

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH

(Declared as Deemed to be University u/s 3 of the UGC Act, 1956)

Regulations governing

**Master of Science degree in Molecular Biology and Human Genetics
(MSMH)**

Under the Faculty of Allied Health and Basic Sciences

**CURRICULUM & SYLLABUS
(2021)**



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MASTER OF SCIENCE IN MOLECULAR BIOLOGY AND HUMAN GENETICS

1. PROGRAMME DESCRIPTION

The Master of Science (M.Sc.) in Molecular Biology and Human Genetics is designed to provide the concepts and techniques of molecular biology and human genetics, with special emphasis on medical aspects of genetics. This includes the preparation of materials for study, importance of molecular alterations, chromosomal variations in structure and number in fields such as population genetics, evolution genetics and medical genetics. The programme trains students to be employable in genetic labs, biotech industries and academia.

2. PROGRAMME OBJECTIVES

The purpose of the programme is to converge the attitude of the student in to research skill in terms of providing a working knowledge of theoretical and practical aspects of molecular cell biology and human genetics. At the end of the programme, the student should be able to a explain the genetic basis of biological functions, explain the genetic basis of simple and complex diseases, evaluate chromosomal aberrations and genetic variations, perform cell culture based bioassays, Conceive and evaluate a novel scientific idea.

3. ELIGIBILITY FOR ADMISSION

A Pass in Bachelor degree in any branch of life sciences, medical laboratory technology, MBBS, BDS, BAMS, BHMS or other equivalent qualifications approved by SDUAHER with a minimum of second class securing at least 50% of the aggregative marks or in an examination recognized as equivalent there to for all the subjects and in case of SC/ST; the minimum marks would be 40% as eligibility criteria.

4. METHOD OF SELECTION

Candidates are expected to appear for an entrance test to be conducted by the university department and thereafter an interview. Admission to the programme will be based purely on merit obtained in the entrance examination. Application forms and other details will be made available by the office of the Registrar on payment of the prescribed application fee or can be downloaded from the website of the Academy www.sduu.ac.in. In case of such downloaded applications, the application should accompany a Demand Draft for the prescribe fee drawn in favor of The Registrar, SDUAHER, payable at Kolar. The applications should be complete in all respects and should accompany copies of relevant marks cards, degree certificates, caste certificate and date of birth certificate. The date, venue and time of entrance examination will be notified in the website to the applicants as soon as it is fixed.

5. PROGRAMME DURATION

The programme comprises of 4 semesters. There will be a minimum of **90 working days** in each semester excluding holidays, vacations and days engaged for examination.

6. ATTENDANCE

- Every candidate should have attendance not less than 75% of the total classes conducted in theory and practical in each calendar year calculated from the date of commencement of the term to the last working day as notified by the Academy in each of the subject prescribed to be eligible to appear for the University Examination.
- Attendance shall be calculated from the total number of hours prescribed by SDUAHER.
- A candidate lacking in the prescribed attendance and progress in any subject (s) in theory or practical in the first appearance shall not be permitted to appear for that subject (s).

7. TEACHING HOURS

- Each subject paper shall include 50 hours of Theory.
- Where relevant, a subject paper may also include Practicals for a duration of 50 hours.
- Seminars and Journal Club shall be organised in conjunction with the subject papers.
- Subject seminars covering the syllabus shall be mandatory. Time table of the same shall be prepared such that atleast one seminar is held each week. HoD shall nominate a faculty member to moderate the seminars.
- Attendance and active participation of the students in the Journal Club presented by Research Scholars/ Faculty of the Department shall be encouraged.
- Assignment on topics related to the curriculum shall be given on weekly basis. A scheduled class shall be held to discuss the write-up.

Table 1: Distribution of teachings hours in each semester

Sl. No.	Paper	Teaching Hours	
		Theory	Practicals
Semester I			
1	Cell Biology	50	50
2	Principles of Genetics	50	50
3	Anatomy	50	50
4	Biochemistry	50	50
	Total	200	200
Semester II			
1	Molecular Basis of Human Diseases I	50	50
2	Physiology	50	50
3	Microbiology	50	50
	Total	150	150
Semester III			
1	Medical Genetics	50	50
2	Molecular Biology Techniques	50	50
3	Research Methodology & Biostatistics	50	-
4	Project Work	50	-
	Total	200	100
Semester IV			
1	Genetics Engineering & Biotechnology	50	50
2	Molecular Basis of Human Diseases II	50	50
3	Project Work	150	
	Total	250	100

7. EXAMINATION AND EVALUATION

7.1 INTERNAL ASSESSMENT:

- a. Regular periodic internal assessment examinations should be conducted throughout the programme. The number of assessments shall be decided by the department.
- b. There should be a minimum of two internal assessments for both theory and practicals during each semester of the programme and average of two examination marks should be taken into consideration while calculating the marks for internal assessment.
- c. The weightage given to the internal assessment is 25% out of the total marks assigned for a subject (200 marks).

- d. Student must secure at least 50% of total marks fixed for internal assessment in a particular subject in order to be eligible to appear in the university examination of that subject.

7.2 ELIGIBILITY TO APPEAR FOR UNIVERSITY EXAMINATION:

To be eligible to appear for University examination a candidate:-

- a. Shall have undergone satisfactorily the approved course of study in the subject/subjects for the prescribed duration.
- b. Shall have attended at least 75% of the total number of classes in theory and practical /clinical jointly to become eligible to appear for examination in those subject/subjects.
- c. Shall secure at least 50% of total marks fixed for internal assessment in a particular subject in order to be eligible to appear in the University Examination of that subject.
- d. Shall fulfil any other requirement that may be prescribed by the University from time to time

7.3 SCHEME OF EXAMINATION

- a. Evaluation components and marks allotment to the respective group is given in Table 2.
- b. All subjects in each semester will include a theory paper.
- c. At the end of each semester, there will be one university examination on each paper for 100 marks.
- d. The duration of the exam will be 3 hours.
- e. The question paper for the theory exam shall follow the pattern given in Table 3.
- f. Some subjects may also include a practical paper.
- g. At the time of Practical Examination, the candidate shall submit to the examiners his/her laboratory notebook duly certified by the Head of the Department as a bonafide record of the work done by the candidate.
- h. Semester IV examination will also include the evaluation of Project Report.

Table 3: Theory Question Paper Pattern			
Type of questions	No of questions	Marks for each question	Total
Long Essay	2	10	20
Short Essay	10	5	50
Short Note	10	3	30

7.4 CRITERIA FOR PASS

- a. For declaration of pass in any subject in the University examination the candidates shall secure a minimum of 50 % of the marks in both in theory and practical components of the examination.
- b. Theory component is the sum total of marks obtained in University Exam Theory + Internal Assessment Theory + University Exam Viva Voce.
- c. Practical component is the sum total of marks obtained in University Exam Practicals + Internal Assessment Practicals.
- d. A candidate not securing 50% marks in both theory and practical components of a subject shall be declared to have failed in that subject and is required to appear for both theory and practical again in the subsequent examination in that subject.

7.5 DECLARATION OF CLASS

- a. A candidate having appeared in all the subjects in the same examination and passes that examination in the first attempt and secures 75% of marks or more of grand total marks prescribed will be declared to have passed in the examination with **Distinction**.
- b. A candidate having appeared in all the subjects in the same examination and passes

that examination in the first attempt and secures 60% of marks or more but less than 75% of grand total marks prescribed will be declared to have passed examination in **First class**.

