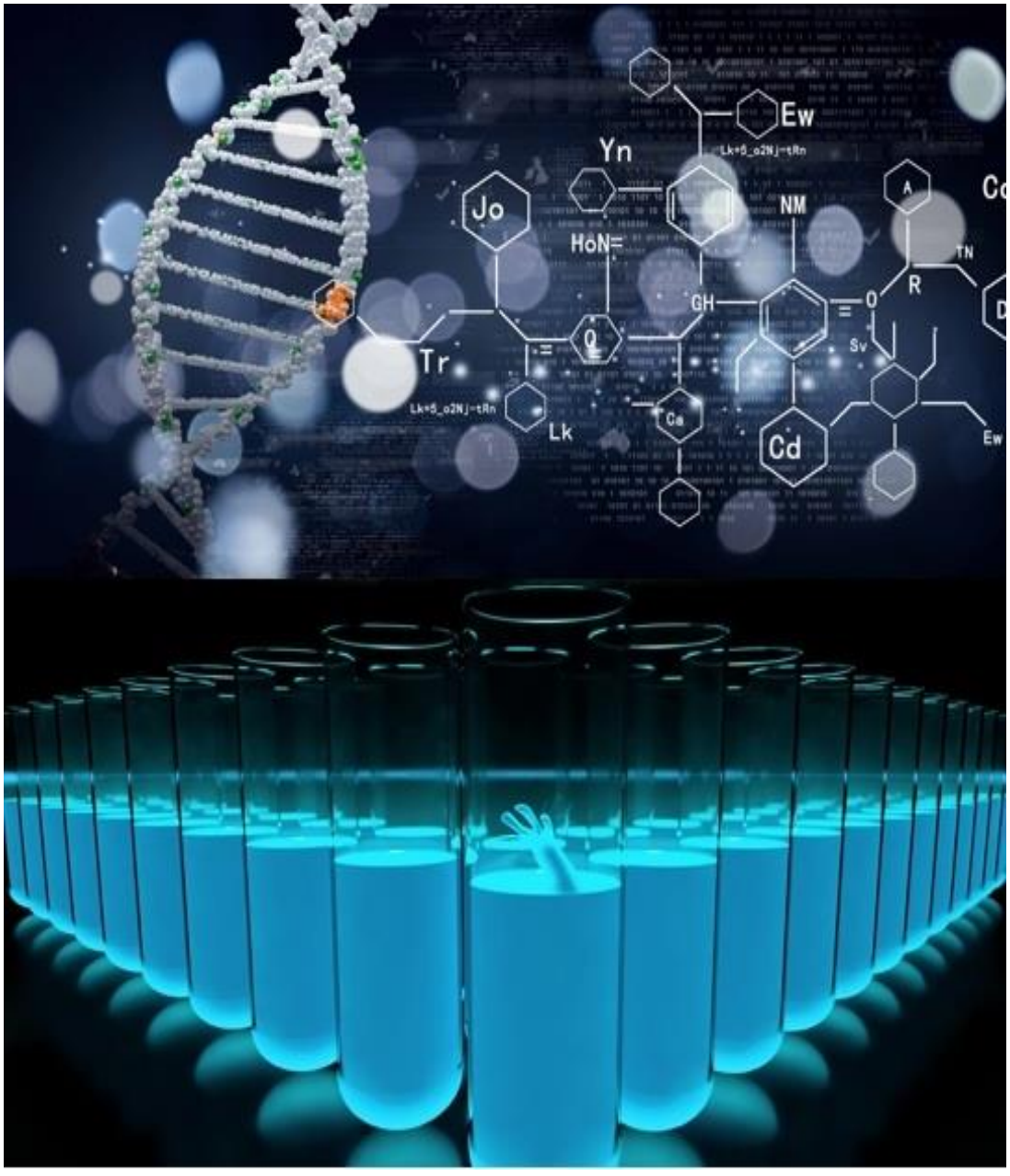
BIOCHEMISTRY
STUDENT HANDBOOK
2017/2018



BIOCHEMISTRY
STUDENT HANDBOOK
2017/2018

DEPARTMENT OF BIOCHEMISTRY

FACULTY OF MEDICINE
SABARAGAMUVA UNIVERSITY OF SRI LANKA

TABLE OF CONTENT

MESSAGE FROM THE DEPARTMENT

Dear Students,

'Biochemistry' is the study of the chemical basis of life, in other words, it is the application of chemistry to the study of biological processes at the cellular, molecular and sub-molecular levels. Knowing the Biochemistry helps to understand the molecular basis of diseases, current therapies, and action of new drugs. In future, therapies will possibly involve gene rather than organ transplants. Pharmacogenomics and Nutritional genomics will create a basis for designer treatments customized to an individual's genetic makeup.To understand all this it is essential to know functional interactions between metabolic pathways, organs and tissues.

This is course is designed to cover the aspects of Biochemistry relevant to medicine. A good knowledge of Biochemistry enables a student to understand normal healthy life and disease atmolecular level.

