

**Note:** It was agreed that a passing grade for the challenge exam would be 75% (even though the prerequisite grade is lower). This will ensure that the students adequately understand the required material if they haven't taken A&P in over 3 years.

### **Anatomy and Physiology Challenge Exam Study Guidelines**

The challenge exam is a 2-hour online exam containing 120 multiple-choice questions. It assesses the understanding of the 14 core curriculum topics covered in a 6 credit post-secondary anatomy and physiology course, including body organization, cytology, histology, and the following organ systems: integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, respiratory, lymphatic, digestive, urinary, and reproductive systems. A minimum of 75% is required to pass the exam.

The following texts are recommended in reviewing the course material for the exam. Older versions of the text are acceptable.

Martini, F.H., Nath J.L. & Bartholomew E.F. (2012). *Fundamentals of Anatomy and Physiology* (9<sup>th</sup> ed.). Pearson.

Tortora, G.J. & Derrickson B.J. (2012). *Principles of Anatomy and Physiology* (13<sup>th</sup> ed.). Wiley.

Marieb, E.N. & Hoehn K. (2013). *Human Anatomy and Physiology* (9<sup>th</sup> ed.). Pearson.

#### **A. Overall Body Organization**

- Define and provide examples of anatomical terms used to describe body regions.
- Define and provide examples of directional terminology.
- Define the body planes.
- Define the body cavities and the organs contained within each cavity. BE able to identify the abdominal cavity into the 4 quadrants and Grid of 9.
- Define homeostasis.
- Describe the components of a feedback system.
- Compare positive and negative feedback systems.

#### **B. Cytology**

- Describe the key components of the cell.
- Describe the composition of the cytoplasm.
- Describe the structure and function of the following organelles: endoplasmic reticulum, Golgi apparatus, mitochondria, ribosomes, lysosomes, peroxisomes, proteasomes, centrosomes, and the cytoskeleton.
- Describe the composition of the plasma membrane.
- Describe the structure of phospholipids.
- Describe the structure and function of the lipid bilayer.
- Explain the function of cholesterol in the plasma membrane.
- Describe the structure and function of plasma membrane proteins.

- Describe the structure and function of the cell organelles.
- Describe the structure and function of the nucleus.
- Describe the structure of DNA, chromatin, and chromosomes.
- Describe the structure of genes and the genetic code.
- Describe the processes of transcription and translation in protein synthesis.
- Compare passive and active membrane transport mechanisms.
- Describe simple diffusion and facilitated diffusion (channel-mediated and carrier-mediated) and provide examples of substances transported by these mechanisms.
- Define osmosis and osmotic pressure.
- Describe the effects of hypertonic, hypotonic and isotonic solutions on cell volume.
- Describe ion pumps and the function of the Na<sup>+</sup> - K<sup>+</sup> pump, H<sup>+</sup> pump, and Ca<sup>2+</sup> pump.
- Describe secondary active transport (symporters and antiporters) and the role of Na<sup>+</sup> and ATP in this transport mechanism.
- Define endocytosis, phagocytosis, and exocytosis.
- Describe the stages of the cell cycle.
- Describe the stages of mitosis.

### **C. Histology**

- Define histology.
- Describe epithelial tissue.
- Describe the specialized structures located on the apical and basolateral surfaces of epithelial cells.
- Describe the classification of epithelial tissue based on cell shape and the number of cell layers, and provide examples.
- Describe connective tissue.
- Describe the composition of the extracellular matrix of connective tissue.
- Describe the structure and function of collagen, reticular fibres and elastic fibres.
- Describe the classification of connective tissue based on physical properties (connective tissue proper, cartilage, bone, blood, and lymph)
- Compare the structure, function, and location of loose and dense connective tissue proper.
- Compare the structure, function, and location of hyaline cartilage, fibrocartilage and elastic cartilage.
- Describe the structure of epithelial membranes.
- Compare mucous membranes and serous membranes in terms of structure, location, and function.

