St. Xavier's College (Autonomous) Mumbai

M.Sc. Syllabus For 2nd Semester Courses in Microbiology (June 2018 onwards)

Contents:

Title: CELL BIOLOGY: STRUCTURE, TRANSPORT, AND JUNCTIONS
Course: SMIC0801

LEARNING OBJECTIVES

1. Understand the origin of cellular life and basic cell structure.
2. Understand the structure and function of the cell membrane
3. Understand the protein transport within cells
4. Understand the role of cellular structures involved in cytoskeleton and cell junctions.

Number of lectures: 60

UNIT 1: ORIGIN OF CELLULAR LIFE AND BASICS OF CELL BIOLOGY
15 LECTURES

LEARNING OBJECTIVES

1. Understand the origin of organic molecules, prokaryotic and eukaryotic cells
2. Understand the structure of cells and cell organelles.
3. Understand the use of microscopy in cell biology

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1. Origin of cellular life **5L**

- Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers
- The first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes**.**

2. Overview of cell and cell organelles **5L**

3. Cell study - microscopy **5L**

- Confocal microscopy
- Electron microscopy.
- Atomic force microscopy
- TIRF microscopy

UNIT 2: MEMBRANE STRUCTURE AND TRANSPORT 15 LECTURES

LEARNING OBJECTIVES

1. Understand the structure of the Cell membrane
2. Understand the transport function of the membrane

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1. Cell membrane structure **7L**

- Lipid bilayer
- Membrane proteins
- RBC membrane as an example of membrane

- Multipass membrane proteins
- Bacteriorhodopsin

2. Membrane Transport **8L**

- Principles of membrane transport
- Transporters and Active Membrane Transport
- Ion channels
- Electrical properties of membranes with examples.

UNIT 3: INTRACELLULAR TRAFFIC **15 LECTURES**

LEARNING OBJECTIVES

Understand protein sorting and trafficking in cells

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1. Intracellular Compartments and protein sorting **9L**

- Compartmentalization of cells
- Transport of molecules between the nucleus and cytosol
- Transport of proteins into mitochondria and chloroplasts
- Peroxisomes
- Endoplasmic reticulum

2. Intracellular vesicular traffic **6L**

- Endocytosis
- Exocytosis
- Transport from the ER through the Golgi apparatus

UNIT 4: CYTOSKELETON AND CELL JUNCTIONS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the structure and function of the cytoskeletal filaments
2. Study aspects of cell junctions and cell adhesion

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1. Cytoskeleton **8L**

- Cytoskeletal filaments
- Microtubules
- Microfilaments, Actin regulation
- Intermediate filaments
- Molecular motors
- Cell behavior

2. Cell Junctions and Cell adhesion **7L**

- Extracellular matrix (ECM): components and ECM examples - Basal lamina and connective tissue ECM

- Types of cell-ECM junctions
    i. Focal adhesions
    ii. Hemidesmosomes
- Types of cell-cell junction
    i. Adherens junction
    ii. Desmosomes
    iii. Tight junction
    iv. Gap junction
- Cell-cell junctions in plants - plasmodesmata

CIA: Test, Assignment

References:-

Unit 1 to 4

1. Cell biology, Gerald Karp, 6th ed., 2010, Wiley
2. Molecular Biology of the Cell – Alberts, B.; Johnson, A.; Lewis, J.; Raff, M.; Roberts K. & Walter P., 6th ed., 2015, Garland Science, Taylor & Francis Group
3. The Cell: A Molecular Approach, Cooper,G., Hausman, R., 5th ed., 2009, ASM Press

Title: GENETICS AND BIOINFORMATICS **Course: SMIC0802**

LEARNING OBJECTIVES

1. Understand the tools available for molecular biology
2. Understand the concepts of population genetics
3. Understand the applications of genetic technology and the ethics involved
4. Understand the use of bioinformatics for biological data analysis

Number of lectures: 60

UNIT 1: MOLECULAR TOOLS FOR GENETICS **15 LECTURES**

LEARNING OBJECTIVES

Understand the significance of molecular tools used in recombinant DNA techniques

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1. Molecular tools for genetics **9L**