This handbook has been prepared to cover the information you will need for your programme and to assist you as a student. Please read it through and use it as a first point of reference.

We in the Department of Biochemistry while extending you a warm welcome to the youngest Medical School in Sri Lanka, wish you a happy and memorable stay with intellectual advancement and mental tranquility.

Yours

Staff/Department of Biochemistry.

STAFF MEMBERS OF THE DEPARTMENT

ACADEMIC STAFF MEMBERS

Professor NirmaliWickramarathne	Ph.D. in Biochemistry (USA), Grad. I.Chem.C.
Dr. N.D. Amal Wageesha	PhD in Biochemistry (Col), M.Philin Biochemistry (USJP), Grad I Cham C, M.I.Chem C.
Dr. I.H.V.Nicholas	Ph.D. in Biochemistry(Pera), B.Sc. (Chemistry Sp.) (USJP)
Mr. A.Y.A.P. Wipulasena	M. Sc (Biochemistry and Molecular Biology) (Col) M.Sc. (Biotechnology) (BU) B. Sc (Biotechnology) (BU),

NON-ACADEMIC STAFF MEMBERS

Ms. ChathurikaKarunarathne	B.Sc (Information Technology Sp) USJP

RECOMMENDED READING MATERIAL

- Lippincott's Illustrated Reviews – Biochemistry, Harvey RA (ed), 8th edition, 2013, Lippincott Williams & Wilkins, Philadelphia.

- Harper's Illustrated Biochemistry, Murray R, Rodwell V, Bender D, Botham KM, Weil AP, Kennelly PJ30th/31stedition

- Textbook of Biochemistry with Clinical Correlations, Devlin TM, 7th edition, 2010, John Wiley & Sons, New York

- Lehninger principles of biochemistry (6th Edition) Nelson, D., and Cox, M.

- Biochemistry. Jeremy M. Berg, John L. Tymoczko, LubertStryer 7th Edition

- Molecular Biology of the Cell (Sixth Edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.

- Nutritional Biochemistry 2nd Edition by Tom Brody.

- Nutritional Biochemistry and Metabolism: With Clinical Applications by Maria C. Linder.

OBJECTIVES

The teaching programmes of the Department of Biochemistry embody a fundamental approach to the chemistry of life and convey the strongly unifying contribution of biochemistry and molecular biology to other scientific disciplines. In order to understand a disease state, it is first necessary to study the normal pathways of the metabolism that is, the bio synthesis and break down of molecules, how different classes of biological molecules interact together to capture energy, build complex molecular machines, utilization of energy and regulation of metabolic pathways.

In addition you will be introduced to Clinical Biochemistry and to Molecular Biology to understand the disease processes at molecular level and modern methods of disease diagnosis.

By the end of the course, students should be able to:

1. Demonstrate knowledge and understanding of the molecular machinery of living cells.
2. Demonstrate knowledge and understanding of the principles that govern the structures of macromolecules and their participation in molecular recognition.
3. Describe the principles underlying enzyme catalysis.
4. Describe the mechanism of action of hormones and how they regulate biochemical pathways.
5. Explain how the genetic information is stored and transferred from generation to generation.
6. Explain how energy is generated, utilized and stored by various organs of the body.
7. Learn how metabolic pathways are regulated and how alteration of one pathway will affect the other.
8. Recognize how the abnormalities in biochemical processes lead to disease/s and the use of biochemical indicators in disease diagnosis.
9. Describe the requirement of micro and macronutrients by humans and how improper intake leads to various clinical conditions.
10. Discuss the importance of molecular biology in medicine.

Your knowledge acquired in this course will enable you to integrate Biochemistry with other basic and clinical sciences and should be able to apply biochemical principles to understand the pathophysiology of disease.

TEACHING/LEARNING METHODS

The teaching and learning methods includes lecture, practical sessions, guided learning sessions, small group discussions and tutorials.

While lectures provide you with basic information, small group discussions and tutorials give you an opportunity to discuss specific problems with your fellow students, and facilitators.

The laboratory practical and demonstrations will provide you the fundamental mechanism of disease diagnosis where some of these tests have to be carried out in a ward setting when you become a medical officer.

DETAIL EVALUATIONS

Assessments in the Department of Biochemistry

Biochemistry Semester-1
End of Semester assessment through a theory paper (End Semester Examination I /Continuous assessment I)

Biochemistry Semester II
End of Semester assessment through a theory paper (End Semester Examination II/Continuous assessment II)

Biochemistry Semester III
Final examination- (Bar examination/2nd MBBS examination)

EXAMINATION STRUCTURE AND FORMAT

a. End Semester Examination

These would be held at the **end of Semesters I & II** and will examine the knowledge acquired within that particular semester. This is a summative assessment. The assessment would be made using a two (2) hours theory question paper consisting of 15 MCQs and, 3 SEQs. Each paper will be marked out of 100. **Each paper** will contribute **ten (10) marks** towards the **final composite mark**.

***The Continuous Assessments will not be repeated**

b. The Final Examination in Biochemistry

There would be **three components** in the final assessment(Bar examination /2nd MBBS examination).

