

# **THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY CHENNAI**

## **REGULATIONS OF THE UNIVERSITY**

In exercise of the powers conferred by section 44 of The Tamil Nadu Dr. M.G.R. Medical University, Chennai , Act, 1987 (Tamil Nadu Act 37 of 1987), the Standing Academic Board of the Tamil Nadu Dr. M.G.R. Medical University, Chennai hereby makes the following regulations.

### **SHORT TITLE AND COMMENCEMENT**

These regulations shall be called “THE REGULATIONS FOR THE MASTER OF SCIENCE (MEDICAL BIOCHEMISTRY) UNDER THE FACULTY OF BASIC SCIENCE OF THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY, CHENNAI”.

They shall come into force from the academic year 2014-2015 session.

The Regulations and the Syllabus are subject to modification by the Standing Academic Board from time to time.

### **REGULATIONS**

#### **1. ELIGIBILITY:**

Candidates shall be required to have passed the B.Sc. Degree ( 3 years duration) Examination in Bio-chemistry or Biotechnology or B.Sc. M.L.T. or a degree with triple major with Biochemistry or Biotechnology as one of the subjects.

#### **2. PHYSICAL FITNESS CERTIFICATE:**

Every candidate before admission to the course shall submit to the Principal of the Institution a certificate of medical fitness from an authorized medical officer that the candidate is physically fit to undergo the academic course and does not suffer from any disability or contagious disease.

#### **3. ELIGIBILITY CERTIFICATE:**

The candidate, who has passed the qualifying examination from any university other than the T.N. Dr. M.G.R. Medical University, as specified in Regulation No. 1 before seeking admission to any one of the affiliated institutions, shall obtain an Eligibility Certificate from the University by remitting the prescribed fees along with application form.

#### **4. ENROLMENT OF CANDIDATES:**

The candidates admitted provisionally shall apply to the University for enrolment within 7 days from the date of admission in a prescribed form which shall be down-loaded from the University web site ( [www.tnmgrmu.ac.in](http://www.tnmgrmu.ac.in) ). The following documents are to be submitted along with the application form:

- i. Provisional admission card issued by the College / Selection Committee
- ii. Eligibility Certificate
- iii. Prescribed fee

#### **5. REGISTRATION:**

A candidate admitted in the Master of Science (Medical Biochemistry) course in any one of the affiliated institutions of this University shall submit the prescribed application form for registration duly filled, along with prescribed fee and declaration in the format, (as in Annexure I of the “Regulation for re-admission after break of study”) to the Controller of Examinations of this University through the affiliated institution within 30 days from the cut-off date prescribed for Master of Science (Medical Biochemistry) course for admission.

#### **6. DURATION OF THE COURSE:**

- a. The period of certified study and training of the M.Sc. (Medical Biochemistry) course shall be three academic years.
- b. No exemption shall be given from this period of study and training for any other experience gained prior to the admission to the course.

#### **7. COMMENCEMENT OF COURSE:**

The Course shall commence from 1<sup>st</sup> September of the Academic Year

#### **8. COMMENCEMENT OF EXAMINATION:**

15<sup>th</sup> October

Theory examinations comence 15<sup>th</sup> October not be held on Saturdays and Sundays. If the date of commencement of the examination falls or declared a public holidays, the examination shall begin on the next working day.

#### **9. CUT- OFF DATE FOR ADMISSION TO EXAMINATION:**

The cut off date for examination to 30<sup>th</sup> September of the year concerned shall be registered to take up their first year examination during October of the next year, after fulfillment of the regulations.

All kinds of admissions shall be completed on or before 31<sup>st</sup> October of the academic year. There shall not be any admissions after to 31<sup>st</sup> October, even if seats are vacant.

## **10. CURRICULUM:**

The curriculum and syllabus for the course shall be as prescribed by the Standing Academic Board from time to time.

## **11. MEDIUM OF INSTRUCTION:**

English shall be the medium of instruction for all the subjects of study for the M.Sc., (Biochemistry) course.

## **12. WORKING DAYS IN THE ACADEMIC YEAR:**

Each academic year shall consist of not less than 270 working days.

## **13. ATTENDANCE REQUIRED FOR ADMISSION TO EXAMINATIONS:**

a) No candidate shall be permitted to appear in any one of the parts of M.Sc. (Medical Biochemistry) Course Examinations, unless he / she has attended the course in all the subjects for the prescribed period in an affiliated Institution recognized by this University and has produced the necessary certificates of study, attendance, satisfactory conduct and progress from the Head of the Institution.

b) A candidate is required to put in a minimum of 85% of attendance out of 270 working days both in theory and practical separate in each subject before admission to the examination.

c) A candidate lacking in the prescribed attendance and progress in any one subject in theory and practical classes, wherever necessary in the first appearance, shall not be permitted for admission to the entire examination.

## **14. CONDONATION FOR LACK OF ATTENDANCE:**

There shall be no condonation of attendance in Post Graduate Courses. As per University norms.

## **15. SUBJECTS OF STUDY**

### **Preliminary Examinations (at the end of first year)**

Paper – I: Anatomy (50 marks) and Physiology (50 marks)	100 marks
Paper – II: Biochemistry	100 marks

## **Final Examinations (at the end of third year)**

Paper – I: Physical and organic aspects of biochemistry, membranes,  
instrumentation and laboratory techniques 100 marks

Paper – II: Enzymes, intermediary metabolism and metabolism of  
biomolecules, nutrition and molecular biology 100 marks

Paper – III: Clinical biochemistry, endocrinology, immunology, free radicals  
and antioxidants, oncogenesis 100 marks

### **16. INTERNAL ASSESSMENT:**

#### **First year of the course:**

Anatomy: 15 marks

Physiology: 15 marks

Biochemistry: 20 marks

#### **Second and third year of the course:**

Project work: 15 marks

Internal assessment based on tests: 35

marks Total marks: 50 marks

### **17. PROJECT**

All candidates must carry out a project during the course. They will be awarded a mark out of 15 for this. This mark will contribute to their internal assessment mark for the second and third years.

### **18. QUESTION PAPER PATTERN:**

The following examination pattern shall be uniformly followed for the M.Sc., (Biochemistry) course and shall come into force for the candidates who join the course in commencing from 1<sup>st</sup> Oct 2014

For each theory paper

1. Essay questions	2x 15 marks	=	30 marks
2. Short notes	10x 5 marks	=	50 marks
Total			80 marks

Duration of examination: 3 hours.

## **19. MARKS QUALIFYING FOR A**

### **PASS: Preliminary examinations:**

A candidate shall be declared to have passed the preliminary examination if he /she obtains the following qualifying marks:

A candidate should obtain at least 50% of the marks, each in Anatomy (written examination + internal assessment), Physiology (written examination + internal assessment) and Biochemistry (written examination + internal assessment).

A candidate who fails in any one subject, viz. Anatomy, Physiology or Biochemistry, may be permitted to take the repeat examination in that subject only, in order to qualify for the preliminary examinations.

A candidate who fails in any subject of the preliminary examinations shall be permitted to join the second year of the course without loss of time.

No candidate shall be permitted to sit for the preliminary examinations on more than 4 occasions.

### **Final examinations:**

A candidate shall be declared to have passed the final examination if he /she obtains the following qualifying marks:

A candidate should obtain at least 50% of the marks in written and practical examinations separately and at least 50% in aggregate for a pass.

If a candidate fails in either the written or the practical examination, they will re-appear for both components of the examination.

## **20. REVALUATION OF ANSWER PAPER:**

There shall be no re-totaling or revaluation of the answer papers of failed candidates in any post -graduate examination. Answer papers of candidates who are found to fail in any paper of the written examination will be subjected to double valuation.

## **21. NUMBER OF APPEARANCES:**

a. A candidate registered for three years Post-Graduate Degree Course must qualify in the examinations within six years of the date of his / her admission.

b. A candidate will not be permitted to appear for more than 7 attempts in the final examination and shall be discharged from the course if he / she fails to pass the examination in the said number of attempts.

**22. DURATION FOR COMPLETION OF THE COURSE OF STUDY:**

The duration for the completion of the course shall be fixed as double the time of the course and the students have to pass within the said period.

**23. RE-ADMISSION AFTER BREAK OF STUDY:**

Please refer to the separate regulations for re-admission after break of study for all courses.

**24. MIGRATION / TRANSFER OF CANDIDATES:**

Migration or transfer of candidates from one recognized college to another recognized college of this University or from another University shall not be granted.

**25. AUTHORITY TO ISSUE TRANSCRIPT:**

The University shall be the Authority for issuing Transcript after remitting the prescribed fee of Rs. 1000/- (Rupees one thousand only) or as may be prescribed from time to time.

**26. SCHEME OF EXAMINATIONS: (At the end of third year)**

The scheme of examinations is as follows:

S.No	Components	Marks	
		Max	Min
Written Paper I	Physical and organic aspects of biochemistry, membranes, instrumentation and laboratory techniques	100	50
Written Paper II	Enzymes, intermediary metabolism and metabolism of biomolecules, nutrition and molecular biology	100	50
Written Paper III	Clinical biochemistry, endocrinology, immunology, free radicals and antioxidants, oncogenesis	100	50
	Practical examination	125	63
	Viva voce examination	25	13
	Internal assessment	50	25
	Total	500	250

### **Practical examinations (125 marks)**

The duration of the practical examinations for M.Sc. Biochemistry shall be two days. It will consist of the following components:

A. Identification of a biochemically important substance and chromatogram marks	50
B. Standard curve for and estimation of an analyte	25 marks
C. Electrophoresis	25 marks
D. Enzyme kinetics	25 marks
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	Total 125 marks
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SYLLABUS FOR MSc (MEDICAL BIOCHEMISTRY) COURSE  
PRELIMINARY YEAR  
**BIOCHEMISTRY**

**1. CELL**

Cell and cellular organelles  
Basics of structure of eukaryotic cells  
Overview of cellular organelles (mitochondria, nucleus, ribosomes, proteasomes, lysosomes, endoplasmic reticulum, peroxisomes and golgi apparatus) and their functions  
Membrane structure (fluid mosaic model) Liposomes  
Transport across membranes

**2. ENZYMES**

Nomenclature and IUBMB classification of enzymes  
General properties and mechanism of action of enzymes  
Specificity of enzymes  
Concept of active site  
Cofactors  
Factors that affect the activity of enzymes Zymogens and their activation  
Enzyme inhibition  
Enzyme regulation: covalent modifications of enzymes, allosteric and feedback regulation; concept of rate -limiting enzymes; constitutive and inducible enzymes  
Importance of enzymes in diagnosis and treatment of diseases; isoenzymes

**3. VITAMINS**

Fat- and water-soluble vitamins: dietary sources, absorption, active forms, recommended dietary allowances and deficiency manifestations Hypervitaminosis

**4. BIOENERGETICS**

Biologic oxidation, electron transport chain and oxidative phosphorylation

**5. CARBOHYDRATES**

Classification of carbohydrates with physiologically important examples and functions of each type



Digestion and absorption of carbohydrates

Examples of common dietary carbohydrates and the foods that they are present in  
Enzymes involved in digestion of carbohydrates: sources, sites of action and effects

End products of digestion and their absorption  
Lactose intolerance

Importance of dietary

fibre  
Glucose transporters

Types, functions, tissue specificity and importance of each  
Pathways of carbohydrate metabolism

Glycolysis; Rapaport-Leubering shunt (2, 3-bisphosphoglycerate shunt)  
Pentose phosphate pathway and related disorders

Citric acid cycle/ Krebs' cycle/ tricarboxylic acid cycle

Glycogenesis, glycogenolysis and glycogen storage disorders (only names and associated enzyme deficiencies are required for the disorders)

Gluconeogenesis; Cori's cycle and glucose-alanine cycle  
Uronic acid pathway

Metabolism of galactose; galactosemia

Metabolism of fructose and related disorders

Polyol pathway and its importance in complications of diabetes mellitus  
Regulation of blood glucose levels

Diabetes mellitus

Investigations in patients with diabetes mellitus - plasma glucose estimations (fasting

and postprandial), glycated haemoglobin (HbA1c), urine analysis for detection of glucose, ketone bodies and proteins in urine, microalbuminuria, glucose tolerance test

(GTT).

