

PHYSIOLOGY
STUDENT HANDBOOK
2017/2018



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DEPARTMENT OF PHYSIOLOGY

FACULTY OF MEDICINE

SABARAGAMUVA UNIVERSITY OF SRI LANKA

Table of Contents

	Page No.
1. Departmental message	01
2. Staff members	03
3.Recommended reading material	04
4. Main objectives	04
5. Teaching and learning methods	05
6. Detailed evaluation	06
7. Examination procedure	07
8. Repeat examination format	08
9. Attendance	08
10 Criteria for Distinction	08
11 Detailed learning outcomes	09

01. Departmental Message

Physiology is the study of the normal functions of the body. This is studied in the context of cellular, tissue and systemic levels. Physiology deals with learning of the mechanisms maintaining the environment surrounding the cell, which is known as homeostasis. The regulatory mechanisms operate at cellular and systemic levels to maintain these functions. An in-depth understanding of these mechanisms is achieved at the end of the course.

Propaedeutics deals with the introduction to the art and science of clinical medicine. It helps in bridging the preclinical and clinical disciplines.

The Students will acquire

Knowledge

In fundamental sciences the student will be able to understand the normal structure and function of the human body and the pathological basis of disease and apply this knowledge to clinical practice.

Skills

To obtain relevant information, perform a clinical examination, investigate appropriately, perform essential clinical procedures, treat the patient and discuss the further management plan with the patient and relatives and care givers.

To appreciate the importance of getting informed consent and encourage the patient to play an active role in their own care.

To apply their knowledge in the effective and humanitarian care of patients.

To play an important role as an active member of the health care team and give leadership when necessary.

To effectively communicate with the patient and their relatives for better management considering psychosocial aspects.

To play a continuous and active role in educating and promoting behaviors that lead to prevention of disease or its complications.

Attitude

To maintain high moral and ethical standards of practice.

To be courteous and respectful to all patients and maintain confidentiality in the doctor-patient relationship.

To be courteous and respectful to staff and be able to work in a multi disciplinary team.

To practice within his or her competency and seek expert advice or refer when necessary.

To be a life-long learner and update their knowledge and skills.

We wish you to make your study fruitful at the Faculty of Medicine, Sabaragamuwa University of Sri Lanka.

Wisdom

To develop a clear and strong mind to sort out problems and develop the correct path.

02. Staff Members

Head of the Department:

- Prof. Anura Weerasinghe
MBBS(Col),MD(Col),DCH(Col),DTM&H(Lond),MRCP
(UK),FRCP(Edin),PhD(Niigata),FCCP

Visiting Professor:

- Prof. Deepthi Samarage
MBBS (col), MD (col), MRCP (UK)

Lecturer Probationary

- Dr.M.M.J.A.Jayawardena
MBBS (USJP)

Technical Staff:

- Mr. D.L.D.D.P.Piyasena

Clerical Staff:

- Ms.R.M.D.P.Rathnayake

03. Recommended reading material

1. Ganong's Review of Medical Physiology,
Barrett KE, Barman SM, Boitano S, Heddwen BL 25th
edition, 2016, McGraw-Hill. New York.
2. Textbook of Medical Physiology,
Hall JE, 13^h edition, 2015, Elsevier Science Health
Science division. Philadelphia.
3. Hutchison's Clinical Methods,
Glynn M, Drake W (eds), 24th edition, 2018,
Saunders Ltd, Philadelphia.
4. Medical dictionary

04. Main objectives

At the end of the course in physiology and Propaedeutics the student should be able to

1. Acquire the knowledge related to the normal function of the human body.
2. Describe the pathophysiological basis of disordered functions of the human body.
3. Acquire the necessary practical skills relevant to human physiology at the preclinical level.
4. Critically analyze the physiological concepts in health and their derangements in disease.
5. Develop specifically communication skills needed for medical practice.
6. Develop basic clinical skills in assessing patients.

05. Teaching and learning methods

1. Lectures
2. Tutorials
3. Small Group Discussions
4. Practical sessions
5. Hospital Visits
6. Field visits
7. Research project

06. Detailed evaluation

1. Formative Assessment

1. Weekly assessment

These are based on weekly lectures. The assessment will include MCQ, SBR, SEQ.

