MED2112: Biochemical Basis of Neuroendocrine, Excretory and Reproductive functions Module 2016/17 Batch

Year 2 Semester 1

Credits: 06

Responsible Department: Biochemistry

Module Coordinators: Prof. C.N.R.A. Alles and Dr. A.W.D.T. Ambagaspitiya

Topic	Time	Objectives	T/L activity	Comments
Introduction to excretion MED2112/1.1	1 hr	1. Explain what is meant by excretion. 2. List the waste material in cells and tissues. 3. Explain the mechanisms involved in the disposal of cell waste, and the consequences of accumulation of waste material. 4. List the organ systems involved in excretion and name the waste products excreted by each of the above system. 5. Explain the role of the following in excretion. i. Skin ii. Liver, biliary complex and the gut iii. Lungs iv. Kidneys and the urinary tract	Lecture (1 hour)	

Disposal of nitrogenous Waste **Urea & Urea cycle** **Uric acid** **Creatinine** **Sulphur** **MED2112/1.2**	2 hrs	1. Justify the modifications that a biomolecule undergoes prior to excretion. 2. List the biomolecules that lead to the formation of nitrogenous waste. 3. Recall / state the role of transamination and oxidative deamination in the removal of amino nitrogen. 4. Describe the importance of urea cycle in excretion of N waste. 5. Describe the urea synthesis pathway and its regulation, giving emphasis to i. Enzymes of the urea cycle ii. Regulation of urea biosynthesis iii. Enzymopathies in urea cycle iv. Effects of hyperammonemia 6. Apply the above knowledge to explain the derangements in nitrogen excretion in liver failure. 7. Explain the rationale for the elevation of Ala, Asp, and Glu concentrations in blood during fasting. 8. State the situations where catabolism of amino acids is increased. 9. Recall the pathways, regulation and derangements of nucleic acid catabolism. 10. State the precursors and function of creatine phosphate. 11. State why creatinine excretion is obligatory. 12. State in which forms sulphur is excreted, and their effect on urine pH.	Lecture (2 hours)	
Normal constituents of urine **MED2112/1.3**	3 hrs	Analyze for the normal constituents of urine and interpret the observations. i. Volume/ appearance/ osmolality/ pH / specific gravity ii. Urobillinogen, creatinine, urea, phosphate iii. Sediments (cells, casts, bacteria)	PD (2 x 3 hours)	
Abnormal constituents of urine **MED2112/1.4**	3 hrs	Analyze for the abnormal constituents of urine and interpret the observations. i. Glucose, protein, blood, bile salts and bile pigments, and ketone bodies ii. Sediments (cells, casts, bacteria) iii. Renal calculi	PD (2 x 3 hours)	

Xenobiotics **MED2112/1.5**	1 hr	1. Explain the term xenobiotic. 2. Describe the characteristics of the Cytochrome P_{450} enzyme system in the metabolism of xenobiotics. 3. Describe the Phase I and Phase II reactions involved in the detoxification of xenobiotics.	Lecture (1hour)	
Prenatal and postnatal growth **MED2112/2.1** **MED2112/2.2**	1 hr	1. Define the term "growth & development". 2. Classify the possible factors that can affect prenatal growth. 3. Discuss the importance of early detection of fetal defects based on biochemical investigations. 4. List the factors affecting postnatal growth and development. i.e. genetic, hormonal, nutritional, immunological and metabolic factors 5. Discuss the effects of each above factors on growth. 6. Workout the possible clinical problems that can arise from improper prenatal and postnatal growth. (Student activity)	Lecture (1 hour)	
Bone growth and remodeling **MED2112/3.1**	3 hrs	1. Compare and contrast bone modeling and remodeling. 2. Describe the phases of bone remodeling 3. Describe the process of remodeling of a callus 4. State How the structure of collagen and ground substances of bone facilitate the deposition of bone mineral 5. State the mechanism of calcification 6. Describe the factors affecting bone metabolism (genetic factors, nutritional factors-calcium, phosphorus, fluoride, mechanical factors, vascular and nerve supply, local factors, hormonal factors- Thyroid Hormones, Parathyroid Hormone (PTH), Estrogen, Calcitonin, 1, 25 (OH) 2 vitamin D 3 or calcitriol, androgens, progesterone, glucocorticoids, growth hormone, and insulin and insulin-like growth factor)	Lecture (3 hours)	2hours Lecture + 1hour Lecture on hormones