1. **A four (4) hour and 30 minutes theory paper covering the entire biochemistry syllabus.**

   The paper will contain **Forty (40) MCQs** (to be answered in 120 minutes) and **five (05) SEQ** (to be answered in 150 minutes).

2. **Objective Structured Practical Examination (OSPE).**

   This would be based on the practical classes, guided learning Sessions and small group discussions conducted throughout the entire Biochemistry course (three semesters). The examination will be of one (1) hour duration and will consist of twenty (20) spot tests where the student will have to observe demonstrations laid out and answer the question / s based on each of them.

3. ***Viva Voce* Examination.**

   This would be a structured card based assessment where a student will pick up a card with question/ topics (as the case may be) and face a viva voce based on the questions / topics in the card. The card is randomly picked by the student.

Calculation of Final Mark for Biochemistry Final Examination (Bar examination /2nd MBBS examination).

Compilation of the final mark will be as follows;

Semester Examination I	**10**
Semester Examination II	**10**
Final Examination (Theory)	**60**
OSPE	**10**
Card Based *viva voce*	**10**
Total	**100**

4. Other conditions

1. No student can omit both semester 1 and 2 (End Semester Examination I & II) examinations under any circumstances. In case of a valid Medical Certificate with University Medical Officers approval / Medical Board approval, 20% from End semester examination I or II will be taken for calculation of the final marks for Biochemistry.

2. In the final Examination students should complete all components of the examination within one attempt (in one sitting). If a student failed to do so the student has to repeat the entire examination (final examination).

3. If a student is unable to attend the total/part of the final examination due to a valid medical reason the student should submit a recognized medical certificate. In such a case the student shall sit the full repeat examination. This attempt will be considered his/her **1st attempt**.

4. In order to '**Pass**' the student should have obtained a minimum of 50% in the Final Examination and a minimum of **45% in theory components** (the average of End Semester Examination I, II and the theory component of the Final Examination (MCQ and SEQ)).

5. Repeat Examination procedure (Final examination in Biochemistry)

The first repeat attempt for the failures will be conducted after a period of 4/6 weeks.
The second repeat attempt will be with the immediate junior batch.

If a student fails Final examinations (proper and repeat), he/she is given two more attempts with the immediate junior batch as 3rd and the 4th attempt.

If a student fails in all 4 attempts he/she will be deregistered.

6. Marks allocation for Repeaters (Final Examination in Biochemistry)

Final examination (Theory)	**70%**
OSPE	**20%**
Viva Voce	**10%**

*****'Semester Examination I & II are not considered'

Maximum grade that a repeat student can obtain is **50%** (Pass mark) only

ATTENDANCE

A student must achieve a **minimum of 80%** attendance for tutorials, practical and small group discussions (SGD). Failure to achieve the 80% attendance the student will not be allowed to sit the Final examination; semester III.

He/ She will be permitted to sit with the repeat examination and this attempt will be considered as a repeat attempt.

CRITERIA FOR DISTINCTION

The student will be awarded a ‘Distinction in Biochemistry’ if he/she obtained a minimum of 60% for both End Semester Examinations(End Semester examination I and II) and a minimum of 70 % in the final examination, provided that the student has obtained these marks at his/her first sitting.

DETAILED LEARNING OUT COMES

Semester 1

Lecture topics

1. **Cell structure functions** 8 hours

   The student should be able to

   - Explain the way in which cell membranes and organelles contribute to cellular functions.
   - List major mechanisms of transport across membranes.
   - Describe the principle of passive and active mediated transport.
   - Explain the mechanisms of simple diffusion with example of voltage gated channels and ligandgated channels.
   - Explain passive mediated (facilitated) transport with examples.
   - Explain active transportusing Na^+/K^+ATPasesystem inglucose, galactose and amino acids transport across the intestinal mucosal system and proximal tubule.
   - Describe exo and endocytosis in macro-molecular transport with examples.
   - Explain the importance of the composition of oral rehydration solution.
   - Describe the action of ionophores.
   - Identify inhibitors of active transport systems with applications in medicine.
   - Explain the role of cytoskeleton in multi cellular organisms.
   - List the chief cytoskeleton protein filaments and briefly describe their structure and functions.
   - List common cytoskeleton disorders.

2. **pH and buffers** 2 hours

   The student should be able to

   - Define pH.
   - Explain how pH is determined.
   - Explain the significance of buffering action, buffering capacity and buffering range.

- Explain Henderson-Hesselbalch equation and list its applications.
- Explain the iso-electric pH.
- List the important buffering systems in the body and describe mechanisms of action.
- Describe metabolic and respiratory acidosis and alkalosis.