2. End of the section assessment (control)

These are carried out periodically to help students to assess their knowledge based on each topic. There could be oral/MCQ/SRB/SEQ and practical sessions. The marks will not be carried forward.

2. Summative Assessment

1. End semester Examination / Continuous Assessment

These are held at the end of each semester and would cover the work during the semester. The marks of this examination will be carried as a continuous assessment mark to the final examination in each discipline. This will include:
- SEQ, MCQ, SBR&OSPE.

There will be no repeat examination. Students who absent themselves without a valid medical certificate will get a zero mark.

2. Final examination in Physiology / 2nd MBBS Examination / Bar Examination

This is the final examination in the discipline and covers work during all semesters.

The repeat examination will be conducted four weeks after results are released.

The students will have 4 attempts at their examination. The final examination will include a theory component (MCQ, SBR, SEQ OSPE) and viva voice. The viva board will consist of at least one external examiner.

07. Examination procedure

Two End Semester Examinations / Continuous Assessments will be held each, at the end of the 1st and 2nd semesters. At the end of the 3rd semester the Final Examination in Physiology / 2nd MBBS examination/ Bar Examination will be held.

End Semester Assessment 1 and 2 / Continuous Assessment 1 & 2

Method of assessment	No of questions in each assessment	Marks allocated to Final Examination in Physiology / 2 nd MBBS from each assessment	Total marks allocated to Final Examination in Physiology / 2 nd MBBS
MCQs+BRQs	30	6	(2×6)12
SEQs	3	6	(2×6)12
OSPE	10	3	(2×3)6
Total			30

2ndMBBS examination

Method of assessment	No of questions	Marks allocated to Final Examination in Physiology / 2 nd MBBS
MCQs	40	25
BRQs	10	
SEQs	5	25
OSPE	25	10
Viva		10
Contribution to 2 nd MBBS examination		70
Continuous assessment contribution		30
Total		100

Viva is based on cards (consisting of questions based on four different topics. Which is picked up by the candidate at the time of viva) and the research project.

08. Repeat examination format

Supplementary Examination for Final Examination in Physiology / 2nd MBBS Examination

Method of assessment	No of questions	Marks allocated to Supplementary / Repeat Examination
MCQs	40	35
BRQs	10	
SEQs	5	35
OSPE	25	20
Viva		10
Total marks		100

09. Attendance

1. To sit for the final examination in the discipline an attendance of at least 80% at small group discussions, practicals, tutorials and weekly assessments is mandatory even if the student submits a valid medical certificate. Those who fail to obtain 80% attendance will have to sit for the repeat examination and it may be counted as the second attempt.
No student will be admitted to the examination hall without the admission card issued by the Registrar.
2. Those who do not sit the Final Examination in Physiology on the stipulated date and without a valid reason acceptable to the Faculty Board will have to sit the repeat examination (considered as the second attempt) and will not be eligible for honors. Those who are capable of providing a valid medical certificate for not attending the final Examination in Physiology on the stipulated date will be allowed to sit for the repeat examination as his / her first attempt.
3. Students will have a maximum of 4 attempts at the final examination of the discipline. (Two attempts with the respective batch, 3rd and 4th attempts with the junior batch.)

10. Criteria for Distinction

To be eligible for a distinction the student should obtain a minimum of 75% in the discipline at the first attempt and obtain at least 60% in each component (including continuous assessments) of the examination of the discipline.