- c. A candidate having appeared in all the subjects in the same examination and passes that examination in the first attempt and secures 50% of marks or more but less than 65% of grand total marks prescribed will be declared to have passed the examination in **Second class**.
- d. A candidate having appeared in all the subjects in the same examination and passes that examination in the first attempt and secures 50% of marks will be declared to have **passed** the examination.
- e. A candidate passing the university examination in more than one attempt shall be placed in pass class irrespective of the percentage of marks secured by him/her in the examination.
- f. **Note:** Fraction of marks should not be rounded off for clauses (a), (b) and (c)

7.6 CARRYOVER / ELIGIBILITY FOR PROMOTION TO THE NEXT SEMESTER

- a. Candidate shall be permitted to carry over the backlog subject till the completion of duration of the programme.
- b. However, she/ he shall be declared passed in the programme only after successfully passing all the subject/ courses of all semesters of the post graduate programme.

7.7 MAXIMUM DURATION OF THE PROGRAMME

The maximum duration of the programme shall be four years from the date of admission. The candidate failing to complete the course within four years from the date of admission will be declared unfit to continue and will be discharged from the programme.

7.8 PROJECT REPORT AND EVALUATION:

- a. Faculty member of the Department of grade Assistant Professor or above shall be assigned to each candidate to serve as Project Guide during Semester III.
- b. Guide and student shall interact and develop a topic worthy of scientific investigation, prepare the necessary skills, materials and approvals (eg. ethics clearance). Preferably, the outcome of the project work should be publishable in a refereed journal.
- c. The project shall commence in the semester III. The title of the topic should be approved by the Department during the Semester III so that the student is fully prepared to engage in project work in Semester IV in the allotted time.
- d. The outcome of the project should be present in the form of a Project Report.
- e. Project Report shall include the following section: Introduction, Objectives, Materials and Methods, Results, Discussion, Summary and Conclusions, Reference.

- f. The report shall be in hard bound form, type set with double space and atleast 1 inch margins on all four sides.
- g. Student, Guide and HoD shall certify the genuineness of the work.
- h. The University shall arrange for evaluation of the submitted Project Report from an external examiner.
- i. Evaluation scheme for the Project Report is given in Table 4

Table 4: Scheme for evaluation of Project Report		
Sl. No.	Section	Marks Assigned
(A)	Project Report	50
I	Introduction	05
II	Review of Literature	05
III	Methodology	10
IV	Results	10
V	Discussion	10
VI	Conclusions	05
VII	Bibliography	05
(B)	Viva Voce	30
	TOTAL	80

Semester 1 - Paper 1 – Cell Biology
[Theory 50 hours, Practicals 50 hours]

Unit I: Cell Organelle and Functions (15 hours)

- Introduction
 - Cell theory and discovery
 - Comparison of prokaryotic and eukaryotic cells
 - Endosymbiotic theory
- Plasma Membrane
 - Organization
 - Transport across membrane
 - Mechanism of endocytosis and exocytosis
- Cytoskeleton:
 - Components and Functions (Cell motility & Cell shape)
 - Microfilaments
 - Intermediate Filaments
 - Microtubule
- Structure and functions of Cilia and Flagella
- Structure and functions Centriole
- Mitochondria: Ultrastructure, Chemiosmotic theory and Respiratory Chain Complexes (oxidative phosphorylation)
- Nucleus:
 - Components
 - Nuclear pore complex
 - Nucleolus
 - Biosynthesis of ribosome
- Structure and functions of peroxisomes and lysosomes, and their differences
- Structure and functions of Endoplasmic Reticulum and Golgi Complex, and their role in glycosylation
- Protein sorting (cytosolic, nuclear, secretory and membrane proteins).

Unit II: Cell cycle and its regulation (10 hours)

- Phases of cell cycle: Mitosis and Meiosis
- Regulation of cell cycle
- Cell cycle check points
- Role of cyclins and cyclin-dependant kinases in cell cycle regulation

Unit III: Chromatin (15 hours)

- Chromatin structure: Histones, DNA, Nucleosome and higher level organization
- Metaphase chromosome: Centromere, Kinetochore, Telomere and its maintenance
- Holocentric chromosomes and supernumerary chromosomes;
- Chromosomal domains (matrix, loop domains) and their functional significance
- Heterochromatin and euchromatin
- Position effect; Variegation; Boundary elements; Chromosome bandings
- Functional states of chromatin and alterations in chromatin organization
- Structural and functional organization of interphase nucleus
- Chromatin remodelling

Unit IV: Cell Interaction and Signalling (10 hours)

- Cell-Cell Interactions:
 - Cell adhesion molecules
 - Cellular junctions
 - Extracellular matrix

- Signal transduction:
 - Intracellular receptor and cell surface receptors;
 - Signalling via G-protein linked receptors (PKA, PKC, CaM kinase)
 - Enzyme linked receptor signalling pathways
 - Network and cross-talk between different signal mechanisms
 - Programmed cell death

REFERENCES

- Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell, 5th ed; USA;2007
- Lodish H, Berk A, Kaise CA, Krieger M, Scott MP, Bretscher A, Polegh H, Matsudaira P; editors; Molecular Cell Biology; 6th ed; USA; 2008
- Verma PS, Agarwal VK. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. New Delhi: S Chand and Company; 2005.
- Weaver RF; Molecular biology; 2nd ed; The McGraw–Hill Companies, 2004
- Brandenberg O; Dhlamini Z; Sensi A; Ghosh K; Sonnino A; editors; Introduction to Molecular Biology and Genetic Engineering; Italy; 2011

LIST OF PRACTICALS

1. Biosafety and aseptic handling techniques.
2. Isolation of PBMCs by density gradient centrifugation
3. Cell viability assay by Trypan Blue method
4. Cytotoxicity assay
5. Adherent cell culture: changing of growth medium
6. Adherent cell culture: sub-culturing
7. Cryopreservation
8. Primary cell culture

Semester 1 - Paper 2 - Principles of Genetics

[Theory 50 hours, Practicals 50 hours]

Unit I: Mendelian Inheritance (10 Hrs)

- Definition of common terminologies: Allele, Phenotype, Genotype, Homozygous, Heterozygous, Hemizygous.
- Mendel's Experiments – Monohybrid Cross, Dihybrid Cross.
- Law of Dominance, Law of Segregation, Law of Independent Assortment
- Punnet Square, Pedigree Analysis
- Problems on Mendelian cross
- Chromosomal basis of sex determination:
 - Mechanism of sex determination in humans (SRY gene)
 - X-chromosome inactivation
- Multiple Alleles: Rh and ABO incompatibilities - HLA genes

Unit II: Population Genetics (5 Hrs)

- Hardy-Weinberg law Factors that disturb Hardy-Weinberg Equilibrium:
 - Stratification
 - Assortative Mating
 - Consanguinity
 - Inbreeding
 - Migration (Gene flow)
 - Genetic Drift
 - Selection (Heterozygote Advantage)

Unit III: Genome Organization (10 Hrs)

- Central dogma of molecular biology - overview of gene expression
- Organization of viral and bacterial genomes
- Organization of eukaryotic genome: structure of eukaryotic chromosomes, nucleosome, 30 nm fibre and its condensation into chromatin.
- Eukaryotic Gene Structure: Introns, Exons, Promoter, 5' and 3' Untranslated Regions (UTR) Structure of a eukaryotic gene.
- Gene Families, Pseudo-genes, Non-coding RNA genes
- Mitochondrial DNA and Cytoplasmic Inheritance
- Genetic Variation:
 - Unique and Repetitive DNA Sequences
 - Mutations - types
 - Difference between Mutation and Polymorphism
 - Types of Polymorphisms: Single Nucleotide Polymorphism, Indels (Microsatellite, Minisatellite/VNTR), Copy number variation