- Labeled tracers (autoradiography, phosphorimaging, liquid scintillation counting, non-radioactive tracers)
- Overview of Nucleic acid hybridization, *In situ* hybridization, DNA sequencing, Restriction mapping
- Mapping and quantifying transcripts (S1 mapping, primer extension, run-off transcription)
- Measuring transcription rates *in vivo* (nuclear run-on transcription, reporter gene transcription), Assaying DNA-protein interactions (filter binding, gel mobility shift, DNase and DMS footprinting, knockouts)
- Aptamers: molecular tools for analytical applications

2. Rational Mutagenesis **4L**

- Oligonucleotide-directed mutagenesis - with M13
- Oligonucleotide-directed mutagenesis - with plasmid DNA
- PCR amplified oligonucleotide-directed mutagenesis
- Random mutagenesis - with a degenerate oligonucleotide primer
- Random mutagenesis - with nucleotide analogues
- Error-prone PCR
- DNA shuffling
- Mutant proteins with unusual amino acids

3. Modifications of PCR **2L**

- PCR
  Hot- Start, Multiplex, Nested, RT-PCR, Broad Range, arbitrarily primed, Quantitative, Real-time

UNIT 2: POPULATION GENETICS 15 LECTURES

LEARNING OBJECTIVES

1. Understand the concepts involved in population genetics and epigenetics
2. Learn the application and analysis based on concepts of population genetics

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1. Population genetics 7L

- Population and gene pool
- Genotypic and allelic frequencies
- Calculation of genotypic frequencies and allelic frequencies for autosomal and X linked loci
- Problems - calculation of allelic and genotypic frequencies
- Hardy-Weinberg Law, genotypic frequencies at HWE
- Implications of the H-W Law
- H-W proportions for multiple alleles
- X-linked alleles
- Testing for H-W proportions and problems
- Genetic ill effects of in-breeding
- Changes in the genetic structure of populations
    i. Mutation
    ii. Migration and gene flow
    iii. Genetic drift
    iv. Natural selection
    v. Simple problems based on the natural forces

2. Epigenetics 8L

- The Nucleosome: Chromatin's structural unit
- Higher order chromatin structure
- Histone: Modifications and epigenetic information
- Chromatin remodelling
- Silencing of gene expression
- Genomic imprinting, Dosage compensation

UNIT 3: APPLICATIONS AND ETHICS OF GENETIC TECHNOLOGY 15 LECTURES

LEARNING OBJECTIVES:

1. Understand molecular mapping of human genes
2. Understand diagnosis and therapy of genetic disorders
3. Understand concepts of recombinant DNA technology
4. Understand the ethical issues concerning the use of recombinant DNA technology

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1. Mapping Human Genes at the Molecular Level 2L

- RFLPs as genetic markers
- Linkage analysis using RFLP - Huntington's diseases, Cystic fibrosis

- Positional Cloning: The gene for neurofibromatosis
- The Candidate Gene Approach: The gene for Marfan Syndrome
- Fluorescent in Situ Hybridization (FISH) gene mapping

2. Genetic Disorders: Diagnosis and Screening **3L**

- Prenatal genotyping for mutations in the β-globin gene
- Prenatal diagnosis of sickle-cell anemia
- Single nucleotide polymorphisms and genetic screening
- DNA microarrays and genetic screening

3. Treating Disorders with Gene Therapy **4L**

- Gene therapy for Severe Combined Immunodeficiency (SCID) - Overview
- Problems and failures in gene therapy
- The future of gene therapy: new vectors and target-cell strategies
- Ethical issues of gene therapy

4. DNA Fingerprints **2L**

- Minisatellites (VNTRs) and microsatellites (STRs)
- Forensic applications of DNA fingerprints

5. The Human Genome Project **2L**

- An overview
- The Ethical, Legal, and Social Implications (ELSI) Program

6. Pharmacogenetics and toxicogenomics **2L**

UNIT 4: BIOINFORMATICS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand and access various types of data relating to molecular biology available on internet portal
2. Understand the concept of sequence alignment of biological macromolecules

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1. Study of biological databases with examples **3L**

- Types of databases
    i. Primary
    ii. Secondary
    iii. Sequence
    iv. Structure
    v. Metabolic (KEGG)
- Biological data retrieval
- Study of data formats

2. Nucleotide sequence analysis **6L**

- Pairwise alignment and scoring matrices
- Multiple sequence alignment
- Phylogenetic analysis
- Sequence logo (WebLogo) and consensus sequences
- Analysis of plasmids and other vectors using a software