11. Detailed Learning Outcomes

(Propaedeutics topics to be covered during hospital and field visits)

1. How to make a portfolio
2. Communication skills and History Taking
3. Clinical problem identification
4. General Examination and pathophysiological mechanisms of common physical signs
5. Examination of the cardiovascular system and pathophysiological mechanisms of signs
6. Examination of the chest and pathophysiological mechanisms of signs
7. Examination of the abdomen and pathophysiological mechanism of signs
8. Examination of the Nervous system and pathophysiological mechanisms of signs
9. Common surgical problems and their pathophysiological mechanisms
10. Common paediatric problems and their pathophysiological mechanisms
11. Common gynaecological problems and their pathophysiological mechanisms
12. Physiological aspects of obstetric care and infertility
13. Diagnostic Principles in medical practice
14. Introduction to preventive measure in medical care
15. Carry out a research project

Cell

- Name the prominent cellular organelles and state their functions in cells
- Name the building blocks of the cellular cytoskeleton and state their contribution to the structure and function
- Name the intercellular and cellular to extracellular connections
- Define the process of exocytosis and endocytosis and describe the contribution of each to the cellular function
- Define proteins that contribute to membrane permeability and transport
- Recognize various forms of intercellular communication and describe ways in which chemical messengers (including second messengers) affect cellular physiology.

Body Fluids & overviews of biomolecules

- Define units used in measuring physiologic properties.
- Define pH and buffering
- Understand electrolytes and define diffusion, osmosis and tonicity
- Understand in general terms the basic building blocks of cell :
nucleotides, aminoacids, carbohydrates and fatty acids
- Understand the higher order structures of the basic building blocks:
DNA, RNA, proteins and lipids.
- Understand the basic contributions of the basic building blocks to
cell structure, function and energy balance.

Excitable tissue

Nerve

- Define and explain the significance of resting membrane potential
- Name the various types of glia and their functions
- Name the parts of a neuron and their functions
- Describe the chemical nature of Myelin and summarize the
different ways in which unmyelinated and myelinated neurons
conduct impulses
- Describe the orthograde and retrograde axonal transport
- Describe the changes in ionic channels that underlie the action
potential
- List the various nerve fiber types found in the mammalian nervous
system
- Describe the function of neurotrophins

Muscle

- Differentiate the major classes of muscle in the body
- Describe the molecular and electrical makeup of the muscle cell
excitation-contraction coupling
- Define the elements of the sarcomere that underlie striated muscle
contraction
- Differentiate the role(s) for Ca^{2+} in skeletal, cardiac and smooth
muscle contraction
- Appreciate muscle cell diversity and function

Synaptic Transmission

- Describe the main morphologic features of synapses
- Distinguish between chemical and electrical transmissions at synapses
- Describe fast and slow excitatory and inhibitory postsynaptic potentials, outline the ionic fluxes that underlie them, and explain how the potentials interact to create action potentials.
- Define and give examples of direct inhibition, indirect inhibition, presynaptic inhibition and post synaptic inhibition
- Describe the neuromuscular junction, and explain how action potentials in the motor neuron at the junction lead to contraction of the skeletal muscle
- Define denervation hypersensitivity

Neurotransmitters

- List the major types of neurotransmitters
- Summarize the steps involved in the biosynthesis, release, action and removal from the synaptic cleft of the major neurotransmitters
- Describe the various types of receptors for amino acids, acetylcholine monoamines, ATP, opioids, nitric oxide, and cannabinoids
- Identify the endogenous opioid peptides , their receptors, and their functions

Autonomic Nervous System

- Describe the location of the cell bodies and axonal trajectories of preganglionic and postganglionic sympathetic and parasympathetic neurons
- Name the neurotransmitters released by the preganglionic autonomic neurons, sympathetic and parasympathetic postganglionic neurons and adrenal medullary cells
- Name the types of receptors on autonomic ganglia and on various target organs and list the ways in which drugs can act to alter the function of the processes involved in transmission in the autonomic nervous system
- Describe the functions of the sympathetic and parasympathetic nervous systems

- Describe the location of some forebrain and brainstem neurons that are components of central autonomic pathways
- Describe the composition and functions of the enteric nervous system

Blood

- Describe the components of blood and lymph, their origins, and the role of hemoglobin in transporting oxygen in red blood cells
- Understand the molecular basis of blood groups and the reasons for transfusion reactions
- Delineate the process of hemostasis that restricts blood loss when vessels are damaged and the adverse consequences of intravascular thrombosis
- Identify the types of blood and lymphatic vessels that make up the circulatory system and the regulation and function of their primary constituent cell types
- Describe how physical principles dictate the flow of blood and lymph around the body
- Understand the basis of methods used to measure blood flow and blood pressure in various vascular segments
- Understand the basis of disease states where components of the blood and vasculature are abnormal, dysregulated or both.

