Programme Structure

Post Graduate in Biotechnology
School of Biotechnology
G.M. University, Sambalpur

Post graduate programme comprising two years, will be divided into 4 (four) semesters each of six months duration.

Year	Semesters	
First Year	**Semester I**	**Semester II**
Second Year	**Semester III**	**Semester IV**

The detail of title of papers, credit hours, division of marks etc of all the papers of all semesters is given below.

- There will be two elective groupsnamely:
- Discipline Specific Elective in SemII.
- Interdisciplinary Elective in SemIII.
- A student has to select one of the DSE paper in Sem II and one of the papers in Sem III as offered by the department at the beginning of the semester II and semester IIIrespectively.
- Each paper will be of 100 marks out of which 80 marks shall be allocated for semester examination and 20 marks for internal assessment (Mid TermExamination).
- There will be four lecture hours of teaching per week for eachpaper.
- Duration of examination of each paper shall be of threehours.

Pass Percentage:

- The minimum marks required to pass any paper shall be 40 percent in each paper and 40 percent in aggregate of asemester.
- No students will be allowed to avail more than three (3) chances to pass in any paper inclusive of first attempt.

Semester-1

Papers		**Marks**		**Total Marks**	**Duration (Hrs)**	**Credit Hours**
Paper No	**Title**	**Mid Term**	**End Term**			
101	Cell & Molecular Biology	20	80	100	4	4
102	Microbiology	20	80	100	4	4
103	Biochemistry	20	80	100	4	4
104	Genetics	20	80	100	4	4
105	Lab course		100	100	4	4
Total				**500**	**20**	**20**

Semester-2

Papers		**Marks**		**Total Marks**	**Duration (Hrs)**	**Credit Hours**
Paper No	**Title**	**Mid Term**	**End Term**			
201	Genetic Engineering	20	80	100	4	4
202	Instrumentation and Computer Techniques	20	80	100	4	4

203	Biostatistics and Basics of Bioinformatics	20	80	100	4	4
204	Developmental Biology (Plant & Animal)	20	80	100	4	4
205	Lab course		100	100	4	4
DSEPapers*						
206 A	Animal Physiology	20	80	100	4	4
206 B	Plant Physiology	20	80	100	4	4
206 C	Bioenergetics and Metabolism	20	80	100	4	4
Total				**600**		**24**

*Discipline Specific Elective Paper. Any one paper can be opted by students of this Department.

Semester-3

Papers		**Marks**		**Total Marks**	**Duration (Hrs)**	**Credit Hours**
Paper No	**Title**	**Mid Term**	**End Term**			
301	Tissue Culture	20	80	100	4	4
302	Bioprocess Engineering and Technology	20	80	100	4	4
303	Cancer and Stem Cell Biology	20	80	100	4	4
304	Environmental Biotechnology	20	80	100	4	4
305	Lab Course		100	100	4	4
IDSEPapers**						
306 A	Medical Biotechnology	20	80	100	4	4
306 B	Agricultural Biotechnology	20	80	100	4	4
306 C	Chronobiology	20	80	100	4	4
Total				**600**		**24**

**Inter Discipline Specific Elective Paper. Any one paper can be opted by students of other Departments.

Semester-IV

Papers		**Marks**		**Total Marks**	**Duration (Hrs)**	**Credit Hours**
Paper No	**Title**	**Mid Term**	**End Term**			
401	Research Methodology	20	80	100	4	4
402	Industrial/ Research exposure (4 months)		300	300	12	12
403	Report submission, Seminar Presentation		100	100	4	4
Total				**500**	**20**	**20**
20 Papers	**Grand Total**			**2200**		**88**

Detailed Syllabus

Post Graduate in Bioterchnology
School of Biotechnology
G.M. University, Sambalpur
SEMESTER-1

101: CELL & MOLECULAR BIOLOGY

Unit 1: Introduction to the Cell and Cell division

The evolution of the cell: From molecules to first cell, From Prokaryotes to eukaryotes, From single cells to multicellular organisms, The Plasma membrane, Membrane structure: The Lipid bilayer, Membrane proteins, Membrane carbohydrates, Membrane transport of Micro & Macromolecules exocytosis and endocytosis, Cell division: Overview of the Cell cycle and its control, The mechanisms for regulating mitotic and meiotic events.Morphology and functional elements of eukaryotic chromosomes, Chromosomal DNA and its packaging and organization: The complex global structure of chromosomes and functions, implications, lampbrush Chromosomes, Polytene chromosomes, Heterochromatin, Centromeres, Telomeres.

Unit 2: Organelles of the eukaryotic cell, Protein sorting and cell signaling

Lysosomes, Peroxisomes, Golgi apparatus, Endoplasmic reticulum, Mitochondria and chloroplast, Structure and Semi autonomic nature of the mitochondria and chloroplast, Protein secretion, synthesis and targeting of mitochondria, chloroplast and peroxisomal proteins, translational modification in the ER. Intracellular traffic, protein sorting in the Golgi, traffic in the endocytic pathway, exocytosis, Cell to cell signaling, Overview of the extracellular signaling, Identification of cell surface receptors, G Protein coupled receptors and their effectors, Secondmessengers.

Unit-3: Prokaryotic Transcription: a) Transcription unit – start site, promoter regions, terminator, b) Structure and function of RNA polymerases, sigma factors, c) mechanism of transcription-initiation, elongation and termination – Rho-dependent and independent termination d) Promoter polymerase interactions –DNA foot printing techniques, e) Promoters- Constitutive and Inducible promoters, other regulatory elements - upstream activating sequences (UAS), anti-termination, f) inhibitors of transcription. Operon concept: Operon concept – inducible and repressible operons. Eg. lac, trp, ara, and his operons; global nutrient (carbon, nitrogen) status sensing mechanisms – link to gene expression. Bacterial small RNA (sRNA) and its role in regulation of gene expression. Eukaryotic transcription: a) RNA polymerases I, II, III –structure and assembly; b) Basal transcription apparatus for the three polymerases with specific promoters and transcription factors, c) Other regulatory elements – enhancers, silencers, response elements, d) Transcriptional factors – general features, motifs - zinc fingers, leucine zippers, helix-turn helix, homeodomains etc.

Unit-4: Gene splicing&post-transcriptional modifications:Splicing–mechanism,catalyticroleofRNA,
b) Group I, II and nuclear introns, nuclear splicing and role of nRNA, tRNA splicing, c) modification of mRNA -5' cap formation, 3' polyadenylation; RNA editing. RNA interference (RNAi)-mechanism and significance. Translation: a) Genetic code – universality and degeneracy, Wobble hypothesis, Chemical synthesis of the gene by Khorana, b) Translation machinery ribosomes; charging of tRNA molecules and formation of aminoacyl tRNA; mechanism - initiation, elongation and termination, c) post- translational modificationsofproteins–glycosylation,amidation,lipidation,processingofpre-proteinsetc.,d)Transportof

proteins and molecular chaperones; Protein stability; Protein turnover and degradation, e) Inhibitors of protein translation.

Recommended Books:

1. Lewin B. Genes. Jones & BartlettPublishers.
2. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. Molecular Biology of the Cell.Garland Science.
3. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. Molecular Biology of the Gene. . Benjamin-Cummins PublishingCo.,
4. Freifelder D. Molecular Biology. Narosa Publishing House.

