CRITERIA I

1.1.1. PO, PSO & CO

Department: Genomic Science

I. Programme outcome:

Genomic Science, an interdisciplinary core programme, has been designed to develop and cater new generation of young minds and research organisms under the genome level. The programme developed the model of research-based teaching methods. The students studied under the programme have continued their knowledge-seeking by doing a PhD. The hands-on experience with genomics tools and techniques guided the students to pursue the carrier in various sectors. The research outcome by the faculties and research scholars placed the department on the global map. The model of the programmes helps the society by means of bioinformatics training and dissemination of knowledge by collaboration and extension activities.

II. Programme specific outcome:

Genomic Science, employing regular updating on curriculum, new courses have been continuously added to prepare the students at a global level. The students who learnt by doing mainly preferred to go for higher studies both in national and international. According to data, so far, 45 students at the national level and 12 students at the international level have chosen PhD. As the department has reached a decade after establishment, our alumni are doing Post-Doc in prestigious institutes globally. In research, based on the expertise of the faculties, the research themes, Plant Genome, Animal Genome, Metagenome, Stem cell and Bioinformatics laboratories were established with basic infrastructure and carried out the research on part with global level. As an outcome, last five years, 125 peer-reviewed journal articles were published and received 2.5 crores funds from DST, DBT and ICMR.
Course outcome:

III. Course Outcome:

1. GEN 5101 Cell and Molecular Biology

Objectives

The Cell and Molecular Biology course aims to explore and provide the students with knowledge of their components and functions. Furthermore, the course provides an in-depth understanding of the chemical composition, metabolic processes, physiological properties, signaling pathways, and the prokaryotic and eukaryotic cells' life cycle. It would also offer special units on the central dogma of molecular biology involving the transcription of rRNA from DNA and its translation from rRNA to enzymes, proteins, and post-translation modifications. Cell and Molecular Biology is the basic unit that is required in various other subjects such as biochemistry, immunology, genetics, and microbiology.

Outcomes

Upon completion of the course, the students would have a clear understanding of the various pieces of machinery required for the proper functions of a cell, metabolic

processing to sustain the organelles, its defense mechanisms against toxic compounds and environmental stress, signaling pathways that involve interactions between cells, growth, and chemotaxis. Furthermore, students shall have complete knowledge on the storage of genetic materials and their processing that determines how a cell is replicated, the possible errors that could be introduced as mutations, and the mutations' repair mechanisms.

2. GEN 5102: BIOCHEMISTRY & MICROBIOLOGY

Objectives

1. Demonstrate knowledge and understanding of the molecular machinery of living cells.
2. Demonstrate knowledge and understanding of the principles that govern the structures of macromolecules and their participation in molecular recognition.
3. Demonstrate knowledge and understanding of the principles and basic mechanisms of metabolic control and molecular signalling.
4. Describe how microorganisms are used as model systems to study basic biology, genetics, metabolism and ecology.
5. Identify ways microorganisms play an integral role in disease, and microbial and immunological methodologies are used in disease treatment and prevention.

Outcomes

1. An ability to acquire in-depth theoretical and practical knowledge of Biochemistry and Microbiology, and ability to apply the acquired knowledge to provide cost efficient solutions in it.
2. An ability to properly understand the technical aspects of existing technologies that help in addressing the biological and medical challenges faced by humankind.
3. An ability to translate knowledge of Biochemistry to address environmental, intellectual, societal and ethical issues through case studies presented in the class.

3. GEN 5103: Principles of Genetics

Objectives

1. To learn the main principles of genetics.
2. To understand the different models of genetic inheritance.
3. To provide information on gene interactions, inheritance of complex traits, linkage and chromosome mapping.

Outcomes

This course provides an overview of genetics including Mendelian and modern concepts of heredity. Further, developments in the field of molecular genetics and the nature of gene action in prokaryotic and eukaryotic cells will be addressed. At the end of the course, students will have a thorough understanding of the patterns of inheritance, structure and function of chromosomes, chromosomal abnormalities, and the clinical features of chromosomal disorders.

4. GEN 5104: Developmental Genomics

Objectives

The genomes of several model organisms, including the major ones, such as mouse, drosophila, arabadopsis etc. have been released, which coincide with the ever-increasing number of genomic technologies, allowing the study of expression, regulation, and function

of genes at the entire genomic level. The advantage of the combination of the whole genome approaches and traditional forward genetic screens is the unbiased exploration of gene function. The developmental Genomics course is designed to learn about the model organisms and various cutting-edge modern methodologies, including genomics that can be used to understand development.

Outcomes

1. Students will learn about the model organisms and the terminologies in developmental biology and genomics
2. Students will learn about the basic concepts of developmental mechanisms and principles.
3. Students will acquire knowledge and a broad understanding of the current developmental genomics including the latest research and research methodologies adopted.
4. Students will master the method of approaching a developmental biology problem through latest research literature, using molecular biology and genomic methods, by learning how to critically evaluate and interpret data.
5. Students will learn to identify important research problems in the developmental biology field and plan research to address these problems.
6. Students will learn to organize and present research and results to an audience.
7. Students will learn preparation of research proposals and manuscripts for publication in scientific journals.

5. GEN 5191 Lab in Biochemistry and Microbiology

Objective

Hands on experience on all basic and applied Biochemistry and microbiology experiments which refresh the students to recall what they learnt during Under-Graduate.

Outcomes

1. Use basic laboratory skills and apparatus to obtain reproducible data from biochemical experiments.
2. Implement experimental protocols and adapt them to plan and carry out simple investigations.
3. Analyse, interpret, and participate in reporting to their peers on the results of their laboratory experiments.
4. Participate in and report orally on teamwork investigations of problem-based assignments.
5. Build on their knowledge and understanding in tackling more advanced and specialized courses, and more widely to pursue independent, self-directed and critical learning.

6. GEN 5205 Biostatistics & Bioinformatics

Objectives

The objective of the course is to introduce students to basics of biostatistics and bioinformatics. Such knowledge will be fundamental for a proper experimental design and data analysis, as well as for statistical interpretation and evaluation of experimental results. This course provides an introduction to a variety of statistical methods of use in describing and analyzing biological data.

Outcomes

On successful completion of this course, the following learning outcomes will be achieved

a. Student can use commonly used bioinformatics tools and understand their pros and cons

b. understand the basics of statistical analysis of data

Knowledge:

a. has advanced knowledge of topics and in the field of Bioinformatics

b. has knowledge of statistical methods for analysis of biological data

Skills:

a. can analyze and use bioinformatics methods associated with sequence alignment, database searches, genome analysis and protein structural studies

b. can understand statistical methods in life sciences

7. GEN 5206 Genomics & Proteomics

Objectives

1. To describe the basic concept of the transmission of genetic information from DNA to proteins.
2. To illustrate how genomics and proteomics related technologies can be used to study gene expression and function and clinical manifestations of genetic diseases.

Outcomes

This course presents basic terms, principles and research methods used in the field of genomics. Students learn about the structure and organization of prokaryotic and eukaryotic genomes. Further it explains the current genomic technologies and illustrates how these techniques can be used to study gene function and their implications in disease diagnostics and therapy. Upon successful completion of the course, students would have sufficient knowledge and skills to describe recent advances in genomics, transcriptomics, and proteomics.

8. GEN 5207 Structural Biology

Objectives

The structural biology course would embark on inquiry-based analytical knowledge on the functions of biomolecules and how such functions are associated with the 3D structure of the biomolecule itself. It would also deal with the importance of 3D structure in the storage of the substantial genetic material within the smallest cell, the thermodynamics that shapes the various levels of structure, chemical bonds that maintain their 3D structure, how the enzymes and proteins acquire their functional roles, and how these enzymes retain their place within, outside, or in the membranes.

Outcomes

The course would transform the students into the acute importance of 3D structures in molecular biology. They shall learn how structural motifs, domains, and chemical bonds shape a biomolecule's functions and possible predictions of the function using the structure with their limitations.

9. GEN 5208 Immunology

Objectives

To learn more about structural features of components of immune system and their function. To understand the mechanism of immune response against pathogens, the nature of antibody diversity etc.

Outcomes

The students should be able to evaluate the usefulness of immunology in different pharmaceutical companies

10. GEN 5292 Lab in Cell Biology and Genetics

Objectives

1. To learn common genetic techniques such as DNA extraction, PCR, DNA sequencing etc.
2. To give a hands-on experience to students in performing genetic techniques.

Outcomes

By completing this course, students are expected to have a clear understanding of the various genetic techniques and their applications in biology.

11. GEN 5293 Lab in Bioinformatics

Objectives

To impart practical exposure to students in using various Bioinformatics tools and databases.

Outcomes

This course will prepare the students for various applications of bioinformatics in life science research by introducing them and giving hands on experience with various databases, BLAST searches, sequence alignment, Phylogenetic analysis and Primer designing.

12. GEN 5309 Genome Analysis

Objectives

The objective of the course is to introduce students to advance knowledge of Bioinformatics which is genome analysis. Such knowledge will be fundamental for proper understanding of genomes, transcriptomes, as well as for interpretation and evaluation of genome data

Outcomes

a. At the end of the course students will be able to comprehend the organisation of the genome, transcriptome and proteome and familiarize themselves with various analytical techniques used for genome analysis

b. The student will be able discern the crucial concepts and techniques applied in genomics, transcriptomics and proteomics.

c. The student will understand the differences in various sequencing technologies and familiarize themselves with the instruments used in next generation sequencing through a site visit to such a facility.