Immunity

- Understand the significance of immunity, particularly with respect to defending the body against microbial invaders
- Define the circulating and tissue cell types that contribute to immune and inflammatory responses
- Describe how phagocytes are able to kill internalized bacteria
- Identify the functions of hematopoietic growth factors, cytokines and chemokines
- Delineate the roles and mechanisms of innate, acquired, humoral and cellular immunity
- Understand the basis of inflammatory responses and wound healing

Cardiovascular System

Electrical Activity of the Heart

- Describe the structure and function of the conduction system of the heart and compare the action potentials in each part
- Describe the way the electrocardiogram (ECG) is recorded, the waves of the ECG and the relationship of the ECG to the electrical axis of the heart
- Name the common cardiac arrhythmias and describe the processes that produce them
- Describe the ECG changes and the changes in cardiac function produced by alterations in the ionic composition of the body fluids

The Heart as a Pump

- Describe how the sequential pattern of contraction and relaxation in the heart results in a normal pattern of blood flow
- Understand the pressure, volume and flow changes that occur during the cardiac cycle
- Explain the basis of arterial pulse, heart sounds and murmurs
- Delineate the ways by which cardiac output can be upregulated in the setting of specific physiologic demands for increased oxygen supply to the tissues, such as exercise
- Describe how the pumping action of the heart can be compromised in the setting of specific disease states.

Cardiovascular Regulatory Mechanisms

- Describe the neural mechanisms that control arterial blood pressure and heart rate including the receptors, afferent and efferent pathway, central integrating pathways, and effector mechanisms involved
- Describe the effects of CO₂ and hypoxia on the rostral ventrolateral medulla
- Define how the process of autoregulation contributes to control of vascular caliber
- Identify the paracrine factors and hormones that regulate vascular tone, their sources and their mechanism of action

Circulation Through Special Regions

- Define the special features of the circulation in the brain, coronary vessels, skin and the fetus, and how they are regulated
- Describe how Cerebrospinal Fluid (CSF) is formed and reabsorbed, and its role in protecting the brain from injury
- Understand how the blood-brain barrier impedes the entry of specific substances into the brain
- Delineate how oxygen needs of the contracting myocardium are met by the coronary arteries and the consequences of their occlusion
- List the vascular reactions of the skin and the reflexes that mediate them
- Understand how the fetus is supplied with oxygen and nutrients in utero and the circulatory events required for a transition to independent life after birth.

Respiratory System

Mechanics of the Respiratory System

- List the passages through which air passes from the exterior to the alveoli and describe the cells that line each of them
- List the major muscles involved in respiration and state the role of each
- Define the basic measures of lung volume and give approximate values for each in a normal adult
- Define lung compliance and airway resistance
- Compare the pulmonary and systemic circulations, and list some major differences between them
- Describe basic lung defense and metabolic functions
- Define partial pressure and calculate partial pressure of each of the important gases in the atmosphere at sea level

Gas Transport

- Describe the manner in which O₂ flows “downhill” from the lungs to the tissues and CO₂ flows downhill from the tissues to the lungs
- List the important factors affecting the affinity of hemoglobin for O₂ and the physiologic significance of each

- List the reactions that increase the amount of CO₂ in the blood and draw the CO₂ dissociation curve for arterial and venous blood
- Define alkalosis and acidosis and list typical causes and compensatory responses to each
- Define hypoxia and describe differences in different types of hypoxia
- Describe the effects of hypercapnia and hypocapnia, and give examples of conditions that can cause them

