COURSE OUTLINE
Human Physiology

Course Description
BI 262. Human Physiology. 4 hours credit. Prerequisites: BI 232 and CH 110 with a C or better or concurrent enrollment in CH 110. This course will enable the student to develop an understanding of the principles and functions of the human body systems. The student will study functions of basic chemistry, cells, tissues, and the following body systems: muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, urinary, digestive, and reproductive. The student will participate in six hours of lecture/laboratory per week. This course is an intermediate study designed primarily for pre-professional students such as dentistry, medicine, pharmacy, and physical therapy. The learning outcomes and competencies detailed in this course outline meet or exceed the learning outcomes and competencies specified by the Kansas Core Outcomes Groups project for this course as approved by the Kansas Board of Regents (Transfers as BIO2030).

Required Materials
For complete textbook information, refer to https://bookstore.butlercc.edu

Butler-assessed Outcomes
The intention is for the student to be able to
1. Apply the concept that form dictates function within the human body to different situations.
2. Discuss how the body systems are interrelated.
3. Apply the concept of homeostasis to body systems.

Learning PACT Skills that will be developed and documented in this course
Through involvement in this course, the student will develop ability in the following PACT skill area(s):

Analytical Thinking Skills
- Critical thinking - Through the application of the scientific process to human physiology, the student will develop the general concepts of physiology and apply those concepts to real-world situations in health-related fields.

Communication
- Reception and interpretation of messages - Through application of the scientific process to human physiology, the student will be able to interpret and evaluate application questions related to human physiology.

Technology
- Discipline-specific technology - Through proper use of a hemoglobinometer, hematocrit, blood pressure cuff, and respirometer, the student will be able to analyze physiological processes of the body.
Major Summative Assessment Task(s)
These Butler-assessed Outcome(s) and Learning PACT skill(s) will be demonstrated by:
1. Completing the department final exam (A-skill) which involves real-world questions that the student must interpret (C-skill) and answer in order to demonstrate a comprehensive understanding of physiology of the human body.
2. Demonstrating the ability to use a hemoglobinometer, hematocrit, blood pressure cuff, and respirometer.

Skills or Competencies
These actions are essential to achieve the course outcomes:
1. Discuss homeostasis.
2. Understand the chemical and metabolic basis of life.
3. Describe the function(s) of these organ systems: muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, urinary, digestive, and reproductive.

Learning Units
I. Introduction to study of physiology
   A. Define homeostasis or dynamic equilibrium and stress
   B. Describe how nervous and endocrine systems regulate homeostasis
   C. Define negative feedback mechanisms
   D. Describe these specific examples of negative feedback: blood pressure and blood glucose levels
   E. Define positive feedback mechanisms
   F. Describe these specific examples of positive feedback: uterine contractions during labor and coagulation of blood

II. Chemistry and metabolism
   A. Distinguish between inorganic and organic compounds
   B. List and describe the four major macromolecules, including the monomers, polymers, examples, and functions
   C. Discuss energy sources and usage within the body and cells
   D. Describe the following types of enzymes: oxidoreductase, hydrolytic liases, transferases, and ligases
   E. Explain how enzymes are regulated, including competitive and noncompetitive inhibition, temperature, and pH
   F. Distinguish between reversible and irreversible enzymes
   G. Define cellular respiration and differentiate between aerobic and anaerobic pathways
   H. Describe the reactants, intermediate products, end-products, and locations within the cell with respect to glycolysis, Krebs’ cycle, and electron transport chain
   I. Discuss alternative pathways to obtaining ATP and precursor molecules such as gluconeogenesis, deamination/transamination of amino acids, Cori cycle, and beta oxidation of fatty acids

III. The cellular level of organization
A. Describe the functions of the following membrane proteins: receptor protein (site/active site), enzyme, ion channel, gated ion channels (symport and antiports), cell-identity markers, and types of cell-adhesion molecules
B. Compare passive to active forms of transportation of ions through the plasma membrane
C. Define these passive forms of transport: simple diffusion, facilitated diffusion, osmosis, and filtration
D. Describe the types of solutions: hypotonic, hypertonic, and isotonic
E. Describe the direction and rate of water flowing across a selectively permeable membrane in hypotonic, hypertonic, and isotonic solutions
F. Define active transport and list examples
G. Define these types of bulk transport: phagocytosis, pinocytosis, and exocytosis
H. Explain G-protein coupled receptor (GPCR), second messenger, and cAMP methods of signal transduction
I. Define the process of protein synthesis: transcription and translation
J. Explain the roles of mRNA, rRNA, and tRNA in protein synthesis
K. Describe regulation of gene expression in human cells
L. Define these terms: cell cycle, cell division, mitosis, and cytokinesis