3. Carbohydrates 4 hours

The student should be able to

- Describe the functions, chemical properties of carbohydrates.
- Describe classification, stereoisomerism and tautomerism of monosaccharide.
- Recognize that monosaccharide units are linked together by glycosidic bonds to form disaccharides and polysaccharides.
- Identify the types of glycosidic linkages and their significance to humans.
- Identifying describe reducing and non-reducing properties of sugars.
- Classify the polysaccharides.
- Know the functions of sugar acids, alcohols and amines.
- Explain the basic features of glycosaminoglycans and recognize that glycosaminoglycans link with proteins to form proteoglycans with examples.
- Compare glycoproteins and proteoglycans with respect to basic structure and functions.

4. Amino acids and proteins 6 hours

The student should be able to

- Classify and name the amino acids.
- Explain the acid-base properties of amino acids.
- Explain zwitterions and iso electric point(pI)of amino acids.
- Understand the dehydration, decarboxylation and transamination reactions for amino acids.
- Describe the levels of organization of proteins and forces that does stabilize these structures.
- Explain the role of the sulpha-hydryl (SH) groups of glutathione in conferring antioxidant properties.

- Explain the structure – function relationship of myoglobin and haemoglobin.
- Explain denaturation and identify the agents that do so and the non-covalent interactions that are affected with examples.
- Explain the methods of protein purification and separation and explain the underline principles of separation methods.

5. Lipids 4 hours

The student should be able to

- Explain the functions of lipids.
- Classify fats, waxes and oils.
- Describe the structure of saturated and unsaturated fatty acids, their nomenclature with examples.
- Describe the structure of triacylglycerol and its general properties.
- Describe the structure of phospholipids and explain its amphipathic propertiesand biological importance.
- Describe the structure of sphingo-lipids and their functions.
- Describe the structure of cholesterol and functions.

6. Nucleic acids 12 hour

The student should be able to

- Explain structures, functions and properties nucleic acids.
- Explain how and why eukaryotic DNA is packaged.
- Explain semi conservative replication of DNA.
- Explain DNA repair mechanisms and the function of telomerase.
- Explain regulation of gene expression, genetic code and protein synthesis.
- Explain why amino acyl tRNAsynthatase consider as the 2^{nd} genetic code.
- Explain the importance of chaperones in protein folding.
- Give examples of protein misfolding in disease states.
- Identify the fundamentals of gene therapy and its medical important.

7. Enzymes 8 hours

The student *should be able to*

- Explain the characteristic properties of enzyme.
- Outline the hypotheses enzyme action (lock and key and induced fit models).
- List the types of reactions catalysed by the main classes of enzymes.
- Identify the factors that affect enzyme catalysed reactions.
- Define K_m and V_{max} values using Michaelis- Mentenand Line-Weaver and Burk plots.
- Recognize that the enzymes can be inhibited and explain different types of inhibitions using examples (competitive, non-competitive and suicide inhibition).
- Illustrate the different types of inhibition by graphical methods.
- Explain the regulation of enzyme activities, *via* induction, repression, allosteric modulation and covalent modification.
- Recognize the iso-enzymes and their biochemical importance.
- Classify cofactors.

8. Hormones 6 hours

The student should be able to

- Classify hormones based on their chemical structure and functions.
- Describe hormone receptors and their regulation (up regulation and down regulation)
- Classify the receptors according to their mechanism of hormone signal transduction.
- Explain hormone signal transduction and the action of second messengers.

Total Lecture Hours 50 Hours

Semester II

Lecture topics

1. **Introduction to metabolism** 2 hours

   The student should be able to

   - Describe ‘Anabolism’ and ‘Catabolism’.
   - Identify high energy compounds and exergonic and endergonicreactions.
   - Identify the points of regulation in metabolic pathways.

2. **Carbohydrate metabolism**

   a. Glycolysis and its regulation 2 hours

   The student should be able to

   - Explain how glucoseis transported into cells.
   - Outline glycol sis pathway and its regulation *via* allosteric, covalent modifications and induction and repression.
   - Explain substrate level phosphorylation
   - Explain the aerobic and anaerobic glycolysisand state the significance.
   - Explain the difference of energy output under aerobic and anaerobic glycolysis.
   - Explain the importance of glycolytic intermediates.
   - Explain glycolytic enzyme deficiency and their clinical significances.

   b.Metabolic pathways of lactose, **galactose and fructose** 2 hours

   The student should be able to

   - Outline lactose, galactose and fructose catabolism.
   - Outline the synthesis of lactose in lactating mammary gland.
   - Explain the consequences of known deficiencies of enzymes in these pathways.
   - Explain why fructose is not a substitute for sugar for uncontrolled diabetic.
   - Explain the development of cataract in diabetics due to excess of monosaccharide.

c. Acetyl CoAmetabolismandTCA cycle 2 hours

The student should be able to

- Explain the reaction catalysed by pyruvate dehydrogenase complex and its regulation.
- List the coenzymes and vitamins required by pyruvate dehydrogenase.
- Indicate the formation of citrate from acetyl CoA.
- Gives the sites and reactions of NADH, $FADH_2$, GTP and CO_2 formation.
- Compare the oxidative decarboxylation of pyruvate and alpha-ketoglutarate.
- Explain the regulation of TCA cycle.
- Explain the amphibolicnature of TCA cycle.
- Outline the anaplerotic reactions in TCA cycle.

