1 – Communication, Control, and Homeostasis

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the concept of communication among organ systems, including the hierarchy of communication among molecules, cells, tissues and organs.
B. To explain the concept of homeostasis, including internal condition, receptors, set point, controller, effectors, responses, and feedback.
2 – Cellular Anatomy

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

C. To explain how the plasma membrane is organized anatomically and how the phospholipid bilayer limits transport through membranes.
D. To explain the structure and function of the membranous organelles, including the mitochondria, nucleus, endoplasmic reticulum, Golgi complex, and vesicles.
E. To explain how the nucleus, endoplasmic reticulum, Golgi complex, vesicles, and plasma membrane are anatomically and functionally interrelated.
F. To explain the structure and function of the non-membranous organelles, including the ribosomes and cytoskeleton.
G. To explain the structure and function of the four major types of tissues, including epithelial, connective, muscle, and nervous tissues.
3 – Cellular Chemistry and Biomolecules

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the major properties of elements and molecules, including molecular bonds.
B. To explain the major properties of water and electrolytes, including cations and anions.
C. To compare and contrast the concepts of molarity and osmolarity.
D. To explain the concepts of pH and buffers.
E. To explain the structure, features and roles of carbohydrates, including monosaccharide, disaccharides, and polysaccharides.
F. To explain the structure, features and roles of lipids, including glycerol, fatty acids, glycerides, phospholipids, cholesterol, and eicosanoids.
G. To explain the structure, features and roles of amino acids and proteins.
H. To explain the structure, features and roles of nucleosides, nucleotides, and nucleic acids.
4 – Cellular Reactions and Enzymes

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the major types of chemical reactions, including the catabolic and anabolic reactions.
B. To explain the role of enzymes and enzyme regulation in chemical reactions, including the catabolic and anabolic reactions.
C. To explain the role glycolysis, decarboxylation, the tricarboxylic acid cycle and the electron transport system in carbohydrate metabolism.
D. To explain how lipids and proteins can be used as a source of energy.
5 – DNA, RNA and Protein Synthesis

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the process of transcribing DNA into RNA.
B. To explain the process of translating messenger RNA into protein and determining the destination of the protein.
C. To explain in a short essay or with diagrams how transcription factors in response to cortisol control the regulation of gene expression
6 – Cell Membrane Transport

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain how the phospholipid bilayer is organized to prevent the unrestricted passage of water and water soluble molecules, such as sodium and glucose, from one side to the other.
B. To explain the composition and organization of integral proteins, including channels, facilitative transporters, co-transporters and counter-transporters, and pumps.
C. To explain the process of passive transport across cell membranes.
D. To explain the process of active transport across cell membranes.
E. To explain the role of pumps and channels in determining the electrical potential across the cell membranes.
F. To explain the process of epithelial transport across the apical and basolateral membranes.
7 – Chemical Messengers and Cellular Signaling

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the similarities and differences among the paracines, autocrines, cytokines, neurotransmitters, hormones, and neurohormones.

B. To explain in a short essay or with diagrams the derivation, characteristics, and general function of chemical messengers, including the amino acids, amines, peptides, steroids, and eicosanoids.

C. To explain how lipid soluble chemical messengers, using cortisol as an example, lead to intracellular mediated responses.

D. To explain how water soluble chemical messengers, through binding to channel linked receptors, tyrosine kinase linked receptors, and G-protein coupled receptors, lead to extracellular mediated responses.
8 – Neural Communication

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To compare and contrast in a short essay or with diagrams the anatomical features and functions of unipolar neurons, multipolar neurons, and glial cells.
B. To explain the role of ion channels and membrane potentials in the generation and conduction of action potentials.
C. To explain the mechanisms responsible for synaptic communication, including synaptic anatomy, neurotransmitter secretion, and neurotransmitter action.
D. To explain the mechanisms responsible for the actions of common neurotransmitters, including glutamate, GABA, glycine, acetylcholine, norepinephrine, and serotonin.
E. To explain in a short essay or with diagrams the process and significance of integrating synaptic potentials.
9 – Sensory Neuron Organization and General Senses

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To compare and contrast in a short essay or with diagrams the anatomical organization and function of sensory receptors.
B. To explain the process of sensory transduction and coding.
C. To describe the somatosensory sensations and the receptors responsible for their detection.
D. To explain the circuitry responsible for processing somatosensory signals, including the posterior column-medial lemniscus pathway, the spinothalamic pathway, and the trigeminal sensory pathway.
E. To explain the modulation and filtering of somatosensory signals, especially pain.
10 – Special Senses