## **6. LIPIDS**

Definition, classification and functions of lipids  
Classification of fatty acids

Importance of cholesterol, phospholipids, gangliosides, triacylglycerols and eicosanoids in the body

Lipoproteins: types and functions

Digestion and absorption of lipids

Dietary lipids, sources, sites and action of enzymes involved in digestion of lipids

Absorption of lipids, steatorrhea, importance of chylomicrons

Pathways of lipid metabolism

Fatty acid oxidation: types of oxidation; beta-oxidation of saturated fatty acids and energetics of the pathway; related disorders.

Concept that fatty acids can be synthesized in the body from acetyl CoA from various sources (pathway not required)

Metabolism in adipose tissue

Metabolism of ketone bodies; regulation and clinical significance of the processes

Metabolism of cholesterol: outline of biosynthesis only with emphasis on regulatory

step; regulation of synthesis of cholesterol and bile acids; cholesterol-lowering agents;

enterohepatic circulation.

Metabolism of lipoproteins; dyslipidemias; lipoprotein (a); risk factors for atherosclerosis and coronary artery disease; definition of metabolic syndrome Eicosanoids and their significance

Phospholipids and their significance; lecithin-sphingomyelin ratio in amniotic fluid

Lipid storage disorders (names of conditions and associated enzyme defect only)

Role of liver in lipid metabolism; fatty liver and lipotropic factors

## **7. INTEGRATED METABOLISM**

Overview of metabolism in the fed and fasting states

Overview of metabolism in liver, brain and muscle

## **8. MINERALS**

Metabolism of macro minerals and trace elements and related disorders

## **9. NUTRITION**

Importance of the various macro- and micronutrients in the diet

Calorific value of various macronutrients; glycemic index of food; importance of dietary

fibre

Balanced diet; specific dynamic action; basal metabolic rate; respiratory quotient Parenteral nutrition

Protein energy malnutrition

Body mass index (BMI); obesity

## **10. PROTEINS**

Classification of amino acids

Separation of amino acids by paper chromatography Classification of proteins.

Structural organization of proteins

Structure and functions of myoglobin, hemoglobin and collagen and associated disorders  
Plasma proteins and their functions  
Separation of serum proteins by paper and gel electrophoresis  
Patterns of serum protein electrophoresis (normal pattern and patterns in multiple myeloma, cirrhosis and nephrotic syndrome)  
Digestion and absorption of proteins  
Overview of amino acid absorption  
Amino acid transporters in the intestine  
Meister's cycle  
Disorders associated with amino acid absorption  
General pathways of amino acid catabolism  
Overview and biochemical importance of the processes of transamination and oxidative deamination  
Urea cycle and related disorders  
Metabolism of individual amino acids  
Overview of biosynthesis of non-essential amino acids  
Functions of individual amino acids  
Physiologically important products derived from amino acids, with overview of the pathways involved.  
Catabolism of amino acids  
Disorders of amino acid metabolism

## **11. NUCLEOTIDES**

Types and functions of nucleotides and nucleic acids  
Synthetic oligonucleotide analogues  
Metabolism of nucleotides  
Outline of synthesis of purine and pyrimidine nucleotides, with reference to precursors and endproducts only  
Salvage pathways and associated disorders  
Degradation of purine and pyrimidine nucleotides and related disorders

## **12. HOMEOSTATIC MECHANISMS IN THE BODY**

Acid base balance: hydrogen ion homeostasis and related disorders; blood gas parameters and clinical applications  
Fluid and electrolyte balance; regulation of osmolality and maintenance of fluids in the various body compartments and related disorders

## **13. HEME METABOLISM**

Heme synthesis, regulation and porphyrias

Heme degradation and related disorders

#### **14. FUNCTION TESTS**

Renal, liver and thyroid function tests

#### **15. MOLECULAR BIOLOGY**

Overview of cell cycle

Structure of DNA and RNA Outline of DNA synthesis, with relevant enzymes

Types of DNA damage and mention of repair mechanisms of clinical

relevance Outline of RNA synthesis, with relevant enzymes; post-transcriptional processing in

eukaryotes

Genetic code and outline of protein synthesis in eukaryotes; post-translational modifications

Mutations

Basic concepts of gene expression in eukaryotes

Recombinant DNA technology; principles and applications of various techniques (polymerase chain reaction, blotting techniques, restriction fragment length polymorphism)

Transgenic animals

Human genome

project Gene therapy

#### **16. MISCELLANEOUS TOPICS**

Metabolism of xenobiotics

Oxidative stress: mechanisms of generation of reactive oxygen species (ROS) in cells and the role of antioxidants

# Physiology syllabus for MSc course

## 1. General Physiology

### Cellular organelles

### Homeostasis

Concept of maintenance of internal environment

### Feedback systems.

- a. Negative feedback as the most common type of physiological control
- b. Examples of negative feedback
- c. Instances of positive feedback in physiology:
  1. Oxytocin and labor
  2. Estrogen and LH in follicular phase of menstrual cycle
1. Action potential formation - depolarization and sodium channel opening  
Coagulation cascade

### Body fluids

- d. Total body water
- e. Body fluid compartments: extracellular, intracellular, transcellular.
- f. Composition of extracellular fluid, intracellular fluid and plasma.
- g. Plasma proteins being the major difference between plasma and the rest of ECF.
- h. Concept of electroneutrality: anion gap refers to unmeasured anions in plasma.
- i. Osmolarity of body fluids
- j. Difference between tonicity and osmolarity
- k. Starling's forces
  1. Edema and its causes in terms of Starling's forces

### Cell membrane

- a. Fluid mosaic model
- b. Composition - lipids, proteins

### Membrane transport

- c. Passive transport
  1. Simple diffusion of respiratory gases through lipid film
  2. Diffusion of ions through ion channels
    1. Sodium, potassium, calcium and chloride channels
    2. Non-gated channels, voltage-gated, ligand-gated channels and mechano-gated channels
  3. Facilitated diffusion - glucose transporters (GluTs)

4. Osmosis – special name given to water diffusion

a. Active transport - primary and secondary

1. Primary active transport:

sodium-potassium pump,

calcium pumps - plasma membrane calcium pumps (PMCA)  
and Sarco/endoplasmic reticulum calcium pumps (SERCA)

Proton pumps - V-type H ATPase, H/K ATPase

1. Secondary active transport: sodium-glucose co-transport (SGLT), sodium-aminoacid co-transport, sodium-hydrogen exchangers, sodium-calcium exchangers, Na/2Cl/K

b. Transport by formation of membrane vesicles ○

Endocytosis

○ Exocytosis

### **Membrane potential**

c. Resting membrane potential - due to dominance of potassium conductance at rest.

d. Action potential

## **Cell Signaling**

## **2. Blood**

Composition

Normal blood volume

Hematocrit (dealt later)

Composition of plasma - electrolytes and non-electrolytes

Plasma versus serum

### **Plasma proteins**

**Albumin:** Production, Functions

Oncotic pressure, Normal levels and causes for variation

**Globulins** - list the alpha, beta and gamma globulins

Role of major alpha and beta globulins

Gamma globulins (dealt under B lymphocytes)

Definition and Normal values, factors influencing ESR (fibrinogen particularly), causes for increased ESR, significance of ESR in disease (acute phase reaction).

## **Erythrocyte Sedimentation Rate**

### **Red Blood Cells**

Physical characteristics, concentration and causes for physiological variation, functions, sites of red blood cell production, general changes that take place during erythropoiesis, regulation/factors affecting erythropoiesis, Life span and destruction of RBCs, Hematocrit/PCV, Normal values for Indian population

### **Hemoglobin**

Components of Hb, types, normal levels (Indian population also)

Role in gas transport:

Oxygen-Hb dissociation curve (done under resp system)

Oxygen carrying capacity of blood

hemoglobin as a buffer

Reduced hemoglobin and cyanosis

Abnormal Hb

Breakdown, Hemolytic jaundice

### **Anemia**

Anemia - Definition, etiological classification, morphological classification , effects, symptoms and signs

Reticulocyte count – normal value and causes for increased and decreased reticulocyte count, reticulocyte response

### **Polycythemia**

Polycythemia rubra vera

Secondary polycythemia- causes

Effects of polycythemia

Principles of treatment

#### **Platelets**

Formation from megakaryocytes, normal count, Life span & removal

Functions,

Thrombocytopenia – causes and effects

## **Hemostasis**

Mechanisms involved in

hemostasis: ○ Vasoconstriction

○ Platelet plug formation

○ Clotting or coagulation - coagulation factors, intrinsic, extrinsic and common pathways

○ Clot retraction

Anticlotting and fibrinolytic mechanisms in the body

Anticoagulants in laboratory

Abnormalities of coagulation\_ - Tests of hemostasis: platelet count, BT, CT, PT, APTT, factor assays

## **Blood groups**

Importance of blood groups

ABO system

Genetic determination

Agglutinins in plasma

Frequency of different blood groups in India

Rh blood group

Rh incompatibility

Presence of other minor blood group systems

Blood grouping/typing

Cross match

Erythroblastosis Fetalis: prevention, treatment

## **White blood cells**

Normal count

Types – granulocytes, agranulocytes

Morphology

Differential count

Conditions in which counts are increased and decreased

Functions of neutrophils, eosinophils, basophils, mast cells

Lymphocytes , monocytes.

Monocyte macrophage system

## **Leucopoiesis**

- gross changes during maturation



## Immunity

### • Types

- Innate immunity – cells and mechanisms involved
- Adaptive – types

Lymphoid organs , Development of T and B cells

Cell mediated immunity - antigen presenting cells, MHC, antigen recognition, processing and presentation, helper T cell activation, killing by cytotoxic T cells

Humoral immunity -

- B cell activation, plasma cells, immunoglobulins – types and functions
- Immunological memory
- Primary and secondary immune response

concept of Complement system

### **Lymph**

Formation and composition of lymph, Types of lymphatics, Lymphatic circulation, functions of lymph, lymphedema

## 3. Muscle

### **1. Structure of Skeletal Muscle**

#### **Features**

Striations

No anatomical connections between muscle fibers

Voluntary

Under nervous control

### **Morphology**

Muscle fibers - myofibrils – filaments

Fiber - long, cylindrical, multinucleated

Begin and end in tendons

Cell membrane – sarcolemma

#### **Proteins**

Actin - two chains

Myosin - two light chains and two heavy chains

Tropomyosin

Troponin I - inhibits interaction between actin and myosin

Troponin T - connects troponin complex to tropomyosin ]

Troponin C - binds to calcium

## **Sarcomere**

I band, A band, H band

Sarcomere - part between two adjacent Z lines

Z line - Actin filaments attached to Z line

## **Sarco-tubular system**

T tubule - continuous with the sarcolemma

Terminal cisterns of the sarcoplasmic reticulum (SR)

Triads -Present at A-I junction

T tubules - important for the transmission of action potential

SR - calcium store

## **Dystrophin-glycoprotein complex**

## **Neuro-muscular junction (NMJ)**

### **Structure**

Terminal boutons or end feet

Vesicles

Motor end plate

Junctional folds

Nicotinic acetylcholine receptors

Synaptic cleft

## **Neuromuscular transmission**

Action potential reaching the axon terminal

Opening of voltage gated calcium channels

Exocytosis of acetyl choline

Quantal release of neurotransmitter

End plate potential

Muscle action potential -RMP -90 mV; action potential duration;

Absolute refractory period - 1 to 3 ms

Acetylcholinesterase

## **Contraction of skeletal muscle**

### **Contraction**

Muscle twitch - response to single action potential

Twitch

duration

## **Molecular mechanism**

Sliding filament theory

Role of ATP in contraction

## **Excitation-contraction coupling**

Action potential reaches the T tubules

Activation of dihydropyridine receptors (DHPR)

Activation of ryanodine receptors (RYR)

RYR and DHPR - physically coupled

Voltage induced calcium release (VICR) from SR

## **Relaxation**

Reduction in cytosolic calcium

Calcium is removed by SERCA

ATP is required for contraction and relaxation

## **Types of contraction**

**Isotonic** – shortening

**Isometric** - no shortening

## **Length-tension relationship**

**Isometric** contractions

**Resting length or optimal length** - length of the muscle at which there is maximum active tension

Muscles at rest are at this length

Maximum cross-linking between actin and myosin at this length

## **Muscle fiber types**

### **Heat production**

### **Denervation**

Physiological basis of denervation hypersensitivity

Atrophy

Fasciculations

### **Motor unit**

Definition

### **EMG**

### **Smooth muscle**

#### **Structure**

Lack of striations

Dense bodies

Lack

of

troponin

- Sarcoplasmic reticulum less extensive

### **Types**

Response of vascular and non vascular smooth muscle to autonomic influences

### **Contraction**

Differences in EC coupling as compared to skeletal muscle

### **Autonomic influences**

Action of epinephrine and norepinephrine and acetylcholine on vascular and non vascular smooth muscle

Bronchodilators - beta adrenergic stimulation – bronchodilation

## **Cardiac muscle**

### **Morphology**

Intercalated disks

Gap junction - spread of action potential from one cell to the adjacent cell-functional syncytium

### **Electrical properties**

Dealt with under cardiovascular system

### **Contraction**

Similar to skeletal muscle

Duration of contraction longer than that of skeletal muscle

Length-tension relationship discussed in the Cardiovascular system

### **Metabolism**

- Almost exclusively dependent on aerobic metabolism-rich in mitochondria, dense capillary network.