### **D. Integumentary System**

- Describe the structure and function of the cutaneous membrane.
- Name and describe the epidermal layers.
- Describe the function of keratinocytes, melanocytes, Langerhans cells, stem cells, and Merkel cells of the epidermis.
- Explain the function of the epidermis in protection and prevention of water loss.

- Explain the role of melanin in the determination of skin colour and protection from DNA damage.
- Describe the composition of the dermis layers.
- Explain how the dermis provides strength and elasticity to the skin.
- Describe the structure of hair and the hair follicle.
- Compare apocrine and eccrine sweat glands.
- Describe the composition and function of sweat.
- Describe the structure and location of sebaceous glands.
- Describe the composition and function of sebum.
- Describe the function of the skin in the synthesis of vitamin D.
- Describe the function of the skin in body temperature regulation.

### **E. Skeletal System**

- Describe the classification of bones based on bone shape.
- Describe the structure of long bones.
- Compare the periosteum and endosteum.
- Describe the composition of osseous tissue.
- Explain the importance of collagen fibres and calcium phosphate salts in bone tissue.
- Compare osteoblasts, osteoclasts, and osteocytes.
- Compare spongy and compact bone.
- Describe the structure of the osteon.
- Describe the structure and function of red and yellow bone marrow.
- Compare intramembraneous and endochondral bone growth.
- Describe the process of bone remodeling.
- Describe the effects of growth hormone, sex hormones, nutrition, and exercise on bone growth and remodeling.
- Explain the role of bone in calcium homeostasis.
- Describe the stages of bone repair following a fracture.
- Identify the bones of the axial and appendicular skeleton.\*(see appendices at the end for list of bones to learn for the exam)
- Describe the classification of joints based on degree of movement and structure.
- Provide examples of fibrous, cartilaginous and synovial joints.
- Describe the structure of synovial joints.
- Describe the function of ligaments and tendons.
- Describe the movements permitted by synovial joints.

### **F. Muscular System**

- Compare skeletal, cardiac and smooth muscle tissue.
- Describe the structure of skeletal muscle cells and the function of the sarcoplasmic reticulum, transverse tubules, and myoglobin.
- Describe the structure of thick and thin myofilaments.
- Describe the structure of the sarcomere.
- Describe the sliding filament mechanism of muscle contraction.

- Describe the structure of the neuromuscular junction.
- Describe the process of muscle cell excitation by motor neurons.
- Describe the contraction cycle.
- Explain the importance of calcium and ATP in muscle contraction.
- Describe the points of origin and insertion of skeletal muscles.
- Identify the major muscles and muscle groups of the muscular system.\* (see appendices at the end for list of muscles to learn for the exam)

## **G. Nervous System**

- Explain the role of the nervous and endocrine systems in homeostasis.
- Describe the organization of the central, peripheral, somatic and autonomic nervous systems.
- Describe the structure and stimuli detected by sensory neurons.
- Describe the structure and targets of motor neurons.
- Describe the structure and function of the cell body, axon, dendrites, and axon terminals of neurons.
- Describe the structure and function of neuroglia of the central and peripheral nervous systems.
- Describe the synthesis and function of myelin.
- Compare gray and white matter of the brain and spinal cord.
- Describe the resting membrane potential, threshold, and graded potential.
- Describe the depolarization, repolarization, and hyperpolarization phases of the action potential.
- Compare continuous and saltatory action potential propagation.
- Describe the process of synaptic transmission.
- Describe the cranial and spinal meninges.
- Identify the ventricles of the brain.
- Describe the function of the choroid plexus and the circulation of cerebral spinal fluid.
- Describe the structure and function of the blood brain barrier.
- Identify and describe the function of the following central nervous system structures: thalamus, hypothalamus, cerebellum, limbic system, basal nuclei, medulla oblongata, pons and midbrain.
- Identify the lobes of the cerebrum and the key functions of each lobe.
- Identify and describe the function of the following cerebral structures: central sulcus, longitudinal fissure, precentral gyrus, postcentral gyrus, motor and sensory association areas, prefrontal cortex, Wernicke's area, and Broca's area.
- Describe the structure of the spinal cord.
- Describe the following spinal nerve and spinal cord structures: anterior and posterior nerve roots; anterior, lateral, and posterior horns; anterior, lateral and posterior columns; posterior root ganglion.
- Describe the following ascending somatic sensory pathways: anterior and lateral spinothalamic tracts and posterior column.
- Describe the following descending somatic motor pathways: anterior and lateral corticospinal tracts.
- Describe the posterior column pathway.