13. GEN 5310 Biomedical Genomics

Objectives

With the success of the human genome project, the genomics field is a witness to the rapid development of modern technologies and new computational approaches, allowing us to unlock the secrets of the human genome, in order to utilise this information to combat diseases and improve health. In the Biomedical Genomics course, the students gain a broad understanding of the human genome, genetic diseases, cancer and personalised medicine using stem cells. They gain mastery of the

cutting-edge research approaches and the latest genomic developments and applications in these areas.

Outcomes

1. Students will acquire broad understanding of the human genome and the diseases brought about by the changes in the genome.
2. Students will acquire knowledge and a broad understanding of the current biomedical genomics including the latest research and research methodologies adopted.
3. Students will master the method of approaching a biomedical problem through latest research literature, using molecular biology and genomic methods, by learning how to critically evaluate and interpret data.
4. Students will learn to identify important research problems in the biomedical field and plan research to address these problems.
5. Students will learn to organize and present research and results to an audience.
6. Students will learn preparation of research proposals and manuscripts for publication in scientific journals.

14. GEN 5311 Genetic Engineering

Objectives

The objective is to teach various approaches to conducting genetic engineering and their applications in biological research as well as in biotech industries

Outcomes

The students should be endowed with strong theoretical knowledge of this technology along with practical skills to conduct routine techniques used in genetic engineering lab

15. GEN 5312 Functional Genomics

Objectives

The goal of functional genomics is to determine how the individual components of a biological system work together to produce a particular phenotype. Functional genomics focuses on the dynamic expression of gene products in a specific context, for example, at a specific developmental stage or during a disease. This course thus will provide an overview of the concept of Functional Genomics and contemporary approaches used to understand the genome function.

Outcomes

1. Apply insights in analyses and evaluations of how functional genomics contributes to systems biology and systems medicine.
2. Analyse and discuss the interdependence of biomedicine/biotechnology, bioinformatics and bioethics within functional genomics.

On completion of this subject, students should have developed the following generic skills:

- The ability to interpret scientific literature and interpret data from electronic databases.
- The capacity to integrate knowledge across disciplines.
- The ability to comprehend a question, evaluate the relevant information and communicate an answer.

16. GEN 5394 Lab in Molecular Biology and Genetic engineering practical.

Objectives

The Molecular Biology and Genetic engineering practical course encompass a series of experiments in eukaryotic and prokaryotic cells. The practical sessions start with necessary investigations such as genomic and plasmid DNA isolation followed by single and double restriction digestions, verifications, and analysis. The students shall also be taught PCR of specific genes and their cloning, blue-white colony screening, and verification. Furthermore, pure compounds' anticancer effects shall also be taught against several cancer cell lines, mode of actions, RNA isolation, real-time PCR, SDS-PAGE, and western blotting.

Outcomes

Upon completing the practical session, the students shall have hands-on expertise in isolation and troubleshooting of plasmids, DNA, RNA, proteins, and the visualization and analysis using agarose gel electrophoresis SDS-PAGE. They shall be confident in cloning and expressing desired genes from any bacterial system and analysis of the anticancer mode of action from a pure compound. Such knowledge shall be handy in various medical and molecular research.

MSC-GENOMIC SCIENCE

BOARD OF STUDIES

APPROVED

PROGRAM OF STUDY
&
SYLLABUS

DEPARTMENT OF GENOMIC SCIENCE
CENTRAL UNIVERSITY OF KERALA
08.07.2020

M.SC (GENOMIC SCIENCE) PROGRAM STRUCTURE

BOARD OF STUDIES APPROVED PROGRAM OF STUDY & SYLLABUS

-Sd/ Head, Dept. of Genomic Science

COURSE CODES & NO	COURSES TITLE (CORE COURSES)	CONTACT HOURS PER WEEK			
		L	T	P	C
GEN 5101	CELL & MOLECULAR BIOLOGY	**4**	**0**	**0**	**4**
GEN 5102	BIOCHEMISTRY & MICROBIOLOGY	**4**	**0**	**0**	**4**
GEN 5103	PRINCIPLES OF GENETICS	**4**	**0**	**0**	**4**
GEN 5104	DEVELOPMENTAL GENOMICS	**4**	**0**	**0**	**4**
GEN 5191	LAB IN BIOCHEMISTRY & MICROBIOLOGY	**0**	**3**	**3**	**1**
	SEMESTER TOTAL	**16**	**3**	**3**	**17**
	DEPARTMENT ELECTIVE				
GEN 5205	BIOSTATISTICS & BIOINFORMATICS	**4**	**0**	**0**	**4**
GEN 5206	GENOMICS & PROTEOMICS	**4**	**0**	**0**	**4**
GEN 5207	STRUCTURAL BIOLOGY	**4**	**0**	**0**	**4**
GEN 5208	IMMUNOLOGY	**4**	**0**	**0**	**4**
GEN 5292	LAB IN CELL BIOLOGY & GENETICS	**0**	**0**	**3**	**1**
GEN 5293	LAB IN BIOINFORMATICS	**0**	**0**	**3**	**1**
	SEMESTER TOTAL	**16**	**0**	**6**	**18**
	DEPARTMENT ELECTIVE				
GEN 5309	GENOME ANALYSIS	**2**	**2**	**0**	**4**
GEN 5310	BIOMEDICAL GENOMICS	**4**	**0**	**0**	**4**
GEN 5311	GENETIC ENGINEERING	**4**	**0**	**0**	**4**
GEN 5312	FUNCTIONAL GENOMICS	**4**	**0**	**0**	**4**
GEN 5394	LAB IN MOLECULAR BIOLOGY & GENETIC ENGINEERING	**0**	**3**	**3**	**1**
	SEMESTER TOTAL	**16**	**5**	**3**	**17**
	DEPARTMENT ELECTIVE				
GEN 5490	DISSERTATION & VIVA-VOCE	**0**	**0**	**35**	**8**
	SEMESTER TOTAL				**8**
	CORE COURSES				**60**
	ELECTIVE COURSES				**12**
	MSC- PROGRAM TOTAL				**72**

L – LECTURE; T – TUTOR; P – PRACTICAL; C - CREDIT

M.SC (GENOMIC SCIENCE) COURSE STRUCTURE

COURSE CODES & No	COURSES TITLE (ELECTIVE COURSES)	CONTACT HOURS PER WEEK			
		L	T	P	C
GEN 5001	IPR AND NATIONAL BIODIVERSITY RULES	**4**	**0**	**0**	**4**
GEN 5002	POPULATION GENETICS	**2**	**2**	**0**	**4**
GEN 5003	SCIENTIFIC COMMUNICATION: A PRACTICAL GUIDE	**3**	**0**	**3**	**4**
GEN 5004	STEM CELL BIOLOGY	**3**	**1**	**0**	**4**
GEN 5005	INFECTIOUS DISEASES	**4**	**0**	**0**	**4**
GEN 5006	EPIGENETICS	**4**	**0**	**0**	**4**
GEN 5007	TRANSLNATIONAL RESEARCH	**3**	**0**	**0**	**3**
GEN 5008	EVOLUTIONARY BIOLOGY	**2**	**2**	**0**	**4**
GEN 5009	PLANT GENOMICS	**2**	**0**	**0**	**2**
GEN 5010	MICROBIAL GENOMICS	**3**	**0**	**0**	**3**
GEN 5011	CONSERVATION GENETICS	**4**	**0**	**0**	**4**
GEN 5012	BASIC BIOINFORMATICS	**2**	**2**	**0**	**4**
GEN 5013	PHARMACOGENOMICS	**2**	**0**	**0**	**2**
GEN 5014	METABOLIC PROCESS AND ENGINEERING	**2**	**0**	**0**	**2**
GEN 5015	METAGENOMICS	**2**	**0**	**0**	**2**
GEN 5016	CANCER GENOMICS	**2**	**0**	**0**	**2**
GEN 5017	MOLECULAR BIOPHYSICS	**4**	**0**	**0**	**4**
GEN 5018	SCIENTIFIC WRITING AND PUBLISHING	**2**	**0**	**0**	**2**
MOOC COURSES					
GEN 5019	BIOMEDICAL NANOTECHNOLOGY				
GEN 5020	BIOSTATISTICS AND MATHEMATICAL BIOLOGY				
GEN 5021	LINUX OPERATING SYSTEM				
GEN 5022	PLANT DEVELOPMENTAL BIOLOGY				
GEN 5023	RESEARCH ETHICS				
GEN 5024	R				
GEN 5025	BIOMASS CHARACTERIZATION				
GEN 5026	BIOSTATISTICS				
GEN 5027	CONSTITUTIONAL STUDIES				
GEN 5028	ENTREPRENEURSHIP AND IP STRATEGY				
GEN 5029	INDUSTRIAL BIOTECHNOLOGY				
GEN 5030	VIROLOGY				
GEN 5031	TISSUE ENGINEERING				
GEN 5032	BIOPHYSICAL CHEMISTRY				
GEN 5033	BIOMOLECULES : STRUCTURE, FUNCTION IN HEALTH AND DISEASE				

MSC-GENOMIC SCIENCE

CORE COURSES

GEN 5101: CELL & MOLECULAR BIOLOGY (4, 0, 0, 4)

Unit-I: Cell theory, Structure and function, Cell Division (Mitosis and Meiosis), Cell Cycle and Checkpoints in Cell Cycle Regulation, Normal and Cancer cells, Apoptosis.

Unit-VI: Discovery of DNA: Early experiments in molecular genetics. Historical events that lead to the conclusion of DNA is the genetic material.