Regulation of Respiration

- Locate the pre-Botzinger complex and describe its role in producing spontaneous respiration
- Identify the location and probable functions of the dorsal and ventral groups of respiratory neurons, the pneumotaxic center, and the apneustic center in the brainstem
- List the specific respiratory functions of the vagus nerves and the respiratory receptors in the carotid body, the aortic body and the ventral surface of the medulla oblongata
- Describe and explain the ventilatory responses to increased CO₂ concentrations in the inspired air
- Describe and explain the ventilatory responses to decreased O₂ concentrations in the inspired air
- Describe the effects of each of the main nonchemical factors that influence respiration
- Describe the effects of exercise on ventilation and O₂ exchange in the tissues
- Define periodic breathing and explain its occurrence in various disease states

Gastro Intestinal System

Overview

- Understand the functional significance of the gastrointestinal system, and in particular, its roles in nutrient assimilation, excretion and immunity
- Describe the structure of the gastro intestinal tract, the glands that drain into it and the subdivision into functional segments

- List the major gastro intestinal secretions, their components, and the stimuli that regulate them
- Describe water balance in the gastro intestinal tract and explain how the level of luminal fluidity is adjusted to allow for digestion and absorption
- Identify the major hormones, other peptides, and key neurotransmitters of the Gastro intestinal system
- Describe the special features of the enteric nervous system and the splanchnic circulation

Digestion and Absorption

- Understand how nutrients are delivered to the body and the chemical processes needed to convert them to a form suitable for absorption
- List the major dietary carbohydrates and define the luminal and brush border processes that produce absorbable monosaccharides as well as the transport mechanisms that provide for the uptake of these hydrophilic molecules
- Understand the process of protein assimilation, and the ways in which it is comparable to or converges , that used for carbohydrates
- Define the stepwise processes of lipid digestion and absorption, the role of bile acids in solubilizing the products of lipolysis, and the consequences of fat malabsorption
- Identify the source and functions of short chain fatty acids in the colon
- Delineate the mechanisms of uptake for vitamins and minerals
- Understand the basic principles of energy metabolism and nutrition

Gastrointestinal Motility

- List the major forms of motility in the gastrointestinal tract and their roles in digestion and excretion
- Distinguish between peristalsis and segmentation
- Explain the electrical basis of gastrointestinal contractions and the role of basic electrical activity in governing motility patterns
- Describe how gastrointestinal motility changes during fasting
- Understand how food is swallowed and transferred to the stomach
- Define the factors that govern gastric emptying and the abnormal response of vomiting

- Define how the motility patterns of the colon sub serve its function to desiccate and evacuate the stool.

Physiology of the Liver

- Describe the major functions of the liver with respect to metabolism, detoxification and excretion of hydrophobic substances
- Understand the functional anatomy of the liver and the relative arrangements of hepatocytes, cholangiocytes, endothelial cells, and Kupffer cells
- Define the characteristics of the hepatic circulation and its role in sub serving the liver's fuctions
- Identify the plasma proteins that are synthesized by the liver
- Describe the formation of bile, its constituents, and its role in the excretion of cholesterol and bilirubin
- Outline the mechanisms by which the liver contributes to whole body ammonia homeostasis and the consequences of the failure of these mechanisms, particularly for brain functions
- Identify the mechanisms that permit normal functioning of the gall bladder and the basis of gallstone disease.

Endocrine Functions of the Pancreas

- List the hormones that affect the plasma glucose concentration and briefly describe the action of each
- Describe the structure of the pancreatic islets and name the hormones secreted by each of the cell types in the islets
- Describe the structure of insulin and outline the steps involved in its biosynthesis and release into the bloodstream
- List the consequences of insulin deficiency and explain how each of these abnormalities are produced
- Describe the insulin receptors, the way they mediate the effects of insulin, and the way they are regulated
- Describe the types of glucose transporters found in the body and the function of each
- List the major factors that affect the secretion of insulin
- Describe the structure of glucagon and other physiologically active peptides produced from its precursor
- List the physiologically significant effects of glucagon and the factors that regulate the glucagon secretion
- Describe the physiologic effects of somatostatin in the pancreas

- Outline the mechanisms by which thyroid hormones, adrenal glucocorticoids, catecholamines, and growth hormone affect carbohydrate metabolism
- Understand the major differences between type 1 and type 2 diabetes