d. Bioenergetics and oxidative phosphorylation 2 hours

The student should be able to

- Explain the significance of malate and glycerol-phosphate shuttles.
- Recognize that reduced coenzymes serve as energy source for oxidative phosphorylation.
- Name the sequence of the components of the electron transport chain (ETC).
- Indicate the entry points of electrons from NADH and $FADH_2$and explain the final reduction of O_2 to H_2O.
- Explain 'Mitchell's Chemiosmotic' hypothesis of ATP generation*via* an electrochemical gradient generated across the innermitochondrial membrane.
- Differentiatesubstratelevelphosphorylationandoxidativephosphorylation.
- Explain the process of uncoupling of oxidative phosphorylation and its significance in brown adipose tissue.
- Explain the effect of inhibitors of the ETC.

e. Gluconeogenesis and Glucose homeostasis 2 hours

The student should be able to

- Describe the five stages of glucose homeostasis in the fed and fasting states.
- Indicate the entry points of gluconeogenic substrates to the pathway.
- Describe the importance of gluconeogenesis, how it is regulated and how it maintains glucose homeostasis in the fasting state.
- Recall that the gluconeogenesis is a metabolically expensive pathway.
- Explain the role played by Insulin/Glucagon in regulation of gluconeogenesis.
- Explain the stimulation of gluconeogenesis under stress.
- Describe how excess ethanol consumption leads to fasting hypoglycaemia.
- Outline the importance of 'Cori cycle' and 'glucose –alanine cycle' in glucose homeostasis.

f. Glycogen metabolism and regulation 2 hours

The student should be able to

- Outline synthesis and breakdown of glycogen.
- Describe the reciprocal control of glycogen metabolism.
- Compare the control of glycogen metabolism inliverand skeletal muscle.
- Explain the biochemical basis of glycogen storage diseases.

g. Hexose monophosphate pathway 2 hours

The student should be able to

- Outline the pathway and state the significance of the oxidative and Non-oxidative phases of this pathway.
- Link the hexose monophosphate pathway to glycolysis.
- Describe the role of NADPH as a source of reducing equivalent in different tissues.
- Explain the effect of glucose-6-phosphate dehydrogenase deficiency in RBC.

3. LipidMetabolismand clinical correlations

a. Introduction to lipidmetabolism 2 hours

The student should be able to

- Describe the digestion and absorption of lipids.

b. Lipid biosynthesis and regulation 2 hours

The student should be able to

- Outline fatty acid synthesis and role of Outline the fatty acid synthesis and acetyl CoA, NADPH and citrate.
- Explain the role of acetyl CoA carboxylase action and its regulation.
- Explain the synthesis of triglycerides andphospholipids.
- Differentiate the lipid metabolism in liver and adipose tissue.

c. Fatty acid catabolism and regulation 2 hours

The student should be able to

- Describe how the fatty acids are activated and transported into the mitochondria.
- Outline the β oxidation pathway.
- Describe the regulation of fatty acid catabolism.
- State the biochemical importance of β oxidation.
- Explain the reciprocal regulation of fatty acid metabolism.

d. Eicosanoids and their metabolism 2 hours

The student should be able to

- List the eicosanoids.
- Explain the cyclo-oxygenase and linear pathways catalysed by prostaglandin synthase and lipooxygenase pathways in the synthesis of thromboxane, prostaglandins and leukotrienes.
- Explain the two enzyme activities of prostaglandin synthase.
- Explain the action of non-steroidal anti-inflammatory drugs (NSAIDS), aspirin and paracetamol on prostaglandin synthesis.
- Explain omega 3 and 6 fatty acids and their significance in synthesis of series 1, 2 and 3 eicosanoids.
- Outline the importance of balancing dietary omega 3 and 6.

e. Ketogenesis and biochemistry of ketone bodies 2 hours

The student should be able to

- List the types of ketone bodies.
- Outline the synthesis of ketone bodies.
- Explain when and why ketone bodies are produced.
- Explain the biochemical importance of ketone bodies.

f. Cholesterol biosynthesis and bile acid metabolism 2 hours

The student should be able to

- Outline the biosynthesis of cholesterol and its regulation.
- Outline the bile acid synthesis and its regulation and excretion.
- Outline the mechanism of cholelithiasis.
- List the mechanism of action of hypocholeterolaemic agents.

3. Proteins and Amino acid Metabolism

a. Protein digestion, absorption and amino acid metabolism 4 hours

The student should be able to

- Identify the enzymes required for digestion of dietary proteins and explain their functions at different sections of the alimentary canal.
- Explain the role of transamination and deamination reactions in amino acid metabolism.
- Describe the central role of glutamate in amino acid metabolism.
- Identify the ketogenic and glucogenic amino acids.
- identify the specialized products synthesized from amino acids (Neurotransmitters, melanin, histamine).
- Know the examples of in-born errors of amino acid metabolism
- (Phenylketonuria (PKU), albinism, Alkaptonuria (AKU) and maple syrup syndrome)

b. Urea cycle and regulation of Urea Cycle 2 hours

The student should be able to

- Describe urea cycle and its regulation.

