UNIVERSITY OF ALBERTA

School of Dentistry
Faculty of Medicine and Dentistry
College of Health Sciences

Human Physiology Challenge Exam Learning Outcomes

(adapted from the HAPS Physiology Learning Outcomes - Spring 2023)

Nervous System

1. List the most common ion channels associated with neurons, their location on the cell, channel type (leak or voltage-gated, chemically [ligand-] gated, or mechanically gated), and the direction ions flow through the open channel.
2. Describe the significance of the different types of glial cells, their structure, major functions, and locations (i.e., central or peripheral nervous system).
3. Describe the structure and function of myelin.
4. Compare and contrast the neurotransmitters acetylcholine and norepinephrine by their synthesis, release, chemical composition, receptor(s), and mechanisms of action.
5. Define, compare and contrast cholinergic and adrenergic receptors including their neurotransmitters, receptor subtypes (e.g., alpha & beta; muscarinic & nicotinic), and general responses (i.e., excitatory or inhibitory).
6. Define graded potential and describe how one is produced.
7. Describe the relation between the size of a stimulus signal, the amplitude of a graded potential (strength), and signal decay distance from the stimulation.
8. Define action potential and describe how one is triggered.
9. Compare and contrast graded and action potentials (location, amplitude (strength), duration, channel types, and functions). Compare and contrast graded and action potentials (location, amplitude (strength), duration, channel types, and functions).
10. Given a graph of an action potential (membrane potential as a function of time), label or describe each phase, name the ions involved in each phase, and describe the direction of ion flow across the membrane.
11. Describe changes in the gating of sodium and potassium ion channels (opening, open, closed or inactivated) and the resultant changes in ion permeability that are responsible for each phase of an action potential.
12. Explain the difference between the relative and absolute refractory periods of an action potential, relating these phases to the closure and inactivation of gated ion channels.
13. Explain how summation of graded potentials can alter the amplitude (strength) of a signal arriving at the trigger zone and influence excitability of the cell.
14. Explain how voltage-gated Na+ and K+ channels enable the conduction (propagation) of action potentials along the length of an axon
15. Explain how refractory periods ensure the unidirectional conduction (propagation) of action potentials from hillock to axon terminal.

16. Explain how the distribution of ion channels in myelinated and unmyelinated segments (neurofibril nodes, nodes of Ranvier) of the axon membrane contributes to saltatory conduction.
17. Compare and contrast the conduction (propagation) of action potentials in myelinated versus unmyelinated axons and in small versus large diameter axons
18. Compare and contrast electrical and chemical synapses.
19. Describe the events of synaptic transmission from the action potential arrival at the axon terminal of the presynaptic cell to the effects of neurotransmitter binding on the postsynaptic cell.
20. Define, compare and contrast excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs).
21. Describe the components of the blood-brain barrier (BBB), including glial cells, that influence permeability and exchange between the blood and the cerebrospinal fluid (CSF).
22. Identify and describe the major structures and regions of the brain, and their functions (e.g., cerebrum, cerebellum, thalamus, hypothalamus, pons, medulla).
23. List the four lobes of the cerebral cortex and describe the major function(s) of each lobe (e.g., occipital lobe is associated with vision).
24. List the major functions of the hypothalamus.
25. Label or describe a cross-sectional view of the spinal cord to show the locations and functions of major structures (e.g., spinal nerves, gray matter, white matter, dorsal root ganglion).
26. Describe the relationships among the efferent divisions of the peripheral nervous system (PNS): autonomic (visceral motor), parasympathetic, somatic motor, and sympathetic
27. Compare and contrast the autonomic and somatic motor divisions with respect to the number of neurons in the efferent pathway, presence or absence of ganglia, chemical classification of synapses at the target (cholinergic vs adrenergic), and the types of targets.
28. Explain the relationship between a sensory receptor and its stimulus (adequate stimulus), its threshold, and receptor potentials.
29. Diagram or describe the path and refraction of light as it passes through the eye to the retina including the major structures.
30. Describe the structure of the human retina, including cell types, arrangement of cell layers, and the special arrangement of the fovea
31. Compare and contrast the functions of rods and cones.
32. Describe the basic phototransduction process.
33. Describe how the energy from sound waves is transduced into action potentials within the cochlea, including the role of hair cells and the tectorial membrane.
34. Describe the functions and three-dimensional structures of the semicircular canals, ampullae, saccule, and utricle and their association with the cochlea.