IV. Skeletal system
A. List the chemical agents that affect bone tissue development and how they are involved in building or reabsorption
B. State the function of bone cells
C. Describe how bone growth relates to osteon structure
D. Compare and contrast how calcitonin and parathyroid hormone affect bone growth and development

V. Muscular system
A. Explain the five functions of the skeletal muscular system
B. Describe the characteristics of muscle cells: excitability, contractility, extensibility, and elasticity
C. Describe the differentiation and growth of muscle fibers
D. Explain electrophysiology concepts as they relate to muscle cells: depolarization, repolarization and sodium-potassium pump
E. Review the comprehensive microanatomy of the muscle cell to the level of sarcomere bands
F. Define motor unit and describe the function of the neuromuscular junction, including the synaptic knob, synaptic vesicles, synaptic cleft, junctional folds, receptor proteins, calsequestrin, dystrophin, acetylcholine, and acetylcholinesterase
G. Describe the sequence of events for excitation, contraction, and relaxation.
H. Define threshold stimulus, latent period, and refractory period
I. Define muscle twitch, treppe, incomplete tetany, and complete tetany
J. Describe the energy sources for muscle excitation, contraction and relaxation, initial (myokinase and creatine kinase), short-term or secondary, and long-term energy sources
K. Describe muscle fatigue and oxygen debt

VI. Nervous system
A. Describe the basic principles of electricity
B. Describe the sodium-potassium pump, events of depolarization, action/local/resting membrane potentials, repolarization, and refractory period, with respect to nerves
C. Distinguish between impulse conduction along myelinated and unmyelinated fibers
D. Describe synaptic transmission and integration
E. Describe the functions of the neuron, astrocyte, microglia, ependymal, oligodendrocytes, Schwann cells, and satellite cells
F. Define neurotransmitter and name the four chemical types of neurotransmitters
G. Give an example of an excitatory and inhibitory neurotransmitter (ie. ACh and GABA.)
H. Describe modification of synaptic transmission: drugs, disease, enzymatic change, and reuptake
I. List the functions of the spinal cord
J. Define somatic/spinal reflex and describe the reflex arc
K. Distinguish between monosynaptic and polysynaptic reflexes in detail
L. Discuss the functions of the twelve pairs of cranial nerves
M. Describe visceral or autonomic reflexes, including pathways, organ effects, neurotransmitters, and receptors
N. Explain how the adrenal medulla is related to the nervous system
O. List the structures of the visceral (autonomic) reflex arc
P. Describe cholinergic and adrenergic fibers and name their types of receptors
Q. Define sensation
R. List the four requirements to experience a sensation
S. Describe the stimulus associated with these types of receptors: chemoreceptor, thermoreceptor, nociceptors, mechanoreceptors (baroreceptors), photoreceptors, and proprioceptors

VII. Endocrine system
A. Describe the general hormonal pathway: hormone, transport protein, target cell/tissue, receptor protein, hormone-receptor complex, and second messenger
B. Describe the chemical structure of various types of hormones and the synthesis of these hormones
C. Describe the steroid mode of action and non-steroid (monoamines, oligopeptides, polypeptides, and glycoproteins)
D. Describe the hormones, target organs, and actions of these glands: hypothalamus, anterior pituitary gland, posterior pituitary gland, thyroid gland, parathyroid glands, adrenal gland, and pancreas

E. Describe types of hormone interactions and processes: permissive, antagonistic, and synergistic effects; negative feedback; and positive feedback

VIII. Immune system

A. Describe the role of the lymphatic system in immunity
B. Describe nonspecific immune response in detail
C. Describe specific immune response in detail
D. Define these cells: T cells (cytotoxic, helper 1, helper 2, and memory), natural killer cells, B lymphocytes (plasma cells), and macrophages
E. Describe the functions of cytokines and complement
F. List factors that increase susceptibility to disease
G. Describe the four hypersensitivity reactions
H. Explain autoimmunity and give examples

