Course Outcomes

- Use the general steps of the scientific method to form hypotheses, collect and evaluate data, and draw conclusions, in order to learn to distinguish between science and pseudoscience, and to evaluate scientific information in both professional journals and the popular press.
- Relate the unifying themes of the relationship between structure and function and the maintenance of homeostasis to the structure and function of the human body.

Give examples for all 11 systems

Endocrine System

1. Describe the major functions of the endocrine system
2. Define the terms hormone, endocrine gland, endocrine tissue (organ), and target cell.
3. Compare and contrast how the nervous and endocrine systems control body function, with emphasis on the mechanisms by which the controlling signals are transferred through the body and the time course of the response(s) and action(s)
4. List the major chemical classes of hormones found in the human body
5. Compare and contrast the types of receptors (cell membrane or intracellular) that each class bind**s** to
6. Compare and contrast the mechanism of response that each class elicits (i.e., change in gene expression or change in an intracellular pathway via phosphorylation mechanism) and relate the response mechanism to the biochemical nature of the hormone molecule.
7. List and describe several types of stimuli that control production and secretion of hormones
8. Describe the roles of negative and positive feedback in controlling hormone release
9. Describe the locations of and the anatomical relationships between the hypothalamus, anterior pituitary and posterior pituitary glands.
10. Define the terms releasing hormone, inhibiting hormone and tropic hormone.
11. Explain the role of the hypothalamus in the release of anterior pituitary hormones
12. Explain the role of the hypothalamus in the production and release of posterior pituitary hormones
13. Use the hormones below (grouped by organs) to perform outcomes 14,15 and 16: (Some may be covered in other modules)
    - **a.** Pituitary: growth hormone, thyroid-stimulating hormone, luteinizing hormone, follicle stimulating hormone, prolactin, adrenocorticotropic hormone, oxytocin, antidiuretic hormone (or vasopressin)
    - **b.** Thyroid gland: thyroxine, triiodothyronine, calcitonin
    - **c.** Parathyroid gland: parathyroid horme,
    - **d.** Adrenal gland: glucocorticoids (cortisol), mineralocorticoids (aldosterone), gonadocorticoids, epinephrine, norepinephrine
    - **e.** Testis: testosterone,
    - **f.** Ovary: estrogen, progesterone,
    - **g.** Pancreas: insulin, glucagon
    - **h.** Kidney: erythropoietin, calcitriol (Vitamin D)
    - **i.** Thymus: thymosin
    - **j.** Heart: atrial natriuretic peptide
    - **k.** Gastrointestinal tract: gastrin, secretin, cholecystokinin, gastric inhibiting peptide
    - **l.** Adipose tissue: leptin,

m. Placenta: estrogen, progesterone, human chorionic gonadotropin

14. Describe the stimulus for release of the hormone

15. Identify the gland or endocrine tissue/organ and the cells within that gland/tissue/organ that produce the hormone.

16. Name the target tissue or cells for the hormone and describe the effect(s) of the hormone on the target tissue or cells.

Cardiovascular System

Introduction/Blood

1. Describe the major functions of the cardiovascular system.

2. Describe the overall composition of plasma, including the major types of plasma proteins, their functions and where in the body they are produced

3. With respect to the structure and numbers of formed elements in blood, identify microscopically each of the following:
- **a.** erythrocytes (red blood cells or RBCs),
- **b.** the five types of leukocytes (white blood cells or WBCs) and
- **c.** thrombocytes (platelets

4. Compare and contrast the morphological features of erythrocytes and the five types of leukocytes

5. List the five types of leukocytes in order of their relative prevalence in normal blood and classify each type as granulocyte or agranulocyte

6. Explain how platelets differ structurally from the other formed elements of the blood

7. With respect to development of formed elements:
- **a.** Describe the location of hematopoiesis and the significance of the pluripotent stem cell (hemocytoblast).
- **b.** Explain the basic process of erythropoiesis, the significance of the reticulocyte, and regulation through erythropoietin
- **c.** Discuss the role of the megakaryocyte in the formation of platelets