- Describe the exchange of amino acids among different organs.
- Describe the effects of enzyme deficiencies of the urea cycle.
- Describe why excess ammonia is toxic to the body.

4. Purineand pyrimidinemetabolism 2 hours

The student should be able to

- Describe the *denovo* synthesis of purines andpyrimidines.
- Explain the regulation of *denovo* synthesis of purines.
- Describe the salvage pathway for purines.
- Explain the role of tetrahydrofolate(B_9) in purine and pyramid inebiosynthesis.
- Explain theeffect of enzyme deficiencies of the salvage pathway on the *denovo*syn thesis of purines.
- Explain purine catabolism and its end products.
- Explain the biochemical causes of hyperuricaemiaand the basis for the use of all opurinol in the treatment of gout.
- Describe the biochemical basis of anticancer drugs methotrexate and 5-fluorouracil.

5. Lipo-protein metabolism and clinical correlations 4 hours

The student should be able to

- List the types of lipoproteins.
- Outline the metabolism and functions of chylomicron, very low density lipoproteins (VLDL), and high densitylipoproteins (HDL).
- Describe different types of apo-lipoproteins and their functions.
- Explain the mechanism of LDLuptakeinto tissues.
- Describe Frederickson-WHO classification of abnormalities of lipo-proteins.
- Identify the electrophoresis of lipo-proteins and interpretation of lipid profiles.

6. Biochemistry of arthrosclerosis, cardiac markers and clinical correlations 2 hours

The student should be able to

- Describe the biochemical basis of atherosclerosis.
- Outline the risk factors for atherosclerosis.

- Explain the uses of cardiac markers in the diagnosis of myocardial infarction.
- explain the role of lipo-protein a (Lp a) in development of cardio vascular diseases
- Interpret laboratory reports.

7. RBC and Hemoglobin metabolism 2 hours

The student should be able to

- Describe the structure and distribution of haem in the body.
- Describe the haem metabolism.
- Describe the transport, hepatic uptake, conjugation and excretion of bilirubin.
- Describe different types of jaundice (haemolytic, intra and extra-hepatic cholestasis).

8. Xenobiotic/Liver metabolism 4 hours

The student should be able to

- Explain the role of liver in metabolism of xenobiotic and bilirubin.
- Outline the overall pathways for drug metabolism.
- Explain the metabolism of paracetamol.
- Explain the metabolism of ethanol and methanol.

9. Reactive oxygen and nitrogen species their clinical applications and anti-oxidants 2 hours

The student should be able to

- Explain what is meant by RONS.
- Name the RONS generated within the body.
- Give the effects of RONS to the body and their clinical significances.
- Importance of neutralizing RONS and role of anti-oxidants.

Total Lecture Hours 50 Hours

Semester III

Lecture topics

1. **Integration of metabolism** 4 hours

   The student should be able to

   - Outline the central role played by insulin and glucagon in coordinating metabolism in response to well fed, early fasting and prolonged fasting and starvation states and the modulatory influences of catecholamines and cortisol.

2. **Biochemistry of Hormonal disorders** 4 hours

   The student should be able to

   - Describe the integration of different endocrine glands to perform function and control homeostasis.
   - Discuss the major disorders associated with following endocrine glands.

     Pituitary
     Thyroid
     Adrenal
     Pancreas (see 3 below)
   - Explain the symptoms for the disorders associated with hormonal imbalance and their biochemical basis.
   - Describe different methods for diagnosis of endocrine-related disorders.

3. **Diabetes mellitus (DM)** 2 hours

   The student should be able to

   - Identify the metabolic alterations which lead to different types of DM.
   - Explain insulin resistance.
   - Describe clinical significance of estimation of fasting, random, postprandial blood glucose, Oral Glucose Tolerance test (OGTT), glucose challenge test, fructosamine, HbA1c, C-petide and Advanced glycated end products (AGE).
   - Inter prêt laboratory reports.

4. Biochemistry of Plasma protein and clinical applications

4 hours

The student should be able to

- List the main plasma proteins.
- Explain the diagnostic values of plasma proteins.
- Identify serum electrophoretic patterns in diagnosing clinical conditions and interpret laboratory reports.

5. Clinical enzymology 2 hours

The student should be able to

- Explain the terms 'upper and lower limit normal', 'time window', 'specificity' and 'sensitivity' in diagnosis.
- Describe the use of iso-enzymes in clinical practice.
- Describe the clinical significance of increased serum enzyme activity.
- Describe the serum enzymes/proteins that aid in diagnosis of different pathological conditions in liver, cardiac muscle, bone, skeletal muscle, kidney, prostate and pancreas.

6. Liver function/ profile test 2 hours

The student should be able to

- Describe what is included in a liver function / profile test.
- Describe the biochemical changes occurring in jaundice, cirrhosis and hepatitis.
- Differentiate the different types of Jaundice based on laboratory reports.
- Interpret liver profile reports.