35. Define thermoregulatory set point and diagram or describe the negative feedback control of body core temperature homeostasis, including the role of the hypothalamic thermoregulatory set point.
36. Describe, compare and contrast the roles of the nervous, endocrine, and immune systems in mediating the short-term (acute) and long-term (chronic) stress responses.

Muscular System

1. Compare the histological, anatomical, functional characteristics and distribution of skeletal, cardiac, and smooth muscle within the human body.
2. Explain the organization, structures, and functions of the following components within a skeletal muscle fiber (cell) (e.g., sarcolemma, transverse tubules (t tubules), sarcoplasmic reticulum, actin, myosin, titin, troponin, tropomyosin, sarcoplasm).
3. Describe the arrangement and composition of myofilaments in a sarcomere including A-band, I-band, H-zone, Z-disc (Z-line), and M-line.
4. Diagram a myosin molecule: label the head, hinge region and tail, and describe the function of each part.
5. Diagram and label the thin filament of striated muscle: an actin chain with its associated troponin and tropomyosin proteins.
6. Describe the sliding filament mechanism of striated muscle contraction.
7. Describe the relationship among troponin, tropomyosin, and actin, and explain their interactions with calcium and roles in the regulation of crossbridge cycling
8. Explain the role of ATP/ADP and myosin ATPase in the contraction cycle and the rigor state.
9. Describe the events involved in the contraction of a skeletal muscle fiber (cell), including events at the neuromuscular junction, excitation-contraction coupling, and contraction cycle.
10. Compare and contrast a motor endplate potential and an action potential in a skeletal muscle fiber (cell).
11. Describe the sequence of events involved in skeletal muscle relaxation, including the role of Ca-ATPase (sarco/endoplasmic reticulum Ca-ATPase, SERCA) and the sarcoplasmic reticulum.
12. Interpret graphs of muscle tension (force) versus stimulus frequency to explain the physiological basis for the phenomena of summation of twitches, unfused tetanus, and complete tetanus.
13. Define a motor unit and describe how action potential frequency and the recruitment of different size motor units are used to progressively increase muscle tension.
14. Explain the importance of glycogen, creatine kinase, and phosphocreatine for ATP production in striated muscles.
15. Describe the characteristics of muscle fiber types classified by speed and duration of contraction and resistance to fatigue: slow twitch oxidative (Type I), fast twitch oxidative-glycolytic (Type IIa), fast twitch glycolytic (Type IIb/IIx).

16. Apply knowledge of the difference(s) in ATP production during glycolysis and oxidative phosphorylation to compare the duration and fatigue resistance of muscle contraction in oxidative and glycolytic muscle fiber types.
17. Compare and contrast the composition, arrangement and functional properties of myofilaments in smooth muscle and skeletal muscle cells.

Cardiovascular System

1. Describe the functions of a circulatory system and list the major substances transported by the human cardiovascular system.
2. Compare and contrast the systemic and pulmonary circuits (circulations) with respect to structure and function.
3. Starting at the venae cavae, trace the path of blood through the heart to the aorta, listing major blood vessels and heart valves the blood passes through, and indicate whether the blood is oxygen-rich or oxygen-poor in each location.
4. Describe the microscopic anatomy of contractile myocardium, including the arrangement of contractile fibers and the location, structure, and function of the intercalated discs and gap junctions.
5. Compare and contrast cardiac and skeletal muscle anatomy (e.g., cell size and shape, arrangement of myofilaments).
6. Diagram or describe a typical action potential in a ventricular contractile cell, labelling the axes, the four phases of the action potential (i.e., depolarization, initial repolarization, plateau, rapid repolarization), and the ionic currents that contribute to the four phases.
7. Explain the role of calcium in determining the force of myocardial contraction (contractility).
8. Describe the advantages of a long refractory period in contractile myocardium.
9. List the parts of the electrical conduction system of the heart in sequence, beginning at the sinoatrial (SA) node, and explain how the electrical conduction system functions.
10. List the waveforms and segments of a typical electrocardiogram (ECG or EKG), and explain the electrical events represented by each waveform or segment.
11. Describe the association between electrical events on a typical electrocardiogram (ECG or EKG) and mechanical events in the myocardium during a cardiac cycle.
12. Diagram or describe the atrial and ventricular events of the cardiac cycle, beginning with atrial and ventricular diastole.
13. Describe the following functions through one cardiac cycle: the left ventricular pressure curve, left atrial pressure curve, aortic pressure curve, left ventricular volume curve, and heart sounds.
14. Explain the relationships among myocardial fiber length, end diastolic volume (EDV), cardiac contractility, and stroke volume (SV).
15. Describe how changes in end diastolic volume (EDV) affect stroke volume (SV) [Frank-Starling Law of the heart], and explain the physiological mechanism responsible (i.e., the length-tension relation in the myocardium).
16. Define preload and afterload and describe the factors that affect them.