8. With respect to the functional roles of formed elements:
- **a.** State the function of red blood cells
- **b.** Discuss the structure and function of hemoglobin, as well as its breakdown products
- **c.** Describe functions for each of the five major types of leukocytes as well as the two major subtypes of lymphocytes (T and B).
- **d.** State the function of platelets

Blood Typing

1. Explain the role of surface antigens on RBCs in determining blood groups.

2. List the type of antigen and the type of antibodies present in each ABO blood type

3. Describe how the presence or absence of Rh antigen results in blood being classified as positive or negative

4. Distinguish between the development of anti-Rh antibodies and the development of anti-A and anti-B antibodies

5. Predict which blood types are compatible and what happens when the incorrect ABO or Rh blood type is transfused.

6. State which blood type is considered the universal donor and which blood type is considered the universal recipient, and explain why

Hemostasis

1. With respect to the phases of hemostasis:
- **a.** Describe the vascular phase including the role of endothelial cells
- **b.** Describe the role of platelets and the steps involved in the formation of the platelet plug
- **c.** Describe the basic steps involved in the formation of the insoluble fibrin clot

Heart

1. Describe the position of the heart in the thoracic cavity
2. On the external heart identify the location of the four chambers as well as the coronary sulcus, anterior interventricular sulcus and posterior interventricular sulcus.
3. Identify and describe the function of the primary internal structures of the heart, including chambers, septa, valves, papillary muscles, chordae tendineae, and venous and arterial openings.
4. Compare and contrast the structure and function of the atrioventricular and the semilunar valves
5. Describe the layers of the pericardium and the location of the pericardial cavity
6. Identify myocardium and describe its histological structure, including the significance of intercalated discs.
7. Discuss the structure and significance of the endocardium
8. Identify the right and left coronary arteries, the cardiac veins, and the coronary sinus
9. List the phases of the cardiac muscle action potential and explain the ion movements that occur in each phase
10. Compare and Contrast Structure and function of the cardiac pacemaker cells, in cardiac contractile cells and in skeletal muscle cells
11. Explain the significance of the plateau phase in the action potential of a cardiac contractile cell
12. Compare and contrast cardiac muscle contraction and skeletal muscle contraction Identify the major blood vessels entering and leaving the heart and classify them as either an artery or a vein and as containing either oxygen-rich or oxygen-poor blood
13. Describe blood flow through the heart naming all chambers and valves passed
14. Explain the major factors that aid in movement of blood through the heart and produce one-way flow
15. Explain how the heart is a double pump and why this is significant
16. With respect to the conduction system of the heart:
    a. List the parts of the conduction system and explain how the system functions.
    b. Define automaticity and explain why the SA node normally paces the heart.
    c. Explain how the cardiac conduction system produces efficient pumping of blood
17. Describe the role of the autonomic nervous system in the regulation of cardiac function
18. With respect to the electrocardiogram (EKG or ECG):
19. Identify the waveforms in a normal EKG
20. Relate the waveforms to atrial and ventricular depolarization and repolarization and to the activity of the conduction system

Circuits

1. With respect to the systemic and pulmonary circuits:
    a. Describe the systemic and pulmonary circuits and discuss the functions of each.
    b. State which blood vessel type carries oxygen-rich blood and which type carries oxygen-poor blood in each circuit.