IX. Cardiovascular system

A. Describe the functions of the formed elements
B. List the components or solutes found in plasma, including nitrogenous wastes and plasma proteins (albumin, globulin, and fibrinogen)
C. Know the normal values of blood: average volume in adults, pH, hematocrit, hemoglobin, erythrocytes, leukocytes, and platelets
D. Describe agglutination, blood typing, the ABO and Rh typing systems, and erythroblastosis fetalis
E. Describe hemostasis, vascular spasm, platelet-plug, and coagulation
F. Define clotting factor, list four examples of clotting factors, describe use of calcium ions and vitamin K in coagulation, and describe how these are affected by liver disease
G. Distinguish between intrinsic and extrinsic coagulation, including the cascade of common pathway of coagulation (clotting)
H. Explain causes of pulmonary embolisms
I. Compare and contrast causes of pulmonary embolus versus cerebral vascular accident
J. List the functions of the cardiovascular system
K. Define and describe cardiac conduction system: sinoatrial node, atrioventricular node, atrioventricular bundle, right and left bundle branches, and Purkinje fibers
L. Define systole and diastole
M. Describe the nervous system structures that control heart rate: cardiac center of medulla oblongata, cardiac accelerator nerve, and vagus nerve
N. Distinguish between depolarization and repolarization and review action potentials in the heart
O. List the events measured by the P-wave, QRS – complex, and T-wave
P. Define these arrhythmias: flutter, fibrillation, tachycardia, and bradycardia
Q. List the events of the cardiac cycle (complete heartbeat)
R. Describe causes of the heart sounds (lub + dub)
S. State normal heart rate or beats per minute for adults
T. Define stroke volume, end-diastolic volume, end-systolic volume, ejection fraction, and cardiac output, and conditions that increase or decrease it
U. Describe preload, afterload, and contractility of the heart
V. Describe the effects on heart rate: blood pressure, body temperature, respiratory rate, and very little K⁺
W. State the effects of sympathetic and parasympathetic stimulation on arteries: skeletal muscle arteries, skin arteries, and visceral organ arteries
X. Define systemic blood pressure and clinical blood pressure measures
Y. Describe how cardiac output, total blood volume, and resistance affect blood pressure
Z. Define resistance and describe how blood's viscosity, vessel length, and vessel diameter influence resistance
AA. Describe how blood pressure is regulated including hormones for vasoconstriction/vasodilation
BB. Describe cardiovascular disorders, including hypotension, hypertension, heart attack, and atherosclerosis
CC. Explain the relationship between exercise and the cardiovascular system.

X. Respiratory system
A. Describe the functions of the respiratory system
B. Discuss the gas laws and how they relate to respiratory functions
C. Describe the mechanisms of the three gas exchanges: pulmonary ventilation, alveolar gas exchange (external respiration), and systemic gas exchange (perfusion/internal respiration)
D. Define the following respiratory volumes and capacities: tidal volume, inspiratory reserve volume, expiratory reserve volume, residual volume, vital capacity, total lung capacity, and dead spaces
E. Describe role of the medulla oblongata and pons: dorsal respiratory group (inspiratory center) and ventral respiratory group (expiratory center) and the pontine center in the pons
F. Describe the stimuli detected and locations of chemoreceptors, baroreceptors, and irritant receptors needed to regulate the respiratory system
G. Describe the effects of histamine in relation to autonomic nervous system and airway resistance
H. List the components of atmospheric air
I. Describe all the ways O₂ and CO₂ gas is transported in the blood
J. Describe how temperature and pH affect oxygen saturation of hemoglobin.