Unit-II: DNA replication in prokaryotes and eukaryotes: Enzymes in DNA synthesis. Methods for studying DNA replication and determination of origin of replication.

Unit-III: DNA damages and repair mechanisms: Types of DNA damages, Direct repair system, excision repair (NER and BER), Mismatch repair (MMR), SOS response, double stranded DNA break repair (DSB).

Unit-IV: Transcription and Translation (Prokaryotes and eukaryotes): RNA polymerase, Transcription factors, RNA splicing and Mechanism of spliceosomes, Genetic code, Post-transcriptional and translation modification (PTM), Exon shuffling, initiation, elongation and termination steps in protein synthesis.

Unit-V: Regulation of gene expression: Operon models-positive and negative control (Lac and Trp operons), regulatory RNA gene silencing, regulatory elements-upstream elements to TATA box, Downstream promoter elements (DPE) and InR elements, their structure and functions.

Recommended Books:

1. The Cell A Molecular Approach-Cooper-Hausman
2. Karp, Gerald and Nancy L., Pruitt. ***Cell and Molecular Biology and Experiments***. Wiley, 2002
3. Weaver, Robert Franklin (2012) ***Molecular biology. 5th edition***. McGraw Hill, New York.
4. Koenberg, A.and Baker, A.T. (2005). ***DNA Replication.2nd edition***. University Science Book, California.
5. Watson, Baker, Bell, Gann, Levine and Losick. (2006). ***Molecular Biology of the Gene, 5th edition***, Pearson Education.
6. Rapely, Ralph and David Whitehouse, Eds ***Molecular Biology and Biotechnology***. Royal society of Chemistry, 2014
7. **Molecular Cell Biology** 5th Edition by Harvey Lodish, W.H Freeman and Company.
8. Brown, Essential Molecular Biology Vol. I &II, Ap, 2000
9. Molecular Cell Biology, 6th Ed., Lodish et al, Freeman & Co. 2008

GEN 5102: BIOCHEMISTRY & MICROBIOLOGY (4, 0, 0, 4)

Unit 1: Biomolecules & Carbohydrate

Overview of Biomolecules; Carbohydrate: Classification and structure; Biosynthesis of carbohydrates-glucose, starch and glycogen, Photosynthesis, Calvin pathway, Hatch-Slack pathway, Krebkres cycle, Photorespiration

Unit 2: Protein & Lipids

a. Structure and function of proteins – Functional diversity of proteins, Structure and classification of amino acids, Properties of amino acids, acid-base properties, Biosynthesis of amino acids.
b. Classification and structure of lipids; Biosynthesis of saturated fatty acids, Triacyglycerols, Phosphoglycerides, Sphingolipids, Cholesterol biosynthesis.

Unit 3: Nucleic acids & Enzymes

a. Biosynthesis of purines and pyrimidines, Degradation of purines and pyrimidines
b. Enzyme: Classification, coenzymes, factors affecting enzyme activity, active site, enzyme kinetics, Michaelis- Menten model, significance of Km and Vmax, Regulation of enzyme activity, Allosteric enzyme

Unit 4:

History of Development of Microbiology; Diversity of Microorganisms, Relevance of Microbiology to Human Health and Environment

Unit 5:

Industrial microbiology, Food and Dairy Microbiology

Suggested Readings

1. Principles of Biochemistry, 7th edition- Smith, Hill, Lehman, Mc Graw Hill Publishers.
2. Biochemistry, 5th edition- LubertStryer, Bery, Jeremy M John Tymoczkq, W.H. Freeman and Co.
3. Principles of Biochemistry, 4th edition- Lehninger, Nelson and Cox. W.H. Freeman and Co. ISBN 0-7167-4339-6.
4. Harper's Illustrated Biochemistry, 27th edition- Robert Murray, Darryl K Granner, Peter A Mayes Victor, W.Rodwell, McGraw Hill Publishers.
5. Biochemistry- Berg JM, Tymoczko JL and Stryer L (2006) W.H.Freeman& Co Ltd

GEN 5103: PRINCIPLES OF GENETICS (4, 0, 0, 4)

UNIT I

Definition and scope of genetics; Mendelism- dominant and recessive traits, alleles, law of segregation, law of independent assortment, back cross, test cross, incomplete dominance; co-dominance, multiple alleles, multiple gene inheritance, lethal genes, complementary genes, pleiotropism, penetrance, epistasis

UNIT II

Chromosome-morphology and structure of chromosome, heterochromatin, euchromatin, chromatid, centromere, functions of chromosomes; karyotype; cell division-mitosis and meiosis, regulation of cell cycle; chromosomal aberrations-numerical and structuralaberrations

UNIT III

Chromosomal theory of sex determination-XX-XY, XX-XO, ZZ-ZW; sex linked inheritance-types of sex-linked inheritance, sex linkage in *Drosophila* and human, sex limited genes, sex influenced genes; extranuclear inheritance-mitochondrial-snail; chloroplast- leaf variegation in *Mirabilis* plants.

UNIT IV

Genetic linkage, crossing over, recombination, mutations; tetrad analysis; DNA markers; genome maps-linkage maps, physical maps, cytogenetic maps, Human genetic diseases.

UNIT V

Hardy-Weinberg Law, evolutionary factors affecting Hardy-Weinberg equilibrium- genetic drift, mutation, migration, natural selection, non-random matting and gene flow; genetic variation in natural population; phenotypic variation; effect of environment on phenotype development-temperature, light, nutrition etc.,

Suggested Readings

1. Krebs JE, Goldstein ES, Kilpatrick ST (2017). Lewin's Genes XII. Jones and Bartlett Publishers, Massachusetts, USA.
2. Pierce BA (2017). Genetics: A Conceptual Approach. W. H. Freeman Company, UK.
3. Snustad DP, Simmons MJ (2015). Principles of genetics. Wiley, USA.
4. Hartl DL (2011). Essential of Genetics. Jones and Bartlett Publishers, Massachusetts, USA.

GEN 5104: DEVELOPMENTAL GENOMICS (4, 0, 0, 4)

UNIT I: Introduction
Concepts and principles of developmental biology

UNIT II: Developmental mechanisms
Early development (Preimplantation development); Gastrulation (reorganization into germ layers) and cell-type specification; Organogenesis, Signalling pathways in development, Programmed cell death in development.

UNIT III: Strategies to study development
Understanding development mechanisms using model organisms (invertebrates, vertebrates and plants: Caenorhabditis elegans, Drosophila melanogaster, Arabidopsis thaliana, Mouse): Forward and Reverse Genetics approaches, Lineage tracing, Transgenic methods, Application of CRISPR/Cas9 in developmental biology.

UNIT IV: Genomic technologies to study development
Applications of genomics, transcriptomics, epigenomics, single cell genomics (Microarray and Next-Generation Sequencing) in developmental biology.

UNIT V: Stem Cells
Stem Cells to understand development, Basics, States of pluripotency, Embryonic, Adult and induced Pluripotent Stem Cells and applications.

Suggested Readings

1. Rossant J. Genetic Control of Early Cell Lineages in the Mammalian Embryo. Annu Rev Genet. 2018 Nov 23; 52: 185-201. (https://www.annualreviews.org/doi/full/10.1146/annurev-genet-120116-024544)
2. Gilbert, Scott F. Developmental biology, Sinauer Associates, Inc., 0-87893-258-5
3. Janet Rossant, Mouse Development, Elsevier 978-0-12-597951-1
4. Moody, Sally A., Principles of developmental genetics, Academic Press, 978-0-12-405945-0
5. Subramoniam, T., Molecular developmental biology, Alpha Science International Ltd., 978-1-84265-661-7
6. Hennig, Lars, Köhler, Claudia, John M. Walker, Plant developmental biology, Humana Press, 978-1-60761-764-8
7. Slack, Jonathan Michael Wyndham, Essential developmental biology, Blackwell Science Ltd, 0-632-05233-3
8. Carlson, Bruce M., Human embryology and developmental biology, Elsevier, 978 0323014878

GEN 5191: LAB IN BIOCHEMISTRY & MICROBIOLOGY (0, 3, 3, 1)

1. Laboratory precautions and safety procedures
2. Qualitative analysis of biomolecules
3. Estimation of glucose using standard graph- Anthrone method
4. Estimation of protein using standard graph -Biuret method
5. Pure culture technique: streak plate, spread plate, pour plate methods.
6. Enumeration of bacterial/ yeast cells- viable count (plate count) total count (haemocytometer count).
7. Staining methods: simple, negatives, acid fast, gram staining, spore staining, metachromatic granular staining, capsule staining, Lactophenol cotton blue staining.
8. Measurement of growth- direct haemocytometer count, viable count- growth curve, determinations of growth rate and generation time.
9. Effect of pH, temperature and osmotic pressure on growth of bacteria.

Suggested Readings

1. Soundravally Rajendiran & Pooja Dhiman (2019). Biochemistry practical manual. Elsevier. USA.
2. Green MR & Sambrook J (2012). Molecular Cloning, A Laboratory Manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA.
3. Jayaraman J (1996). Laboratory manual in Biochemistry, New Age International Publisher, New Delhi, India.

GEN 5205: BIOSTATISTICS & BIOINFORMATICS (4, 0, 0, 4)

Unit1: Definition, scope and role of statistical methods in biological research. Basic principles of experimental design- principles of replication, randomization and local control. Informal and formal experimental designs- completely randomized design, randomized block design, Latin square design and factorial designs.

Unit 2: Tests of statistical significance: Hypothesis testing student 't' test, one tailed and two tailed, one sample and two sample, multi sample One way analysis of variance, two – way analysis of variance and multivariate analysis of variance. Multiple comparisons- the Tukey test, The Newman – Keuls test and Duncans multiple range test.