Cardiac Cycle

1. Define cardiac cycle, systole, and diastole
2. Describe the phases of the cardiac cycle including ventricular filling, isovolumetric contraction, ventricular ejection, and isovolumetric relaxation
3. Explain how atrial systole is related to ventricular filling.
4. Relate the opening and closing of specific heart valves in each phase of the cardiac cycle to pressure changes in the heart chambers

5. Define systolic and diastolic blood pressure and interpret a graph of aortic pressure versus time during the cardiac cycle
6. Compare and contrast pressure and volume changes of the left and right ventricles during one cardiac cycle.
7. With respect to cardiac output (CO):
    a. Define cardiac output, and state its units of measurement
    b. Calculate cardiac output, given stroke volume and heart rate
    c. Predict how changes in heart rate (HR) and/or stroke volume (SV) will affect cardiac output
    d. Expalin the value of cardiac reserve.
8. With respect to stroke volume (SV):
    a. Define end diastolic volume (EDV) and end systolic volume (ESV) and calculate stroke volume (SV) given values for EDV & ESV
    b. Define venous return, preload and afterload, and explain the factors that affect them as well as how each of them affects EDV, ESV and SV
    c. Explain the significance of the Frank-Starling Law of the heart
    d. Discuss the influence of factors that affect SV.
9. With respect to HR:
    a. Discuss the influence factors that affect HR
    b. Explain the relationship between changes in HR and changes in filling time and EDV.

Blood Pressure

1. Define blood flow, blood pressure, and peripheral resistance
2. State and interpret the equation that relates blood flow to pressure and resistance
3. List the local, hormonal and neuronal factors that affect peripheral resistance and explain the importance of each
4. Interpret relevant graphs to explain the relationships between vessel diameter, cross-sectional area, blood pressure, and blood velocity
5. Using a graph of pressures within the systemic circuit, interpret the pressure changes that occur in the arteries, capillaries, and veins
6. Given values for systolic and diastolic blood pressure, calculate pulse pressure (PP) and mean arterial pressure (MAP)

Regulation of Blood Pressure

1. With respect to regulation of blood pressure:
    a. During the baroreceptor reflex, explain how cardiac output and peripheral resistance are regulated to maintain adequate blood pressure on a moment-to-moment basis
    b. During the chemoreceptor reflex, explain how the respiratory and cardiovascular systems are coordinated to provide flow and oxygen to body tissues
    c. Explain the role of the sympathetic nervous system in regulation of blood pressure and volume.
    d. Explain the role of hormones in regulation of blood pressure, including the mechanism by which specific hormones affect preload, heart rate, force of contraction or vascular resistanc

Blood Vessels

1. Compare and contrast the structure of arteries and veins and arterioles and venules
2. With respect to arteries and veins:
3. List the types of arteries and veins
4. Correlate the anatomical structure of each type of blood vessel with its function

5. Define vasoconstriction and vasodilation
6. Describe the role of arterioles in regulating tissue blood flow and systemic arterial blood pressure.
7. With respect to capillaries:
    a. Explain how the composition of capillary walls differs from that of other blood vessels
    b. List types of capillaries and state where in the body each type is found
    c. Correlate the anatomical structure of capillaries with their functions.
8. Describe how veins act as blood reservoirs.
9. Define anastomosis and explain the significance of anastomoses, such as the Circle of Willis
10. Identify the following major arteries and veins:

Arteries

- Ascending Aorta
- Arch of the Aorta
- Brachiocephalic Artery
- Common Carotid Arteries
- Subclavian Arteries
- Internal Carotid Arteries
- External Carotid Arteries
- Vertebral Arteries
- Axillary Arteries
- Brachial Arteries
- Radial Arteries
- Ulnar Arteries
- Thoracic Aorta
- Abdominal Aorta
- Celiac Trunk
- Left Gastric Artery
- Common Hepatic Artery
- Splenic Artery
- Superior Mesenteric Artery
- Renal Arteries
- Gonadal Arteries
- Inferior Mesenteric Artery
- Common Iliac Arteries
- Internal Iliac Arteries
- External Iliac Arteries
- Deep Femoral Arteries
- Femoral Arteries
- Popliteal Arteries
- Anterior Tibial Arteries
- Posterior Tibial Arteries