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the anatomical organization of the eye and the mechanisms responsible for accommodation.
B. To explain the organization of the retina and the mechanisms responsible for the detection of light by the photoreceptors.
C. To explain the processing of visual information by the retina.
D. To explain the circuitry for processing of visual information by the central nervous system.
E. To explain the organization of the ear.
F. To explain the organization of the cochlea and the mechanisms responsible for the detection of sound by the hair cells.
G. To explain the circuitry for processing of auditory information by the central nervous system.
H. To explain the organization of the semicircular canals, utricle and saccule, and the mechanisms responsible for the detection of movement by the hair cells.
I. To explain the circuitry for processing of vestibular information by the central nervous system.
J. To explain the organization of the tongue and the mechanisms responsible for the detection of taste by the taste cells.
K. To explain the circuitry for processing of gustatory information by the central nervous system.
L. To explain the organization of the nose and olfactory epithelium and the mechanisms responsible for the detection of odorants by the olfactory cells.
M. To explain the circuitry for processing of olfactory information by the central nervous system.
11 – Skeletal, Cardiac and Smooth Muscle Contraction

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the anatomical organization of skeletal muscle.
B. To explain the sliding filament mechanism of contraction of skeletal muscle.
C. To explain the mechanism for activation of skeletal muscle contraction.
D. To explain how different rates of activation influence contraction and tension development in different types of skeletal muscle.
E. To explain the anatomical organization of cardiac muscle.
F. To compare and contrast the contraction of cardiac muscle and the contraction of skeletal muscle.
G. To explain the mechanisms for activation and modulation of cardiac muscle contraction.
H. To explain the anatomical organization of smooth muscle.
I. To compare and contrast the contraction of smooth muscle and the contraction of cardiac muscle.
J. To explain the mechanisms for activation and modulation of smooth muscle contraction.
12 – Motor Neuron Organization, Reflexes and Movement

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the anatomical organization of motor neurons and motor units.
B. To explain the function of and the circuitry for stretch reflexes.
C. To explain the function of and the circuitry for withdrawal reflexes.
D. To explain the function of and the circuitry for tendon reflexes.
E. To explain the function of and the circuitry for vestibuloocular reflexes.
F. To compare and contrast the general function and circuitry of the medial and lateral motor pathways.
G. To explain the specific functions and circuitry of the vestibulospinal tract, the tectospinal tract, and the reticulospinal tracts.
H. To explain the specific functions and circuitry of the corticospinal tract, and the rubrospinal tract.
I. To explain the control of voluntary movement by the cerebral cortex.
J. To explain the role of the basal nuclei and cerebellum in the control of movement.
13 – Autonomic Nervous System

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To compare and contrast the general neural organization of the somatic motor and autonomic motor systems.
B. To explain the organization and function of the parasympathetic nervous system, including brainstem and spinal neurons, ganglia and ganglionic neurons, neurotransmitters and receptors involved.
C. To describe representative motor actions of the parasympathetic nervous system on the organs.
D. To name representative drugs acting on the parasympathetic nervous system and to explain their actions.
E. To explain the organization and function of the sympathetic nervous system, including the brainstem and spinal neurons, ganglia and ganglionic neurons, neurotransmitters and receptors involved.
F. To describe representative motor actions of the sympathetic nervous system on the organs.
G. To name representative drugs acting on the sympathetic nervous system and to explain their actions.
14 – Hormonal Communication, Endocrine Glands, and Hormones

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To compare and contrast the general patterns of organization seen in neural, neuroendocrine, and endocrine communication; including the general actions of hormones.
B. To describe the major endocrine glands, and to name representative hormones produced by these glands and their functions.
C. To explain the characteristics, synthesis and secretion of catecholamine hormones.
D. To explain the characteristics, synthesis and secretion of thyroid hormones.
E. To explain the characteristics, synthesis and secretion of peptide hormones.
F. To explain the characteristics, synthesis and secretion of steroid hormones.
G. To summarize the synthesis and secretion of water soluble hormones.
H. To summarize the synthesis and secretion of lipid soluble hormones.
I. To explain the role of extracellular receptors and second messenger systems in the actions of water soluble hormones, using as an example the control of cellular metabolism by insulin.
J. To explain the role of intracellular receptors and modulation of gene expression in the actions of lipid soluble hormones, using as an example the control of cellular metabolism by cortisol.
15 – Hypothalamus, Pituitary, Adrenal, Thyroid, Sympathetic NS, and Stress