7. Renal function/profile test 2 hours

The student should be able to

- Describe what is included in a renal function /profile test.
- Describe the clinical significance of glomerular filtration rate (GFR) and estimated glomerular filtration rate (e-GFR).
- Significance of serum creatinine and cystatin C, microalbuminuria, albumin/creatinineexcretion ratio in urine.

- Know the significance of eGFR and urine protein excretion in diagnosis of chronic kidney disease (CKD).
- Know to interpreturine full report and renal function test report.

8. Tumour Markers 2 hours

The student should be able to

- List commonly used tumor markers (ovary, breast, prostate, colon, liver, bone)
- Describe the significance of tumor markers in disease diagnosis and prognosis.
- Know to interpret laboratory reports.

9. Nutrition

a. Energy and protein requirement

i. Introduction and Energy of food 2 hours

The student should be able to,

- Recall the ways in which energy is used by humans(note; major protein Na/K pumps).
- Recall units of energy (kcal and J).
- Define the term 'Recommended Dietary Allowance' (RDA).
- Explain the terms 'gross energy' and 'metabolizable energy' values of food.
- Define "Atwater factors" and calculate energy value of food using the different values for macronutrients and alcohol.

ii.Amino acid and protein nutritive value 2 hours

The student should be able to,

- Distinguish between indispensable, dispensable and conditionally indispensable amino acids.
- List functions of amino acids and explain sparing action of amino acids.
- State the *in vitro* and *in vivo* methods that could be used for assessing the nutritive value of proteins ie. Biological

value, true digestibility, net protein utilization, chemical score and compare the advantages and disadvantages ofin *vivo* and *in vitro* methods.

iii. Energy requirements 2 hours

The student should be able to,

- Define respiratory quotient, specific dynamic action. Basal/resting metabolic rate (BMR/RMR) and state the conditions under which BMR are measured.
- Explain the effects of body size and composition, physical activity, hormones, gender and climate on energy expenditure.
- State the methods used in estimating energy requirements of an individual (BMR multiples depending on activity/ physical activity factors or equations with activity factors).
- Describe the energy and protein requirements in infant, child, adult elderly, pregnancy and lactation.
- Outline methods of nutritional assessment (ABCD approach).
- Describe the anthropometric measurements used in assessing the nutritional status of adults (waist circumference, hip circumference, waist: hip, mid upper arm circumference, BMI) and children (weight for height/weight for age/ height for age/ occipito-frontal circumference).

IV. Protein requirements and homeostasis 2 hours

The student should be able to,

- State the WHO definition of protein requirement of an individual,
  (a) an adult man (b) a pregnant woman (c) a lactating woman (d) pre-school child.
- Explain the term “nitrogen balance” and state the significance of N balance.
- State the effect of energy intake on N balance.

- Explain the term “protein-sparing action” and the importance of this action on energy requirement of an individual.
- State the mechanisms by which protein homeostasis is maintained during
  (a) amino acid imbalance (b) protein deficiency and (c) starvation.

V. Energy protein malnutrition (EPM) 2 hours

The student should be able to,

- State the changes seen in plasma in (a) Kwashiorkor and(b) Marasmus.
- List the clinical signs and symptoms in kwashiorkor and marasmus and relate them to biochemical changes occurring in EPM.
- List methods of assessing EPM.

b. Vitamins as nutrients

i. Introduction 2 hours

The student should be able to,

- Recall the discovery of vitamins.
- Define the terms vitamin, pro-vitamin and vitamer and state how a vitamin differ from a hormone and an enzyme.
- State the classification of vitamins.
- State good sources of fat soluble (A, D, E, K) and water soluble (B complex and C) vitamins.
- State the RDA of each fat and water soluble vitamins for infants/adolescents/adults/pregnant and lactating women wherever possible.
- Know the biochemical assessments for vitamin deficiencies.

ii. Fat soluble vitamins 2 hours

The student should be able to,

a. Vitamin A

- Outline the transformation of pro-vitamin A to Vitamin A, absorption and transport of vitamin A from intestine to liver and extra hepatic tissues.
- Explain the main biochemical and physiological functions vitamin A (role of vision cycle, influence of genomic expression of cell/protein synthesis, relationship between retenoids with cancer and immunity).
- Deficiency symptoms.
- Explain the Hyper vitaminosis A.

b. Vitamin D

- Outline the synthesis of Vitamin D in the skin and absorption from intestine.
- State the functions (calcium absorption and mineralization of bones, calcium and phosphate re-absorption).
- Deficiency symptoms (adults and symptoms).
- Explain the Hyper vitaminosis D.

c. Vitamin E

- Explain the role as an anti-oxidant and sparing action.
- State how the requirement is influence by vitamin A, intake of poly unsaturated fatty acids and advancing age.

d. Vitamin K

- Explain the biochemical functions of vitamin K dependent α carboxylase derive proteins (hemeostatsis and role in bone).
- State the actions of dicumorol and warfarin on vitamin K re-generation.

iii. Water soluble vitamins 4 hours

The student should be able to,

a. Thiamine (Vitamin B_1)

- Effect of milling, extraction rate and cooking of serials on vitamin content.
- State the biochemical functions (B_1 dependent reactions in metabolism) and biochemical consequences in deficiency.