Unit3. Introduction to Bioinformatics: Basic principles of computing: Introduction to computers- hardware, software, operating systems, Internet; Principles of programming - logics, algorithms, languages. Genes, Genomes, biochemical pathways; Computer fundamentals- UNIX operating system, languages for Bioinformatics relational databases (RDBMS), networking and hardware fundamentals, Internet, World Wide Web, web authoring.

Unit 4. Biological databases: Online databases and major web resources for Bioinformatics, file formats and sequence databases- DNA sequence databases, Proteomic databases, Metabolic databases, base searches- text based and sequence based, sequence alignment- local/ global, pairwise/multiple. Scoring methods

Unit 5. Sequence Alignments & Phylogeny

(i) Pairwise sequence alignment- similarity, homology and analogy, Global and local alignment, gap penalty, weight matrices, PAM and Blosum

(ii) Multiple alignments- CLUSTALW, MUSCLE sequence alignments

Sequence analysis: BLAST, FASTA, PSI-BLAST, BLASTX, TBLAST, TBLASTX algorithms, Homology modelling, Databases for comparative genome analysis

Phylogeny: Phylogenetic trees- introduction, molecular clock, Methods of constructing phylogenetic trees, Neighbour Joining method, maximum parsimony method, Maximum Likelihood methods, Bootstrapping, Phylogenetic software

s. Phylip MEGA, PAUP.

Unit 6. Protein structure, Structural databases- PDB, MMDB, *Domain searching* PFAM, PROSITE *Homology modeling* Swiss model, DaLi, Threading, Rosetta *Protein-protein interactions,* Protein structure prediction methods. small molecular interactions and docking.

Suggested Readings

1. Bioinformatics concepts, skills and applications- S.C.Rastogi, N,Mendirattar and Y.Rastogi, CBS Publishers, New Delhi.
2. Bioinformatics- Westhead, Parish and Twynan, Bio Scientific Publishers, Oxford.
3. Introduction to Bioinformatics: A theoretical and practical approaches- S.A. Krawetzt, D.D. Womble, Human Press.
4. Bioinformatics: sequence and genome analysis- D.W.Mount, CSH lab press.
5. Internet for the molecular biologist- S.R. Swindell, R.R.Miller, G.S.A. Meyers, Horizon Scientific Press.

GEN 5206: GENOMICS & PROTEOMICS (4, 0, 0, 4)

UNIT I

Introduction and scope of genomics; types of genomics-structural, functional and comparative genomics; structure, organization and composition of eukaryotic and prokaryotic genomes; evolution and structure of mitochondrial genome, mitochondrial diseases;chloroplast genome

UNIT II

DNA extraction methods; primer synthesis; polymerase chain reaction; conventional sequencing techniques- Maxam-Gilbert and Sanger sequencing, Evolution of DNA sequencing methods; shotgun genome sequencing; Next Generation Sequencing (NGS) techniques and its applications.

UNIT III

Gene structure, organization, expression; impact of single nucleotide polymorphism on gene function and phenotype; gene expression analysis using microarray RT-PCR, RNA-Seq; pseudogenes; non-coding RNA- short ncRNAs and long ncRNAs

UNIT IV

Genome projects-history, composition and characteristic features of *Drosophila melanogaster, Saccharomyces cerevisiae*, *Arabidopsis thaliana*, *Gallus gallus*, *Mus musculus*, *Bubalus bubalis*, and *Homo sapiens* genomes.

UNIT V

Introduction and scope of proteomics; types of proteomics-quantitative proteomics; functional proteomics, structural proteomics; protein isolation; detection and quantitation of proteins-isoelectric focusing (IEF), two-dimensional PAGE, protein microarrays, MALDI- TOF mass spectrometry, NMR spectroscopy, x-ray crystallography.

Suggested Readings

1. Lesk AM (2017). Introduction to Genomics. Oxford University press. Oxford, UK.
2. Green MR & Sambrook J (2014). Molecular Cloning, A Laboratory Manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA.
3. Twyman R (2013). Principles of Proteomics. Garland Science, Taylor & Francis Group, LLC, New York, USA.
4. Liebler DC (2002). Introduction to Proteomics- Humana Press, New York, USA.

GEN 5207: STRUCTURAL BIOLOGY (4, 0, 0, 4)

Unit-I: Overview on structural biology of the cell-historic perspective-breakthrough discoveries; Basic concepts on structural origin for macromolecules; Structure of atoms, molecule; Physico-chemical forces, covalent bonds, Hydrogen bonds, Ionic bond, hydrophobic interactions, polar and non-polar molecules.

Unit-II: DNA and RNA structures (A, T, G, C, U); forces and stabilizing geometries, glycosidic bond, rotational isomers; Stabilizing ordered forms of DNA (A, B and Z); Base stacking, and tertiary structure of Supercoiled DNA; Small molecules, RNA secondary and tertiary structures, t-RNA tertiary structure.

Unit-III: Anatomy of proteins: Hierarchical organization of Protein structure and Calculation of phi, psi and chi torsion angles of Peptide bond; Ramachandran map, Protein folding, stability and alternative conformations.

Unit-IV: Bimolecular structure and function; Affinity and specificity in molecularinteractions; Receptor-ligand interactions; Protein-drug binding; Protein-nucleic acid recognition.

Unit-V: Basic principles of UV-Vis and Nano spectroscopy; Fluorescence spectroscopy Chromatography, PAGE, HPLC, NMR, and Mass spectrometry, X-RD, Circular Dichroism (CD) and their limitations and precautions.

Recommended Books:

1. *Textbook of Structural Biology By* Nissen Poul, Publisher: World Scientific Publishing Co Pte Ltd ISBN: 9789813142473, 9813142472
2. Lehninger AL (2000) Principles of Biochemistry- Worth Publishers, New York
3. Keith Wilson & John Walker, (2010), Principles and Techniques of Biochemistry and Molecular Biology, ed., Cambridge Univ. Press.
4. M. B. Jackson (2006) "Molecular and Cellular Biophysics" Cambridge U. Press, (abbr: MJB) (ISBN 0-521-62470-3)
5. Handbook of structural biology (Methods & Application), 2009, HG Bohr, Wiley
6. Biomolecule NMR Spectroscopy- Jeremy NS Evans.
7. Principles and techniques of practical Biochemistry- Keith Wilson, John Warker.
8. CD and conformational analysis of biomolecules- Gerald D Fasman
9. Principal of Protein Structure, GE Schulz, RH Schirmer (2004), Springer
10. Biophysical Chemistry, The Behaviour of biological macromolecules, Vol I,II, III, Cantor and Schimel, (2008), W H Freeman & Co
11. Subramanian MA (2005) Principles and Techniques- MJP Publishers, Chennai

GEN 5208: IMMUNOLOGY (4, 0, 0, 4)

- Introduction to immunology – types of immunity – innate and acquired, passive and active – lymphoid organs- autoimmunity- physiology of immune response- humoral and cell mediated immunity- immunohaemotology.
- Antigens and haptens, antibody- types, structure, functions and generation of diversity– - mechanism of antigen recognition by T and b cells- lymphocyte activation- growth factors- cellular co –operation – complement components- classical and alternative pathways- hypersensitivity reactions- idiotype network- immunity to infectious diseases- mechanisms in immunity- macrophage activation- cell mediated cytotoxicity- hypersensitivity reaction- mechanism of immune-regulation- tolerance.
- Immunogentics- molecular genetics of human inherited diseases, transplantations immunology- rejection- graft vs. host reaction- transplantation- antigen- HLA tissue typing and MHC – tumor immunology- tumor antigens- immunotherapy of malignancy- autoimmune disorders and diagnosis, immune suppression, tolerance; allergy and hypersensitivity; AIDS and Immunodeficiencies; resistance and immunisation; Vaccines-Basic principles of vaccine development; protein based vaccines; DNA vaccines; Plant based vaccines; recombinant antigens as vaccines
- Immunotherapeutics- engineered antibodies; poly and monoclonal antibodies, application of monoclonal antibodies, catalytic antibodies; idiotypic antibodies; combinatorial libraries for antibody isolation

Suggested Readings

1. Introductory Immunology, 1st edition – Hue Devis, Chapman Hall Publisher, London, 1997.
2. Immunology 4th edition- Roitt JM, Brostaff JJ, Male DK, CV Mosby Publisher, St. Louis,1996.
3. A hand book of Practical Immunology (vol I & II)- Talwar GP, Gupta SK, Vikas Publishing House Pvt.Ltd, New Delhi, 1992.
4. Immunology 3rd edition- Bellanti, WB Saunders Co.Ltd, Philadelphia, 1985.

GEN 5292: Lab in Cell Biology & Genetics (0, 0, 3, 1)

- Basic experiments of Cell Biology
- Mammalian cell culture medium preparation and culture and, propagation of mammalian primary or cell line.
- Isolation of DNA from blood and animal tissues, separation of DNA on agarose gel electrophoresis.
- Spectrophotometric quantification of DNA
- PCR techniques;
- DNA Sequencing, Technology and methods.
- Buccal smear - identification of Barr body
- Mitosis and the cell cycle in onion root-tip cells
- Pedigree analysis

Suggested Readings

1. A short course in bacterial genetics: a laboratory manual and handbook for E coli and related bacteria- Jeffrey H Muller, Cold Spring Harbor Laboratory Press, USA, 1992.
2. Experiments in molecular genetics- Jeffrey H Muller, Cold Spring Harbor Laboratory Press, USA, 1972.
3. Molecular cloning : a lab manual, 2nd edition- Sambrook J, Fritsch EF, Maniatis T, Cold Spring Harbor Laboratory Press, USA, 1989.