## **4. The Endocrine System**

### **Introduction**

Classification of hormones

concept of feedback regulation of hormone release

Mechanism of action of hormones

Receptors

Second messengers

Hormone

disposal

## Hypothalamus

Relation of hypothalamus to pituitary gland:

Hypothalamohypophyseal tract

Hypothalamohypophyseal portal circulation–

Hypothalamic hormones which control anterior pituitary gland

- Thyrotropin-releasing hormone (TRH),
- Corticotropin releasing hormone (CRH),
- Gonadotropin releasing hormone (GnRH),
- Growth hormone releasing hormone (GHRH),

synthesized in hypothalamus and released from posterior pituitary gland: Anti-diuretic hormone, Oxytocin

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## Pituitary Gland

Anterior pituitary gland:

Hormone secreting cells of anterior pituitary:

Somatotropes, Lactotropes, Corticotropes, Thyrotropes, Gonadotropes

All hormones released here are either short peptides or proteins.

Anterior pituitary gland hormones:

- Tropic hormones:
- Thyroid-stimulating hormone (TSH)
- Adrenocorticotrophic hormone (ACTH)
- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)

Growth hormone

Prolactin

Posterior pituitary hormones:

- Anti diuretic hormone or vasopressin
- Oxytocin

Growth hormone:

Actions of growth hormone – action on tissue and skeletal growth, carbohydrate, lipid and protein metabolism

Insulin-like growth factors (IGFs) or Somatomedins

Regulation of growth hormone secretion

Stimuli which affect growth hormone secretion: Stimuli that increase secretion, stimuli that decrease secretion

Abnormalities related to growth hormone secretion

Gigantism

- Causes of gigantism
- Features of gigantism

Acromegaly

- Features of acromegaly

Pituitary dwarfism

- Features of pituitary dwarfism

### **Prolactin**

- Actions of prolactin
- Regulation of prolactin release

### **Antidiuretic hormone (ADH)**

- Site of synthesis and release
- Mechanism of action
- Main site of action – Distal tubules and collecting ducts
- Functions of ADH : Role in osmotic regulation, and volume regulation
- Disorders of ADH secretion : Diabetes insipidus

### **Oxytocin**

Site of synthesis and release

Actions of oxytocin

Role in milk-ejection

reflex Role in parturition

- Regulation of secretion

### **Thyroid Gland**

Functional anatomy of thyroid gland

Outline of synthesis of thyroid hormones

Release of thyroid hormones

Thyroid hormones – Thyroxine (T4), T3

Peripheral conversion of T4 to T3

## Mechanism of action

### Actions of thyroid hormones on

- metabolic rate or calorigenesis
- heart
- muscle
- bone
- nervous system
- Gastrointestinal system and lipid metabolism

## Regulation of thyroid hormone secretion

Role of TRH, TSH

T3 – the principal feedback regulator

## Pathophysiology of thyroid hormones:

### **Hypothyroidism:**

- Myxoedema
- Cretinism
- Endemic goiter
- Features of hypothyroidism

### **Hyperthyroidism:**

- Graves disease
- Features of hyperthyroidism
- Thyroid Function tests

## **Adrenal Gland**

### **Adrenal cortical hormones:**

Outline of synthesis of adrenal cortical hormones

Layers of adrenal cortex and hormones secreted by each:

- Glucocorticoids
- Mineralocorticoids
- Sex steroids

## **Glucocorticoids**

Mechanism of action

Functions of glucocorticoids:

- Action on carbohydrate metabolism
- Action on lipid metabolism
- Action on protein metabolism
- Glucocorticoids as anti-inflammatory agents
- Effect on blood cells

Diseases related to glucocorticoids:

- Cushing's syndrome:
- Features of Cushing's syndrome – Moon face, buffalo hump, pendulous abdomen, purple striae, ecchymoses, hypertension, hyperglycemia, osteoporosis

Regulation of glucocorticoids:

- Control through ACTH
- Diurnal rhythm
- Control via limbic system

## **Mineralocorticoids**

Mechanism of action of mineralocorticoids:

- Aldosterone binding to cytoplasmic receptor – formation of receptor hormone complex – effect on gene transcription

Action of mineralocorticoids:

- Sodium and water homeostasis
- Action on epithelial sodium channels (ENaCs)
- Reabsorption of sodium from nephron, sweat, saliva, colon
- $H^+$  and  $K^+$  exchange for sodium

Regulation of aldosterone secretion:

- Renin-angiotensin II – as the important regulator
- Plasma K concentration
- ACTH



## Hormonal imbalances of mineralocorticoids:

### **Hyperaldosteronism:**

Primary hyperaldosteronism – Conn's syndrome

Features of hyperaldosteronism:

- K depletion
- Na retention
- Muscle weakness
- Hypertension
- Hypokalemic alkalosis

Aldosterone escape

### **Adrenal insufficiency:**

Primary adrenal insufficiency – Addison disease (Disease of adrenal cortex)

○ Hypotension

○ 'Addisonian Crisis'

○ Increased ACTH levels

○ Skin pigmentation

Clinical features of adrenal insufficiency

## **Hormones concerned with calcium homeostasis**

Parathyroid hormone, Calcitonin, Vitamin D

### **Calcium:**

Normal distribution of calcium in the body

Calcium in bones

Calcium in plasma – Total calcium and ionized calcium

### **Parathyroid hormone:**

Actions of parathyroid hormone on bone, kidney, intestine and 1,25-cholecalciferol formation

Regulation of parathyroid hormone secretion – plasma calcium as the important regulator

### Pathophysiology of Parathyroid hormone:

#### **Hyperparathyroidism:**

- Primary hyperparathyroidism

- Hypercalcemia
- Increased bone resorption
- calcium stones in kidney

### **Hypoparathyroidism:**

#### Clinical application:

Parathyroidectomy resulting in hypocalcaemia and associated complications  
– neuromuscular excitability, tetany

### **Calcitonin:**

Secretion from parafollicular cells of thyroid gland

Actions of calcitonin

### **Vitamin D:**

- Sites of synthesis of calcitriol
- Mechanism of action
- Regulation of 1,25-cholecalciferol synthesis – by plasma calcium and PTH

#### Clinical application:

Rickets

- Deficiency of vitamin D
- Poor mineralization of bones
- Feature of rickets – bowing of weight bearing bones, dental

defects Osteomalacia in adults

## **Hormones of Pancreas**

Islets of pancreas hormones secreted by them

### **Insulin:**

Mechanism of insulin release

Actions of insulin – on adipose tissue, muscle, liver

Insulin as an anabolic hormone

#### Regulation of Insulin secretion:

Regulation of insulin secretion via plasma glucose

### **Diabetes mellitus:**

Diabetes mellitus type I

Diabetes mellitus type II

Clinical features of diabetes mellitus

## **Glucagon:**

Actions of glucagon:

Glycogenolytic, gluconeogenic, lipolytic, and ketogenic

## **Other Endocrine glands & Hormones**

### **Pineal gland:**

Circadian rhythm

Role of melatonin

Concept of 'Biological clock'

### **Kidney:**

As an endocrine organ secreting erythropoietin

### **Atrial natriuretic peptides:**

ANP

- Actions of ANP

### **• Gastrointestinal hormones:**

Listed under GIT

## 5. Reproductive System

### **Sex determination**

Normal chromosomal pattern, Sex chromosomes, Genetic sex determination, Sex chromatin

Genetic sex, Gonadal sex and phenotypic sex

Development of gonads – role of SRY gene, testis determining factor

Development of male and female internal genitalia – development of Wolffian duct and Mullerian duct , role of testosterone and Mullerian inhibiting substance

Development of external genitalia – role of dihydrotestosterone

### **Puberty**

Definition, age of onset, mechanism of onset of puberty

### **Menopause**

- definition

### **Pituitary gonadotropins (LH, FSH), prolactin**

receptors, mechanism of action , functions, regulation of secretion

### **Male reproductive system**

#### **Functional anatomy**

- Testis – seminiferous tubules, Sertoli cells, Leydig cells, Blood Testis barrier, Epididymis, Vas deferens, Seminal vesicle, Prostate gland

### **Spermatogenesis**

Factors regulating spermatogenesis

Structure of spermatozoa

#### **Hormones produced by the testis**

Testosterone

- Source, conversion to DHT in tissues
- Mechanism of action
- Physiological actions
- Other hormones : Inhibin - source and functions

**Control of testicular function** Hypothalamic and pituitary control on testis

Feed back control of testicular hormones on hypothalamus and pituitary

### **Male sexual**

**act** ○Erection

- Ejaculation

## Female reproductive system

**Functional anatomy of the female reproductive system** – ovaries, internal genitalia (uterus, vagina, fallopian tubes), external genitalia

### Oogenesis

Stages

Oocyte attrition

Differences between spermatogenesis and oogenesis

**Development of ovarian follicles** Stages of follicle development  
ovulation, luteinisation, luteal regression

Control of follicular development, ovulation and luteinisation – role of FSH, estrogen and LH

Follicle attrition

## Hormones produced by the ovaries

- Steroids – estrogens and progestins
  - Synthesis- synergistic role of thecal and granulosa cells
  - Mechanism of action
  - Functions – effect on organs of reproductive system, secondary sexual characteristics and systemic effects
  - Synthetic estrogens and progestins – use as oral contraceptives

## Feedback regulation of ovarian function

### Menstrual cycle

- Ovarian cycle: Phases and duration, hormonal changes during the cycle
  - changes in FSH, LH, estrogen, progesterone
- Uterine cycle : Phases and duration, Cyclical changes in the uterus (correlated with ovarian and hormonal changes). Mechanism of menstrual bleeding. Normal menstruation- composition, amount of blood loss
- Cyclic changes in the cervix, vagina and breast
- **Ovulation** : Mechanism, Indicators of ovulation, importance of detecting ovulation and its time

**Contraception** – rhythm, barrier, oral contraceptives, IUCD, permanent – physiological basis of their use as contraceptives

## **Physiology of pregnancy**

**Fertilization and implantation** ( not to dealt in detail – covered in embryology) : Transport of sperm, changes occurring in the sperm in the female genital tract, fusion of gametes – acrosomal reaction, zygote formation, blastocyst formation, implantation, formation of placenta – chorionic villi, placental sinus

Corpus luteum of pregnancy

### **Hormones secreted by the placenta :**

- hCG - secretion, functions, hCG as the basis for the immunological tests for pregnancy.
- Roles of estrogen and progesterone secreted by placenta.