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To compare and contrast the organization of the posterior pituitary and the anterior pituitary.
B. To explain the organization and control of the hypothalamic – pituitary axis in the control of metabolic hormones, and their role in the control of thyroid, adrenal cortical, and hepatic hormones.
C. To explain the organization and control of the hypothalamic – pituitary axis in the control of reproductive hormones, and their role in the control of the testes, ovaries, and mammary glands.
D. To explain the organization of the cerebral cortex, amygdala, hypothalamus, and brainstem in the integration of stress responses; including the role of CRF and the control and action of epinephrine, cortisol and T4/T3.
16 – Cardiac Pumping, Cardiac Output, HR, and Stroke Volume

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the flow of blood through the circulatory system; including the heart, systemic arteries and veins, and pulmonary arteries and veins.
B. To explain the pumping of blood through the heart and the functions of the phases of the cardiac cycle.
C. To explain the organization of the cardiac conduction system and its role in coordinating the pumping actions of the heart.
D. To explain the ionic basis of cardiac pacemaker potentials and action potentials and their role in the control of cardiac contractile cells.
E. To explain the foundation for the measurement of the electrocardiogram.
F. To explain the significance of the P, QRS, and T waves and to calculate heart rate and wave intervals in an ECG print out.
G. To explain the causative relationships between the electrical activity of the ECG and the systolic and diastolic blood flows.
H. To explain the role of heart rate and stroke volume, including end diastolic volume and end systolic volume, in determining cardiac output.
I. To explain the control of cardiac pacemakers and cardiac muscle by the parasympathetic and sympathetic nervous systems, including the adrenal medulla.
J. To explain the control of cardiac function by baroreceptor reflexes.
K. To name representative drugs acting on the heart and to explain their actions.
17 – Blood Vessels, Blood Flow, Vascular Resistance, and Blood Pressure

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the anatomical features of the blood vessels and to explain how their organization and size affect the movement of blood through the systemic and pulmonary vessels.
B. To explain the change in the blood pressure that occurs as the blood moves through the blood vessels, and to describe the calculation of mean arterial pressure.
C. To define blood flow, to explain the flow of blood through vessels in series and in parallel, and to describe the calculation of blood flow.
D. To define vascular resistance, explain how blood vessel size influences vascular resistance, and describe the calculation of vascular resistance.
E. To explain how the size of blood vessels influences the distribution of cardiac output and the flow of blood to different organs.
F. To explain the effects of changes in cardiac output and total peripheral resistance on mean arterial pressure.
G. To explain the effects of changes in blood volume and vascular compliance on mean arterial pressure.
H. To explain how local factors control the size of blood vessels.
I. To explain how the sympathetic nervous system, the posterior pituitary, and the renin-angiotensin system controls the size of blood vessels.
J. To explain how baroreceptor reflexes control blood vessel size and regulate arterial pressure.
K. To name representative drugs acting on the blood vessels and to explain their actions.
18 – Blood, Microcirculation, Exchange, and Fluid Volumes

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the composition and general function of the blood.
B. To explain the differences and functions of the erythrocytes, leukocytes, and thrombocytes.
C. To explain blood types, including A, B, AB, O, RH+ and RH-, and Rh incompatibility during pregnancy.
D. To explain hemostasis, including vascular responses, platelet responses, clotting, and clot removal.
E. To describe the capillary epithelium and explain its role in capillary diffusion and exchange.
F. To explain capillary filtration and absorption, and the role of vascular pressures and vasoconstriction in moving fluid into the vascular space.
19 – Ventilation, Gas Exchange and Transport