102: MICROBIOLOGY

Unit 1-: Microbial Classification and Bacteria Biogenesis and abiogenesis Contributions of Redi,**,** Spallanzani, Needham, Pasteur, Tyndal, Joseph Lister, Koch [Germ Theory], Edward Jenner and Flemming [Penicillin], Scope of Microbiology, Classification of Microbes - Systems of classification, Numerical taxonomy, Identifying characters for classification, General properties and principles of classification of microorganisms Systematics of bacteria, Nutritional types [Definition and examples]. Classification on the basis of oxygen requirement Molecular taxonomy of microorganisms.

Unit 2-: Bacteriology

Bacteriology: The fundamental structure of bacteria, especially structures important for pathogenicity and virulence. Basic biology and host-pathogen interactions with reference to important infections due to Gram negative bacteria (pathogenic E. coli, Vibrio cholera, Salmonella, Yersinia pestis), Gram positive bacteria (Staphylococci, Streptococci), tuberculosis, zoonotic diseases: leptospirosis, Helicobacteri pylori and peptic ulcer. Stress reactions and Survival of bacteria: Prokaryotic responses to Environmental stress: Quorum sensing in Bacteria: Gram negative bacteria: LUXI LUXRType: Gram Positive bacteria: Peptide mediated quorum sensing

Unit 3-: Mechanisms In Bacteria

Mechanisms in bacteria with special emphasis on Caulobacter development and cell cycle control, Interactions between Humans and microorganisms: Nonspecific and specific defense mechanisms. Mechanisms of pathogenesis. host factors influencing resistance to infection, Physiology of growth: Growth kinetics. Regulation. Effect of environmental factors on growth e.g., pH. Temperature. Oxygen. Nutrient limitations etc

Unit 4-: Applied Microbiology

Physiology and vaccine development: Use of proteomics and genomics and physiology for the development of vaccine of specific microorganisms, Environmental Microbiology: Microbial degradation of xenobiotics. Catabolic genes and their regulation. Biomaterials. Isolation. Production. Characterization and its use, Industrial Microbiology: The application of fundamental principles of Microbiology to industrial Fermentations and processing. Antibiotics production etc

Recommended Books:

1. Prescott L, Harley J and Klein D. Microbiology. McGraw HillPublishers.
2. Tortora G.J. Funke B.R. and Case CMicrobiology:.L. An Introduction.Benjamin-Cummins PublishingCo.,
3. Pelzer, M. J. Chan, E.C.S. and Kreig, N. R. McGraw-Hill PublishingCo.

103: BIOCHEMISTRY

Unit 1: Principles of Biochemistry

Cellular environment and applicability of basic laws of chemistry and thermodynamics. Concept of micro and macromolecules, Molecular interactions and its importance in understanding cellular processes, Concept of energy rich compounds, Central role of ATP in metabolism, Common types of reactions involved in ATP metabolism, ATP Synthesis.

Unit 2:Macromolecules-1

Monosaccharides and derivatives of sugars, (glucose, fructose, sugar alcohol– mannitol and sorbitol);Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin); Isomers of glucose, derivatives of glucose. Carbohydrate Metabolism Metabolic importance of glycolysis, TCA cycle, Amphibolic nature of TCA cycle, Energetics of Glucose oxidation, gluconeogenesis from TCA cycle intermediates and amino acids. Regulation of gluconeogenesis, Glycogenolysis, HMP shunt, Synthesis of Starch by C3 and C4 pathways of photosynthesis.

Unit 3:Macromolecules-2

Structure of amino acids and peptide bonds, Primary structures of protein, Ramachandran Plot, alpha helical and beta pleated structures, Dynamics of protein structure , Protein modifications and their functional implications , Basic concepts of protein folding, folding pathways, role of accessory proteins in protein folding, protein stability, globular proteins and maintenance of specific conformation. Lipids: Definition and major classes of storage and structural lipids. Fatty acids structure and functions. Essential fatty acids. Triglycerides; structure and function, Saponification, Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: structure of sphingosine, ceramide. Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers. Degradation of odd and even carbon-fatty acids, minor pathways of fatty acid oxidation, Energetics of Beta Oxidation, The Glyoxylate cycle, Biosynthesis of saturated fatty acids. Oxidative degradation of aminoacids leading to Acetyl Co-A, Alpha- Keto Glutarate pathway, Succinate Pathway, Fumarate Pathway, Oxaloacetate pathway of amino acid oxidation, decarboxylation and deamination.

Unit 4: Metabolism of Vitamins and Nucleotides.

Nomenclature and roles of vitamins, Sources and deficiency symptoms in plants, metabolism of water soluble vitamins, Biosynthesis of thiamines, riboflavins, Vitamin B6, Pantothenic acid, Co-enzyme A, Nucleotide biosynthesis and degradation, salvage pathways, its regulation and diseases. Mechanisms of hormone action, metabolism of lipids during seed germination.

Recommended Books:

1. Voet V and Voet J.G. Biochemistry. John WileyPublishers.
2. Lehninger A.L. Principles of Biochemistry. W.H Freeman andCompany.
3. Stryer L. Biochemistry. W.H. Freeman andCompany.

104: GENETICS

Unit 1-: Introduction and scope of Genetics

Chromosomal basis of inheritance during cell division, DNA as genetic material, Basic mechanism of DNA replication, Basic structure of DNA and RNA, DNA replication: Messelson and Stahl Experiment, Carins Experiment, Okazaki Experiment, Allele, multiple alleles, pseudoallele, complementation tests , Gene mapping

methods : Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

Unit 2-: Mendelian and non Mendelian inheritance

Basic Principles of Mendelian Inheritance: Segregation and Independent Assortment, Alleles and Multiple Alleles, Human pedigrees and inheritance, Gene Interaction: Sex determination and Sex linked inheritance, Drosophila and other animals, Sex-determination in plants, Pedigree analysis, Dominance, segregation, independent assortment, Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influencedcharacters

Unit 3-: Molecular and Cellulargenetics-1

Linkage analysis and gene mapping in eukaryotes, Coupling and repulsion phases, Crossover and recombination. Yeast, *Chlamydomonas/ Neurospora* and higher plants, Basic Principles of Genetic Engineering, Fine Structure of gene and gene concept: Fine structure of rII gene – Benzer's experiments, complementation analysis and fine structure of gene, Recombination, concept of gene. maternal inheritance. Microbial genetics : Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. IOD score for linkage testing, karyotypes, genetic disorders. Quantitative genetics : Polygenic inheritance, heritability and its measurements, QTLmapping.

Unit 4-: Molecular and Cellular genetics-2

Mutations, Spontaneous and induced mutations, Chromosomal mutation and aberrations, Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids –nullisomics, monosomics, and uisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes, Main type of changes– deletions duplications, inversions. Mechanism of chromosome mutations genetic and cytological features of deletions, Duplications, inversions and translocations, Somatic vs germinal mutation, Population genetics: application of Mendel's laws to whole population, Calculation of allele frequencies, Hardy-Weinberg principle for calculating recessive gene frequency, Calculating frequency of sex –linkedalleles

Recommended Books:

1. Griffiths A.J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C and Gelbart, W. M. An Introduction to Genetic Analysis, W. H. Freeman &Company.
2. Strickberger,M.W. Genetics, Macmillan PublishingCo.
3. Gardner, E.J., Simmons,M.J. and Snustad, D.P. Principles of Genetics, John Wiley & Sons.

