonomic nervous system regulates systolic and diastolic arterial pressures.

147. Explain the determinants of mean arterial pressure and how the autonomic nervous system regulates mean arterial pressure.

148. Explain the cardiovascular adjustments and the underlying mechanism that operate during exercise.

### **Microcirculation and Lymphatics**

149. Explain the basic structural arrangement of the microcirculation including precapillary resistors, metaarterioles, capillaries and postcapillary resistors.

150. Explain the characteristic of capillary blood flow in terms of precapillary sphincter control, vasomotion and Rouleaux formation.

151. Define and explain the determinants of transcapillary fluid (TCF) exchange, including interstitial and plasma hydrostatic and oncotic pressures.

152. Explain TCF exchange in different pathological conditions, i.e. hemorrhage, nephrosis, liver damage, portal hypertension, congestive heart failure.

153. Understand the importance of albumin in TCF exchange.

154. Define pre/post capillary resistance ratio and how it determines capillary hydrostatic pressure.

155. Explain the structure and function of the lymphatic system.

156. Define edema and the conditions that predispose edema.

### **Control of the Circulation**

157. Define basal arterial tone and resting sympathetic tone.

158. Define passive and active vasoconstriction and vasodilation.

159. Understand how alpha-1 and beta-2 adrenergic receptors mediate the regulation of arterial vascular tone.

160. Identify the anatomy of arterial baroreceptors.

161. Explain the arterial baroreceptor reflex.

162. Explain the anatomy and function of peripheral chemoreceptors.

163. Explain the renin-angiotensin-aldosterone mechanism of blood pressure regulation.

### **Local Regulatory Mechanisms**

164. Define the arterial resistance vessels.
165. Explain the cellular mechanisms responsible for contraction of vascular smooth muscle.
166. Explain the myogenic, metabolic, endothelial and mechanical mechanisms that regulate blood flow.
167. Define autoregulation of blood flow.
168. Compare/contrast autoregulation of blood flow to neural, metabolic and endothelial regulation of blood flow.
169. Define and explain active and reactive hyperemia.

### **Special Circulations**

170. Describe the general anatomy of the coronary circulation.
171. Describe how cardiac tissue pressure determines coronary blood flow.
172. Explain the effects of cardiac diastolic pressure on endocardial and epicardial coronary blood flow.
173. Describe the relative importance of neural and metabolic effects on the regulation of coronary blood flow.
174. Explain the factors that determine myocardial oxygen supply and demand, and how the balance of these factors relates to the development of ischemia.
175. Explain the concept of “coronary steal”.
176. Understand the metabolic, mechanical and neurohumoral mechanisms that regulate the skeletal muscle circulation.
177. Describe the anatomy and general characteristics of the cerebral circulation including the blood brain barrier.
178. Explain how autoregulation, tissue pressure (Monro-Kelli doctrine), metabolites, and neural activity affect cerebral blood flow.
179. Define the Cushing’s response and the underlying mechanisms.
180. Describe the general anatomy and pressures within the pulmonary circulation.
181. Describe the respiratory effects on pulmonary circulatory pressures.
182. Describe the hydrostatic (gravitational) and “waterfall” effects on pulmonary blood flow.
183. Explain the primary function of the cutaneous circulation.
184. Identify the characteristics of apical and non-apical skin in terms of blood flow and their specific anatomical and functional differences.
185. Describe the neural and thermal factors that regulate cutaneous blood flow.
186. Describe the general anatomical features of the splanchnic circulation including the hepatic portal system.
187. Describe the neural and local regulatory mechanisms governing splanchnic blood flow.

### **Pulmonary**

188. Describe the mechanical factors involved in ventilating the air spaces of the lung.
189. Defend why ventilation and perfusion must be matched with the lung for the most efficient transfer of gases between air and blood compartments.
190. Show how oxygen and carbon dioxide are transported by the blood for distribution to and from the tissue capillaries.
191. Draw a generalized schematic “wiring” diagram of the pulmonary control system complete with controller, effectors and sensors.

192. Describe how respiratory muscles cause air to move into and out of the lungs on a cyclic basis.
193. Draw a typical spirometer trace identifying the four primary lung volumes and four lung capacities.
194. Plot simultaneous pressure fluctuations in intrapleural and alveolar spaces as functions of time during eupnea and exercise breathing.
195. Draw pulmonary function spirograms expected from patients with low pulmonary compliance or high airway resistance.
196. Give the formulae for alveolar, dead space and total ventilations and the effect each has on carbon dioxide levels in the systemic arterial blood.
197. Define compliance and show how pulmonary versus chest wall compliances can vary in various respiratory diseases.
198. Explain the origination of surface tension forces at air/water interfaces in terms of the Law of LaPlace.
199. Show how pulmonary surfactants directly proportion lung surface tension forces to lung volume and how this helps maintain airway patency.
200. Explain the deceleration/acceleration of air in terms of three air flow profiles that occur during each inspiratory/expiratory half cycle.
201. List the four primary factors that affect the prevailing airway resistance centrally and peripherally.
202. Diagram how forced expirations cause flow limitations at lung volumes below FRC in exact accordance with a Starling resistor model.
203. Name the two major components contributing to the work of breathing and show how each is altered in different disease states.
204. What is your understanding of partial pressures, how do PO<sub>2</sub> and PCO<sub>2</sub> values vary from atmosphere, to trachea, to alveolar space, and what is the importance of the alveolar gas equation?
205. Give explicit physiological reasons why ventilation is not uniformly distributed throughout the normal vertical lung.
206. Show why pulmonary blood flow is not uniformly distributed throughout the normal vertical lung based on gravitational arguments and lung volume arguments.
207. What are the principle differences between alveolar flooding and pleural effusions and why is each dangerous for different reasons?
208. Describe the importance of ventilation/perfusion matching at the alveolar level in maintaining proper levels of systemic arterial blood gases.
209. Explain how ventilation/perfusion matching is physiologically achieved in gravity fields operating on fluids (air/blood) of such different mass.
210. Generate an alveolar PO<sub>2</sub>-PCO<sub>2</sub> diagram that identifies the three alveolar types, showing the continuum of ventilation/perfusion ratios.
211. Identify in vivo pulmonary reflexes that help to correct for vascular shunts or airway obstructions causing ventilation/perfusion disturbances.
212. Trace the pathways molecules of oxygen and carbon dioxide must traverse as pulmonary capillary blood become arterialized.
213. Contrast the diffusion constant for any gas versus diffusing capacity of the lung in mathematical terms of Fick's law of diffusion.