GEN 5293: Lab in Bioinformatics (0, 0, 3, 1)

Experiments

1. One experiment each in A. Basic sequence handling; B. Gene Prediction using softwares
2. Study of Biological data bases
3. BLAST
4. Sequence alignment,
5. MSA with Muscle, Mafft
6. MEGA/PAUP/Phylip
7. ORF & Gene finding
8. Protein Structure Prediction
9. Molecular Docking
10. Genome/ Transcriptome Assembly
11. Genome Transcriptome Annotation

GEN 5309: Genome Analysis (2, 2, 0, 4)

Unit I: Understanding the Basics of genomic analysis at various levels (DNA and mRNA), and bioinformatics methods used in these analyses.

Unit II: Principles of DNA Sequencing Technologies, DNA sequencing (1st, 2nd and 3rd generation Technologies), Comparison of various sequencing platforms and technologies, Genotyping Tools for Genotyping.

Unit III: Transcriptome; Transcriptome Analysis and Tools, Transcriptome Assembly, Transcriptome Annotation tools, RNA-Seq, Differential Gene Expression, Non-coding RNA seq.

Unit IV: Metagenome; Metagenome Analysis Tools, Metagenome Assembly, Assessment of Variation.

Industry Visit: Visiting of Next Generation Sequencing Facilities in Bangalore/ Cochin/other Cities for first hand exposure to instrumentation and technologies used in various next generation analysis in Bangalore.

Ref:

1. Metagenomics, Methods and Protocols Editors: **Streit**, Wolfgang, **Daniel**, Rolf (Eds.) 2017
2. Metagenomics for Microbiology • Jacques Izard and Maria C. Rivera 2015
3. Genomes. 2nd edition. 2002, Garland Science.
4. Applied Computational Genomics (Translational Bioinformatics) Yin Yao 2018

GEN 5310: BIOMEDICAL GENOMICS (4, 0, 0, 4)

UNIT I: Human Genome: Human Genome Project, 10K and 100K genome projects, ENCODE, Human Genome Organization, Genome Asia 100K, HapMap Project, Human Genome

UNIT II: Genome analysis, editing and Diagnostics: Genome wide association studies (GWAS) for identifying disease associated genes, Single cell genomics, Recurrent and rare cancer associated aberrations, Microsatellite markers, DNA Fingerprinting, DNA in forensics and Medico-legal applications, SNPs, translocations, Pedigree analysis, DNA specific identification, Genome editing – Applications of CRISPR/Cas9 in cancer and genetic diseases, Applications of microarrays and NGS for studying human genetic diseases and cancer, Identifying gene fusions using RNA sequencing, recent research

UNIT III: Models of diseases and Cancer: Cancer cell lines, Patient derived xenografts (PDXs), Transgenic mouse models for human diseases (Transgenesis, Single-Gene Knock- out and Knock-in, Conditional Gene Modifications), Examples of disease-specific mouse models, such as such as Huntington's or Alzheimer's disease, Validation of disease-associatedgenes using *in vitro* and *in vivo* models by pharmacological inhibition, Personalised/Precision medicine

UNIT IV: Molecular Therapeutics:
Principle, types and applications of gene therapy, Genome based medicine –Positional cloning for identifying disease genes, Ethics in gene therapy, Drug resistance mechanism(s)- targeted therapy using proteo-genomic analysis using PDX or other *in vivo* models, Recent research/advances

UNIT V: Stem Cells Therapy and Regenerative medicine: Stems Cells for regenerative medicine, disease modeling, drug discovery and gene-correction, induced Pluripotent Stem Cells for personalized medicine/therapy, Tissue engineering

Suggested Reading:

1. Korf, Bruce R., Human genetics and genomics, Wiley-Blaclwell, 978-0-4706-5447-7
2. Richards, Julia E., Hawley, R. Scott, The human genome, Elsevier, 978-0-12-333445-9
3. Nagy, Andras, Turksen, Kursad, Patient-Specific Induced Pluripotent Stem Cell Models, Springer New York
4. Rendl, Michael Stem cells in development and disease, Elsevier
5. Erik J. Sontheimer The Use of CRISPR/cas9, ZFNs, TALENs in Generating Site Specific Genome Alterations, Elsevier, 978-0-12-801185-0
6. Levy SE, Myers RM. Advancements in Next-Generation Sequencing. Annu Rev Genomics Hum Genet. 2016 Aug 31; 17: 95-115. (https://www.annualreviews.org/doi/10.1146/annurev-genom-083115-022413)

GEN 5311: GENETIC ENGINEERING (4, 0, 0, 4)

- Tools for genetic engineering; restriction and modification in bacteria *E.coli*, K and B system, restriction endonuclease type I, II and III, ligases vectors- plasmids- phages, cosmids, phagemids, special vectors- broad host range, expression, integrating shuttle vectors- yeast vectors.
- Principles of gene cloning – α complementation, genomic library and cDNA library-shot gun cloning- screening of recombinants- phenotypic expression of characters-colony hybridization- southern hybridization- use of antibody- western blot-physical mapping of the cloned gene. Eukaryotic gene cloning
- Analysis of differential gene expression using Suppression Subtraction Hybridization, mRNA differential display, cDNA AFLP, knock out and GMO's.
- Genome editing: Genome editing strategies based on Homologous recombination, ZFN, TALENS, CRISPR/Cas9
- Gene silencing: Transcriptional gene silencing –Genomic imprinting, effect of paramutation, position effect, RNA directed DNA methylation, role of transposon silencing in gene expression. Post-translational gene silencing – RNA interference, Si and MiRNA mediated gene silencing, Anti-sense RNA technology. Gene silencing methods in plants – MIR-VIGS, MIGS
- Biosafety guidelines in rDNA technology- Role of IBSC, RCGM and GEAC in genetic engineering research and release of GMOs/LMOs

Suggested readings

1. Gene cloning and DNA analysis – An introduction. 7th Edition Wiley Blackwell 2016
2. Principles of Gene Manipulation and Genomics - Richard M Twyman and S. B. Primrose. 7th edition, Blackwell Publishing. 2006
3. Lewins Gene XII. J.E Krebs, E.S Goldstein, S.T Kilpatrick. 2018
4. Molecular Cloning- a Laboratory Manual- Joseph Sambrook and Russell (2002) 3rd edn., CSHL Press

GEN 5312: FUNCTIONAL GENOMICS (4, 0, 0, 4)

Unit 1: Genome organization, Prokaryotic and Eukaryotic genomes, Genome sizes, Chromosome organization, Anatomy of gene, Types of eukaryotic DNA, Genetic variation, non-coding RNAs

Unit 2: DNA as basic material for Functional Genomics? – Forward and Reverse Genetics, Linkage and Recombination, Mapping population, Linkage mapping, Biparental and Association mapping, Map-based cloning, TILLING, Gene cloning with NGS techniques

Unit 3: RNA as basic material for Functional Genomics? – Various role of Coding and Non-coding RNA, Application of cDNA-AFLP, cDNA Library, Microarray – case studies, RNA-Seq,

Unit 4: Protein as basic material for Functional Genomics? – DNA-Protein interaction,Protein-Protein interaction, Protein Docking, Chip-seq, Amino acid sequencing, Techniques

Unit 5: Metabolomics, Tools and Techniques to identify metabolomes, Combined omics concept in Functional genomics, Epigenetics, Bioinformatics software for Functional genomics

Suggested readings:

1. Functional Genomics- Chris Town (2002) Springer
2. Functional genomics: An introduction to EMBL-EBI resources - http://www.ebi.ac.uk/training/online/course/functional-genomics-introduction-embl-ebi-resource/what-functional-genomics/technologies-us-1
3. Bioinformatics and Functional Genomics, 3rd Edition - Jonathan Pevsner, 2015. Wiley-Blackwell
4. Functional Genomics. GermanaMeroni and Francesca Petrera, 2012. InTech publisher (Open access)
5. Reference books in University Library (631.523 GRE/P, 572.862 MEK/H, 572.8636 KOR/M, 572.86 yub/I, 572.862 ALO/p, 576.5 San/G, 572.8615 HUN/G, 616.96 MEL/p, 572.8636 BRO/F, 572.86 KHO/M1, 572.8636 MUL/M, 572.8633 BIN/G, 572.86293 ZHO/M, 572.82 TOW/F, 572.86 PEV/B)

GEN 5394: Lab in Molecular Biology & Genetic Engineering & (0, 3, 3, 1)

Molecular Biology:

- Isolation of plasmid DNA from bacterial culture and separation on Agarose gel electrophoresis.
- Isolation of total RNA from Mammalian cells and separation of RNA by formaldehyde/agarose gel electrophoresis.
- Western blotting techniques for protein expression studies
- Preparation of Competent cells

Genetic Engineering:

- Restriction digestion of plasmid- single and double digestion- determination of molecular weight- physical mapping.
- Cloning of gene of interest in appropriate vector- insertional inactivation/ Blue white selection.
- Isolation of plasmid from the recombinant clone, restriction digestion and agarose gel electrophoresis- confirmation of size by insert.
- IPTG induction of expression of cloned gene in E coli: SDS-PAGE.
- PCR amplification of DNA, RAPD/ISSR, gel electrophoresis- analysis of fragments- Finger printing analysis.
- cDNA synthesis, isolation of target cDNA using degenerate primers
- Gene expression analysis using SYBR green assay

Suggested Readings

1. A short course in bacterial genetics: a laboratory manual and handbook for E coli and related bacteria- Jeffrey H Muller, Cold Spring Harbor Laboratory Press, USA, 1992.
2. Experiments in molecular genetics- Jeffrey H Muller, Cold Spring Harbor Laboratory Press, USA, 1972.
3. Molecular cloning: a lab manual, 2nd edition- Sambrook J, Fritsch EF, Maniatis T, Cold Spring Harbor Laboratory Press, USA, 1989.