Veins

- Superior Vena Cava
- Brachiocephalic Veins

- Internal Jugular Veins
- Vertebral Veins
- Subclavian Veins
- External Jugular Veins
- Axillary Veins
- Cephalic Veins
- Basilic Veins
- Brachial Veins
- Radial Veins
- Ulnar Veins
- Median Cubital Veins
- Inferior Vena Cava
- Hepatic Veins
- Renal Veins
- Gonadal Veins
- Common Iliac Veins
- Internal Iliac Veins
- External Iliac Veins
- Great Saphenous Veins
- Femoral Veins
- Small Saphenous Veins
- Popliteal Veins
- Anterior Tibial Veins
- Posterior Tibial Veins

Capillary Dynamics

1. With respect to capillary exchange
    a. Explain the role of diffusion in capillary exchange of gases, nutrients, and wastes
    b. Explain the roles of filtration and reabsorption in capillary exchange of fluid
    c. Describe how net filtration pressure across the capillary wall determines movement of fluid across the capillary wall
    d. Relate net filtration pressure to potential edema and the need for a functional lymphatic system
2. Discuss how muscular compression and the respiratory pump aid venous return
3. With respect to autoregulation:
    a. Explain how autoregulation controls blood flow to individual tissues
    b. Explain the role of the precapillary sphincter in autoregulation.
    c. List some chemicals that cause vasodilation and explain when they are active
    d. List some chemicals that cause vasoconstriction and explain when they are

Lymphatic System and Immunity

1. Describe the major functions of the lymphatic system
2. Compare and contrast lymphatic vessels and blood vessels in terms of structure and function.
3. Describe the path of lymph circulation
4. . Describe the mechanisms of lymph formation & circulation
5. Describe the basic structure and cellular composition of lymphatic tissue and correlate it to the overall functions of the lymphatic system

6. For the lymph nodes, thymus, spleen, tonsils and other aggregations of mucosae-associated lymphatic tissue (MALT):
    a. Describe the location in the body of each organ or tissue
    b. Describe the function of each organ or tissue.

Specific and Nonspecific Defenses - Innate and Adaptive Immunity
Innate Immunity

1. Compare and contrast innate (nonspecific) defenses with adaptive (specific) defenses.
2. Define immunity and the immune system
3. Describe the roles of various types of leukocytes in innate and adaptive body defenses
4. Analyze ways in which the innate and adaptive body defenses cooperate to enhance the overall resistance to disease.
5. Name the surface membrane barriers and describe their physical, chemical, and microbiological mechanisms of defense.
6. Define diapedesis, chemotaxis, opsonization, and membrane attack complex and explain their importance for innate defenses
7. Describe the steps involved in phagocytosis and provide examples of important phagocytic cells in the body
8. Describe natural killer cells and discuss their function
9. Explain how complement and interferon function as antimicrobial chemicals
10. With respect to the inflammatory response:
    a. Describe the mechanisms of inflammation initiation
    b. Summarize the cells and chemicals involved in the inflammatory process
    c. List and explain the cause of the four cardinal signs of inflammation
    d. Explain why inflammation can be beneficial
11. With respect to fever:
    a. Describe the mechanism of fever and the role of pyrogens.
    b. Explain why fever can be beneficial.

Adaptive Immunity

1. Distinguish between humoral and cell-mediated immunity
2. Describe the immunological memory response
3. Define antigen and antigen receptor
4. With respect to major histocompatibility complex (MHC):
    a. Define MHC
    b. Describe where class I and class II MHC and MHC proteins are found
    c. Explain the function of class I and class II MHC in adaptive immunity
5. Explain the role of antigen-presenting cells (APCs) and provide examples of cells that function as APCs
6. Differentiate between humoral and cell-mediated responses.
7. Differentiate the roles of macrophages, dendritic cells, NK cells, memory cells, plasma cells, helper T cells, cytotoxic T-cells, regulatory T-cells, and antigen presenting cells.
8. Descibe the formation and importance of immunocompetence and self vs non-self recognition
9. Describe the differences between primary and secondary response to antigens and give reasons for the differences
10. Recognize the differences between antigens, antibodies, and antibiotics.
11. Describing the structure and function of different classes of antibodies
12. Compare and contrast natural and innate active and passive immunity