214. Plot as a function of time the change in blood PO<sub>2</sub> and PCO<sub>2</sub> as pulmonary capillary blood flows through the lungs.
215. List and explain four different causes of arterial hypoxemia found in abnormal human pathophysiology.
216. Differentiate between gas partial pressures in the blood versus gas contents in the blood, illustrating the importance of each.
217. Explain the numerous ramifications of the oxyhemoglobin dissociation curve in physiological terms.
218. Describe how oxygen supply and demand are balanced in the lungs and tissues in various metabolic states of activity.
219. Determine why carbon monoxide poisoning is a much more serious threat to life than anemia in terms other than decreased arterial oxygen content..
220. List the three forms of carbon dioxide carried by the blood and how they interact to form the total CO<sub>2</sub> dissociation curve.
221. Diagram using pertinent chemical reactions how CO<sub>2</sub> is processed by red blood cells traversing tissue and lung capillaries.
222. Graph the relationship between arterial blood gas tensions and alveolar ventilation during hyperventilatory and hypoventilatory maneuvers.
223. Contrast the changes in blood gas contents and partial pressures of oxygen and carbon dioxide during hyperventilation and hypoventilation.
224. Draw a generalized diagram of how information flows to and from the central nervous system for the state-dependent regulation of breathing.
225. List the participant nuclei in the brain stem responsible for the rhythmic and coordinated act of automatic breathing.
226. Identify ten mechanoreceptor reflexes that alter the respiratory pattern to overcome various perturbances to normal breathing.
227. Explain the protective role of peripheral and central chemoreceptors in normal breathing and pathological situations.

### **Renal**

228. List the principle functions of the kidneys that govern the production of urinary wastes while conserving both desirable solutes and water.
229. Trace the several intravascular and extravascular pathways a water molecule might traverse on multiple passes through the kidney.
230. Elaborate on those substances that are found in both blood and urine as contrasted with other substances which are found only in the blood, but not urine.
231. Discuss compromises to normal renal functions and consequences to body fluids in diseases such as hypertension, congestive heart failure, and glomerulonephritis.
232. Using words and equations, give working definitions for clearance of substances from the blood as processed by the kidney.
233. Explain why exogenous insulin and endogenous creatinine can be used for determining the glomerular filtration rate and why one substance might be superior to the other.
234. Show how RPF and RBF can be estimated and explain why no substance in the blood can have a clearance exceeding that of PAH.
235. Defend the statement that the GFR is a reference flow against which the clearance of unknown substances can be compared and their renal processings understood.

236. Describe how the glomerular capillaries are uniquely designed for the filtration of plasma and how  $K_f$  in the kidney is analogous to  $DL$  in the lung.
237. Give a formula for GFR using terms of pressure and conductance and show how various renal diseases can lead to changes in GFR for different reasons.
238. Name the capillary beds in the kidney which form portal systems and defend why their distinct anatomical placements are of functional significance.
239. Show how intrinsic factors within the kidney can explain autoregulation of GFR and RBF and how extrinsic factors can override this autoregulation.
240. Detail the several mechanisms in the kidney that can be exploited to move substances across tubular cells (tubule to blood and vice versa).
241. Draw a graph relating filtered, reabsorbed, and excreted loads of glucose as functions of plasma [glucose] and derive a general formula for  $T_m$ .
242. Draw a graph relating filtered, secreted, and excreted loads of PAH as functions of plasma [PAH] and derive a general formula for  $T_m$ .
243. Cite specific examples how the kidney operates like a computer, retaining specific solutes by reabsorption, and rejecting others for excretion.
244. Describe the active and passive mechanisms involved in isosmotic reabsorption along the proximal tubule accounting for 67% reabsorption of solutes and water.
245. Compare and contrast the proximal and distal nephron in terms of reabsorptive capacity,  $Na^+/K^+$ -ATPase, tight junctions, luminal potentials and gradients, and hormone receptors.
246. List regions along the nephron where water can (water permeability) and cannot (water impermeability) move down its osmotic gradient.
247. Integrate in your mind several different intrinsic and extrinsic regulators on salt and water reabsorption, including G-T balance, sympathetic inputs, ADH, ANP and aldosterone.
248. Compare and contrast the different body water compartments with respect to volume, composition, and osmolality, and how volumes are individually measured.
249. Work through the specific details of the ADH-release reflex from stimulus through response, highlighting the points of negative feedback.
250. Discuss how passive water reabsorption is directly dependent upon the permissive action of ADH, but indirectly dependent upon active ATP processes in the kidney.
251. Predict changes in EC water and IC water osmolalities and volumes following ingestion of hypertonic, isotonic and hypotonic solutions.
252. Distinguish antidiuresis from water diuresis, normal physiological stimuli evoking each state, and the resultant urine volumes and osmolalities.
253. Link the principles of countercurrent multiplication, countercurrent exchange and active ion pumping with the generation of high osmolality within the renal medulla.
254. Review how urea is processed by the kidney, urea's contribution to the medullary osmolality gradient, and the effect of increased urine flow on urea excretion.
255. Derive the formula for positive and negative free water clearances and show how  $CH_2O$  and  $TCH_2O$  change in different states of hydration and dehydration.
256. Explain some the similarities and differences between extracellular fluid volume, effective circulating volume and plasma volume.
257. Step by step, detail the renin-angiotensin-aldosterone system from multiple effective stimuli to coordinated responses.
258. List causes and effects of increased circulating levels of natriuretic peptide in terms of negative feedback control on sodium processing by the kidney.