17. Predict how end diastolic volume (EDV), end systolic volume (ESV), stroke volume (SV), ejection fraction (EF), and cardiac output (CO) are affected by an increase or decrease in venous return (VR), preload, or afterload.
18. Define systolic arterial pressure and diastolic arterial pressure.
19. Predict and describe how mean arterial pressure (MAP) is affected by changes in total peripheral resistance (TPR), cardiac output (CO), heart rate (HR) and stroke volume (SV).
20. Predict and explain how mean arterial pressure (MAP) is affected by changes in preload or afterload
21. Explain the role of the lymphatic system in preventing edema.
22. Describe the cellular elements and extracellular matrix (plasma) of blood.
23. Describe the structure of hemoglobin (Hb, Hgb) and relate its structure to its functions.
24. Identify the site of erythropoietin (EPO) production, the stimulus for EPO release, the target tissue(s) for EPO, and the action of EPO at its target.
25. List the five types of leukocytes (white blood cells, WBCs) found in healthy blood, compare their relative abundance.
26. Describe the structure and functions of platelets (thrombocytes).
27. Define hemostasis and describe its three major steps (i.e., vascular spasm, platelet plug formation, and coagulation).
28. Describe the process of platelet activation and the formation of a platelet plug.
29. Diagram or describe the positive feedback loops in the platelet and coagulation phases and explain their significance to the process of hemostasis.
30. Diagram or describe the positive feedback loops in the platelet and coagulation phases and explain their significance to the process of hemostasis.
31. Explain how erythrocyte surface proteins determine blood type by the ABO blood groupings and rhesus (Rh) factor classifications.
32. List the cell surface antigens and corresponding antibodies for each ABO and Rh blood type.

Digestive System

1. Describe the primary functions of the digestive system (i.e., digestion, absorption, secretion, and motility) and identify the locations where each process occurs.
2. Define, compare and contrast segmental contractions and peristaltic contractions, and identify the locations where each occurs in the gastrointestinal (GI) tract.
3. Describe the source, stimuli for release, targets, and target responses of the major gastrointestinal (GI) tract hormones (e.g., gastrin, cholecystokinin [CCK], secretin).
4. Explain how external stimuli (e.g., the smell or thought of food) can initiate the feedforward cephalic phase of digestion.
5. Diagram or describe the steps of the deglutition (swallowing) reflex, including the actions of the tongue, soft palate, pharynx, epiglottis, esophagus, and esophageal sphincters.
6. Describe the general functions of the stomach (e.g., digestion, storage, defense).