13. Communicate the role of immune system mechanisms in preventing disease.

Respiratory System

Anatomy and Histology

1. Describe the major functions of the respiratory system.
2. Describe the four respiratory processes - ventilation, external respiration (gas exchange at lung), internal respiration (gas exchange at body tissues), and cellular respiration.
3. Describe and distinguish between the upper and lower respiratory tracts.
4. Describe and distinguish between the conducting and respiratory zones of the respiratory tract
5. For each of the following: nasal cavities,paranasal sinuses, pharynx, larynx, trachea, bronchi, lungs, pleural membranes, pulmonary blood vessels,and nerves, thoracic and pleural cavities, and diaphragm:
    a. Identify each structure
    b. Describe the gross anatomical features of each structure
    c. State the function of each structure
6. For each of the following: respiratory (nasal) mucosa, the layers of the tracheal wall, the bronchi and bronchioles, the three cell types found in alveoli, and the respiratory membrane:
    a. Identify each structure
    b. Describe the microscopic anatomy of each structure
    c. State the function of each structure
7. Describe the changes in epithelial and connective tissue seen in various portions of the air passageways and relate these changes to function.

Pulmonary Ventilation

1. Define pulmonary ventilation, inspiration, and expiration.
2. Identify the muscles used during quiet inspiration, during forced inspiration, and during forced expiration, as well as the nerves responsible for stimulating those muscles.
3. Define and state relative values for atmospheric pressure, intrapulmonary pressure, intrapleural pressure, and transpulmonary pressure
4. State Boyle's Law and relate this law to the specific sequence of events (muscle contractions/relaxations and pressure/volume changes) causing inspiration and expiration.
5. Explain how each of the following affect pulmonary ventilation: bronchiolar smooth muscle contractions, lung and thoracic wall compliance and recoil, and pulmonary surfactant and alveolar surface tension
6. Describe the forces that tend to collapse the lungs and those that normally oppose or prevent collapse

Pulmonary Volumes and Capacities

1. Define, identify, and determine values for the respiratory volumes (IRV, TV, ERV, and RV) and the respiratory capacities (VC, and TLC).
2. Define and calculate values for minute ventilation and alveolar ventilation.
3. Define anatomical dead space and explain the effect of anatomical dead space on alveolar ventilation and the composition of alveolar and expired air

Mechanisms of Exchange

1. State Dalton's Law, and relate to the events of external and internal respiration and to the amounts of oxygen and carbon dioxide dissolved in plasma.
2. With respect to external respiration:

    a. Describe oxygen and carbon dioxide concentration gradients and net gas movements
3. With respect to internal respiration:
    a. Describe oxygen and carbon dioxide concentration gradients and net gas movements.
    b. Explain the factors that maintain oxygen and carbon dioxide gradients between blood and tissue cells.

Gas Transport

1. With respect to oxygen transport:
    a. Describe the ways in which oxygen is transported in blood and discuss the relative importance of each to total oxygen transport
    b. State the reversible chemical equation for oxygen binding to hemoglobin and predict how raising or lowering the partial pressure of oxygen will shift the equilibrium
2. With respect to the oxygen-hemoglobin saturation curve:
    a. Interpret the curve at low and high partial pressures of oxygen.
    b. List factors that shift the curve down and to the right, and explain how this results in increased oxygen delivery to the tissues
    c. List factors that shift the curve up and to the left, and explain how this facilitates oxygen binding to hemoglobin in the lungs
3. With respect to carbon dioxide transport:
    a. Describe the ways in which carbon dioxide is transported in blood and discuss the relative importance of each to total carbon dioxide transport.
    b. State the reversible chemical equation for the reaction of carbon dioxide and water to carbonic acid and then to hydrogen ion and bicarbonate ion.
    c. Predict how changing the partial pressure of carbon dioxide will affect the pH and the concentration bicarbonate ions in the plasma.
    d. Predict how changing the pH or the concentration of bicarbonate ions will affect the partial pressure of carbon dioxide in the plasma
    e. State the reversible chemical equation for carbon dioxide binding to deoxyhemoglobin and predict how changing carbon dioxide concentrations will affect deoxyhemoglobin levels in the tissues and the lungs.
    f. Explain how each of the following relates to carbon dioxide transport: carbonic anhydrase, hydrogen ions binding to hemoglobin and plasma proteins, and the chloride ion shift.