3. Protein analysis **4L**

- Using 3D structure viewers (Rasmol, PDB)
- CATH and SCOP classification

4. Reference management software **2L**

- Making a reference library
- Adding references from the library into a word document

CIA: Test, Assignment

References:

Unit 1:

1. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd
2. Genetics: A Conceptual Approach, Benjamin Pierce 6th ed. , 2017, W. H. Freeman & Co
3. Molecular Biology, R. F. Weaver, 5th ed.,2011 McGraw-Hill
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R. Glick, Jack J. Pasternak, 4th ed., (2010), ASM Press
5. Principals of Genetics, Snustad & Simmons, 6th ed., 2012, John Wiley & Sons Inc
6. Recombinant DNA, J.D. Watson, 2nd ed., 1992, Scientific American Books
7. Lakhin, A. V., Tarantul, V. Z., & Gening, L. V. (2013). Aptamers: problems, solutions,and prospects. Acta Naturae, 5(4 (19)).
8. Mairal, T., Özalp, V. C., Sánchez, P. L., Mir, M., Katakis, I., & O'Sullivan, C. K. (2008). Aptamers: molecular tools for analytical applications. Analytical and bioanalytical chemistry, 390(4), 989-1007.

Unit 2:

1. Chromatin and Gene Regulation Mechanisms in Epigenetics, Bryan M. Turner, 2001 Blackwell Science.
2. iGenetics, A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International Ed.
3. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, 5th ed., 2007, Pearson Education
4. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, 7th ed., 2013, Pearson Education
5. The Concept of Genetics, William S. Klug & Michael R. Cummings, 7th ed., 2007, Pearson Education

Unit 3:

1. iGenetics, A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International Ed.
2. Recombinant DNA, J.D. Watson, 2nd ed., 1992, Scientific American Books
3. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd

Unit 4:

1. Bioinformatics and Functional Genomics, Pevsner J., May 2009, Wiley-Blackwell
2. Essential Bioinformatics, Jin Xiong, 1st ed., 2007, Cambridge University Press
3. Introduction to Bioinformatics, Attwood T.K., Parry-Smith D.J., Phukan Samiron, Pearson Education 2007

Title: MICROBIAL BIOCHEMISTRY II **Course: SMIC0803**

LEARNING OBJECTIVES

1. Understand various methods of analytical biochemistry
2. Understand enzyme kinetics, regulation and mechanism of enzyme action
3. Understand the metabolism of one and two carbon compounds
4. Understand the biosynthesis of macromolecules

Number of lectures: 60

UNIT 1: ANALYTICAL BIOCHEMISTRY 15 LECTURES

LEARNING OBJECTIVES

Study the purification techniques and analytical methods for biomolecules

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Extraction, purification and analysis of proteins, carbohydrates and lipids 15L

- General methods of extraction
- Purification methods and determination of purity (based on Solubility, Molecular weight, Charge): pH, Salting out, solvent precipitation, molecular exclusion chromatography, PAGE, SDS-PAGE, western blotting, Ion exchange , chromatography, isolelectric focussing, 2-D gel electrophoresis, Affinity chromatography, Dye ligand chromatography
- Qualitative and quantitative analysis of carbohydrates and lipids

UNIT 2: ENZYMOLOGY 15 LECTURES

LEARNING OBJECTIVES

1. Understand the basic aspects of enzyme kinetics
2. Study the regulation of enzymes with specific examples
3. Study the catalytical mechanism of action of enzymes.

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1. Enzyme kinetics 6L

- Kinetics of one substrate reactions
    i. Equilibrium assumptions
    ii. Steady state assumptions
    iii. Lineweaver-Burk, Hanes-Woolf, Eadie-Hofstee equations and plots
- Kinetics of enzyme inhibition.
  Competitive, non-competitive and uncompetitive inhibition
- Effect of changes in pH and temperature on enzyme catalysed reaction
- Kinetics of two substrate reactions
- Pre steady state kinetics
- Kinetics of immobilized enzymes
- Problem solving

2. Enzyme catalysis **6L**

- Catalytic mechanisms with type examples, catalytic mechanisms and testing - Serine proteases and Lysozyme
- Problem solving.