7. Define chyme and list the secretions of the gastric mucosa (e.g., gastric acid [HCl], mucus, pepsin), their stimuli for release, associated cell types, and describe the function of each.
8. Diagram or describe the integrated functions of gastric acid (HCl), gastric lipase, and pepsin in chemical digestion in the stomach.
9. Explain the importance of the acidic environment of the stomach for the initiation of enzymatic protein digestion.
10. Identify the divisions of the small intestine (duodenum, jejunum, ileum), and structures linking the accessory organs: liver, pancreas, and gallbladder.
11. Describe the general functions of the small intestine (e.g., absorption, peristalsis).
12. Diagram or describe the structural and functional relationships among structures of the intestine and vessels (i.e., villi, microvilli, brush border, crypts, lacteals, and blood vessels).
13. Describe the secretions of the liver, pancreas, and gallbladder related to gastrointestinal (GI) function (i.e., endocrine and exocrine pancreatic secretions, bile).
14. Diagram or describe the microscopic organization of a liver lobule including hepatocytes, associated blood vessels, and bile ducts.
15. Identify the sources and describe the functions of the secretions released into the intestinal lumen (e.g., digestive enzymes, bile, bicarbonate, mucus, and isotonic NaCl solution).
16. Diagram or describe the mechanism by which epithelial cells of the small intestine and exocrine pancreas produce and secrete a sodium bicarbonate solution into the lumen, including the role of carbonic anhydrase.
17. Explain the importance of inactive enzymes (zymogens, proenzymes) in the digestive system (e.g., pepsinogen, trypsinogen) and identify locations where they are found.
18. Diagram or describe the mechanism by which inactive pancreatic enzymes are activated in the small intestine, including the relationships among enteropeptidase (enterokinase), trypsinogen, and trypsin.
19. Define emulsification and explain how the amphipathic structure of bile salts assists in emulsification of fats.
20. Identify the enzyme responsible for glucose polymer breakdown, its source/location(s) in the GI tract, and the products that result from this breakdown.
21. Describe the pathway by which absorbed monosaccharides enter the blood.
22. List the common enzymes involved in protein digestion, sources of these enzymes, and identify where they are found in the GI tract.
23. Diagram or describe the mechanisms for intestinal absorption of Na+, K+, Cl- ions and water.
24. Compare and contrast the mechanisms for absorption of fat-soluble vitamins (e.g., vitamins A, D, E, K) and water-soluble vitamins (e.g., vitamin C and most B vitamins) by the intestine.
25. Describe the general functions of the large intestine.
26. Describe mass movement in the colon and explain its role in defecation.

27. Diagram or describe the steps of the defecation reflex.
28. Describe the roles of the liver, adipose tissue, and skeletal muscle in carbohydrate, lipid, and protein metabolism.
29. Describe the effects of the following hormones on metabolism: insulin, glucagon, cortisol, growth hormone, and thyroid hormone.
30. List the major hormones secreted from the endocrine pancreas (e.g., insulin, glucagon, somatostatin), list their cells of origin, and describe their chemical classification (e.g., peptide, protein).

Respiratory System

1. Describe the major functions of the respiratory system.
2. List and describe the major steps required for the movement of atmospheric gases between the environment and the body's cells.
3. Explain the structural and functional relationships of the visceral and parietal pleura (pleural sacs), pleural fluid, thoracic cage, heart, and lungs.
4. Describe the branching structure of the airways, starting at the trachea and ending at alveoli, and explain the microscopic and macroscopic anatomical differences from trachea to bronchi and bronchioles to alveoli (e.g., cartilage, smooth muscle, epithelia).
5. Define ventilation, inspiration (inhalation), and expiration (exhalation).
6. Graph or describe the change in intrapleural pressure, alveolar pressure, airflow, and lung volume during a normal quiet breathing cycle, identifying the onset of inspiration, cessation of inspiration, onset of expiration, cessation of expiration, and the timepoints where atmospheric pressure is equal to alveolar pressure.
7. Define anatomic dead space.
8. Explain the role of surface tension and surfactants in lung compliance [Law of Laplace].
9. List the factors influencing airway resistance.
10. Describe the influence of cellular respiration on the O_2 and CO_2 gradients promoting gas exchange between systemic capillaries and body tissues.
11. Graph or describe an oxyhemoglobin dissociation curve (O_2-Hb saturation curve) explaining the relationship between O_2 partial pressure and Hb saturation.
12. Explain what happens to hemoglobin’s affinity for oxygen and to oxygen release at the tissues when the oxyhemoglobin saturation curve shifts to the right or left.
13. Diagram or describe the reversible chemical equation for the conversion of CO_2 and H_2O to hydrogen ion (H^+) and bicarbonate ion (HCO_3^-), then explain the role of carbonic anhydrase in this reaction (i.e., bicarbonate buffer system).
14. Compare and contrast the locations and functions of the central and peripheral chemoreceptors associated with the control of ventilation.
15. Diagram or describe the reflex control of ventilation, including the major stimuli, sensors, neural control pathways, and targets.
16. Diagram or describe the reflex pathways that link changes in plasma PCO_2 or pH to changes in ventilation.