105: LAB COURSE

Study of chromosome behaviour during Mitosis and meiosis (Onion / Garlic root tips, Onion buds, human lymphocytes, rat or bird testis /grass hopper testis or any other materials).
Calculation of mitotic index in growing Onion / Garlic root tips
Squash preparation: Polytene chromosome (in chironomus / Drosophila or other insect salivary gland) and Barr body (in buccal epithelial cells).
Demonstration of secretory granules in the salivary gland cells of insect.
Demonstration of mitochondria by vital staining.

Study of permanent slides.
Estimation of DNA
Estimation of RNA
Sub-cellular fractionation and marker enzymes
Identification of biomolecules in different tissues by histochemical techniques
Preparation of mitotic plate by carmine squashing method and phase identification.
Demonstration of the nuclear matrix networks in onion cells.
Study of the effect of chemical agents on chromosomes plant cells.
Isolation of protoplast, measurement of cell density plating efficiency.
Preparation of Karyotype of metaphase plate.
Specific tests for sugars, amino acids and lipids
Formal titration of amino acids
Estimation of proteins using ninhydrin and biuret method
Estimation of sugar by Anthrone and Folin-Wu method
Saponification value and iodine number of fat.
Estimation of ascorbic acid
Achromic point determination using salivary amylase
Effect of ions on salivary amylase activity
Enzyme assay and kinetics (ex. Amylase, Protease)
Glassware preparation and sterilization techniques- wet heat- dry heat- filter types- laminar flow chamber types- CDC- safety levels
Preparation of liquid & solid media, plating, pouring, inoculation and incubation for growth of microorganism
Methods of obtaining pure culture of microorganisms (a) streak plate (b) Pour plate, and (c) spread plate methods
Microscopic examination of the microorganisms, identification and staining methods
Micrometery and camera lucida drawings
Study of bacterial growth by turbiditimetry/ spectrophotometry
Biomass measurement for fungi
Isolation and enumeration of microorganisms from soil by serial dilution agar plating method
Enumeration of viruses by plaque assay technique
Motility of bacteria by hanging drop technique

SEMESTER 2

201: GENETIC ENGINERING

Unit-1: Generation of DNA fragments: Mechanical shearing, restriction endonucleases (REs) – classification, mechanism of action, use of REs for molecular cloning, PCR technology and its application in recombinant DNA technology, cDNA synthesis – strategies for isolation of full length cDNAs, chemical synthesis of a DNA fragment. Vectors used in molecular cloning: a) Plasmids – general concepts, eg. pUC, pBlueScript, pGEM vectors; Expression vectors; pMal, GST-based, pET vectors, b)Bacteriophage λ vectors – λgt10, λgt11, λ ZAP and replacement vectors – EMBL, c) Phagemids - M13-derived vectors, d) cosmids - Artificial chromosome vectors (YACs; BACs), e) Other viral vectors: SV-40, vaccinia, baculovirus & retroviral vectors.

Unit-2: Cloning strategies & Introduction of recombinant DNA into hosts: a) Other enzymes used in cloning - DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, b) cloning strategies – basic concepts of cohesive and blunt end ligation; directional cloning, use of linkers and adaptors; c) Homopolymer tailing, d) T-vectors and cloning of PCR products, e) Introduction of recombinant DNA into suitable hosts - transformation, conjugation, transduction, transfection, particle bombardment techniques, f) Ti plasmids and Agrobacterium-mediated transformation; particlebombardment.

Unit-3: Construction and screening of genomic libraries: a) Construction of genomic and cDNA libraries – using for λgt11,. λ ZAP vectors, b) Screening: DNA probe-based screening - molecular hybridization techniques: Preparation of nucleic acid probes by nick translation, random primer labeling and end labeling, hybridization techniques for identification of clones with gene of interest, c) Screening by antibody-based methods: induction of protein expression, immunodetection using specific antibodies, radioactive and chemiluminescent methods of detection.

Unit-4: Characterization of cloned genes: a) Sequencing of DNA- Sanger's enzymatic method and Gilbert's chemical sequencing method; automated DNA sequencing, b) Identification of promoters and regulatory elements – promoter reporter fusions, c) Site directed mutagenesis. Expression of recombinant proteins. a) Protein expression*E.* in*coli* as a host - Factors influencing the expression of recombinant proteins. Purification of recombinant proteins - -Histag, GST-tag, MBP-tag etc., commercially available *E. coli* hosts for expression of recombinant proteins, b) examples of alternate expression systems – yeast, baculovirus, mammalian systems and plants. MolecularPharming.

Recommended Books:

1. Primrose S.B, Twymand R.M, and Old R.W. Principles of Gene Manipulation. BlackwellScience.
2. Sambrook J and Russell D. Molecular Cloning: A laboratory Manual. Cold Spring Harbor Laboratory Press.

202 : INSTRUMENTATION AND COMPUTER TECHNIQUES

Unit-1: Centrifugation, Microscopy and Spectroscopy: Principle, techniques. Preparative, analytical and ultracentrifuges, sedimentation coefficient and factors affecting sedimentation coefficient. Application of centrifugation. Photometry: Basic principles of colorimetry, UV- visible spectrophotometry & IR-spectrophotometry. Spectroflurometry, Atomic absorption spectroscopy: Principle, Instrumentation and applications Microscopic techniques: light microscopy, phase-contrast microscopy, scanning and transmission electron microscopy, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy.

Unit-2: Chromatography and Immunotechniques: Paper and Thin Layer Chromatography. Gel filtration, Ion exchange chromatography and Affinity chromatography. Gas-liquid chromatography and HPLC. Histochemical and immunotechniques: Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immune fluorescence microscopy, detection of molecules in living cells, In situ localization; FISH and GISH.

Unit-3: Electrophoresis and Blotting techniques: Agarose, PAGE, 2D-E. Radioactivity: GM counter, liquid Scintillation counter, solid Scintillation counter, gamma counters. Lyophilization: Principle, instrumentation and applications. Microtomy: types, principle andapplications.

Unit-4: Introduction to MS-Office software: Word processing; Creating new document, Editing documents, Adding graphics to documents, Word tables. Management of Workbook & Worksheets; Applications, Features, Using formulas and functions, Features for Statistical data analysis, Excel-Tool Pack for data analysis; Generating charts/ graph. Presentation software; Working in PowerPoint, Creating new presentation, Working with slides. Introduction to Internet and Applications. Basics of internet, e-mailing. **Recommended Books:**

1. K Wilson and John :Walker Practical Biochemistry: Principles &Techniques
2. RF Boyer: Biochemistry Laboratory: Modern Theory &Techniques
3. S Carson, H Miller and D Scott: Molecular Biology Techniques: A Classroom LaboratoryManual
4. TC Ford and J. M. Graham : An Introduction toCentrifugation
5. R Baserga and D Malamud: Autoradiography: techniques andapplication
6. T Chard: An Introduction to Radioimmunoassay and Related Techniques , Volume6
7. MD Bruch: NMR SpectroscopyTechniques
8. BA Wallace and R William:Modern Techniques for Circular Dichroism and Synchrotron Radiation, Volume1
9. J Sambrook, EF Rritsch and I Maniatis: Molecular cloning: A LaboratoryManual
10. PD Dabre: Introduction to Practical MolecularBiology
11. JD Watson, NH Hopkins, JW Roberts, JA Steitz and AM Weiner: Molecular Biology of Gene(4^{th} Edition)
12. J Darnell, H Lodish and D Baltimore: Molecular Cell Biology (2^{nd}Edition)
13. BAlberts,DBray,JLewis,MRaff,KRobertsandJDWatson:MolecularBiologyoftheCell(2^{nd} Edition)
14. Benjamin Lewin: GeneVII
15. JM Walker and R Rapley: Molecular Biology andBiotechnology
16. SB Primrose: MolecularBiotechnology

203: BIOSTATISTICS & BASICS OF BIO INFORMATICS

Unit 1: Introduction to biostatistics.