Control of Ventilation

1. Describe the locations and functions of the brainstem respiratory centers
2. List and describe the major chemical and neural stimuli to the respiratory centers
3. Compare and contrast the central and peripheral chemoreceptors
4. Explain why it is possible to hold one's breath longer after hyperventilating than after eupnea.

Digestive System

Anatomy

1. Describe the major functions of the digestive system.
2. With respect to the wall of the alimentary canal:
    a. Identify, and describe the histological structure and the function of, each of the four layers of the wall - the mucosa, the submucosa, the muscularis externa, and the serosa (visceral peritoneum),

   b. Describe regional specializations in the histological structure of the alimentary canal and relate these specializations to the functions of the particular organs in which they are located
3. With respect to the oral cavity:
   a. Identify the boundaries of the oral cavity
4. Identify the naso-, oro- and laryngopharynx and classify these regions with respect to passage of food and/or air through them.
5. With respect to the esophagus:
   a. Describe the structure and discuss the function of the lower esophageal (cardiac) sphincter.
   b. Describe the locations of skeletal and smooth muscle within the wall of the esophagus
6. With respect to the stomach:
   a. Describe the structure and discuss the function of the cardiac and pyloric sphincters.
   b. Discuss the significance of rugae.
   c. Discuss the function of the oblique muscle layer of the stomach.
   d. Identify the structure of a gastric gland including the location of the chief (zymogenic) cells, parietal (oxynic) cells, enteroendocrine cells, and mucous cells, and discuss the functions of these different cell types.
7. With respect to the small intestine:
   a. Identify the location and discuss the relative length and the functions of the duodenum, jejunum, and ileum.
   b. Identify and discuss the histology and functions of the plicae circulares (circular folds), villi, and microvilli.
8. With respect to the large intestine:
   a. Describe the structure and discuss the function of the ileocecal valve and the internal and external anal sphincters.
   b. Identify the location of the cecum and appendix, the ascending, transverse, descending, and sigmoid colon, the rectum, and the anus.
9. With respect to the salivary glands:
   a. Describe the location of the parotid, submandibular, and sublingual glands and their respective ducts.
   b. Contrast the products of the serous cells and the mucous cells.
10. With respect to the liver:
   a. Identify the hepatic artery, hepatic portal vein, and hepatic vein and discuss the function of each of those blood vessels
   b. Identify the histological components of a liver lobule (including hepatocytes, hepatic sinusoids, Kupffer cells, bile canaliculi, central vein, and the components of a hepatic triad) and discuss the function of each
   c. Identify the hepatic duct, cystic duct, gallbladder, common bile duct, sphincter of the hepatopancreatic ampulla
11. With respect to the pancreas:
   a. Identify the pancreatic acini and discuss their functions.
   b. Identify the pancreatic islets and discuss their functions.
   c. Identify the pancreatic duct and the hepatopancreatic sphincter and discuss their roles in the flow of pancreatic enzymes

Peritoneum and Mesenteries

1. Describe the histology of the visceral and parietal peritoneum
2. Differentiate between intraperitoneal and retroperitoneal location of digestive structures

3. Identify the mesentery proper and the mesocolon and explain their function

Motility

1. List the structures involved in the process of deglutition and explain how they function, including the changes in position of the glottis and larynx that prevent aspiration.
2. Define the terms peristalsis, segmentation, and mass movement, and discuss the role that these activities play in the function of various regions of the alimentary canal
3. Explain the enterogastric reflex.
4. Describe the defecation reflex and the function of the internal and external anal sphincters