MSC-GENOMIC SCIENCE

ELECTIVE COURSES

GEN5001: IPR, NATIONAL BIODIVERSITY RULES & REGULATIONS (4, 0, 0, 4)

Intellectual Property Rights

Unit I. Types of Intellectual property (IP): Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology Agreements and Treaties History of GATT & post GATT scenario, TRIPS Agreement; Important International agreements

Unit II. Role of WIPO and WTO in the international scenario. Geographical indications of Goods- Recent examples in Indian scenario, Plant varieties and farmers right, undisclosed information

Unit III. Introduction to Patents; Indian Patent Act – an overview and its major amendments. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet (EPO), PATENT Scope (WIPO), IPO, etc.) National & PCT filing procedure; Precautions while patenting – disclosure/non-disclosure; Patent licensing and agreement Patent infringement meaning, scope, litigation, case studies

National Biodiversity rules and regulations

Unit IV. The Biological Diversity Act, 2002 and Biological Diversity Rules, 2004. Functions and powers of the National Biodiversity Authority. State Biodiversity Boards and their functions. Biodiversity Management Committees, Local Biodiversity fund.

Unit V. Procedure for access to biological resources and associated traditional knowledge, restriction on access, prior approval before seeking intellectual property protection, approval for transferring of results from bioresources collected from India, third party transfer of the approval granted, criteria for equitable benefit sharing on development of product/processes from bioresources / TK, case studies

Suggested readings

1. Intellectual Property and Development; Theory and Practice. Olwan, Rami M. Springer-Verlag Berlin Heidelberg. 2013

2. Intellectual Property Rights in Agricultural Biotechnology- Erbisch FH and Maredia KM (2004) CABI Publishing

3. The Biological Diversity ACT 2002 and Rules 2004. National Biodiversity Authority, India. 2015

GEN 5002: POPULATION GENETICS (2, 2, 0, 4)

1. Introduction to Population Genetics; Basic concepts and definitions, Origin of variation and Molecular Genetics, Mendelian Genetics, The Hardy-Weinberg Equilibrium

2. Phenotypic Diversity and Genetic variation, estimating genotype and allele frequencies, Measuring genetic diversity, Linkage disequilibrium and sex linkage, Changes in gene frequencies.

3. Genetic variation, Mutation, Gene flow and admixture, Natural selection, Migration, Genetic drift, Inbreeding and effective population size, Neutral theory, Selection and Selection Models, Hierarchical structure of populations (*F* statistics), Genetic distance, Population differentiation and Speciation, Phylogenetics. Microsatellite / Short tandam ewpeat (STR) Analysis, mtDNA analysis.

4. Introduction to Genomes, Sequencing Principles, Genome Sequencing Techniques and application, Comparison between classic sequencing and next generation sequencing.

Tutorials: Allele frequency, Genotype Frequency Estimation, data preparation for Analysis. Data Interpretation. Data Analysis using population genetic software's, Popgene, Arlequin, FSTAT Structure, Sequence Analysis Software MEGA/PAUP. Computer programs and trees, Distance trees, Parsimony & Maximum likelihood trees, Phylogenetics.

References:

1. Principles of Population Genetics, Fourth Edition Daniel L. Hartl and Andrew G. Clark. **2007.** 565 Pages,

2. Phylogenetic Trees Made Easy: A How-To Manual, Fourth Edition Barry G. Hall © 2011 282 pages

3. Molecular Evolution and Phylogenetics : Masatoshi Nei, Sudhir Kumar Oxford University Press Inc. **2000**. 348 pages

GEN 5003: Scientific communication & Research Methodology (3, 0, 3, 4)

Concept:

- To provide an introduction to popular science communication in the broader contexts of (a) the role of communication in science, and (b) the cultural, practical and policy-related role of science communication in wider society;
- To provide intellectual resources for constructive critical analysis of popular science communication in a variety of real-world settings;
- To cultivate students' practical communication skills, with particular emphasis on effective speaking, writing and exhibiting on scientific and science-related topics to a variety of audiences;
- To provide students with a range of resources and skills for effective communication of complex material;
- To provide students with the opportunity to undertake a substantial practical project in either science writing or science exhibiting.

Outcomes:

This class develops the abilities of students to communicate science effectively in a variety of real-world contexts. It covers strategies for dealing with areas like genomics, environmental science, plant and animal science, and addresses challenges in communicating about topics such as climate change and evolution. Projects focus on speaking and writing, being an expert witness, preparing briefings for policy-makers, writing blogs, and giving live interviews for broadcast, as well as the creation of an interactive exhibit for display in the CUK.

GEN 5004: STEM CELL BIOLOGY (3, 1, 0, 4)

UNIT I: Introduction

Concepts and principles of early developmental biology, Preimplantation development, Gastrulation (reorganization into germ layers) and cell-type specification, Regulators of transcription, Transcription Factors, Markers, Signalling pathways in early development

UNIT II: Types and basic concepts of Stem Cells: Adult Stem Cells, Embryonic Stem Cells, Induced Pluripotent Stem Cells, Important concepts, such as totipotency, pluripotency, states of pluripotency, chimera formation, lineage specification, plasticity, trans- differentiation, embyoid bodies, Recent research/advances

UNIT III: Gene editing, other technological advances and applications of Stem Cells: Single Cell genomics, Genomic methods, CRISPR-Cas9, Organoids, Tissue engineering and scaffolds, 3D printing, Bioreactors, Stems Cells for regenerative medicine, disease modeling, drug discovery, gene-correction and therapy, Personalized medicine/therapy, Recent research/advances

UNIT IV: Biological Literature and databases pertaining to Stem Cell and Developmental Biology

Discussion and critical analysis of a diverse range of research papers and databases. This unit will involve group discussions on the significance and hypothesis of the study, methods, critical analysis and interpretation of results. Active participation of students will involve formulation of future directions, design of experimental strategies and scientific writing.

GEN 5005: INFECTIOUS DISEASES (4, 0, 0, 4)

UNIT-I: Infection & Diseases: Infectious and non-infectious disease; Causative agents, prognosis and treatments: cholera, malaria, tuberculosis (TB), HIV/AIDS, smallpox and measles, smallpox (*Variola*) and measles (*Morbilli virus*), host response mechanism

UNIT-II: Antibiotics: The 'age of antibiotics'; Bactericidal and Bacteriostatic Antibiotics; Broad-spectrum and Narrow-spectrum Antibiotics; Antibiotics Classification; Mode of action and side effects of antibiotics; antibiotic resistance genes (ARGs) and antibiotic resistant bacteria (ARBs) are and the origins of ARGs (the resistome); Costs of antibiotic resistance

UNIT-III: Immunology: Overview of the immune system; Antigens and Antibodies; Specific and Non-Specific (Innate) Immunity; Antibody, Complement and Cell Mediated Immunity; Immunology of the gastrointestinal tract - Anatomical and chemical barriers to intruders; Antibodies as Drug

UNIT-IV: Disease control: Vaccination; Behavioral changes; culling; Multi-host pathogens; biodiversity and disease: the "dilution effect"; the ecology of emerging infectious diseases.

Textbooks and Resources:

- Kenrad E. Nelson & Carolyn Masters Williams. Infectious Disease Epidemiology: Theory and Practice. Second Edition. Jones and Bartlett Publishers, 2006
- Kilpatrick, A. M. and Altizer, S., **Disease Ecology**. Nature Education Knowledge1 (11), 13 (2010).
- Smith,et.al, **Ecological theory to enhance infectiousdisease control and public health policy** Frontiers in Ecology and the Environment3 (1), 29 (2005).
- Karlan, Arno. **Man and Microbes: Disease and Plagues in History and Modern Times** New York: Simon & Schuster, 1995.
- **Antibiotic Resistant Threats**, CDC 2013 http://www.cdc.gov/drugresistance/threat-report-2013/pdf/ar-threats-2013-508.pdf

GEN 5006: EPIGENETICS (4, 0, 0, 4)

UNIT I

Introduction and scope of epigenetics; concept of epigenetics; epigenetic code; epigenetic inheritance; epigenetics and environment; role of epigenetics in biological processes; DNA packaging and chromatin architecture; The nucleosome: chromatin's structural unit.

UNIT II

Histone post-translational modifications-Acetylation, methylation, phosphorylation, ubiquitination; epigenome; epi-mutation; Single Nucleosome Epi-Polymorphism; epimutation detection-Chromatin immunoprecipitation, ChiP-CHIP, ChiP-Seq.

UNIT III

DNA methylation-CpG island, mechanism of DNA methylation; Methylation and gene expression; DNA methylation detection-Methyl-Seq; genomic imprinting, imprinting mechanisms; genomic imprinting inorganisms.

UNIT IV

Epigenetic influences and disease-cancer, mental retardation, neuropsychiatric disease, autoimmunity, obesity, allergic and cardiovascular diseases; epigenetic therapy-perspectives and challenges in epigenetic therapy.