Types of biological data: data on different scales. Frequency distributions. Cumulative frequency distributions. Random sampling. Parameters and statistics. Measures of central tendency and dispersion: Mean, Median, Mode, Range, Variance and Standard deviation. Coefficient of variation. The effects of coding data. Data transformations: Log-transformation, Square-root transformation and Arcsine transformation. Distribution: normal and binomial. Probability: Basic laws of probability, addition law, multiplication law. Probability and frequency.

Unit 2: Statistical errors in hypothesis testing.

Testing goodness of fit: Chi-square goodness of fit. Heterogeneity Chi-square. The 2 x 2 contingency table. One sample hypothesis. Two-sample hypothesis. Testing for difference between two means (*t*-test). Testing for difference between two variances (*F*-test). The paired sample *t*-test. Multiple-sample hypothesis (ANOVA): Single factor and two factors ANOVA. Multiple comparisons: Duncan's multiple-range tests. Simple linear regression. Regression *vs.* Correlation. Regression equation. Interpretations of regression functions. Simple linear correlation. The correlationcoefficient.

Unit 3-: Bioinformatics

Introduction to Bioinformatics and Computational Biology with historical background, major developments , Biological databases, data query and data mining; Boolean operators; Problems and Applications to biological problems , Nucleic acid sequence analysis, alignment, similarity searches including remote similarity searches, secondary structure element, motifs, Protein sequence analysis; alignment, similarly searches including remote similarity searches, secondary structure elements, motifs , Genomics and annotation, RNA, secondary structure, small non-codingRNAs.

Unit 4: Public domain databases: overview and retrieving of gene sequences, BLAST analysis of DNA and protein sequences, Analysis of genes: restriction sites, translation of DNA sequence etc, Primer designing, *In silico* prediction: signal peptide,transmembrane domains, nuclear export and import signals, mitochondria targeting signals, DNA binding domains, post translational modifications on proteins like phosphorylation and glycosylation

204:DEVELOPMENTAL BIOLOGY (PLANTS AND ANIMALS)

Unit 1: Seed development: Phases of development, Maturation; accumulation of desiccation related compounds, ABA regulation. Seed Dormancy: Physiological and molecular basis, Testa, Endosperm, Aleurone layers & Hormonal cross talk in dormancy. Alleviation of dormancy; Protein oxidation. Dormancy breaking chemicals and mechanism. Seed Germination: Pre-germination, Germination and post germination
Metabolism. Reactivation of the metabolic pathway. Cellular repair. Hormonal regulation and metabolism; GA & ABA, ROS metabolism.

Unit 2: Seed Ageing: Seed storage physiology: Orthodox & Recalcitrant; ROS metabolism, Mechanism of desiccation tolerance, dehydrins/LEA/peroxiredoxin, HSPs, Sugars. Longevity markers; β-mercaptopyruvatesulfurtransferase (MST), L –isoaspartyl O-methyltransferase (PIMT). Seed Technology: Priming technology; biochemical and molecular aspects. Cryobanks, Cryopreservation of seed and embryo; Cryoprotective molecules, Vitrification, Encapsulation and Drying. Synthetic seeds

Unit: 3 Gametogenesis in animals. Molecular events during fertilization. Activation of egg metabolism. Cleavage patterns and fat maps. Regulation of Cleavage cycle. Cleavage and nuclear activity. Concepts of determination, competence, induction and differentiation. Determination in *Caenorhabditis elegans*. Germ cell determination, migration and differentiation. Totipotency and nuclear transfer experiments. Embryonic induction. Formation of vulva in *C. elegans*. Mechanism of differentiation in *Dictyostelium*. Morphogenetic determinants in egg cytoplasm. Role of maternal contributions in early embryonic development. Genetic regulation of early embryonic development in Drosophila. Homeotic genes. Genetic interaction during differentiation. Hox genes and limb patterning.

Unit 4: Concepts and theories of organic evolution. The processes of Evolutionary change-Genetic drift,

Natural selection and the Hardy-Weinberg equilibrium. Speciation. Molecular evolution and origin of life. Evolution of Prokaryotes and Eukaryotes. A brief outline of the evolutionary history of Metazoans including-Evolution of tissue grade, coelomic body plans and Chordates. Evolution of Mankind.

Recommended Books:

1. Alberts *et al*. : Molecular Biology of theCell
2. SF Gilbert: DevelopmentalBiology
3. Lewin Benjamin : GeneVIII
4. PO Moody : Introduction to Evolution, 1970, Harper andRow
5. Dobzhansky et al. : Evolution, W. H. Freeman. NewYork
6. SW Fox and K Dose: Molecular Evolution and the Origin of Life, 1972, W.H. Freeman & CoLtd.
7. FJ Ayala and JW Valentine: Evolving: The theory and processes of Organic evolution, 1979, Benjamin/Cummings Pub. Co.: EO Dodson: Evolution: Process andProduct
8. MW Strickberger: Evolution, 1979, James and BarlettInternational

205: LAB COURSE

Verification of Beers Law
Determination of absorption maxima
Quantitative determination, Enzyme kinetics
Amino acid and carbohydrate separation by paper and TLC
Ion exchange and gel filtration chromatography
SDS Polyacralamide Gel Electrophoresis
DNA electrophoresis
Isoenzymes
Separation of sub-cellular organelles by differential centrifugation.
Isolation of DNA and Agarose gel Electrophoresis
Amplification of RAPD and AFLP markers.
Isolation of RNA and Electrophoresis of RNA on denaturing gels.
cDNA synthesis and cloning
Isolation of Protein and SDS-PAGE
In vitro DNA ligation, transformation of E. coli
Characterization of transformants: DNA gel electrophoresis, Restriction map analysis
Study of developmental stages in Snail/Amphibian/Chick
Study on Drosophila development
Role of hormones in metamorphosis and development
Effect of Vitamin A on tail regeneration in frog
Biochemical estimations in developing embryos
Structure of hen's egg and its vital staining
Demonstration of cell death by vital staining
Study of permanent slides of chick embryos
Histological studies of Gametogenesis
Induced breeding in fishe
Protein estimation by Lowry, Bradford and Spectrophotometric method
Estimation blood cholesterol

Estimation of sugar by Nelson-Sompgy and Benedict's reagent
Isolation and estimation of lipid from seeds and egg
Estimation of inorganic and total phosphorus by Fiske-Subba Rao method
Assay of phosphatases in blood and seeds
Urease estimation in plant tissues

Discipline Specific Elective (DSE) 206

A: Animal Physiology

Unit -1: Physiology–Physiology of digestion, Mechanism of respiration, Respiratory pigments, Oxygen equilibrium curve, Structure of heart and its working, Cardiac cycle and its regulation, Blood coagulation, Structure and function of nephron, Mechanism of urine formation, Osmoregulation.