Unit IV: DNA Replication, Repair and Recombination (10 Hrs)

- Structure of DNA – A, B, Z and triplex forms
- Mechanism of replication in prokaryotes and eukaryotes: semiconservative – origin of replication - bidirectional - replication fork - enzymes and accessory proteins.
- DNA Repair and Recombination:
 - Types of DNA damages
 - Direct repair (photoreactivation),

- Single strand damage repair (Base Excision Repair, Nucleotide Excision Repair, Mismatch Repair)
- Double strand damage repair (homologous recombination – non- homologous end joining)
- Translesion DNA synthesis
- Transposons and DNA transposition
- Immunoglobulin gene assembly by recombination

Unit V: Transcription (8 Hrs)

- Overview of gene structure and gene expression
- Promoters – Enhancers (Inducible , Constitutive) - Operators – Silencers – RNA Polymerases- transcription factors
- Types of RNA – mRNA, rRNA, tRNA, catalytic RNA, noncoding RNA
- Mechanism – Initiation, elongation, termination
- mRNA splicing - nuclear export of mRNA – RNA editing
- Gene expression in bacteria: *lac*-operon, *trp*-operon (structure and regulation)

Unit VI: Translation (7 Hrs)

- Open Reading Frame (ORF) - Universal Genetic code – Wobble hypothesis – Degeneracy of codons – Start Codon – Terminator codon
- Ribosome structure
- Mechanism: Amino acid activation – Initiation – Elongation – Termination
- Protein folding
- Co- and Post-translational modifications
- Transport of proteins and molecular chaperones
- Protein turnover and degradation

REFERENCES

- Nussbaum RL, McInnes RR, Willard HF, Hamosh A. Thompson and Thompson Genetics in Medicine. 7th ed. Philadelphia: Saunders-Elsevier; 2007.
- Ahluwalia KB. Genetics. 2nd ed. New Delhi: New Age International Publishers; 2009
- Nelson DL, Cox MM. Leninger Principles of Biochemistry. 4th ed. W.H. Freeman
- Krebs JE, Goldstein ES, Kilpatrick ST. Lewin's Genes XI. Oxford: Oxford University Press; 2003.
- Tropp BE. Principles of Molecular Biology. Massachusetts: Jones & Bartlett Learning; 2014
- Verma PS, Agarwal VK. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. New Delhi: S Chand and Company; 2005.

LIST OF PRACTICALS

1. Media preparation
2. Lymphocyte culture
3. Lymphocyte harvest
4. Preparation of test slide (chromosomal spreads)
5. GTG banding
6. Determine the effect of phytohemagglutinin supplementation on the yield of chromosomal spread
7. Determine the effect of pre-harvest colchicine treatment on the quality of chromosomal spread
8. Determine the effect of pre-harvest hypotonic salt treatment on the quality of chromosomal spread
9. Determine the effect of trypsin treatment on the quality of G-banding
10. Determine the effect of incubation time on the quality of chromosomal spread
11. Determine the effect of fetal bovine serum on chromosomal spread
12. Determine the effect of cell culture medium on chromosomal spread

Semester 1 - Paper 3 – Anatomy
[Theory 50 hours, Practicals 50 hours]

UNIT I: Introduction (6 hrs)

Definition of anatomy & its divisions.
Terms of location, positions & planes.
Cell & its organelles.

Epithelium- definition, classification, describe with examples, functions.

Glands-classification, describe serous & mucous glands with examples.

Basic tissues- Epithelial tissue, Connective tissue, Muscular tissue & Nervous tissue. Classification with examples.

UNIT II: Locomotion & support (5 hrs)

Cartilages- types with example & histology.

Bone- classification, names of bone cells, parts of long bone, microscopy of compact bone, names of all bones, Vertebral column, Invertebral disc, Fontanelles of fetal skull.

Joints-Classification of joints with examples, synovial joint(in detail for radiology)

Muscular system- classification of muscular tissue & histology, Names of muscles of the body.

UNIT III: Cardiovascular system (6 hrs)

Heart- Size, Location, Chambers, Exterior & Interior, Blood Supply of Heart, Pericardium, Systemic & Pulmonary Circulation, Branches of Aorta, Common Carotid Artery, Subclavian Artery, Axillary Artery, Brachial Artery, Femoral Artery, Superficial Palmar arch, Internal Iliac artery, Peripheral pulse, Inferior Vena cava, Portal Vein, Great Saphenous vein, Dural Venous Sinuses.

UNIT IV: Lymphatic System (3 hrs)

Thoracic duct, Cisterna Chyli.
Histology of Lymphatic Tissues, Names of regional Lymphatics, Axillary & Inguinal Lymph nodes.

UNIT V: Gastro- Intestinal System (4 hrs)

Parts of GIT, Oral Cavity(lip, tongue with histology), Tonsil, Dentition, Pharynx, Salivary glands, Waldeyer's ring, Oesophagus, Stomach, Small & large intestine, Liver, Gall Bladder, Pancreas, Radiographs of Abdomen

UNIT VI: Peritoneum (1 hr)

Peritoneal folds Describe in brief

UNIT VII: Respiratory System (4 hrs)

Parts of Respiratory System, Nose, Nasal cavity, Larynx, Trachea, Lungs, Histology

of Trachea, lung & pleura, Names of Paranasal air sinuses, Bronchopulmonary Segments.

UNIT VIII: Urinary System (4 hrs)

Kidney, Ureter, Urinary bladder, male & female urethra, Histology of kidney, Ureter, Urinary bladder, Male & Female urethra.

UNIT IX: Reproductive System (3 hrs)

Parts of **male reproductive system**, testis, Vas deferens, epididymis, prostate(gross & histology) Parts of **female reproductive system**-uterus, Fallopian tubes, ovary (gross & histology) Mammary gland- gross.

UNIT X: Endocrine glands (4 hrs)

Names of all endocrine glands in detail on Pituitary gland, Thyroid gland, Parathyroid gland, Supra renal glands- (gross & Histology)

UNIT XI: Nervous System (4 hrs)

Neuron, Classification of CNS, Cerebrum, Cerebellum, Midbrain, Pons, medulla oblongata, Spinal cord with spinal, Nerve (gross & histology), Meninges, Ventricles & Cerebrospinal fluid, Names of basal nuclei, Blood supply of brain, Cranial nerves, Sympathetic trunk & Names of Parasympathetic ganglia.

UNIT XII: Sensory Organs (3 hrs)

Skin- Types, Histology, Appendages of Skin.

Eye- Parts of Eye & Lacrimal apparatus, Extra ocular muscles& nerve supply

Ear- Parts of Ear-External, Middle and inner ear and contents.

UNIT XIII: Embryology (3 hrs)

Spermatogenesis & oogenesis, Ovulation, Fertilization.
Placenta & Fetal circulation.