Excretory/Renal/Urinary System

1. Diagram and describe the segments of the nephron in the order in which a filtered solute encounters them (e.g., glomerular capsule [Bowman's capsule], proximal convoluted tubule, nephron loop [loop of Henle], distal convoluted tubule).
2. Compare and contrast reabsorption and secretion in the nephron describing the direction of solute and water movement and location where each process occurs (i.e., the renal tubule segments).
3. Explain how the integration of renal filtration, reabsorption, and secretion determines the volume and composition of the urine.
4. Describe the following microscopic structures associated with the glomerular filtration barrier (e.g., afferent and efferent arterioles, glomerular capillaries, podocytes, mesangial cell, glomerular [Bowman's] capsule).
5. Diagram or describe the roles of blood pressure (hydrostatic pressure), capsule fluid pressure, and colloid osmotic (oncotic) pressure in determining net filtration pressure.
6. Define tubuloglomerular feedback and describe the mechanism of tubuloglomerular feedback that mediates autoregulation of glomerular filtration rate (GFR).
7. For the important solutes of the body (e.g., Na+, K+, glucose, urea), describe how each segment of the nephron handles the solute (reabsorption, secretion, or both).
8. List examples of direct active transport, indirect (e.g., secondary) active, and passive transepithelial renal transport, including the substance being transported, any membrane proteins involved, and the direction of movement across the tubule wall.
9. Diagram or describe the micturition (urination) reflex, including the role of stretch receptors.
10. Describe voluntary control of micturition, including changes in the activity of specific neural pathways.
11. Using a negative feedback pathway, diagram or describe the reflex release of vasopressin (ADH, antidiuretic hormone), including stimuli, location and role of relevant sensors, locations of vasopressin synthesis and release, target tissue(s), and response(s).
12. Identify the renal tubule sites of Na+ reabsorption and describe which locations are subject to endocrine or neural control.
13. For the renin-angiotensin system (RAS), diagram or describe the factors that initiate renin release, the pathway from angiotensinogen to angiotensin II (ANGII), and the effects of ANGII on target tissues.
14. Diagram or describe the effect of aldosterone on the nephron, including the tubule segments involved and the transport mechanisms that are altered by aldosterone.
15. List the types and locations of sensors (receptors) in the cardiovascular, nervous, endocrine, and urinary systems that monitor blood volume, blood pressure, or osmolarity.
16. Describe the general mechanisms of respiratory and renal compensations for disruptions of pH homeostasis.

Endocrine System

1. Explain the role of the hypothalamus in the synthesis, storage, and release of neurohormones from the posterior pituitary.
2. Explain the role of hypothalamic neurohormones in the release of anterior pituitary hormones and list the hypothalamic releasing/inhibiting neurohormone(s) for each anterior pituitary hormone.
3. Describe the role of the hypothalamic-hypophyseal portal system in communication between the hypothalamus and anterior pituitary.
4. Describe the biosynthesis and processing of thyroid hormones (T3 and T4) in the thyroid gland.
5. Diagram the hypothalamic-hypophyseal control of thyroid hormone secretion by thyrotropin releasing hormone (TRH) and thyroid-stimulating hormone (TSH or thyrotropin).
6. Diagram or describe the control of secretion of growth hormone (GH) by growth hormone releasing hormone (GHRH) and somatostatin (SS; also called growth hormone inhibiting hormone or GHIH).
7. Describe the targets, mechanisms of action, and physiological effects of growth hormone (GH) and insulin-like growth factors (IGFs).
8. Diagram or describe the epithelial transport mechanisms for intestinal absorption of calcium, and renal reabsorption of calcium.
9. List the targets for parathyroid hormone (PTH) and describe the effect(s) of PTH on each target (e.g., intestinal absorption and renal excretion of calcium and phosphate, bone resorption, calcitriol synthesis).
10. Diagram or describe steps in the processes of modification of vitamin D to biologically active calcitriol (vitamin D3; 1,25(OH2)D3; 1,25 dihydroxycholecalciferol) and the location each step occurs.
11. Explain the relationship between calcitonin and calcitonin gene-related peptide (CGRP) and describe the biological activity of calcitonin and CGRP.
12. Describe, compare and contrast the control pathways for release of adrenal glucocorticosteroids and adrenal catecholamines.
13. Describe the hypothalamic-hypophyseal control of cortisol secretion by corticotropin releasing hormone (CRH) and adrenocorticotropic hormone (ACTH or corticotropin).
14. Describe the primary targets of cortisol and the major physiological actions at each target.
15. Describe the physiological importance of adrenal catecholamines, including their major targets and the adrenergic receptor subtypes that mediate the responses.