Unit-2: Physiology–Nerve conduction and synaptic transmission of impulses, euromuscular junction; Reflex action and its types – reflex arc; Mechanism of muscle contraction. Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor Unit, summation and tetanus.

Unit-3: Endocrinology- Functional Histology of endocrine glands -pineal, pituitary, thyroid, parathyroid, pancreas, adrenals; hormones secreted by them and their mechanism of action, Classification of hormones; Regulation of their secretion; Mode of hormone action; Signal transduction pathways utilized by steroidal and non-steroidal hormones; Hypothalamus (neuro endocrine gland) -principal nuclei involved in neuro endocrine control of anterior pituitary and endocrine system, Placental hormones.

Unit 4: Reproductive System

Histology of male and female reproductive systems, Puberty, Physiology of male and female reproduction; Methods of contraception (depicted through flowchart)

Recommended Books:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTELtd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley &sons,
3. Victor P. Eroschenko. (2008). diFiore‟s Atlas of Histology with Functional correlations. XII Edition. Lippincott W. &Wilkins.

206 B : Plant Physiology

Unit 1-: Mineral nutrition and assimilations of inorganic nutrients.Plant mycrorrhiza association, nitrogen metabolism, assimilation of cations, chloride dynamics, Essential and beneficial elements, macro and micronutrients, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents, Soil as a nutrient reservoir, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 2-: Plant Growth Regulators.

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene.Brassinosteroids and Jasmonic acid, Physiology of flowering: Photoperiodism, flowering stimulus, florigen concept, vernalization. Seeddormancy.

Unit 3-: ATP Synthesis

Mechanism of ATP synthesis, substrate level phosphorylation and oxidative phosphorylation), chemiosmotic mechanism, ATP synthatase, Boyers conformational change model, role of uncouplers.

Unit 4-: Stress Physiology

Defining plant stress, Acclimation and adaptation. Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction, stress related proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates, Stress sensing mechanisms in plants, Role of nitric oxide. Calcium modulation, Phospholipid signaling, Adaptation in plants; Changes in root: shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production. Calcium, phospholipids, cGMP

Recommended Books:

1. Fosket DF: Plant Growth &Development
2. Foyer CH:Photosynthesis
3. Bacon Ke: Photosynthesis:Photobiochemistry&Photobiophysics
4. Leopold AC &Kriedemann PE: Plant Growth &Development
5. Moore TC: Biochemistry & Physiology ofHormones
6. L Taiz & E Zeiger: PlantPhysiology
7. BB Buchanan, W Gruissem & RL Jones: Biochemistry & Molecular Biology ofPlants
8. MB Wilkins: Advanced PlantPhysiology
9. JA Hopkins: Introduction to PlantPhysiology
10. FB Salisburry& CW Ross: PlantPhysiology
11. Hans-Walter Heldt: Plant biochemistry & Molecular Biology

206 C: Bioenergetics and Metabolism

Unit 1: First and second laws of thermodynamics. Gibbs free energy G, free energy change ΔG, endergonic & exergonic reactions,. Standard state free energy changes-ΔG, ΔG^0 and $\Delta G'^0$, Relationship between equilibrium constant and $\Delta G'^o$, Feasibility of reactions. ATP-Structure, properties and energy currency of the cell, Importance of Coupled reactions, other high energycompounds.

Unit 2: Carbohydrate metabolism: Glycolysis, Kreb's cycle, glycogenolysis, glycogenesis, pentose phosphate pathway, gluconeogenesis, and glyoxylate pathway. Regulation of carbohydratemetabolism.

Unit 3: Electron transport and oxidation phosphorylation: electron carriers, complexes I to IV, substrate level phosphorylation, mechanism of oxidative phosphorylation. Shuttle system for entry of electron. Biosynthesis and degradation of Lipids. Regulation of lipid metabolism

Unit 4: Nitrogen Assimilation: Overview of Nitrogen in biosphere and uptake by organism. Biosynthesis and degradation of amino acids. Regulation of amino acid metabolism. Biosynthesis and degradation of purine and pyrimidinenucleotides.

RecommendedBooks:

1. Nelson, Cox and Lehninger: Principles ofBiochemistry
2. G Zubay:Biochemistry
3. Stryer:Biochemistry
4. Garrett and Grosham:Biochemistry
5. West, Tood, Mason and Bbruglen: Text book ofbiochemistry
6. White, Handler and Smith:Biochemistry
7. D.Voet and J C Voet:Biochemistry
8. Dixon and Webb:Enzymes
9. Price and Steven: Fundamentals ofEnzymology
10. Plummer: Practicalbiochemistry
11. G Tripathi: Enzymebiotechnology
12. Walsh: Enzyme ReactionMechanism
13. Hammes: Enzyme catalysis andregulation

SEMESTER 3

301 : TISSUE CULTURE

Unit 1: Culture techniques

Introduction to cell and tissue culture, tissue culture as a technique to produce novel plants and hybrids
Tissue culture media (composition and preparation) Initiation and maintenance of callus and suspension culture; single cell clones Organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil, Shoot tip culture: Rapid clonal propagation and production of virus free plant. Embryo culture and embryo rescue. Anther, pollen and ovary culture for production of haploid plants and homozygous lines. Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids. Germplasm conservation: Cryopreservation and slow growth cultures. Chloroplast Transformation: Advantages, vectors, success with tobacco and potato.

Unit 2: Plant transformation technology: Basis of tumor formation, Mechanism of DNA transfer, Features of Ti and Ri plasmids, role of virulence genes, use of Ti and Ri as vectors, binary vectors, markers, use of reporter genes, 35S and other promoters, use of scaffold attachment regions, multiple gene transfers, particle bombardment, electroporation, microinjection Applications of plant transformation for productivity and performance: herbicide resistance, insect resistance, Bt genes, Non–Bt like protease inhibitors & amylase inhibitors, virus resistance, nucleocapsid gene, disease resistance, PR (Pathogenesis Related) proteins, nematode resistance, abiotic stress, male sterile lines.

Unit3:MammalianCellCulture:Preparationofculturemedia,Establishmentofprimarycellculture: mouse splenocyte culture, Handling mammalian cell lines: thawing, culture maintenance and cryopreservation,Cellcountingusinghemocytometer,Cellviabilityandproliferationassays:Trypan blueexclusiontest,MTTassay,PropidiumIodidestaining,CFSClabeling,Mammaliancelltransfection

(transient),Immunofluorescencedetectiontochecktransfectionefficiency(usingfluorescenceand confocalmicroscopes)

Unit 4: Regulatory mechanisms in Embryonic and adult stem cells: Core regulatory circuitry, DNA methylation, histone modifications, histone modifiers, chromatin remodelers, RNA PolII code, post transcriptional control of gene expression in ESC: role of miRNAs, LincRNAs and RNA binding proteins. Spatial organization of genome during ESC development and differentiation. Stem cell therapies: Generation of induced pluripotent cells, and molecular mechanism of iPSCs reprogramming. Direct differentiation.