Mechanical and Chemical Processes of Digestion

1. With respect to mechanical digestion:
2. Define mechanical digestion
3. List the organs and structures of the digestive system that function in mechanical digestion and explain the details of the process for each
4. With respect to enzymatic hydrolysis:
    a. Define enzymatic hydrolysis
    b. List the organs and structures of the digestive system that function in enzymatic hydrolysis
5. List the enzymes used in enzymatic hydrolysis and discuss activation where applicable
6. Describe the mechanisms used to regulate secretion and/or activation of each enzyme
7. Discuss the function, production, and regulation of secretion of hydrochloric acid (HCl)
8. With respect to the process of emulsification:
    a. Define emulsification and describe the process
    b. List the organs and structures of the digestive system that function in the process of emulsification

Absorption

1. With respect to monosaccharides, peptides and amino acids, and fatty acids and monoglycerides:
    a. List the organs and specific structures involved in the absorption of each of these types of nutrient
    b. Explain the processes involved in absorption of each type of nutrient.

Regulation

1. List the components of both a short reflex and a long reflex in the digestive system.
2. Explain the effect of the cephalic phase, gastric phase, and intestinal phase on the functions of the stomach and give examples for each phase
3. Explain the effect of the cephalic phase, gastric phase, and intestinal phase on the functions of the small intestine and give examples for each phase
4. With respect to the following hormones or paracrine agents – gastrin, cholecystokinin,
    a. State the organ or structure that produces each hormone or agent
    b. State the target organ for each hormone or agent.
    c. Describe the action of each hormone or agent.

Urinary System

Anatomy and Major Functions

1. Describe the major functions of the urinary system
2. With respect to gross anatomy of the urinary tract

    a. Describe the external structure of the kidney, including its location, support structures and covering
    b. Identify, and describe the structure and location of, the ureters, urinary bladder and urethra.
    c. Identify the major internal divisions and structures of the renal tissue
3. Trace the path of blood through the kidney
4. With respect to the nephron and collecting system:
    a. Identify the major structures and subdivisions of the renal corpuscles, renal tubules and renal capillaries
    b. Compare and contrast cortical and juxtamedullary nephrons.
    c. Identify the location, structures and cells of the juxtaglomerular apparatus
5. With respect to the histology of the kidney:
    a. Describe the histological structure of the proximal convoluted tubule, loop of Henle, distal convoluted tubule, and collecting duct.
    b. Distinguish histologically between renal cortex and medulla
6. Trace the path of filtrate/urine from the renal corpuscle to the urethral opening

Formation of Urine

1. List the three major processes in urine formation and where each occurs in the nephron and collecting system.
2. With respect to filtration
    a. Describe the structure of the filtration membrane
    b. Explain the anatomical features that create high glomerular capillary blood pressure and explain why this blood pressure is significant for urine formation.
    c. Describe the hydrostatic and colloid osmotic forces that favor and oppose filtration
    d. Describe glomerular filtration rate (GFR), state the average value of GFR, and predict how various factors will increase or decrease GFR
3. With respect to reabsorption:
    a. List specific transport mechanisms occurring in different parts of the nephron, including active transport, osmosis, and facilitated diffusion
    b. List the different membrane proteins of the nephron, including aquaporins, channels, transporters, and ATPase pumps.
    c. Compare and contrast passive and active tubular reabsorption
    d. Describe how and where water, organic compounds, and ions are reabsorbed in the nephron.
4. Explain why the differential permeability or impermeability of specific sections of the nephron tubules is necessary for urine formation.
5. Explain the role of the loop of Henle, the vasa recta, and the countercurrent multiplication mechanism in the concentration of urine.
6. State the percent of filtrate that is normally reabsorbed and explain why the process of reabsorption is so important
7. With respect to tubular secretion:
    a. List the location(s) in the nephron where tubular secretion occurs
    b. Describe the physiological processes involved in eliminating drugs, wastes and excess ions
8. Compare and contrast blood plasma, glomerular filtrate, and urine and then relate their differences to function of the nephron

