**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.


**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⁺- K⁺ pump, H⁺ pump, and Ca²⁺ pump.
• Describe secondary active transport (symporters and antiporters) and the role of Na⁺ 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 intramembranous 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
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**Veins**

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