Renal Physiology

Basic Renal Functions

- Describe the morphology of a typical nephron and its blood supply
- Define autoregulation and list the major theories advanced to explain autoregulation in the kidneys
- Define glomerular filtration rate, describe how it can be measured and list the factors affecting it
- Outline tubular handling of Na⁺ and water
- Discuss tubular reabsorption and secretion of glucose and K⁺
- Describe how the countercurrent mechanism in the kidney operates to produce hypertonic or hypotonic urine
- List the major classes of diuretics ; understand how each operates to increase urine flow

Volume Homeostasis

- Describe how the tonicity (osmolality) of the extracellular fluid is maintained by alterations in the water intake and vasopressin secretion
- Discuss the effects of vasopressin, the receptors on which it acts, and how its secretion is regulated
- Describe how the volume of the extracellular fluid is maintained by alterations in renin and aldosterone secretion
- Outline the cascade of reactions that lead to the formation of angiotensin II and its metabolites in the circulation
- List the functions of angiotensin II and the receptors on which it acts to carry out its functions
- Describe the structure and functions of atrial natriuretic peptide (ANP), B-type natriuretic peptide (BNP), and C- type natriuretic peptide (CNP) and the receptors on which they act
- Describe the site and mechanism of action of erythropoietin, and the feedback regulation of its secretion

Renal Acid – Base Balance

- Outline the processes involved in the secretion of H^+ into the tubules and discuss the significance of these processes in the regulation of acid base balance
- Define acidosis and alkalosis, and give (in mEq/L and pH) the normal mean and the range of H^+ concentrations in blood that are compatible with health
- List the principle buffers in blood, interstitial fluid, and intracellular fluid, and using the Henderson-Hasselbalch equation, describe what is unique about the bicarbonate buffer system
- Describe the changes in blood chemistry that occur during the development of metabolic acidosis and alkalosis, and the respiratory and renal compensations for these conditions
- Describe the changes in blood chemistry that occur during the development of respiratory acidosis and alkalosis, and the respiratory and renal compensations for these conditions

Endocrine System

Basic concepts

- Describe hormones and their contribution to whole body homeostatic mechanisms
- Understand the chemical nature of different classes of hormones and how this determines their mechanism of action on target cells
- Define how hormones are synthesized and secreted by cells of endocrine glands, including how peptide hormones are cleaved from longer precursors
- Explain the relevance of protein carriers in the blood for hydrophobic hormones and the mechanisms that determine the level of free circulating hormones
- Understand the principles of feedback control for hormone release and its relevance for homeostasis
- Understand the principles governing disease states that result from over or under production of key hormones

Hypothalamic Regulation of Hormones

- Describe the anatomic connections between the hypothalamus and the pituitary gland and the functional significance of each connection
- List the factors that control water intake, and outline the way in which they exert their effects
- Describe the synthesis, processing, storage, and secretion of the hormones of the posterior pituitary
- Discuss the effects of vasopressin, the receptors on which it acts, and how its secretion is regulated
- Discuss the effects of oxytocin, the receptors on which it acts, and how its secretion is regulated
- Name the hypophysiotropic hormones, and outline the effects that each has on anterior pituitary function
- List the mechanisms by which heat is produced in and lost from the body, and comment on the differences in the temperature in the hypothalamus, rectum, oral cavity and the skin
- List the temperature- regulating mechanisms and describe the way they are integrated under hypothalamic control to maintain normal body temperature
- Discuss the pathophysiology of fever

The Pituitary Gland

- Describe the structure of the pituitary gland and how it relates to its function
- Define the cell types present in the anterior pituitary and understand how their numbers are controlled in response to physiologic demands
- Understand the function of hormones derived from proopiomelanocortin in humans and how they are involved in regulating pigmentation in humans, other mammals and lower vertebrates
- Define the effects of the growth hormone in growth and metabolic function and how insulin like growth factor I (IGF-I) may mediate some of its actions in the periphery
- List the stimuli that regulate growth hormone secretion and define their underlying mechanisms
- Understand the relevance of pituitary secretion of gonadotropins and prolactin and how these are regulated

- Understand the basis of conditions where pituitary function and growth hormone secretion and function are abnormal and how they can be treated