Suggested Readings

1. Turner BM (2001). Chromatin and Gene Regulation: Mechanisms in Epigenetics. Blackwell Science Ltd, Oxford, UK.

2. Allis CD, Jenuwein T, Reinberg D, Caparros M-L (2007). Epigenetics. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, USA.

3. Armstrong L (2013). Epigenetics, Garland Science, USA.

4. Tollefsbol T (2012). Epigenetics in Human Disease, Academic Press, USA.

GEN 5007: TRANSLATIONAL RESEARCH (4, 0, 0, 4)

Unit I. Translational molecular biology

gene mutations and diseases, basics of gene therapy, single gene recessive disorders, cystic fibrosis and gene therapy- a case study

Unit II. Ethics, rules and regulations in translational research

Basic ethical principles in translational research – regulations for clinical research, role of government agencies in drug/device development

Unit III. Translation of research to product

Translation of discovery in basic science to a marketable product- steps involved, stakeholders, impediments, platforms available in the national and international scenario, role of public-private- partnership including industry- academic programmes

Unit IV. Classification of drugs, comparison of drug development process. FDA vs Indian scenario. Issues on product development and commercialization in pharmaceutical industry, Factors affecting new product development

Unit V. Breach of contract, damages in pharmaceutical industry, Alternative methods for dispute settlement. Role of Arbitration in dispute settlement – Indian and global scenario. Amendments in Arbitration & Conciliation Act in 2015. Steps in Arbitration process, selection of arbitrator, venue and seat of arbitration, award of the arbitration tribunal, implementation of the award at the Indian and global scenario. Advantages of arbitration overlitigation.

Unit VI Case history

Development of cardiovascular device in the Indian scenario, development of single molecule entity as drug, development of drug formulation based on traditional or ethnomedicine

Suggested readings

1. Translational medicine and Drug discovery. Editors Bruce H. Littman & Rajesh Krishna. Cambridge University Press. 2011
2. Translational Research: Recent Progress and Future Directions. Francesco Chiappelli. Nova Science Publishers. 2019
3. Principles of Translational Science in Medicine. From Bench to Bedside. Ed. Martin Wehling. Academic Press. 2015

GEN 5008: EVOLUTIONARY BIOLOGY (2, 2, 0, 4)

What is evolution, Evolutionary processes: Mutation, recombination; History of Life: Origin of Life

Human Evolution, Phylogenetic Analysis – Evidence for Evolution, The Fossil Record, Ancient DNA studies

The Evolution of Biodiversity, Adaptive Radiation, Genetic Variation, Evolution through genetic drift, Natural Selection, Genetics of Natural Selection

The Evolution of Phenotypic Plasticity, Process of Speciation, Life History Adaptations and Sexual Selection

Evolution of Genomes

Tutorial sessions: observation of different specimens and tracing their evolutionary histories. Appreciation for Evolution: Video Critique and Various Exercise and Calculations from various educational videos from NOVA Foundation, National Geographic, Science etc

Molecular Evolution and Phylogenetics : Masatoshi Nei, Sudhir Kumar Oxford University Press Inc. **2000**. 348 pages

GEN 5009: PLANT GENOMICS (2, 0, 0, 2)

- Plant Genome concept & genomics
- Plant whole genome sequences: Arabidopsis, Rice, Wheat, Maize, Sorghum, Pulses, Medicinal plants
- Transcriptomic studies of wheat
- Metabolomics
- Identification of candidate genes using genetic information
- Characterization and functional analysis of candidate genes
- Comparative plant genomes: Tools and application
- Bioinformatics tools and resources for plant genome study

GEN5010: MICROBIAL GENOMICS (3, 0, 0, 3)

Unit-I: Introduction to Microbial Genomics: History and Introduction to Genomics, Microbial genomics. Introduction to Omics sciences. Microbial Genomes-Size, number, structure/topology, organization and complexity of microbial genomes. Architecture of organelle genome, genome islands, pseudogene, genome duplications/Ploidy, Microbial Genetics, Gene transfer-vertical and horizontal, Microbial evolution, speciation.

Unit-II: Methods of genome analysis: Types of gene map: Genetic and physical and restriction site mapping. Genomic finger printing. Genome sequencing: Different methods, high-throughput sequencing, next generation DNA sequencing technologies. Gene identification. Microarrays and DNA chips. Gene expression analysis Up and down regulation, identification of unknown genes.

Unit-III: Microbial Diversity & Metagenomics: Microbial communities: culture and culture independent approach, 16S rRNA analysis in community profiling. 16S rRNA based survey, functional/sequence based analysis. Phylogenetics & phylogenomics. Genomic features of *Escherichia coli*, *Sachharomycess cereviciae*, *Aspergillus fumigatus*, Bacteriophage, *Chlamydomonas reinhardtii*, *Caenorhabditis elegans*.

Unit-IV: Microbial genome data resources: Microbial genome data lifecycle, databases services. Comparative genomics, whole genome alignment, lateral gene transfer, online tools to analyze genome sequences NCBI, IMG and IMG/M, DMAS, MBGD, CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis, GOLD™ Genomes OnLine Database, CMR, MaGe.

Textbooks and Resources:

- Microbial genomes By Claire M. Fraser, Timothy D. Read, Karen E. Nelson Humana Press
- Bacterial genomes: physical structure and analysis. By Frans J. de Bruijn, James R. Lupski, George M. Weinstock.
- Microbial evolution: gene establishment, survival, and exchange By Robert Verne Miller, Martin J. Day
- Genome analysis: a laboratory manual, Volume 2 edited by Eric D. Green
- Next-generation genome sequencing: towards personalized medicine, By Michal Janitz
- Young, P. (2008). Exploring genomes: Web-based bioinformatics tutorials. New York, W. H. Freeman and Company.
- Microbial Functional Genomics. Jizhong Zhou, Dorothea K. Thompson, Ying Xu, James M. Tiedje. John Wiley & Sons, Inc. 2004.
- Next generation DNA sequencing, Nature Publishing Group, 2008.

GEN 5011: CONSERVATION GENETICS (4, 0, 0, 4)

UNIT I

Introduction to conservation genetics; definition of species, population and community; IUCN Classification- threatened, endangered and extinct species; biodiversity and its importance; Indian biodiversity hot-spots; factors affecting biodiversity; threats to biodiversity; exotic species-impact on biodiversity

UNIT II

Basics of population genetics and evolution; Hardy-Weinberg equilibrium and mutation, migration, gene flow, natural selection, genetic drift, inbreeding; genetic consequences of small population size and extinction.

UNIT III

Genetic diversity; origin of genetic diversity; DNA markers and its types; assessment of genetic diversity using DNA markers; DNA barcodes- role of DNA barcoding in biodiversity assessment; conserving genetic diversity in declining populations, eDNA.

UNIT IV

Ex-situ & *in-situ* conservation; wildlife parks; wildlife reserves & biosphere reserves; conservation breeding; genetic monitoring and management of wild and captive populations; DNA markers and identification of "units of conservation" in natural populations; use of molecular genetics in wildlife forensics.

Suggested Readings

1. Frankham R, Ballou JD, Briscoe DA, McInnes KH (2012). Introduction to Conservation Genetics. Cambridge University Press, UK.
2. Frankham R, Ballou JD, Briscoe DA, McInnes KH (2012). Primer of Conservation Genetics. Cambridge University Press, UK.
3. Allendorf FW, Luikart GH, Aitken SN (2012). Conservation and the Genetics of Populations. Wiley-Blackwell, USA.
4. Hartl DL (2006). Principles of Population Genetics Sinauer Associates is an imprint of Oxford University Press, UK.

GEN 5012: Basic Bioinformatics (2, 2, 0, 4)

Introduction to Basic Genetics, Mendelian Genetics and Population genetics, Genes, Genomes, Introduction to computers- hardware, software, operating systems, UNIXoperating system, languages for Bioinformatics

Databases and major web resources for Bioinformatics, Sequence file formats and sequence databases- DNA sequence databases, Proteomic databases,

Sequence analysis: Principles of BLAST, FASTA, PSI-BLAST, BLASTX, TBLAST, TBLASTX algorithms, Homology modelling,

Sequence Alignments: Pair wise sequence alignment- similarity, homology and analogy, Global and local alignment, gap penalty, weight matrices, PAM and Blossom Matrix. Multiple alignments- CLUSTALW, MUSCLE sequence alignments

Phylogenetic Analysis: Phylogenetic trees- introduction, molecular clock, Methods of constructing Phylogenetic trees, Neighbour Joining method, maximum parsimony method, Maximum Likelihood methods, Bootstrapping, Phylogenetic softwares. Phylip MEGA, PAUP.

Tutorials

Basic sequence handling; B. Gene Prediction using software's, Study of Biological data bases, BLAST, Sequence alignment, Analysis using MEGA/PAUP/Phylip, ORF & Gene finding etc.

Suggested Readings

1. Introduction to Bioinformatics: A theoretical and practical approaches- S.A. Krawetzt, D.D. Womble, Human Press.
2. Bioinformatics: sequence and genome analysis- D.W.Mount, CSH lab press.

GEN 5013: PHARMACOGENOMICS (2, 0, 0, 2)

Unit-I: Introduction to pharmacogenomics: Pharmacogenomics: Historical perspectives and current status. Research benefits and practical applications, leading topersonalized medicine. The role of genetic Polymorphism in Metabolic Reactions. CYP gene variation leading to variable metabolism of drugs, distribution of genetic variation, in ethnic and racial groups. Clinical pharmacology, drugs, drugs legislationand safety, drug potency and efficacy and toxicity, drug absorption, drugdistribution, drug metabolism and drug excretion, drug therapeutic levels, therapeuticindex.