Markers of bone metabolism **MED2112/3.2**	4 hrs	1. Recall what biochemical markers are. 2. State the biochemical markers of bone metabolism and classify them. 3. Discuss the relevance of markers identifying the state of bone formation and resorption. (State alkaline phosphatase isoforms, differences between them and their tissue distribution) 4. Explain how serum concentrations of calcium, phosphorus and alkaline phosphatase is estimated and their clinical relevance.	Lecture (1 hour) PD (2 x 3 hours)	
Ageing **MED2112/4.0**	1 hrs	1. Describe the changes in the tissue composition in ageing (general & specific). 2. Describe the general changes in the cell, apoptosis and nutritional problem in ageing. 3. Describe how to delay the tissue changes in ageing.	Lecture (1 hour)	
Biochemistry of hormones **MED2112/5.0**	13 hrs			
Functional organization of the endocrine system **MED2112/5.1**		1. Explain the role of the endocrine system in homeostasis and metabolism. 2. Compare and contrast the characteristics of the nervous system and the endocrine system. 3. Describe the interaction between the nervous system and the endocrine system (hypothalamus – pituitary, autonomic nervous system – adrenal medulla). 4. Define the term 'hormone'. 5. Describe the terms ‘autocrine action’, ‘paracrine action’ and ‘endocrine action’, giving examples for each. 6. Classify hormones based on their physical and chemical properties. 7. List the subcellular locations of hormone receptors (cell membrane, cytoplasm, nucleus) and correlate the physical nature of hormones with the location of receptor. 8. Define the terms ‘first messenger’ and ‘second messenger’.	Lecture (2 hours)	SGD (2 hours) x 2 Covering all the objectives from MED2112/6.1 to MED2112/6.6

		9. Explain the role of second messenger systems in controlling cell function with examples (ligand-gated ion channels, G-protein-coupled receptors, cyclic AMP, cyclic GMP, IP_3, DAG, Ca^{2+}, protein tyrosine kinase cascade). 10. Compare and contrast a steroid and a peptide hormone with regard to structure and function (chemical nature, transport in blood, half-life in blood, site and type of corresponding receptor, second messenger system, mechanism of action, main effects on cell). 11. List the hormones synthesized and/ or secreted by the following: Hypothalamus, Pituitary, Thyroid, Parathyroid, Adrenal cortex and medulla, Gonads and placenta, Endocrine pancreas, Gastrointestinal system, Kidney, Heart and vascular endothelium, Pineal gland. 12. List the endocrine glands that are under hypothalamic control.		
Thyroid: Biochemistry of thyroid hormones MED2112/5.2		1. List the hormones secreted by the thyroid gland (T_3, T_4 and calcitonin). 2. Describe the steps involved in the synthesis and storage of thyroid hormones (trapping of iodine, oxidation, organification, conjugation). 3. State the role of iodine, thyroglobulin, thyroperoxidase and TSH, and the effect of anti-thyroid substances in thyroid hormone synthesis. 4. Describe the process of secretion of thyroid hormones into blood and how it is regulated. 5. State the role of proteins that bind thyroid hormones in blood (thyroxine-binding globulin, transthyretin and albumin). 6. Describe the metabolism of thyroid hormones in blood and compare the activity of T_3, T_4 and rT_3. 7. Describe the thyroid hormone receptor and explain the mechanism of action of thyroid hormones at cellular level. 8. Describe the actions of thyroid hormones on metabolism. 9. Correlate the biochemistry of thyroid hormone synthesis with the causes of hypothyroidism and hyperthyroidism. 10. Correlate the biochemistry of thyroid hormone and interpret the investigations of thyroid hormone status (TSH, total and free T_3/ T_4).	Lecture (2 hours)	

Adrenal medulla: Biochemistry of catecholamines (adrenaline and noradrenaline) MED2112/5.3		1. List the catecholamines secreted by the adrenal medulla 2. Outline the steps in biosynthesis and secretion of catecholamines 3. List the different types of adrenoceptor 4. Describe how catecholamines have different actions on different tissues based on the properties of adrenoceptors (second messenger system) 5. Describe the actions of the catecholamines on metabolism 6. State the enzymes involved in catabolism of catecholamines (MAO, COMT) and principle metabolites of adrenaline and noradrenaline (vanillylmandelic acid)	Lecture (1 hour)	
Adrenal cortex: Biochemistry of adrenocortical hormones MED2112/5.4		1. List the hormones secreted by the adrenal cortex. 2. Recall the biosynthesis of adrenocortical hormones. 3. Describe the functions of mineralocorticoids. 4. Describe the metabolic functions of glucocorticoids and their role in stress response. 5. Workout the possible consequences of enzymatic derangements in the biosynthesis of adrenocortical hormones (17α hydroxylase deficiency and congenital adrenal hyperplasia).	Lecture (1 hour)	
Biochemistry of sex hormones MED2112/5.5		1. List the sex hormones of human body. 2. List the tissues/cells which produce above sex hormones. 3. Outline the main steps of sex hormone synthesis. 4. Describe how the synthesis is regulated. 5. State how the sex hormones are transported to target cells. 6. Describe the mode of action of sex hormones in target cells. 7. Describe how the knowledge on biochemical action of sex hormones are used in clinical applications. (contraceptive methods, breast cancer treatment, infertility)	Lecture (2 hours)	