Reference books

- Text book of Anatomy by B.D.Chowrasiya
- Text book of Anatom by Vishram Singh
- Text book of Anatomy by I. B. Singh

List of Practicals

SL. No.	Demonstration of gross features of following	Histology
1	Parts of the long bone, identification of the individual bone. Fontanelles of fetal skull.	Serous and mucus salivary glands
2	Name and identification of important and major muscles of the body	Cardiac muscle TS and LS of skeletal muscle
3	Pericardium, external and internal features of heart, blood supply of heart and identification of major blood vessels of the body	Hyaline, elastic and white fibro cartilage.
4	Lymph node	TS and LS of compact bone
5	Parts of GIT: oral cavity, stomach, duodenum, small intestine, large intestine, caecum and appendix, liver, gall bladder, pancreas.(radiographs of abdomen)	Lymph nodes
6	Important folds of peritoneum	Tongue, stomach
7	Respiratory system: nose, trachea, lungs	Trachea and lungs
8	Urinary system: kidney, urinary bladder	Kidney, ureter and urinary bladder
9	Male reproductive system: testes, epididymis, prostate.	testes, epididymis, prostate
10	Female reproductive system: uterus and fallopian tube, mammary gland	Ovary, uterus and fallopian tube
11	Thyroid and supra renal gland	Pituitary thyroid, parathyroid and supra renal gland
12	Spinal cord, brain stem, cerebellum. External features and interior cerebellum, blood supply of brain. ventricles and CSF of brain	Spinal cord cerebellum and cerebrum
13	Eye ball and extra ocular muscles with nerve supply.	LS of thick and thin skin
14	Demonstration of models of spermatogenesis and oogenesis, ovulation, fertilization, placenta and fetal circulation.	

Semester 1 - Paper 4 – Biochemistry
[Theory 50 hours, Practicals 50 hours]

UNIT I: Biomolecules (15 hrs.)

Carbohydrates

Lipids

Proteins

Nucleic Acids

UNIT II: Enzymes (4 hrs.)

UNIT III: Bioenergetics (3 hrs.)

UNIT IV: Vitamins (6 hrs.)

UNIT V: Digestion & Absorption (3 hrs.)

UNIT VI: Nutrition (3 hrs.)

UNIT VII: Biophysical Chemistry (6 hrs.)

PH, Buffers

Henderson's equilibrium

Colloidal Solutions

Donnan Membrane

Equilibrium

Osmosis, Diffusion, Viscosity

Isotopes

Water, electrolyte, Acid base Metabolism

UNIT VIII: Biochemical techniques (10hrs.)

Chromatography

Electrophoresis

Photometry/ Spectrophotometry

Centrifugation

Cell Organelle fractionation techniques

Reference books

- Lehninger Principles of Biochemistry by Albert L. Lehninger
- Biochemistry by Donald Voet
- Harper's Illustrated Biochemistry by Robert K. Murray

LIST OF PRACTICALS

GENERAL INSTRUCTIONS

1. Laboratory Hazards and First Aid

QUALITATIVE ANALYSIS

2. Qualitative analysis of carbohydrate
3. Qualitative analysis of proteins
4. Qualitative analysis of Non- protein nitrogenous substances
5. Identification of unknown physiologically important substance
6. Qualitative analysis of normal urine
7. Analysis of abnormal constituents of urine

QUANTITATIVE ANALYSIS

1. Principle of colorimetric and spectrophotometer
2. Estimation of blood sugar by O- toluidine/DNS/GOD-POD method
3. Estimation of blood urea by di-acetyl Monoxime method
4. Estimation of urine creatinine by jaffes method
5. estimation of serum inorganic phosphate by fiske subbarao method
6. Estimation of serum total proteins by biurett method and calculation of A/G
7. Estimation of protein by Folin ciocalteus method
8. Estimation of serum ALT and AST by Reitman and franklin method
9. Estimation of serum cholesterol by ferric chloride acetic acid method
10. Chromatography (paper, thin layer, adsorption, ion exchange)
11. Electrophoresis, Agarose gel, SDS PAGE
12. Estimation of total carbohydrate by Anthrone method
13. Assay of trypsin and calculation of specific activity

CASE REPORTS

1. Normal values of common biochemical parameters

Semester 2 - Paper 1 – Molecular Basis of Human Diseases I
[Theory 50 hours, Practicals 50 hours]

Unit I Biochemical Genetics (20 Hours)

- Inborn errors of metabolism – Enzymopathy - Enzyme Replacement Therapy
- Disorders of Carbohydrate Metabolism
 - Galactosemia
 - Hereditary Fructose Intolerance
 - Pyruvate Dehydrogenase Deficiency
 - Diabetes Mellitus
- Disorders of Amino Acid Metabolism
 - Phenylketonuria (PKU)
 - Alkaptonuria
 - Oculocutaneous albinism Type 1
 - Maple Syrup Urine Disease
- Disorders of Purine/Pyrimidine Metabolism
 - Lesch-Nyhan syndrome
 - Orotic aciduria
 - Xanthinuria
- Lysosomal Storage Disease
 - Lipid storage disorders
 - Sphingolipidoses (Gaucher's Disease, Niemann-Pick disease)
 - Gangliosidosis (Tay-Sachs disease)
 - Mucopolysaccharidiosis (Hunter Syndrome, Hurler Syndrome)
- Glycogen Storage Diseases (Type I and Type II)
- Disorders of lipid metabolism: Familial hypercholesterolemia
- Urea cycle disorders
- Disorders of trace elements
 - Hereditary Hemochromatosis
 - Wilson's Disease
- Disorders of endocrine regulation
 - Congenital Adrenal Hyperplasia
 - Androgen Insensitivity Syndrome
 - Congenital Hypothyroidism

Unit II Cancer Genetics (20 Hours)

- Introduction to Cancer Biology: Definition – Benign – Malignancy - Metastasis
- Properties of Cancer cell
 - Loss of Contact Inhibition
 - Anchorage Independent Growth
 - Aberrations in Cell Cycle Regulation
 - Aberrations in apoptosis
 - Telomerase Activation

- Stages of Oncogenesis
 - Tumor initiation, promotion and progression
 - Tumor angiogenesis
- Cancer causing genes
 - Oncogenes – Classification - Mechanism of Activation
 - Tumor Suppressor Genes (*p53*, *Rb*)
 - Knudson's Two-Hit Theory
- Carcinogens
 - Classification and Mechanism of Action
 - Physical (Radiation)
 - Chemical (DNA Modifying Agents, DNA Intercalators, Base Analogs)
 - Biological carcinogens
- Epigenetic Changes in Cancer
 - DNA Methylation
 - Histone Modification
 - Micro-RNA mediated gene silencing
- Role of Virus in Cancer
 - Viral Oncogenes
 - Role of HPV and Cervical Carcinoma
- Familial Cancers
 - Difference between familial and sporadic cancers
 - Hereditary Breast and Ovarian Cancer Syndrome
 - Hereditary Non-Polyposis Colorectal Cancer
 - Familial Adenomatous Polyposis
- Genetic Instability Syndromes:
 - Fanconi Anemia
 - Xeroderma Pigmentosum
- Cancer treatment:
 - Classification of chemotherapeutic agents and their mechanism of action
 - Common examples: Cisplatin, Vincristine, Taxol, 5-Fluorouracil, Methotrexate
 - Molecular Basis of Radiotherapy

Unit IV 10 Hours

- Disorders of the Blood System
 - Haemoglobin disorders: Thalassemia , Sickle Cell Anaemia
 - Disorders of Hemostasis: Haemophilia, Factor V Leiden
 - Porphyria
- Disorders of the Eye
 - Retinitis Pigmentosa
 - Color-blindness
 - Retinoblastoma
- Neuromuscular disorders
 - Spinal Muscular Atrophy
 - Duchene Muscular Dystrophy
- Disorders of immune system: Severe combined immune deficiency (SCID)

REFERENCES

- Nussbaum RL, McInnes RR, Willard HF, editors. Thompson & Thompson Genetics in Medicine. 7th ed. Philadelphia: Saunders-Elsevier; 2007.
- Rimoin DL, Pyeritz RE, Korf BR, editors. Emery and Rimoin's Essential Medical Genetics. 1st Indian ed. Oxford: Academic Press- Elsevier; 2013.
- Ahluwalia KB. Genetics. 2nd ed. New Delhi: New Age International Publishers; 2009.
- Nelson DL, Cox MM. Leninger Principles of Biochemistry. 4th ed. W.H. Freeman
- Scriver CR, Beaudet AI, Sly WS, Valle D, editors. The Metabolic and Molecular Bases of Inherited Diseases. 8th ed. McGraw-Hill; 2001.