3. Enzyme regulation **3L**

- Allosteric enzyme - general properties, Hill, MWC and KNF models.
- Covalent modification by various mechanisms.
- Regulation by proteolytic cleavage - blood coagulation cascade.
- Regulation of multi-enzyme complex- Pyruvate dehydrogenase
- HIV enzyme inhibitors and drug design
- Problem solving

UNIT 3: METABOLISM OF ONE AND TWO CARBON COMPOUNDS

15 LECTURES

LEARNING OBJECTIVES

Understand the metabolism of one and two carbon compounds

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1. Metabolism of one carbon compounds **11L**

- **Methylotrophs**
  i. Oxidation of methane, methanol, methylamines
  ii. Carbon assimilation in methylotrophic bacteria and yeasts
- **Methanogens**
  i. Methanogenesis from H_2, CO_2, CH_3OH, HCOOH, methylamines
  ii. Energy coupling and biosynthesis in methanogenic bacteria
- **Acetogens**
  Autotrophic pathway of acetate synthesis and CO_2 fixation
- **Carboxidotrophs**
  Biochemistry of chemolithoautotrophic metabolism
- **Cynogens and cynotrophs**
  Cynogenesis and cyanide degradation

2. Metabolism of two-carbon compounds **4L**

- **Acetate**
  i. TCA and Glyoxylate cycle, modified citric acid cycle
  ii. Carbon monoxide dehydrogenase pathway and disproportionation to methane
- **Ethanol**
  Acetic acid bacteria
- **Glyoxylate and glycolate**
  i. Dicarboxylic acid cycle
  ii. Glycerate pathway
  iii. Beta hydroxyaspartate pathway

- **Oxalate as carbon and energy source**

UNIT 4: OVERVIEW OF METABOLISM 15 LECTURES

LEARNING OBJECTIVES

1. Understand the catabolism and anabolism of carbohydrates, amino acids, ribonucleotides and fatty acids
2. Understand the interrelation of metabolic pathways

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1. Metabolism of carbohydrates 8L

- Glycolysis
- TCA cycle
- Gluconeogenesis
- Pentose phosphate pathways
- Tracer studies
- Metabolic regulation
- Metabolic pathway analysis: quantitative aspects

2. Biosynthesis of ribonucleotides and deoxyribonucleotides 3L

- The de novo pathway
- Regulation by feedback mechanisms
- Recycling via the salvage pathway

3. Amino acid degradation and biosynthesis (revision) 2L

4. Lipid degradation and biosynthesis (revision) 2L

CIA: Tests

References: -

Unit 1

1. Principles of Biochemistry, Horton, R. and Moran, L., 5th ed., 2011, Prentice Hall
2. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
3. Principles of Biochemistry, Zubay, G., 4th ed., 1998, Wm.C. Brown Publishers

Unit 2

1. Biochemistry, Berg J.M.,Tymoczko J.L. and Stryer L., 7th ed.,2012, W. H. Freeman and co.
2. Biochemistry, Voet D. and Voet J.G.,4th International student ed.,2011, John Wiley and sons.
3. Biochemistry- A Problem Approach, Wood W. B. Wilson J.H., Benbow R.M. and Hood L.E.2nd ed.,1981, The Benjamin/ Cummings Pub.co.
4. Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons

5. Fundamentals of Enzymology, Price N.C. and Stevens L. 3rd ed.,1999, Oxford University Press.
6. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
7. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 7th ed., 2017, WH Freeman and company, NY.

Unit 3

1. Bacterial metabolism, Gottschalk, G., 2nd ed., 1985, Springer-Verlag
2. Biotechnology: The biological principles, Trevan M. D., Boffey S., Goulding K. H., Stanbury P., 1998, Tata MacGraw-Hill, 8th reprint.
3. The physiology and biochemistry of prokaryotes, White D., Drummond, T. J., and Fuqua C., 4th ed., 2007, Oxford University Press

Unit 4

1. Biochemistry, Voet D. and Voet J.G.,4th International student ed., 2011, John Wiley and Sons.
2. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
3. Lehninger Principles of Biochemistry, Nelson DL, Cox MM, 7th ed,, 2017, WH Freeman and company, NY.