259. Discuss the renal handling of sodium and water along the tubules and alterations in GFR during: euvoemia; volume contraction and expansion; the edematous state.
260. Outline the many factors involved in potassium homeostasis, clarifying why the maintenance of plasma  $[K^+]$  within narrow limits is so crucial to life.
261. List and detail the mechanisms of five primary factors that alter the rate of potassium secretion/excretion by the kidney.
262. Draw a detailed diagram showing the interaction of gastrointestinal, endocrine, and renal systems in the regulation of calcium concentration in the extracellular fluid.
263. What physiological factors alter the delicate balance between free phosphate in the plasma and bound phosphate in the bone.
264. Compare and contrast the renal processing of metabolic  $H^+$  by the proximal tubule and distal tubule, and explain the consequences of tubular failure at each level.
265. Name and detail seven factors that alter bicarbonate ion reabsorption and discuss how the kidney regulates plasma levels of this important anion.
266. List the three different expressions of  $H^+$  in the urine, discussing why the minimal urinary pH is around 4.4, but not lower.
267. On the same graph plot titration curves for monohydrogen phosphate and ammonia and clarify why  $HPO_4^{2-}$  is a titratable acid and  $NH_3$  is not.
268. Draw a wiring diagram for the bladder, showing sympathetic and parasympathetic pathways between the spinal cord and muscles of the bladder.
269. Reconstruct a normal cystometrogram, explaining the different phases in terms of changing bladder compliance and micturition contractions.
270. Explain how the micturition reflex works and how the bladder-storage function switches to the bladder-emptying mode either voluntarily or involuntarily.
271. List and describe several pathologies that result in abnormal bladder function, making suggestions for patient management.

### **Acid-Base**

272. Explain how hydrogen ions interact with enzymatic proteins, altering reaction rates within intracellular spaces (from MCBG).
273. Give the general form of the Henderson-Hasselbalch equation and explain why a buffer is most effective when its pK matches the environmental pH (from MCBG).
274. Give the specific form of the Henderson-Hasselbalch equation for the bicarbonate buffer system, identifying the respiratory and renal variables.
275. Compare and contrast the phosphate/protein buffer systems (closed) and the bicarbonate buffer system (open) in regulating extracellular  $[H^+]$ .
276. Answer the paradox as to why the quantitative assessment of a single buffer system is adequate despite the presence of multiple buffer systems.
277. Explain the utility of a simple, first-pass diagnosis of acid-base disturbances of respiratory and renal origin without the use of graphs.
278. Give specific and detailed examples of how acid-base disturbances of primary respiratory origin can be compensated by renal responses.
279. Give specific and detailed examples of how acid-base disturbances of primary metabolic origin can be compensated by respiratory responses.
280. Show how mass action shifts in the  $CO_2$  hydration reaction can explain both the direct and inverse couplings between  $[HCO_3^-]$  and pH.

281. Draw the generalized Davenport diagram, dividing the graph into six labeled regions of acid-base disturbances and compensations.
282. Throw a dart at a calibrated Davenport diagram and diagnose the situation, following the proper rules of movement along the lines.
283. Defend the necessity of taking several blood samples in the assessment and treatment of acid-base disturbances in a clinical setting.
284. Show how specific cardiopulmonary disturbances that can precipitate as problems of either acidosis or alkalosis.
285. If a patient is diagnosed with primary metabolic alkalosis and primary respiratory acidosis, predict the upset in acid-base balance during acute and aggressive ventilatory therapy.
286. Explain how proximal versus distal tubular failures can both lead to metabolic acidosis, but for different reasons.
287. Discuss several different scenarios that can ultimately result in hypokalemic metabolic alkalosis and the paradoxical production of an acidified urine.
288. Contrast the altered acid-base status in patients losing significant body fluids from the upper GI tract versus lower GI tract.
289. Make a list of medications and procedures physicians can impose on patients for various reasons that might induce serious acid-base side effects.
290. Explain why and how the regulation of plasma concentrations of glucose and hydrogen ions are greatly disturbed in the disease of diabetes.
291. Work through the steps that lead from chronic alcoholism to liver cirrhosis to ascites fluid accumulation to acid base disturbances.

### **Nervous System**

292. Describe the key functional parts of a typical neuron (location and functional role).
293. Explain differences between electrical and chemical synapses.
294. Describe the steps in normal neuromuscular transmission.
295. Explain EPSPs and IPSPs (including why a depolarizing IPSP can be inhibitory).
296. Compare & contrast small molecule neurotransmitters and neuropeptides
297. Explain how information is spatially and temporally *integrated* and *coded* in neurons.
298. Compare & contrast receptor (or generator) potentials and EPSPs.
299. Identify the 6 main components of the CNS.