LIST OF PRACTICALS

1. Optimization of PCR annealing temperature
2. Optimization of MgCl₂ concentration for PCR
3. Effect of PCR Additives
4. Mutation analysis by RFLP method
5. Multiplex PCR
6. HPV DNA testing by PCR
7. Micro Satellite Analysis
8. Mutation analysis by DNA Sequencing (Demonstration of Experiment + Identification of sequence variation and analysis of the impact of polymorphism/mutation on protein function).

Semester 2 - Paper 2 – Physiology

[Theory 50 hours, Practicals 50 hours]

(Marks given in brackets indicate the depth of each topic to be covered)

UNIT I: General Physiology (6 hrs.)

- Structure of cell and Cell organelles. (information)
- Principles of Homeostasis. (information)
- Transport Across cell membrane (essay)
- Fluid Compartments of the Body – classification and normal values. (3 marks)

UNIT II: Blood (5 hrs.)

- Composition & functions of blood. (5 mark)
- RBC – formation, function & anemia. (essay)
- WBC – Classification of WBCs and function of each. (5 mark)
- Platelets: Structure of Functions of platelets. (3 marks)
- Steps of platelet plug formation. (5 marks)
- Mechanism of coagulation and haemophilia (Essay)
- Plasma Proteins: List the plasma proteins & the functions. (5 marks)
- Blood Groups – basis of blood grouping, clinical importance. (5 marks)
- Anticoagulants: calcium chelating agents, Vitamin K antagonist (3 marks)

UNIT III: Nerve and muscle Physiology (5 hrs.)

- Structure & functions of a neuron (information)
- Function of neuroglia. (3 marks)
- Molecular basis of resting membrane potential (5 marks)
- Molecular basis of action potential.(5 marks)
- Structure of a neuromuscular junction, neuromuscular transmission and Myasthenia gravis. (Essay)
- List the properties of skeletal muscle (5 marks)
- Describe strength –duration curve. (3 marks)

UNIT IV: Renal System (5 hrs.)

- Peculiarities of renal function. (5 marks)
- Starling forces that help in filtration. (3 marks)
- Definition of GFR , normal value, and factors regulating GFR.(Essay)
- Glucose absorption in the proximal tubule. (5marks)
- Mechanism of concentration of urine. (5 marks)
- Action of ADH on renals.(3 marks)
- Innervation of bladder. 5 marks)
- Micturation reflex. (5 marks)

UNIT V: Digestive System (3 hrs.)

- Basic Structure of Digestive system.(Information)

Composition and Functions of

- Salivary secretion. (5 marks)
- Gastric secretion , phases and regulation with experimental evidence (Essay)
- Pancreatic secretion. (5 marks)

- Intestinal secretion. (3 marks)
- Functions of bile/liver. (5 marks)
- Gastro –intestinal movements: Law of gut. (3 marks)
 - Mastication. (5 marks)
 - Movements of Stomach. (3 marks)
 - Movements of Colon (3 marks)
 - Movements of small intestine . (3 marks)

UNIT VI: Endocrinology (5 hrs.)

- Mechanism of action of hormones: (essay)
- List the hormones secreted and the functions of pituitary gland: and name the disease associated with increase/decrease secretion (essay)
- Classify endocrine receptors. Describe the concept of up/down regulation. (5marks)
- List the function of thyroid hormone. (5 marks)
- List the functions of Insulin (5 marks)
- Name the disease associated with insulin deficiency: diabetes mellitus. (3 marks)
- List the functions of cortisol (5 marks)
- Give the cause of Cushing's syndrome (3 marks)

UNIT VII: Reproductive system (3 hrs.)

- Functions of testis /testosterone. (5 marks)
- Functions of Ovary/oestrogen/progesterone. (5 marks)
- Menstrual Cycle – hormonal, uterine and ovarian changes(5 marks)
- Spermatogenesis(5 marks)

UNIT VIII: Cardiovascular System (5 hrs.)

- Conducting system of Heart. (5marks)
- Pacemaker potential & the ions responsible. (3marks)
- Cardiac Ventricular action potential & ions responsible (5 marks)
- Classification of refractory period. (Information)
- Why cardiac muscle cannot be tetanized. (3marks)
- Define cardiac cycle & list the events of cardiac cycle. (5marks)
- Define cardiac output. Give the normal value. Factors regulating cardiac output (Essay)
- List the effects of autonomic nervous system on heart rate. (3marks)
- List the effects of sympathetic system on CVS: Increase in heart rate, contractility of heart, increase in stroke volume or blood pressure and vasoconstriction. (5marks)
- List the mechanisms of blood pressure regulation: baroreceptor reflex (5marks)
 - Chemoreceptor mechanism (information)
 - CNS ischemic response (information)
 - Renin-angiotensin- aldosterone mechanism. (5marks)
- Normal coronary circulation and list the factors regulating it. (5marks)
- ECG in lead II and cause of each wave. (5marks)
- Reynold's number. (3marks)
- Hagen Pousille's law. (3marks)

UNIT IX: Respiratory system (4 hrs.)

- Functional Anatomy. (Information)
- Mechanisms of normal respiration. (Essay)
- Compliance. (3marks)
- Functions of surfactant (3marks)

- Regulation of respiration. (Information)
- Transport of oxygen. (5marks)
- Oxygen dissociation curve and factors affecting it.(5marks)
- Transport of carbon dioxide (5marks)
- Regulation of respiration.(5marks)
- Definition of hypoxia and classification of hypoxia.(3marks)

UNIT X: Central Nervous system (4 hrs.)

- Organisation of nervous system.(information)
- Classify synapse and list the properties of synapse. (5marks)
- Draw a neat labelled diagram of a reflex arc. (3marks)
- Define receptor and list the properties of receptor. (3marks)
- List the functions of cerebral cortex(5marks)
- List the ascending tracts. (information)
- List the sensations carried by Dorsal column.(3marks)
- List the sensations carried by spinothalamic tract(3marks)
- List the functions of corticospinal tract(3marks)
- List the functions of cerebellum(3 marks)
- List the functions of basal ganglia(3 marks)
- List the function of CSF(3 marks)
- List the functions of hypothalamus(5marks)

UNIT XI: Special Senses (4 hrs.)