- Identify the components of a spinal reflex.
- Compare the functions of sympathetic and parasympathetic divisions of the autonomic nervous system.
- Describe the organization of preganglionic neurons, autonomic ganglia, and postganglionic neurons.
- Describe the neurotransmitters released by autonomic neurons and the different receptor types.
- Explain how sympathetic and parasympathetic neurons act on the same target but produce opposite effects.

## **H. Endocrine System**

- Describe the key characteristics of hormones.
- Compare water-soluble and lipid-soluble hormones.
- Describe the mechanism of action of hormones on target cells (plasma membrane versus intracellular receptors).
- Describe the location and structure of the pituitary gland.
- Identify the hormones of the anterior and posterior pituitary gland.
- Describe the stimulus for release and the actions of pituitary hormones on target cells.
- Describe the hypothalamic-pituitary axis.
- Describe the location and structure of the thyroid gland.
- Describe the synthesis of thyroid hormone, the stimulus for release, and actions on target cells.
- Describe the location and structure of the parathyroid gland.
- Explain the role of parathyroid hormone and calcitonin in regulating calcium homeostasis.
- Describe the structure of the endo- and exocrine pancreas.
- Describe the synthesis of insulin and glucagon, the stimulus for release, and actions on target cells.
- Describe the location and structure of the adrenal gland.
- Identify the hormones released by the adrenal cortex and adrenal medulla.
- Describe the stimulus for release and the actions of adrenal hormones on target cells.

## **I. Cardiovascular System**

### **Blood**

- Describe the composition of blood.
- List the key plasma proteins and describe the function of albumin.
- Describe the process of hematopoiesis.
- Describe the structure of red blood cells.
- Describe the structure and function of hemoglobin.
- Describe erythropoiesis and the function of erythropoietin.
- Describe the process of red blood cell degradation in the spleen.
- Define hematocrit.
- Describe the ABO blood group.

- Describe the structure and function of neutrophils, monocytes / macrophages, basophils, eosinophils, and lymphocytes.
- Describe the structure and function of platelets.
- Describe the process of hemostasis (platelet plug formation / clotting).

### **The Heart**

- Describe the location of the heart.
- Describe the pericardium and layers of the heart wall.
- Identify the heart chambers, heart valves, and great vessels.
- Describe the function of atrioventricular and semilunar heart valves.
- Describe the flow of blood through the heart and circulation.
- Describe the pacemaker and conduction system of the heart.
- Describe the phases of the cardiac cycle.
- Define cardiac output, heart rate and stroke volume.
- Describe the factors that affect heart rate and stroke volume.

### **Blood Vessels**

- Describe the structure and function of elastic arteries, muscular arteries, arterioles, capillaries, venules and veins.
- Compare arteries and veins in terms of wall layers.
- Describe capillary pressures and capillary exchange.
- Define blood pressure.
- Describe the determinants of blood pressure.
- Describe the autoregulatory, neural and hormonal mechanisms that regulate blood pressure and cardiac output.
- Describe the location and function of baroreceptors.
- Compare pulmonary and systemic circulations.
- Identify the major blood vessels of the body.\* (see appendices at the end for list of vessels to learn for the exam)
- Describe the fetal circulation and placental blood supply.

### **J. Lymphatic System**

- Identify the structures of the lymphatic system.
- List the functions of the lymphatic system.
- Describe the process of lymph formation.
- Describe the structure of lymphatic capillaries.
- Describe the organization of lymphatic vessels and the flow of lymph.
- Describe the structure and function of lymph nodes, the thymus, and the spleen.