**Parturition** : Onset of labor- hormonal factors, mechanical factors, mechanism of labor – positive feed back

## **Lactation**

breast development- role of estrogen and progesterone

Initiation of lactation after delivery

Milk ejection reflex

Effect of lactation on menstrual cycle

## 6. Gastro Intestinal System

### **Salivary glands**

Function of saliva  
Control of secretion

### **Gastric secretion**

Chief cells - pepsinogen & gastric lipase  
Parietal cells - HCl & intrinsic factor  
Mechanism of gastric secretion  
Stimuli for secretion - gastrin, histamine and acetylcholine  
Phases of secretion - cephalic, gastric & intestinal  
Importance of mucus-bicarbonate barrier  
Proton pump  
Physiological basis for the use of proton pump blockers and histamine receptor blockers

### **Pancreatic secretion**

Enzymes – Trypsin, Chymotrypsin, Elastase, Carboxypeptidase, Lipase, Amylase, Nucleases  
Activation of trypsinogen by enterokinase  
Activation of other pro-enzymes by trypsin  
Alkaline pH and its importance  
Regulation of secretion  
Mainly Hormonal regulation – secretin and cholecystokinin  
Neural regulation

### **Small intestine**

Succus entericus and the enzymes in it  
Enterokinase

### **Liver**

Portal system  
Functions of liver  
○ Metabolism  
○ Detoxification  
○ Synthesis of proteins like albumin, fibrinogen, alpha globulins, clotting factors II, VII, IX, X (vitamin K dependent), angiotensinogen, transport and storage proteins

- Hormone metabolism
- Cholesterol excretion
- Biliary secretion

## Bile

- Composition
- Bilirubin
- Bile acids
- Functions of bile acids
- Emulsification of fat
- Absorption of fat
- Micelles
- Entero-hepatic circulation - terminal ileum
- Regulation of biliary secretion

## Gall bladder

- Concentration of bile

### **Digestion and absorption**

#### **Digestion and absorption of carbohydrates**

#### ● Digestion

- Salivary amylase
- Pancreatic amylase
- Brush border enzymes - lactase, sucrase, maltase

#### Absorption

- Sodium-dependent glucose transporter
- Glucose transporter

#### **Digestion and absorption of proteins**

- Pepsin
- Endopeptidases – trypsin, chymotrypsin and elastase
- Exopeptidase – carboxypeptidase, Aminopeptidases

#### Dipeptidases

- Intracellular peptidases
- Absorption - co-transport with sodium

#### **Digestion and absorption of lipids**

#### Digestion -Pancreatic lipase

#### Absorption

- Chylomicrons
- Lacteals
- Fat soluble vitamins



## **Iron**

Absorption

## **Water movement in intestine**

### **GI Motility**

#### **Mouth and oesophagus**

Deglutition

Lower oesophageal sphincter and its importance

#### **Stomach**

Gastric emptying

Factors affecting gastric emptying

Vomiting

#### **Movements of small intestine**

Peristalsis

Segmentation    contractions    or    mixing

contractions

Tonic contractions

#### **Movements of large intestine**

Peristalsis

Segmentation contractions

Mass action contraction

Defecation reflex

#### **Gastro intestinal hormones**

Gastrin

Cholecystokinin

Secretin

#### **Enteric nervous system**

Myenteric plexus

Meissner's plexus

Control by autonomic nervous system

## 7. The Cardiovascular System

### **Functional anatomy of heart**

4 chambers, 4 valves, Input and output vessels  
Conducting system  
AV ring and electrical discontinuity  
Coronary supply

### **Myocardial cell Physiology:**

#### **SA nodal cell**

Contour of action potential: phases 4, 0 and 3  
Currents responsible for generation of action potential:  $I_f$ ,  $I_{CaT}$ ,  $I_{CaL}$   
Intrinsic rate of the SA node and Influence of autonomic nervous system, hormones and temperature.  
Sinus arrhythmia, sinus bradycardia, sinus tachycardia

#### **Ventricular cell**

Contour of action potential, phases 0,1,2,3,4  
Currents responsible for AP  
Calcium-handling in ventricular cell:  
L-type calcium channels, RyR, SERCA, CICR (Calcium-Induced Calcium Release)  
Excitation-contraction coupling - Calcium binding to Troponin C

#### **Atrial cell**

Cells of conducting pathway:

- AV node: Main site of conduction delay  
Purkinje fibres are fastest

#### **ECG**

Basics of ECG  
12 Leads  
P, QRS, T and U waves  
PR, QT intervals  
Significance of ST segment being on the isoelectric line;

### **Properties of cardiac**

#### **muscle: Automaticity**

Of SA node

Regulation of heart rate

## **Excitability and Refractoriness**

Refractory period and its significance

## **Conductivity**

AV node as the point of conduction delay

## **Contractility**

### **Determinants of force of contraction:**

#### ○ **Preload (Starling's law)**

Venous return (considered in detail later) as preload;

Family of Starling curves

Different parameters used to construct Starling curves: X axis: Right atrial pressure (RAP); Left Ventricular end diastolic pressure (LVEDP), Left Ventricular end diastolic volume (LVEDV). Y axis: Stroke volume (LVEDV-LVESV),

Cardiac output

Ejection fraction (EF) as a measure of cardiac function.

#### ○ **Afterload**

Aortic impedance and

Arterial pressure (considered in detail later) as

#### afterload ○ **Inotropic status**

Determined by neural, hormonal influences and ECF milieu

**Frequency** (or heart rate), (Bowditch phenomenon or Force-frequency relation)

## **Cardiac cycle**

Chronological relationship of the following events shown on the same time axis:

ECG

Valvular events

Heart sounds

Pressure curves : Ventricular, atrial (RAP), aortic

Volume curve: Ventricular

## **Cardiac output**

- Determinants of cardiac output:

$$CO = SV \times HR$$

## **Stroke volume**

Determinants of stroke volume: same as those of force of contraction. Refer to cell 4.4

## **Heart rate**

Considered under cell 4.1

## Vascular Physiology

### **Aorta and Arteries as windkessel vessels**

Elasticity of these vessels serves to minimize extreme excursions of blood pressure during systole and diastole

**Aortic impedance** as a long term determinant of Blood pressure – this is not regulatable by neural or hormonal mechanisms.

(age-related hypertension) -

### **Arterioles as resistance vessels**

**Vascular resistance** in regional circulations as determinant of **blood flow**

**Total Peripheral Resistance** (TPR, in all arterioles) as determinant of arterial pressure.

## **Total Peripheral Resistance**

### **Determinants of TPR:**

From Poiseuille's flow equation: the determinants should be **length** of vessels, **viscosity** of blood and **radius of arterioles**.

Consider the importance or otherwise of each determinant

**Radius (or Diameter) of arterioles** - is the most important determinant of TPR and is capable of being regulated.

### **Factors affecting arteriolar diameter:**

sympathetics

hormones (adrenalin, AT II, ANP)

local metabolic factors (carbon dioxide, pH, K, adenosine)

EDRF or NO

**Capillaries** as exchange vessels

**Veins** as capacitance vessels

**Venous return (VR)** - forms the preload

Factors which affect

VR: ○ Venomotor tone

○ Blood volume (ECF vol)

○ Right atrial pressure

(RAP) ○ Posture

- Atrial contractility

Significance of JVP

The relationship between RAP, VR and Cardiac output (CO)

## **Blood pressure**

### **• Determinants of blood pressure:**

- Poiseuille's flow equation rearranged to get arterial pressure
- Mean Art Press =  $CO \times TPR$
- Determinants of CO - Refer to item 6
- Determinants of TPR - refer to item 7

### **Regulation of blood pressure:**

Short-term

Long-term

Measurement of blood pressure

Non-invasive – Sphygmomanometry – its principles

Invasive – arterial pressure transducer

## **Cardiovascular autonomic reflexes**

Baroreceptor reflexes

Chemoreceptor reflexes

Vasovagal syncope

Cushing's reflex

The reflex pathways for the above and the purpose of each of those reflexes

## **Effects of exercise on cardiovascular system**

Immediate effects

Long term effects

## **Pathophysiology**

### **Hypertension**

Essential, secondary, age-related

### **Hypotension or Shock**

Pathophysiology of shock:

Hypovolemic, cardiogenic, Distributive (septic, anaphylactic, Obstructive, neurogenic)

## **Heart failure**

Definition; effects of forward and backward failures  
Congestive heart failure - in terms of Starling curves

### **Myocardial infarction or heart attack**

Definition; Gross ECG changes  
Difference between ischemia and infarction  
Angina

### **Valvular diseases**

### **Congenital heart diseases**

**Regional circulations** with emphasis on peculiarities and what controls flow in them

#### **Coronary**

#### **Cerebral**

**Renal** circulation - autoregulatory mechanisms to override global sympathetic discharge - myogenic factors and TG feedback

#### **Splanchnic**

**Cutaneous circulation and temperature regulation**

#### **Skeletal muscle**

**Pulmonary** (its pressures, hypoxic vasoconstriction)

### **Miscellaneous**

## **8. The Respiratory System**

**Functional anatomy**

Overview of the respiratory tract

Functions of the nose and para-nasal sinuses.

The structure of the bronchial tree.

conducting zone

respiratory zone.

Bronchial musculature: Influences of sympathetics and parasympathetics

Overview of the pul

monary vasculature

## **Ventilation**

### **Muscles of respiration**

Muscles of inspiration and expiration

Accessory muscles of respiration

The normal respiratory rate

Applied Physiology

- The importance of recognizing usage of the accessory muscles of respiration

### **Respiratory pressures**

Intra alveolar pressure

Intra pleural pressure. Emphasis on the importance of the negative intra pleural pressure.

Trans pulmonary pressure

Changes in alveolar and intra pleural pressures during respiration

Applied Physiology

The negative intrapleural pressure as a cause for pneumothorax in trauma, and iatrogenic cases

### **Airway resistance**

Sites of air way resistance

Changes in airway resistance with inspiration and expiration

Role of the sympathetics and parasympathetics on bronchial tone

### **Compliance**

Definition

factors affecting compliance – elasticity of lung tissue and surface tension of alveolar lining

Applied Physiology

- Conditions of increased and decreased compliance

## **Surface tension, surfactant**

Surface tension in air-liquid interface

Law of Laplace

Surfactant – its role in reducing surface tension and keeping the lung dry

## **Lung volumes and capacities**

Spirogram

Lung volumes & capacities

The physiological significance of the functional residual capacity

Changes in FEV1 and FVC and the FEV1/FVC ratio in obstructive and restrictive diseases.

## **Dead space**

Anatomical dead space

Physiological dead space

Ventilation/perfusion ratio V/Q

Applied Physiology

- High V/Q contributing to the physiological dead space

Low V/Q effectively serving as a shunt

## **Gas Exchange**

Fick's law of diffusion

Factors that affect rate of gas diffusion

Composition of atmospheric, tracheal and alveolar air

Oxygen uptake is diffusion-limited

Type I respiratory failure

## **Transport of oxygen**

The forms of transport of oxygen

Oxygen carrying capacity of the blood

Oxygen hemoglobin dissociation curve

Gradient of partial pressures of oxygen from atmosphere to tissues

## **Applied physiology**

Type I respiratory

failure • Hypoxia - types



Asphyxia  
High altitude physiology – acute and chronic mountains sickness  
High altitude pulmonary edema  
Cyanosis

### **Transport of Carbon dioxide**

Forms of transport of carbon dioxide in blood  
Chloride shift  
Haldane effect  
Respiratory acidosis and alkalosis Carbon dioxide expulsion is ventilation-limited.  
Hypercapnea, Type II respiratory failure

### **Control of Respiration**

Respiratory centres  
Neural control of respiration  
Chemical control of respiration

### **Pulmonary Circulation**

Pressure within pulmonary blood vessels  
Blood volume in lungs and its significance in posture  
Hypoxic vasoconstriction.