- Functional anatomy of eye. (information)
- Brodmans area for visual cortex (information)
- Types of Refractive errors- draw.
- Receptors of vision (3marks)
- Colour vision and colour blindness (3marks)
- Functional anatomy of ear (information)
- Functions of middle ear. (3marks)
- Traveling wave theory of hearing (3marks)
- Perception of loudness and pitch: amplitude and frequency (3marks)
- List the primary taste sensations. (3marks)

Reference books

- Review of medical physiology by Ganong
- Text book of Medical Physiology by Guyton
- Text book of Medical Physiology by Indhu Khurana

LIST OF PRACTICALS

1. Study of a compound microscope (a) parts of the microscope (b) formation of Image (c) Focusing of an object (d) precautions
2. An introduction to experiments on blood (a) collection of blood samples (b) commonly used anticoagulants (c) Haematological values for normal individuals (d) Haemocytometer (e) RBC and WBC pipettes (f) Improved Neubauers counting chamber
3. Determination of total erythrocyte count (RBC count)
4. Determination of total leucocyte count
5. Preparation of peripheral blood smear and determination of differential leucocyte count 6. Estimation of Haemoglobin
8. Determination of blood groups
9. Determination of bleeding time.
10. Determination of clotting time
11. Recording of systemic arterial blood pressure. (only demonstration)
12. Recording of pulse. (only demonstration)
13. Recording of Electrocardiogram (only demonstration)
14. Recording of Lung functions. (only demonstration)
15. Recording of respiratory movements. (only demonstration)

Semester 2 - Paper 3 – Microbiology
[Theory 50 hours, Practicals 50 hours]

UNIT I: General Microbiology (25hrs.)

Microscopy.

Morphology of bacteria and other Microorganisms.
Nomenclature and classification of Microbes. Growth and nutrition of bacteria.

Bacterial metabolism.

Sterilization and disinfection.

Bacterial toxins.

Isolation, description and identification of bacteria.

Antibacterial substances used in the treatment of infections and drug resistance in bacteria.

UNIT II: Immunology (14 hrs.)

Normal Immune system.

Innate Immunity.

Antigens.

Immunoglobulin.

Complement.

Antigen-Antibody reactions.

Cell Mediated Immunity.

Hypersensitivity.

Immunodeficiency.

UNIT III: Virology (6 hrs.)

The nature of Viruses.

Classification of Viruses.

Morphology, virus structure

Viral replication.

The genetics of Viruses.

Pathogenicity of Viruses.

Bacteriophages.

UNIT IV: Mycology (5 hrs.)

The morphology, Structure and reproduction in fungi.

Classification of Fungi.

Reference books

- Textbook of Microbiology by Ananthnarayana and Paniker
- Bailey and Scott's Diagnostic microbiology"
- Practical Microbiology by Mackie and McCartney

LIST OF PRACTICALS

1. Orientation to Microbiology
2. Microscopy
3. Sterilization instruments
4. Staining
5. Culture media
6. Culture methods
7. Antibiotic sensitivity testing
8. Laboratory diagnosis of bacterial infections
9. Serological techniques I
10. Serological techniques II
11. Laboratory diagnosis of viral infections
12. Laboratory diagnosis of fungal infections

Semester 3 - Paper 1 – Medical Genetics
[Theory 50 hours, Practicals 50 hours]

Unit I: Introduction to genetic disorders (10 Hours)

- Classification of genetic disorders: chromosomal – monogenic – polygenic (multifactorial) – prevalence of common genetic disorders
- Common indications for genetic testing
- Pedigree drawing – Pedigree analysis
- Factor affecting pedigree analysis (Reduced penetrance, Variable expressivity, Genetic and Phenotypic Heterogeneity)
- Risk calculation and risk assessment
- Dysmorphology: Malformations, Deformations, Disruptions
- Genetic counselling and its significance
- Ethical and legal issues in genetic testing

Unit II: Chromosomal disorders (15 Hours)

Numerical aberrations

- Autosomal trisomies: Trisomy 21 (Down syndrome), Trisomy 18 (Edwards's syndrome), Trisomy 13 (Patau syndrome).
- Aneuploidy - Causes - Types

Structural aberrations:

- Balanced and Unbalanced Rearrangements
- Deletion and Duplication
- Translocation - Reciprocal translocation, Robertsonian translocation,
- Inversion and Insertion
- Marker and Ring Chromosomes
- Isochromosomes and Dicentric Chromosomes
- Chromosome instability syndromes

Sex chromosome abnormalities:

- Trisomy of sex chromosomes: Triple X syndrome, Klinefelter syndrome, 47, XYY syndrome
- Monosomy (Turner syndrome)

ISCN Classification

- International System of Cytogenetic Nomenclature
- Karyotype designation
- Band resolution
- Sequence of chromosomal abnormalities in karyotype
- Normal chromosomal variants

Unit III: Inheritance patterns of monogenic disorders (5 Hours)

- Classification of inheritance patterns of monogenic disorders
- Autosomal dominant, incompletely dominant and recessive pattern
- Sex-linked: X and Y- linked dominant and recessive patterns
- Mitochondrial inheritance
- Uniparental disomy - Imprinting

Unit IV: Types of Genetic Tests (10 Hours)

- Classification of genetic tests
- Conventional Cytogenetics: GTG-banding, Q-banding, C-banding, Ag-NOR staining, High resolution banding, R-banding, T-banding.
- Molecular Cytogenetics: FISH, (Preparation of FISH probes, Chromosome painting), Array-Comparative Genomic Hybridization (Array-CGH)
- Molecular Tests - PCR-ARMS, PCR – RFLP, RT-PCR, DNA Sequencing by Sanger and NGS methods (Discuss only application of these techniques in genetic testing; Principles covered in Semester 2 - Paper 3)

Unit V: Advanced Medical Genetics (10 Hours)**Prenatal Genetics**

- Indications for prenatal testing
- Methods of Prenatal Diagnosis: Invasive and Non-invasive testing
- Invasive tests: Amniocentesis – Chorionic Villus Sampling – Percutaneous Umbilical Blood Sampling
- Non-invasive tests: Maternal serum screening, Fetal DNA in Maternal Circulation
- Preimplantation Genetic Diagnosis (PGD)

Newborn screening

- Newborn screening and its significance
- Commonly tested disorders
- Testing methods

Genetic tests for cancer

- Philadelphia chromosome
- HER2

REFERENCES

- Nussbaum RL, McInnes RR, Willard HF, editors. Thompson & Thompson Genetics in Medicine. 7th ed. Philadelphia: Saunders-Elsevier; 2007.
- Rimoin DL, Pyeritz RE, Korf BR, editors. Emery and Rimoin's Essential Medical Genetics. 1st Indian ed. Oxford: Academic Press- Elsevier; 2013.
- Ahluwalia KB. Genetics. 2nd ed. New Delhi: New Age International Publishers; 2009
- Scriver CR, Beaudet AI, Sly WS, Valle D, editors. The Metabolic and Molecular Bases of Inherited Diseases. 8th ed. McGraw-Hill; 2001.