The Thyroid Gland

- Describe the structure of the thyroid gland and how it relates to its function
- Define the chemical nature of the thyroid hormones and how they are synthesized
- Understand the critical role of protein binding in the transport of thyroid hormones and peripheral metabolism
- Identify the role of the hypothalamus and the pituitary in regulating thyroid function
- Define the effects of the thyroid hormones in homeostasis and development
- Understand the basis of conditions where thyroid function is abnormal and how they can be treated

The Adrenal Medulla and Cortex

- Name the catecholamines secreted by the adrenal medulla and summarize their biosynthesis, metabolism and function
- List the stimuli that increase adrenal medullary secretion
- Differentiate between C₁₈, C₁₉, and C₂₁ steroids and give examples for each
- Outline the steps involved in steroid biosynthesis in the adrenal cortex
- Name the plasma proteins that bind adrenocortical steroids and discuss their physiologic role
- Name the major site of adrenocortical hormone metabolism and the principal metabolites produced from glucocorticoids, adrenal androgens and aldosterone
- Describe the mechanisms by which glucocorticoids and aldosterone produce changes in cellular function
- List and briefly describe the physiologic and pharmacologic effects of glucocorticoids
- Contrast the physiologic and pathologic effects of adrenal androgens
- Describe the mechanisms that regulate secretion of glucocorticoids and adrenal sex hormones

- List the actions of aldosterone and describe the mechanisms that regulate aldosterone secretion
- Describe the main features of the diseases caused by excess or deficiency of adrenal hormones

Hormonal Control of Calcium and Phosphate

- Understand the importance of maintaining homeostasis of body calcium and phosphate concentrations and how this is accomplished
- Describe the body pools of calcium their rates of turnover and the organs that play central roles in regulating movement of calcium between stores
- Delineate the mechanisms of calcium and phosphate absorption and excretion
- Identify the major hormones and other factors that regulate calcium and phosphate homeostasis and their sites of synthesis as well as targets of their action
- Define the basic anatomy of bone
- Delineate cells and their functions in bone formation and resorption

Reproductive System

Female Reproductive System

- Name the key hormones secreted by Leydig cells and Sertoli cells of the testes and by the Graffian follicles and Corpora Lutea of the ovaries
- Outline the role of chromosomes, hormones and related factors in sex determination and development
- Summarize the hormonal changes in the body at puberty in males and females
- Outline the hormonal changes and their physiologic effects during menopause and perimenopause
- Describe the physiologic changes that occur in the female reproductive organs during the menstrual cycle
- Know the general structures of 17β - estradiol and progesterone and describe their biosynthesis, transport, metabolism and actions

- Describe the roles of the pituitary and the hypothalamus in the regulation of ovarian function and the role of feedback loops in this process
- Describe the hormonal changes that accompany pregnancy and parturition
- Outline the processes involved in lactation

Male Reproductive System

- Name the key hormones secreted by Leydig cells and Sertoli cells of the testes
- Outline the steps involved in spermatogenesis
- Outline the mechanisms that produce erection and ejaculation
- Know the general structure of testosterone and describe its biosynthesis, transport, metabolism and actions
- Describe the processes involved in regulation of testosterone secretion

Neurophysiology

Learning, Memory, Language and Speech

- Describe the various forms of memory
- Identify the parts of the brain involved in memory processing and storage
- Define synaptic plasticity, long term potentiation (LTP), long term depression (LTD), habituation, and sensitization and their roles in learning and memory
- Describe the abnormalities of brain structure and function found in Alzheimer disease
- Define the terms categorical hemisphere and representational hemisphere and summarize the difference between these hemispheres
- Summarize the differences between fluent and non-fluent aphasia and explain each type on the basis of pathophysiology

Reflex & Voluntary control of Posture & Movement

- Describe the elements of the stretch reflex and how the activity of Y-motor neurons alters the response to muscle stretch.
- Describe the role of Golgi tendon organs in control of skeletal muscle.
- Describe the elements of the withdrawal reflex.