### **Exercise**

Effect of exercise on the respiratory system  
Types of exercise – aerobic (endurance) and anaerobic (resistance) exercises, and their benefits  
Concept of  $VO_2$  maximum  
The concept of oxygen debt

### **Integrated lectures**

Acid base balance  
Respiratory failure I and II  
Interpretation of arterial blood gases

### **Pulmonary Function testing**

Spirometry  
Arterial

blood

gases

- Peak flow

Miscellaneous

## **9. The Renal System**

**Overview of the structure and functions of the kidney**

**Overview of Functions of kidneys**

Formation and composition of urine

Regulation of:

- Blood volume
- BP
- Plasma electrolytes
- Plasma osmolarity
- Plasma pH

Synthesis of enzymes and hormones (Renin, Erythropoietin, Calcitriol, Kinins-Bradykinin, Prostaglandins)

### **Macroscopic Structure**

**L.S of kidney:** Hilum, cortex, medulla, renal pyramids, papilla, minor calyces, major calyces, Renal pelvis

### **Nephron**

Cortical Nephron (CN)

Juxta medullary nephrons (JMN).

Differences between the two types of nephrons

PCT, LOH, DCT, Collecting duct

Afferent arteriole, Glomerulus and the efferent arteriole; Peritubular capillaries and vasa recta

Juxtaglomerular apparatus:

- Its role in RAA axis to regulate blood pressure
- Its role in Tubuloglomerular feedback to autoregulate Renal Blood flow and therefore GFR

### **Formation of Urine**

Glomerular filtration

Tubular reabsorption

Tubular secretion.

### **Glomerular filtration**

Glomerular filtration:

Factors

affecting

filtration:

- Surface area of Glomerular Capillaries
- Starling's forces:  $[GFR = K_f \times (P_G - P_B - \pi_G + \pi_B)]$
- MW of the substances
- Electrical charge of the substance

Glomerular filtrate as an ultrafiltrate of plasma

Glomerular filtration rate (GFR) – determinants and regulation

Renal blood Flow (RBF) – Determinants and regulation

Regulation of GFR parallels regulation of renal blood flow

Autoregulation of GFR and RBF

Myogenic mechanism

Tubulo-Glomerular feed back.

### **Juxtaglomerular apparatus**

- Macula densa of tubule
- JG cells of the arteriole

Role of JG cells in:

Autoregulation of GFR and RBF (TG feedback)

Regulation of blood pressure via the Renin-AT-Aldosterone

axis Concept of Renal clearance

Inulin clearance (to measure GFR) and PAH clearance (to measure Renal blood flow)

Creatinine clearance to assess GFR

Serum creatinine as renal function test

### **Tubular reabsorption and Secretion**

#### **PCT**

Important transporters in PCT

Reabsorption of sodium, chloride and water (2/3 of filtered load)

Glomerulotubular balance.

Almost 100 % reabsorption for glucose, bicarbonate and amino acids;

Details of bicarbonate reabsorption

### **Loop of Henle (LOH)**

#### **Permeability characteristics**

- **Descending Limb:** Impermeable to solutes, permeable to water

- **Ascending Limb:** Impermeable to water, permeable to solutes;  
     Na/2Cl/K transporter and the sodium potassium pump in the TAL segment of ascending limb.  
     Function of LOH: Creation of hyperosmolar medullary interstitium (MI) by two mechanisms:  
         Active transport of salt in TAL segment  
         Counter-current multiplication of the active transport  
     Role of vasa recta in maintaining the hyperosmolarity of the MI.  
     Transporters in the luminal and basolateral borders

### **Distal Convoluted Tubules (DCT)**

- Regulated reabsorption of sodium (aldosterone)
- Regulated secretion of potassium (aldosterone)
- Generation of bicarbonate including factors affecting the same:
  - Presence of proton pumps
    - Luminal electronegativity
    - Urinary buffers - Phosphate and ammonia

### **Collecting duct (CD)**

- Site of concentration of urine.
  - Role of ADH in regulated water absorption
  - Gradient for water absorption provided by hyperosmolarity of the medullary interstitium(MI) (created by LOH)
  - Role of ADH in urea absorption abetting the hyperosmolarity of MI.

### **Micturition reflex**

- Reflex pathway
- Cystometrogram

### **Kidney Function Tests**

- Urine volume, urine albumin, urine microscopy
- Plasma Creatinine
- Creatinine clearance

### **Diuretics**

### **Pathology**

- Definition of acute and chronic renal failures

## **Artificial kidney**

### **Regulation of Na<sup>+</sup> conc. & ECF osmolarity**

#### **Regulation of K concentration**

Osmoreceptor, Thirst mechanism

ADH

Aldosterone, Angiotensin II, ANP

Handling of K at DCT, (Aldosterone)

Relationship between K concentration and pH of blood.

#### **Regulation of Acid base balance**

Buffer systems: Bicarbonate, hemoglobin, Intracellular Proteins

Respiratory regulation of Acid Base balance

Renal regulation of Acid Base balance: Bicarbonate reabsorption in PCT and Bicarbonate generation in DCT

Primary acid base disturbances: Respiratory acidosis, Respiratory alkalosis Metabolic acidosis, Metabolic alkalosis.

Concept of Anion gap

## **10. Autonomic Nervous System**

### **Organization**

- Sympathetic and parasympathetic divisions

Pre-ganglionic neuron  
Post-ganglionic neuron

### **Sympathetic division**

Thoraco-lumbar outflow  
Ganglia close to vertebral column  
Post ganglionic neurons longer – travel along vessels to reach viscera  
Adrenal medullary cells are post-ganglionic neurons that have lost their axons

### **Parasympathetic division**

Cranio-sacral outflow  
Head - through the oculomotor, facial and glossopharyngeal nerves  
Thorax and upper abdomen - through the vagus  
Sacral - through S2, S3 and S4 sacral nerves to the viscera  
Ganglia are within or close to the organ of supply  
post-ganglionic neurons are short

### **Chemical transmission**

Acetylcholine - all pre-ganglionic neurons, post-ganglionic parasympathetic neurons, sympathetic post-ganglionic neurons that innervate sweat glands,  
All other sympathetic post-ganglionic neurons secrete nor-epinephrine

### **Acetylcholine**

Removal by acetylcholinesterase  
Receptors  
Muscarinic receptors - distribution and difference in action through these receptors  
Nicotinic receptors – distribution

### **Catecholamines**

Receptors  
alpha 1 – vasoconstriction  
alpha 2  
beta 1 increases heart rate  
beta 2 – bronchodilation  
beta 3

## **Effects of sympathetic and parasympathetic stimulation**

### **General functions**

Sympathetics - fight or flight response

## Eye

Parasympathetic – accommodation, miosis

Sympathetic – mydriasis

## Heart

### •SA node

- Parasympathetic - decreases heart rate – muscarinic receptor
  - Sympathetic - Increases heart rate - beta 1 receptors
- Atria & Ventricle
- Parasympathetic - decreases force of contraction
  - Sympathetic - increases force of contraction - beta 1 & 2 receptors
- AV node and Purkinje fibers
- Parasympathetic - decreases conduction velocity
  - Sympathetic - increases conduction velocity - beta 1 & 2 receptors

## Lungs

Parasympathetic – bronchoconstriction

Sympathetic

Dilation - beta 2

## Vessels

### • Arterioles

- Sympathetic - vasoconstriction - alpha 1 & 2

Veins

Sympathetic - constriction - alpha 1 & 2

## Stomach and intestine

### • Parasympathetic

- Increases motility & secretion
- Relaxes sphincters

Sympathetic

- Decreases motility & secretion
- Contracts sphincters

## Gall bladder

Parasympathetic – contraction

Sympathetic – relaxation

## Urinary bladder

### • Detrusor

- Parasympathetic – contraction



- Sympathetic – relaxation  
Sphincter
- Parasympathetic – relaxation
- Sympathetic – contraction

### **Male sex organs**

Erection – parasympathetic  
Ejaculation – Sympathetic

### **Skin**

Pilomotor - Sympathetic – contraction  
Sweat glands  
Parasympathetic - generalized dilute secretion

### **Liver**

Sympathetic – glycogenolysis

### **Pancreas**

Exocrine  
Parasympathetic increases secretion  
Sympathetic -decreases

### **Salivary gland**

Parasympathetic - profuse watery secretion  
Sympathetic - thick viscous secretion rich in enzyme

### **Lacrimal gland**

Parasympathetic – secretion

### **Adipose tissue**

### **Drugs acting on the autonomic nervous system**

### **Higher control**

Hypothalamus  
Medulla – RVLM

### **Diseases**

## **11. The Nervous System**

### **Organisation**

1. CNS

2. PNS
  - Somatic NS
  - Autonomic NS
  - Enteric NS

## **Neural tissue**

1. Neuron - Structure, functional features, types - structural & functional classification
  - Ganglion & Nucleus
  - Neuroglia - General features, types, functions, myelination

## **Nerve fibres**

1. Broad principles of Erlanger & Gasser's classification
  - Functions & susceptibility to damage
2. Anterograde & retrograde axoplasmic transport, with clinical application
3. Neural growth, Nerve injury & repair of injured peripheral nerve fibre with clinical application

## **Nerve impulses**

1. Concept, characteristics, genesis & ionic basis of Resting membrane potential, Electrotonic potential, Action potential in the neuron
  2. Continuous & Saltatory conduction of action potential
- Factors affecting conduction velocity

## **Synapses**

1. Electrical & chemical synapse
2. Functional anatomy of chemical synapse
3. Types of chemical synapse
4. Steps in synaptic transmission
5. Post-synaptic potential
  1. **Properties of synapse:**
    - One-way conduction
    - Synaptic delay
    - Convergence and Divergence of synapses
    - Summation
      - Spatial summation
      - Temporal summation
    - Pre-synaptic inhibition & Facilitation
    - Post-synaptic inhibition

## **Neurotransmitters**

1. Important neurotransmitters of the CNS - Excitatory, Inhibitory
2. Receptors - determine action of neurotransmitters; 2 types - Ionotropic & metabotropic with examples
3. Types of acetylcholine & adrenergic receptors
4. Names of ionotropic receptors of Glutamate
5. Denervation hypersensitivity

## **Introduction to CNS**

1. Anatomical parts of CNS
2. Functional divisions - Sensory & Motor systems, Higher functions

## **Spinal cord**

1. Functional anatomy
  - Horns
  - Neurons - motor, sensory, autonomic, interneurons
  - Spinal nerves - Bell-Magendie law
  - Tracts

## **Sensory system**

1. Classification of sensations
2. List of receptors of somatic sensations
3. Sensory nerves
4. Concept of adaptation of receptors

## **Muscle spindle**

1. Structure - intrafusal fibres with actin & myosin at its ends
2. Afferent & efferent innervation
3. Mechanism of stimulation
4. Branches (divergence) of muscle spindle afferents in the spinal cord & its terminations
5. Effects of spindle stimulation - Proprioception, Stretch reflex, Muscle tone & reciprocal innervation
6. Deep tendon reflexes - monosynaptic reflex, reflex arc
7. Physiological basis for hypertonia, hypotonia & exaggerated deep tendon reflexes

## **Golgi tendon organ**

1. Mechanism of stimulation
2. Inverse stretch reflex - a polysynaptic reflex, reflex arc

## Reflexes

1. Definition
2. Types/ classification of reflexes
3. Components of reflex arc
4. Monosynaptic reflex
5. Polysynaptic reflexes
6. Flexor or withdrawal reflex
7. Crossed extensor reflex
8. Mass reflex & its use in spinal cord injury patients

## Ascending sensory tracts

1. Names of tracts
2. Three neuron pathway of sensory system
3. **Dorsal column & spinothalamic tracts** - sensations carried, receptors involved, pathway up to the cortex, with salient features
  - o Pathway for sensations from face
  - o Clinical application of lesions of above pathways at various levels

## Pain sensation

1. Visceral pain - causes, pathway, special features
2. Referred pain - concept, examples
3. Collaterals from pain pathway to reticular formation - stimulates the ARAS
4. **Endogenous pain control mechanisms & Endogenous analgesia** -  
Concept of & mechanism of activation of
  - o Gate control theory of pain
  - o Descending pain control pathways
  - o Endogenous opioid systems – endorphins