Gastrointestinal Hormones MED2112/5.6		1. Name the GI hormones and their sites of release (gastrin, secretin, cholecystokinin, ghrelin, motilin, GIP, VIP, histamine, somatostatin). 2. State the sites of action and functions of the GI hormones. 3. Illustrate the role of GI hormones in regulation of gastric, biliary and pancreatic secretions, GI motility and satiety, based on the composition of diet. 4. Workout the possible consequences of abnormal secretion of GI hormones.	Lecture (1 hour)	
Endocrine pancreas MED2112/5.7	2 hrs	1. List the hormones secreted by the pancreatic islets. (Insulin, Glucagon, Somatostatin and Pancreatic polypeptide) 2. Describe the biochemical actions of glucagon, somatostatin and Pancreatic polypeptide. 3. Describe the regulation of glucagon, somatostatin and Pancreatic polypeptide secretion. 4. List the steps involved in the biosynthesis and secretion of insulin. 5. Explain the regulation of insulin secretion. 6. Describe the insulin receptor. 7. Describe the signal transduction pathway initiated by insulin. 8. Describe the effects of insulin on carbohydrate*, lipid, protein and nucleic acids metabolism and growth. (* To be discussed under the glucose homeostasis)	Lecture (2 hours)	

Glucose homeostasis **MED2112/5.8**	2 hrs	1. Justify the importance of glucose homeostasis (maintenance of blood glucose concentration within a narrow range) 2. State the different types of glucose transporters and their locations 3. Discuss the role of insulin on glucose uptake of hepatocyte, myocyte, adipocyte, red blood cell, neurons, renal tissue, pancreatic islet cells, adrenal cortical cells, retinal cells, etc 4. Describe the biochemical and clinical significance of Obj. No. 3. 5. Discuss the role of hormones in glucose homeostasis in the cellular level (hepatocyte and myocyte). 6. Explain the role of liver, adipose tissue and muscles in glucose homeostasis (including the fed and fasting states).	Lecture (2 hours)	
Tests for glucose homeostasis **MED2112/5.9**	3 hrs	1. Measure glucose in blood. 2. Test for presence of sugars and ketone bodies in urine. 3. Interpret laboratory reports related to glucose homeostasis.	PD (2 x 3 hours)	
Derangement of glucose metabolism **MED2112/5.10**	6 hrs	1. Define the terms hypoglycemia and hyperglycemia. 2. Describe the causes of hyperglycemia and hypoglycemia. 3. Describe the short and long-term effects of hyperglycemia and hypoglycemia on different organs and tissues. 4. Define and explain, Impaired glucose tolerance, Impaired fasting glucose, prediabetes, Diabetes, gestational diabetes and Diabetic ketoacidosis.	Lecture (3 hours)	
		5. Describe the laboratory diagnosis of the above conditions. 6. Describe the oral glucose tolerance test. 7. Describe the significance of the analysis of glycated Hb in blood and microalbumin in urine. 8. Interpret the results of OGTT and HbA_{1C} and microalbuminuria.	PD (2 x 3 hours)	

Endocrine pancreas, Glucose homeostasis and diabetes MED2112/5.11	7 hrs	All above objectives in endocrine pancreas, glucose homeostasis and diabetes sections	CCR (2+2+1hours) SGD (2 hours)	Objectives on MED2112/6.7 MED2112/6.8 MED2112/6.9 & MED2112/6.10
Disorders of lipid metabolism 1.Lipoproteins & dyslipidaemias MED2112/6.1	5 hrs	1. List the major classes of lipoproteins and state their functions. 2. Draw the basic structure of plasma lipoproteins. 3. State the functions of important apoproteins. 4. Describe the basic steps in metabolism of chylomicrons, VLDL, TAG, HDL and LDL. 5. Describe the role of liver in transportation and metabolism of lipids. 6. Describe the hormonal regulation of lipid metabolism. 7. Describe the basis of derangements in lipid metabolism (dysfunctions of apoproteins and receptors). 8. State primary and secondary causes of dyslipidaemia. 9. Explain the biochemical basis of atherosclerosis (including atherogenic dyslipidaemia). 10. Describe the effects of dyslipidaemia. 11. State and interpret the laboratory tests available to assess derangements of lipid metabolism (lipid profile). 12. State the indications and patient preparation for laboratory analysis of serum lipids. 13. Describe the effects of dietary and lifestyle modifications on lipid profile. 14. Describe the mode of action of lipid lowering drugs (statins and fibrates, cholestyramine, fiber).	Lecture (2 hours) PD (2x 3 hours)	