### **Gastrointestinal**

300. What are the functions of the GI system? What are the basic properties that underlie those functions?
301. Describe the anatomy of the GI system.
302. Describe the general histological features of the GI tract.
303. List the different classes of modulation of the GI system and their interactions.
304. What are the major GI hormones and their origin and effects?
305. Describe the major paracrine factors and how significant they are for the (patho)-physiology of the GI tract.
306. Describe the distinct neuronal modulations of the GI system and their interactions.
307. Explain in detail the consequences of release of serotonin by enterochromaffin cells on the localized neuronal modulation of GI tract (“law of intestine”).
308. Describe the major neuromodulators of the GI system, and their effects.

309. Explain the basic electromechanical features of smooth muscle cells.
310. Describe the sequence of events, their underlying neural pathways, and general effects on the GI function during the cephalic and oral phases.
311. What are the functions of chewing and saliva?
312. Describe the distinct salivary glands, define serous and mucous glands and their histophysiological distinctions.
313. What are the major components in the saliva and their functions?
314. Describe the changes in electrolyte concentrations as saliva is being produced and secreted.
315. Describe the innervation and its effects on salivary glands.
316. What are the major intracellular pathways in the synthesis and secretion of saliva.
317. Describe the pharyngeal and esophageal phases of swallowing.
318. Describe in considerable detail the normal pressure gradient along the pharynx and esophagus during swallowing and transfer of bolus to stomach.
319. Understand the innervation and its effects on esophageal sphincters.
320. Explain the mechanisms of vomiting and their reflexes.
321. Describe the most important gastric secretions, the cells where they originate from, their locations in the stomach, and their digestive functions.
322. Describe the distinct types of motility in different regions in the stomach. Correlate those differences with the electromechanical properties of smooth muscle cells in those regions.
323. What are the types of innervation that control gastric motility in distinct gastric regions?
324. Explain the trajectory of chyme in the stomach when the pylorus is constricted.
325. What is the importance of [mucins+bicarbonate]?
326. Describe the cellular mechanisms responsible for HCl secretion.
327. Describe the endocrine, paracrine, and neural controls of acid secretion.
328. What are the major and common signal transduction pathways responsible for the control mechanisms in the previous item.
329. What are the consequences of a dysfunctional pylorus?
330. Describe the major mechanisms (endocrine, paracrine, and neural) involved in the contraction/relaxation of the pylorus.
331. Discuss the significance of digestion in the stomach.
332. To understand the various factors that determine the emptying of the gastric content into the duodenum.
333. Describe the distinct stimuli for the two major pancreatic secretions.
334. Describe the feedback loop of secretin secretion and pH in the lumen of duodenum.
335. What is the major effect of secretin on pancreatic cells?
336. What causes the release of CCK by duodenal cells?
337. Describe the major gastrointestinal events stimulated by CCK.
338. Describe the differences between segmentation and peristalsis, and their physiological roles in the small intestine.
339. List the neuronal control of pancreatic secretions and the major reflexes.
340. What are the major components of pancreatic mucous secretion? What do they do?
341. Summarize the main pathways for pancreatic secretions.
342. What are the components of the bile?
343. Describe the main function of bile acids.
344. Describe the distinct types of motility of the small intestine and their origins and controls.
345. Describe the "Law of Intestine".

346. Explain the origin and propagation of the migrating motor complex.
347. Explain the enzyme action on carbohydrates (amylase + brush border enzymes).
348. How are carbohydrates absorbed?
349. List the sequence of enzymatic reactions that hydrolyze a protein in the diet into small peptides and amino acids.
350. How are amino acids and di-or tri-peptides transported in the small intestine?
351. How are hydrophobic substances handled in the GI lumen and absorbed?
352. To understand the dynamics of water secretion/absorption along the GI system.
353. List the main sites in the GI system where the major ions in the plasma are absorbed or secreted.
354. How are  $\text{Ca}^{2+}$  and vitamin B12 transferred from the GI lumen to the blood?
355. What are the main functions of the large intestine?
356. Define haustration and propulsion of bolus and the muscles involved and their regulations.
357. What is the significance of peptide YY?
358. What is the significance of bacterial flora in the GI system?
359. Describe the actions of the various muscles in the final stages of digestion.

### **The Liver**

360. List the main functions of liver.
361. Describe the Portal Circulation and understand its significance.
362. What are the main histological features of the hepatic lobule?
363. What are the phases involved in detoxication and excretion of toxic substances by the liver?
364. What is the significance of Kupffer cells?
365. What are the main components of bile secretion?
366. How are lipids absorbed in the small intestine?
367. Starting with the cholesterol molecule, describe the major steps (and where they occur) in the synthesis of bile acids.
368. What are the main membrane transporters in cholangiocytes and hepatocytes?
369. How is the bile secreted into the gallbladder?
370. What are the main mechanisms for bile concentration in the gallbladder?
371. What factors promote or cause the development of gallstones in the gallbladder?
372. Explain the consequences of the obstruction of the common bile duct by a gallstone.
373. Why is it important to control the concentration of bilirubin in the blood?
374. Describe the major steps in the transformation and excretion or absorption of bilirubin.
375. Why does the destruction of the hepatic parenchyma lead to Portal hypertension?
376. List some of the consequences of Portal hypertension.
377. What causes jaundice?
378. What accounts for pruritus?
379. List some of the causes of hyperbilirubinemia.

### **Metabolism**

380. List the alternative fates of acetyl-CoA.
381. Compare the “preferred fuels” of liver, skeletal muscle, heart, adipose tissue and brain.
382. Identify the major carbohydrates and the foods in which they are found.
383. Explain the consequences of consuming milk by an individual who has lactose intolerance (genetic deficiency of lactase).