Recommended Books:

1. Lanza R, Gaerhart J, Hogan B, Melton R, Thomas D,ThomasJ, andWilmutS.
2. Essentials of Stem Cell Biology. Elsevier Inc.
3. Stillman B, Stewart D and Grodzicker T, Control and Regulation of StemCells.
4. Tursen Kursad, Stem Cell Biology and Regenerative Medicine, HumanaPress.
5. MK Razdan: Introduction to Plant Tissue Culture, 2nd Edition, Oxford & IBH Publishing Co. Pvt Ltd, 2010
6. IK Vasil : Plant Cell and Tissue Culture; Springer Publication,1994
7. SS Bhojwani and MK Razdan: Plant Tissue Culture;Elsevier
8. TJ Fu, G Singh and WR Curtis : Plant Cell and Tissue Culture for the production of Food Ingredients. Kluwer Academic/ Plenum Press,1999
9. J Hammond, P McGarvey and V Yusibov Plant Biotechnology, Springer Verlag,2000
10. HS Chawla Biotechnology in Crop Improvement, International Book Distributing Co.,1998
11. HS Chawla : Introduction to plant biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.,2000
12. BD Singh : Biotechnology- Expending Horizons. 1st Edition, Kalyani Publisher, Ludhiana,2004
13. Roberta H Smith: Plant Tissue Culture: Techniques and Experiments, 2ndEdition: Academic Press,2000
14. Kyte L and Kleyn J: Plants from Test Tubes: An Introduction to Micropropagation, 3rdEdition, Timber Press, 1996
15. M Smith: Plant Propagator's Bible, 1st Edition, Rodale Books,2007
16. MR Ahuja: Micropropagation of Woody Plants, Springer,1993
17. YPS Bajaj: Trees III, Springer,1991
18. YPS Bajaj: Trees IV, Springer,1996
19. HolmeD.JandPeckH.AnalyticalBiochemistry.LongmanScientificandtechnicalPublishers.
20. PlummerD.T.AnIntroductiontoPracticalBiochemistry.TataMcGraw---HillPublishing CompanyLimited.
21. SambrookJandRussellD.W.MolecularCloning,volumes1,2and3.ColdSpringHarborLab Press.
22. WilsonKandWalkerJ.PrinciplesandtechniquesofBiochemistryandMolecularBiology. Cambridge UniversityPress.
23. HarlowEandLaneD.Antibodies:ALaboratoryManual.ColdSpringHarborLabPress.

302: INFECTION BIOLOGY AND IMMUNOLOGY

Unit-1: Infection biology

Historic perspectives, Kochs hypothesis, General events in establishment of infection, infectious dose, lethal dose, infectious disease epidemiology, nosocomial infections, antisepsis, modes of disinfection/sterilization, modes of disease transmission, specific and non-specific defense responses. Importance of different virulence factors, e g. exotoxins, the endotoxin, secretion systems, the invasiveness, intracellular survival, antigenic variation and other mechanisms to avoid the immune system. Antibiotics and drug resistance: Principles for mechanisms of antibiotic action, bacteriostatic and bacteriocidal effect. Mechanisms of antibiotics resistance and its importance within the healthcare: MRSA, MDR and XDR intuberculosis.

Unit-2: Virology & Parasitology Components and structures of virus particles; classification of viruses; DNA and RNA viruses. Host immune response to viral infections: Flu, HIV, polio, hepatitis etc. Control measures: diagnosis, anti-viral therapy, vaccines. Parasitic infections Malaria, toxoplasmosis, leishmaniasis, trypanosomiasis etc. Immune evasion: adaptation of parasites for survival within the mammalian host. Mechanism of antigen export and antigen presentation in *Plasmodium* and *Toxoplasma*. Host immune responses to protozoan diseases and model systems to study immune activation during protozoan infections. Diagnostics: Identification of the infecting bacteria by staining and culture technqiues, immuno assays including ELISA, Western blotting, agglutination etc. and molecular techniques using PCR, RT-PCR.

Unit-3: Cell, molecular and developmental biology of immune system: Evolution of the immune system, development and survival of immune cells. Molecular mechanisms of immune recognitions, and effector responses against pathogens. Molecular components of Immune system: Structure, function and generation of antigen receptors, regulation of immune responses, signal transduction, autoimmunity, tolerance. Adaptive immune system: Antigen recognition, lymphocyte activation, humoral and cell mediated immunity, immunological memory, physiological and pathological aspects of inflammation.

Unit-4: Immune Dysfunction: Autoimmunity, immunodeficiency, allergy, hypersensitivity, alloantigens and transplantation rejections. Cancer immunology: Tumor cell recognition, Mechanic insights of anti-tumor immunity, immunosuppressive mechanisms, inhibitory receptors, cancer vaccines, and new approaches for delivery of immunotherapies into tumors.

Recommended Books:

1. Cole ST, Eisenach K.D, McMurray D.N and Jacobs W.RTuberculosis. and the tubercle bacillus. ASM Press.
2. Schaible U.E andHaasA, Intracellular Niches of Microbes: A Pathogens Guide Through the Host Cellby Modern Parasitology. Wiley BlackwellPublishers.
3. A textbook of Parasitology by F.E.G. Cox. Wiley Blackwell Publishers.
4. Frank SA, Immunology University Press. andEvolution of Infectious Disease.Princeton
5. J.D Smyth, Introduction to Animal Parasitology. Cambridge UniversityPress.
6. Ahmed N, DawsonN, Smith C and Wood Ed. Biology of Disease. Taylor and FrancisGroup.

7. Sherman I.WMalaria. Parasite Biology, Pathogenesis and Protection. ASMPress.
8. Ajioka J.W and Soldati D. Toxoplasma Molecular and Cellular Biology. HorizonBioscience.
9. Pommerville J.C.Alcamo's Fundamentals of Microbiology. Jones and BartlettPublishers.
10. Salyers A. A and Whitt D.D. Microbiology-Diversity, Disease and Environment. Fitzgerald Sciences Publishers.
11. Goldsby RA, Kindt TK, Osborne BA and Kuby J. Immunology, 7th Edition, W.H. Freeman and Company.
12. Janeway CA, Travers P, Walport M, and Shlomchik M. Immunobiology, 8th Edition, Garland Publishing.

***302: BIOPROCESS ENGINEERING AND TECHNOLOGY**

Unit-1: Basics of Biochemical Engineering

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics. Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit-2: Bioreactor design

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit-3: Downstream Process and product recovery:

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit-4: Applications of microbial technology in food process operations and production, biofuels and biorefinery:

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery

Recommended Books:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York:
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*.: McGraw-Hill.

5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.