### **K. Respiratory System**

- List the structures of the upper and lower respiratory tracts.
- Compare conducting and respiratory airways.
- Describe the structure and function of the respiratory epithelium along the respiratory tract.

- Describe the structure and function of the nasal cavity, pharynx, larynx, and trachea.
- Describe the location and structure of the lungs.
- Describe the structure and function of the pleural membranes.
- Describe the organization of the bronchial tree.
- Describe the structure and function of alveoli.
- Define surface tension and explain the role of surfactant.
- Compare pulmonary and bronchial circulations.
- Describe the pressure and volume changes that occur during ventilation.
- Describe the function of the diaphragm, external intercostal muscles, and accessory muscles during ventilation.
- Define minute ventilation and alveolar ventilation.
- Define the lung volumes and capacities.
- Describe the factors that influence diffusion across the alveolar-capillary membrane.
- Describe the mechanism of oxygen and carbon dioxide transport in the blood.
- Describe the location and function of the respiratory control centres of the brain.
- Describe the location and function of peripheral and central chemoreceptors.
- Describe the stimuli that activate respiratory reflexes.

#### **L. Digestive System**

- Identify the structures of the digestive system.
- Describe the gastrointestinal tract wall layers and identify differences in wall layers between gastrointestinal tract regions.
- Describe the structure and function of the peritoneum, mesenteries, and omentum.
- Define chemical and mechanical digestion.
- Compare segmentation contractions and peristalsis.
- Describe the enteric nervous system and the nervous regulation of gastrointestinal function.
- Describe the composition and function of saliva.
- Describe the location and structure of the esophagus.
- Describe the swallowing reflex.
- Describe the location and structure of the stomach.
- Describe the structure of gastric glands and identify the cell types that produce gastric secretions.
- Describe the functions of the gastric secretions HCl, pepsinogen, mucus, intrinsic factor and gastrin.
- Describe the regulation of gastric function during the cephalic, gastric and intestinal phases of digestion.
- Describe the process of mechanical and chemical digestion in the stomach.
- Describe the location and structure of the small intestines.
- Describe the structure and function of circular folds, villi, and microvilli.
- Describe the function of intestinal secretions.
- Describe the location and function of brush border enzymes.
- Describe the location and structure of the pancreas.
- Describe the functions of pancreatic secretions.
- Describe the location and structure of the liver.

- Describe the key functions of the liver.
- Describe the composition of bile and the function of bile in lipid digestion.
- Describe the location and functions of the gallbladder.
- Describe the location, structure and function of the large intestines.
- Describe the function of bacteria in the large intestines.
- Describe the digestion of carbohydrates, proteins, and lipids along the length of the gastrointestinal tract.
- Describe the absorption of carbohydrates, proteins, and lipids along the length of the gastrointestinal tract.

## **M. Urinary System**

- Identify the structures of the urinary system.
- Identify the location of the kidneys.
- Describe the layers that surround and protect the kidneys.
- Describe the organization of the internal kidney into the renal cortex, renal medulla, renal pyramids, and renal columns.
- Describe the route of blood flow through the kidney.
- Describe the structure the nephron.
- Describe the route of urine drainage from the collecting duct to the ureter.
- Define filtration, reabsorption and secretion.
- Describe the structure and function of the renal corpuscle.
- Identify the layers of the glomerular filtration membrane.
- Identify the filtration pressures at the level of the glomerulus.
- Define glomerular filtration rate (GFR) and describe how GFR is regulated.
- Describe the processes of reabsorption and secretion at the level of the proximal convoluted tubule, nephron loop, distal convoluted tubule and collecting duct.
- Explain the role of the kidneys in regulating blood osmolarity and blood volume.
- Describe the effects of aldosterone and antidiuretic hormone on nephron function.
- Describe the location, structure and function of the ureters.
- Describe the location, structure and function of the bladder.
- Describe the micturition reflex.
- Describe the location, structure and function of the urethra.