384. Compare the pathways of carbohydrate metabolism that are active in red blood cells, brain, skeletal muscle, heart, adipocytes and hepatocytes.
385. Identify the glucose/monosaccharide transporters (GLUT's) that are responsible for Sodium dependent glucose transport.
386. Insulin dependent glucose transport.
387. Insulin independent low affinity, high capacity transport in liver.
388. Identify the three glycolytic reactions that are irreversible under physiological conditions; list the enzymes that catalyze each of these reactions.
389. Compare the tissue localization, kinetic characteristics and regulation of hexokinase and glucokinase.
390. Compare the allosteric activators and inhibitors of the three enzymes that catalyze the irreversible glycolytic reactions.
391. Predict the physiological role of each of these activators/inhibitors. (Why is it advantageous that high cytoplasmic ATP (etc.) inhibits PFK-1 and glycolysis?)
392. Identify the pancreatic hormone that leads to the inhibition of hepatic glycolysis.
393. Describe the mechanism by which the pancreatic hormone (above) exerts its inhibitory effect on hepatic glycolysis.
394. Predict the separate effects of an increased concentration of insulin and glucagon on the synthesis of the three irreversible glycolytic enzymes in liver.
395. Explain the mechanism by which epinephrine inhibits hepatic glycolysis and activates cardiac glycolysis.
396. Compare the conditions in which the favored end-product of glycolysis is lactate with the conditions that promote formation of pyruvate and acetyl-CoA.
397. Predict the effects of ischemia (partial obstruction of blood flow), caused by a brain tumor, on lactate formation in brain.
398. Identify the allosteric inhibitors of PDH.
399. Predict the effect of covalent modification/phosphorylation on PDH activity.
400. Identify the factors that cause PDH to be phosphorylated and dephosphorylated.
401. Identify the vitamin cofactors that participate in the reactions catalyzed by PDH.
402. Predict the effect of a thiamine deficiency, a genetic deficiency/abnormality in PDH, or arsenic poisoning on circulating levels of lactate and pyruvate.
403. Predict the physiological consequences of a genetic deficiency of fructose aldolase, and identify the food(s) the affected individual should avoid.
404. Predict the physiological consequences of a genetic deficiency of either galactokinase or galactose 1-phosphate uridyl transferase and identify the food(s) the affected individual should avoid.

### **Nutrition**

405. Explain significance of iron, folate and cobalamin for adequate erythropoiesis.
406. Describe differences between heme and non-heme iron and the absorption processes for each.
407. Contrast anemias caused by deficiencies of iron versus of folate and/or cobalamin.
408. Explain the interaction between folate and cobalamin in terms of the biochemistry.
409. Describe the etiology of hyperhomocysteinemia.
410. Describe the three processes by which parathyroid hormone and vitamin D function to regulate calcium balance.

411. Explain the calcium intracellular signaling pathway.
412. Explain the significance of adequate sun exposure for vitamin D sufficiency.
413. Describe vitamin D deficiency: signs, symptoms, etiology & treatment/prevention recommendations.
414. Explain how free radicals are produced and oxidative stress is manifested in proteins, lipids and nucleic acids.
415. Describe the different functions of vitamin E and vitamin C with regard to their antioxidant properties.
416. Describe the deficiency state of ascorbic acid and how the physical signs are manifested.

### **Endocrinology**

417. List the sources of free amino acids in the body.
418. Define the terms essential and non-essential amino acids.
419. Predict whether biosynthesis of amino acids is sufficient to allow net synthesis of protein when dietary protein is not available.
420. Describe the "turnover" of endogenous proteins, indicating the range of half-lives of endogenous proteins and the amount of protein turned over each day.
421. Describe how free amino acids are utilized
422. Predict the consequences of a protein-free diet.
423. Indicate how much protein must be present in the diet to maintain body protein.
424. Indicate what happens to dietary protein that is in excess of the RDA.
425. Define nitrogen balance.
426. Be able to predict the nitrogen balance status for various physiological situations.
427. Describe the transamination reaction in terms of the types of substrates, products, and cofactor that are involved.
428. Indicate which amino acid serves as a reservoir of nitrogen following transaminase reactions involving other amino acids.
429. Indicate how glutamate is converted to aspartate and ammonia.
430. Draw the chemical structure of urea.
431. Indicate the organ responsible for urea biosynthesis.
432. Draw the urea cycle, indicating the names (not the structures) of intermediates; the name of the enzyme that produces urea from arginine.
433. Predict the effect of a high protein diet on the rate of urea production.
434. Indicate which two amino acids are the major carriers of nitrogen to the liver
435. Describe the consequences of decreased urea production.
436. Define the terms glucogenic and ketogenic.
437. Recognize whether an amino acid is glucogenic, ketogenic, or both based on the final products of the degradative pathway.
438. Indicate how this transient net synthesis and degradation of protein is thought to be regulated in muscle.
439. Indicate the function of the amino acids released during an overnight fast.
440. Describe the enzyme deficiency in classic (Type I) phenylketonuria and the biochemical consequences of this deficiency.
441. Describe how symptoms of certain genetic diseases of amino acid catabolism can often be prevented by modification of diet.