303: CANCER AND CANCER STEM CELL BIOLOGY

Unit 1: Cancer: Epidemiology of cancer, Cancer types, Characteristics of cancer cells; Carcinogenesis: cancer initiation, promotion and progression, termination.Factors responsible for carcinogenesis: Physical, chemical and biological. Tumor Development:Models, Tumor angiogenesis, Overview of invasion and metastasis, Cell- cell interactions in cancer, Invasion and the extracellular matrix, Specific cases of Prostate, Breast, Intestinal cancers

Unit 2: Carcinogen Mechanisms and Oncogenes and their role in Cancer: Introduction to oncogenes, Mechanisms of oncogene activation (gene amplification), Mechanisms of oncogene activation (chromosomal translocations), Chromosomal translocations with dominant negative effects, Introduction to tumor suppressor genes. Cell-Cycle Regulation and Cancer: Mutations affecting mitogenic signal transduction pathways, Cell Cycle Regulation - Mutations affecting the cell cycle, Loss of checkpoint control and genetic instability,Replicative senescence, DNA damage and repair, Carcinogenesis: Chemical and physical agents, Carcinogenesis: Repair mechanisms, Aberrant repair and genetic instability, Genetic predisposition to cancer

Unit 3: Stem cell technologies: Cellular potency, lineage commitment, cellular development, differentiation, dedifferentiation & trans differentiation, Cell cycle control, Immortal DNA strand hypothesis, Asymmetric cell division, telomerases in relevance to stem cell development and differentiation. Germline stem cells and germ line- derived pluripotent cells, Stem cell niche, epithelial stem cells, mesenchymal stem cells, neural stem cells, haematopoitic stem cells, cardiac stem cells, Cancer stem cells, Markers, molecular and evolutionary mechanisms addressing origin and maintenance of cancer stem cells, Generation of chimeric animals and animalcloning;Pro-nuclearinjectionofblastocysts,transplantationofblastocystesintopseudo-pregnantmice and generation of chimeric and knockout animals. Potential application of transgenic animals: Reprogramming of the nuclei and generation cloned animals. Gene editing technologies - TALEN, CRISPR Cas9.

Unit 4: Biology of Cancer Stem cells :. Tumor immunology [tumor antigens, cytokines, vaccine development , immunotherapy and its limitations, Tumor cell evasion of immune defenses. self-renewing properties, disease prognosis and resistance to therapies Epigenetics, miRNAs in human cancer, Principles of chemotherapy and chemoprevention.

Suggested reading:

1. Wilson J.D. Text Book of Endocrinology. SaundersPublishers.
2. Schatten H and Constanitinescu G.M. Comparative Reproductive Biology. Blackwell Publishers,UK
3. Joy K.P, Krishna A, andHaldar C. Comparative Endocrinology and Reproduction. Narosa Publishers, Delhi.
4. NusseySandWhitehead.Endocinology-AnIntegratedApproach,Oxford: BIOSScientificPublishers
5. PolonskyK.S,LarsenP.RandKronenberg.WilliamsTextbookH.MofEndocrinology,lsevier.

304: ENVIRONMENTAL BIOTECHNOLOGY

Unit 1: Ecotoxicology Definition; classification of toxicants in environment; Factors affecting toxicity; Mutagenesis; Teratogenesis; Carcinogens; Hellucinogens; Phytotoxins and animal toxins;

Toxic response of different body system likes respiratory, gastro-intestinal tract, liver, kidney, immune system and reproductive system; Toxicants types; Absorption and distribution of toxicants in animal body; Bio-transformation of toxicants; Antidotes treatment and detoxification of toxicants; Bio-accumulation.

Unit 2: Environmental Quality Assessment and Monitoring

What is environmental quality? Quality of environment for life on earth and man; Deterioration of environmental quality with reference to anthropogenic impact; Methods of assessment of environmental quality; Short term studies/surveys; Rapid assessment; Continuous short and long term monitoring Environmental Impact Assessment (EIA) Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies; Environmental Impact Assessment techniques- checklist method, overlay mapping method, network method, simulation and modeling technique, matrix method, and system diagram technique; Merits and Demerits of EIA studies.

Unit 3: Remote sensing & Geographical Information System (GIS)

Principles of Remote sensing, its applications in Environmental Monitoring Concept of Remote sensing; EMR & its interaction with matter; Aerial Photography: Types, Camera, Elements of photo interpretation (Aerial Photography/image recognition); Sensors & platforms; IRS satellites & their sensors; Application of remote sensing in environmental studies. Geographical Information System (GIS) Concept of GIS; Types of Geographical Data; Data Structure; Vector and Raster data: their Advantages and Disadvantages; Input, verification, storage and out put of geographical data; Importance of Geographical Information System in environmental studies.

Unit 4: Pollution Biotechnology

Concept of solid waste; Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Major sources of solid wastes; Solid waste management: Causes, effects and control measures of urban and industrial wastes.Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes.

Recommended Books:

1. S. Glassstone, D. Van Nastrand, Source book on atomic energy, 3rd Edition, Germany,1967.
2. M. Eisendbud, Environmental radioactivity, , AcademicPress.
3. E.D.Enger, B.E. Smith, Environmental Science- A study of Inter relationships, WCBPublication.

305: LAB COURSE:

Preparation of culture media
To performe meristem/ bud culture, shoot multiplication & rooting
phenomenon To studyorganogenesis
To perform somatic embryogenesis
To study the process of plantlet
acclimatization to perform embryo

culture
To study the process of anther culture
development Study of molecular markers
Extraction of DNA from plant cultures
Estimation and separation of DNA using agarose gel electrophoresis and spectrophotometer
Biomas estimation by different methods
Estimation of BOD & COD
Testing for microbiological quality of potable water (Coli form test)
Microbial degradation of organic matter
Testing for effect of chemical pesticides on soil microbial respiration
Testing for microbial biodegradation of pesticides

Inter Disciplinary Elective

(IDSE) 306A:

Unit-1: Oxidative stress: Role in physiological and pathological processes

Inflammation & pathogen defenses, Reproduction, ovulation, fertilization, implantation, parturition, Brain development: Differentiation into type I & II neurons, Chronic respiratory disorders-asthma, Cardiovascular disease atherosclerosis**,** Neurodegenerative disorders, stroke, Parkinson's, Alzheimer's, Diabetes**,** Cancer, Aging

Unit-2: Vaccinology

Historical perspective work of Edward Jenner on smallpox and cowpox, Louis Pasteur's contribution to vaccinology. Biology of vaccination-Basis of immunization, antigenicity and immunogenicity. Classical categories of vaccines-killed live; adjuvants and vehicles-mineral oil compounds, liposomes, saponins, and biodegradable micro particles. Modern categories of vaccines - multivalent vaccines, synthetic peptide vaccines, recombinant vaccines, DNA vaccines, combination vaccines. Commercial preparation of vaccines, cell culture based vaccines, regulatory aspects of vaccination for humans and veterinary use. Technical aspects of vaccination-routes of vaccination, schemes for vaccination - primary and boosters, storage of vaccines, risks of vaccination. Examples of vaccination-success of small pox vaccine, hepatitis B vaccine, rabies vaccine, challenges in vaccination against HIV, malarial parasites etc.

Suggested reading:

1. KaufmannS.H.E.Conceptsinvaccinedevelopment.InVaccinesforthe21stCentury:AToolfor DecisionmakingbyInstituteofMedicine(U.S.).NationalAcademiesPress.

2. BrostoffJ,SeaddinJK,MaleDandRoittIM.ClinicalImmunology,GowerMedicalPublishing.

Recommended Books:

1. PackerLandHelumtS.OxidativeStressandInflammatoryMechanismsi n Obesity,Diabetes,andtheMetabolicSyndrome.CRCPress.
2. QureshiA.GandParvezSH.Oxidativestressandneurodegeneratdisorders Elsevier Publishers.
3. Singh.OxidativeStressDiseaseandCancer.WorldScientificPublishing.

4. SurhY.JandPackerL.OxidativeStress,Inflammation,andHealth.CRCPress.
5. OzbenmT.FreeRadicals,OxidativeStress,andAntioxidants:Pathologicaland PhysiologicalSignificance.SpringerPublishers.