- State criteria used to define thiamine states.
- Identify the symptoms of B_1 deficiency.
- Outline the laboratory assessment of vitamin B_1 deficiency.

b. Riboflavin (Vitamin B_2)

- State the biochemical functions (Biochemical role in cellular functions).
- Identify the deficiency symptoms.

c. Niacin (Vitamin B_3)

- State the biochemical functions.
- Explain the symptoms of Niacin deficiency and basis of mental depression in Pellagra and fatty liver.

d. Pyridoxine (Vitamin B_6)

- List naturally occurring pyridoxine derivatives.
- Describe the biochemical functions.

e. Folic acid (B_9)

- List the biochemical functions.
- Explain folate and vitamin B_{12} deficiency and erythropoiesis.
- Outline the anti folates and principles of their action.

f. Cobalamine (Vitamin B_{12})

- State the role of GIF on B_{12} absorption.
- List the biochemical functions and effect of deficiency on the cell cycle.
- Explain the Deficiency symptoms (Pernicious Anaemia and Neurological symptoms).
- Distinguish folate and B_{12} deficiency.

g. Ascorbic Acid (Vitamin C)

- List the biochemical functions (Hydroxylation and other reactions, iron absorption and anti-oxidant functions).
- List the deficiency symptoms.

C. Minerals as nutrients 4 hours

The students should be able to,

- State the mineral content of the body in terms of the fat- free body weight.
- List the seven "principle elements" and the"micro- nutrient elements" essential to humans.
- State good dietary sources requirements (infants, children, adults and for pregnant and lactating women, vegetarians) and functions of minerals stated below.

a. Calcium

- Recall the normal ranges for serum Ca and phosphate and the formsin which Ca is found in serum.
- Recall the factors that influence Ca^{2+} absorption in the intestine and explain their mode of action.
- Explain the part played by calcitriol in "adaptation to a low Ca intake".
- Explain the deficiency diseases (a) rickets (b) osteomalacia.

b. Iron

- List the different tissues in which iron is found, and the functions performed by iron in these tissues.
- List the factors that influence the absorption of dietary iron and explain their mode of action.
- Discuss iron absorption, transport and loss.
- Explain the diseases related to iron overload.
- Discuss the deficiency disease (stages of anaemia) & clinical symptoms and biochemical markers (TIBC, BI, PS, ferritin) and normal values.

c. Iodine

- Outline the steps in thyroid hormone synthesis and role of iodine
- State the factors that (a) stimulate or inhibit (b) trapping of iodine to release of T_3 and T_4.

- Explain the term iodine deficiency disorder (IDD) and endemic goiter.
- Recall that IDD should be prevented as early as possible in the reproductive life, preferable before conception, during pregnancy and early in infancy.
- Know how iodized salt need to be use and store and distributed in Sri Lanka.

d. Fluorine

- Explain the function of fluorine in bone and teeth with special reference to prevention of dental caries.
- Outline the toxicity (dental fluorosis & osteofluorosis) & defluoridation of water.

e. Selenium and Chromium

- State the relationship between selenium and chromium.
- Explain that selenium as an essential component of glutathione peroxidase.
- Outline the association between selenium and vitamin E.
- Outline the association between chromium and GTF.

d. Foods and Diet 2 hours

The student should be able to

- State factors that influence nutritional requirements of individuals.
- State the principles behind formulating diets.
- Outline the principles of complementary feeding.
- State factors taken into account when prescribing a diet for infants/child/adult/pregnancy/lactation/elderly/athletes/metabolic diseases such as diabetes mellitus [ketogenic diet], atherosclerosis and obesity.
- Explain what are functional foods, nutraceuticles, probiotics and prebiotics.

10. Molecular techniques in Medicine 6 hours

The student should be able to

- Describe molecular techniques and their applications.
- Ageing and Molecular basis of cancer and explain the causes of ageing.
- Describe the characteristics of cancer and metastatic cells.
- Explain the mechanism of oncogenes and tumor suppressor genes in thedevelopment of cancer.
- Understand the basics of ‘Gene therapy’

Total Lecture Hours **52 Hours**

SUMMARY OF EXAMINATIONSFORMAT

Exam structure

Component	MCQs	SEQs
End Semester Examination I	15 (45 minutes)	3 (90 minutes)
End Semester Examination II	15 (45 minutes)	3 (90 minutes)
Final Examination	40 (120 minutes)	5 (150 minutes)
(Theory)	20 stations (60	
(OSPE)	minutes)	
(*Viva Voce*)	10 minutes	

Marks Percentages

Component	Proper	Repeat
End Semester Examination I	10%	-
End Semester Examination II	10%	-
Theory (MCQs + SEQs)	60%	70%
OSPE	10%	20%
Viva voce	10%	10%
Total	**100**	**100**