Objectives

Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the organization and general function of respiratory system.
B. To explain the relationship of the pleural membranes to the pleural cavities and the lungs, and the function of the pleural fluid.
C. To explain respiratory system pressure and transpulmonary pressure and their roles in lung function.
D. To compare and contrast the processes of exhalation and inhalation, including the roles of the respiratory pressures and the elastic connective tissues of the lungs.
E. To define airway flow and explain the calculation of airflow.
F. To define airway resistance, explain how airway size influences airway resistance, and describe the calculation of airway resistance.
G. To explain how changes in lung compliance affect lung volume and transpulmonary pressure.
H. To explain the role of respiratory rate and tidal volume in determining minute volume.
I. To describe ventilatory volumes commonly measured and explain their significance in respiratory evaluation.
J. To explain how local factors control the size of the respiratory airways.
K. To explain how the parasympathetic and sympathetic nervous systems control the size of the respiratory airways.
L. To explain the concept of partial pressures of gasses.
M. To explain the process of gas exchange between the alveoli and blood in the lungs, and gas exchange between muscle cells and blood in a muscle.
N. To explain the process of oxygen transport through the blood.
O. To explain the process of carbon dioxide transport through the blood.
P. To describe the control of respiration by neural circuits in the brainstem.
Q. To explain how mechanoreceptor and chemoreceptor reflexes control the rate and depth of respiration.
R. To explain how the respiratory system regulates acid-base balance.
20 – Digestion and Nutrient Absorption and Metabolism

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the general organization and function of the digestive system.
B. To explain the movement of food and digestion in the mouth and esophagus.
C. To explain the movement of food and digestion in the stomach.
D. To explain the movement of food through the small intestine and the interconnection of the small intestines with the pancreas and liver.
E. To explain the digestion and absorption of carbohydrates in the small intestines.
F. To explain the digestion and absorption of proteins in the small intestines.
G. To explain the digestion and absorption of fats in the small intestines.
H. To explain the movement of food and absorption in the large intestines.
I. To explain how the parasympathetic and sympathetic nervous systems control the gastrointestinal tract, pancreas, and liver.
J. To explain how gastrointestinal hormones control the gastrointestinal tract, pancreas, and liver.
K. To explain the absorptive metabolic pathways for the use of glucose, triglycerides, and amino acids.
L. To explain the postabsorptive metabolic pathways for the retrieval of glucose, and non-glucose sources of energy.
M. To explain the control of glucose metabolism by insulin.
N. To explain the control of glucose metabolism by glucagon.
O. To explain the control of glucose metabolism by epinephrine and sympathetic nerves.
P. To explain the control of glucose metabolism by cortisol.
Q. To synthesize the regulation of glucose metabolism by the various controlling hormones.
21 – Body Fluids, Filtrate and Urine Formation

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To describe the general organization and function of the urinary system, especially the kidney and the nephron.
B. To explain the process of blood filtration by the glomerular capillaries, including glomerular filtration rate.
C. To describe the tubular epithelium and its role in reabsorption.
D. To explain reabsorption in the proximal tubules.
E. To explain reabsorption and formation of an osmotic gradient by the nephron loop.
F. To explain reabsorption in the early distal tubules.
G. To explain reabsorption in the late distal tubules and collecting ducts.
H. To explain how local factors control renal blood flow and glomerular filtration rate.
I. To explain how the sympathetic nervous system, the posterior pituitary, and the renin-angiotensin system controls filtration and reabsorption.
J. To name representative drugs that affect renal filtration and absorption and to explain their actions.
K. To explain how baroreceptor reflexes regulate fluid and electrolyte balance in response to low blood volume.
L. To explain how osmoreceptor reflexes regulate fluid and electrolyte balance in response to low water intake (increased blood osmolarity).
M. To explain how the kidney controls acid secretion and bicarbonate reabsorption and participates in the regulation of acid base balance.
N. To explain how the kidney controls potassium secretion and participates in the regulation of potassium balance.
O. To explain how the kidney controls calcium and phosphate reabsorption and participates in the regulation of calcium and phosphate balance.
22 – Reproduction and Reproductive Cycles

Objectives
Given lecture and laboratory, competence in each objective will be demonstrated by writing short essays, drawing diagrams, and responding to multiple choices or matching questions, at the level of 85% or greater proficiency for each student.

A. To explain the general process of gametogenesis.
B. To explain the basic processes in sex differentiation.
C. To explain spermatogenesis in the male.
D. To explain the transport of sperm through the male reproductive system, and the mechanisms for causing an erection.
E. To explain the hypothalamic-pituitary-gonad control of male reproductive function.
F. To explain oogenesis in the female.
G. To explain the development of the ovarian follicle and the transport of the oocyte.
H. To explain the hypothalamic-pituitary-gonad control of female reproductive function.
I. To compare and contrast the early follicular, late follicular, and luteal phases of the menstrual cycle.
J. To explain how pregnancy prevents the sloughing off of the endometrium of the uterus.