# 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 ). 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 1st September of the Academic Year

**8. COMMENCEMENT OF EXAMINATION:**

15th October

Theory examinations comence 15th 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 30th 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 31st October of the academic year. There shall not be any admissions after to31st 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 boyh 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 1st 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 | 50 marks |
| B. Standard curve for and estimation of an analyte | 25 marks |
| C. Electrophoresis | 25 marks |
| D. Enzyme kinetics | 25 marks |
| Total | 125 marks |

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, steatorrhoea, 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 lipotrophic 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

l. 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),

- Hormones

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

## 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)
  - Adrenocorticotropic 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 hyperparath yroidism

- 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

o 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: $I_f$, $ICa_T$, $ICa_L$
- 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 X 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**:
  - Poiseulle's flow equation rearranged to get arterial pressure
  - Mean Art Press = CO X 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, neurogenic) Obstructive

**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 atomosphere 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.

**Exercis**e

- 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 = Kf X (PG – PB – πG + πB)]
- MW of the substances
- Electrical charge of the substance

Glomerular filtrateas 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 measeure Renal blood flow)
- Creatinine clearance to assess GFR
- Serum creatinine as renal function test

**Tubular reabsorption and Secretion**

**PCT**

- Importnt 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 $Na^+$ 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
    - Pathway for sensations from face
    - 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
    - Gate control theory of pain
    - Descending pain control pathways
    - Endogenous opioid systems – endorphins

**Sensory System – underlying principles**

1. Labeled line code
2. Law of projection
3. Sensory Cortex-Primary sensory area SI & SII
    - Sensory homunculus
    - Cortical sensations
    - 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
    - Pathway
    - Functions
2. Extra-pyramidal tracts
    - Names of tracts
    - Origin & termination
    - Gross functions
    - Net influence on spinal motor neurons & spinal reflexes
    - 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
    - Physiological basis of the same
2. Effects of lesion of pyramidal tract fibres at different levels, stroke
3. Muscle paralysis - Hemiplegia, quadriplegia, paraplegia
    - 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
    - Need for sensory input to initiate these motor reflexes
    - 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
    - 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 nucleii 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 nucleii
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 & hydrocephalous

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 nucleii

**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
   - Macula & vestibular hair cells
   - Otolithic membrane
   - 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 nucleii
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 – 2nd and 3rd 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, oon 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, methhemoglobinemia

**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, aminotic 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, compelement 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**

| ***Qualitative Analysis*** |
|---|
| **Reactions of carbohydrates** |
| 1. Reactions of monosaccharides - glucose, fructose and galactose, mannose and arabinose |
| 2. Reactions of disaccharides - maltose, lactose and sucrose |

| |
|---|
| 3. Reactions of polysaccharides – starch, dextrins and glycogen; hydrolysis of starch by acid |
| 4. Analysis of carbohydrate mixtures |
| 5. Paper chromatography of carbohydrates |
| **Reaction of amino acids** |
| 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 |
| **Reactions of proteins** |
| 10. Colour reactions of proteins |
| 11. Precipitation of proteins (with cations and annions, 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 |
| **Reaction of lipids** |
| 15. Reactions of fatty acids, glycerol, fats and cholesterol |
| **Examination of bile** |
| 16. Tests for bile salts and bile pigments |
| **Urinary analysis** |
| 17. Identification of normal and abnormal constituents in urine |
| **Experiments on milk** |
| 18. Identification of constituents in milk |
| **Haemoglobin derivatives** |
| 19. Identification of hemoglobin derivatives using direct vision spectroscopy |
| ***Quantitative Analyses*** |
| 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) |
| 26. Agarose gel electrophoresis (for separation of serum proteins) |
| |

| ***Demonstrations*** |
|---|
| 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**

| **GLUCOSE** |
|---|
| 1. Estimation of plasma glucose |
| 2. Glucose tolerance test |
| 3. Stability check of glucose standards |
| |
| **LIPIDS** |
| 4. Estimation of serum cholesterol |
| 5. Estimation of serum triglycerides |
| 6. Estimation of HDL cholesterol |
| |
| **LIVER FUNCTION TESTS** |
| 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 |
| |
| **RENAL FUNCTION TESTS** |
| 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 |
| |
| **MINERALS AND ELECTROLYTES** |
| 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 |
| |
| **CSF ANALYSIS** |
| 25. Estimation of CSF glucose (GOD-POD method) |
| 26. Estimation of CSF protein (sulphosalycylic acid method) |
| 27. Estimation of CSF chloride (Schales and Schales method) |
| |
| **MISCELLANEOUS ENZYME ASSAYS** |
| 28. Estimation of serum amylase, creatine kinase, lactate dehydrogenase, acid phosphatase, glucose-6-phosphate dehydrogenase and cholinesterase |
| |
| **MISCELLANEOUS** |
| 29. Estimation of serum ceruloplasmin and methemoglobin |
| 30. Estimation of vanillyl mandelic acid (VMA) |
| **HANDS-ON EXPERIENCE WITH AUTOMATED TECHNOLOGY (FOR ESTIMATION OF ALL THE ANALYTES LISTED ABOVE) IN DIAGNOSTIC LABORATORY TO WHICH POSTED** |
| |
| **DEMONSTRATIONS** |
| 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, 29th edition.
2. John Baynes and Marek Dominiczak. Medical Biochemistry, 3rd edition,
3. Albert L. Lehninger, David Lee Nelson, Michael M. Cox. Lehninger's Principles of Biochemistry, 5th edition.
4. Donald Voet & Judith Voet, Biochemistry, 4th edition.
5. Thomas M. Devlin. Text book of Biochemistry with clinical correlations – 6th edition.
6. Lubert Stryer. Biochemistry, 5th edition.
7. N. V. Bhagavan. Medical Biochemistry, 4th edition.
8. David E. Metzler. Biochemistry: The Chemical Reactions of Living Cells, 2nd 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, 5th edition.
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