XI. Urinary system
A. Describe the functions of the urinary system
B. Describe the urine-producing processes: glomerular filtration, tubular reabsorption, tubular secretion, and water conservation
C. Define juxtaglomerular apparatus
D. Describe how the filtration rate is regulated: autoregulation, sympathetic control, and the renin-angiotensin mechanism
E. Describe how aldosterone, natriuretic peptide, and antidiuretic hormone influence water/electrolyte balance
F. Describe these normal attributes of urine: color, clarity, odor, osmolarity, pH, substances present, and average daily volume
G. Define the term diabetes and name the hormone deficient in diabetes mellitus and diabetes insipidus
H. Describe the components and functions of the ureters, urinary bladder, detrusor muscle, internal/external sphincters, and urethra
I. Describe the differences between male and female urethra
J. Distinguish between the involuntary and voluntary reflexes for micturition
K. Describe the compartments/places where water is distributed from largest to smallest quantities
L. Describe how fluids move through the body compartments
M. Describe the sources of water (input) and the routes of water loss (output) and list the excretory organs
N. Describe how the antidiuretic hormone regulates fluid intake
O. Describe how the thirst response is triggered by the hypothalamus
P. Describe the enzymatic, hormonal, and protein effects on hydration
Q. Describe electrolyte vs. non-electrolyte (milliequivalents per liter, mEq/L) cations, and anions with respect to urinary processes
R. Describe the most common electrolytes by major locations, functions, and regulation of levels: Ca^{2+}, Na^{+}, K^{+}, Cl^{-}, HPO_{4}^{2-}, and HCO_{3}^{-}
S. Describe how aldosterone, calcitonin, and parathyroid hormone regulate Na^{+}, K^{+}, and Ca^{2+} levels and potential consequences of abnormal levels
T. Define pH, the pH scale, acids, and bases
U. Describe buffer, chemical buffer systems, and physiological buffer systems
V. Describe how bicarbonate-carbonic acid, phosphate, and protein chemical buffering systems work
W. Describe how the respiratory and urinary systems work as physiological buffer systems
X. Describe symptoms, metabolic causes, and respiratory causes of acidosis and alkalosis
Y. Explain in detail why the kidney is susceptible to hypertension

XII. Digestive system
A. Describe the functions of these components of saliva: salivary amylase, lingual lipase, mucus, lysozyme, and immunoglobulin A
B. Describe the functions of these components of gastric juice: mucus, hydrochloric acid, intrinsic factor, pepsinogen, gastric lipase, gastrin, serotonin, histamine, and somatostatin
C. Describe the functions of these components of pancreatic juice: trypsinogen, chymotrypsinsogen, procarboxypeptidase, pancreatic amylase, pancreatic lipase, ribonuclease, and deoxyribonuclease
D. Describe the components and actions of bile and the metabolic pathway of bilirubin into bile.
E. Describe the role of ANS in gastrointestinal absorption and motility.
F. Explain the role of gastrointestinal peptides including ghrelin, anorexogenic antagonist, leptins, GIP (gastric inhibitory peptide), CCK (cholesystokinin), gastrin, and secretin.
G. List examples of gastrointestinal abnormalities such as celiac disease, diverticulitis, diabetes Type I and Type II, fatty liver, hiatal hernia, gastritis, GERD, IBS, and peritonitis.
H. Explain alterations in metabolism as related to certain pathological digestive conditions such as constipation, nausea, vomiting, and diarrhea.
I. Differentiate between Type I and Type II diabetes and alternative pathways for glucose metabolism in the diabetic.
J. Explain nervous integration of digestive reflexes.
K. Describe the hepatic portal vein pathway and all of its tributaries.

XIII. Reproductive systems
A. Describe sexual reproduction, gametes, and zygote.
B. Describe the primary and secondary functions of the male reproductive system.
C. Describe the primary and secondary functions of the female reproductive system.
D. Distinguish between menarche and menopause.
E. Define meiosis, chromatid, chromatin, and chromosome.
F. Describe terms associated with the amount (number) of chromosomes present: diploid, haploid, and replicated chromosome.
G. Describe the stages of spermatogenesis (spermatogonium, primary spermatocyte, secondary spermatocyte, spermatid, and spermatozoa) and hormones that stimulate them.
H. Describe the parasympathetic response of erection and the sympathetic responses of emission and ejaculation.
I. Describe unequal cytokinesis and oogenesis.
J. Describe these developmental stages of the follicle: primordial follicle, primary follicle (granulosa cells), and Graafian (mature) follicle.
K. Define ovulation, corpus luteum, and corona radiata.
L. Describe these cells produced during oogenesis: oogonium, primary oocyte, secondary oocyte, and ootid/ovum.
M. Describe the phases and hormones associated with the menstrual cycles.
N. Describe non-uterine effects of estrogen and progesterone.
O. Describe the effects of androgens in women.
P. Describe the basic physiology of pregnancy.
Q. Describe sex determination.
R. Define the process of sex differentiation.
Independent and collaborative learning activities will be assigned to assist the student to achieve the intended learning outcomes. The following learning activities will assist the student to achieve course outcomes: lecture, lab, class discussion, group activities, written assignment, computer activities/simulations, textbook reading assignments, and other activities at the discretion of the instructor. These activities may either be face-to-face or online.

**Grade Determination**
The student will be evaluated on the basis of performance on the following: quizzes, assignments, oral presentation(s), lecture exams, lab practicals, and other methods of evaluation at the discretion of the instructor.