## Sensory System – underlying principles

1. Labeled line code
2. Law of projection
3. Sensory Cortex-Primary sensory area SI & SII
  - o Sensory homunculus
  - o Cortical sensations
  - o Cortical plasticity
4. Clinical application - Phantom limb pain

## Motor system

1. Outline of motor control
2. Concept of UMNs & LMNs

## **Descending motor tracts**

1. Corticospinal & cortico-bulbar tracts
  - o Pathway
  - o Functions
2. Extra-pyramidal tracts
  - o Names of tracts
  - o Origin & termination
  - o Gross functions
  - o Net influence on spinal motor neurons & spinal reflexes
  - o Effect of its lesion on spinal motor neurons, spinal reflexes & muscle tone

## **Lesions of motor system**

1. Features of Upper motor neuron & lower motor neuron lesion
  - o Physiological basis of the same
2. Effects of lesion of pyramidal tract fibres at different levels, stroke
3. Muscle paralysis - Hemiplegia, quadriplegia, paraplegia
  - o Hemiparesis, quadriparesis & paraparesis
4. Hemisection of spinal cord - Brown sequard syndrome
5. Approach to a patient with muscle weakness or paralysis

## **Postural reflexes**

1. Need for maintenance of posture & balance
2. Role of postural reflexes in maintaining posture and balance
  - o Need for sensory input to initiate these motor reflexes
  - o Parts of the CNS integrating these reflexes

## **Cerebellum**

1. Functional divisions
2. Outline of inputs & outputs
3. Functions of cerebellum & its connections
4. Features of cerebellar lesions

## **Basal ganglia**

1. Nucleii forming the basal ganglia
2. Input & output nucleii
3. Skeletomotor circuit- Input & output connections
4. Mention of the direct & indirect pathways
  - o Effect on motor activity due to activation of these pathways
5. Function of dopaminergic nigro-striatal pathway

6. Functions of Basal ganglia
7. Movement disorders of basal ganglia - special emphasis on Parkinson's disease

### **Reticular formation**

1. Groups of nuclei forming  
○ Vital centres
2. Ascending Reticular Activation System
3. Functions of reticular formation

### **EEG**

Physiological basis of EEG

Types of EEG waves with trends in their amplitude & frequency, and conditions in which they are recorded

Uses of EEG

### **Sleep**

1. Definition
2. Stages of NREM & its features
3. Features of REM
4. Cycles of above stages

### **Thalamus**

1. Parts of the Diencephalon
  2. Groups of thalamic nuclei
  3. Outline of connections of thalamus
- Functions of thalamus

### **Hypothalamus**

1. 4 major regions of hypothalamus
2. Functions of hypothalamus

### **Limbic system**

1. Outline of components of Limbic system
2. Importance of Papez circuit
3. New concept of the Limbic circuit - emphasis on Amygdala
4. Functions of the limbic system

### **Cerebrum**

1. Blood brain barrier - components, functions, clinical applications
2. CSF - composition, pressure, secretion, circulation, drainage, functions & clinical application - papilloedema & hydrocephalus

1. Blood-CSF barrier
2. Hemispheric specialisation (dominance), handedness
3. Main sensory, motor & association areas - and their functions Wernicke's area

### **Higher functions of nervous system**

1. Language - definition
  2. Physiology of language & speech - Role of Wernicke's & Broca's areas in language & speech
- Learning & memory - definition, classifications, basic principles of each type of memory & learning with examples, role of the Hippocampus

## **12. Special Senses**

### **Overview of functions of structures of Eye**

1. Broad functions of Orbit, Eyelids, Extra-ocular muscles, layers of eyeball, Iris, Ciliary body, Intra-ocular muscles, Lens, Aqueous humor, Vitreous body, Optic nerve
2. Secretion, circulation & drainage of Aqueous humor

### **Optics of eye**

1. Optics of the eyes – similar to a camera
2. Normal image formation - refracting media & refractive interfaces, refractive power,
3. Mechanism of accommodation for near vision
4. Physiological basis of Refractive errors & their spectacle correction

### **Retina**

1. Optic disc, Macula lutea & Fovea - Structural features & its functional significance
2. Photoreceptors - rods & cones, bipolar cells & ganglion cells
3. Function of rods & cones

### **Photo-transduction**

1. Visual pigments - breakdown by light
2. Resulting in a Hyperpolarizing receptor potential in rods & cones
3. RMP of rods & cones - depolarized potential

### **Light & Dark adaptation**

1. Events occurring during light & dark adaptation
2. Nyctalopia

### **Colour vision**

1. By Cone pigments
2. Overlap in spectra of light absorbed by them
3. Colour blindness

### **Optic pathway**

1. Visual pathway from the photoreceptors to the striate cortex of occipital lobe
2. Visual field defects produced by lesions at various levels of the pathway

### **Pupillary reflexes**

1. Direct & indirect light reflex and its pathway (afferent & efferent)
2. Accommodation reflex & its pathway
3. Argyl Robertson pupil



4. Horner's syndrome

### **Clinical tests of Vision**

1. Test of Visual acuity - method of testing for distant & near vision
2. Recording of visual fields - Confrontation test - Blind spot
3. Testing for colour vision - Ishihara's chart
4. Testing for pupillary light reflexes

### **Miscellaneous**

### **Hearing**

#### **External ear**

Functions of Pinna, External auditory canal and Tympanic membrane

#### **Middle ear**

1. Components of the middle ear
2. Functions of the middle ear
3. Clinical application: Eustachian tube block, Hyperacusia

#### **Sound**

Pitch & loudness of sound

#### **Inner ear**

1. Name the components
2. General outline of the anatomy & structural relationship between the various parts of inner ear
3. Organ of Corti with its hair cells - sense organ of hearing with auditory receptors

#### **Mechanism of hearing**

1. Role of external ear & middle ear
2. Setting up of vibrations of cochlear membranes
3. Mechanotransduction by auditory hair cells
4. Firing of cochlear afferent fibres
5. Difference between Air conduction & Bone conduction of sounds to the cochlea

#### **Pitch discrimination**

'Place principle' of hearing

#### **Auditory pathway**

1. Auditory pathway
2. Cause for unilateral deafness - damage to cochlea, 8th cranial nerve & cochlear nuclei

## **Deafness**

Types of deafness - Conductive & Neural

## **Tests of hearing**

1. Tests of tuning fork - Rinne's, Webers, Schwabach
2. Principle of the Audiogram

## **Ear – Vestibular Apparatus**

### **Semicircular canals**

1. Orientation
2. General outline of structure
3. Receptors - hair cells & its innervation
4. Mechanism of stimulation of vestibular hair cells
5. Function

### **Otolith organs**

1. Utricule & saccule - structural details to explain function
  - o Macula & vestibular hair cells
  - o Otolithic membrane
  - o Otoconia
2. Orientation of hair cells & mechanism of stimulation
3. Function

### **Vestibular pathway**

1. Vestibular hair cells - vestibular division of the 8th cranial nerve to vestibular nuclei
2. Connections to cerebellum & the Vestibulospinal tracts
3. Function of Vestibular system - Maintenance of Balance, Equilibrium, & Posture

## **Tests of Vestibular function**

## **Smell**

### **Chemical senses**

Similarities between Smell & Taste

## **Olfaction**

1. Olfactory membrane & its cells in Nose
2. Olfactory neurons - features, life span
3. Mechanism of detection of smell

### **Olfactory pathway**

1. Special features
2. Key structures of the pathway - up to olfactory cortex on lower medial aspect of temporal lobe

### **Abnormalities of smell**

1. Test of olfaction
2. Common causes for Anosmia, Hyposmia, Parosmia

### **Gustation**

#### **Taste sensation**

1. Importance
  2. Taste buds - structure, cells & renewal
- Mechanism of stimulation of taste cell

#### **Taste pathway**

1. Special feature
2. The 3 cranial nerves carrying taste sensation
3. Key synapses before projection to Gustatory cortex

#### **Clinical application**

1. Testing for taste sensation
2. Abnormalities of taste sensation

## **M.Sc – List of Physiology Practicals**

### **I. Haematology**

1. Collection of Blood
2. Microscope and Haemocytometer
3. Erythrocyte count
4. Total Leucocyte count
5. Absolute Eosinophil count
6. Differential Leucocyte count
7. Estimation of Hemoglobin
8. Blood grouping
9. Packed Cell Volume
10. Erythrocyte Sedimentation Rate
11. Osmotic fragility
12. Specific gravity of blood
13. Bleeding time
14. Clotting time
15. Erythrocyte indices
16. Clinical problems in Hematology

### **II. Cardiovascular system**

1. Examination of Arterial Pulse
2. Determination of Arterial blood pressure
3. Recording of Electrocardiogram
4. Effect of Posture on Blood pressure and heart rate
5. Effect of rhythmic Muscular exercise on Blood pressure and Heart rate
6. Tests of Physical fitness
7. Cutaneous Circulation

### **III. Respiratory System**

- a.i.1. Volumetric measurements in Respiration and the effect of posture
- a.i.2. Forced Expiratory Volume
- a.i.3. Recording of chest movements
- a.i.4. Effect of Exercise on Ventilation

## **M.SC. (PRELIMINARY) – ANATOMY SYLLABUS**

### **INTRODUCTION:**

Definition and subdivisions of human anatomy  
Anatomical position of the body and terminology  
Regions and systems of the body  
Cavities of the body and their contents

### **TISSUES OF THE BODY:**

Definition and types of the tissues  
Characteristics and locations of different types of tissues

### **BONES:**

Definition of skeleton, axial and appendicular skeleton  
Types of bones, bony prominences, names, locations and general features of the bones of the body

### **JOINTS:**

Definition and types of joints with examples  
Kinds of movements possible  
Names, locations, types, bony parts and joints, ligaments (no attachments), movements possible and chief muscles producing such movements of the main joints of the body

### **MUSCLE:**

Parts of a skeletal muscle.  
Definition of origin and insertion.  
Names and locations of skeletal muscles.  
Actions and nerve supply of muscles

### **NERVOUS SYSTEM:**

Subdivisions of nervous systems  
Spinal cord:  
Location, extent, spinal segments, external features, gross internal structure.  
Examples of important ascending and descending tracts.

### **Brain:**

Subdivisions – location and external features of medulla oblongata, pons, midbrain, cerebellum and cerebrum.  
Location and general features of thalamus and hypothalamus  
Location and subdivisions of basal ganglia.  
Names of meninges and spaces around them.

Name and location of ventricles of brain and circulation of cerebrospinal fluid. Names of blood vessels supplying brain and spinal cord.

Cranial nerves:

Name, serial number and general distribution.

Spinal nerves:

Typical spinal nerve.

Groups of spinal nerves

Name and location of plexuses.

Nerves forming and main branches of each plexus.

Location and distribution of each main branch.

Autonomic nervous system:

An overview of sympathetic and parasympathetic nervous system.

Sense organs:

Location, general features of nose, tongue, eye, ear and skin.

**CARDIOVASCULAR SYSTEM:**

Shape, size, location, coverings and general external and internal features of heart.

List of blood vessels supplying the heart (development of blood vessels not necessary).

Name and location of principal arteries and veins.

Name, location and features of the lymphatic organs.

**RESPIRATORY SYSTEM:**

Location and general features of nose, pharynx, larynx, trachea, bronchi and lungs.

Pleura (definition).

**DIGESTIVE SYSTEM:**

Location and general features of mouth, pharynx, oesophagus, stomach, small and large intestine.

Location and general features of salivary glands, liver, gall bladder and pancreas.

Peritoneum (definition).

### **URINARY SYSTEM:**

Location and general features of the male reproductive organs – scrotum, testis, epididymis, vas deferens, seminal vesicle, ejaculatory duct, prostate gland and penis, spermatic cord.

Location and general features of the female reproductive organs – uterus, uterine tube, vagina, ovary, breast.

### **ENDOCRINE SYSTEM:**

Location and general features of the pituitary, thyroid, parathyroid and suprarenal gland.