Adipose tissue and obesity **MED2112/6.2**	5 hrs	1. State the two major types of adipose tissue in humans (brown adipose tissue (BAT) and white adipose tissue (WAT). 2. Compare and contrast the morphological and molecular characteristics of BAT and WAT. 3. Describe the functions of adipose tissue (BAT and WAT). 4. List the hormones secreted by adipose tissue. 5. Explain the role of above secretions in energy regulation, insulin sensitivity and obesity (Leptins, Agouti, Eicosanoids, Angiotensin II, Adiponectin, Resistin, IL-6, TNFα). 6. Describe the role of hypothalamus in maintaining energy balance (feeding & satiety). 7. Define obesity. 8. Describe the distribution of fat in the body- Central distribution, Peripheral distribution. 9. Describe the differences in metabolism in central and peripheral fat. 10. State the current prevalence of obesity; Sri Lankan & global. 11. State the methods available to measure adiposity. 12. Perform and interpret following anthropometric measurements, according to accepted guidelines; BMI, ideal body weight, body fat percentage (skin fold thickness), waist to hip ratio, waist circumference, waist to height ratio. 13. Calculate BMI, ideal body weight & body fat percentage. 14. Discuss the impact of obesity on health. 15. Discuss the role of diet and physical activity in prevention/treatment of obesity.	Lecture (2 hours) PD (2 x 3 hours)	
Nucleic acids & gene **MED2112/7.1**	1 hr	1. Describe the structure of nucleic acids. 2. Describe the functions of nucleic acids. 3. Compare and contrast the structure and functions of DNA and RNA. 4. Critically analyze the structure of DNA to identify the key features that are vital for its function. Define 'gene' and state the role of genes in the body.	Lecture (1 hour)	SGD (2hours) on MED2112/7.1 to MED2112/8.2

Gene expression and its regulation **MED2112/7.2**	1 hr	1. Define gene expression. 2. State the major steps involved in gene expression. 3. Critically analyze the concept of gene expression with emphasis on why gene expression should be regulated. 4. Briefly describe how eukaryotic gene expression is regulated. Compare and contrast the prokaryotic and eukaryotic gene expression.	Lecture (1 hour)	
DNA replication **MED2112/7.3**	1 hr	1. Define DNA replication 2. List the components required for DNA replication 3. Describe the major events of DNA replication Compare and contrast DNA replication and transcription	Lecture (1 hour)	
Cell Cycle **MED2112/7.4**	1 hr	1. State what is meant by the "cell cycle". 2. Describe the events that take place in the cell cycle. 3. State the cells which are in G_0 phase. 4. State how the cell cycle is regulated by cyclins, CDK, growth factors and products of oncosuppressor genes. Critically analyze the importance of cell cycle regulation in maintenance of health.	Lecture (1 hour)	
DNA damage, cancer and metabolic adaptations of cancer cell **MED2112/7.5**	2 hrs	1. State the factors that could damage DNA. 2. State how damaged DNA is repaired. 3. Define "oncogenes", "oncosuppressor genes" and "oncogenesis". 4. Explain how mutations of DNA repair genes, oncogenes and oncosuppressor genes lead to oncogenesis. 5. Analyze the new challenges that a cancer cell will encounter. 6. Describe how a cancer cell is metabolically adapted to face these challenges (including multidrug resistance). Briefly describe the systemic biochemical changes in terminal stages of cancer.	Lecture (2 hours)	

Application of molecular methods in Medicine MED2112/8.1	7 hrs	1. State how the molecular methods are applied in various fields of medicine (pre and postnatal identification or screening of genetic diseases, forensic medicine, identification of viral, bacterial and parasitic infections, for therapeutic purposes etc.). 2. Describe the basis of commonly used molecular tools or methods 2.1. Isolation of genetic material 2.2. DNA amplification and reverse transcriptase (including real time PCR)	Lecture (1 hour) PD (2 x 3hours)	(Obj. 2.1 - detailed in practical)
		2.3 DNA electrophoresis, Southern blotting, Northern blotting and DNA sequencing etc. 2.4 Restriction endonucleases and restriction fragment length polymorphism (RFLP)	Lecture (1 hour)	
		2.5 Separation of protein's, Western blotting, Enzyme-Linked Immunosorbent Assay (ELISA) and Enzyme Immuno-Assay (EIA).	Lecture (1 hour)	
Recombinant proteins MED2112/8.2		3. Define "recombinant proteins" and state why they are necessary. 4. State the application of recombinant proteins in treatment of diseases. 5. Describe the basis of the method involved in the production of recombinant proteins.	Lecture (1 hour)	