## **N. Reproductive System**

### **Male Reproductive System**

- Describe the location and structure of the testes.
- Describe the structure of the wall of a seminiferous tubule.
- Describe the process of meiosis.
- Describe the process of spermatogenesis and spermiogenesis.
- Compare spermatogonia, primary and secondary spermatocytes, spermatids, and spermatozoa.



- Identify the location, structure and function of the following structures of the male reproductive tract: epididymis, ductus deferens, ejaculatory duct, and urethra.
- Identify the location, structure and function of the following accessory glands: seminal glands, prostate gland, and bulbourethral glands.
- Identify the hormones involved in male reproductive function.

### **Female Reproductive System**

- Identify the location, structure and function of the ovaries, uterine tubes, uterus, and vagina.
- Describe the process of oogenesis.
- Compare the following phases of the menstrual cycle: ovarian cycle and uterine cycle.
- Identify the events of the follicular phase, ovulation, and luteal phase of the ovarian cycle.
- Describe the structure of ovarian follicles.
- Compare oogonia, primary oocyte, secondary oocyte, ovum, zygote, and polar body.
- Identify the wall layers of the uterus.
- Identify the events of the proliferative phase, secretory phase, and menses of the uterine cycle.
- Explain the changes that occur in the uterus and ovaries if fertilization does not occur.
- Identify the hormones involved in female reproductive function.
- Describe the structure of the breasts and the function of the mammary glands.

## **BONE LABELING**

### **Axial Skeleton**

#### **Skull**

- cranial bones -- frontal, parietal, occipital, temporal, sphenoid, ethmoid
- facial bones -- maxilla, mandible, zygomatic, nasal

#### **Vertebral Column**

- cervical (atlas and axis), thoracic, and lumbar vertebrae (recognize each based on shape and size)
- sacrum and coccyx

#### **Thorax**

- sternum (manubrium, body and xiphoid process)
- ribs (true, false, floating)

### **Appendicular Skeleton**

#### **Pectoral Girdle**

- scapula
- clavicle

#### **Upper Limbs**

- humerus
- radius
- ulna
- carpals
- metacarpals
- phalanges

#### **Pelvic Girdle**

- coxal bones (ilium, ischium, pubis, acetabulum)
- pubic symphysis

#### **Lower Limbs**

- femur
- patella
- tibia
- fibula
- tarsals (calcaneous, talus)
- metatarsals
- phalanges

## **MUSCLE LABELING**

### **Thorax**

- diaphragm
- external intercostals
- internal intercostals

### **Chest**

- Pectoralis major
- Pectoralis minor

### **Back**

- Trapezius
- Latissimus dorsi
- Erector spinae

### **Shoulders and Arms**

- Deltoid
- Triceps brachii
- Biceps brachii

### **Abdomen**

- Rectus abdominus
- External oblique
- Internal Oblique
- Diaphragm

### **Hips and Legs**

- Gluteal group (3 muscles)
- Quadriceps femoris group (4 muscles)
- Hamstring group (3 muscles)
- Gastrocnemius

## **BLOOD VESSEL LABELING**

### **Great Vessels**

aorta

pulmonary trunk

pulmonary arteries (left and right)

superior vena cava

inferior vena cava

pulmonary veins (left and right)

### **Arteries**

ascending aorta

aortic arch

thoracic aorta  
abdominal aorta  
bronchial artery  
celiac trunk  
common hepatic artery  
left gastric artery  
splenic artery  
mesenteric artery  
suprarenal artery  
renal artery common  
iliac artery femoral  
artery brachiocephalic  
trunk subclavian  
artery brachial artery  
common carotid artery  
external carotid artery  
internal carotid artery  
vertebral artery

### **Veins**

external jugular vein  
internal jugular vein  
brachiocephalic vein  
subclavian vein  
brachial vein  
cephalic vein  
hepatic portal vein  
hepatic vein  
renal vein  
common iliac vein  
femoral vein