Title: RESEARCH METHODOLOGY AND BIOSTATS Course: SMIC0804

LEARNING OBJECTIVES

1. Understand the overall process of designing a research study from its inception to its report.
2. Be able to distinguish between the writing structure used for a quantitative study and one used for a qualitative study.
3. Know the different conventions for scholarly/ report writing

Number of lectures: 60

UNIT 1: RESEARCH FUNDAMENTALS, TERMINOLOGY AND REPORT WRITING 15 LECTURES

LEARNING OBJECTIVES

1. To know how to identify a research problem
2. Understand importance of educational research
3. Understand basics of research design

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1. Meaning and Objective of research 2L

- Features of a good research study
- Scientific method

2. Study designs and variations 8L

- Basic, applied, historical, exploratory, experimental, ex-post-facto
- Case study, diagnostic research
- Crossover design, case control design, cohort study design, multifactorial design

3. Report writing and presentation 5L

- Types of research reports, guidelines for writing a report, report format, appendices
- Miscellaneous information
- Poster and oral presentations (use of software)
- Project proposal

UNIT 2: DEFINING A RESEARCH PROBLEM, DATA COLLECTION AND DATA ANALYSIS15 LECTURES

LEARNING OBJECTIVES

1. Understand concepts of quantitative and qualitative data collection
2. Understand how to analyze data

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1. Hypothesis, theory and scientific law 2L

- Difference between hypothesis, theory and scientific law
- Formulation of hypothesis

2. Methods and techniques of data collection **7L**

- Types of data
- Methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/ pilot study)
- Methods of secondary data collection (internal/ external), schedule method
- Use of computers in data collection- Literature survey using web, handling search engines

3. Experimental data collection and data processing **4L**

- Processing operations, problems in processing
- Elements of analysis in data processing

4. Introduction to design of experiments **2L**

UNIT 3: BIOSTATISTICS: INTRODUCTION AND PARAMETRIC TESTS

15 LECTURES

LEARNING OBJECTIVES

1. Understand sampling, types of data and distribution of data
2. Understand how to conduct a statistical test of a hypothesis.
3. Understand how to apply tests for comparison of one, two or multiple means for normally distributed data

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1. Sampling, Sampling Distributions & Sampling Errors **2L**

- Simple random sampling, systematic sampling, stratified random sampling, cluster sampling
- Non random sampling
- Sampling Errors

2. Types of data and distribution **3L**

- Nominal, ordinal, interval and ratio scale
- Continuous and discrete data
- Skewness and Kutosis
- Normal distribution- Box plot

3. Test of Significance **3L**

- Null Hypothesis, Alternate Hypothesis, Type I & Type II errors
- Level of Significance, one tailed & two tailed test
- Concept of Standard error

5. Comparison of means of one or two samples **4L**

- t test
- z test
- test for homogeneity of variance

6. Comparison of means of 3 or more samples **3L**

- 1-way ANOVA
- Types of ANOVA

UNIT 4: BIOSTATISTICS: NON- PARAMETRIC TESTS, CORRELATION AND REGRESSION **15LECTURES**

LEARNING OBJECTIVES

1. Understand the application of parametric tests for nominal and ordinal data
2. Understand correlation and regression

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1. Non parametric tests for nominal data **4L**

- Chi square test
- Fisher's exact test

2. Non parametric tests for ordinal data **4L**

- Wilcoxon rank-sum test (aka Mann-Whitney U)
- Sign test
- Wilcoxon signed-rank test

3. Non parametric alternatives to ANOVA **2L**

4. Correlation & Regression **5L**

- Types of Correlation
- Degree of Correlation
- Linear Regression Analysis
- Regression Lines & Regression Equations

CIA: Problem Solving- Biostatistics, Test

References:-

Units 1 and 2:

1. Research Methodology - Methods and Techniques, Kothari, C.R., 2004, 2nd ed., New Delhi, New age international publishers.
2. Research Methodology - Bhattacharya, D.K., 2006, 2nd ed., New Delhi, Excel Books.
3. Research Methods in Biosciences, Holmes D., 2006, Oxford University Press
4. Research Methodology: A Handbook, Misra R.P., 1989, New Delhi, Concept Publishing Company
5. Introduction to Biostats and Research Methodology, Sunder Rao P. S. S., 4th ed., 2006, Prentice-Hall Pvt. Ltd.
6. Design and analysis of experiments, D.C. Montgomery, Wiley Student Ed., 8thed., 2009