Immune System

1. Describe the structure, function, and major locations of primary and secondary lymphoid structures.

2. Compare and contrast how chemical, physical, and mechanical barriers act as defense mechanisms in the body.
3. Compare and contrast the basic types of pathogens (e.g., bacteria, viruses, fungi, parasites).
4. Compare and contrast innate (nonspecific) with adaptive (specific) defenses in terms of the timing of response, specificity of response, and defenses utilized.
5. List and describe the typical molecules involved in an innate immune response (e.g., opsonins, complement, histamine, chemotaxins) and their functions.
6. Explain how the innate (nonspecific) and adaptive (specific) immune responses coordinate and cooperate in resistance to disease.
7. Compare and contrast antibody-mediated (humoral) and cell- mediated (cellular) immunity in terms of mechanisms of action, time course, and response.
8. Describe the mechanism of phagocytosis and destruction of pathogens.
9. Describe the mechanism of antigen presentation by antigen- presenting cells (APCs).
10. Explain the functions of antibodies (e.g., opsonization, agglutination, neutralization, activation of adaptive [specific] defenses) in an antibody-mediated (humoral) response.
11. Describe and explain the physiological importance of immunological memory.
12. Compare and contrast active and passive immunity with regard to the mode of acquisition of immunity and the presence/absence of immunological memory.
13. List and explain the causes of the classic signs of inflammation (e.g., heat, swelling, and pain).
14. Explain the benefits of local inflammation.
15. Compare and contrast the functions of class I and class II major histocompatibility complex (MHC) proteins in adaptive (specific) immunity.
16. Describe how the body differentiates between self and non-self, then predict the consequences of failure to recognize self (e.g., autoimmune disorders, blood transfusion reactions, organ donation rejection).

Reproductive (male and female) Systems

1. Describe, compare and contrast the anatomical structures and organs of the adult human reproductive systems.
2. Compare and contrast the roles of hormones (e.g., gonadotropin releasing hormone [GnRH], follicle stimulating hormone [FSH], luteinizing hormone [LH], androgens, inhibin, estrogens, progesterone) involved in reproductive processes (e.g., gamete production, sex drive).
3. Compare and contrast the processes of oocyte and sperm production with regard to the timing of meiotic divisions and the number of gametes produced from a single germ cell.
4. Identify and describe the structure and function of the spermatic cord and the transporting ducts (e.g., ductus [vas] deferens, ejaculatory duct, urethra).

5. Identify and describe the structure and function of accessory glands (i.e., seminal glands [seminal vesicles], prostate gland, bulbourethral [Cowper] glands).
6. Describe the pathway of sperm from the seminiferous tubules to the external urethral orifice of the penis.
7. Diagram or describe the hypothalamic-pituitary-gonad axis and the feedback loops that control the production and regulation of androgens, inhibin, and androgen-binding protein in the testis.
8. Diagram or describe the steps of spermatogenesis in the seminiferous tubule, including the roles of nurse (sustentacular, [Sertoli]) and interstitial [Leydig] cells.
9. Identify and describe the structure and functions of the uterus and the transporting ducts (e.g., uterine [Fallopian] tubes/oviducts and vagina).
10. Identify and describe the structure and functions of the prototypical female external genitalia (e.g., mons pubis, labia majora, labia minora, clitoris, greater vestibular glands).
11. Diagram or describe the hypothalamic-pituitary-gonad axis and the feedback loops that control production and regulation of estrogens, progesterone, and inhibin in the ovary.
12. Diagram or describe the phases of the ovarian cycle.
13. Graph or describe the cyclic patterns of blood concentrations of GnRH, FSH, LH, estrogen, progesterone, and inhibin through the ovarian cycle.
14. Graph or describe how estrogens and progesterone function to coordinate the timing of ovarian and uterine cycles into a menstrual cycle.
15. Identify the key events in oogenesis corresponding to each stage of follicular development.
16. Diagram or describe endocrine control of oogenesis and folliculogenesis by FSH, LH, estradiol, and inhibin, including the feedback loops.
17. Compare and contrast patterns of hormone secretion and corpus luteum lifespan in cycles when fertilization does or does not occur.
18. Describe the process and specific events occurring before and at fertilization (e.g., sperm capacitation, acrosomal reaction, corona radiata penetration, zona pellucida penetration, fusion of the oocyte and sperm plasma membranes).
19. Identify the source of human chorionic gonadotropin (hCG) and describe the role of hCG in the maintenance of the corpus luteum.