LIST OF PRACTICALS

1. Buccal smear for Barr Body
2. Identification of Human Chromosomes
3. Karyotyping of G-banded spreads
4. Q-banding
5. R-banding
6. T-banding
7. FISH Technique
8. Image acquisition and analysis of FISH preparations
9. Risk assessment of genetic disorders

Semester 3 - Paper 2 – Molecular Biology Techniques

[Theory 50 hours, Practicals 50 hours]

Unit I: Techniques for DNA Analysis (25 hours)

- PCR:
 - Principle
 - Components (Template DNA, Primers, dNTPs, Thermostable polymerase, Buffer with magnesium)
 - Steps (Denaturation, Annealing, Extension)
 - Applications
- General Properties of PCR Primer, Concept of DNA melting, T_m and GC content.
- Factors affecting specificity and efficiency of PCR: Annealing temp, Primer design.
- Types of PCR
 - Multiplex PCR
 - Reverse Transcriptase PCR
 - Hot-Start PCR
 - Touch-Down PCR
 - Nested PCR
- Real-Time PCR:
 - General Principles and Applications
 - SYBR Green Method
 - TaqMan Method
- DNA sequencing by Sanger method
- Next Generation Sequencing
 - General Principle & Applications
 - Whole Genome Sequencing
 - Exome Sequencing
 - Clinical Exome Sequencing
- Principles and Applications of Southern Blotting and Northern Blotting – DNA Probe.
- DNA microarray - Principle and Applications
- Multiplex Ligation Dependent Probe Amplification (MLPA) - Principle – Methods - Application
- Restriction Fragment Length Polymorphism (RFLP) - Principle – Methods
- Variable Number Tandem Repeat (VNTR) – DNA Fingerprinting – Technique – Application
- Application of the above techniques for detection of Point Mutations, Frame-shifts, Gene/Exon Deletion, Duplication and Amplification.

Unit II: Techniques for Protein Analysis (25 hours)

- Spectroscopy:
 - Lambert-Beer Law
 - Fluorescence Spectroscopy
 - Fluorophore
 - Fluorescence Microscopy
- Chromatography:
 - General principles
 - Ion-Exchange chromatography
 - Affinity chromatography
 - Size-exclusion chromatography

- Hydrophobic-interaction chromatography
- HPLC
- Flow Cytometry and Fluorescence activated cell sorting (FACS)
- Centrifugation – Ultracentrifugation
- PAGE
 - Principles and applications
 - Native-PAGE
 - SDS-PAGE
 - 2D-PAGE
- Western Blotting - Principle – Methods – Applications – Antibody probe
- Mass spectrometry:
 - Principle and Applications
 - LC-MS
 - MALDI-TOF

REFERENCES

- Hollas JM; Modern spectroscopy; 4th ed; John Wiley and Sons, Inc; England; 2004
- Mistry BD; A Handbook of Spectroscopic Data CHEMISTRY;1st ed; Oxford Book Company; India; 2009
- Wilson K; Walker J; Principle and techniques of bio-chemistry and molecular biology; 7th ed; New York; 2010
- Brown TA. Gene cloning and DNA Analysis: An introduction. 6th ed. Wiley; USA 2010)
- Glick BJ, Pasternak JJ, Pattn CL. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th ed; American Society for Microbiology; 2010

LIST OF PRACTICALS

2. Genomic DNA isolation extraction from PBMC.
3. Genomic DNA isolation extraction from human tissue sample.
4. DNA quantification by UV spectrophotometry
5. DNA analysis by agarose gel electrophoresis
6. Primer design
7. Polymerase Chain Reaction
8. DNA sequencing and analysis
9. Ammonium sulphate precipitation of protein and dialysis
10. Native- PAGE
11. SDS-PAGE

Semester 3 - Paper 3 – Biostatistics and Research Methodology
[Theory 50 hours]

Unit I: Biostatistics (25 Hours)

- Sampling – Definition of sampling, Random sampling, representative sampling, Types of sampling, Probability sampling, Non probability sampling techniques, SRS, Systematic Random Sampling, Cluster sampling, Non probability sampling, Purposive, convenient, snow ball sampling, Sample size, (1) sample size for estimation (2) Testing of hypothesis, sample size estimation for various study designs.
- Data – Types of data, Variables, Types of variables, Scaling techniques, methods of data collection. Presentation of data, Types of presentation of data, Tabular presentation, and simple frequency tables, cross tabulation, principles of tabulation. Diagrammatic and graphic presentations- for qualitative and discrete data, continuous data. Bar diagrams, pie chart, Histograms, frequency polygon, line graphs, orgies, scatter plots and Box plots.
- Descriptive statistics – Meaning of central tendency, purpose, measures of central tendency- Arithmetic mean, Median, mode, harmonic and geometric mean for ungrouped and grouped data. Dispersion – Meaning, purpose, measures of dispersion- Standard deviation, Coefficient of variation, range, and inter quartile range. Normal distribution, Confidence intervals.
- Correlation – Types, correlation coefficient, significance. Regression – Meaning, Model, Types of regression, Linear and multiple regression. Introduction to Logistic regression.
- Inferential Statistics – Meaning, Methods of drawing inference in (1) Estimation (2) Testing of hypothesis, Parametric methods- Types, requirements of parametric methods, types of tests used based on hypothesis, Tests- Student t test, Z-test, Variance ratio test (F-test).Non- parametric tests – Chi-square test, Fisher’s Exact test, Mc.Nemars test, Wilcoxn, Mann Whitney U test.

Unit II: Research Methodology (25 Hours)

- Research hypothesis / Research question
 - Research question – Features (SMART)
 - Research hypothesis
 - Null hypothesis
- Review of literature
 - Need for Review of Literature
 - Sources of literature : Print and Digital formats
 - Types of literature
 - Journals
 - Magazines
 - Monographs
 - Text Books
 - Types of Journal Articles:
 - Research Article
 - Review Article
 - Case-report
 - Types of scientific analysis
 - Systematic review
 - Meta-analysis

- Electronic literature databases and search engines
 - PubMed
 - EMBASE
 - IndMED
 - Cochrane Library
- Use of Boolean operators, keywords and filters for searching electronic literature
- Bibliography - Reference writing styles
- **Study Designs for Biomedical Research**
 - Pilot study
 - Observational study
 - Case Control Study
 - Cohort Study
 - Cross-Sectional Study
 - Experimental
 - Randomised Clinical Trials (RCT)
 - Non RCT
 - Preclinical studies
 - Clinical trials
 - Phases of clinical trials (Blinding, Randomization)
 - Nuremberg code
 - Declaration of Helsinki
 - Belmont principles
 - International Conference on Harmonization (ICH)
 - Good Clinical Practice (GCP)
 - Good Laboratory Practice (GLP)
 -

REFERENCES

- Rothman K.J. Epidemiology. Oxford University Press. New York, 2002.
- Byrne D.W. Publishing your research paper; Transcontinental Printing Inc; Maryland, USA.
- Bijlani R.L. Medical Research. 1st ed; Jaypee Publishers; India; 2008.
- Goyal R.C. Research Methodology for Professionals. 1st ed, Jaypee Publishers, India; 2013.
- Bowers D. Medical statistics from scratch. 2nd ed; John Wiley and Sons Ltd, England; 2009.
- Kirkwood B.R, Sterne J.A.C; Medical Statistics;2nd ed; Blackwell Sciences; USA; 2003.
- Mahajan B.K; Methods in Bio-statistics; 7th ed; Jaypee Publishers; India;2010.