### **METHODS OF TEACHING:**

1. Lecture
2. Seminars
3. Demonstration
  - a) Skeleton
  - b) Dissected**

specimens

# SYLLABUS FOR MSc (BIOCHEMISTRY) COURSE – 2<sup>nd</sup> and 3<sup>rd</sup> YEARS

## PAPER I - PHYSICAL AND ORGANIC ASPECTS OF BIOCHEMISTRY, MEMBRANES, INSTRUMENTATION AND LABORATORY TECHNIQUES

### **A. PHYSICAL AND ORGANIC ASPECTS OF BIOCHEMISTRY AND MEMBRANES**

Electrolytic dissociation, mass law, acids and bases, pH, buffers, surface tension, viscosity, colloidal state, Donnan equilibrium, osmosis, colloids, diffusion, dialysis, applications to biological systems, hydrogen bonding, hydrophobic interactions and ionic bridges, determination of molecular weights. Prokaryotic and eukaryotic cells. Structure of eukaryotic cells – sub cellular organelles, and their functions.

Sub-cellular fractionation – density gradient centrifugation, differential centrifugation, markers for each organelle and fraction

Biomembrane and its structure, fluid mosaic model and assembly of membranes

Properties of biological membranes artificial membranes and liposomes

Transport across membranes – active, facilitated and passive

Transport mechanisms – ion channels including gated channels, carrier proteins, glucose transporters (GLUT), active transporters, symporters and antiporters.

Cell interactions and adhesion – types of junctions : tight junctions and gap junctions.

Surface glycoproteins and cell surface labeling – ABO blood groups, major histo-compatibility complex (MHC), adhesion molecules

**Carbohydrates**: Classification of carbohydrates, structure, configuration, reactions and functions of pentoses, hexoses, oligosaccharides and polysaccharides (including glycosaminoglycans, glycoproteins)

**Lipids**: Classification, Structure, physical and chemical properties of lipids Fatty acids, saturated and unsaturated fatty acids, polyunsaturated fatty acids, triacylglycerols, phospholipids, glycolipids, lipoproteins, steroids, eicosanoids

**Amino acids**: Classification of amino acids, their physical and chemical properties and general reactions, peptides, modified amino acids, amino acids as buffers, amino acid titration, zwitterions and isoelectric point, dissociation constant

**Proteins**: Classification of proteins, structure, properties and function; hemoglobin, myoglobin, collagen, elastin  
Relationship of function to the three dimensional structure of myoglobin,



haemoglobin, collagen and elastin

Biologically important peptides, cross-links, hydrogen bonds, disulphide bonds, non-covalent and ionic bonds in peptides

Primary, secondary, tertiary and quaternary structure of proteins and elucidation of these

**Nucleotides and nucleic acids:** Chemistry of purine and pyrimidines, nucleic acids, DNA structure and function, organisation of chromatin, role of histones in chromatin formation

Types of RNA, their structures and functions, biologically important nucleotides and their derivatives, analogues of purines, pyrimidines, nucleosides and nucleotides and their clinical importance

## **B. INSTRUMENTATION AND LABORATORY TECHNIQUES** **(PRINCIPLES AND APPLICATIONS)**

### **Centrifugation**

Ultracentrifugation

### **Radio-immuno assay**

Radioactivity, properties of radionuclides and measurement of radioactivity, techniques, autoradiography, *Geiger-Müller* counter, scintillation counting  
Immuno-radiometric assay (IRMA), stable isotopes and mass spectrometry

### **Colorimetry**

Beer- Lambert's law, spectrophotometry, reflectance photometry, automated techniques, semi- and random autoanalysers, flow cytometer  
Flame emission photometry, atomic absorption spectrophotometry  
Flurometry, phosphorescence, chemiluminescence and bioluminescence  
Nephelometry, turbidimetry  
Direct vision spectroscope

### **Electrochemistry**

Chemical sensors, potentiometry, ion selective electrodes, optical chemical sensors, enzyme electrodes and enzyme immobilization  
Osmometry

### **Electrophoresis**

Paper, agarose gel, polyacrylamide gel electrophoresis (PAGE), SDS - PAGE, iso-electric focusing

## **Chromatography**

Column, paper, thin layer chromatography (TLC), gas liquid chromatography (GLC), high pressure liquid chromatography (HPLC), gel filtration, ion exchange and their applications

## **Immunochemistry**

Principles of immunochemistry, immune-electrophoresis, enzyme-linked immunosorbent assay (ELISA) techniques, blotting techniques

## **Principles of laboratory analyses and safety:**

Automation in a clinical chemistry laboratory

Units of measurement, international system of units in laboratory medicine

Conversion from conventional units to SI units, IFCC and IUPAC system recommendations, reference materials, reagent grade water production

## **Basic bio-statistic principles as applied to health sciences**

Mean, standard deviation, standard error of mean, tests of significance (confidence interval student's t test, chi-square test, ANOVA), correlation coefficient, probability

Selecting an analytical method, evaluation of an analytical method, evaluation of a diagnostic test

## **PAPER II : ENZYMES, INTERMEDIARY METABOLISM AND METABOLISM OF BIOMOLECULES, NUTRITION AND MOLECULAR BIOLOGY**

### **A. ENZYMES**

Nomenclature, classification, chemistry, isolation, purification and characterization, general properties, co-enzymes, metal-activated enzymes, metallo-enzymes, mechanisms of action, factors influencing enzyme activity, Michaelis- Menten constant, kinetics of enzyme action, Km value and its significance, influence of activators and enzyme inhibitors, regulation of enzyme activity, allosteric enzymes, isoenzymes, clinically important enzymes and role of enzymes in clinical medicine, enzyme therapy, immobilized enzymes, serine proteases

### **B. INTERMEDIARY METABOLISM AND METABOLISM OF BIOMOLECULES** **Vitamins**

Chemistry, structure, functions, natural occurrence, dietary sources, daily human requirements and deficiency manifestations of water soluble and fat soluble vitamins, hyper-vitaminosis, antivitamins, assays of vitamins and screening of vitamin status in humans

## **Bioenergetics and biological oxidation**

The role of ATP and other high-energy phosphates, biologic oxidation, respiratory chain, oxidative phosphorylation, inhibitors and uncouplers, mitochondrial diseases

## **Carbohydrate metabolism**

Digestion and absorption, glycolysis, Rapaport-Leubering cycle, pentose phosphate pathway, glycogenesis and glycogenolysis, citric acid cycle, uronic acid pathway, gluconeogenesis and their regulation, metabolism of fructose and galactose, regulation of blood glucose, metabolism of glycosaminoglycans and glycoproteins and associated disorders, hypoglycemia, hyperglycemia, renal glycosuria, diabetes mellitus, glucose tolerance tests (GTT), inborn errors of carbohydrate metabolism, disorders of fructose metabolism, lactose intolerance, glycogen storage diseases, metabolism of alcohol

## **Lipid metabolism**

Digestion and absorption, fatty acid synthesis and elongation, synthesis of unsaturated fatty acids, oxidation of fatty acids, metabolism of ketone bodies and unsaturated fatty acids, essential fatty acids, metabolism of eicosanoids and their biological role, metabolism of triglycerides, phospholipids, sphingolipids and cholesterol, compounds derived from cholesterol, fatty liver, lipotropic factors, metabolism of lipoproteins, inborn errors of lipid metabolism, metabolism in adipose tissue (including brown adipose tissue), disorders of lipid metabolism, lipid storage disorders, obesity, metabolic adaptations in starvation and obesity

## **Proteins**

Digestion and absorption of proteins, gamma-glutamyl cycle, catabolism of amino acids, ammonia production, nitrogen balance, inter-organ transport of amino acids, urea cycle and associated disorders, hyperammonemia  
Catabolism of carbon skeleton of amino acids, biosynthesis of nonessential amino acids.

degradation of individual amino acids, creatinine and creatinine metabolism, biogenic amines, specialized products formed from amino acids, neurotransmitters, polyamines, biologically important peptides, plasma proteins, paraproteins, aminoacidurias, inborn errors of amino acid metabolism

## **Nucleic acids**

Metabolism of purines, disorders associated with abnormalities in the metabolism of purines, primary and secondary gout, metabolism of pyrimidines, disorders associated with abnormalities in the metabolism of pyrimidines,

nucleotide analogues in chemotherapy

**Integration of metabolism** and metabolic adaptation during fed state and starvation

**Metabolism in specialized tissues**

Erythrocytes, liver, muscle, central nervous system, adipose tissue, lens, kidney

**Metabolism of haem**

Biosynthesis, disorders associated with defects in biosynthesis  
Degradation of haem, metabolism of bilirubin, disorders associated with abnormalities in the metabolism of bilirubin, laboratory diagnosis in these disorders

Abnormal haemoglobins and haemoglobinopathies, thalassemia, sickle cell anemia, methemoglobinemia

**Biochemical and molecular aspects of processes in the body**

Muscle contraction, nerve conduction, coagulation of blood

**Metabolism of minerals**

Sodium, potassium, calcium, phosphorus, magnesium, copper, zinc, iron, chromium, selenium, cobalt, manganese, other trace minerals  
Inborn errors of mineral metabolism

**Metabolism of xenobiotics and detoxification**

Environmental hazards, biochemical aspects of environmental hazards, occupational hazards (exposure to lead and organophosphorous compounds), hazards due to modern industrialization and noise pollution

**C. NUTRITION**

Energy metabolism, basal metabolic rate and specific dynamic action, energy requirements, macronutrients and their roles, balanced diets, biological value of proteins, essential amino acids, dietary fibre, dietary deficiencies, supplementary relationship among proteins, dietary requirements in the elderly, diabetes mellitus, etc, parenteral nutrition, disorders of nutrition (protein malnutrition, protein energy malnutrition, obesity), biochemical assessment of nutritional status, laboratory diagnosis of nutritional disorders, National Nutrition Programmes

**MOLECULAR BIOLOGY**

Organisation of nucleosomes, chromatin and chromosome, histones, structure and types of DNA and RNA, mitochondrial and plasmid DNA, eukaryotic and prokaryotic DNA replication, DNA damage and repair, eukaryotic and prokaryotic RNA synthesis and processing, post-transcriptional modifications, mutation, operon concept, gene rearrangement, gene amplification and transposons, gene-protein interaction, helix turn helix motif, zinc finger motif and leucine zipper motif, signal peptides, protein targeting and chaperones, protein synthesis and post - translational modifications of proteins, recombinant DNA technology and its application in medicine, restriction enzymes, cloning, vectors (definition, characteristics of different vectors), genome library, cDNA library, DNA probes and blot transfer techniques, polymerase chain reaction (PCR), reverse transcription PCR (RT-PCR), restriction fragment length polymorphism and its applications, fluorescent in-situ hybridization (FISH), transgenic animals, RNA interference, gene therapy, DNA diagnostics (methods of identifying genes in human disease), Human Genome Project, gene mapping, DNA and RNA viruses

Cell cycle, regulation of cell cycle, regulators, cyclins and their regulators, extracellular regulators of cell cycle, programmed cell death

## **PAPER – III. CLINICAL BIOCHEMISTRY, ENDOCRINOLOGY, IMMUNOLOGY, FREE RADICALS AND ANTIOXIDANTS AND ONCOGENESIS**

### **A. CLINICAL BIOCHEMISTRY**

Collection of samples and preservation, pre-analytical errors in clinical biochemistry, standardization of laboratory methods, use of pooled serum, acquisition of standards for laboratory estimations, quality control methods, use of reference values, selection of methods for estimation of common analytes like blood glucose, urea, creatinine, plasma proteins, etc, automation in clinical biochemistry, microprocessors and use of computers in clinical biochemistry, statistical methods of analysis of results.