Unit-II: Functional analysis of gene variation and Genotyping techniques: Genome- Wide Analysis of Allele-Specific Gene Expression Using Oligo Microarrays, Roche Ampli Chip, HaploChIP*In Vivo* Assays. Genotyping methods, Denaturing HPLC, Pyrosequencing, Kinetic Fluorescence-Quenching Assay for Allele Frequency Estimation, MALDI–TOF, Mass Spectrometry, Fluorescence-Based Fragment Size Analysis,

Unit-III: Pharmacogenomics and personalized medicine: Pharmacogenomics in Cardiovascular Diseases, Pharmacogenomics in Cancer treatment,Pharmacogenomics in Neurodegenerative Diseases, Pharmacogenomics in Depression treatment, Pharmacogenomics in Respiratory diseases, Pharmacogenomics in AIDS, Pharmacogenomics in Antibiotics.

Textbooks and Resources:

- **Pharmacogenomics: Methods and Protocols** (Methods in Molecular Biology) First Edition (2005) Federico Innocenti, Humana Press Inc, New Jersey, USA.
- **Pharmacogenomics and Personalized Medicine** (Methods in Pharmacology and Toxicology) First Edition (2005) Nadine Cohen, Humana Press Inc, New Jersey, USA.
- **Pharmacogenomics:** Applications to Patient CareAmerican College of Clinical Pharmacy
- (2004).
- **An A-Z Guide to Pharmacogenomics**, First Edition (2006) M.C. Catania, Published by American Association for Clinical Chemistry
- **Pharmacogenomics: Social, Ethical, and Clinical Dimensions**, First Edition (2003) Mark A. Rothstein, Wiley-Liss Publications.
- Evans, W.E., Relling, M.V. Moving towards individualized medicine with pharmacogenomics. Nature 429 (6990), 464-8, 2004
- Stearns, V., et al. Pharmacogenetics in breast cancer treatment. Pharmacogenomics Journal 4: 143-153, 2004.

GEN 5014: METABOLIC PROCESS AND ENGINEERING (2, 0, 0, 2)

Link between primary and secondary metabolism, derivation of primary and secondary metabolites from carbon metabolism, highlights of pentose phosphate pathway, glycolysis, TCA

Classification of secondary metabolites, alkaloid biosynthesis- metabolism and trafficking, terpenoid synthesis, structure and dynamics of isoprenoid pathway network, cross talk between MVA and MEP pathway, rate limiting steps, application of metabolite inhibitors in pathway analysis

Polyketide pathway, classification of polyketide enzymes, molecular mechanism of structural and functional diversity in plant polyketides, biosynthesis of anthraquinones- role of alternate pathway, biosynthesis of aromatic compounds, shikimic acid pathway, acetate hypothesis, biosynthesis of amino acids, glycosides, saponins

Identification of targets for metabolic engineering, elicitation as tool for identification of differentially expressed genes in metabolite production, engineering multifunctional enzyme system for optimal conversion, multi-scale approaches for predictive modelling of metabolic regulation, case studies in metabolic engineering

Suggested reading

Plant Secondary Metabolites: Occurrence, Structure and Role in the Human Diet. Editor(s): Alan Crozier Michael N. Clifford Hiroshi Ashihara. Blackwell Publishing Ltd. 2006

Plant Secondary Metabolism Engineering Methods and Applications Editors: Fett-Neto, Arthur Germano (Ed.). Humana Press. 2010

Metabolic Engineering of Plant Secondary Metabolism. R. Verpoorte & A.W. Alfermann. Kluwer Academic Publishers. 2000

GEN 5015: METAGENOMICS (2, 0, 0, 2)

UNIT-I: Introduction: - From genomics to metagenomics, history of the culture divide, 16S rRNA analysis and culturing, culture independent insight, why genomics is not enough, global impact of metagenomics; next generation of DNA sequencing technologies and potential challenges, the developments and impact of 454 and illumines next generation sequencing.

UNIT-II: Approaches to metagenomics analysis:-16S rRNA based survey, 16S rRNA – microarray (phylochip), sequence base analysis, functional based analysis, heterologous expression, identifying active clones- clone screens, selection and functional anchors, identifying habitats and collecting metadata, gene expression system, single cell analysis; data management and bioinformatics challenges of metagenomics -genomics data, metagenomics data, the importance of metadata, databases for metagenomics data, software, analysis of metagenomics sequence data.

UNIT-III: Pioneering projects in metagenomics:-The acid mine drainage project, the Sargasso sea metagenomics survey and community profiling, the soil-resistome project, the human-micro biome project, viral metagenomics, large scale sequencing of mammoth DNA; metagenomics of gut: insects, mouse and human beings.

UNIT-IV: Ecological inference from metagenomics:-Symbiosis, competition and communication; the metagenomics of soil and soil health; microbial community-genomics in ocean; application of metagenomics - technical advancement in the field, application and expected benefits from large scale metagenomics data, application in human health, industry and environment remediation.

Textbooks and Resources:

1. **The New Science of Metagenomics: Revealing the secrets of our microbial planet**, Academic press, Washington DC, USA
2. **Metagenomics:** Sequence from the Environment, NCBI
3. Next generation DNA sequencing, Nature Publishing Group, (Vol. 26 No.10, Oct, 2008)
4. **Metagenomics-Sequences from the Environment**, National Center for Biotechnology Information (US); 2006.
5. **The New Science of Metagenomics**: Revealing the secrets of our microbial planet, Academic press, Washington DC, USA.

GEN 5016: CANCER GENOMICS (2, 0, 0, 2)

Unit-I: General Principles, Role in cancers of the Breast, thyroid, prostate, kidney etc. Complications and their management, cancer education and oncology organization, psychosocial aspects of cancer and Rehabilitation.

Unit-II: Causes of cancer. Cancer related genes, including oncogenes and tumor suppressor genes; their normal cellular function, mutagenesis and consequences of their mutant state in cancer. Hereditary cancer. The major treatment principles of cancer (surgery, radiotherapy, hormonal treatment, and biological therapy).

Unit-III: Diagnosis, molecular sub-classification, aggressiveness (prognosis)characterization of metastases, Genomic testing of cell free tumour DNA in blood, for diagnosis and monitoring of solid cancers, Importance of sample quality for tumour genomic analysis, Environmental factor and lifestyle predisposition and protection; molecular action; genomic interaction; epigenetic factors.

Unit-IV: Genomic and cellular markers and optimal treatment regimes: in hematological cancer, in solid tumours. Companion diagnostics in cancer, Breakthrough tumour /metastases and molecular mechanisms.DNA chips, automation, gene therapy; applications in diagnosis of genetic disorders, ethical considerations

Unit-V: Metastasis: Micro-metastasis, and cancer dormancy Pre-metastatic niche and organ-specific metastasis, Key signaling pathways in tumor metastasis; regulation of tumor metastasis

Textbooks and Resources:

- Weinberg, Robert *A.*"The biology of cancer" Taylor & Francis, cop. 2007 - xix, 796, 4, 20, 24 s. ISBN:0-8153-4076-1
- Vieira and Gamarra (2016)Advances in the use of nanocarriers for cancer diagnosis and treatment. Einstein vol.14 no.1 Jan./Mar. 2016
- Genetics & Genomics in Medicine: Strachan, Goodship and Chinnery
- Garland Science (1st Ed, 2014): ISBN: 9780815344803
- A Practical Guide to Human Cancer Genetics: Hodgson, Foulkes, Eng, and MaherISBN: 978-1-4471-2374-3 (Print) 978-1-4471-2375-0
- Weinberg, R.A. (2013), The Biology of Cancer, Garland Science

GEN 5017: MOLECULAR BIOPHYSICS

Unit-I: Molecular hierarchy: Basic concepts on structural origin for macro-molecules, Hierarchy in cell structure (single to supra molecular structures), Building blocks in biological system, Molecules geometrics, Hydrogen bonding between bases.

Unit-II: Nucleic acids and structural organization: A-DNA, B-DNA, C-DNA conformation, Triple helix of DNA-DNA denaturation and renaturation, DNA-RNA hybrids, Z-DNA formation

Unit-III: RNA Structure: RNA double helices, RNA triple helices, Watson-Crick and Hoogsteen base pairing.

Unit-IV: Basic structural principles of proteins: Building blocks of proteins, Peptide bond, Ramachandran plot, Protein folding, Motifs of protein structure, Alpha domain structures, alpha and beta structures, anti-parallel beta structures.

Unit-V: Biophysical techniques: Basic principles of UV-Vis and Nano spectroscopy, Chromatography, PAGE, HPLC, NMR, and Mass spectrometry, X-RD, Circular Dichroism (CD) and RT-PCR techniques, limitations and precautions.

Recommended Books:

1. Subramanian MA (2005) Biophysics-Principles and Techniques- MJP Publishers, Chennai
2. Keith Wilson & John Walker, (2010), Principles and Techniques of Biochemistry and Molecular Biology, ed., Cambridge Univ. Press.
3. M. B. Jackson (2006) "Molecular and Cellular Biophysics" Cambridge U. Press, (abbr: MJB) (ISBN 0-521-62470-3)
4. Handbook of Molecular Biophysics (Methods & Application), 2009, HG Bohr, Wiley
5. Principles and techniques of practical Biochemistry- Keith Wilson, John Warker.
6. Principal of Protein Structure, GE Schulz, RH Schirmer (2004), Springer
7. Biophysical Chemistry, The Behaviour of biological macromolecules, Vol I,II, III, Cantor and Schimel, (2008), W H Freeman & Co

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