306 B: AQUACULTURE: NUTRACEUTICAL & PHARMACEUTICAL APPLICATIONS

Unit 1: Aquaculture and fish seed production: Hypophysiation, hCG injections and Linpe technique, Algae, shellfish, shrimp and prawn culture, Impacts of endocrine disrupters on aquaculture. Marine bio/fish resources and its applications in pharmaceutical and Nutraceutical industries, Fish meal and oil- products of marine algae, Fresh water and marine (oyster) pearl culture technology.

Unit 4-: Plant breeding

Introduction and objectives, Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding. Selection methods: For self-pollinated, cross pollinated and vegetative propagated plants; Hybridization: For self, cross and vegetative propagated plants – Procedure, advantages and limitations. Quantitative inheritance, Concept, mechanism, examples of inheritance of Kernel colour in wheat, Monogenic vs polygenic Inheritance. Inbreeding depression and heterosis, History of genetic basis of inbreeding depression and heterosis; Applications. Crop improvement a n d breeding, Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in cropimprovement.

Recommended Books:

1. Ostrander G.K. The laboratory fish. Academic Press.
2. Dunham R.A. Aquaculture and Fisheries Biotechnology and Genetic Approaches. CABI Publishing, UK.
3. Zaborski O.R and Attaway D.H. Marine Biotechnology. Pharamaceutical and bioactive naturalProducts. SpringerScience.

***306 C: Cronobiology**

Unit 1: Basic Chronobiology

Historical developments in chronobiology. Different types of geophysical and biological cycles with examples of circadian rhythms. Quantification of biological rhythms - Average, amplitude, phase, and period. Brief introduction to time series analysis. Methods of time series analyses: COSINOR, AUTOCORRELATION, FOURIER, MESA, CHI-SQUARE PERIODOGRAM.

Unit 2: Characteristics of circadian rhythm: Free-run, Temperature and nutrition compensation, and Entrainment. Zeitgeber Time (ZT) and Circadian Time (CT). After-effects and Aschoff's rule. Aging and circadian clocks. Photoperiodism. Plant Rhythms. Synchronization (=Entrainment) and masking. Entrainment by single light pulse, complete and skeleton photoperiods. Zeitgebers for circadian clocks. Key properties of a Zeitgeber. Photic and non-photic zeitgebers. Mechanisms of entrainment. Phase response curves (PRC), phase transition curves, strong and weak PRC. Circadian pacemakers in insects with special reference to *Drosophila*. Suprachaismatic nucleus as mammalian circadian clock. Multi-oscillatory organization: master and slave oscillators, morning and evening oscillators, pacemaker and peripheral oscillators. Adaptive significance of circadian rhythms. Social consequence of circadianrhythms.

Unit 3: Molecular mechanisms underlying clock functions in organisms: Autoregulatory transcriptional feedback loops; Circadian clock mutant types in *Drosophila* (*per*, *tim*, *dbt*, *dclock*,

cycle, *vrille*, *pdf*, *lark*, *takeout*), *Neurospora*, cyanobacteria, mouse, and humans. Temporal expression pattern of clock genes, Regulation of expression of clock genes, Expression patterns under constant light and darkness; Autonomous functions of clock genes in peripheral tissues. Techniques involve in molecular mechanism of clock functions. Human circadian organization: Methods to study human circadian rhythm; Free-running rhythms in humans, Constant routine protocol, and Forced desynchronization protocol. Cronotypes and its assiment methods. Marker rhythms in humans: Core body temperature (CBT), melatonin, and cortisol. Sleep-wake alertness and performance rhythms inhumans.

Unit 4: Circadian rhythms and human health: Chronopharmacology; Basics of chronopharmacology – clinical chronopharmacology – circadian dependence of drug pharmacokinetics. Chronotherapy; Application of chronotherapy in treatment of cancer, cardiovascular diseases, allergies, asthma, and circadian rhythm sleep disorders (for example, DSPS and ASPS) & mood disorders (SAD). Circadian rhythms in occupational and travel stresses: Shift work; Types of shift system, direction and frequency of shift rotation, Effect on rhythm parameters, Desynchronization of circadian rhythm, Consequences on sleep, Psychosocial problems, Clinical and non-clinical problems. Shift work tolerance/ intolerance. Shift optimization: Nap, Bright light therapy, Melatonin therapy. Jet lag: Consequences of jet lag; direction asymmetry & variable asymmetry; Approaches to jet lag alleviation. Sports Cronobiology.

Recommended Books:

1. MJ Berridge: Biochemical oscillations and cellular rhythms. The molecular bases of periodic and chaoticbehaviour
2. E Bunning : The physiologicalclock
3. FH Columbus : Trends in chronobiology
4. G Cornelissen & F Halberg: Introduction tochronobiology
5. JC Dunlap, JJ Loros& PJ DeCoursey: Chronobiology: Biologicaltimekeeping
6. JC Hall : Genetics and molecular biology of rhythms in *Drosophila* and otherinsects
7. PJ Lumsden& AJ Millar: Biological rhythms and photoperiodism inplants
8. JD Palmer : The livingclock
9. AK Pati : Chronobiology: The dimension of time in biology and medicine; PINSA (Biological Sciences), December2001
10. AK Pati (Ed.):Chronobiology
11. DS Saunders : An introduction to biologicalrhythms
12. B Thomas & D Vince-Prue : Photoperiodism inplants
13. V Kumar (Ed.) : Biologicalrhythms
14. MK Chandrashekaran: Time in the LivingWorld
15. AT Winfree: The Geometry of BiologicalTime
16. MC Moore-Ede, FM Sulzman, & CA Fuller : The clocks that time us, Harvard UniversityPress,1982
17. DS Saunders: Insect clocks, Pergamon,2002

SEMESTER 4

401: Research Methodology

Unit-I Scope of Research and Ethics

Introduction and Scope, Research problem: Identification, Selection, Formulation of research objectives, Research design: Components, Types and Importance, Research ethics, Institutional ethics committee, Plagiarism-Pitfall

Unit-II Technical Writing

Types of technical documents; Full length research paper, Short/Brief communications, Letters to editor, Book chapter, Review, Conference report, Project proposal Components of a full length research paper; Title/Topic statement, Abstract/key words, Aims and objectives, Hypothesis building, Rationale of the paper, Work plan, Materials and methodology, Results and discussion, Key issues and arguments, Acknowledgement, Conflict of interest statement, bibliography, Technical Resumes and Cover Letters Components of a research proposal; Project summary Key words, Origin of the proposal, Major objectives Methodology, Instrument facility available in the PI's department, Overview of status of Research and Development in the subject, Importance of the proposed project in the context of current status, Bibliography

Unit-III Scientometrics

How to cite and how to do referencing Literature search technique, using SCOPUS, Google Scholar, PUBMED, Web of science, Indian Citation Index, and RG Styles of referencing; APA, MLA, Oxford, Harvard, Chicago Annotated bibliography Tools for citing and referencing, Grammarly, Endnote etc

Unit-IV IPR and Cyber Law and literature searching.

Patents, Patent laws, process of patenting a research finding, Intellectual property (IP), Intellectual property right (IPR), Copyright, Trademarks, GI, Cyber laws, COPE. Search engine – Google and Yahoo; Pubmed, Scopus, Web of Science, Google Scholar, Indian Citation Index, Science Citation Index (SCI), h-index, i-10- index. Journal Impact Factor (JIF). Introduction to Plagiarism and Cyberlaws.

402: Industrial/ Research exposure (3 months)

403: Report Submission and Seminar Presentation