7. http://www.cebm.net/wp-content/uploads/2014/06/CEBM-study-design-april-2013.pdf
8. http://www.cebm.net/study-designs/

Unit 3 and 4:

1. Biostatistical Analysis, Czar J. H., 5th ed., 2014, Pearson India education services, India.
2. Biostatistics The Bare Essentials, Norman G.R., Streiner D.L., 3rd ed., 2008, B. C. Decker Inc

MICROBIOLOGY **SMIC08PR**

Semester 2 practical

CELL BIOLOGY AND BIOINFORMATICS

1. Mitosis in onion root tip
2. Meiosis in *Tradescantia*
3. Isolation of mitochondria
4. Isolation of chloroplast
5. Study of cell membrane integrity
6. Study of cell cytology using Phase contrast Microscopy. Demonstration
7. Study of Cell structure using Confocal Microscopy. Demonstration
8. Study of Cell structure using Fluorescence Microscopy. Demonstration
9. Understanding PubMed databases
10. Introduction to National Center for Biotechnology Information (NCBI)
11. Analysis of protein sequence from protein databases
12. Analysis of nucleotide sequence from nucleotide databases
13. Similarity search using the BLAST and interpretation of the results
14. Getting the gene sequences by exploring and querying the nucleic acid databases
15. Pair-wise sequence alignment by using BLAST and ClustalW
16. Multiple sequence alignment by using ClustalW
17. Phylogenetic analysis using web tool
18. Tertiary protein structure analysis using Rasmol
19. Understanding of Kyoto Encyclopedia of Genes and Genome (KEGG) database for biological pathways, metabolism, cellular process, genetic information processing

MOLECULAR BIOLOGY

1. Genomic DNA isolation
2. Primer designing
3. PCR
4. Restriction digestion
5. Ligation in a suitable vector for cloning
6. Transformation in bacteria
7. Plasmid isolation
8. Agarose gel electrophoresis at each of the above stages.
9. Isolation of RNA
10. β galactosidase assay
11. Problems on population genetics

BIOCHEMISTRY

1. Purification of an extracellular enzyme (β-amylase) by salting out and dialysis.
2. SDS PAGE to be done at each stage of purification
3. Native PAGE and activity staining to be done at the end of purification step.

4. Enzyme kinetics-effect of enzyme concentration, substrate concentration, pH, temperature and inhibitors on enzyme activity with Amylase.
5. Isolation of Lysozyme from egg white and purification using ion exchange chromatography.
6. Western blot- Demonstration

RESEARCH METHODOLOGY, BIOSTATISTICS AND MATHEMATICS

1. Writing of a grant proposal
2. Literature survey and reference management tools
3. Use of software in biostatistical analysis
4. Introduction to mathematical modeling
5. Mathematics
    i. Limits, derivatives and integration
    ii. Vectors and matrices
    iii. Basic Algorithms

CIA: Bioinformatics assignment/ Cell biology experiment, Enzymology experiment, Molecular biology technique, Grant proposal writing

References:

1. Bioinformatics and functional genomics, J. Pevsner, 2nd ed., 2009, Wiley-Blackwell publishers
2. Introduction to bioinformatics, T. Attwood, 1steidition, 2001, Benjamin Cummings publishers
3. iGenetics- A Molecular Approach, Russell, P.J., 2010 Third Ed., Pearson International Ed.
4. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd
5. Concepts of Genetics, Klug, Cummings , Spencer, Palladino, Killian 12th ed., 2018, Pearson Education
6. Genetics: A Conceptual Approach, Benjamin Pierce 6th ed. , 2017, W. H. Freeman & Co
7. Genes-X, Lewin, B., 2008, Jones and Bartlett Publishers
8. Molecular Cloning: A Laboratory Manual (3 Volume Set), J. Sambrook, E. F. Fritsch, T. Maniatis, 2nded., 1989, Cold Spring Harbor Laboratory Pr.
9. Principles and techniques of practical biochemistry, 4thed. (1998), Wilson K. and Walker J. (Ed.) Cambridge University Press.
10. Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons
11. An introduction to practical biochemistry 3rd ed., 1998, David T Plummer, Tata McGraw Hill