- Define spinal shock and describe the initial and long-term changes in spinal reflexes that follow transection of the spinal cord.
- Describe how skilled movements are planned and carried out.
- Compare the organization of the central pathways involved in the control of axial (posture) and distal (skilled movement, fine motor movements) muscles.
- Define decerebrate and decorticate rigidity, and comment on the cause and physiologic significance of each.
- Identify the components of the basal ganglia and the pathways that interconnect them, along with the neurotransmitters in each pathway.
- Explain the physiology and symptoms of Parkinson disease and Huntington disease.
- Discuss the functions of the cerebellum and the neurologic abnormalities produced by diseases of this part of the brain.

Vision

- Describe the various parts of the eye and list the functions of each
- Describe the organization of the retina
- Explain how light rays in the environment are brought to a focus on the retina and the role of accommodation in this process
- Define hyperopia, myopia, astigmatism, presbyopia, and strabismus.
- Describe the electrical responses produced by rods and cones, and explain how these responses are produced.
- Describe the electrical responses and function of bipolar, horizontal, amacrine, and ganglion cells.
- Trace the neural pathways that transmit visual information from the rods and cones to the visual cortex
- Describe the responses of cells in the visual cortex and the functional organization of the dorsal and ventral pathways to the parietal cortex.
- Define and explain dark adaptation and visual acuity
- Describe the neural pathways involved in colour vision
- Identify the muscles involved in eye movements
- Name the four types of eye movements and the function of each

Somatosensory Neurotransmission: Touch, Pain, & temperature

- Name the types of touch and pressure receptors found in the skin.
- Describe the receptors that mediate the sensations of the pain and temperature.
- Define generator potential.
- Explain the basic elements of sensory coding.

- Explain the differences between pain and nociception, first and second pain, acute and chronic pain, hyperalgesia, and allodynia.
- Describe and explain visceral and referred pain.
- Compare the pathway that mediates sensory input from touch, proprioceptive, and vibratory senses to that mediating information from nociceptors and thermoreceptors.
- Describe processes involved in modulation of transmission in pain pathways.
- List some drugs that have been used for relief of pain and give the rationale for their use and their clinical effectiveness.

Hearing & Equilibrium

- Describe the components and functions of the external, middle, and inner ear.
- Describe the way that movements of molecules in the air are converted into impulses generated in hair cells in the cochlea.
- Explain the roles of the tympanic membrane, the auditory ossicles (malleus, incus and stapes) and scala vestibule in sound transmission.
- Explain how auditory impulses travel from the cochlear hair cells to the auditory cortex.
- Explain how pitch, loudness and timbre are coded in the auditory pathways.
- Describe the various forms of deafness and the tests used to distinguish between them.
- Explain how the receptors in the semicircular canals detect rotational acceleration and how the receptors in the saccule and utricle detect linear acceleration.
- List the major sensory inputs that provide the information that is synthesized in the brain into the sense of position in space.

Smell & Taste

- Describe the basic features of the neural elements in the olfactory epithelium and olfactory bulb.
- Describe signal transduction in odorant receptors.
- Outline the pathway by which impulses generated in the olfactory epithelium reach the olfactory cortex.
- Describe the location and cellular composition of taste buds.

- Name the five major taste receptors and signal transduction mechanisms in these receptors.
- Outline the pathways by which impulses generated in taste receptors reach the insular cortex.

Electrical activity of the brain

- Describe the primary types of rhythms that make up the electroencephalogram (EEG)
- List the main clinical uses of EEG
- Summarize the behavioral and EEG characteristics of each of the stage of non-rapid eye movement (NREM) and rapid eye movement (REM) sleep and the mechanism responsible for their production
- Describe the pattern of normal nighttime sleep in adults and the variations in this pattern from birth to old age
- Describe the interplay between brainstem neurons that contain norepinephrine, serotonin, and acetylcholine as well as GABA and histamine in mediating transitions between sleep and wakefulness
- Discuss the circadian rhythm and the role of the suprachiasmatic nuclei (SCN) in its regulation
- Describe the diurnal regulation of synthesis of melatonin from serotonin in the pineal gland and its secretion into the bloodstream.