442. Recognize the structures of the two purine bases (adenine and guanine) and the three pyrimidine bases (cytosine, uracil, and thymine).
443. Identify which bases are found in DNA and which are found in RNA.
444. Explain the differences in the structures of bases, nucleosides, and nucleotides.
445. Explain the difference between the structures of ribose and deoxyribose.
446. Indicate the biosynthetic source of each atom in the purine ring.
447. Indicate whether the purine ring is synthesized first and then attached to ribose or whether the purine ring is synthesized on top of ribose.
448. Indicate the first two enzymatic steps in purine biosynthesis starting with ribose-5-phosphate. Name the products and indicate the source of ribose-5-phosphate. Identify the enzyme that catalyzes the committed and major regulated step.
449. Indicate which nucleotide stands at the branch point leading to the synthesis of AMP and GMP.
450. Draw a figure showing how purine biosynthesis is regulated.
451. Suggest why an inhibitor of purine biosynthesis might be useful in slowing tumor growth.
452. Describe the mechanism of action of the anti-tumor agent, 6-mercaptopurine
453. Indicate the biosynthetic source of each atom in the pyrimidine ring.
454. Describe the regulated step in pyrimidine biosynthesis.
455. Indicate whether the pyrimidine ring is synthesized first and then attached to ribose or whether the pyrimidine ring is synthesized on top of ribose.
456. Name the pyrimidine nucleotide that is biosynthesized first and becomes a precursor for the synthesis of the other pyrimidine nucleotides.
457. Indicate which metabolic pathway is blocked by the rheumatoid arthritis drug, leflunomide.
458. Describe the synthesis of dTMP from dUMP.
459. Describe how 5-fluorouracil acts as an antitumor agent.
460. Describe how methotrexate acts as an antitumor agent.
461. Name the enzyme responsible for the synthesis of the deoxyribonucleotides and indicate the substrates for this enzyme.
462. Indicate which hydroxyl group is removed from the ribose in this process.
463. Describe the mechanism of the antitumor effect of hydroxyurea (small group problem).
464. Describe how deoxyribonucleotide biosynthesis is regulated during the cell cycle.
465. Name the classes of enzymes involved in degradation of DNA and RNA.
466. Indicate which bases are formed by degradation of DNA and RNA.
467. Describe the enzymatic reaction involved in salvaging hypoxanthine and guanine.
468. Indicate the genetic deficiency in Lesch-Nyhan syndrome.
469. Indicate the final product of purine degradation in humans.
470. Name the enzyme that catalyzes the conversion of hypoxanthine to xanthine, and xanthine to uric acid.
471. Indicate the forms of uric acid present in blood and urine.
472. Describe the consequences of overproduction or underexcretion of uric acid.
473. Describe the mechanism by which allopurinol relieves the symptoms of gout.
474. Define body fuel homeostasis.
475. Present an overview of whole body energy balance.
476. List the major body fuels, their caloric equivalents and quantities stored as such in the body.
477. List the three fundamental processes of body fuel homeostasis.
478. Discuss the peptide leptin in relation to regulation of energy stores.

479. Distinguish between extracellular fuel homeostasis and intracellular fuel homeostasis.
480. Do an analysis of body fuel homeostasis as a physiological control system.
481. List the major hormones involved in body fuel homeostasis.
482. Diagram the major processes and hormones involved in regulation of blood glucose concentrations.
483. Compare and contrast the endocrine effects of glucagon vs. insulin.
484. Diagram the paracrine network of the pancreatic islets.
485. Discuss the enteroinsular axis.
486. Compare and contrast the metabolic physiology of the fed, fasted, sympathetic stimulation, severe injury/trauma state.
487. Outline the basic events thought to be involved in development of the diabetic state.
488. Distinguish between metabolic physiology and homeostasis vs. metabolic pathophysiology and dyshomeostasis of body fuels.
489. Trace the flow of nutrients in liver, adipose tissue and muscle in the fed and fasting states; contrast this pattern with that in diabetes.
490. Describe the events leading to: dehydration and coma with insulin lack.
491. Describe the events leading to loss of Na and K with insulin lack.
492. Explain the importance of pulsatile hormone release.
493. Explain the use of suppression and stimulation testing in evaluation of the endocrine function.
494. Describe how the hypothalamus is regulated by higher CNS connections.
495. Identify the known hypothalamic hormones and their target troph cells and hormones.
496. Describe how the hypothalamus regulates hormone synthesis and secretion in the anterior pituitary gland.
497. Discuss the regulation of the secretion of ACTH, FSH/LH, PRL and GH.
498. Discuss the regulation of the secretion of ADH and Oxytocin.
499. List the major hyperfunctional or hypofunctional states of the growth hormone, prolactin and ADH pituitary neuroendocrine axes.
500. Be knowledgeable of target organs for glucocorticoids (esp. cortisol) other than liver, muscle and fat.
501. Be familiar with the molecular mechanisms by which cortisol and synthetic glucocorticoids suppress inflammation.
502. Understand the general aspects and modular structure of intracellular receptors for steroid hormones (and other lipophilic hormones).
503. Describe gene activation by steroid receptors, including key target genes for cortisol.
504. Explain aldosterone's mechanism of kidney action in terms of its physiological effects and why cortisol is normally blocked from exerting a similar effect.
505. Describe Cushing's disease and differentiate it from other hypercortisolemias.
506. Explain the basic differences between 1, 2 and 3 degrees Addison's syndromes.
507. Understand the importance of  $Ca^{2+}$  intake and homeostasis in health and disease
508. Explain why albumin levels are important when assessing  $Ca^{2+}$  status
509. Detail the hormones regulating plasma  $Ca^{2+}$  and phosphate and their target organs
510. Describe the basic role of bone in  $Ca^{2+}$  and phosphate regulation
511. Clarify the steps in the biosynthesis and secretion of PTH, including its regulation
512. Classify PTH with regard to its receptor sites and associated 2nd messenger systems