Inborn errors of metabolism MED2112/9.1	2 hrs	1. Explain what is meant by "Inborn errors of metabolism". 2. Explain how genetic defects can cause inborn errors. 3. Justify the importance of the knowledge of biochemical basis of Inborn errors of metabolism in clinical practice.	Lecture (1 hour)	SGD (2hrs) SGD on inborn errors of metabolism and neurotransmitters
Derangements of amino acid &nucleic acid metabolism MED2112/9.2		4. List the types of amino acidurias. 5. Apply the biochemical knowledge on derangement of amino acid metabolism in the management of related clinical conditions; 5.1 Phenylketonuria 5.2 Homocystinuria 6. Recall the synthesis and catabolism of nucleic acids. 7. Explain how the normal metabolism of nucleic acids can be deranged and its clinical impact. 8. Explain the effect of the accumulation of adenosine/deoxyadenosine, uric acid, xanthine and hypoxanthine in blood.		
Derangements of carbohydrate metabolism MED2112/9.3		1. List the types of derangement of carbohydrate metabolism. 2. State the causes and effects of derangements of fructose and galactose metabolism. 3. Describe the causes and effects of derangement of glycogen metabolism.	Lecture (1 hour)	
Derangements of lysosomal function and mucopoly- saccharide Metabolism MED2112/9.4		1. State the molecular basis of the derangement of lysosomal function. 2. Recall knowledge on mucopolysaccharides (MED 1103) 3. Discuss the derangements in mucopolysaccharide metabolism and relate its significance to diseases and their diagnosis.		
Derangements in porphyrin synthesis MED2112/9.5		1. Define the term "porphyria". 2. Recall the role played by ALA synthase. 3. Describe the significance of derangement in porphyrin synthesis.		

Neurotransmitters **MED2112/10.1**	4 hrs	1. Define the terms “neurotransmitters” and “neuromodulators” 2. Classify the neurotransmitters based on the structure and mode of action 3. Explain the mechanism of action of receptors with respect to neurochemistry. 4. Describe the biochemical aspect of specific receptors for neurotransmitters - ionotropic receptors (ion channels) - metabotropic receptors. 5. Describe the synthesis and hydrolysis of common neurotransmitters 6. State the mode of action of neurotransmitters aminobutyric acid (GABA), Norepinephrine and epinephrine, Dopamine, Serotonin, Acetyl choline, Glutamate, Nitric oxide and Peptides 7. Recognize that all of the known amino-acid neurotransmitters are non-essential amino acids.	Lecture (2 hours)	
Neurotransmitters and disease **MED2112/10.2**	1 hr	1. Describe the biochemical basis of commonly found neurological disorders. 2. Workout the pathogenesis of common neurological disorders based on biochemical derangement of neurological function. 3. Workout the possible treatment for above conditions with the basic knowledge of biochemistry.	Lecture (1 hour)	
Maintenance of brain environment **MED2112/10.3**	1 hr	1. Describe the chemical environment of the brain with special reference to blood-cerebrospinal fluid barrier and the blood-brain barrier. 2. Describe the importance of selective transport of substances across the above barriers. 3. Workout the clinical applications of the entry of xenobiotics across the above barriers. 4. Describe the importance of maintaining the composition of CSF. 5. Describe the importance of CSF as a diagnostic tool for diagnosis of certain neurological disorders.	Lecture (1 hour)	

Student centered learning activity	7 hrs	Present and discuss the key areas that are learnt during the module.	Student presentation 7 hours	Holistic approach on the module Revision of major topics by presentation and discussion to improve the student-centered learning**.**

Lectures – 46 hours **SGD – 10 hours** **Practical – 24 hours** **Student Seminar – 07 hours** **CCR – 05 hours**

Examination Format

Module	Credits	Total duration of examination	MCQ	SAQ	OSPE A	OSPE B
MED2112: Biochemical Basis of Neuroendocrine, Excretory and Reproductive functions	06	3 hours	20 (1 hour)	04 (1 hour)	10 (30 minutes)	10 (30 minutes)