Semester 4 – Paper 1 - Genetic Engineering & Biotechnology

[Theory 50 hours, Practicals 50 hours]

Unit I: Recombinant DNA Technology (20 Hrs)

- Overview of recombinant DNA technology: Application of recombinant DNA technology
- Vectors:
 - General properties
 - Cloning vector
 - Expression vector
 - Types (Plasmid, Cosmid, Phagemid, BAC and YAC)
- Enzymes and their applications :
 - DNA Polymerase
 - Proof reading polymerase
 - Thermostable polymerase
 - Exonuclease
 - Restriction endonuclease and restriction digestion
 - DNA ligase – cohesive and blunt end ligation
 - Alkaline phosphatase
 - Polynucleotide kinase and end labelling.
- Transfer of foreign DNA into host cell
 - Transformation selection & screening of transformants
 - Antibiotic selection
 - Blue white assay
- Construction of genomic DNA and cDNA libraries
- Cloning of PCR Product
 - Addition of restriction
 - Sites to Primers
 - Ta Cloning
- Protein Tags for affinity purification:
 - His tag
 - GST tag
 - MBP tag
 - Ammonium sulphate precipitation
 - Inclusion bodies

Unit II: Genetic Manipulation (5 Hrs)

- Gene silencing : Principle – methods – Applications
- Gene knockout : Techniques for creation of knock out mouse - applications

Unit III: Protein Engineering (5 Hrs)

- Site – Directed mutagenesis – Principle – Methods - applications.
- PCR based Directed evolution of protein – Principle - Methods – applications
- Phage display technology

Unit IV: Molecular Therapeutics (15 Hrs)

- Cell based therapies :
 - Definition, properties, potency of stem cells.
 - Sources : Embryonic & adult stem.
 - Induced pluripotent cells (iPS cells)

- Clinical applications of stem cells.
- Recombinant therapeutics:
 - Protein Bio-similars: Insulin, Erythropoietin and Human Growth Hormone.
 - Thombolytic agents (streptokinase, tissue plasminogen activator)
 - Immunotherapeutics:
 - Targeted cancer therapy (mechanism of action of Trastuzumab, Cetuximab, Bevacizumab)
 - Anti-inflammatory therapeutics (mechanism of action of Etanercept, Infliximab, Adalimumab)
 - Recombinant vaccines & clinical application
- Gene Therapy:
 - General principles and overall mechanism
 - Intracellular barriers to gene delivery
 - Methods for gene transfer: viral (retrovirus, adenovirus) and non-viral (liposome, nanoparticle)
 - Genome editing: CSIPR-Cas9 technology
 - Examples of gene therapy
 - Limitations

Unit V: Intellectual Property Rights (5 Hrs)

- Principles of IPR
- Types of IPR
- Intellectual property infringement
- TRIPS agreement
- Criticism of IPR

REFERENCES

- Griffiths AJF, Wessler SR, Lewontin RC, Carroll SB; editors; Introduction to Genetic Analysis; 9th ed; USA; 2008
- Sambrook J, Russell DW; editors; Molecular Cloning; 3rd ed; Cold Spring Harbor; New York; 2001
- Freshney RI; Culture of Animal Cells; 6th ed; John Wiley and Sons, Inc.;New Jersey; 2010
- Brown TA. Gene cloning and DNA Analysis: An introduction. 6th ed. Wiley; USA 2010)
- Glick BJ, Pasternak JJ, Pattn CL. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th ed; American Society for Microbiology; 2010

LIST OF PRACTICALS

1. Plasmid purification
2. Restriction digestion
3. DNA ligation
4. Transformation of recombinant construct
5. Blue-white screening of transformants

Semester 4 – Paper 2 - Molecular Basis of Human Diseases II
[Theory 50 hours, Practicals 50 hours]

Unit I: Non-Mendelian Inheritance (20 Hrs)

- Factors affecting Mendelain inheritance
- Interaction of alleles and genes:
 - Dominance: Complete dominance Incomplete dominance, Co-dominance, Overdominance (heterozygote advantage)
 - Epistasis and types of epistatic interactions (dominant epistasis, recessive epistasis, duplicate gene, additive genes, complementary genes, suppressor genes)
 - Modifier genes
 - Lethal genes
- Simple and Complex diseases:
 - Monogenic, and polygenic (multifactorial) traits
 - Pleiotropy
 - Types of polygenic inheritance (continuous and discontinuous)
- Gene and environment
 - Penetrance
 - Expressivity
 - Phenocopy
- Estimation of genetic component of multifactorial traits:
 - Risk Ratio
 - Heritability
 - Coefficient of Relationship
 - Familial Aggregation Studies
 - Twin Studies
- Genomic imprinting - Anticipation - Mosaicism & Chimerism
- Spontaneous mutations
 - Sources of spontaneous mutation (replication, recombination, chemical changes, transposons)
 - Factors affecting fixing of spontaneous mutation into familial mutation
 - Germline mutation rate in humans with common examples
 - Effect parental age and gender on the rate of spontaneous mutations

Unit II: Genetic basis of diseases (15 Hrs)

- Ion-channel Diseases: Cystic Fibrosis, Long QT Syndrome , Brugada Syndrome
- Skeletal and connective tissue disorders: Achondroplasia, Marfan Syndrome
- Hearing disorders: Non-syndromic Hearing Loss (*GJB2* gene mutations)
- Kidney disorder: Polycystic Kidney Disease
- Triplet repeat expansion disorder: Huntington disease, Fragile X syndrome, Myotonic dystrophy
- Multifactorial Disorders: Alzheimer's Disease, Age related macular degeneration
- Multifactorial Congenital Malformations – Neural tube defects, Cleft lip/palate, congenital heart malformation
- Disorders due to Genomic Imprinting – Uniparental Disomy: Beckwith Wiedemann Syndrome, Prader Willi syndrome, Angelman syndrome

- Mitochondrial Disorders

Unit III: Gene Mapping (5 Hrs)

- Linkage and Crossing Over
- Genetic markers
- Two point mapping – Multipoint Mapping
- Recombination frequency - Map distance - LOD Analysis
- Linkage map

Unit IV: Identification of human disease genes (5 Hrs)

- Human Genome Project
- Positional Cloning
- Candidate Gene approach
- Genome Wide Association Studies

Unit V: Pharmacogenetics (5 Hrs)

- Brief overview of drug metabolism
- Genetic polymorphisms of drug metabolising enzymes:
 - Pseudocholinesterase deficiency
 - N-Acetyl Transferase polymorphism and isoniazid adverse reaction
- Genetic polymorphisms of drug target :
 - G6PD deficiency and drug induced hemolysis
 - Vitamin K Epoxy Reductase Complex 1 and warfarin dosage
- Role of pharmacogenetics in personalised medicine

REFERENCES

- Nussbaum RL, McInnes RR, Willard HF, Hamosh A. Thompson and Thompson Genetics in Medicine. 7th ed. Philadelphia: Saunders-Elsevier; 2007.
- Ahluwalia KB. Genetics. 2nd ed. New Delhi: New Age International Publishers; 2009
- Verma PS, Agarwal VK. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. New Delhi: S Chand and Company; 2005.
- Nelson DL, Cox MM. Leninger Principles of Biochemistry. 4th ed. W.H. Freeman

LIST OF PRACTICALS

1. Polymorphism and Pharmacogenetics: Analysis of promoter SNP of *VKORC1* gene
2. Mutation and Pharmacogenetics: analysis of *BCHE* gene
3. Mutational analysis of Achondroplasia (*FGFR3* gene)/Cystic Fibrosis (*CFTR* gene)
4. Mutational analysis of Non-Syndromic Hearing Loss (*GJB2* gene).
5. Allele specific PCR for Beta-thalassemia 619 bp deletion
6. Mutational analysis of *HBB* gene by Sanger Sequencing
(All experiments shall include an analysis of the impact of polymorphism/mutation on protein function)