513. List organs and steps involved in endogenous 1,25-Vit. D formation, and understand the difference between endogenous and exogenous pathways
514. Explain the role of plasma transcalciferin in 1,25-Vit. D biosynthesis and activity
515. Describe the regulation of kidney formation of 1,25-Vit D
516. Summarize the receptor mechanism for 1,25-Vit. D and in which target organs
517. Describe the intracellular actions of 1,25-Vit. D. on intestinal mucosal cells
518. Be aware of differential gene product processing for calcitonin (hormone) and CGRP (brain)
519. Explain how calcitonin could be involved (or not) in human Ca<sup>2+</sup> homeostasis
520. Be familiar with the structures of EPI, NE, DA, serotonin and melatonin.
521. Describe the enzymatic steps for EPI biosynthesis in the adrenal medulla.
522. Explain the hormonal and neuronal regulation underlying EPI synthesis and release.
523. Describe the two main enzymatic pathways in EPI and NE catabolism
524. Be familiar with the four classes of catecholamine receptors and their 2<sup>nd</sup> messengers
525. Explain the effects of EPI on plasma fatty acids, keto acids, insulin and glucagons
526. Integrate the physiological significance of “fright, fight or flight” with regard to EPI, NE, and other stress hormones
527. Define pheochromocytoma and explain the value of “metanephrines” and VMA in its diagnosis
528. Be familiar with the differences in plasma EPI and NE levels in response to stresses
529. Clarify where and how melatonin is primarily synthesized, and its secretion at night
530. Summarize the known and suspected physiological roles for melatonin.
531. Explain the physiological importance of thyroid hormones in overall development and metabolism.
532. Recognize structures T<sub>4</sub>, T<sub>3</sub> and reverse T<sub>3</sub>, and understand importance of dietary iodide and its thyroid gland uptake for adequate hormone biosynthesis.
533. Detail the hypothalamic-pituitary-thyroid (HPT) axis, including negative feedback, with understanding of the role of thyroid releasing hormone (TRH)
534. Understand how TSH stimulates T<sub>3</sub> and T<sub>4</sub> biosynthesis in the thyroid follicle
535. Describe the role of thyroglobulin and thyroperoxidase in T<sub>3</sub>/T<sub>4</sub> biosynthesis
536. Clarify the importance and role of plasma proteins involved in thyroid hormone transport
537. Be familiar with the similarities and differences between thyroid hormone receptors and steroid hormone receptors.
538. Explain how thyroid hormone receptors act to regulate gene transcription, including the importance of retinoic acid and its receptors in the process.
539. Relate the key effects of thyroid hormone+receptors on the physiology of specific organs
540. Explain the clinical picture of hyperthyroidism and the importance of TSH assays.
541. Explain the clinical picture of hypothyroidism, overt and subclinical and the importance of TSH assays.

## **Reproduction**

542. Distinguish between mitosis and meiosis and outline the major pattern of gamete development in males and females.
543. Compare and contrast human male and female sexual development relative to genetic sex, gonadal sex and genital sex.
544. What aspects of development are hormone dependent and which hormones are involved?

545. Describe the major types of disorders of sexual differentiation and give some common examples.
546. Explain the essential elements of the neuroendocrine axis for the regulation of testicular function.
547. Describe spermatogenesis and the role of different cell types in this process.
548. List the key functions of the Sertoli and Leydig cells and important interactions.
549. Identify the cell of origin for testosterone, its biosynthesis, mechanism of transport within the blood, how it is metabolized and how it is eliminated. List other physiologically produced androgens.
550. List the target organs for testosterone and describe its effects on each.
551. Describe the cellular mechanisms of action for testosterone and DHT.
552. List the neural, vascular, and endocrine components of the erection and ejaculation response.
553. Identify the causes and consequences of male hypogonadism.
554. Contrast male infertility with impotence.
555. Identify the essential elements of the neuroendocrine axis that regulate ovarian, reproductive tract and behavioral aspects of reproduction.
556. Describe the hormonal regulation of estrogen and progesterone biosynthesis and secretion by the ovary. Identify the cells responsible for their biosynthesis, the mechanism of transport in the blood and how they are degraded and removed from the body.
557. Describe oogenesis and its relationship to changes in the ovarian follicle. Explain the roles of FSH, LH, estradiol, inhibin and activin in oogenesis and follicular maturation.
558. Outline and discuss the phases of the monthly reproductive cycle and the temporal relationship between the hormones of the hypothalamus, pituitary and ovary at each phase.
559. List the major changes that occur in the female reproductive tract during the monthly reproductive cycle and correlate these with changes in circulating hormones.
560. Explain the differences between tonic and surge modes of gonadotropin release.
561. Identify the physiological changes that occur during menopause.

### **Histology of the Lungs**

562. List the functions of the conducting portion of the airway. Draw a diagram of the mucociliary escalator and describe how it functions. Be sure to include the different cell types involved.
563. List the components of the wall of the trachea. Compare and contrast the structural features of the wall of the trachea, an intrapulmonary bronchus and a bronchiole.
564. List the cell types you would expect to find in an alveolus. Correlate alveolar structure with alveolar function.
565. Describe the path of an oxygen molecule from the trachea throughout the conducting portion of the airway into a capillary in the wall of an alveolus. List the barriers to a molecule of oxygen from the alveolar space to a red blood cell in a pulmonary capillary.
566. Compare and contrast the architecture of a normal lung with that of a smoker, someone with emphysema, fibrosis, or asthma.
567. Remember that lungs are your friends (so don't smoke).