#### **Metabolism of minerals**

Metabolism of calcium, phosphorous, magnesium, sodium, potassium and chloride – their relation to endocrinology

Trace elements and their metabolism

**Acid -base, water and electrolyte balance:** Buffers of the body, acidosis and alkalosis, interpretation of acid-base disorders

#### **Function tests**

Investigation of kidney function, liver function, gastric function and pancreatic function

Renal calculi, tumor markers, cerebrospinal fluid analysis, amniotic fluid analysis and prenatal diagnosis of inborn errors of metabolism

### **Clinical enzymology**

Estimation of serum enzymes like aspartate transaminase, alanine transaminase, alkaline phosphatase, acid phosphatase, amylase, lactate dehydrogenase, creatine phosphokinase and gamma-glutamyl transferase

### **Diagnostic tests**

In diabetes mellitus, myocardial infarction, nephrotic syndrome, liver diseases

## **B. ENDOCRINOLOGY, IMMUNOLOGY AND**

### **ANTIOXIDANTS Endocrinology**

General mechanism of action of hormones, evaluation of endocrine functions, hormones of hypophysis, hypothalamus, thyroid, parathyroid, pancreas, adrenals and gonads, hormones secreted by the gastrointestinal tract and kidneys, fetoplacental functions

### **Immunology**

Immune system, immunoglobulins, monoclonal antibodies, antigen-antibody reactions, complement system, cell-mediated immunity, mononuclear phagocytes, immunoassays, organ transplantation and histocompatibility, principles of immunization, immunological techniques in clinical chemistry.

### **Free radicals and anti-oxidants**

## **ONCOGENESIS**

Biochemical basis of cancer, oncogenes, tumor suppressor genes, tumor markers, genetic cancer syndromes (familial breast cancer, familial adenomatous polyposis coli and retinoblastoma), inherited conditions that predispose to development of cancer (e.g., ataxia telangiectasia, xeroderma pigmentosum, Fanconi syndrome), basics of cytogenetics

## **PRACTICALS**

### **GENERAL BIOCHEMISTRY**

<b><i>Qualitative Analysis</i></b>
<b>Reactions of carbohydrates</b>
1. Reactions of monosaccharides - glucose, fructose and galactose, mannose and arabinose

## 2. Reactions of disaccharides - maltose, lactose and sucrose

3. Reactions of polysaccharides – starch, dextrans and glycogen; hydrolysis of starch by acid
4. Analysis of carbohydrate mixtures
5. Paper chromatography of carbohydrates
<b>Reaction of amino acids</b>
6. General reactions of amino acids
7. Reactions of cysteine, cystine, methionine, phenylalanine, tryptophan, tyrosine, histidine and arginine.
8. Analysis of amino acid mixtures
9. Paper chromatography of amino acids
<b>Reactions of proteins</b>
10. Colour reactions of proteins
11. Precipitation of proteins (with cations and anions, by acidic and alkaloidal reagents, by concentrated salt solutions and by alcohol)
12. Action of mineral acids on albumin and globulin
13. Heat coagulation of albumin and globulins
14. Reactions of casein and gelatin
<b>Reaction of lipids</b>
15. Reactions of fatty acids, glycerol, fats and cholesterol
<b>Examination of bile</b>
16. Tests for bile salts and bile pigments
<b>Urinary analysis</b>
17. Identification of normal and abnormal constituents in urine
<b>Experiments on milk</b>
18. Identification of constituents in milk
<b>Haemoglobin derivatives</b>
19. Identification of hemoglobin derivatives using direct vision spectroscopy
<b>Quantitative Analyses</b>
20. Determination of iodine number of edible oils
21. Determination of saponification number of fats
22. Estimation of nitrogen – Micro Kjeldahl method
23. Estimation of phosphorus - Fiske and Subharao method
24. Estimation of glycogen in rat liver – anthrone method
25. Study of enzyme kinetics - effects of pH, temperature, substrate concentration, enzyme concentration and time - using catalase (from rat liver) and acid phosphatase (from potatoes)
<b>26. Agarose gel electrophoresis (for separation of serum proteins)</b>



<b>Demonstrations</b>	
27.	Enzyme-linked immunosorbant assay (ELISA)
28.	Polymerase chain reaction
29.	Extraction of DNA and RNA.
30.	Animal feeding and care (2-day observership in the animal house)

## **ESTIMATIONS OF CLINICALLY RELEVANT ANALYTES**

<b>GLUCOSE</b>	
1.	Estimation of plasma glucose
2.	Glucose tolerance test
3.	Stability check of glucose standards
<b>LIPIDS</b>	
4.	Estimation of serum cholesterol
5.	Estimation of serum triglycerides
6.	Estimation of HDL cholesterol
<b>LIVER FUNCTION TESTS</b>	
7.	Estimation of serum bilirubin
8.	Estimation of serum total protein
9.	Estimation of serum albumin
10.	Estimation of serum transaminases
11.	Estimation of serum alkaline phosphatase
12.	Estimation of serum alkaline phosphatase
<b>RENAL FUNCTION TESTS</b>	
13.	Estimation of serum urea
14.	Estimation of serum creatinine
15.	Estimation of creatinine clearance
16.	Estimation of urine protein levels
17.	Estimation of urine protein-creatinine ratio
18.	Estimation of uric acid
19.	Analysis of calculi
<b>MINERALS AND ELECTROLYTES</b>	
20.	Estimation of serum calcium
21.	Estimation of serum phosphorus
22.	Estimation of serum iron
23.	Estimation of serum iron-binding capacity

24.	Estimation of serum copper
<b>CSF ANALYSIS</b>	
25.	Estimation of CSF glucose (GOD-POD method)
26.	Estimation of CSF protein (sulphosalicylic acid method)
27.	Estimation of CSF chloride (Schaes and Schaes method)
<b>MISCELLANEOUS ENZYME ASSAYS</b>	
28.	Estimation of serum amylase, creatine kinase, lactate dehydrogenase, acid phosphatase, glucose-6-phosphate dehydrogenase and cholinesterase
<b>MISCELLANEOUS</b>	
29.	Estimation of serum ceruloplasmin and methemoglobin
30.	Estimation of vanillyl mandelic acid (VMA)
<b>HANDS-ON EXPERIENCE WITH AUTOMATED TECHNOLOGY (FOR ESTIMATION OF ALL THE ANALYTES LISTED ABOVE) IN DIAGNOSTIC LABORATORY TO WHICH POSTED</b>	
<b>DEMONSTRATIONS</b>	
31.	Arterial blood gas analyses
32.	Estimation of lipoproteins by nephelometry
33.	Estimation of insulin by radioimmunoassay
34.	Estimation of serum magnesium (atomic absorption spectrometry)
35.	Detection and estimation of Bence-Jones proteins
36.	Estimation of glycated hemoglobin (HPLC)

## **REFERENCE BOOKS :**

### **General Biochemistry**

1. Robert K. Murray, David A. Bender, Peter J. Kennelly, Victor W. Rodwell and P. Antony Weil. Harper's Illustrated Biochemistry, 29<sup>th</sup> edition.
2. John Baynes and Marek Dominiczak. Medical Biochemistry, 3<sup>rd</sup> edition,
3. Albert L. Lehninger, David Lee Nelson, Michael M. Cox. Lehninger's Principles of Biochemistry, 5<sup>th</sup> edition.
4. Donald Voet & Judith Voet, Biochemistry, 4<sup>th</sup> edition.
5. Thomas M. Devlin. Text book of Biochemistry with clinical correlations – 6<sup>th</sup> edition.
6. Lubert Stryer. Biochemistry, 5<sup>th</sup> edition.
7. N. V. Bhagavan. Medical Biochemistry, 4<sup>th</sup> edition.
8. David E. Metzler. Biochemistry: The Chemical Reactions of Living Cells, 2<sup>nd</sup> edition.
9. Reginald H. Garrett, Charles M. Grisham. Biochemistry, 2nd edition.
10. Vasudevan DM, Sreekumari S and V. Kannan: Text Book of Biochemistry for Medical Students, 7th edition
11. U. Satyanarayana and U. Chakrapani: Biochemistry, 4th edition.

### **Clinical Biochemistry**

1. Carl A. Burtis, Edward R. Ashwood, David E. Bruns. Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, 5<sup>th</sup> edition.
2. Carl A. Burtis, Edward R. Ashwood, David E. Bruns. Tietz Fundamentals of Clinical Chemistry – 6<sup>th</sup> edition.
3. Michael L. Bishop, Edward P. Fody, and Larry Schoeff: Clinical Chemistry: Principles, Procedures, Correlations, 7th edition.
4. Richard A. McPherson, Matthew R. Pincus. Henry's Clinical Diagnosis and Management by Laboratory Methods. 21<sup>st</sup> edition.
5. Alan H. Gowenlock, Janet R. McMurray and Donald M. McLauchlan. Varley's Practical Clinical Biochemistry. 6<sup>th</sup> edition
6. Philip D. Mayne. Clinical Chemistry in Diagnosis and Treatment. 6<sup>th</sup> edition

### **Analytical Biochemistry**

1. Wilson, K, Walker, J. Principles and Techniques of Practical Biochemistry. 5<sup>th</sup> edition.
2. Rodney Boyer. Modern Experimental Biochemistry, 3<sup>rd</sup> edition.

### **Cell and Molecular Biology**

1. Bruce Alberts. Molecular Biology of the Cell, 5<sup>th</sup> edition.
2. Geoffrey M. Cooper and Robert E. Hausman. The Cell: A Molecular Approach, 5<sup>th</sup> edition.
3. Benjamin Lewin. Genes IX.
4. De Robertis, De Robertis Jr. Cell and Molecular Biology, 8<sup>th</sup> edition.



## SYLLABUS

### Epidemiology, Biostatistics and Medical Ethics

#### **UNIT I: Epidemiology**

Introduction: Historical aspects and evolution of epidemiology, definitions and concepts in Epidemiology.

Approaches in epidemiology: Descriptive and analytical epidemiology, disease burden, natural history of diseases and measures of risk and death.

Study design and sampling: Sample size estimation and introduction to study design in epidemiological investigations.

#### **UNIT II: Biostatistics**

Fundamentals of biostatistics: Introduction, types of data, tabular and graphical presentation of data. Measures of location, dispersion and correlation: Measures of central tendency. Mean, mode, median, GM, HM, quartiles Measures of dispersion—range, standard deviation, variance, coefficient of variation.

Probability and statistical inference: Concept and probability distribution. Normal distribution—density curves, applications and statistical tables. Concept of significance tests, parametric and nonparametric tests, standard error and confidence intervals.

Inferential statistics: Probability and distributions – Poisson, Binomial and Normal distribution – Chi-square test – Hypothesis test - Student's t-test – Correlation and Regression – ANOVA.

#### **UNIT III: Medical Ethics**

Bioethics and Medical ethics: Historical perspectives & Introduction to Bioethics, Nuremberg Code, Declaration of Helsinki, Principle of essentiality, informed consent, confidentiality, minimisation of risk, accountability and responsibility. Ethics of clinical trials: Drug trials, vaccine trials, Clinical trials with medical devices/surgical procedures/radioactive materials, Research in transplantation and stem cell therapy. Regulatory framework and guidelines for conduction of human research: Review processes, Institutional ethical committees, composition of committees, review procedures, WHO, UNESCO and ICMR guidelines.

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iv. Epidemiology. Leon Gordis. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.

v. Diseases and Human Evolution. Ethne Barnes. Latest edition / Latest edition / Pub. Date: March 2005. Publisher: University of New Mexico Press.

- d) Epidemiology: Beyond the Basics. F. Javier Nieto, Moyses Szklo. Latest edition / Pub. Date: November 2003. Publisher: Jones & Bartlett Publishers, Inc.
- e) Basic and Clinical Biostatistics. Beth Dawson, Robert G. Trapp, Robert Trapp. Latest edition / Pub. Date: March 2004.
- f) Discovering Statistics Using SPSS. Andy Field. Latest edition / Pub. Date: April 2005. Publisher: SAGE Publications.
7. Arora PN & Malhon PK (1996). Biostatistics Imalaya Publishing House, Mumbai.
- c. Sokal & Rohlf (1973). Introduction to Biostatistics, Toppan Co. Japan.
- d. Stanton A & Clantz, Primer of Biostatistics — The McGraw Hill Inc., New York.
10. Government of India. Good Clinical Practices for Clinical Research in India. New Delhi: 2001
17. Indian Council of Medical Research. Ethical Guidelines for Biomedical Research on Human Subjects. New Delhi: 2000
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