Regulation

1. With respect to autoregulation:

    a. Describe the myogenic and tubuloglomerular feedback mechanisms and explain how they affect urine volume and composition
    b. Describe the function of the juxtaglomerular apparatus
2. Describe how the renin-angiotensin mechanis functions in the extrinsic control of GFR
3. Describe how aldosterone, antidiuretic hormone regulate reabsorption and secretion, so as to affect urine volume and composition
4. Predict specific factors involved in creating dilute versus concentrated urine.

Other Roles of the Kidney

1. Describe the role of kidney in vitamin D activation.
2. Describe the role of kidney in regulating erythropoiesis

Fluid Compartments/pH Regulation

1. Describe the fluid compartments (including the subdivisions of the extracellular fluid) and state the relative volumes of each.
2. Compare and contrast the relative concentrations of major electrolytes in intracellular and extracellular fluids.
3. Explain how dehydration and overhydration (water intoxication) develop and how fluids shift between the three major body compartments during each.
4. Define acid, base, pH and buffer
5. Describe important blood buffers
6. Describe the role of the respiratory system in regulation of blood pH and predict how hypo- and hyperventilation will affect blood pH.
7. Explain the mechanisms by which the kidneys secrete hydrogen ions, and how this process affects blood pH

Major Functions and Anatomy of the Reproductive System

1. Describe the major functions of the male and female reproductive systems.
2. With respect to the gross anatomy, identify and describe the anatomy of the male and female reproductive system, including the gonads, ducts, accessory glands, associated support structures, and external genitalia.
3. With reference to microscopic anatomy:
    a. Identify and describe the reproductive and supporting cells of the seminiferous tubules of the testis
    b. Identify and describe the different stages of follicular development in the ovary, including the preovulatory follicle and the corpus luteum

Gametogenesis

1. Relate the general stages of meiosis to the specific processes of spermatogenesis and oogenesis
2. Contrast the process and the final products of spermatogenesis and oogenesis

Female Reproductive System

1. Describe the pathway of the female gamete from the ovary to the uterus
2. Describe the ovarian cycle and relate the events of the ovarian cycle to oogenesis
3. Describe the events of the uterine cycle
4. Analyze the typical female monthly sexual cycle and correlate ovarian activity, hormonal changes, and uterine events

Male Reproductive System

1. Discuss the relationship between the location of the testes and sperm production
2. Explain the role of the sustentacular cells and interstitial cells in sperm production
3. Describe the pathway of sperm from the seminiferous tubules to the external urethral orifice of the penis
4. Identify and describe the organs involved in semen production
5. Discuss the composition of semen and its role is sperm function

Hormonal Control

1. State the functions of gonadotropin releasing hormone, follicle stimulating hormone, luteinizing hormone, testosterone, estrogen and progesterone
2. Compare and contrast endocrine regulation of spermatogenesis and oogenesis
3. Compare and contrast the events and endocrine regulation of female and male puberty
4. Define secondary sex characteristics and describe their role in reproductive system function
5. Compare and contrast female and male sexual responses

Conception

1. Describe conception, including sperm capacitation, acrosomal reaction, sperm penetration, cortical reaction, and fusion of pronuclei
2. Define fertilization
3. Describe the early events of embryonic and placental development if time allows

Apply the basic principles of biology to the function of cells and cell membranes in the human body in order to be able to predict the nature of processes involving membrane transport, receptors, surface area, and energy, thus learning from understanding rather than memory.
Describe the results of homeostatic imbalance of the same important variables in order to relate changes to the underlying causes of disease
Communicate accurately and clearly both in writing and orally in order to educate patients (for students entering allied health fields) and communicate with professional colleagues