### **Renal Histology**

568. List the organs of the urinary system and describe the specific function of each organ.

569. Identify the structures and regions seen grossly in a frontal section of kidney as well as describe their organization and general function(s).
570. Trace the flow of blood through the kidney and identify the various renal vascular elements in histologic sections.
571. Describe the structure and contents of a renal lobe and lobule.
572. Describe the structure, function and location of each component of a cortical versus a juxta-medullary nephron and the collecting ducts into which the nephrons empty and be able to identify these structures in histologic sections.
573. Trace the flow of urinary filtrate from Bowman's urinary space to the exterior, naming in order the tubules and urinary tract components through which it flows and describe any changes in filtrate composition that occur in each component of the system.
574. Compare the roles of ADH and aldosterone in renal function. Identify what cells have receptors for them.
575. Identify the components of the glomerular filtration barrier in a transmission electron micrograph (TEM) or diagram a portion of a renal corpuscle. Describe the components of the physical versus charge barriers.
576. Describe the structure and function of mesangial cells.
577. Describe the function of the juxtaglomerular apparatus and identify its components: macula densa, JG cells, lacis cells.
578. Describe the differences between transitional epithelium in the ureter and bladder

### **Gastrointestinal Histology**

579. State the parts of the digestive tract and the primary function of each.
580. List the four layers that form the walls of the tubular organs of the digestive tract and the tissue types found in each layer.
581. Compare the tubular organs of the digestive tract with respect to the structure of each layer and relate any structural variations to differences in their functions.
582. Diagram the distinguishing structural features of the various regions of each area of the digestive tract.
583. List the secretory products(s), the distinguishing structural features, and (where appropriate) the staining properties for each type of secretory cell lining the digestive tract.
584. List the features of small intestine lining absorptive cells that promote nutrient absorption and the steps in this process.
585. At the light or ultrastructural level identify the organ, region, cell types present as well as their function from a slide or photomicrograph of a section of any part of the digestive tract.

### **Histology of Salivary Glands, Pancreas and Liver**

586. Identify the cellular regions that make up the accessory organs of digestion.
587. Describe the unique features of the cells comprising the accessory organs of digestion.
588. Describe the functions associated with the cells comprising the accessory organs of digestion.

### **Neuroendocrine Histology**

589. Understand the embryological origin of the pituitary and how it relates to the two main tissue types: adenohypophysis (anterior pituitary) and neurohypophysis (posterior pituitary).
590. Know the 3 main parts of the anterior pituitary: pars distalis, pars intermedia, pars tuberalis.

591. Know the 2 main parts of the posterior pituitary: pars nervosa and infundibulum (which includes the stem and median eminence).
592. Describe the hypophyseal portal circulation and its relation to the release of regulatory hormones from the hypothalamus.
593. Describe the histology of the anterior pituitary. Identify chromophils (basophils/acidophils) and chromophobes,
594. Know the 5 types of hormone-secreting cells in the anterior pituitary, their location, and hormones made by each. Know how the hypothalamus is involved in regulating release of anterior pituitary hormones.
595. Understand the organization of the posterior pituitary and the term “hypothalmohypophyseal tract”. Know the histological structure of the pars nervosa.
596. Identify the 2 hormones that are liberated from the posterior pituitary lobe, where the hormones are made and how they are stored.

### **Reproductive Histology (Male)**

597. Identify different tissue structural components that comprise the male reproductive system and to explain specific function of each component.
598. Identify histology each component of the male reproductive system and to explain the cellular composition of each component.
599. Describe the spermatogenesis process and to explain changes at the cellular and DNA levels associated with the developmental events.
600. Outline spermatogenesis and oogenesis and discriminate the two developmental pathways.

### **Reproductive Histology (Female)**

601. Identify organs in the female reproductive system and to describe cellular composition of each organ.
602. Identify changes at the cellular and tissue levels during development of ovarian follicles and explain these changes.
603. Identify hormones that affect the development of ovarian follicles and the cellular sources of these hormones.
604. Discriminate functions of hormones that affect the development of ovarian follicles.
605. Identify at the light microscopic level changes in the uterine wall that occur during menstrual cycle.
606. Explain how the hypothalamus-anterior pituitary gland affects the ovaries, oviducts, and uterus in a cyclical manner.
607. Identify the composition of fetal membranes and explain their formation.
608. Identify cellular composition of the placenta and explain its function.
609. Describe the cellular composition and tissue structure of vaginal wall, vaginal smears, and mammary glands.
610. Discriminate the effects of hormones on mammary gland function.

## **II. INTERPERSONAL AND COMMUNICATION SKILLS**

By the end of FHB, students must have demonstrated knowledge of the basic principles of effective interpersonal communication, and the skills and attitudes that allow effective interaction with their peers, faculty, and support staff. Students will:

1. Use verbal language effectively.
2. Use effective listening skills and elicit and provide information using effective nonverbal, explanatory, and questioning skills.
3. Use written language effectively.
4. Facilitate the learning of other students, including giving effective feedback.
5. Communicate essential information effectively within their small group and with others in their class.

## **III. LIFELONG LEARNING, PROBLEM-SOLVING AND PERSONAL GROWTH**

By the end of this course students must demonstrate the knowledge, skills and attitudes needed to be able to use appropriate tools of evidence to identify and analyze books, reviews, online resources, and basic science reports for their applicability towards quality in healthcare and quality improvement. Students will:

1. Apply acquired knowledge effectively.
2. Locate, appraise, critically review and assimilate evidence from scientific studies and medical literature.
3. Demonstrate an investigatory and analytic thinking approach in SGPSS and course projects.
4. Demonstrate a commitment to individual, professional and personal growth.

## **IV. PROFESSIONALISM, MORAL REASONING AND ETHICAL JUDGEMENT**

By the end of this course, students must demonstrate a combination of knowledge, skills, attitudes, and behaviors necessary to function as a respected member of a learning team in both small group and large class settings. Students will:

1. Behave professionally in the context of the small group problem-solving session, including attendance, punctuality, preparedness, and ability to interact effectively with other small group members in the educational setting.
2. Recognize and effectively deal with unethical behavior of other members of the class, if encountered.